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NSW GOVERNMENT

Coffs Harbour Bypass

Amendment Report

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Appendix H

Updated flooding and hydrology assessment

Transport for New South Wales

Coffs Harbour Bypass

Flooding and hydrology assessment

FLD02

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Arup Australia Pty Ltd ABN 76 625 912 665

Arup
Level 4, 108 Wickham Street
Fortitude Valley
QLD 4006
GPO Box 685 Brisbane QLD 4001
Australia
www.arup.com

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1 Introduction

1.1 Project overview

Transport for New South Wales (TfNSW) is seeking approval for Coffs Harbour bypass (the project) under Division 5.2 of the EP&A Act as critical State significant infrastructure (CSSI).

The project includes a 12 km bypass of Coffs Harbour from south of Englands Road to Korora Hill in the north and a two-kilometre upgrade of the existing highway between Korora Hill and Sapphire. The project would provide a four-lane divided highway that bypasses Coffs Harbour, passing through the North Boambee Valley, Roberts Hill ridge and then traversing the foothills of the Coffs Harbour basin to the west and north to Korora Hill. **Figure 1** illustrates the project extents.

The key features of the project include:

- Four-lane divided highway from south of Englands Road roundabout to the dual carriageway highway at Sapphire
- Bypass of the Coffs Harbour urban area from south of Englands Road intersection to Korora Hill
- Upgrade of the existing Pacific Highway between Korora Hill and the dual carriageway highway at Sapphire
- Grade-separated interchanges at Englands Road, Coramba Road and Korora Hill
- A one-way local access road along the western side of the project between the southern tie-in and Englands Road, connecting properties to the road network via Englands Road
- A new service road, located east of the project, connecting Solitary Islands Way with James Small Drive and the existing Pacific Highway near Bruxner Park Road
- Three tunnels through ridges at Roberts Hill (around 190 m long), Shephards Lane (around 360 m long), and Gatelys Road (around 450 m long)
- Structures to pass over local roads and creeks as well as a bridge over the North Coast Railway
- A series of cuttings and embankments along the project
- Tie-ins and modifications to the local road network to enable local road connections across and around the alignment
- Pedestrian and cycling facilities, including a shared path along the service road tying into the existing shared path on Solitary Islands Way, and a new pedestrian bridge to replace the existing Luke Bowen footbridge with the name being retained

- Relocation of the Kororo Public School bus interchange
- Noise attenuation, including low noise pavement, noise barriers and at-property treatments as required
- Fauna crossing structures including glider poles, underpasses and fencing
- Ancillary work to facilitate construction and operation of the project, including:
  - Adjustment, relocation and/or protection of utilities and services
  - New or adjusted property accesses as required
  - Operational water quality measures and retention basins
  - Temporary construction facilities and work including compound and stockpile sites, concrete/asphalt batching plant, sedimentation basins and access roads (if required).

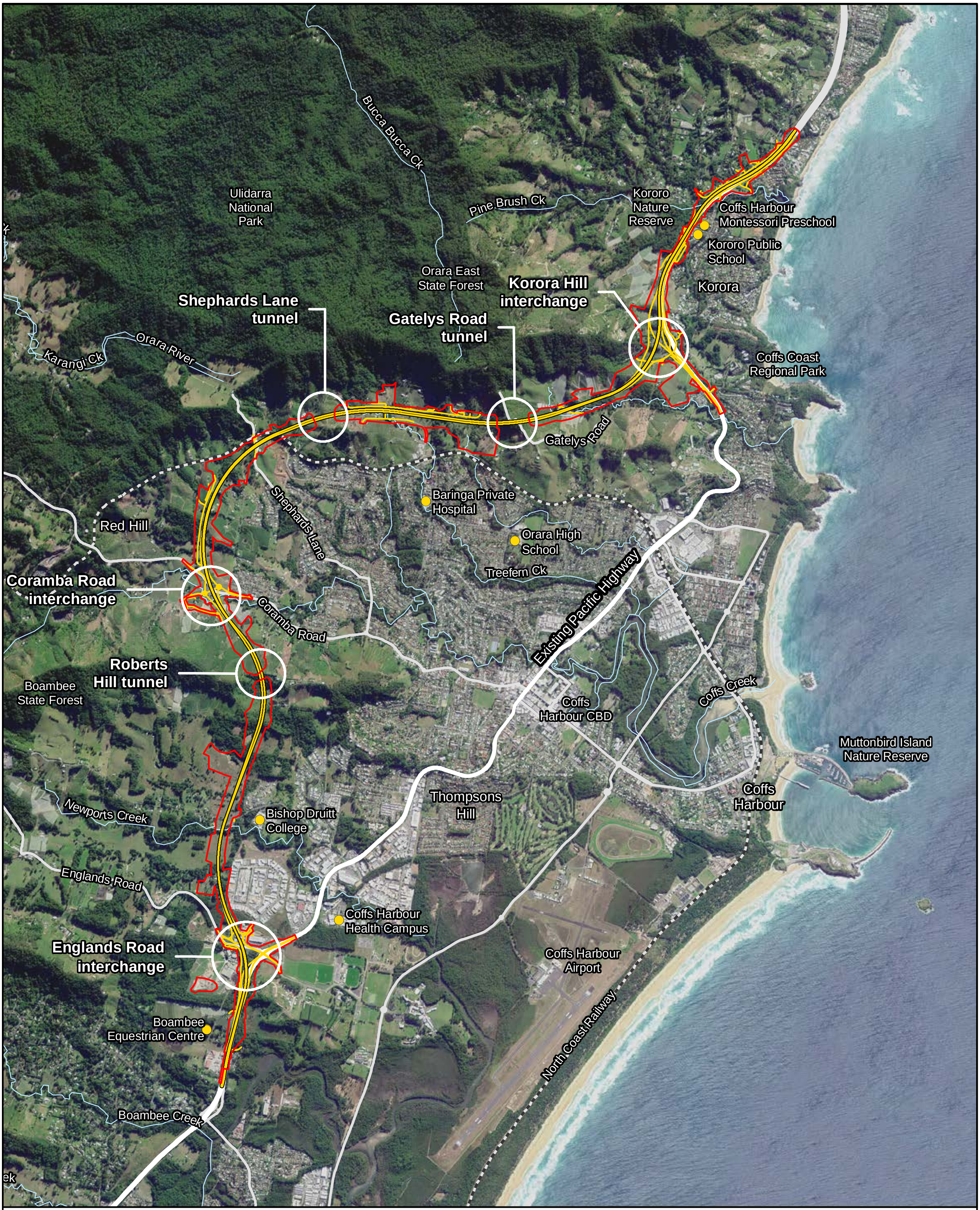
1.2 Design changes

The environmental impact statement (EIS) was exhibited by the Department of Planning, Industry and Environment for 47 days from 11 September 2019 to 27 October 2019. TfNSW has refined several aspects of the project as exhibited in the EIS. These changes have been developed in response to:

- Consultation with stakeholders, community and landowners during the EIS public exhibition period (11 September 2019 to 27 October 2019)
- Submissions received during the EIS public exhibition period
- Continued development and refinement of the concept design and consultation with government agencies.

There are a number of design and construction changes to the project as presented in the EIS. The design and construction changes are:

- Englands Road interchange
- North Boambee Valley vertical alignment
- Coramba Road bus stop
- Korora Hill interchange
- Kororo Public School bus interchange and Luke Bowen footbridge
- Pine Brush Creek and Williams Creek realignment
- New and revised ancillary sites
- Water quality basins.



Legend

- Construction footprint
- Alignment
- North Coast Railway
- Sensitive receiver
- Watercourse

Coffs Harbour Bypass
Key features of the project
Figure 1

NOTE: Elements are indicative only for the purpose of project planning and may change prior to construction.

0 0.5 1 1.5 km
Scale @A4: 1:50,000
GDA 1994 MGA Zone 56
N

1.3 Assessment methodology

Following exhibition of the EIS, several model updates have been made to the hydrologic and hydraulic models (refer **Section 2.5** and **2.6**). These changes have resulted in changes to the existing case modelled flooding behaviour (refer **Section 3**). In addition, the amended design in combination with model updates have resulted in revised design case flooding behaviour. The amended design includes the proposed design changes (listed in **Section 1.2**) design refinements, as part of ongoing design development, and outcomes of community consultation.

This amended design case flooding behaviour has been assessed against the revised existing case flooding behaviour to identify the impacts of the amended design. This methodology is outlined in **Figure 2** below. Due to the large number of changes, the flooding and hydrology assessment technical paper has been updated to present the same level of assessment and content as carried out for the EIS. The body of this technical paper does not provide a comparison of potential impacts (ie EIS project impacts compared with project impacts of amended design). This comparison is provided in **Appendix G1**.

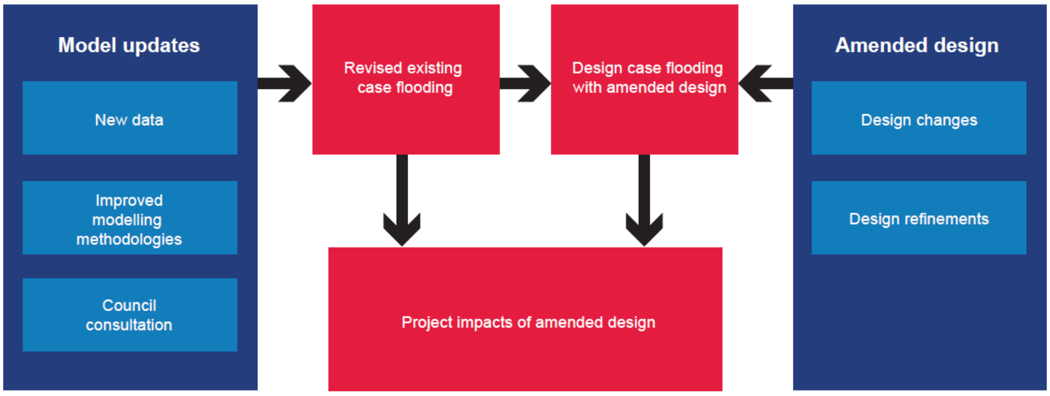


Figure 2: Assessment methodology

1.4 Purpose of this report

This technical report has been prepared to provided details of the methods and processes undertaken to address specific Secretary's Environmental Assessment Requirements (SEARs) for flooding and hydrology and to provide a detailed analysis for input into the amendment report for the project.

The SEARs relevant to hydrology and flooding are contained within **Table 1**. A number of these requirements also require assessment with regard to groundwater and surface water quality.

Table 1: Relevant SEARs

Key Issue and Requirement	Location
11. Water - Hydrology 1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	Section 2.1 Section 3 Section 4 Section 5
2. The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	
(a) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	Section 4 Section 5
(d) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	Section 4 Section 5
(e) minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re - use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Section 4 Section 5
12. Flooding 1. The Proponent must assess (and model where required) the impacts from the project on flood behaviour, in particular Coffs Creek, during the construction and operation for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including:	
(a) Any detrimental increases in the potential flood affectation of the project infrastructure and other properties, assets and infrastructure;	Section 4.1 Section 5 Section 6
(b) Consistency (or inconsistency) with applicable Council floodplain risk management plans;	Section 5.3
(c) Compatibility with the flood hazard of the land;	Section 4 Section 5 Section 6
(d) Compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;	Section 4 Section 5 Section 6
(e) Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, or adjacent to or downstream of the site;	Section 5 Section 6
(f) Downstream velocity and scour potential;	Section 5
(g) Impacts the project may have upon existing community emergency management arrangements for flooding, including Council's upper catchment detention basins. These matters must be discussed with the State Emergency Services and Coffs Harbour City Council;	Section 5
(h) Any impacts the project may have on the social and economic costs to the community as consequence of flooding;	Section 5
(i) Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses; and	Section 4 Section 5
(j) Any mitigation measures required to offset potential flood risks attributable to the project.	Section 4 Section 5

1.5 Study area

The project is located within the Coffs Harbour City Council (CHCC) local government area.

Key drainage features of the study area are two topographic zones. These include a hillside zone (areas above the 50 m contour) and the lowland area (areas below 50 m contour).

The hillside zone comprises steep slopes and ridges which rise to about 150-250 mAHD. Major ridge lines project from the Great Dividing Range such as the prominent ridge to the south of Coramba that ends at Roberts Hill. Numerous drainage channels that typically flow east to the lowland area, incise the hillside area. Most of the steep slopes and ridges are either forested or used for banana cultivation.

The lowland area is characterised by low undulating residual hills with gentle gradients and alluvial floodplains including back swamps and dunes.

The project covers several catchments which predominantly drain from the western ridges of the Great Dividing Range towards the Pacific Ocean, as illustrated in **Figure 2.**

The catchments have been grouped by locality and relate to the creeks and watercourses to which they drain. They also relate to catchments as they are defined within existing flood models.

The project catchments as listed below are referred to throughout the report as, North Boambee Valley, Coffs Creek and northern creeks. The primary waterways within each catchment are:

- North Boambee Valley:
  - Tributary of Boambee Creek
  - Newports Creek.
- Coffs Creek:
  - Coffs Creek
  - Treefern Creek.
- Northern creeks:
  - Jordans Creek
  - Kororo Basin – Kororo Basin is a catchment located south east of the Pine Brush Creek, it is not related to the Korora, which is located in the upper catchment area of Pine Brush Creek
  - Pine Brush Creek
  - Sapphire Beach – this relates to an unnamed waterway at this location.

1.5.1 North Boambee Valley

The catchment drains from the west to the Pacific Ocean via Boambee Creek and Newports Creek. The combined Boambee and Newports Creek catchment area is about 50 km^2.

The existing Pacific Highway crossings of Newports Creek and its southern tributary provide access to and from the Coffs Harbour Health Campus (which is located north of the southern tributary crossing and south of the Newports Creek crossing).

The upper catchment to the west is primarily steep and densely vegetated. The middle and lower catchment areas are characterised by a large floodplain and become more urbanised towards the coastline to the east.

The North Boambee Valley (west) urban release area is an approved planned development area north of North Boambee Road and west of the residential area at Highlands Estate.

1.5.2 Coffs Creek

The catchment drains from the west to the Pacific Ocean via Coffs Creek, Treefern Creek and other unnamed tributaries. It generally drains through natural channels surrounded by urban areas. Coffs Creek converges west of the Pacific Highway and forms an estuary at the coast.

The catchment area is about 25 km^2 and consists of a flat coastal floodplain from the Pacific Ocean to the east rising to a steep escarpment in the west. This terrain is conducive to orographic effects, quickly rising from 10 to 500 mAHD. About 23 per cent of the catchment is densely vegetated, 33 per cent grazing and farmland, with the remainder urban (GeoLINK, 2015).

The Coffs Creek catchment is prone to flash flooding due to the steep upper terrain and a relatively high level of urban development within the floodplain (BMT WBM 2018).

1.5.3 Northern creeks

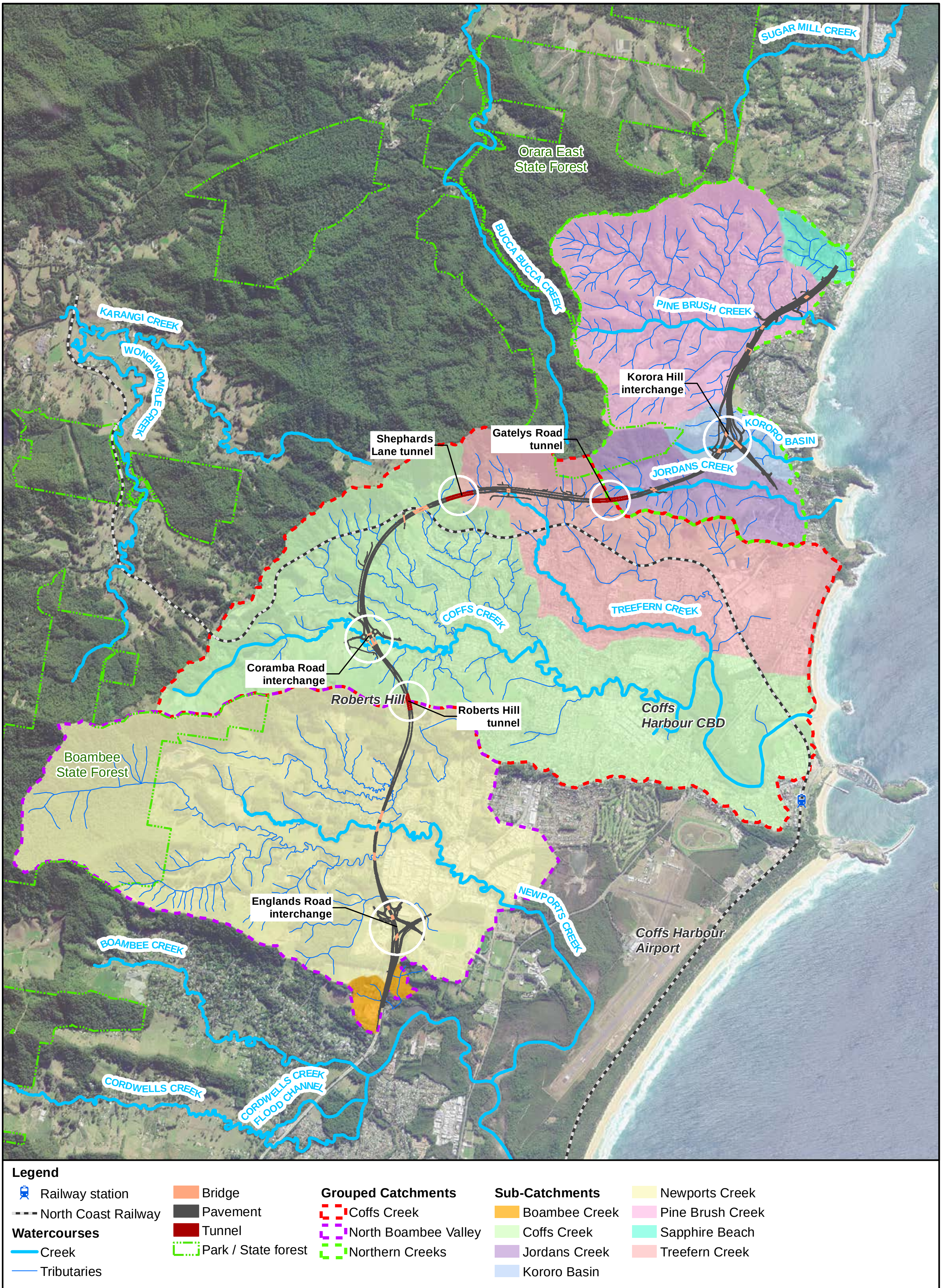
The combined catchment named northern creeks drains to the Pacific Ocean via a number of creeks and watercourses. These are, Kororo Basin, Jordans Creek, Pine Brush Creek and an unnamed waterway at Sapphire Beach. The total area of the Northern catchment is about 13 $km^{2.}$

The catchment is divided into four sub catchments, which reflect the creeks and waterways to which they drain. The defined sub-catchments and their areas are listed in **Table 2**.

Table 2: Northern creeks sub-catchments

Sub-catchment	Total area (km2)
Jordans Creek	2.7
Kororo Basin	1.4
Pine Brush	8.4
Sapphire Beach	0.5

All sub-catchments flow from steep terrain in the west, in an easterly direction towards the coastline. Land use within the catchment area consists of about 40 per cent dense bushland, 50 per cent pastural and the remainder urban (primarily in the lower regions of the catchment).



Coffs Harbour Bypass
Figure 3
Study area

1.6 Terminology

Specific flooding and hydrology terms used in this report are defined in **Table 3**.

Table 3: Glossary of terms

Term	Definition
Afflux	Predicted increase in developed peak flood level relative to the existing condition
Australian Height Datum (AHD)	Standard height above the average sea level at which a flood level is measured
Average recurrence interval (ARI)	Average number of years between exceedances of a flood event of the same size
Annual exceedance probability (AEP)	Percent likelihood a flood event of a certain size will occur within any one year
Climate change	Predicted future rainfall intensities and sea levels affecting flood behaviour
BMT WBM	The developers of the TUFLOW flood modelling software
Developed case	Operational phase with the project in place (post-construction).
Detention basin	Excavated (or bunded) land to increase floodplain storage, with an outlet designed to attenuate flows and decrease flooding downstream
Existing case	Existing conditions without the project in place (pre-construction).
Finished Floor Level (FFL)	Existing internal floor elevation of a structure
Hydrologic model	Represents catchment rainfall-runoff processes. Runoff generation are modelled at the sub-catchment scale and resulting runoff hydrographs are routed along catchment stream reaches and storages
Hydraulic model	Simulates conveyance to predict characteristics such as flood level and velocity, based on hydrologically derived inflows
Intensity frequency duration (IFD)	Design event storm parameters provided by BoM based on statistical analysis of historic events
Manning's '*n*' roughness	An empirically derived coefficient, generally representative of the hydraulic roughness of a surface ($s/m^{1/3}$)
Orographic effect (or rainfall gradient)	The influence of mountainous topography on rainfall patterns, dependant on surface gradients, wind direction and storm sources, which may concentrate rainfall
Probable maximum flood (PMF)	The worst-case flood event that could possibly occur based on Probable maximum precipitation (PMP) and the most extreme catchment conditions
TUFLOW	The name of the hydraulic (flood) modelling software used in this study
XP-RAFTS	The name of the hydraulic (flood) modelling software used in this study

1.7 Design event nomenclature

The report adopts design flood nomenclature in terms of AEP, as detailed in *Australian Rainfall and Runoff* (ARR) (Ball, et al., 2019). **Table 4** presents the relationship between ARI and AEP for a range of design events.

Table 4: Design event nomenclature

AEP (%)	AEP (1 in x)	ARI (year)
50	2	1.44
39.35	2.54	2
20	5	4.48
18.13	5.52	5
10	10	9.49
5	20	20
2	50	50
1	100	100
0.5	200	200
0.2	500	500
0.05	2000	2000

1.8 Policy context and legislative framework

In addition to the SEARs set out in Section 1.2, there are local, State and National legislation, policies and guidelines which are relevant to the project.

The policies, guidelines and legislation used for the assessment of hydrology and flooding are summarised in **Table 5**. The table also details the relevance of each document to the project and this report.

Table 5: Relevant legislation, policies, and guidelines

Level	Legislation/Policy/Guideline	Relevance
National	*Australian Rainfall and Runoff* (ARR) (Pilgrim, 1987) (Ball, et al., 2019)	National guideline for design flood estimation.
	Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017)	Developed with consideration of the *National Strategy for Disaster Resilience* (COAG, 2011) and intended to provide broad guidance on all aspects of managing flood risk.

Level	Legislation/Policy/Guideline	Relevance
State	*Floodplain Development Manual* (DIPNR, 2005)	This manual details methods which aim to reduce the impact of flooding and flood liability while recognising the benefits of the use, occupation, and development of flood prone land. It does this by promoting a merit approach to balance social, economic, environmental, and flood risk parameters. The manual defines the categorisation of flood risk in NSW. This manual is nominated under the project SEAR for flooding as relevant for consideration. The methods contained with the manual have been used to inform the development of the project specific Floodplain Management Objectives against which the project impacts have been assessed. Details of this method are contained within Section 1.7 of this report.
	Practical Consideration of Climate Change – Flood Risk Management Guideline (DECC, 2007)	Assists flood consultants and councils in the preparation and implementation of flood risk management plans with climate change considerations. This guideline has also been nominated under the project SEARs for flooding as relevant for consideration. The methods contained with the manual have been used to inform the development of the project specific Floodplain Management Objectives against which the project impacts have been assessed. Details of this method are contained within Section 1.7 of this report.
	NSW 2021: A Plan to Make NSW Number One (DPC, 2011)	Presents the strategy for the decade, including priority actions to increase the capacity to prepare for, prevent, respond to, and recover from future extreme weather events and hazards. The methods contained with the manual have been used to inform the development of the project specific Floodplain Management Objectives against which the project impacts have been assessed. Details of this method are contained within Section 1.7 of this report.
	Upgrading the Pacific Highway – Design Guidelines (Roads and Maritime, 2015)	Detail of design guidelines relevant to the project, including hydraulic design criteria The methods contained with the manual have been used to inform the development of the project specific Floodplain Management Objectives against which the project impacts have been assessed. Details of this method are contained within Section 1.7 of this report.

Level	Legislation/Policy/Guideline	Relevance
	North Coast Regional Plan 2036 (DPE, 2017)	Encompasses goals aimed towards delivering greater prosperity in the region. It specifically aims to manage natural hazards and climate change by identifying, avoiding, and managing vulnerable areas and hazards. It also calls for action to review and update floodplain risk, particularly where urban growth is being considered.
Local	*Coffs Creek Floodplain Risk Management Plan* (Bewsher Consulting, 2005)	A result of the Floodplain Risk Management Study commissioned by CHCC, recommends floodplain management improvements for the Coffs Creek Floodplain. This management plan has also been nominated under the project SEARs for flooding as relevant for consideration. The methods contained with the manual have been used to inform the development of the project specific Floodplain Management Objectives against which the project impacts have been assessed. Details of this method are contained within Section 1.7 of this report.
	Coffs Harbour Local Environmental Plan 2013 (NSW Government, 2013)	Aims to make local environmental planning provisions for land in Coffs Harbour in accordance with the relevant standard environmental planning instrument, and specifically to minimize the exposure of development to natural hazards and natural risks.
	Floodplain Development and Management Policy (CHCC, 2017)	Standard for flood assessment in the Coffs Harbour LGA and is supported by the EPA Act. Sets policy to minimise flood risk and effects of development
	Coffs Harbour Local Flood Plan (SES, 2017)	Details the flood preparedness, response and recovery procedures for the occurrence of a significant storm event.

1.9 Project floodplain management objectives

Based on the documents referenced in Section 1.6, the project SEARs, project floodplain management objectives have been developed similar to objectives established for other Pacific Highway upgrade projects and other major TfNSW projects.

The project floodplain management objectives have been defined for two areas of project infrastructure management objectives (elements within the project construction boundary) and external to the construction footprint management objectives. The objectives are listed in **Table 6**.

Table 6: Project floodplain management objectives

Project infrastructure	
Element	**Criteria**
Alignment	1% AEP flood immunity for proposed main carriageway and 5% AEP for ramps and interchanges
Tunnel portals	Above the PMF or the 1% AEP flood level +0.5 m (whichever is greater), where ingress of floodwaters would collect at the sag in the tunnel
Waterway crossings	Bridge soffits >0.5 m above 1% AEP flood level. Appropriate scour protection designed for areas at risk of scour due to the project to ensure long term bed and bank stability
Construction	Potential impact of ancillary site locations is identified, to ensure appropriate flood risk assessment of vulnerable sites and to inform a future construction flood management plan
External to construction footprint	
Element	**Criteria**
Level	A merit-based approach, considering the relative impact to peak flood level, hazard, extent and potential damages. In general, the following afflux criteria is applied for design events up to the 1% AEP: <10 mm for residential, commercial and industrial areas and buildings affected by FFL inundation; <50 mm for agricultural land; and <250 mm pastural, forest and recreational areas.
Scour	No adverse increase in peak flood velocity for design events (up to 1% AEP)
Access	All affected existing local and access roads are to be ultimately configured (where feasible during construction) such that the existing level of flood immunity, inundation duration and available evacuation time is maintained or improved (subject to CHCC and stakeholder consultation)
Direction	No change to flow direction / receiving catchment except for constriction into and expansion out of discrete openings (culverts and bridges) and constructed diversions.
Critical infrastructure	No adverse modifications to flood behaviour or hazard on critical or vulnerable infrastructure such as hospitals, nursing homes, childcare facilities and schools (up to PMF).
Emergency management	No adverse impact upon community flood emergency management plans - unless alternate risk mitigation is proposed.

Section 4 of this report details an assessment of the above objectives during construction of the project.

The project has been assessed against the floodplain management objectives, noting that a merit-based approach has been adopted for the flood level objectives as outlined in **Table 6** (refer to **Section 5**).

2 Hydrology and flooding methodology

This assessment has been carried out in line with the NSW Floodplain Development Manual (DIPNR, 2005) with reference to the Coffs Creek Floodplain Risk Management Plan (Bewsher Consulting, 2005) and the Boambee Newports Creek Floodplain Risk Management Plan (GHD, 2016). The following process has been carried out for the assessment:

- Review all relevant information and data applicable to the project including availability of existing hydrological and hydraulic models, digital terrain data, aerial imagery, survey data, project design components and any other relevant information
- Review documentation in relation to applicable guidelines, floodplain risk management plans and establish project objectives and floodplain management objectives and design criteria for the project
- Review the flood risk of the existing environment for the study area, understanding the key flooding mechanisms, and reviewing information for historical flood events
- Refining and updating the existing flood models and developing new flood models for areas where no previous flood modelling had been undertaken
- Ensuring orographic rainfall effects were included in the flood models
- Carry out model validation for the new flood models and for those that had been refined and updated
- Simulate and establish the existing case scenario to understand the current flooding conditions for a range of rainfall events
- Consultation with NSW State Emergency Service (SES) and CHCC about flooding and the potential impacts of the project and proposed mitigation measures
- Assess the potential flooding impacts during construction of the project including relevant changes since EIS exhibition and identify environmental management measures to avoid, minimise and/or mitigate potential flood impacts on the project or because of the project
- Assess the potential operational impacts of the project including relevant changes since EIS exhibition and identify and recommend mitigation measures which have been incorporated into the design of the project to reduce and manage potential flood impacts
- Provide inputs into the design process to achieve flood immunity objectives
- Provide environmental management measures to manage residual operational impacts following the implementation of the flood mitigation measures.

2.1 Background information

2.1.1 Historic floods

Coffs Harbour has historically been affected by significant flooding, with the largest flooding events on record detailed below.

November 1996 event

The most significant flood event in Coffs Harbour's history which resulted in declaration of a natural disaster zone. About 500 mm of rainfall fell in six hours, with the most intense rainfall falling in the upper catchments (Maddocks & Rowe, 2004). The flood affected 800 properties, with inundation above floor level of over 250 residential and 210 commercial and public properties (CHCC, 2018). Coffs Creek peaked at a record 5.4 mAHD (Speer, Phillips, & Hanstrum, 2011), over one metre greater than the predicted 1 per cent AEP event and caused $31 million in claimed damages. This event resulted in CHCC commissioning a revised flood study to investigate the orographic rainfall effects of the catchment, resulting in predicted peak flood level increases of 500 mm or more in many areas (Maddocks & Rowe, 2004).

Figure 4: Flooded commercial areas of Coffs Harbour in 1996 flood (Maddocks & Rowe, 2004)

March 2009 event

About 440 mm of rainfall was recorded within 24 hours (ABC, 2009). Coffs Creek peaked at 5.1 mAHD (700 mm above 1 per cent AEP), isolating 3200 people (Speer, Phillips, & Hanstrum, 2011). The flood event affected key rail infrastructure, causing closure landslides just north of Coramba.

Figure 5: Flooded tracks north-west of Coffs Harbour on April 1, 2009 (ABC, 2012)

2.1.2 Current flood mitigation

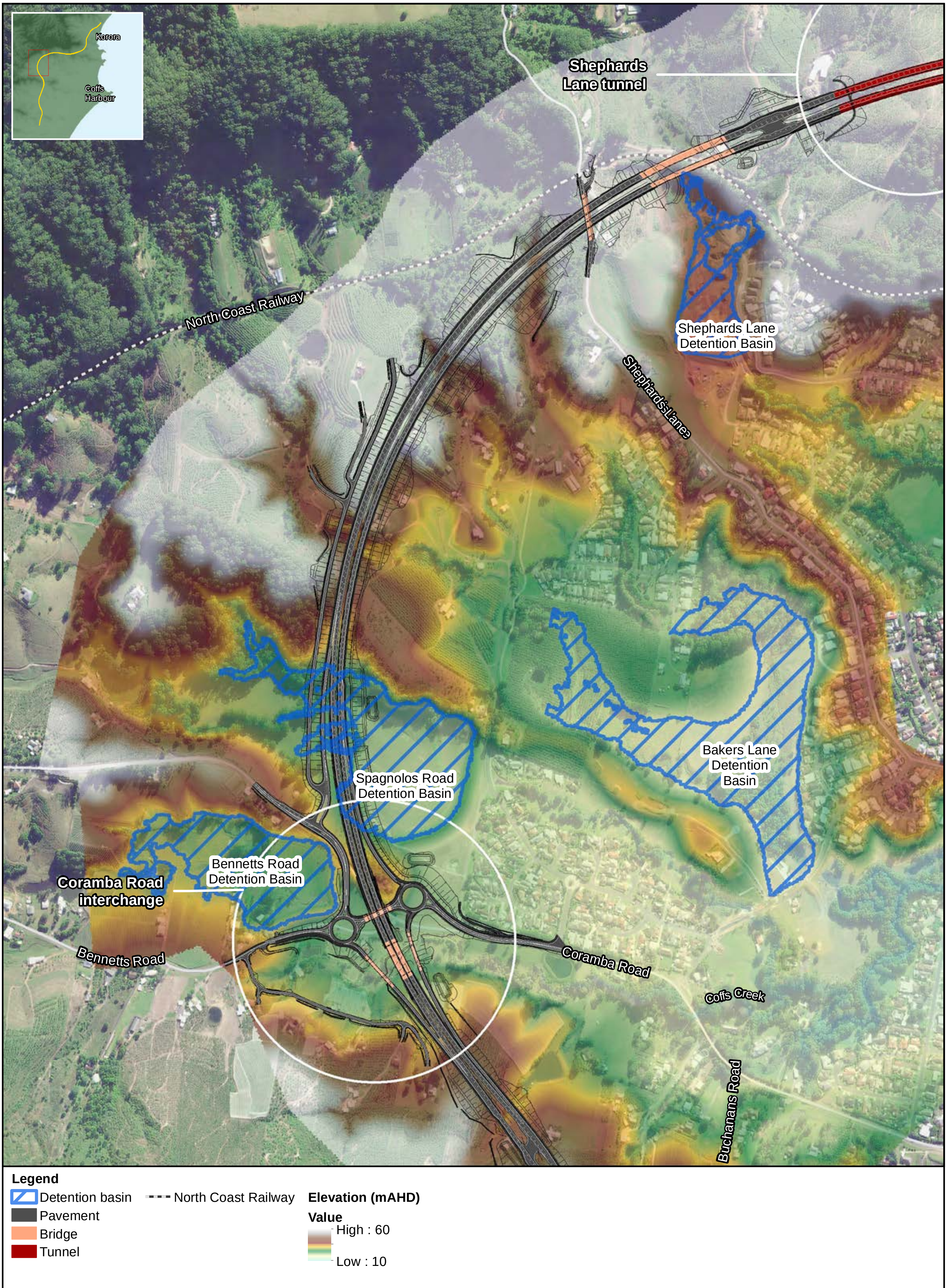
Several detention basins have been constructed to mitigate the flood risk to the community, including:

- The upper tributaries of Coffs Creek near Goodenough Terrace
- Isles Drive Industrial Estate (WMAwater, 2011)
- Several agricultural dams in the upper catchment.

The CHCC Flood Mitigation Programme (CHCC, 2018) incorporated additional detention basins at the following locations:

- Bakers Lane detention basin at William Sharpe Drive, West Coffs
- Bennetts Road detention basin
- Spagnolos Road detention basin
- Shephards Lane detention basin.

Figure 5 illustrates the above basins interaction with the project.



Coffs Harbour Bypass

Figure 6

Operational detention basins

2.1.3 Previous flood studies

Relevant existing flood studies were identified and reviewed as part of the assessment of hydrologic and flooding impacts for the project. These are summarised in **Table 7**.

Table 7: Relevant flood studies

Flood study	Summary
Coffs Creek Flood Study (Webb, McKeown & Associates, 2001)	• RORB hydrology with application of rainfall gradients • RUBICON hydraulic model calibrated to historic events • Assessment of previously constructed flood mitigation work, catchment development and tailwater variability.
Coffs Creek Floodplain Risk Management Plan (Bewsher Consulting, 2005)	• Updates to previous flood models with assessment of potential mitigation measures • Provides recommendations based on cost-benefit analysis of flood mitigation options.
***Coffs Creek and Park Beach Flood Study* (BMT WBM, 2018)	• XP-Rafts hydrologic modelling with application of rainfall zones based on recorded events • 2D TUFLOW hydraulic modelling with linked 1D elements • Calibration and validation to 2009 and 1996 events respectively • Sensitivity testing of climate change, blockage, roughness and rainfall gradients.
Boambee Creek and Newports Creek Flood Study (WMAwater, 2011)	• WBNM hydrologic model with weighted catchment zones to represent orographic effects • MIKE 11 / 2D TUFLOW hydraulic models to represent the upper and lower catchment areas respectively • Calibrated to 1996 event.
***North Boambee Valley (West) Flood Study* (de Groot & Benson, 2014)	• Finer delineation of sub-catchments of the previous hydrology model • 2D TUFLOW hydraulic model with linked 1D elements of upper catchment • Validated to previous results.
***Boambee Newports Creek Floodplain Risk Management Study* (GHD, 2016)	• Minor updates to the flood models (WMAwater, 2011) with assessment of potential mitigation measures • Provides recommendations based on cost-benefit analysis of flood mitigation options.

** Denotes flood studies models which have been adopted for the assessment of flooding and hydrology for the project. Section 2.2 details the methodology for adoption and use of these models.

2.2 Adopted flood models

After consultation with CHCC, it was agreed to adopt the previously established flood models of North Boambee Valley (de Groot & Benson, 2014) and Coffs Creek (BMT WBM, 2018) as the basis for this assessment.

No previously completed studies were available for the northern creeks catchment. Flood models for the northern creeks were developed and established for the purposes of this assessment.

A description of the hydrology and hydraulic models used for the project for each of the three catchments (as outlined in **Section 1.5**) is provided in **Section 2.5** and **Section 2.6** respectively.

The extents of the hydraulic (flood model) and hydrologic models are shown in **Figure 7** and **Figure 8** respectively.

2.3 Design storm events

The following design storm events were assessed:

- 18, 10, 5, 2 and 1 per cent AEP and PMF
- 1 per cent AEP climate change sensitivity tests (DECC, 2007):
  - 2050 climate: +400 mm sea level and +10 per cent rainfall intensity
  - 2100 climate: +900 mm sea level and +30 per cent rainfall intensity.

It is noted the 2050 and 2100 climate change rainfall intensity increases are roughly equivalent to the 0.5 and 0.1 per cent AEP events respectively.

2.4 Adopted rainfall parameters

The previously established hydrologic models, refer **Section 2.2**, were developed in accordance with the established practice at the time of their development, which was detailed within ARR (Pilgrim, 1987) (referred to as ARR 1987) – ie single design storm temporal patterns. These models included modifications to account for orographic effects (effects of mountains forcing moist air to rise) of the Coffs Harbour region.

At the time of EIS commencement an update to ARR (Ball, et al., 2019), hereafter referred to as ARR 2019, was developed and was still in draft form. The differences between the design storm depths (IFDs) and storm losses as contained in the established hydrologic models (ARR 1987) and design storm depths and losses contained within ARR 2019 were compared to determine if the existing hydrology was suitable to assess the impact of the project. A comparison of the design storm depth and design storm losses are provided in **Table 8** and **Table 9** respectively which indicate that the use of ARR 1987 hydrology is appropriate for this stage of the project.

Table 8: Design storm data ARR 2019 vs ARR 1987

Duration (hour)	2019 Rainfall depth difference (%) (ARR 2019 minus ARR 1987)					
	39% AEP	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP
1	-9.7	-0.8	5.7	8.1	11.7	14.8
2	-13.1	-3.8	3.5	6.7	11.5	15.4
3	-14.7	-5.5	2.7	5.4	10.9	15.0
6	-15.7	-7.6	0.3	3.6	8.2	11.6
12	-15.7	-8.8	-1.8	0.1	3.1	5.5

Table 9: Storm losses comparison ARR 2019 vs ARR 1987

	ARR 1987	ARR 2019
Initial losses (mm)	0	65
Continuing losses (mm/h)	2.5	4.8

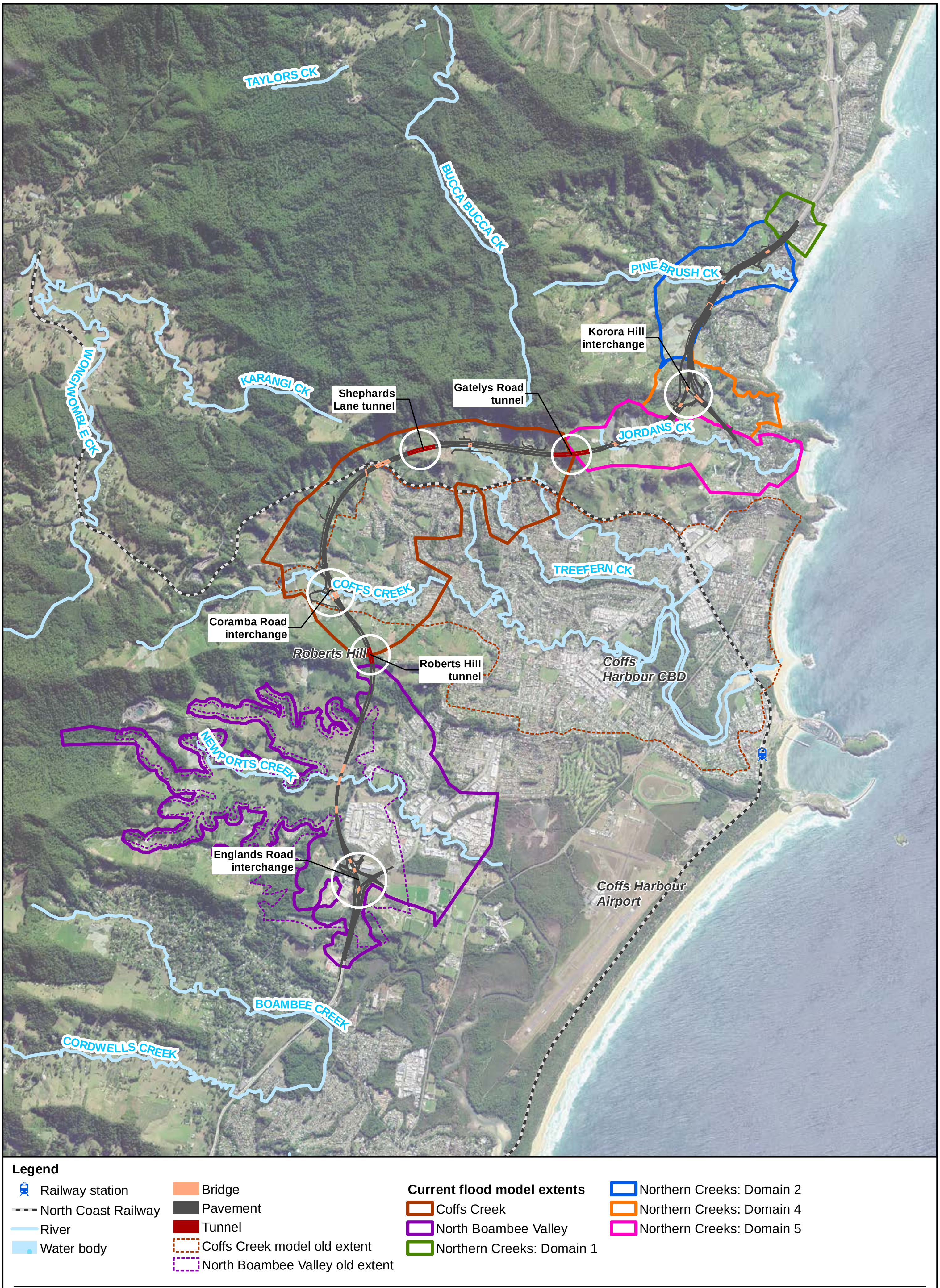
The design storm depths from ARR 2019 are extracted from a data grid of around 2.6 km^2, which BoM has noted care should be used in areas of steep rainfall gradients when using these design storm depths – such as the Coffs Harbour coastal escarpment.

The comparison of design storm depths indicated differences up to ±15 per cent between ARR 1987 and ARR 2019. The recommended design losses from ARR 2019 were higher compared to ARR 1987. To ascertain the effect of adopting ARR 2019 hydrology, a test was undertaken on the northern creeks Domain 2 hydraulic model following exhibition of the EIS. Preliminary results for the 1 per cent AEP event showed that at the bridge crossing within Domain 2, adopting ARR 2019 hydrology resulted in a reduction of peak water levels and flows.

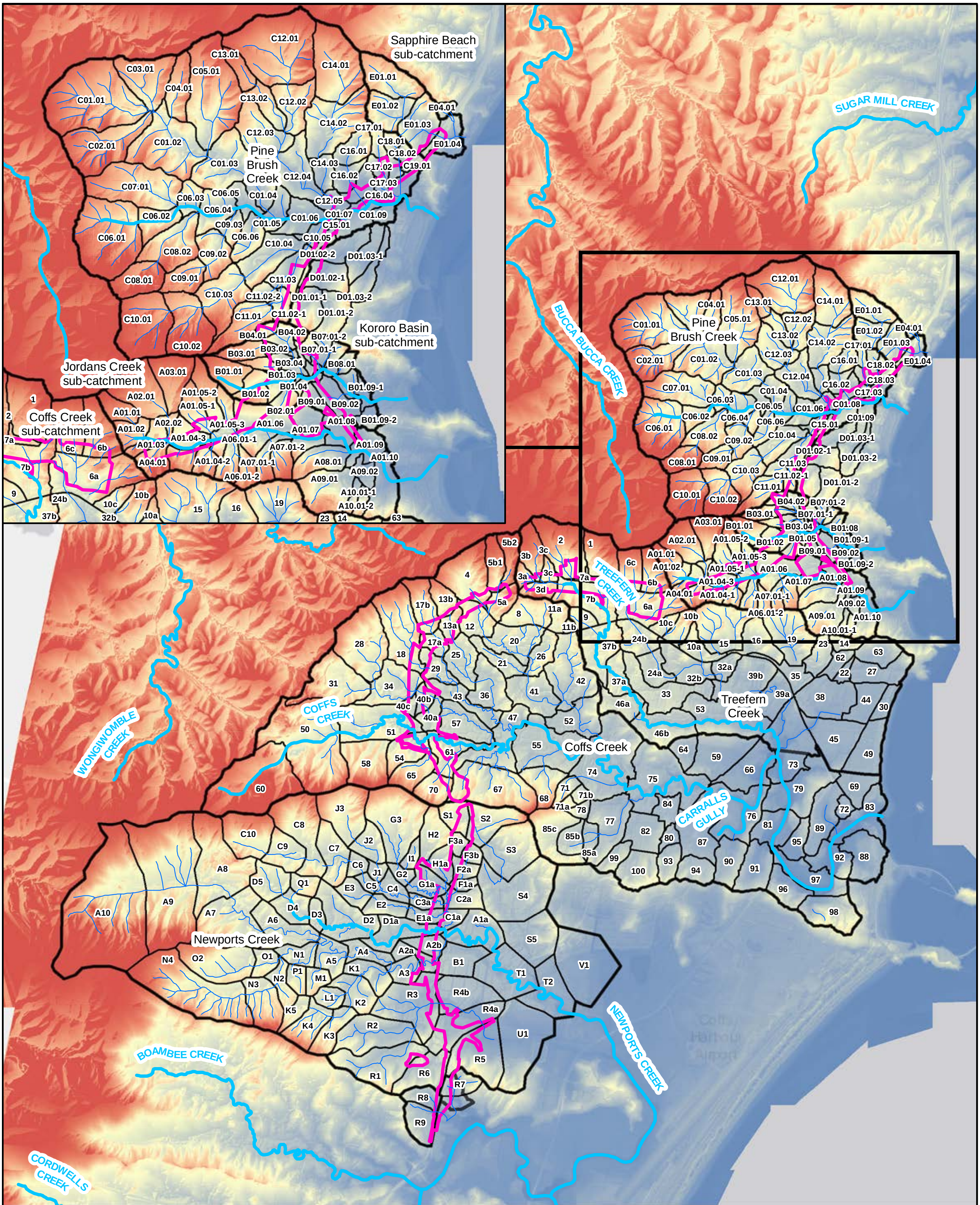
Based on this test, it is anticipated that peak flood levels and flows would reduce marginally with the adoption of ARR 2019 hydrology as the project design progresses. Hence, the adoption of ARR 1987 hydrology for this assessment is likely to result in marginally conservative estimates of flood immunity.

The orographic effects of the Coffs Harbour region, as determined in the *Coffs Creek and Park Beach Flood Study* (BMT WBM, 2018), were incorporated into the established model for the North Boambee Valley catchment and updated for the Coffs Creek catchment. These include calibrated orographic patterns of up to +60 per cent for the ARR 1987 design storm depths.

Based on the comparison of the design storm depths between ARR 1987 and ARR 2019 and the application of orographic effects to the ARR 1987 design storm depths, the hydraulic models within previously established flood models were adopted for the project. These include the design storm flows from the established hydrologic models combined with the established orographic effects.



Coffs Harbour Bypass
Figure 7
Flood model extents



Legend

Creek
Tributaries
Sub-Catchment
Construction footprint

Topography
High : 586.156
Low : -1.88012

Coffs Harbour Bypass
Figure 8
Hydrological model subcatchments

0 0.6 1.2 1.8 km
N
Scale @A4: 1:60,000
GDA 1994 MGA Zone 56

Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

2.5 Hydrology

2.5.1 North Boambee Valley

Existing scenario development of North Boambee Valley model for EIS

The WBNM model developed by (de Groot & Benson, 2014) was adopted for this assessment with the following changes:

- Sub-catchments along the project were adjusted/split where necessary.
- The model was extended (adopting the applicable parameters and orographic factors) to capture an additional nine sub-catchments to the south and two to the north affected by the project.
- Addition of the PMF storms, as per Generalised Short Duration Method (GSDM) (BoM, 2003) and climate change intensity increases, as detailed in **Section 2.3**.

The model parameters are detailed within **Table 29** of **Appendix A1**.

Developed scenario North Boambee Valley hydrology model for EIS

To represent the project, existing scenario hydrologic flows were adopted for the developed scenario, based on the following:

- There is an insignificant increase in impervious area (0.4 per cent) between the existing and developed scenarios.
- The response time of the upstream catchment (nine hours) is significantly divergent relative to local project runoff response time (10 minutes).

Changes to North Boambee Valley hydrology model post EIS

The following changes were made to the North Boambee Valley model following the exhibition of the EIS:

- The application of orographic factors into the hydrology model can be achieved in numerous ways. The adopted model achieved the factoring by factoring sub-catchment areas in the hydrologic model and this approach was adopted in the EIS. Ideally factors should be applied to rainfall intensities or flows. Testing determined that applying the factors to the flows provided similar results to applying the factors to the rainfall intensities. As a result, the orographic factors are now applied to the flows. This is now consistent across all hydrologic models used for the project.
- The model was extended further to capture an additional seven sub-catchments to the south and one to the north affected by the project. This extension was required to represent sub-catchments flowing into the extended hydraulic model area. Further information on the model extension can be found in **Section 2.6.1**. This extension, combined with the model extension carried out as part of the EIS assessment, results in a total extension of sixteen sub-catchments to the south and three to the north.

- Continuing losses were reduced from 3.5mm/h to 2.5mm/h to achieve consistency with CHCC's adopted hydrologic model (GHD, 2016).
- The lag parameter was updated from 1.6 to 1.29 to achieve consistency with the CHCC's adopted hydrologic model (GHD, 2016).

2.5.2 Coffs Creek

Existing scenario development of Coffs Creek hydrology model for EIS

The XP-Rafts model developed for the *Coffs Creek and Park Beach Flood Study* (BMT WBM, 2018) was adopted for this assessment. It should be noted that sub-catchment delineation was provided in pdf format rather GIS format, which is used in the project models, hence there are fractional discrepancies based on minor redefinition differences. The XP-Rafts model included the following changes:

- Sub-catchments along the project were adjusted/split where necessary with applicable model parameters applied

Model validation for the Coffs Creek model is detailed in **Section 2.6.2**.

The model parameters are summarised in Table 30 and Table 31 of Appendix A1.

Developed scenario Coffs Creek hydrology model for EIS

The developed scenario was updated to reflect changes in flow direction and fraction impervious in accordance with the project.

Changes to Coffs Creek hydrology model post EIS

The following changes were made to the Coffs Creek model following the exhibition of the EIS:

- The application of orographic factors into the hydrology model can be achieved in numerous ways. The adopted model achieved the factoring by factoring the rainfall intensities. Ideally factors should be applied to rainfall intensities or flows. Testing determined that applying the factors to the flows provided similar results to applying the factors to the rainfall intensities. As a result, the orographic factors are now applied to the flows to be consistent across all hydrologic models used for the project

2.5.3 Northern creeks

Existing scenario development of northern creeks hydrology model for EIS

A new XP-Rafts hydrologic model was established for the northern creeks catchments. Key model aspects are summarised below:

- The model parameters adopted are as per the project Coffs Creek model due to the absence of available rainfall or stream gauge data for calibration

- The adopted sub-catchment roughness values (PERN) range from 0.015 to 0.12, with an average of 0.08, in accordance with recommended values of typical catchment land uses. The values were determined based on the average within each sub-catchment (accounting for surface area taken up by roughness values)
- Pervious initial and continuing losses of 0 mm and 2.5 mm/hour respectively (no impervious losses)
- Orographic effects were determined using the methodology of the Coffs Creek study (BMT WBM, 2018)
- Validation of the model was performed to the Rational Method, refer to **Section 2.7.3**.

The model parameters are summarised in Table 32 and Table 33 of Appendix A1.

Developed scenario northern creeks hydrology model for EIS

The developed scenario was updated to reflect changes in flow direction and fraction impervious in accordance to the project. The design scenario hydrology methodology adopted in the EIS for the northern creeks included delineating road sub-catchments for all domains.

Changes to northern creeks hydrology models post EIS

The following changes were made to the northern creeks models following the exhibition of the EIS:

- A review of the hydrology model resulted in revised lag (K) and routing (x) parameters. These parameters were derived from the catchment characteristics to better reflect the local hydrological response. These replaced the generic parameters used in the EIS assessment.
- Following the EIS, the methodology for representing the impervious elements of the project in the hydrological model was updated:
  - Domain 1: as the horizontal alignment of the project is the same alignment as the existing Pacific Highway, the increase in percentage impervious is negligible. As a result, the existing scenario hydrology was adopted in the design scenario
  - Domain 2: as the horizontal alignment of the project is the same alignment as the existing Pacific Highway, the increase in percentage impervious is negligible. As a result, the existing scenario hydrology was adopted in the design scenario with the exception of the addition of the Korora Public School bus interchange sub-catchment area. This is to accommodate the Kororo Public School bus interchange and Luke Bowen footbridge design change
  - Domain 4 and 5: as the alignment of the project traverses primarily greenfield land, the increase in percentage impervious is explicitly represented in the hydrologic model. This approach is consistent with the EIS.

2.6 Hydraulics

TUFLOW HPC (version 2018-03-AC) was adopted for all models excluding the northern creeks Domain 2 model. TUFLOW Classic (version 2018-03-AD) was adopted for the northern creeks Domain 2 model due to an instability found when using the HPC solver.

Hydraulic modelling generally includes the following approach:

- Model topography has been constructed from a range of supplied Aerial Laser Survey (ALS) datasets and detailed survey. Note that a detailed digital terrain survey was completed following the exhibition of the EIS which has required model updates. In addition to this, a review of the ALS data was undertaken and found that the regional ALS captured in 2013 was more accurate than the project ALS captured in 2016. It is likely that this is because of how the data was post-processed. As a result, the regional ALS is now applied on top of the project ALS. The priority of terrain data applied in the model, is applied in the model in ascending order as follows:
  - Project ALS (captured May 2016)
  - Regional ALS (captured September 2013)
  - Detailed digital terrain survey (captured 2018 – 2019).
- Incorporation of initial water levels such as that storages are assumed as full (up to drainage invert) before an event
- Simulation of a range of durations initially to determine critical storm(s)
- Bridges were schematised as layered flow constrictions and culverts as linked 1D elements. Applied blockage factors are in accordance with ARR (Ball, et al., 2016). Refer to **Table 34** and **Table 35** in **Appendix A2** for existing and developed structure parameters respectively, based on the following:
  - Structure information was obtained from detailed survey commissioned by TfNSW for drainage structures within the construction footprint and at some additional critical locations, such as under the North Coast Railway. This data was finalised following the EIS submission requiring model updates. In all other locations, structure information was obtained from CHCC or TfNSW unless otherwise stated:
    - CHCC supplied depth to invert to the nearest 5 mm. Adopted invert levels were based on the topographic data minus depth to invert.
    - TfNSW supplied depth of cover provided to the nearest 100 mm. Adopted invert levels were based on topographic data minus depth of cover and structure dimensions.
    - In some cases, the provided data was insufficient and invert levels were assumed based on surrounding drainage information and topographic data.
  - Bridge deck depths for all developed bridges based on preliminary bridge designs for the purposes of hydraulic assessment.
- Updates to model roughness in accordance to latest aerial imagery at the time of model development, as per **Table 10**.

Table 10: Model roughness

	Description	Manning's n
1	Roads	0.02
2	Pasture and rip rap rock protection	0.04
3	Smooth creeks & lakes, maintained channels with minimal vegetation	0.03
4	Urban areas (excluding buildings) and rough, boulderer creek beds	0.06
5	Vegetation light (including batters)	0.05
6	Vegetation Medium	0.08
7	Vegetation Dense	0.12
8	Buildings	1.00

2.6.1 North Boambee Valley

Existing scenario

The TUFLOW model (de Groot & Benson, 2014) was adopted for this assessment and later validated against the CHCC model (GHD, 2016) with the following changes:

- Four metre grid resolution, including trimming of extent to relevant study area and extension to include the proposed Englands Road interchange and its approaches
- Enforcement of critical hydraulic controls (such as key crests and gullies)
- Adjustment of the inflow locations and boundary conditions to match the amended hydrology and extents, as per **Table 11**
- Updates / additional structures as summarised in **Table 34**.

Table 11: Model boundaries – North Boambee Valley

Boundary	Schematisation
Local	85 Source A inflows (including inflows at upstream boundaries)
Downstream	5 HT boundaries extracted (GHD, 2016)

Changes to North Boambee Valley hydraulic model post EIS

The following changes were made to the North Boambee Valley hydraulic model following the exhibition of the EIS:

- The downstream boundary of the hydraulic model used in the EIS, was influencing the modelled flood behaviour at the project and existing Pacific Highway. This reduced the EIS model accuracy of the impact assessment and the existing flooding behaviour (e.g. existing highway flood immunity). This issue was raised during consultation with CHCC. Following discussions with CHCC, the hydrologic and hydraulic models were extended sufficiently far downstream (600 m to 900 m) to remove the influence of the downstream boundary on flood model behaviour near the project and provide consistency with CHCC's adopted model (GHD, 2016). The amended hydraulic model now captures an additional 240 hectares. Terrain data, structure information and downstream water level boundaries were extracted from CHCC's model. CHCC's model was also used to validate the project model.

- Updated digital terrain data as described in **Section 2.6**: The largest differences in terrain data were observed in the waterways. A review of the terrain data used in the EIS showed vegetation reduced the accuracy of the ALS data in waterways. The detailed survey, obtained after the EIS, generally shows the bed of the waterway to be lower and banks to be better defined. This is particularly noticeable at the confluence of the main arm and northern tributaries of Newports Creek (adjacent to Bishop Druitt College). The difference in modelled terrain data between the EIS and revised models is shown in **Appendix F.**
- Updated structure information: The most notable changes to structure information were observed within the Isles Drive bypass channel (ES257) and under the existing Pacific Highway, south of the Coffs Harbour Health Campus (ES04 and ES05). A complete list of the modelled structures can be found in **Table 34** of **Appendix A2**. Refer to the Flooding and hydrology assessment (Arup, 2019) prepared as part of the EIS for structures modelled in the EIS.
- Updated Manning's '*n*' roughness values to be consistent project wide.

Developed scenario

The developed scenario hydraulic model was used to inform the design response of key flood design elements including:

- The optimisation of bridge locations and configurations throughout the design process to achieve conveyance for low and high flow events, as well as for biodiversity objectives for flora and fauna
- Appropriate sizing and positioning of longitudinal and transverse drainage culverts and channels
- The optimisation throughout the design development of the road embankments to reduce impact on floodplain storage. This includes lowering of the alignment to reduce embankment width as part of the North Boambee Valley vertical alignment design change that forms part of the amended design.
- Provision of table drains along either side of North Boambee Road to provide sufficient drainage for low flow events
- Realignment of a northern tributary of Newports Creek (DS14) and addition of a free draining storage area beneath the bridge over North Boambee Road (DS13 [BR04]) to provide compensatory flood storage. This is an element of the North Boambee Valley vertical alignment design change that forms part of the amended design.
- Provision of a compensatory storage area upstream of DS11 to increase the flow through the drainage structure and improve conveyance. This is an element of the North Boambee Valley vertical alignment design change that forms part of the amended design.

The above elements were incorporated into the developed model via:

- Application of the project to model topography and roughness
- Incorporation of design structures as summarised in **Table 35** in **Appendix A2**
- Definition of drain inverts and bund crests.

2.6.2 Coffs Creek

Existing scenario

The TUFLOW model (BMT WBM, 2018) was adopted for this assessment with the following changes:

- Four metre grid resolution, extension to include the project and trimming where appropriate
- Enforcement of critical hydraulic controls (such as key crests and gullies)
- Adjustment of the inflow locations and boundary conditions to match the amended hydrology and extents (including further proportioning of flow to better represent flooding behaviour), as per **Table 12**
- Updates / additional structures as summarised in **Table 34.**

Table 12: Model boundaries – Coffs Creek

Boundary	Schematisation
Local	52 SA inflows
Downstream	5 HT extracted from BMT WBM (2018) model.

Changes to Coffs Creek hydraulic model post EIS

The following changes were made to the Coffs Creek hydraulic model following the exhibition of the EIS:

- Updated terrain data and structure information for the Shephards Lane Detention Basin, as described in **Section 2.6**: This is because previous data was collected prior to the construction of the basin in 2018 and assumptions were made to represent the basin in the modelling for the EIS. The detailed survey captures the basin and basin outlet (ES36). The differences in terrain data between the EIS and revised models is shown in **Appendix F.**
- Updated digital terrain data as described in **Section 2.6**: The largest differences in terrain data were observed in the waterways. A review of the terrain data used in the EIS showed vegetation reduced the accuracy of the ALS data in waterways. The detailed survey, obtained after the EIS, generally shows the bed of the waterway to be lower and banks to be better defined. The differences in terrain data between the EIS and revised models is shown in **Appendix F.**
- Updated structure information: The detailed survey also collected the information for the culverts under the North Coast Railway (ES166 and ES168 which are upstream of Baringa Private Hospital) as committed to by TfNSW

in the EIS. As the rail line forms a significant hydraulic control, this information affected flooding conditions upstream and downstream of the rail line. In addition to this, many other critical structures were surveyed following the EIS. A complete list of the modelled structures can be found in **Table 34** of **Appendix A2**. Refer to the Flooding and hydrology assessment (Arup, 2019) prepared as part of the EIS for structures modelled in the EIS.

- Updated Manning's '*n*' roughness values to be consistent project wide.

Developed scenario

The developed scenario hydraulic model was used to inform the design response of key flood design elements including:

- Optimisation of bridge locations and configurations throughout the design process to achieve conveyance for low and high flow events as well as for biodiversity objectives
- Ensuring increased runoff does not adversely impact flood levels external to the project
- Appropriate sizing and positioning of longitudinal and transverse drainage culverts and channels
- Mitigating adverse impacts by optimising the location of proposed water quality treatment basins to not impact on existing flow paths
- Provision of table drains and appropriate scour protection along either side of the project to capture flows and minimise the risk of adverse impacts on the existing waterway and bank stability
- Extension of the Bennetts Road basin outlet (ES23) to incorporate the proposed interchange with no change to basin performance (as the culvert flow is dominated by inlet control). Note that the additional excavation within Bennetts Road Detention Basin that was proposed as part of the EIS design is no longer required to mitigate impacts for the amended design. This is part of the Coffs Creek flood mitigation design change that forms part of the amended design.
- Provision of additional localised flood detention areas to retard flows. This includes the detention areas upstream and downstream of DS27. These detention areas are elements of the Coffs Creek flood mitigation design change that forms part of the amended design. An additional localised detention area is proposed within the construction footprint at Mackays Lane (DS108 and DS109 are drainage outlets from the detention area).

The above elements were incorporated into the developed model via:

- Application of the project to model topography and roughness
- Incorporation of design structures as summarised in **Table 35** in **Appendix A2**
- Definition of drain inverts and bund crests
- Application of developed case flows at downstream water quality treatment basins or drainage lines. Proportional flows of alignment catchments were applied at locations in accordance to the linear drainage design.

2.6.3 Northern creeks

Existing scenario

Four new models were developed for the assessment of the northern creeks area, with the following setup:

- 2.5 m grid resolution, apart from Domain 1 and 4 where a two-metre grid was used
- Enforcement of critical hydraulic controls (such as key crests and gullies)
- Incorporation of structures as summarised in **Table 34** in **Appendix A2**
- Model boundaries and inflows as per **Table 13**.

Table 13: Northern creeks model boundary conditions

<table>
<tr><th>Parameter</th><th>Domain 1</th><th>Domain 2</th><th>Domain 4</th><th>Domain 5</th></tr>
<tr><td>Inflows</td><td>4 SA</td><td>25 SA (existing case)
26 SA (design case)
6 QT</td><td>27 SA</td><td>22 SA</td></tr>
<tr><td>Downstream boundaries</td><td>As below</td><td>As below and 1 automatic QH normal depth boundary based 1% slope</td><td>As below and 1 automatic QH normal depth boundaries based 1% slope</td><td>As below</td></tr>
<tr><td></td><td colspan="4">All domains: HT boundary as per BMT WBM (2018). presented in Figure 9 and as follows:
<table>
<tr><th>Local event</th><th>Ocean event</th><th>Peak ocean WL (mAHD)</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>18% AEP</td><td>HHWS(SS)</td><td>1.13</td></tr>
<tr><td>5% AEP</td><td>HHWS(SS)</td><td>1.13</td></tr>
<tr><td>2% AEP</td><td>5% AEP</td><td>2.0</td></tr>
<tr><td>1% AEP</td><td>5% AEP</td><td>2.0</td></tr>
<tr><td>PMF</td><td>1% AEP</td><td>2.1</td></tr>
<tr><td>1% AEP year 2050 climate change</td><td>5% AEP (+0.4m)</td><td>2.4</td></tr>
<tr><td>1% AEP year 2100 climate change</td><td>5% AEP (+0.9m)</td><td>2.9</td></tr>
</table>
</td></tr>
</table>

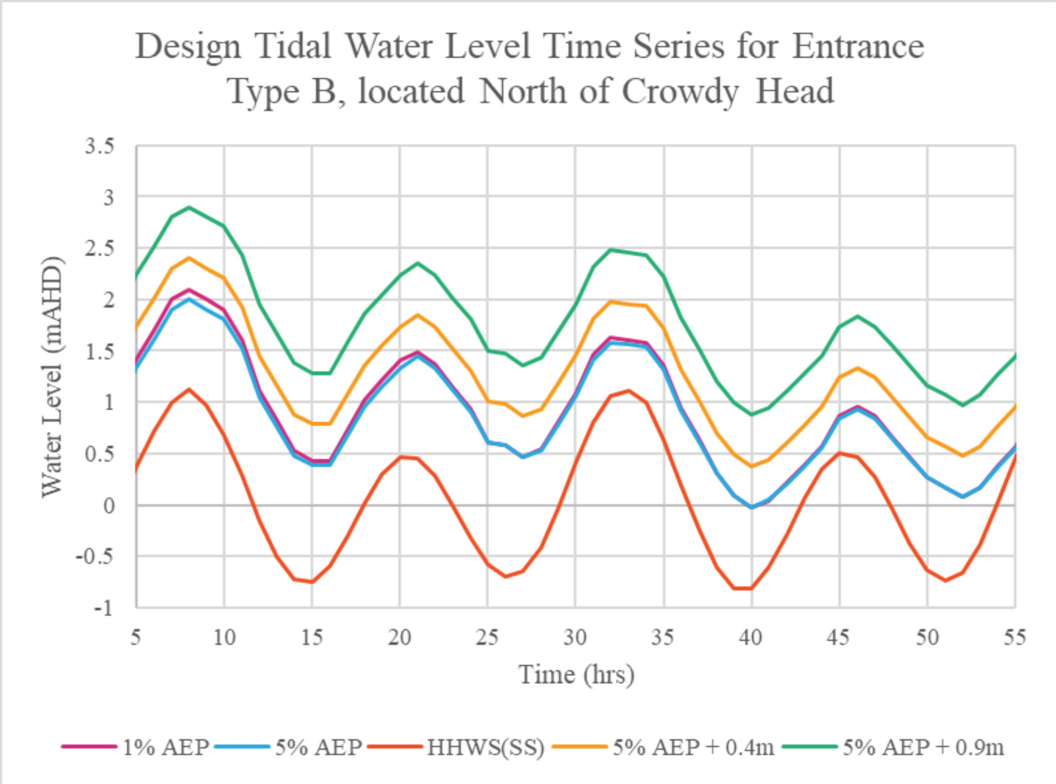


Figure 9: Design tides for entrance Type B, north of Crowdy Head (OEH, 2015).

Changes to the northern creeks hydraulic models post EIS

The following changes were made to the northern creeks hydraulic models following the exhibition of the EIS:

- Updated digital terrain data, as described in **Section 2.6**: The largest differences in terrain data were observed at the Pacific Bay Resort/Pacific Bay Eastern Lands and within waterways, particularly upstream tributaries of Jordans Creek and within Pine Brush Creek. A review of the terrain data used in the EIS showed vegetation reduced the accuracy of the ALS data in waterways. The detailed survey generally shows the bed of the waterways to be lower and shows the banks to be better defined. The difference in modelled terrain data between the EIS and revised models is shown in **Appendix F.**
- Updated structure information and additional structures: The most notable changes to structure information were observed on Pacific Bay Resort land (ES99, ES152 and ES158) and near Campbell Close (ES83 and ES84). Several structures were identified in the detailed survey that were previously not included in the models. In addition to this, many other critical structures were surveyed following the EIS. A complete list of the modelled structures can be found in **Table 34** of **Appendix A2**. Refer to the Flooding and hydrology assessment (Arup, 2019) prepared as part of the EIS for structures modelled in the EIS.
- Updated Manning's '*n*' roughness values to be consistent project wide
- Application of orographic factors to flows through the boundary condition database.

- Some local inflows were removed and accounted for by total inflows downstream of the existing Pacific Highway in an area of urban drainage and outside the influence of the project, such as the urbanised area in Domain 5 (adjacent to West Korora Road, upstream of the existing Pacific Highway).
- Inclusion of a local inflow to account for the amended Kororo Public School bus interchange design. This area previously drained towards an unmodeled catchment that did not interact with the project. Following design developments, this area now drains towards Pine Brush Creek (Domain 2).
- Manual modification of the Intermittently Closed and Open Lake or Lagoon (ICOLL) in Domain 2 to align with upstream detailed survey.

Developed scenario

The developed scenario hydraulic model was used to inform the design response of key flood design elements including:

- Optimisation of bridge locations and configurations throughout the design process to achieve conveyance for low and high flow events as well as for biodiversity objectives for flora and fauna
- Appropriate sizing and positioning of longitudinal and transverse drainage channels and culverts
- Managing overland flows from small steep upstream catchments to achieve the flood immunity objectives of the project within an urbanised environment
- Ensuring any increased stormwater runoff from the project did not adversely impact flood levels downstream of the project
- Mitigating adverse impacts by optimising the location of water quality treatment basins to not impact on existing flow paths
- Provision of table drains and appropriate scour protection to capture flows and minimise the risk of adverse impacts on the existing waterway and bank stability
- Design coordination and optimisation to ensure that the Korora Hill interchange road runoff catchments would be captured and outlet to manage downstream impacts.

The above elements were incorporated into the developed model via:

- Application of the project to model topography and roughness
- Incorporation of design structures as summarised in **Table 35** in **Appendix A2**
- Definition of drain inverts and bund crests
- Application of developed case flows at downstream water quality treatment basins or drainage lines.

2.7 Validation

2.7.1 North Boambee Valley

Following the post EIS model extension, verification was carried out on the extended model (refer to **Section 2.5.1**), to validate the model against the CHCC's adopted model (GHD, 2016). The comparison of flows between the updated models (CHB) and CHCC models (GHD, 2016) are shown below in **Figure 10**.

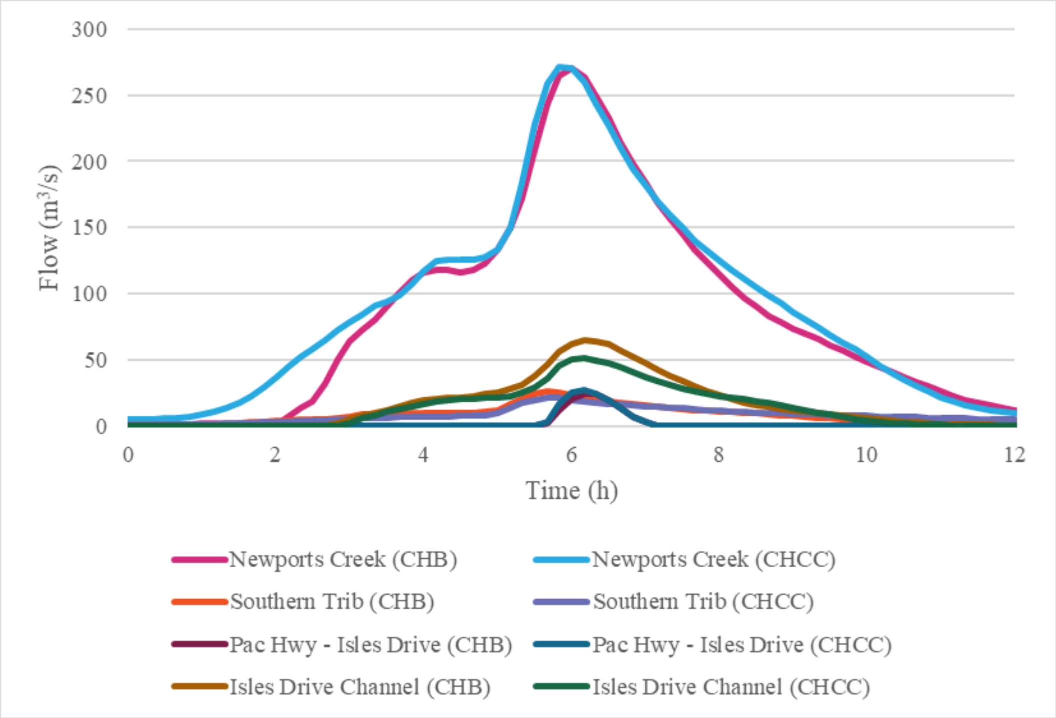


Figure 10: Comparison of flows for the 1% AEP event

A comparison of flows between the models showed results are reasonably consistent except for the flows within the Isles Drive bypass channel and a vegetated channel between Englands Road and Isles Drive.

The peak flow is 26 per cent larger in the updated model at the location of the Isles Drive bypass channel. This difference is because of the changes to the terrain data used (refer to **Section 2.6.1**) and the difference in the size of the drainage structure, which is larger than the structure in the CHCC model (GHD, 2016). The size of the drainage structure used in the updated model is now based on detailed survey data collected following the exhibition of the EIS.

Peak flows within the vegetated channel between Englands Road and Isles Drive increased by 24 per cent when compared to the CHCC model (GHD, 2016). The increase is because of the different modelling methods and changes in terrain data used (refer to **Section 2.6.1**). The CHCC model (GHD, 2016) represents this flow path as a 1D element whereas the updated model used the detailed survey to model the flow path in 2D.

The project model is considered to be more representative at these locations because of the changes noted above.

Other predicted differences were considered reasonable and are likely to be because of the following:

- New ALS and detailed survey data – particularly elevations of the new Highlander Drive development area including floodplain fill
- Model schematisation (TUFLOW vs. MIKE/TUFLOW combination) and boundary effects.

2.7.2 Coffs Creek

The revised Coffs Creek model was checked to previous results (BMT WBM, 2018). The critical 1 per cent AEP event noted negligible peak flood level differences for a majority of the model area.

Localised differences are noted which are attributed to recently captured detailed digital terrain survey and other model updates, as discussed in **Section 2.5.2** and **Section 2.6.2**. Overall, the revised model was considered reasonable.

2.7.3 Northern creeks

In the absence of historical data, validation was performed to the Rational Method. **Table 14** presents the critical 1 per cent AEP event peak flow comparison.

Table 14: Northern creeks 1 per cent AEP validation

Domain	Sub-catchment ID	Critical duration (min)	XP-Rafts peak flow (m^3/s)	Rational peak flow (m^3/s)	Difference (m^3/s)	Difference (%)
1	E01.02	120	10.8	10.8	-0.01	-0.1%
2	C10.04	120	28.9	30.6	-1.6	-6%
4	B01.02	120	8.1	7.4	0.7	8%
5	A01.03	120	8.8	8.9	-0.07	-1%

** Sub-catchment IDs are shown in **Figure 8**.

Flows derived from the TUFLOW model exhibit a good fit when compared to the Rational Method with differences small in magnitude as shown in **Table 14**.

3 Existing condition

The flood models were simulated for the existing case for the range of flood events listed in **Section 2.3**. General results are discussed below, with peak flood level, depth, velocity and hazard maps presented in **Appendix B**.

Hazard categories have been defined in accordance with Figure L2 of the NSW Floodplain Development Manual (DIPNR, 2005). Figure L2 has been recreated in **Figure 11** below.

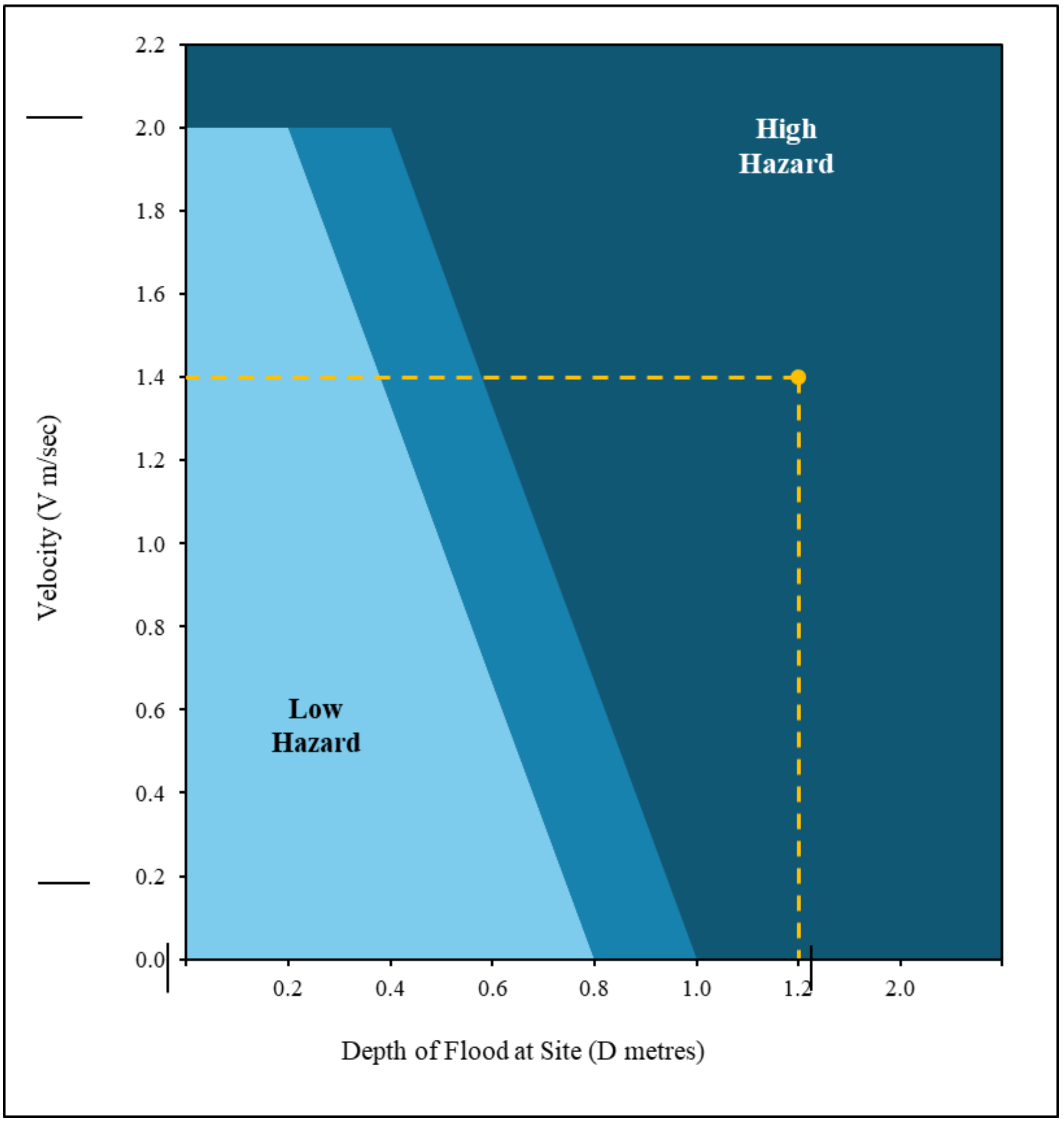


Figure 11: Flood hazard categorisation (DIPNR, 2005)

3.1 North Boambee Valley

The following observations are noted:

- The project is located within the lower reaches of the floodplain of Newports Creek, hence flooding is characterised by relatively low velocity flows outside the main creek channels.
- The Isles Drive bypass channel forms a significant hydraulic control and heavily influences surrounding flooding behaviour.
- North Boambee Road is overtopped during an 18 per cent AEP event with a peak flood depth of 570 mm.
- Several North Boambee Road rural properties and the northern extent of Highlander Drive are affected by the 18 per cent AEP event. However, no existing structures are affected by high hazard flooding during the 1 per cent AEP event.
- Flooding of the unnamed drainage line south of the Isles Drive Industrial Estate is generally controlled by the road crossings.
- Englands Road overtops in the 2 per cent AEP event, with a predicted peak depth of 280 mm. Isles Drive overtops during the 10 per cent AEP event, with a predicted depth of 330 mm.
- The existing Pacific Highway crossings of Newports Creek and its southern tributary are located north and south of the Coffs Harbour Health Campus access. Modelling predicts that the northbound access across the southern tributary (near ES04 and ES05) is affected by the 5 per cent AEP event on the northbound lanes with a peak depth of up to 300mm. Southbound access across the southern tributary (from the health campus) is affected by the 2 per cent AEP event on the southbound lanes with a peak depth of 90 mm. Access across Newports Creek from the north (near ES270) is affected in the 2 per cent AEP event with peak depths of up to 100 mm at the intersection of the Pacific Highway and Isles Drive.
- Inundation of localised areas of the road network within the Isles Drive Industrial Estate occurs in all events, with a majority of industrial lots flooded during the PMF.
- The listed critical infrastructure within the model extents include Coffs Harbour GP Super Clinic, Bishop Druitt College and Coffs Harbour Health Campus. Coffs Harbour GP Super Clinic and Bishop Druitt College are PMF immune. The Coffs Harbour Health Campus is affected in the 10 per cent AEP event within the Rural Clinical School and localised areas of road on the eastern side.
- The North Boambee Valley (west) urban release area includes extensive high hazard PMF areas throughout the Newports Creek floodplain, as illustrated in **Appendix B3.1.8.**
- Critical design storm durations (ie producing maximum flood levels) over the project are:
  - Design AEP events: Nine hours
  - PMF: Two hours.

3.2 Coffs Creek

The following observations are noted:

- Existing flooding through the project is characterised by high velocity flow paths generally contained to the established tributaries of the western escarpment.
- Modelling predicts the North Coast Railway is overtopped during the 18 per cent AEP event north of Jensen Close (near ES166 and ES168), with a peak overtopping depth of 100 mm.
- The listed critical infrastructure Cow & Koala Professional Child Care is within the Coffs Creek model extents. Cow & Koala Professional Child Care is immune in the 1 per cent AEP event but inundated in the PMF event.
- 1 per cent AEP event inundation of existing structures are noted in the following areas (generally outside of PMF high hazard):
  - Within Shephards Lane detention basin and Bennetts Road detention basin
  - Several Coramba Road properties backing onto Coffs Creek
  - Several properties around Gillon Street and Pearce Drive.
- The CHCC Flood Mitigation Programme detention basins were designed to achieve efficient flood protection of downstream properties for a variety of storm events (CHCC, 2018). Maximum flow attenuation is generally achieved if the basin flood level remains below the spillway crest. The minimum overtopping (ie spillway engagement) design storm event and corresponding peak flood level for each basin potentially affected by the project are listed below:
  - Bennetts Road basin: 1 per cent AEP / 28.6 mAHD
  - Spagnolos Road basin: 0.05 per cent AEP / 24.0 mAHD
  - Bakers Road basin: 0.05 per cent AEP / 19.2 mAHD
  - Shephards Lane basin: 0.05 per cent AEP / 43.4 mAHD.
- Critical design storm durations are:
  - Design AEP events: Two and nine hours
  - PMF: One hour.

3.3 Northern creeks

The following observations are noted:

- Flooding is generally characterised by numerous, relatively small flow paths draining off the western escarpment, controlled by the existing Pacific Highway drainage structures.
- There is a significant hydraulic control upstream of the Pacific Highway / Bruxner Park Road intersection (ES61) resulting in peak flood depths up to 5.9 m in the 1 per cent AEP event (attenuating flooding to the downstream Pacific Bay Resort).

- The existing Pacific Highway is above the 1 per cent AEP peak flood level, except for the Jordans Creek crossing, which is affected in the 10 per cent AEP event, and minor inundation of northbound lanes just west of Opal Boulevard.
- There are several urban areas next to the project currently affected by 1 per cent AEP flooding (these are generally affected by PMF high hazard) including:
  - Nautilus Villas
  - James Small Drive residential lots backing onto Pine Brush Creek
  - Banana Coast Caravan Park
  - Various rural lots immediately upstream of the project.
- The listed critical infrastructure of Kororo Public School and Coffs Harbour Montessori Preschool are PMF immune.
- Critical design storm durations:
  - Design AEP events: Two hours
  - PMF:
    - Domain 1, 2 and 5: One hour
    - Domain 4: 1.5 hours.

4 Assessment of construction impacts

This section of the report details the aspects relating to construction objectives.

As detailed within **Section 1.7**, the project floodplain management objectives have been divided into sub criteria objectives for specific measurable elements.

The relevant objective for construction of the project is:

- **Construction** – Potential impact of ancillary site locations is identified, to ensure appropriate flood risk assessment of vulnerable sites and to inform a future construction flood management plan.

An assessment of the relative hydraulic and hydrologic impacts, the flood risk and potential impact of the predicted construction activities to construct the project infrastructure and the impacts on ancillary sites to support construction activities was conducted. These activities and ancillary site locations are reflective of the anticipated uses and activities at this concept design stage.

Construction of the project is anticipated to take four years and would likely be built using conventional methods used on most highway projects. The methods may be modified during the detailed design or construction stages to address site-specific environmental or engineering constraints.

The detailed uses and construction methodologies would be refined within the detailed design of the project and by the construction contractor, prior to and during construction, based on the site constraints and in accordance with any conditions of approval.

This report identifies the potential flood impact which would inform a future Construction Flood Management Plan (CFMP) to be completed as part of the detailed design phases of the project. A CFMP should include the following:

- Stockpiles, site compounds, plant machinery, elevated haul roads and construction facilities should be located outside defined streams and/or low-lying areas subject to frequent flooding.
- Where stockpiling or haul roads within the floodplain cannot be avoided, low velocity locations or appropriate materials should be utilised to minimise loss of material during flooding.
- Flood monitoring and response measures should be implemented to mitigate flood risks to life, equipment and property. Given the flash nature of flooding there would be limited warning time and hence monitoring may largely rely on forecasts issued by BOM.
- When a storm/flood warning forecast is issued and it safe to do so, the developed protocols to relocate site materials and machinery to flood immune (or less hazardous) locations should be undertaken.
- Procedures for safe site evacuation should be implemented.
- Induction of all staff and visitors to brief emergency response procedures.

The potential hydrology and flooding impact of the following construction activities have been assessed, individually within this section of the report:

- Ancillary facilities
- Temporary waterway crossings
- Earthworks
- Catchment drainage.

The assessment of each of these potential construction impacts have been developed to address the specific requirements of the project SEARS and the project floodplain management objectives.

4.1 Ancillary sites

Several ancillary sites have been identified to facilitate construction of the project. These sites may be used for various construction activities and may include, site compounds, the stockpiling or laydown of materials, crushing and screening facilities, concrete batching plants, haul roads to and from the main construction works, temporary access roads to and from the ancillary sites and the storage of plant.

The assessment of ancillary facilities considers potential facilities located within the 5 per cent AEP flood extent because these sites would have a higher risk of potential flood impacts than sites located outside the 5 per cent AEP flood extent. The peak flood extents for the 5 per cent AEP flood, 1 per cent AEP flood and PMF events (1 per cent AEP and PMF flood extents were used to provide an indication of the flood risks for the proposed ancillary facilities), and construction zones (including ancillary facilities) are shown in **Appendix C**.

Twelve of the 17 potential sites for ancillary facilities identified for the project are located within potential flood hazard areas (areas within the 5 per cent AEP flood extent). The flood extents and construction zones (including ancillary facilities) are shown in **Appendix C**. These maps show the flooded portions of each site.

An assessment has been carried out to identify the potential flood risk of each ancillary site considering the 5 and 1 per cent AEP, and PMF events for the existing case. The assessment also considers the ancillary sites that are at risk of frequent (18 per cent AEP) high flood depths and hazard in the existing case. This approach has been adopted as these facilities could exist prior to the construction of the project in the early phases of construction. Qualitative assessments of the likely change to the flood risks during the construction phase have also been carried out to ascertain if the management measures require adaptation during this phase. Further flood modelling assessments of potential flood impacts of the construction ancillary sites would be carried out during detailed design to inform the appropriate uses within these facilities. **Table 15** presents the potential hydrology and flooding impacts of the proposed ancillary facility sites. Of the sites listed in **Table 15**, sites 1C, 3A, 3D and 3F are new/revised sites as part of the amended design. In addition to this, site 3C which was assessed in the EIS, is no longer proposed as a potential facility and is not considered any further.

Locating ancillary facilities in areas of high flood risk or in areas subject to flooding may result in flood impacts to surrounding areas.

Key ancillary site plant and facilities should be positioned to the least flood affected site areas to reduce potential impacts.

Table 15: Flood affected ancillary sites

Site	Flood risk and potential impact	Management measure
1C	The northern portion of this site (0.2 ha / 15% of the total site area) is part of the Newports Creek floodplain. It is within the 5% AEP flood extent and is at risk of frequent (18% AEP) high flood depths and velocities. Isles Drive industrial area and the existing Pacific Highway (providing access to the Coffs Harbour Health Campus) are downstream of this site. Locating site compounds or other facilities within the flood-prone portion of this site could cause higher risk of impacts to Englands Roads, Isles Drive and nearby industrial lots.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood-prone portion of the site.
1D	The northern portion of this site is part of the Newports Creek floodplain, is within the 5% AEP flood extent and at risk of frequent (18% AEP) high flood depths and velocities. Because Isles Drive industrial area is affected in the PMF event and is immediately downstream of this site, locating site compounds or other facilities within the flood-prone portion of this site could cause higher risk of impacts to nearby industrial lots in the PMF event.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood-prone portion of the site.
1G	This area is predominately flood immune apart from small areas at the north east corner and along the southern boundary which are part of the Newports Creek floodplain. Locating ancillary facilities in areas affected by flooding may result in redirection of flows and cause previously flood free areas to be inundated. As the site is in the upper reaches of the catchment, potential impacts on flooding are expected to be minimal.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood-prone portion of the site. Conveyance of the existing small tributary within the site and its associated flows should be maintained.
2A	This site is flood immune in the 1% AEP event and is subject to flooding during a PMF event. Use of this area for ancillary facilities has a relative low flood risk.	Not required.
2C	This area is predominately flood immune apart from a tributary which originates in the site. The redirection of this tributary and its flows may cause previously flood free areas to be impacted, however, because the site is in the upper reaches of the catchment, potential impacts on flooding and hydrology are expected to be minimal.	A CFMP will be prepared to manage potential flood risk. Conveyance of the existing small tributary within the site and its associated flows should be maintained.

Site	Flood risk and potential impact	Management measure
2D	An existing farm dam upstream of the site controls inundation of this area and the site is impacted by the 5% AEP flood event. Ancillary facilities may result in redirection of flows and may cause previously flood free areas to be impacted, however, because the site is in the upper reaches of the catchment, potential impacts on flooding and hydrology are expected to be minimal.	A CFMP will be prepared to manage potential flood risk. Inspection of the existing condition of the dam before construction activities. Inspection of the dam should also be carried out, after storm events during construction. Site compounds, stockpiling and plant machinery should be placed outside of the flood-prone portion of the site.
2E	The southern portion of this site is in the upper reaches of Treefern Creek and is impacted in a 5% AEP flood event. Locating ancillary facilities in areas affected by flooding may result in redirection of flows and cause previously flood free areas to be inundated. As the site is in the upper reaches of the catchment, potential impacts on flooding are expected to be minimal. Because of the proximity of residences to the flood extents downstream of the rail line, locating ancillary facilities within the areas of flood risk could cause higher risk of impacts to downstream properties and the rail line.	A CFMP will be prepared to manage potential flood risk. Conveyance of existing small tributary within the site and its associated flows should be maintained. Site compounds, stockpiling and plant machinery should be placed outside of the flood-prone portion of the site.
2G	Most of this site is within the 5% AEP flood extents and is at risk of frequent (18% AEP) high flood depths and velocities. Locating ancillary facilities within the area of frequent flooding may result in redirection of flows and result in flood impact to surrounding agricultural land and the residential property nearby.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood-prone potion of the site.
3A	The south eastern part of this site (1.5 ha / 17% of the total site area) is within the 5% AEP flood extent and is at risk of frequent (18% AEP) high flood depths and velocities. Locating ancillary facilities within the flood-prone portion of this site may result in flood impacts to surrounding areas (i.e. the Banana Coast Caravan Park) and cause previously flood free areas to be inundated.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood-prone portion of the site.
3D	This area is predominately flood immune apart from three flow paths which pass through the site in all events. Redirection of these flows may cause previously flood free areas to be impacted, however, because the site is in the upper reaches of the catchment, potential impacts on flooding are expected to be minimal.	A CFMP will be prepared to manage potential flood risk. Conveyance of existing small tributaries within the site and its associated flows should be maintained.

Site	Flood risk and potential impact	Management measure
3E	Most of the site is within the 5% AEP flood extent and is at risk of frequent (18% AEP) high flood depths and velocities. Consequence of inundation is high because of the relative proximity of properties.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area. Use of this site should be limited to outside of the 1% AEP flood affected area due to the risk of frequent high flood depths and velocities.
3F	This site is flood immune in the 1% AEP event and is subject to flooding during a PMF event (in the existing case). With the project in place, approximately 20% of the site would experience shallow inundation in a 1% AEP event. Use of this area for ancillary facilities has a relative low flood risk and the consequence of inundation is low because surrounding areas are predominantly recreational land.	Management of the site uses outside of the PMF event are not required because of the low probability of flooding. As the construction phase progresses, consideration of changes to the flood risk need to be carried out.
3G	Most of this site is flood free apart from an area along the southern boundary which is at risk of frequent (18% AEP) high flood depths and velocities. Locating ancillary facilities in areas affected by flooding may result in redirection of flows and cause previously flood free areas to be inundated, potentially impacting nearby residences.	A CFMP will be prepared to manage potential flood risk. Site compounds, stockpiling and plant machinery should be placed outside of the flood hazard area. Conveyance of existing stream should be maintained.

4.2 Temporary waterway crossings

There is a potential that the construction and operation (during construction) of temporary waterway crossings, including temporary structures, may impact the existing flooding and hydrology regimes. These temporary crossings have the potential to impact on the hydraulic function of the waterway, aquatic environment and bank stability, causing water levels to rise upstream of the crossing during a flood event.

Temporary crossing structures may be required to cross Newports Creek, Coffs Creek, Treefern Creek, Jordans Creek, Pine Brush Creek and other small unnamed drainage lines and watercourses to enable materials to be hauled within the construction footprint (rather than using the existing road network) while the adjacent culvert or bridge is being built.

Once final culverts or bridges are suitable for trafficking those structures would be used as haul routes for the project.

To minimise flood impacts from temporary creek crossings, the works should be designed, constructed and maintained in accordance with the following mitigation requirements:

- Affected waterway crossings are to be constructed so that natural flow conditions are maintained as much as possible and carried out in accordance with environmental and fish conservation requirements.
- Existing waterway areas are to be maintained as much as possible to minimise potential flood impact during construction.
- Flood modelling may be required to determine the extent of flood impacts and to aid in the appropriate sizing and location of temporary culverts or structures. This is recommended for temporary crossings of larger waterway systems such as Newports Creek, Coffs Creek, Jordans Creek, Pine Brush Creek.
- Erosion and sediment control measures (including scour protection) are to be implemented immediately around the affected watercourses.
- Realigned channels (if required) are to be constructed offline and generally remain free of external flows to allow adequate establishment of vegetation, prior to initiation of the ultimate waterway arrangement
- Temporary haul road crossing structures may also be required in areas of overland flows and are to be constructed such that low and high flows are maintained and fine sediment materials are avoided or contained within the haul road formation.
- Following construction completion, affected waterway crossing areas are to be rehabilitated to existing (or improved) conditions.

4.3 Earthworks

Significant earthworks would be required for the construction of the road embankments and cuttings and tunnels within all construction zones.

Earthwork activities during construction would include, the stripping and temporary stockpiling of topsoil, bridge pier foundation works, geotechnical investigations, landscaping, drainage channels, swales, temporary and permanent water quality basins.

Primarily, construction earthworks activities would comprise of temporary stockpiles, temporary water quality basins, construction of embankments, cuttings and tunnels.

The assessment of construction earthworks impacts has been carried out by reference to the final arrangement of the earthworks following construction of the project.

Details of the assessment for the developed scenario are contained in **Section 5**. The assessment examines the impacts of flows, velocity and duration and the assessment is based on the earthworks within their operational / final position. To align the mitigation measures proposed for the operational earthwork arrangements, construction earthworks within flood affected areas are to be constrained to the ultimate (developed scenario) condition of the project to avoid adverse impact.

Development of the detailed design (or operation of the construction plan), may result in earthworks within flood affected areas extending beyond the final arrangement of the earthworks considered in this assessment. Revised flood modelling would be carried out to assess the impact of this change in earthworks if this were to occur.

4.4 Catchment drainage

Construction activities will be required to establish and construct project infrastructure. These works would include, clearing of vegetation, earthworks for embankments, cuttings, temporary haul roads, local road construction and structures. These construction activities have the potential to impact on the surface water quality, volume and velocity discharging to adjacent waterways and hydrological process during and after rainfall events.

Catch drains and cross drainage structures would be built to divert overland flows away from the project and to convey overland flows under the project. Construction of the project would require diversion and management of overland flows to drain new works as they are being built and these activities would have the potential to impact on flooding and hydrology.

The construction of the catch drains and cross drainage structures (including pits, pipes, culverts and open drains/swales) would occur progressively in conjunction with temporary, staged and permanent road drainage to enable continuity of natural watercourses and hydrological processes.

To further support the continuity of natural water courses and hydrological processes, catchment drainage would be designed to divert flows from entering areas of construction. This is to minimise the erosion effect of such flows and minimise the subsequent requirement to treat any flows which are discharging from the works.

The potential impacts of changes in catchment drainage during construction have been assessed considering the differences between existing flow attributes and the predicted flow attributes with the project in place. The following flow attributes have been considered for the 1 per cent AEP flood event:

- Peak flow rates
- Peak flood levels and flow velocities
- Duration of inundation.

The assessment of the potential changes in the above flow attributes is provided in **Section 5.4**.

If during detailed design construction impacts are predicted to be worse than the operational flood impacts, mitigation measures will be developed in accordance with the floodplain management objectives and the construction flood management plan (CFMP).

5 Assessment of operational impacts

Flood modelling was carried out during development of the design for the project to identify areas of impact and determine appropriate mitigation measures to be incorporated into the design of the project to reduce and manage potential flood impacts, which represents the developed case discussed in the following sections.

The flood models were simulated for the range of storm events listed in **Section 2.3** for the developed case (ie with the project) and compared to the existing case (ie without the project) flood conditions. The flood impacts were reviewed against the floodplain management objectives in **Table 6** and the outcomes are summarised in the following sections.

5.1 Project infrastructure

As detailed within **Section 1.8** floodplain management objectives for project infrastructure has been set for the alignment, tunnel portal and waterway crossing elements of the design as described below:

Alignment

All areas of the proposed alignment achieve required flood immunity criteria of 1 per cent AEP flood immunity for proposed main carriageway and 5 per cent AEP for ramps and interchanges.

Appropriate scour protection designed for areas at risk of scour due to the project to ensure long term bed and bank stability.

Tunnel portals

All tunnel portals achieve required flood immunity criteria of being the PMF or the 1 per cent AEP flood level +500 mm (whichever is greater). In addition, there are no sags located within any of the project tunnels.

Waterway crossings

The project bridge soffits have been developed to meet a design criterion to be set at least 500 mm above 1 per cent AEP flood level to provide potential debris clearance, as presented in **Table 16**. Bridge soffit levels for all bridges were adopted from preliminary bridge drawings.

Table 16: Project bridge soffit flood clearance

Hydraulic structure ID	Bridge ID	Bridge Soffit (mAHD)	Peak 1% AEP Level (mAHD	Clearance (m)
DS10	BR03	11.08	10.91	0.17
DS12	BR23	12.98	10.31	2.67
DS13	BR04	13.14	9.88	3.77
DS32	BR07	26.86	22.66	4.20
DS33	BR06	23.00	21.68	1.32

Hydraulic structure ID	Bridge ID	Bridge Soffit (mAHD)	Peak 1% AEP Level (mAHD	Clearance (m)
DS35	BR08	26.32	20.35	5.97
DS45*	BR12NB	76.30	60.19	16.11
DS50	BR13SB	72.40	67.65	4.75
DS51	BR13NB	73.10	68.56	4.54
DS85	BR21	13.00	11.74	1.26

* Bridge DS45 reported clearance is the minimum clearance due to the variable depth of the deck

All project bridges achieve required clearances above the 1 per cent AEP level, except DS10 (BR03). Opportunities to increase clearance for this bridge to achieve the required clearance above the 1 per cent AEP level will be investigated during detailed design of the project.

During detailed design of the project all structures would be designed with appropriate scour protection and velocity dissipation treatments as required. Typical treatments would include rock protection, rip rap and stilling basins. These treatments would be identified at the detailed design phase of the project (once structure arrangements are confirmed).

5.2 Operational impact

Assessment of the potential operational impacts of the project on flooding and hydrology against the design criteria and flooding objectives outlined in **Section 1.9** are outlined in the following sections.

5.2.1 North Boambee Valley

Key elements of the project relating to flooding and hydrology for North Boambee Valley catchment which have been incorporated into the design of the project are described in **Section 2.6.1**.

Level

Peak flood level differences for the 1 per cent AEP flood event in the North Boambee Valley catchment are shown in **Appendix D1** and potential impacts of the project in terms of flood levels for representative points of interest (POI) in the catchment are summarised in **Table 17**.

Bridges, culverts and additional floodplain storage (north of North Boambee Road) have been incorporated into the project to mitigate potential flood impacts.

All areas external to the project in the North Boambee Valley catchment achieve required flood afflux criteria (as summarised in Table 6) with the exception of:

- Newports Creek floodplain upstream of the project (points of interest E and Z), primarily due to the reduced flood conveyance and storage

- Downstream of Englands Road (point of interest B), however this is on land owned by TfNSW (refer to **Table 17**)
- Upstream of the existing Pacific Highway (point of interest A), primarily because of road widening.

Table 17: Predicted flood impacts for the 1 per cent AEP flood event in the North Boambee Valley catchment

POI	Potential flood impact	Mitigation measures included in the design
A	The project widens the road embankment into the low-lying area currently drained by the existing culvert (ES01) causing the following flood impacts: • Increase in peak water level in events up to the 2% AEP over the current dam, with a maximum increase of 380 mm predicted in the 18% AEP event. As these impacts are contained within a dam, the consequences are reduced. • Peak water level is reduced (ie negative afflux) from 5.1 mAHD to 5.0 mAHD in the 1% AEP event on Lot 232 DP740659. It is noted that the flood extent does not extend to the residential building.	The existing culvert (ES01) is proposed to be lengthened to match the width of the widened road embankment. A new culvert (DS02) is proposed adjacent to ES01 to partially alleviate potential flood level increases upstream. New culverts (DS03) have also been included and raising of the affected driveway crest is proposed to maintain flood access.
B	The project has the potential to impact the tributary adjacent to Englands Road at point of interest B. Afflux up to 350 mm is predicted in the 1% AEP event which would be contained on land owned by TfNSW between the project and Englands Road. The afflux is contained to the heavily vegetated floodplain with no impact to Englands Road flood immunity. Time of inundation is predicted to increase by 5 minutes. This minor increase in duration is not expected to impact environmental processes.	The approach of attenuating flood flows upstream of the project via the proposed culvert (DS09) results in peak flood level reductions to the downstream areas.
C	Stormwater drainage from the Englands Road interchange discharges to the existing drainage channel adjacent to the existing Pacific Highway, resulting in a change in flow distribution over Lot 61 DP1026815.	The proposed culvert (DS05) discharges directly into the downstream channel generally resulting in peak flood level reductions.

POI	Potential flood impact	Mitigation measures included in the design
D	The tie-in with the existing Pacific Highway slightly modifies the road profile and embankment width affecting flood conveyance and storage causing the following impacts in the 1% AEP event: • Decreases in peak water level on the northbound lanes of up to 22 mm. • Increases in peak water level of up to 17 mm on vegetated recreational areas downstream of design structures (DS07, DS08).	Extension of cross-drainage culverts on the upstream and downstream sides has been included to match the width of road embankment (DS07, DS08). Four additional culverts (DS07) have also been included to maintain trafficability and immunity.
E	The project traverses the Newports Creek floodplain at this location and the project embankments affect flood storage and conveyance to the main creek channels. Localised afflux of up to 380 mm in the 1% AEP event is predicted immediately upstream of the project. Afflux reduces to around 65 mm as the flood extends upstream to: • The existing agricultural/forested areas • The residential property adjacent to North Boambee Road (property is owned by TfNSW). Flood depth increase by 180 mm in the 1% AEP event • Towards North Boambee Road.	The proposed bridge and culvert structures (DS10 (BR03) to DS12 (BR23)) have been included to provide for flood flow conveyance but do not eliminate afflux upstream.
F / Z / AA /Y	The project traverses the Newports Creek floodplain. Embankments reduce floodplain storage in this area (point of interest F) resulting in afflux up to 110 mm in the 1% AEP event on the surrounding pastural/forested areas west of point of interest F (outside of the construction footprint). Within the northern extent of Highlander Drive (point of interest AA) afflux of up to 16 mm is predicted on the road in the 1% AEP event. No residential buildings are impacted at point of interest AA. Afflux of up to 25 mm is predicted at the residential property of Lot 1 DP711234 – on the north side of North Boambee Road (point of interest Z). Survey of the residential building determined that the finished floor level is about 450 mm above the predicted 1% AEP flood levels.	The proposed bridges DS13 (BR04) and DS12 (BR03) have been optimised to balance upstream and downstream afflux reflecting the different land-uses upstream and downstream. In addition, cross drainage structures (DS14) and excavation areas beneath BR04 provide further mitigation of flood conveyance loss and compensatory flood storage. These are elements of the North Boambee Valley vertical alignment design change.
G	The project traverses the northern upper sub-catchments of Newports Creek requiring conveyance.	Proposed culverts (DS16 to DS21) provide conveyance of upstream flows. The outlets of these culverts would require sufficient scour protection /dissipation to address the high velocities which are predicted here.

Comparison with the EIS impacts

Potential flood level impacts for the North Boambee Valley catchment compared with the EIS include:

- Improvements to flood level impacts at points of interest B, D and E because of model updates and design developments
- Slight worsening of flood level impacts at points of interest A, F/Z, AA, and Y because of model updates and design developments, including the replacement of Bridge 05 with culverts as part of the North Boambee Valley vertical alignment design change
- Consistent with flood level impacts reported in the EIS for point of interest C and G.

Mitigation measures for residual impacts

The following design options will be investigated during detailed design to reduce the predicted afflux in those areas where afflux is forecast to be greater than the floodplain management objectives (refer to **Section 1.9**):

- Optimised bridge lengths: Bridge lengths could be further optimised to provide a balance between upstream and downstream afflux.
- Downstream channel works: Minor modifications to the channel of Newports Creek downstream of the project could be considered in consultation with CHCC, to reduce predicted afflux
- Additional storage areas: Compensatory excavation of floodplain areas could be considered to mitigate the storage loss from embankments for the project. There is limited available area within the project footprint and maintenance of free drainage of low-lying areas may be constrained.
- Cross-drainage: Mitigation measures incorporated into the project would hold back flood waters upstream of the project (point of interest B), on heavily vegetated areas on land owned by TfNSW. This would result in a decrease in the flood levels downstream of the project in the 1 per cent AEP flood event, improving flood conditions downstream of the project. Refinement of the cross-drainage design during detailed design could provide a better balance between retaining water upstream of the project and managing downstream flood levels consistent with the floodplain management objectives in **Section 1.9**. Refining the cross-drainage design at point of interest A is also recommended to better balance impacts.
- Whole-of-government approach: Through discussions with CHCC and DPIE (Environment, Energy and Science Group), a whole-of-government approach would be investigated which considers the relationship between the project and North Boambee Valley (West) urban release area. Reasonable and feasible flood mitigation options could be implemented to assist in managing flood risks (existing and future flood risks). A potential outcome of this is decreasing bridge lengths to manage downstream flooding conditions.

Investigation of the potential mitigation measures listed above would need to be carried out in consultation with CHCC and other relevant stakeholders.

Scour and velocity

The peak velocity difference maps presented in **Appendix D2** illustrate relatively consistent flood velocities under the developed scenario except where flows are concentrated through the proposed structures:

- Flow velocities near proposed bridge structures DS12 (BR23) and DS13 (BR04) are predicted to increase by up to 1.0 m/s to peak velocities of 1.5 m/s in the 1 per cent AEP event. These increases are within the construction footprint.
- Localised increases in velocities at drainage structure outlets. Downstream of DS03 (point of interest A) velocities increase to up to 2 m/s in the 1% AEP event. This increase is localised and does not affect the nearby residential building. At all other locations velocity increases are less than 0.2 m/s outside the construction footprint in the 1% AEP.

Adequate revegetation and scour protection would be required through and around these areas (subject to further mitigation design as above).

As there are no other areas with significant changes in peak velocity, no notable adverse impacts are expected to the adjacent riparian vegetation due to increases in erosion or sedimentation potential.

Access

Table 18 presents the predicted minimum design flood event road closure and overtopping depth for the existing and developed scenarios. For this assessment, a road or access point is considered non-trafficable where there would be 100 mm or more water over the crest of the road or access point. There are some cases where there would be a minor increase or decrease in the depth of flooding with the project in place, however the predicted flood depth would remain greater than 100 mm. Despite a minor change in flood depth, the access would be non-trafficable and would remain as such because there would be more than 100 mm over the road or access point.

Table 18: North Boambee Valley flood access

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Impact to level of access	Description
		Existing	Developed		
A	Lot 232 DP740659	<18% / 330	<18% / 240	Maintained	Under current conditions, the driveway access of Lot 232 DP740659 is not trafficable in the 18% AEP event with a depth of up to 330 mm on the road. With the project in place the trafficability remains unchanged.
B	Englands Road	<2% / 280	<2% / 280	Maintained	No change to flood immunity. Note there would be no reduction in the time of inundation.

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Impact to level of access	Description
		Existing	Developed		
D	Pacific Highway Newports Creek	<2% / 250	<2% / 240	Maintained	The tie-in with the existing Pacific Highway modifies the road profile and embankment width affecting flood conveyance. The existing flood immunity is less than the 2% AEP event and would not be affected, with minor reductions of 10 mm at the road crest. The duration of inundation is slightly decreased by 9 minutes from 1 hour 39 minutes to 1 hour 30 minutes.
W	Isles Drive	<10% / 330	<2% / 400	Increased	Under current conditions, Isles Drive would not be trafficable in the 10% AEP event with a depth of up to 330 mm on the road. With the project in place the trafficability of Isles Drive is improved to the 2% AEP event.
X	Engineering Drive	>1% / 0	>1% / 0	Maintained	Flood immunity of Engineering Drive is achieved for all events excluding the PMF.
Y	North Boambee Road	<18% / 580	<18% / 580	Maintained	Under current conditions, North Boambee Road has a flood immunity of less than the 18% AEP event with a depth of up to 580 mm on the road. Although the project results in minor increases of afflux at some locations along North Boambee Road, it does not worsen the immunity of the road, or increase the duration of inundation that this road would be closed for, or cause adverse flood impacts in this area when compared to existing conditions.
AA	Highlander Drive North	<18% / 110	<18% / 120	Maintained	With the project in place, the trafficability remains unchanged for Highlander Drive North with the maximum depth increasing only by 10 mm in the 18% AEP event.
AA	Glengyle Close	<10% / 140	<10% / 170	Maintained	With the project in place, the trafficability remains unchanged for Glengyle Close with the maximum depth increasing only by 30 mm in the 10% AEP event. Note there would be a very minor increase in time of inundation by 1 minute from 1 hour 10 minutes to 1 hour 11 minutes.

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Impact to level of access	Description
		Existing	Developed		
Z	Lot 2 DP711234	<18% / 300	<18% / 300	Maintained	Under current conditions driveway access to Lot 2 DP711234 would not be trafficable in the 18% AEP event with a peak flood level depth of up to 300 mm. With the project in place the trafficability remains unchanged.
Z	Lot 100 DP1145073	<18% / 250	<18% / 250	Maintained	Under current conditions driveway access to Lot 100 DP1145073 is not trafficable in the 18% AEP event with a peak flood levels depth of up to 250 mm. With the project in place the trafficability remains unchanged.

Table 18 demonstrates the project is not predicted to adversely impact currently flood affected access routes and no additional mitigation would be required for access in the North Boambee Valley catchment. This is consistent with access impacts presented in the EIS.

Consultation with CHCC indicates North Boambee Road could be upgraded to improve flood immunity. The project has allowed for sufficient vertical clearance at the crossing with North Boambee Road to enable it to be upgraded in the future.

Direction

Realignment of a northern tributary of Newports Creek is required as it passes beneath the project north of North Boambee Road. Approximately 145m of realignment was required as the tributary was redirected through culverts (DS14).

At all other locations in both the EIS design and the amended design, the project results in minimal changes to surface water source and direction where possible, except for constriction into and expansion out of structures and constructed diversions, in line with the project floodplain management objectives

At all other locations, the project results in minimal changes to surface water source and direction where possible, except for constriction into and expansion out of structures and constructed diversions, in line with the project floodplain management objectives.

Hazard

The project is predicted to increase the flood hazard on the upstream side of the project (point of interest E) to high, over an area of less than one hectare for all design AEP flood events. This increase is contained within the construction footprint.

An increase of flood hazard is also predicted at point of interest B (within forested land) in events greater than the 5% AEP. An increase in flood hazard is predicted on Englands Road (point of interest B) during the PMF.

No changes to flood hazard classifications are predicted over existing buildings and upstream of the project throughout the North Boambee Valley (West) urban release area.

Critical infrastructure

Project results of critical infrastructure within the flood model extents shown in **Appendix D** maps are presented in **Table 19**.

Table 19: Critical infrastructure impact in North Boambee Valley

Location	Potential flood impact
Bishop Druitt College	All buildings are outside flood extents. A portion of carpark and sporting fields are inundated but not impacted by the project. No impact predicted.
Coffs Harbour GP Super Clinic	Outside flood extents. No impact predicted.
Coffs Harbour Health Campus	At least one building is within the 10% AEP existing flood extents. Several buildings are within the 1% AEP flood extents. No impact predicted.

Emergency management

Newports Creek and its tributaries are current flooding concerns for the SES. Flooding around Newports Creek, adjacent the Coffs Harbour Health Campus, is a current issue and SES rely on a stream gauge adjacent the Isles Drive industrial estate to provide flood levels.

Peak flood level difference maps within **Appendix D** illustrate no adverse impact to the identified evacuation routes and assembly areas within the North Boambee Valley flood model. Access to the Coffs Harbour Health Campus from both the north and south is not adversely impacted by the project for events up to and including the 1 per cent AEP event. Minor peak water level reductions in the order of 10-30 mm are predicted south of the Coffs Harbour Health Campus in the 1 per cent AEP event, however the level of access remains unchanged, as described in **Table 18**. These reductions are a result of design refinements done to mitigate the increased footprint that is part of the Englands Road interchange design change.

The project provides additional routes and connections above predicted flood levels resulting in potentially more effective flood evacuation procedures.

Consultation with SES and CHCC will be carried out during detailed design if there are any changes to the existing flood evacuation routes or associated roads which may be impacted during operation.

Change in impacts compared with the EIS impacts

Impacts to evacuation routes in the North Boambee Valley catchment are consistent with those presented in the EIS. That is, there are no adverse impacts to all identified evacuation routes. It is important to note that the modelled existing flooding behaviour (refer **Section 3.1**) on the existing Pacific Highway (near the Coffs Harbour Health Campus) has changed because of the downstream extension of the flood model which was an outcome of consultation with CHCC. This is discussed in **Section 2.6.1**.

Boambee Newports Creek Floodplain Risk Management Plan

The current management plan (CHCC, 2016) indicates a development control plan to provide detailed flood planning controls. This includes a high priority to reduce the flooding on the approaches to the Coffs Harbour Health Campus. The project does not impact the flood immunity of the existing Pacific Highway approach, in addition to providing an alternate route. However, as part of any future whole-of-government initiatives, opportunities to improve the flood immunity of access to the Coffs Harbour Health Campus could be considered.

5.2.2 Coffs Creek

Key elements of the project relating to flooding and hydrology for Coffs Creek catchment which have been incorporated into the design of the project are described in **Section 2.6.2**.

Level

Peak flood levels differences for the 1 per cent AEP flood event in the Coffs Creek catchment are shown in **Appendix D1** and potential impacts of the project in terms of flood levels for representative points of interest (POI) in the catchment are summarised in **Table 20**.

Bridges, culverts and additional flood detention areas (upstream and downstream of the project north at DS27 as part of the Coffs Creek flood mitigation design change for the amended design) and near Mackays Lane (downstream of point of interest L) have been incorporated into the project to mitigate potential flood impacts.

All areas external to the project achieve required flood afflux criteria (as summarised in **Table 6**) except for Coffs Creek downstream of the Coramba Road interchange (point of interest AQ). In some areas, the impacts of the increased pavement area result in more stormwater runoff entering the creek and increased peak water levels downstream. This is predicted to impact a downstream residential property backing onto Coffs Creek (point of interest AQ). Survey of the residential building determined the floor level was 900 mm above the predicted peak flood level for the 1% AEP event.

No mitigation measures, such as excavation, within the Bennetts Road Detention Basin are proposed.

Table 20: Predicted flood impacts for the 1 per cent AEP flood event in the Coffs Creek catchment

POI	Potential flood impact	Mitigation measures included in the design
H	The project traverses the southern upper sub-catchment of Coffs Creek requiring conveyance. The increase in flood extent, which is within the construction footprint, is because additional storage has been provided to retain flows upstream of the project.	Proposed culverts (DS27) provide conveyance of upstream flows. The outlet of these culverts would require sufficient scour protection/dissipation measures during detailed design as high velocities are predicted.
I	No adverse impact is predicted within the Bennetts Road detention basin.	No mitigation measures, such as excavation, are proposed within the basin. This is part of the Coffs Creek flood mitigation design change.
BM	Afflux of up to 190 mm during the 1% AEP flood event is predicted within Coffs Creek upstream of the Coramba Road interchange bridge crossing.	The basin outlet pipe (DS37) has been extended, the spillway flows are routed through a proposed culvert (DS36) and the proposed bridges (DS32 to 35 (bridges BR06, BR07 and BR08)) would provide conveyance to Coffs Creek.
AQ	Predicted afflux in the 1% AEP flood event is 30 mm within Coffs Creek downstream of the project. The increase in flood level at this location is because of the increased area of impervious surfaces (the project pavement), resulting in additional stormwater runoff entering the creek. Afflux of up to 26 mm is predicted at the residential building. Survey of the residential building (Lot B DP363629) determined that the floor level was 900 mm above the predicted 1% AEP flood event.	Alignment drainage allows for a proportion of flood flows (10% AEP) to discharge at the various tributary crossings upstream of Coffs Creek to reduce the volume of stormwater runoff from the project, discharging directly to Coffs Creek. Excavation south of Coramba interchange (upstream and downstream of DS27 at POI H) increase flood storage and balance the volume of flows downstream in Coffs Creek. These changes are part of the Coffs Creek flood mitigation design change.
J	The project extends into the existing Spagnolos Road detention basin, decreasing storage volume and attenuation effectiveness. Predicted afflux upstream of the project and the Spagnolos Road detention basin in the 1% AEP flood event would be up to 3650 mm. This afflux is contained to the heavily vegetated areas on land owned by TfNSW. A discussion on changes to the duration of inundation at this location is provided in **Section 5.4**. Downstream of the project, afflux of up to 40mm is predicted in Spagnolos Road detention basin for events up to the 1% AEP flood event.	The approach of attenuating flood flows upstream of the project via the proposed culvert (DS38) results in peak flood level reductions to areas downstream of existing structure (ES30).

POI	Potential flood impact	Mitigation measures included in the design
K	The project traverses the upper sub-catchments of Coffs Creek requiring conveyance.	Proposed structures (DS39 to DS46) provide conveyance of upstream flows with localised minor afflux upstream generally within project objectives. The outlets of these culverts would require sufficient scour protection/dissipation to address the high velocities which are predicted here.
L	The reconfiguration of access roads resulted in modification of flood flow distribution.	Proposed structures (DS47 to DS60) are sized to ensure no adverse impact to access flood immunity.
M	Afflux of up to 100 mm during the 1% AEP flood event is predicted within the Treefern Creek area downstream of project near point of interest M. Afflux is contained to vegetated creek areas and the proposed design results in no adverse flood impact to access.	
N	The project traverses the upper sub-catchments of Coffs Creek requiring conveyance.	Proposed culverts (DS61 and DS63) provide conveyance of upstream flows with afflux contained to vegetated creek areas. The outlets of these culverts would require the design and detailing of sufficient scour protection/dissipation to address the high velocities which are predicted here.

Comparison with the EIS impacts

Potential flood level impacts for the Coffs Creek catchment compared with the EIS include:

- Improvements to flood level impacts at points of interest I, J, M, AQ and BM, because of model updates and design developments
- Consistent with flood level impacts reported in the EIS for points of interest H, K, L and N.

Mitigation measures for residual impacts

The following design options will be investigated before construction of the project, to reduce the predicted afflux in those areas where afflux is forecast to be greater than the floodplain management objectives (refer to **Section 1.9**):

- Main carriageway drainage: The Coffs Creek crossing forms the longitudinal low point of the alignment between the Roberts Hill and Shephards Lane tunnels. The design of the main carriageway for the project in this area includes a drainage system which would collect stormwater from the main carriageway (up to the 10 per cent AEP event) and discharge the flows at the various tributary crossings north of Coramba Road interchange. For storm events greater than a 10 per cent AEP event, stormwater collected on the main carriageway up to the 10 per cent AEP event flows would be collected in the drainage system, and the remaining flows would bypass the drainage system and discharge to Coffs Creek. Refinement of the drainage system to carry flows greater than the 10 per cent AEP event could reduce the total amount of runoff from the main carriageway entering Coffs Creek at Coramba Road interchange, and potentially reduce downstream impacts along Coffs Creek.

- Downstream channel works: In areas where afflux is predicted, modifications to the Coffs Creek channel may reduce potential impacts to adjacent properties and could be considered in consultation with CHCC. These works may however shift afflux further downstream and would impact existing established vegetation along the existing creek channel.
- Cross-drainage: The project as proposed would retard flood waters upstream of the project (point of interest J), on heavily vegetated areas on land currently owned by TfNSW. This would cause the road formation to act as a detention basin and offset the reduction in available storage cause by the carriageway and embankments. Refinement of the cross-drainage design would aim to maintain the existing flooding / hydrological regime by providing a better balance between holding water upstream of the project and managing downstream flood levels consistent with the floodplain management objectives in **Section 1.9.**

Investigation of the potential mitigation measures listed above would need to be carried out in consultation with CHCC and other relevant stakeholders. The investigation and further consultation may also result in additional mitigation options to those identified above.

As such, the final design solution may involve combinations of the above mitigation options and the design response developed as part of the concept design.

Scour and velocity

The peak velocity difference maps presented in **Appendix D** illustrate relatively stable developed flood velocities with the exception of the locations detailed below:

- **Coffs Creek**: Peak velocity increases (up to +1.5 m/s in the 1 per cent AEP event) are predicted within Coffs Creek downstream of Bennetts Road detention basin that may increase scour potential during flood events. Predicted peak velocity increases are less than 0.5 m/s downstream of the construction footprint.
- **Minor tributaries**: Localised increases in velocity at drainage structure outlets. At the outlet of design culverts DS41, DS55 and DS61, localised increases in velocity of up to 0.5 m/s in events larger than the 5 per cent AEP are predicted. At all locations velocity increases are less than 0.4 m/s outside the construction footprint in the 1% AEP event.

Adequate revegetation and scour protection would be required through and around these areas (subject to further mitigation and refinement during detailed design). In addition to this, localised earthworks within the construction footprint, downstream of Bennetts Road detention basin, would be required to reduce peak velocities in Coffs Creek.

As there are no other areas with significant changes in peak velocity, no notable adverse impacts are expected to the adjacent riparian vegetation due to increases in erosion or sedimentation potential.

Access

Table 21 presents the predicted minimum design flood event road closure and overtopping depth for the existing and developed scenarios. For this assessment, a road or access point is considered non-trafficable where there would be 100 mm or more water over the crest of the road or access point. There are some cases where there would be a minor increase or decrease in the depth of flooding with the project in place, however the predicted flood depth would remain greater than 100 mm. Despite a minor change in flood depth, the access would be non-trafficable and would remain as such because there would be more than 100 mm over the road or access point.

Table 21: Coffs Creek flood access

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Impact to level of access	Description
		Existing	Developed		
AD	Lot 60 DP586574	<18% / 220	>1% / 0	Increased	Driveway access would currently be closed during the 18% AEP event with a peak flood depth of 220 mm. The project would be expected to improve flood access to a 1% AEP event standard.
AD	Lot 730 DP1066743	<18% / 200	<1% / 120	Increased	Driveway access would currently be closed during the 18% AEP event with a peak depth of 200 mm. With the project in place the flood immunity of the driveway access is achieved for the 2% AEP event with a peak overtopping depth in the 1% AEP of 120 mm.
AE	William Sharp Drive west	>1% / 0	>1% / 0	Maintained	Flood immunity of William Sharp Drive west is achieved for all events excluding the PMF.
AF	Rosalee Close	>1% / 0	>1% / 0	Maintained	Flood immunity of Rosalee Cl is achieved for all events excluding the PMF.
AK	Roselands Drive near Spagnolos Road	>1% / 0	>1% / 0	Maintained	Flood immunity of Roselands Dr near Spagnolos Road is achieved for all events excluding the PMF.

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm) Existing	Developed	Impact to level of access	Description
AL	Roselands Drive near Barnet Street	>1% / 0	>1% / 0	Maintained	Flood immunity of Roselands Dr near Barnet Street is achieved for all events excluding the PMF.
AM	Gillon Street	>1% / 0	>1% / 0	Maintained	Flood immunity of Gillon Street is achieved for all events excluding the PMF.
AN	Polwarth Drive	<18% / 140	<18% / 140	Maintained	Under current conditions access for Polwarth Drive is not trafficable in the 18% AEP event with a peak flood level of 140 mm. The project is not predicted to impact access at Polwarth Drive. Note there would be a minor reduction in the time of inundation.
AG	Spagnolos Road	>1% / 0	>1% / 0	Maintained	Flood immunity of Spagnolos Road is achieved for all events excluding the PMF.
AI	Lot 5 DP1104404	<1% / 120	<1% / 110	Maintained	The project is anticipated to provide a minor flood depth reduction (10 mm) to the driveway, currently closed during the 1% AEP event with a peak depth of 120 mm. Note there would be negligible increase in time of inundation.
AH	Lot 102 DP1150637	<18% / 820	<18% / 820	Maintained	Driveway access to Lot 102 DP1150637 is predicted to remain unchanged and would overtop in an 18% AEP event in both existing case and developed case flood conditions.
AJ	Lot 4 DP1157157	<18% / 300	<18% / 300	Maintained	Access would remain unchanged.
M	Mackays Road Treefern Creek North	<18% / 300	<18% / 300	Maintained	The project is anticipated to maintain existing flooding over behaviour Mackays Road, currently would be closed during the 18% AEP event with a peak depth of 300 mm. Note there would be a minor increase in the time of inundation of up to 5 minutes.
L	Mackays Road Treefern Creek North	1% / 0	1% / 90	Maintained	No adverse impact due to the project, road is still trafficable with depths less than 100 mm up to the 1% AEP event.

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm) Existing	Developed	Impact to level of access	Description
AP	Mackays Road Treefern Creek South (Bray Street)	<18% / 310	<18% / 280	Maintained	The project is anticipated to slightly decrease flooding over Mackays Road by 30 mm, currently would be closed during the 18% AEP event with a peak depth of 310 mm. Note there would be a minor increase in the time of inundation.
BL	Mackays Road	<18% / 1640	<18% / 1700	Maintained	Driveway access via Mackays Road is predicted to remain unchanged and would overtop in an 18% AEP event in both existing case and developed case flood conditions. Note there would be a minor increase in time of inundation of 4 minutes from 6 hours and 19 minutes to 6 hours and 23 minutes.

Table 21 demonstrates the project is not predicted to adversely impact currently flood affected access routes and in some cases, access is improved, and no additional mitigation is required for access in the Coffs Creek catchment. This is consistent with access impacts presented in the EIS.

Direction

The project results in minimal changes to surface water source and direction where possible, except for constriction into and expansion out of structures and constructed diversions, in line with the project floodplain management objectives.

Hazard

Hazard in the Coffs Creek model typically remains unchanged with the exception of:

- Localised increases in hazard levels in areas of increased flood extent, including on the main carriageway in the PMF event
- Hazard levels have been adversely impacted upstream of the existing Spagnolos Road detention basin (near point of interest J). Under current conditions, the existing Spagnolos Road detention basin provides a level of flood storage and is a Declared Dam under the *Dam Safety Act 2015*. With the project in place this flood storage is reduced. The project as proposed would hold back flood waters upstream of the project (point of interest J), on heavily vegetated areas on land currently owned by TfNSW. This would cause the road formation to act as a detention basin and could be a Declared Dam under the act. While this is forecast to improve flood conditions downstream of the project, there would be greater operational and management risks for the main

carriageway as well as ongoing maintenance and management requirements for this location. Further considerations of risks created by the design in this location will be carried out during detailed design. This may include consideration of the road formation under the *Dam Safety Act 2015* in consultation with Dam Safety NSW.

Critical infrastructure

Project results of critical infrastructure within the flood model extents shown in **Appendix D** maps are presented in **Table 22**.

Table 22: Critical infrastructure impact in Coffs Creek

Location	Potential flood impact
Baringa Private Hospital	No change to peak flood levels for all design events. Minor peak flood level reductions are predicted for the PMF event.
Cow & Koala Professional Child Care	Cow & Koala Professional Child Care remains immune in design events up to and including the 1% AEP. Peak flood level reductions of up to 120 mm are predicted in the PMF event by.

Change in impacts compared with the EIS impacts

Following the EIS, the Coffs Creek model was updated with detailed survey (refer **Section 2.6.2**) of the drainage structures under the rail line (ES166 and ES168). This new information combined with design refinements has resulted in changes to the potential impacts to the Baringa Private Hospital when compared with the EIS. The results presented in the EIS predicted peak water level reductions for all events up to and including the 1 per cent event and increases in the PMF event. The latest results predict no change to peak water levels in all events up to and including the 1 per cent AEP event and reductions in peak water levels in the PMF event. This is because potential impacts caused by the project have been mitigated through the inclusion of an additional detention area, within the construction footprint, downstream of point of interest L.

Emergency management

Peak flood level difference maps within **Appendix D** illustrate no adverse impact to the identified evacuation routes and assembly areas surrounding the Coffs Creek flood model. Furthermore, the project provides additional routes and connections above predicted flood levels resulting in potentially more effective flood procedures.

Consultation with SES and CHCC will be carried out during detailed design if there are any changes to the existing flood evacuation routes or associated roads which may be impacted during operation.

Coffs Creek Floodplain Risk Management Plan

The recommended floodplain management measures within the Coffs Creek Floodplain Risk Management Plan (CHCC, 2005) are consistent with the project. All four existing detention basins have been incorporated in the hydraulic assessment.

The project is generally predicted to have a positive impact to the existing flood detention basins, modifying the peak 1 per cent AEP flood level as below:

- 30 mm increase of Spagnolos Road detention basin (downstream of project)
- 20 mm decrease of Bakers Road detention basin
- 20 mm decrease of Shephards Lane detention basin
- No change of Bennetts Road detention basin.

5.2.3 Northern creeks

Key elements of the project relating to flooding and hydrology for northern creeks catchments which have been incorporated into the design of the project are described in **Section 2.6.3**.

Level

Peak flood levels difference for the 1 per cent AEP flood event in the northern creeks catchments are shown in **Appendix D1** and potential impacts of the project in terms of flood levels for representative points of interest (POI) in the catchment are summarized in **Table 23**.

Bridges and culverts have been incorporated into the project to mitigate potential flood impacts.

All areas external to the project achieve required flood afflux criteria (as summarised in **Table 6**).

Table 23: Predicted flood impacts for the 1 per cent AEP flood event in the northern creeks catchments

POI	Potential flood impact	Mitigation measures included in the design
O	The project and revised local access road traverses the northern sub-catchments of Jordans Creek requiring conveyance.	Proposed culverts (DS65-70) have been sized to provide conveyance and no flood impact to local access.
P	No impact is predicted at this location.	
Q	The Korora Hill interchange results in the removal of floodplain storage upstream of the Bruxner Park Road intersection, increased road runoff and redistribution of flood flows to the downstream Pacific Bay Resort. Afflux of 35 mm is predicted in the 18% AEP flood event within the vegetated creek and lakes, golf course and carpark areas. No impacts are predicted in other events up to the 1% AEP flood event. Peak water level reductions of up to 40 mm are predicted in the 1% AEP event.	Afflux is generally contained to open space/vegetated areas with no flood impact to Resort Drive. Upstream drainage structures have been sizes to mitigate impacts at Pacific Bay Resort. This is an element of the Korora Hill interchange design change.
BI	No impact is predicted for the approved development area of Pacific Bay Eastern Lands.	

POI	Potential flood impact	Mitigation measures included in the design
R	The project reconfigures the existing Pacific Highway Pine Brush Creek crossings (ES71) including additional twin bridges (DS85 (BR21)), embankment work and creek realignments. Localised peak water level reductions of up to 200 mm are predicted within the waterway in the 1% AEP flood event. No flood impact is predicted to the existing Old Coast Road (ES69 and ES72) bridges.	Proposed bridges (DS85 (BR21)) and creek realignment have been re-designed to ensure adequate flood conveyance. This is part of the Pine Brush Creek and Williams Creek realignment design change.
BP	Predicted afflux in the 1% AEP flood event is up to 13 mm over heavily vegetated creek areas (outside the project boundary). No flood impact is predicted to the existing James Small Drive (ES74) bridges. Survey of the residential building (Lot 20 DP841807) determined that the floor level was at 11.14 mAHD. Afflux is predicted in events up to and including the 5% AEP. The peak water level in these events is below the floor level. The peak water level for the 1% AEP event under existing conditions is observed to be 11.39 mAHD. Afflux is not predicted in the 1% AEP event. This building is owned by TfNSW.	Proposed bridges (DS85 (BR21)) and creek realignment have been re-designed to ensure adequate flood conveyance. This is part of the Pine Brush Creek and Williams Creek realignment design change.
S	The project and revised local access road traverses the northern sub-catchments of Pine Brush Creek requiring conveyance.	Proposed culverts (DS86 to DS101) have been sized to ensure adequate flood conveyance and no flood impact to local access.
T	The project reconfigures the existing Opal Boulevard access, resulting in a modified flood distribution. Localised afflux of up to 85 mm is predicted in the 1% AEP event immediately upstream and downstream of the Opal Boulevard crossing of Pine Brush Creek.	Proposed roadside channels generally provide conveyance of upstream flood flows to the main creek channel. Afflux is contained to the vegetated creek areas with no adverse flood impact to Opal Boulevard flood access.
U	The proposed water quality basins extend into the waterway of the main Sapphire Beach tributary, resulting in localised afflux of up to 90 mm within the waterway. No change to the existing flood extents is predicted.	
V	No impact is predicted for the Nautilus Villas.	

Comparison with the EIS impacts

Potential flood level impacts for the northern creeks catchment compared with the EIS include:

- Improvements to flood level impacts at points of interest P, Q, R, T, U, V, BI and BP because of model updates and design developments
- Consistent with flood level impacts reported in the EIS for points of interest O and S.

Scour and velocity

The peak velocity difference maps presented in **Appendix D** illustrate relatively stable developed flood velocities with the exception of the locations detailed below:

- **Pacific Bay Resort:** Minor (up to +0.2 m/s) peak velocity increases are predicted within the existing course flow paths and lakes. Peak velocity increases of up to 1.0 m/s are predicted downstream of ES57 and ES157 (POI BI), within the existing flow path.
- **Pine Brush Creek and Williams Creek:** Existing peak velocities reach approximately 3.5m/s in Pine Brush Creek and 2.9m/s in Williams Creek in the 1% AEP event. Peak velocity increases of up to 0.6 m/s are predicted through the waterway realignment of Williams Creek in the 1% AEP event. Peak velocities for the amended design are predicted to reach 3.5m/s in Pine Brush Creek and 3.5m/s in Williams Creek in the 1% AEP event. Impacts are generally contained within the construction footprint and do not affect any residential buildings.
- **Minor tributaries:** Localised increases in velocity at drainage structure outlets. Downstream of DS87 (point of interest T) an increase of up to 1.0 m/s is predicted in the 1% AEP event. This increase is localised and is contained within the waterway. At all other locations velocity increases are less than 0.2 m/s outside the construction footprint in the 1% AEP event.

Adequate revegetation and scour protection would be required through and around these areas (subject to further mitigation and refinement during detailed design).

As there are no other areas with significant changes in peak velocity, no notable adverse impacts are expected to the adjacent riparian vegetation due to increases in erosion or sedimentation potential.

Access

Potential flood impacts of the project on existing local and access roads in the northern creeks catchments are summarised in **Table 24**.

For this assessment, a road or access point is considered non-trafficable where there would be 100 mm or more water over the crest of the road or access point. There are some cases where there would be a minor increase or decrease in the depth of flooding with the project in place, however the predicted flood depth would remain greater than 100 mm. Despite a minor change in flood depth, the access would be non-trafficable and would remain as such because there would be more than 100 mm over the road or access point.

The proposed reconfiguration of all local roads and driveways affected by the project resulted in no adverse impact to access during flood events.

Table 24: Northern creeks flood access

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Impact to level of access	Description
		Existing	Developed		
AR	West Korora Road, Jordans Creek	<18% / 540	1% / 70	Increased	Driveway access to Lot 19 DP771618 would be closed during the 5% event with a peak flood depth of 110mm. The project is expected to improve access to a 1% AEP event.
AX	Lot 19 DP771618	5% / 110	1% / 0	Increased	Driveway access to Lot 19 DP771618 predicted to remain unchanged with an immunity of 1% AEP event achieved. Note there would no increase in time of inundation.
AS	Pacific Highway, Jordans Creek	<5% / 250	<5% / 250	Maintained	Access via Pacific Highway remains unchanged and overtops in an 5% AEP event flood with a peak flood depth of 250 mm. The project is anticipated to maintain existing flooding behaviour over the Pacific Highway.
AY	Bruxner Park Road	<18% / 110	<18% / 10	Maintained	Bruxner Park Road would not be trafficable in current conditions in the 18% AEP event with peak flood depths up to 110 mm. With the project in place the trafficability remains unchanged with peak flood depths reducing by 10 mm in the 18% AEP event. Access flood immunity is maintained.
AZ	James Small Drive	>1% / 0	>1% / 0	Maintained	Flood immunity of James Small Drive is achieved for all events.
Q	Resort Drive	>1% / 0	>1% / 0	Maintained	Access via Resort Drive (ES99) remains unchanged and is predicted to remain flood immune in all events excluding the PMF.
AU^	Langley Close	<18% /300	<18% / 300	Maintained	Access via Langley Close remains unchanged and would overtop in an 18% AEP event in both existing case and developed case flood conditions with peak flood depths of 300 mm. Note there would be negligible increase in the time of inundation (less than 1 minute).
AT^	Driftwood Court	<18% / 660	<18% / 660	Maintained	Access via Driftwood Court remains unchanged and would overtop in an 18% AEP event in both existing case and developed case flood conditions.

POI	Affected road / driveway	Minimum event closure (AEP) / crest depth (mm)		Impact to level of access	Description
		Existing	Developed		
AU^	Cutter Drive	<18% / 270	<18% / 270	Maintained	Access via Cutter Drive remains unchanged and would overtop in an 18% AEP event in both existing case and developed case flood conditions.
AT^	Firman Drive	<18% / 770	<18% / 770	Maintained	Access via Firman Drive remains unchanged and would overtop in an 18% AEP event in both existing case and developed case flood conditions.
AZ	Ballantine Drive	>1% / 0	>1% / 0	Maintained	Flood immunity of Ballantine Drive is achieved for all events excluding the PMF.
R	Old Coast Road, Pine Brush Creek	5% / 340	5% / 330	Maintained	Local access via Old Coast Road remains the same, the road would overtop in both existing case and developed case flood conditions in the 5% AEP event. The road would overtop by an additional 10 mm and there is predicted to be negligible change in duration of inundation (less than 5 minutes).
T	Opal Boulevard	2% / 120	>1% / 0	Increased	Local access to Opal Boulevard would be improved, now does not overtop in 1% AEP event flood conditions.
S	Lot 1 DP270147	<18% / 140	<18% / 140	Maintained	Local access to Lot 1 DP270147 would be maintained.
S	Lot 100 DP1112799	>1% / 0	>1% / 0	Maintained	Local access to Lot 100 DP1112799 would be maintained.
S	Lot 1 DP527497	<2% / 130	<2% / 130	Maintained	Local access to Lot 1 DP527497 would be maintained.
V	Ocean Dream	<18% / 640	<18% / 640	Maintained	Access flood immunity for Ocean Dream would be maintained.

^Points of interest AU and AT are located approximately 500 m and 650 m downstream of point of interest AS. This is not within the mapping extent shown in the figures. However, these locations are not impacted by the project.

Table 24 demonstrates the project is not predicted to adversely impact currently flood affected access routes and, in some cases, access is improved. No additional mitigation is required for access in the northern creeks catchment.

This is an improvement from the access impacts presented in the EIS. In the EIS, four local access roads were impacted at points of interest S, T, AZ and AX/P. The revised assessment predicts no impacts to access in the northern creeks catchment.

Direction

As part of the Pine Brush Creek and Williams Creek realignment design change a creek realignment is required at DS85 (BR21). Details on this design change can be found in **Chapter 2, Design changes**. The realignment includes the relocation of the confluence of the two creeks to approximately 20 m upstream of the existing confluence location. In addition to this, Williams Creek and Pine Brush Creek have been realigned by approximately 90 m and 85 m respectively to maintain existing velocities and hydraulic grades upstream of the confluence. These changes result in improved flood flow management through three bridges.

Since the EIS exhibition, opportunities to improve the highway crossing of Pine Brush Creek, adjacent creek realignments and associated flooding impacts have been identified. Design development at this location is ongoing and will be considered further during detailed design. Potential developments could include adjustments to the waterway realignment to better match existing waterway characteristics (such as length and slope).

At all other waterway crossings, the project results in minimal changes to surface water source and direction where possible, except for constriction into and expansion out of structures and constructed diversions, in line with the project floodplain management objectives.

Hazard

Increases in flood hazard classifications are predicted over the area immediately upstream of the culvert DS86 in the PMF event.

Critical infrastructure

Project results of critical infrastructure within the flood model extents shown in **Appendix D** maps are presented in **Table 25**.

Table 25: Critical infrastructure impact in northern creeks

Location	Potential flood impact
Kororo Public School	Outside flood extents. No impact predicted.
Coffs Harbour Montessori Preschool	Outside flood extents. No impact predicted.

Kororo Public School bus interchange

The proposed Kororo Public School bus interchange is located adjacent to, and to the east of, the Pine Brush Creek catchment (Domain 2). The design presented in the EIS had the bus interchange draining towards the unmodeled catchment between Pine Brush Creek and Kororo Basin. An assessment at the time of the EIS demonstrated that that the bus interchange would not have an appreciable impact on the flooding characteristics downstream. As a result, the bus interchange was not modelled.

Design developments that occurred following the exhibition of the EIS resulted in the bus interchange area now draining towards Pine Brush Creek (Domain 2) in the developed case. This is part of the Kororo Public School bus interchange and

Luke Bowen footbridge design change. As a result, the hydrologic and hydraulic models have been updated to account for the additional impervious sub-catchment.

The findings of this assessment demonstrate that the bus interchange would not have an appreciable impact on the flooding characteristics downstream. This assessment will be revisited should any changes in the design or assumptions occur at a later stage in the project.

Emergency management

No evacuation routes and assembly areas have been identified within the northern creeks catchment area. As discussed under *access*, the project does not cause any adverse impacts to the level of access provided by existing roads affected by flood waters. Furthermore, the project will provide additional routes and connections that may improve flood procedures. The current flood evacuation plan (SES, 2017) should be revised following completion of the project to ensure the most effective management strategy.

Consultation with SES and CHCC will be carried out during detailed design if there are any changes to the existing flood evacuation routes or associated roads which may be impacted during operation.

5.3 Social and economic cost

The project includes mitigation and management measures to minimise short and long-term impacts from flooding including consideration for future climate conditions (see **Section 6**). In the majority of the populated areas downstream of the project, a reduction in peak water levels is predicted.

The project would improve transport efficiency of the existing Pacific Highway through Coffs Harbour, relieve congestion on the wider Coffs Harbour road network and provide an alternative route for some local trips. The project would provide a route which is above 1 per cent AEP flood level from the north of Coffs Harbour to the south of Coffs Harbour, with additional access points for local traffic to access this flood free route (e.g. via Coramba Road interchange). There would be significant economic benefits from increasing the reliability of a major national freight route such as the Pacific Highway. The project would also improve the local emergency management procedures during storm events, reducing the social and economic impact of flooding to the local community.

5.4 Hydrological impact

The project would maintain hydrologically dependant environmental values of affected waterways, by ensuring:

- Natural processes, aquatic habitat and connectivity within waterways is maintained
- Environmental water availability and flows are maintained
- Erosion and sedimentation processes are managed
- The effects of proposed stormwater management are minimised.

These environmental issues can be assessed via a comparison of existing and design case for the following elements:

- Flows
- Velocities
- Durations of inundation.

Flows

Peak flow rates are largely related to the size of the catchment area and the proportion of impervious areas within the catchment. A comparison of the proportion of impervious areas and the peak flow rates between the existing and developed case flood conditions at several points of interest (POI) downstream of the project, for the 1 per cent AEP flood event, is provided in **Table 26**. Discussion on hydrological runoff changes due to change in imperviousness for each catchment is detailed in **Section 2.5**.

Points of interest downstream of the project demonstrate the impact of the project on existing flow conditions. Points downstream of the project were selected to assess whether the impacts of the project would be localised to areas close to the construction footprint, or if there would be changes in the downstream flow conditions. The points of interest for each catchment are shown in the maps in **Appendix D**.

Table 26: Hydrologic comparison

Catchment	POI	Scenario	Catchment (ha)	Impervious area (%)	1% AEP peak flow (m^3/s)
North Boambee Valley	D	Existing	172.0	26.2	33.1
		Developed	172.0	26.2	31.7
		Difference	0.0	0.0	-4.3%
	BA	Existing	1162.8	0.7	269.4
		Developed	1162.8	0.7	272.1
		Difference	0.0	0.0	1.0%
Coffs Creek	BB	Existing	673.1	3.1	81.6
		Developed	672.8	5.3	81.5
		Difference	-0.3	2.2	-0.1%
	BC	Existing	156.7	16.9	45.0
		Developed	154.4	17.3	45.3
		Difference	-2.3	0.4	0.6%
	AP	Existing	159.5	9.5	62.5
		Developed	166.8	13.4	62.5
		Difference	7.3	4.0	0.0%
	BD	Existing	73.7	11.1	19.5
		Developed	75.6	13.3	19.3
		Difference	1.9	2.2	-1.0%

Catchment	POI	Scenario	Catchment (ha)	Impervious area (%)	1% AEP peak flow (m^3/s)
Northern creeks	P	Existing	136.8	0.3	76.8
		Developed	137.2	4.2	73.7
		Difference	0.4	3.9	-4.0%
	Q	Existing	74.6	6.8	42.5
		Developed	75.5	17.8	41.7
		Difference	0.9	11.0	-1.9%
	T	Existing	724.0	2.4	238.5
		Developed	723.7	2.4	238.4
		Difference	-0.3	0.0	0.0%
	V	Existing	52.1	5.9	17.3
		Developed	52.1	5.9	17.3
		Difference	0.0	0.0	0.0%

The assessment is based on the comparison between the existing case and the developed case flood conditions. Conditions would change progressively during construction of the project. To be consistent with the floodplain management objectives outlined in **Section 1.9**, flood conditions during construction would be expected to be no worse than the developed case flood.

The assessment indicates peak flow rates in the developed case would generally be within five per cent of the existing flow rates downstream of the project.

No adverse impacts to natural processes within waterways and floodplains, including the availability of water for ecological purposes, would be expected. The minor changes in peak flow rates would not be anticipated to adversely impact on existing stormwater infrastructure.

No adverse impacts to the environmental availability of water or natural processes within the waterways would be expected. In addition, the minor changes would not be anticipated to adversely impact on the existing stormwater infrastructure.

If during detailed design construction impacts are predicted to be worse than the developed case flood impacts, mitigation measures will be developed in accordance with the floodplain management objectives and the CFMP.

Velocities

Peak flood levels and flow velocities provide an indication of the potential change in natural processes within waterways. The locations where the most change would be expected is at the waterway crossings where flows would be constricted to pass beneath bridges at those locations. A comparison of the peak flood levels and flow velocities between the existing and developed case flood conditions at the major creek crossings, for the 1 per cent AEP flood event, is provided in **Table 27**.

Table 27: Flood conditions of waterway crossings

Waterway	ID	Bridge ID	Peak 1% AEP Level (mAHD)			Peak 1% AEP Velocity (m/s)		
			Existing	Design	Impact	Existing	Design	Impact
Newports Creek	DS10	BR03	10.90	10.92	0.02	1.41	1.47	0.06
	DS12	BR23	10.02	10.31	0.29	1.03	1.05	0.02
	DS13	BR04	9.86	9.88	0.02	0.68	0.37	-0.31
Coffs Creek	DS33	BR06	21.62	21.68	0.06	0.90	0.92	0.02
	DS45	BR12	60.23	60.19	-0.04	1.12	1.11	-0.01
Pine Brush Creek	DS85	BR21	11.87	11.74	-0.13	2.26	2.69	0.43

The assessment is based on the comparison between the existing case and the developed case flood conditions. Conditions would change progressively during construction of the project. To be consistent with the floodplain management objectives outlined in **Section 1.9**, flood conditions during construction would be expected to be no worse than the developed case flood.

The differences in flood conditions between the existing and developed case shown in **Table 27** indicates there would be limited change in peak flood conditions at these waterway crossings. The exception is at DS12 (BR23) over Newports Creek where there would be a 290 mm flood level increase. The extent of flood level impact at this location is shown on the flood maps within **Appendix D1.1** and **Appendix D2**. These maps show impacts would be localised.

Natural waterway processes would be maintained or improved following rehabilitation of the waterways affected by construction of the project.

If during detailed design construction impacts are predicted to be worse than the developed case flood impacts, mitigation measures will be developed in accordance with the floodplain management objectives and the CFMP.

Duration

The project would result in minor increases in flood levels consistent with the floodplain management objectives. These flood level increases would result in inevitable minor increases in flood duration. However, these increases would be in the order of minutes and be limited to large, rare flood events. More relevant to the impacts on stream morphology and hydrological regime are the expected changes to low flow events. Changes to the duration of low flows and frequent floods (e.g. annual floods) are likely to be negligible due to the inclusion of adequate transverse drainage structures in the design.

There are two locations (points of interest B and J) where the project would result in flood duration increases as a design outcome to meet downstream floodplain management objectives. At these locations, flood flows would be retarded to offset the loss of flood storage due to the project footprint.

A comparison of the time of inundation between the existing and developed case flood conditions at these locations for the 1 per cent AEP flood event is provided in **Table 28**.

Table 28: Impacts to flood duration of inundation

POI	1% AEP Flood duration (hr:min)		
	Existing	Design	Difference
B	14:25	14:30	00:05
J	4:40	15:05	10:25

These changes to flood flow durations are consistent with the changes to flood flow durations resulting from continued urbanisation of the catchments over recent decades and the more recent construction of dedicated flood detention basins for flood management. Hence, the duration of flooding in these catchments has been in a state of flux.

As discussed above, more relevant to the impacts on stream morphology and hydrological regime are the expected changes to low flow events. Due to the inclusion of low-flow outlets from these detention areas, the impacts on low flow durations would be negligible.

6 Climate change

Rainfall and sea level are the two predominant factors which determine the degree and severity of flood events. Climate change has the potential to significantly influence both factors, by increasing sea levels and causing an increase in the severity of extreme weather events.

The *Practical Consideration of Climate Change – Floodplain Risk Management Guideline* prescribes indicative changes in extreme rainfall. The indicative changes are sourced from the CSIRO report for *Climate Change in NSW Catchments* published in 2007 (DECC, 2007). That report has been superseded by *Climate Change in Australia - Projections for Australia's Natural Resource Management Regions* technical report published in 2015, which has been referenced for the climate change effects on the project.

The CSIRO predicts, with very high confidence, that mean sea level will continue to rise and the height of extreme sea-level events will also increase (CSIRO, 2015). Since the NSW Government announced its Stage One Coastal Management Reforms on 8 September 2012, it is no longer recommended to apply state-wide sea level rise benchmarks by local councils. Sea level rise has therefore been modelled as a sensitivity check on predicted flood levels.

The project is located at elevations high enough to be unaffected by potential sea level scenarios. Nevertheless, the 2050 and 2100 scenarios have been assessed by increasing the ocean boundary levels by 400 mm and 900 mm, respectively (CHCC, 2018).

The CSIRO predicts average rainfall will decrease and that wet years will become less frequent. Despite this they also predict, with high confidence, that intense rainfall events will become more frequent and extreme while the magnitude of the increases cannot be confidently projected (CSIRO, 2015). In conjunction with sea level rise, the sensitivity assessment was undertaken to include a 10 per cent and 30 per cent increase in rainfall for 2050 and 2100 scenarios.

In summary, two climate change scenarios have been modelled (DECC, 2007):

- 2050 climate: 400 mm sea level rise and 10 per cent increase in rainfall intensity
- 2100 climate: 900 mm sea level rise and 30 per cent increase in rainfall intensity.

The 1 per cent AEP event was used as the basis for the sensitivity assessment with impacts of peak flood level and velocity compared to the following scenarios:

- Predicted impact of the project during climate change events (ie developed compared to existing scenario under climate change events)
- Predicted climate change impact to the project (ie developed comparison of current to future climate conditions).

The impacts identified from the sensitivity assessment are detailed by project catchments in the following sections.

6.1 North Boambee Valley

Impact of the project

The peak flood level and velocity impacts in the North Boambee Valley catchment for the climate change scenarios are shown in **Appendix D1** and **Appendix D2**.

When compared with the velocity and peak flood level impact from the 1 per cent AEP (see **Figure D1.1.5** of **Appendix D1**), the afflux pattern under climate conditions in the North Boambee and Newports Creek study catchment would not be appreciably altered compared to the baseline conditions (see **Figure D1.1.6** and **Figure D1.1.7** of **Appendix D1**).

An increase in peak water level impact was observed in the 2050 and 2100 climate scenarios downstream of ES17 (near point of interest BA). The impact occurs where previously no peak water level impact was observed. The increase is contained within the existing extent of inundation which is within the waterway and open pasture/grass land.

Flood immunity outcomes for the project did not change from those reported in **Section 5.2**. ie the mainline of the project remains trafficable in the 1 per cent AEP event in the 2050 and 2100 climate scenarios.

Hazard classification for climate scenarios generally remains the same as the 1 per cent AEP event, with increases in high hazard areas upstream of the project at points of interest B and E.

Impact to the project

The 1 per cent AEP flood immunity is achieved under future climate scenarios within the North Boambee Valley. **Appendix E** contains details of the 1 per cent AEP (see **Figure E1.1** and **Figure E1.2**).

Flood immunity of the project does not change under the climate change scenarios, with the main carriageway remaining trafficable in the 1 per cent AEP event in the 2050 and 2100 climate scenarios within the North Boambee Valley catchment.

6.2 Coffs Creek

Impact of the project

When compared with **Figure D1.2.5** in **Appendix D1**, the water level afflux pattern under climate conditions (see **Figures D1.2.6** and **D1.2.7** of **Appendix D1**) in the Coffs Creek study catchment shows improvements in the conditions downstream of the project.

In many of the areas that were observed to be impacted in the 1 per cent AEP event under current climate conditions, the project alignment either prevents inundation completely or decreases the peak water level of up to 350 mm (see Coffs Creek) under climate change conditions. The exception is downstream of the project in Treefern Creek. Peak water level increases of up to 35 mm are predicted in the 2100 climate scenario, with increases of up to 13 mm on the Baringa Private Hospital.

Peak water level increases of up to 700 mm were observed within Bennetts Road detention basin (point of interest I) in the 2100 climate change scenario. Increases in peak flood level were otherwise generally observed on the upstream side of the project following a consistent afflux pattern observed for the non-climate future scenarios modelled.

Hazard classifications for both 2050 and 2100 climate scenarios remain generally the same as the existing case, except for an increase in high hazard upstream of point of interest J. This high hazard area is located within vegetated and open pasture area.

Impact to the project

The 1 per cent AEP flood immunity is achieved under future climate scenarios within the Coffs Creek. **Appendix E** contains details of the 1 per cent AEP (see **Figure E2.1** and **Figure E2.2**).

Flood immunity of the project does not change under the climate change scenarios, with the main carriageway remaining trafficable in the 1 per cent AEP event in the 2050 and 2100 climate scenarios within the Coffs Creek catchment.

6.3 Northern creeks

Impact of the project

The peak flood level impacts in the northern creeks for the climate change scenarios are shown in **Appendix D1** and **Appendix D2**.

When compared with **Figure D1.3.5** in **Appendix D1**, the afflux pattern under climate conditions in the northern creeks study catchment is generally consistent with the baseline afflux conditions under existing climate conditions. Increases in peak water level impact are observed within Pine Brush Creek at points of interest BP, T and BG in the 2100 climate change scenario. The residential property, owned by TfNSW, at point of interest BP is predicted to be impacted by up to 13 mm.

Hazard in the future climate scenarios follows the same pattern as the 1 per cent AEP in both existing and design scenarios.

Impact to the project

Illustrated in **Appendix E (**see **Figure E3.1** and **Figure E3.2)** are the predicted flood increases under future climate predictions.

Flood immunity for the project mainline would be maintained in both future climate change scenarios, remaining trafficable in the 1 per cent AEP event within the northern creeks catchments.

7 Conclusion

This flooding assessment technical report has been prepared to address the relevant SEARs for the project. The pertinent background information, applied methodology, flood model development and key outcomes have been detailed.

This assessment and established flood models will form the basis of future detailed design stages of the project.

Flood model results were used to inform the concept design and determine the required mitigation measures, including optimising bridge/culvert arrangements, drainage channels and detention, and appropriate structure outlet scour protection / velocity dissipation, to achieve the required objectives, including:

- Minimum 1 per cent AEP flood immunity for proposed main carriageway, 5 per cent AEP for ramps and interchanges and PMF for tunnel portals
- No adverse peak flood level impact external to the site
- Negligible impact to external waterway stability or riparian vegetation
- Minimal changes to flood flow direction
- No adverse change to affected local road access during flood events
- No adverse flood impact to local infrastructure or emergency management.

The project will maintain hydrologically dependant environmental values of affected waterways, by ensuring crossings are rehabilitated and protection provided where required. Peak flow rates are generally consistent, with minor increases in runoff volumes predicted because of the additional impervious area of the project.

It is noted there are several locations identified requiring further development to achieve the above objectives, potentially via alternative mitigation measures.

Further investigation of these measures requires consultation with CHCC and other applicable stakeholders and will be carried out during the detailed design of the project.

The predicted impacts of the project under the 2050 future climate scenario do not extend to any additional buildings relative to current climate conditions. Under the 2100 future climate scenario, the residential property, owned by TfNSW, at point of interest BP is predicted to be impacted by up to 13 mm. Flood immunity objectives for the project are maintained in future climate change scenarios.

A conceptual assessment of the relative flood risk and potential impact of the predicted construction activities was also conducted. With sufficient measures in place the project can achieve required flood and hydrologic objectives throughout the construction phase.

The project would provide 1 per cent AEP flood immune thoroughfare and local connections not serviced by current roads. There are substantial economic benefits of increasing the reliability of a major national freight route such as the Pacific Highway. Furthermore, it is considered the project would reduce the social and economic impact of flooding to the local community.

References

ABC. (2009, April 1). *Flooded Coffs Harbour declared disaster zone*. Retrieved from ABC News: https://www.abc.net.au/news/2009-04-01/flooded-coffs-harbour-declared-disaster-zone/1638018

ABC. (2012, January 23). *Flood warning for Orara River*. Retrieved from ABC North Coast NSW: http://www.abc.net.au/local/stories/2012/01/23/3413600.htm

AIDR. (2017). *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia.* Australian Institute for Disaster Resilience.

Ball, J., Babister, M., Nathan, R., Weeks, W., Weinmann, E., Retallick, M., & Testoni, I. (Eds.). (2019). *Australian Rainfall and Runoff: A Guide to Flood Estimation.* Commonwealth of Australia.

Bewsher Consulting. (2005). *Coffs Creek Floodplain Risk Management Plan.* Coffs Harbour City Council.

BMT WBM. (2018). *Coffs Creek and Park Beach Flood Study - Draft Report for Public Exhibition.* Coffs Harbour City Council.

BoM. (2003). *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method.* Commonwealth Bureau of Meteorology.

CHCC. (2016). *Boambee Newports Creek Floodplain Risk Management Plan.* Coffs Harbour: GHD.

CHCC. (2016). *Boambee Newports Creek Floodplain Study and Plan.* Coffs Harbour City Council. Retrieved from https://www.coffsharbour.nsw.gov.au/environment/flooding/Pages/Boambee-Newports-Creek-Floodplain-Study-and-Plan.aspx

CHCC. (2017). *Floodplain Development and Management Policy.* Coffs Harbour City Council.

CHCC. (2018). *Coastal Inundation Hazard Zones FAQs*. Retrieved April 2018, from https://www.coffsharbour.nsw.gov.au/environment/our-coast/Pages/frequently_asked_questions.aspx

CHCC. (2018, January 29). *Flood Mitigation in the Coffs Harbour LGA.* Retrieved from Coffs Harbour City Council: http://www.coffsharbour.nsw.gov.au/environment/flooding/Pages/flooding_in_the_coffs_harbour_LGA.aspx

COAG. (2011). *National Strategy for Disaster Resilence.* Council of Australian Governments.

CSIRO. (2015). *Climate Change in Australia - Projections for Australia's NRM Regions*. Retrieved from Climate Change in Australia: https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/clusters/?current=ECC&popup=true&tooltip=true

CSIRO. (2015, October 22). *How is climate likely to change in the future?* Retrieved from CSIRO: https://www.csiro.au/en/Research/OandA/Areas/Assessing-our-climate/Climate-change-QA/Future-climate

de Groot & Benson. (2014). *North Boambee Valley (west) - Flood Study.*

DECC. (2007). *Practical Consideration of Climate Change - Flood Risk Management Guideline.* NSW Department of Environment and Climate Change.

DECC. (2007). *Practical Consideration of Climate Change - Flood Risk Management Guidline.* NSW Government Department of Environment and Climate Change.

DIPNR. (2005). *Floodplain Development Manual: The Management of Flood Liable Land.* NSW Department of Infrastructure, Planning and Natural Resources.

DPC. (2011). *NSW 2021: A Plan to Make NSW Number One.* NSW Department of Premier and Cabinet.

DPE. (2017). *North Coast Regional Plan 2036.* NSW Department of Planning and Environment.

FloodSafe. (2012). *Coffs Harbour City Local Flood Plan.* NSW State Emergency Services.

GeoLINK. (2015). *Coffs Creek Estuary - Coastal Zone Management Plan.* Coffs Harbour: NSW Office of Environment and Heritage.

GHD. (2016). *Boambee Newports Creek Floodplain Risk Management Study.*

GHD. (2016). *Boambee Newports Flood Risk Management Study.* Coffs Harbour: Coffs Harbour City Council.

Maddocks, J., & Rowe, J. (2004). Managing the Flood Risk in Coffs Harbour in the Aftermath of the 1996 Flood. *44th Floodplain Management Authorities Conference.* Coffs Harbour.

NSW Government. (2013). *Coffs Harbour Local Environmental Plan 2013.*

OEH. (2015). *Flood Risk Management Guide.* NSW Office of Environment and Heritage.

Pilgrim, D. H. (Ed.). (1987). *Australian Rainfall & Runoff - A Guide to Flood Estimation.* Institution of Engineers, Australia.

Roads and Maritime. (2015). *Upgrading the Pacific Highway - Design Guidelines.* NSW Roads and Maritime Services.

SES. (2017). *Coffs Harbour Local Flood Plan.* NSW State Emergency Service.

Speer, M. S., Phillips, J., & Hanstrum, B. N. (2011). Meteorological aspects of the 31 March 2009 Coffs Harbour flash flood. *Australian Meteorological and Oceanographic Journal*, 201-210.

Webb, McKeown & Associates. (2001). *Coffs Creek Flood Study.*

WMAwater. (2011). *Boambee Creek and Newports Creek Flood Study.*

Appendix A

Hydrologic and hydraulic model parameters

A1 Hydrologic model parameters

Table 29: North Boambee Valley WBNM

Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Sub-catchment	Area (ha)	Impervious (%)	Orographic factor
A10	144.4	0	1.7	H2	17.4	0	1.15
A1a	26.7	15	1	I1	5.5	0	1.02
A2a	12.59	0	1	J1	4.8	0	1
A2b	6.939	0	1	J2	14.2	0	1.08
A3	11.3	2	1	J3	32.9	0	1.375
A4	11.2	0	1	K1	14.4	10	1
A5	15.4	1	1	K2	18.1	2	1.02
A6	26.3	1	1.03	K3	15.7	0	1.14
A7	47.5	0	1.2	K4	19.4	0	1.19
A8	55.6	0	1.2	K5	8.1	0	1.2
A9	107.7	0	1.3	L1	8.3	0	1.075
B1	18.6	60	1	M1	8	2	1.075
C10	30.2	0	1.525	N1	11	1	1.02
C1a	7.951	15	1	N2	11.3	1	1.08
C2a	11.9	15	1	N3	24.6	1	1.2
C3a	6.229	0	1	N4	72.1	0	1.55
C4	9.8	0	1	O1	9.1	2	1.08
C5	4	0	1	O2	36.3	0	1.25
C6	6.3	0	1.02	P1	8	0	1.08
C7	21.7	0	1.09	Q1	8.2	5	1.11
C8	39	0	1.3	R9	15.71	30	1.2
C9	18.7	0	1.15	R8	9.771	20	1.2
D1a	21.28	0	1	R6	23	0	1.2
D2	32.6	0	1	R7	12.18	0	1
D3	6.6	0	1.02	R1	39.16	0	1.2
D4	15.2	0	1.05	R2	35.12	0	1.2
D5	17.5	0	1.15	R3	42.38	15	1.2
E1a	6.585	5	1	R4	55.39	70	1
E2	11.2	5	1	R5	37.71	0	1
E3	10.4	2	1.05	S1	12.13	0	1
F1a	4.621	0	1	S2	23.89	0	1
F2a	6.391	0	1	S3	34.54	10	1
F3a	3.839	0	1.05	S4	54.2	35	1
F3b	6.027	0	1.05	S5	32.52	40	1
G1a	13.43	0	1	T1	34.78	60	1

Table 30: Coffs Creek XP-Rafts – existing scenario

Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)	Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)
C1	20.9	0	1.2	25.5	C49	23.1	55.8	1	0.3
C2	34.6	0	1.2	20.3	C50	83.5	0	1.2	7.6
C3	33.5	0	1.2	13.5	C51	39.4	0	1.2	1.6
C4	34.3	0	1.2	13.2	C52	24	36	1.2	1.1
C5	37.7	0.1	1.2	12.9	C53	37.9	44.1	1	0.8
C6	57.3	0	1.2	7.1	C54	17.8	0	1.2	4.7
C7a	9	0	1.2	9.7	C55	45.2	48.4	1.2	0.7
C7b	28.4	0.3	1.2	2.3	C57	23.4	32.8	1.2	0.7
C8	19.2	0.5	1.6	18.4	C58	29.4	0	1.2	15.3
C9	7.1	1.1	1.6	9	C59	31.2	74.7	1	1.1
C10	24.9	0	1.2	3.5	C60	67.4	0	1.2	13
C11	9.2	0.8	1.6	13.5	C61	19.2	0	1.2	1.3
C12	16.1	13.4	1.2	6	C62	5.7	33.9	1	1.2
C13	18	0	1.2	8.8	C63	15.1	55.8	1	4.6

Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)	Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)
C14	6	24.7	1	21.7	C64	10	54.4	1	3.9
C15	32.9	0	1.2	7.9	C65	15.7	0	1.2	11.9
C16	17.6	0.1	1.2	9.2	C66	25.6	37.8	1	0.3
C17	27	0	1.2	7.2	C67	46.1	0	1	9.6
C18	41.5	0	1.2	6.3	C68	17.2	2.1	1	16.7
C19	29.4	3.3	1.2	5.6	C69	14	56.5	1	0.3
C20	23.4	53.8	1.6	2.1	C70	18.7	0	1	18.3
C21	13	35.1	1.6	2.2	C71	12.5	10.6	2	17.6
C22	5.9	46.8	1	1.7	C72	4.3	54.4	1	0.7
C23	11.3	27.8	1	6	C73	41.4	51.8	1	0.6
C24	29.9	49.7	1.2	2	C74	59	52.9	1	0.5
C25	19.8	29.4	1.6	2.6	C75	54.2	53.8	1	0.1
C26	13	54.4	1.6	2.8	C76	42.8	34.8	1	2.5
C27	19.7	28.1	1	1.2	C77	30.1	51.5	1.2	1
C28	44	0	1.2	6.6	C78	4.5	15.6	1.2	24.3
C29	11.9	0.3	1.6	2.5	C79	36.7	29.4	1	1
C30	7.6	36.7	1	0.3	C80	4.9	74.5	1	0.6
C31	37.7	0	1.2	7.7	C81	20.3	2.5	1	0.4
C32	30.9	38.7	1	0.9	C82	19.8	51	1	0.6
C33	31	56.4	1	1.5	C83	26.1	11.8	1	4.7
C34	26.5	0	1.6	2.9	C84	9.7	90.4	1	0.2
C35	9.9	82.2	1	2.3	C85	44.4	44.6	1.2	4.8
C36	23.4	28.9	1.6	2.3	C87	26.9	85.5	1	1
C37	38.3	57.4	1.6	1.6	C88	25	31.8	1	1.1
C38	30.6	73	1	1.6	C89	24.5	43	1	0.7
C39	49.6	54.6	1	0.5	C90	18.4	50.1	1	1.4
C40a	5.1	4.3	1.6	3.6	C91	22	58.9	1	1.2
C40b	11.7	0	1.6	0.7	C92	16.9	14.1	1	0.6
C40c	2.2	0	1.6	9.3	C93	11	63.7	1	2.2
C41	25.4	52.2	1.6	1.7	C94	13.4	63.3	1	2.2
C42	38.4	45.7	1.6	2.3	C95	10.6	15.7	1	0.5
C43	18.6	5.2	1.6	0.9	C96	16.7	50.1	1	3.6
C44	15.7	26.2	1	0.2	C97	24	10.5	1	1.9
C45	30.4	47.8	1	0.4	C98	26	65.1	1	3.9
C46	41.8	44.5	1	1.3	C99	9	64.7	1.2	2.2
C47	29.3	20.2	1.2	0.7	C100	20.6	61.8	1	0.9

Table 31: Coffs Creek XP-Rafts – developed modifications

Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)	Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)
C4	33.5	0	1.2	13.2	CC6	2.1	100	1.2	2.2
C5	36.8	0	1.2	12.9	CC7	0.7	100	1.2	3.8
C12	15.2	14	1.2	6	CC8	0.4	100	1.2	3.2
C13	16.4	0	1.2	8.8	CC9	0	100	1.2	1.2
C17	25.9	0	1.2	7.2	CC10	0.1	100	1.2	0.1
C18	40.9	0	1.2	6.3	CC12	0.3	100	1.2	3.9
C29	11.2	0	1.6	2.5	CC13	0	100	1.2	0.6
C34	25.5	0	1.6	2.9	CC15	0.3	100	1.2	6.8
C40a	3.8	6	1.6	3.6	CC16	0.8	100	1.6	5.4
C40b	11	0	1.6	0.7	CC17	1.9	100	1.2	2.8
C40c	1.6	0	1.6	9.3	CC18	3.8	100	1.2	0.1
C51	39.1	0	1.2	1.6	CC19	1.4	100	1.2	1.9
C54	16.9	0	1.2	4.7	CC20	0.5	100	1.2	2.3
C61	16.5	0	1.2	1.3	CC21	0.2	100	1.2	4.3
C67	44.9	0	1	9.6	CC22	0.1	100	1.2	13
CC1	4.9	100	1.4	3.3	CC23	0.1	100	1.2	1.9
CC2	3.6	100	1.4	3.3	CC24	0.1	100	1.2	0.5
CC3	0.5	100	1.2	1.1	CC25	0.4	100	1.2	0.5
CC4	0.2	100	1.2	1.6	CC26	0.4	100	1.2	5.7
CC5	1.5	100	1.2	1.5	CC27	0.2	100	1.2	2.6

Table 32: Northern creeks XP-Rafts – existing scenario

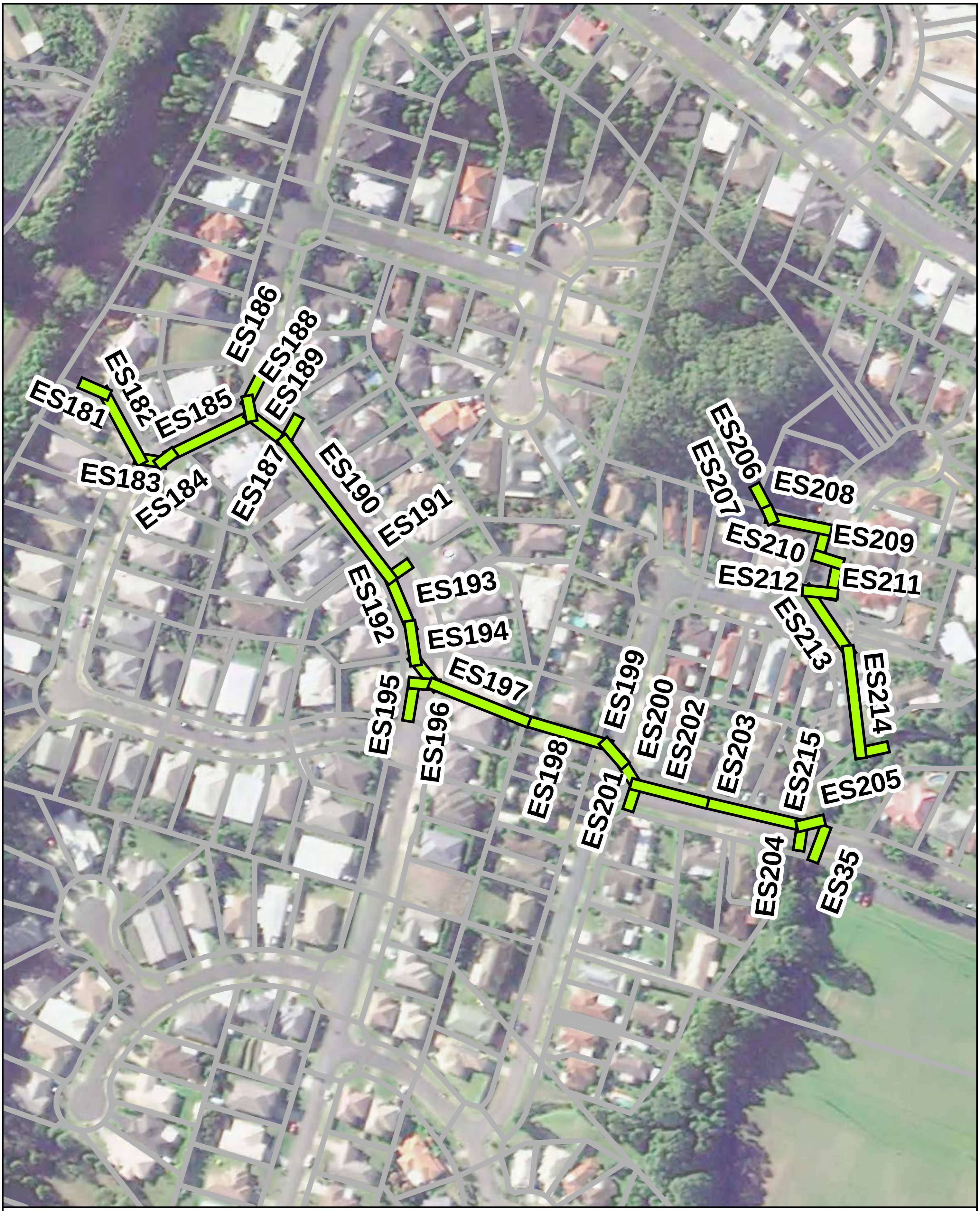
Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)	Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)
A01.01	6.7	0	1.2	35.6	C02.01	24.4	0	1.2	11.5
A01.02	6.5	0	1.2	26.8	C03.01	17.9	0	1.2	18.2
A01.03	6.1	0	1.2	13.8	C04.01	10.9	0	1.2	20.9
A01.04	18	2	1.2	11.7	C05.01	38.5	0	1.2	11.6
A01.05	26.8	0	1.6	10	C06.01	38	0	1.2	21.9
A01.06	18.3	0	1	10.6	C06.02	8.6	0	1.6	8.4
A01.07	11.9	0.2	1	3.6	C06.03	5.9	0	1.6	8.1
A01.08	7.2	20	1	4	C06.04	10.7	0	1	9
A01.09	8.5	27.5	1	2.7	C06.05	5.7	0	1.3	6.9
A01.10	13.6	67.2	1	5.6	C06.06	8.4	0	1	6.4
A02.01	18.5	0	1.2	29.4	C07.01	28.6	0	1.6	13.1
A02.02	2.3	0	1.2	9.4	C08.01	12.4	0	1.2	32.6
A03.01	14	0	1.2	26.9	C08.02	17.9	0	1.6	12.5
A04.01	7.1	0	1.2	9.7	C09.01	9.1	0	1.6	26.1
A06.01	12.5	0	1.2	11.3	C09.02	10.9	0	1	12.1
A07.01	12.7	0	1.2	15.7	C09.03	4.6	0	1	8.5
A08.01	11	8	1.2	13.9	C10.01	26.4	0	1.2	30.1
A09.01	17.3	30	1.2	10.9	C10.02	21	0	1.6	35.4
A09.02	4.3	30	1	4	C10.03	18.5	0	1.4	13.1
A10.01	5.3	30	1	12.5	C10.04	15.7	0	1	4.6
B01.01	9.5	0	1.6	38	C10.05	4	10	1	13.1
B01.02	7.4	5	1.6	19.3	C11.01	13.8	0	1.6	18.2
B01.03	4.6	5	1	6.9	C11.02	8.9	0	1	6.4
B01.04	0.8	5	1	3	C11.03	9.4	0	1	3.7
B01.05	2.4	20	1	11	C12.01	43.4	0	1.2	23.8
B01.06	0.4	0	1	3.8	C12.02	12.9	5	1.6	11
B01.07	1.3	0	1	3.8	C12.03	17	0	1	7.3
B01.08	4.2	0	1	3.1	C12.04	18.4	5	1.2	3.5
B01.09	7.3	100	1	3.7	C12.05	4.7	5	1	1
B02.01	4.5	5	1	7.7	C13.01	5.8	0	1.2	36.9
B03.01	6.3	0	1.6	34.8	C13.02	7.7	5	1.6	11.5
B03.02	2.2	5	1	10.2	C14.01	26.8	0	1.2	19.5
B03.03	0.6	0	1	8.7	C14.02	25	10	1	6.6
B03.04	2.4	0	1	10.2	C14.03	6	5	1.1	3.6
B04.01	3	5	1.6	8.8	C15.01	4.7	5.9	1	6.3
B04.02	4.2	0	1	8.8	C16.01	8.2	5	1	12
B05.01	3.1	5	1.6	30.3	C16.02	6	0	1	4.5
B05.02	1.9	0	1	10	C16.03	5.8	15	1	1.3
B06.01	1.6	20	1	1.6	C16.04	0.4	30	1	2.2
B06.02	1	70	1	4.3	C17.01	3.8	0	1	16.1
B06.03	0.9	40	1	7.9	C17.02	3.6	5	1	7.5
B07.01	9.7	20	1	7.4	C17.03	2.1	20	1	2.8
B08.01	2.6	0	1	13.8	C18.01	2.5	0	1	17.3
B09.01	4.3	0	1	9.3	C18.02	2.8	30	1	11.1
B09.02	9.4	10	1	3.1	C18.03	2.4	30	1	7
C01.01	45.7	0	1.2	12.4	C19.01	2.1	70	1	4
C01.02	29.8	1	1.6	6.7	D01.01	19.9	35.5	1	5.2
C01.03	21.3	2	1	7.3	D01.02	18.8	63.8	1	4.7
C01.04	8.4	0	1.2	3.7	D01.03	16.4	68	1	3
C01.05	7.1	0	1	7.3	E01.01	15.3	0	1.2	13.9
C01.06	9.9	0	1	7.6	E01.02	11.6	0	1.2	9.1
C01.07	0.8	20	1	9.4	E01.03	13.7	0	1	3.2
C01.08	9	30	1	1.7	E01.04	9.5	31.5	1	4.9
C01.09	9.7	34	1	2.9	E04.01	2	5	1	1

Table 33: Northern creeks XP-Rafts – developed modifications

Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)	Sub-catchment	Area (ha)	Impervious (%)	Orographic factor	Vectored slope (%)
A01.04	16.3	2	1.2	11.7	B06.03	0.7	40	1	7.9
A01.05	25.9	0	1.5984	10	B07.01	9.6	20	1	7.4
A01.06	16.6	0	1	10.6	B09.01	3.5	0	1	9.3
A04.01	6.4	0	1.2	9.7	B09.02	8.4	10	1	3.1
B01.02	7.1	5	1.6	19.3	C11.02	8.7	0	1	6.4
B01.03	2.4	5	1	6.9	D01.01	19.5	36.4	1	5.2
B01.04	0.6	5	1	3	A01.05_IP	0.6	100	1.6	2
B01.05	2	20	1	11	A01.06_IP	3.2	100	1	2
B03.02	1.9	5	1	10.2	A04.01_IP	1.7	100	1.2	2
B03.03	0.2	0	1	8.7	B01.03_IP	0.9	100	1	2
B03.04	1.2	0	1	10.2	B01.04_IP	1.8	100	1	2
B04.01	3	5	1.6	8.8	B01.05_IP	1.8	100	1	2
B04.02	2.9	0	1	8.8	B02.01_IP	2	100	1	2
B05.02	1.5	0	1	10	B03.04_IP	1.3	100	1	2
B06.01	1.2	20	1	1.6	B06.03_IP	1.3	100	1	2
B06.02	0.6	70	1	4.3	B09.02_IP	1.6	100	1	2

A2 Hydraulic structure parameters

Refer to Figures within **Appendix B** and **Appendix D** for existing and developed structure IDs respectively. **Figure A2-1** to **A2-4** below presents a reduced scale insert of heavily populated areas within figures within **Appendix B** to **Appendix D.**



Legend

Cadastre

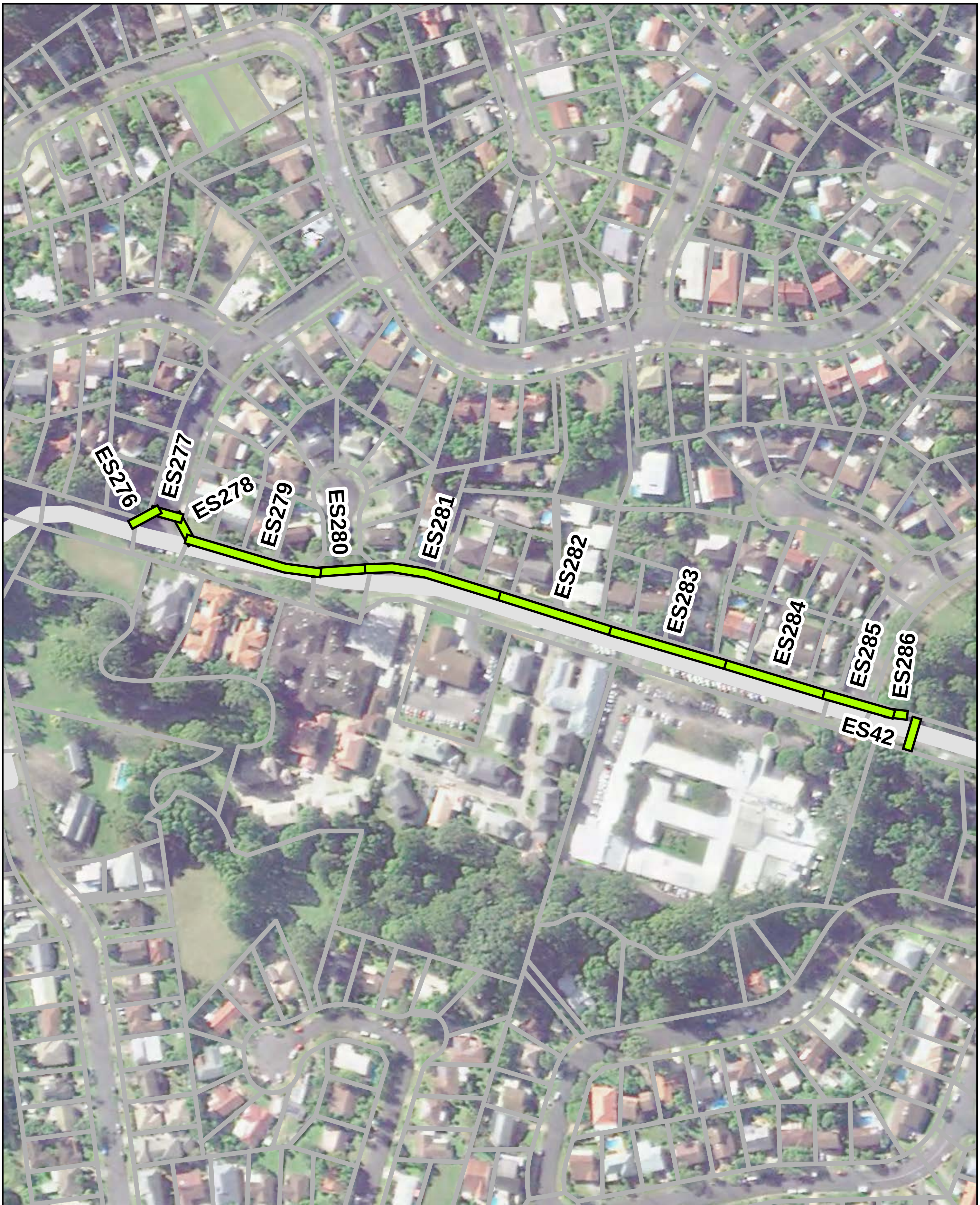
Modelled structures

Coffs Harbour Bypass
Modelled structures
A2-2

0 0.02 0.04 0.06 km

N

Scale @A4: 1:2,200
GDA 1994 MGA Zone 56



Legend

Cadastre

Modelled structures

Coffs Harbour Bypass
Modelled structures
A2-3

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N

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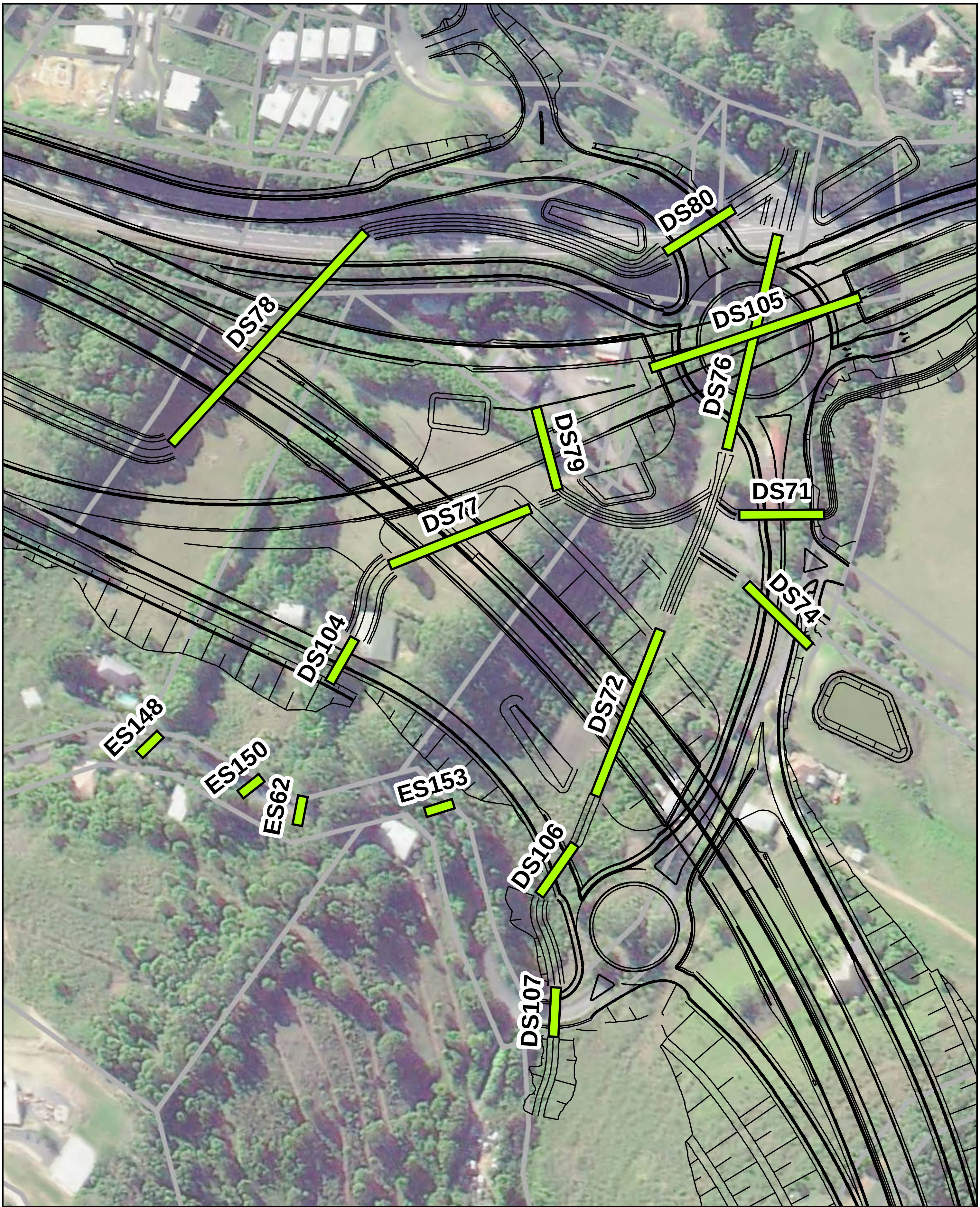
GDA 1994 MGA Zone 56



Legend

Cadastre

Modelled structures

Alignment

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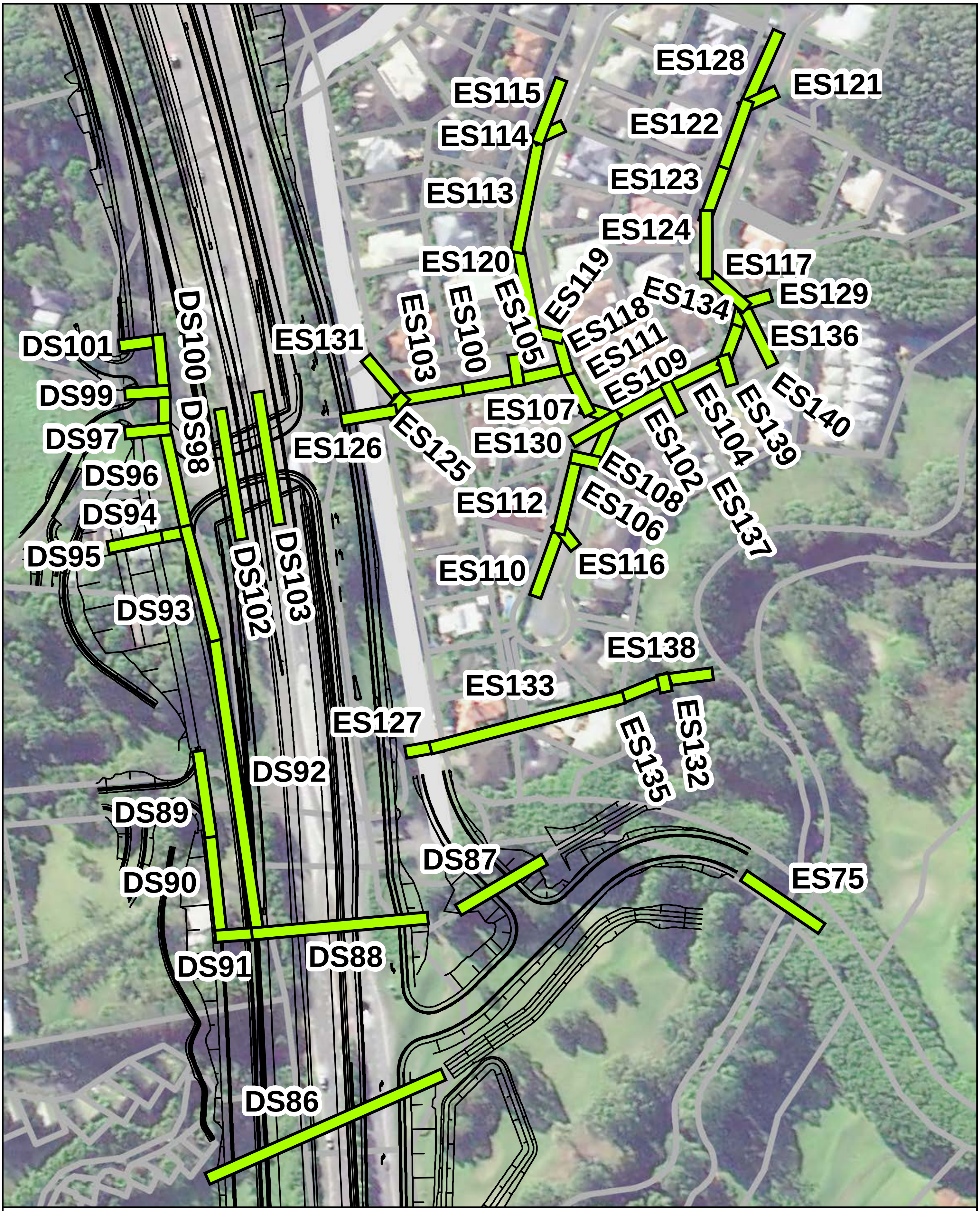
Scale @A4: 1:2,500

GDA 1994 MGA Zone 56

N

Coffs Harbour Bypass
Modelled structures
A2-4



Legend

Cadastre

Modelled structures

Alignment

Coffs Harbour Bypass
Modelled structures
A2-5

Scale @A4: 1:2,000
GDA 1994 MGA Zone 56

Table 34: Hydraulic structures – existing

ID	Arrangement	Length (m)	US/DS Invert level (mAHD)	Additional comments
ES01	1/1.5 m RCP	56	3.09 / 2.02	Developed extension (DS02)
ES04	4/1.05 m RCP	32	2.79 / 2.69	Developed extension (DS07)
ES05	4/4.2 x 0.9 m RCBC	31	2.94 / 2.66	Developed extension (DS08)
ES06	4/2.4 x 0.75 m RCBC	21	3.81 / 3.66	
ES07	3/1.5 m RCP	9	4.9 / 4.7	
ES08	1/1.8 m RCP	8	14.44 / 14.4	
ES09	1/1 x 0.5 m RCBC	4	12.2 / 12.2	
ES10	1/0.9 m RCP	10	24.5 / 23.25	
ES11	1/0.6 m RCP	9	24.17 / 24.05	
ES12	2/1.8 m RCP	9	28.38 / 26.26	
ES13	2/3.6 x 1.5 m RCBC	10	23.4 / 23.35	
ES17	1/15 m bridge spans	17	8.8	NB Road Bridge, loss coefficient 0.00
ES18	2/0.875 m RCP	5	9.5 / 9.5	
ES19	2/ 3.3 x 3.6 m RCBC	10.9	12.42 /12.4	Complete detailed survey
ES20	2/1.8 m RCP	4	18.65 / 18.2	Complete Detailed Survey, Developed removal
ES21	1/2.7 x 1.8 m RCBC	3	18.65 / 18.2	Complete Detailed Survey, Developed removal
ES23	1/3.3 x 1.2 m RCBC	55	21.46 / 20.92	Complete Detailed Survey, Developed extension
ES24	3/3 x 0.9 m RCBC	14	12.7 / 12.7	Modified to suit terrain from BMT WBM model
ES25	1/3 x 0.9 m RCBC	5	11.2 / 11.2	Inherited from BMT WBM model
ES26	1/3 x 2.4 m RCBC	35	11.2 / 11.2	Inherited from BMT WBM model
ES27	6/0.825 m RCP	13	17.25 / 17.05	ILs inferred from regional lidar, No. of cells assumed from aerial imagery
ES28	6/0.9 m RCP	17	16.7 / 16.5	ILs inferred from regional lidar, No. of cells assumed from aerial imagery
ES29	6/1.05 m RCP	9	13.5 / 13.49	Inherited from BMT WBM model
ES30	2/1.05 m RCP	77	18 / 16.4	Inherited from BMT WBM model
ES31	4/0.9 m RCP	22	20.21 / 20.2	ILs inferred from regional lidar data, slightly diff to inherited data from BMT WBM model
ES32	1/1.5 m RCP	15	18.17 / 18.14	Inherited from model
ES33	1/0.75 m RCP	15	22.9 / 22.64	ILs inherited from model
ES34	1/0.75 m RCP	24	26.69 / 26.04	Assumed info
ES35	3/2.15 x 2.15 m RCBC	12	20.72 / 20.57	Inherited in BMT WBM model
ES36	1/2.7 x 0.9 m RCBC	66	34.77 / 34.21	Incomplete Detailed Survey - ILs taken from headwalls
ES38	1/0.91 x 0.91 m RCBC	19	65.73 / 64.1	ARTC provided info to TfNSW
ES39	1/1.52 x 1.52 m RCBC	43	53.26 / 51.51	ARTC provided info to TfNSW
ES40	1/1.5 m RCP	41	51.79 / 48.56	ARTC provided info to TfNSW
ES41	1/1.5 m RCP	11	40.4 / 40.28	Inherited in BMT WBM model
ES42	2/3.3 x 2.4 m RCBC	14	28.36 / 28.31	Complete Detailed Survey
ES43	1/0.375 m RCP	10	41.63 / 41.46	Complete Detailed Survey, Developed removal
ES44	1/1.35 m RCP	7	40.26 / 40.25	Complete Detailed Survey
ES45	1/1.8 m RCP	11	35.36 / 35.17	No IL info
ES46	1/0.45 m RCP	7	31.1 / 30.93	No IL info, alignment shifted slighted to suit topography
ES47	1/0.9 m RCP	8	27.4 / 27.25	No IL info
ES48	1/0.75 m RCP	7	28.5 / 28.37	No IL info
ES49	1/0.9 m RCP	6	22.57 / 22.33	No IL info
ES50	2/0.525 m RCP	7	12.81 / 12.74	No IL info
ES51	5/1.8 m RCP	26	9.19 / 8.96	Complete Detailed Survey

ID	Arrangement	Length (m)	US/DS Invert level (mAHD)	Additional comments
ES57	1/0.45 m RCP	37	19.36 / 16.66	Complete Detailed Survey
ES58	1/4.8 x 3 m RCBC	28	18.26 / 16.9	Incomplete DS - only headwall info provided, all else interpreted, Developed extension
ES59	1/0.225 m RCP	13	28.61 / 28.61	Complete Detailed Survey, Developed removal
ES60	1/1.05 m RCP	17	39.69 / 38.75	Complete Detailed Survey, Developed removal
ES61	1/2.7 x 2.1 m RCBC	59	18.49 / 16.46	Incomplete DS survey, ILs of headwalls only
ES62	1/0.45 m RCP	10	54.57 / 53.59	Complete Detailed Survey
ES63	1/0.9 m RCP	19	69.07 / 64.13	Complete Detailed Survey
ES67	1/2.5 x 2.86 m RCBC	0	44.27 / 44.18	No info, aerial indicates not drainage culvert. Dry in model., Developed removal, 15% blockage
ES69	1/18 m bridge spans	20	10.8	Old Coast Road, loss coefficient 0.00
ES70	2/20 m bridge spans	40	12.88	BR20, loss coefficient 0.08
ES71	2/20 m bridge spans	40	13.45	BR21, loss coefficient 0.08
ES72	1/15 m bridge spans	15	10.97	Upper Old Coast Road, loss coefficient 0.00
ES74	1/30 m bridge spans	30	9.2	James Small Dr, loss coefficient 0.00
ES75	1/30 m bridge spans	30	6.73	Opal Blvd
ES76	3/0.75 m RCP	44	9.91 / 9.16	Complete detailed survey, Developed removal
ES79	3/0.75 m RCP	37	13.72 / 13.18	Complete detailed survey, Developed removal
ES82	1/1.2 x 1.2 m RCBC	62	14.56 / 12.18	Partial detailed survey (DS IL only), remaining info requested, Developed removal, 15% blockage
ES83	3/1.8 x 1.5 m RCBC	185	10.4 / 6.58	Cadence partial survey – confirmation requested – headwalls don't align well, old TfNSW survey requested
ES84	3/1.8 x 1.8 m RCBC	27	11.8 / 11	Detailed survey requested, info assumed based on DS culvert
ES99	1/25 m bridge spans	25	3.15	Complete Detailed Survey, loss coefficient 0.00
ES100	1/1.5 m RCP	25	7.59 / 7.09	ILs assumed from Cadence pit survey; CHCC has size of 0.9m
ES102	1/1.5 m RCP	25	5.44 / 5.09	CHCC Depth to invert info not used as no reliable topographic survey in this area
ES103	1/1.5 m RCP	23	10.06 / 9.6	ILs assumed from Cadence pit survey
ES104	1/1.5 m RCP	26	5.07 / 4.71	CHCC Depth to invert info not used as no reliable topographic survey in this area
ES105	1/1.5 m RCP	22	6.23 / 5.94	ILs assumed from Cadence pit survey; CHCC has this culvert as 1050mm dia
ES106	1/0.45 m RCP	7	7.43 / 6.48	CHCC Depth to invert info not used as no reliable topo survey in this area
ES107	1/0.375 m RCP	8	8.27 / 8.11	ILs assumed from Cadence pit survey;
ES108	1/0.525 m RCP	20	6.48 / 6.46	CHCC Depth to invert info not used as no reliable topo survey in this area
ES109	1/1.5 m RCP	12	5.63 / 5.46	CHCC Depth to invert info not used as no reliable topo survey in this area
ES110	1/0.375 m RCP	28	7.74 / 7.61	CHCC Depth to invert info not used as no reliable topo survey in this area
ES111	1/1.5 m RCP	19	5.92 / 5.65	CHCC Depth to invert info not used as no reliable topo survey in this area; CHCC dia = 1.35 not used
ES112	1/0.375 m RCP	29	7.61 / 7.43	CHCC Depth to invert info not used as no reliable topo survey in this area
ES113	1/0.375 m RCP	46	13.97 / 10.83	CHCC Depth to invert info not used as no reliable topo survey in this area
ES114	1/0.375 m RCP	8	12.46 / 13.97	CHCC Depth to invert info not used as no reliable topo survey in this area
ES115	1/0.375 m RCP	23	15.77 / 13.97	CHCC Depth to invert info not used as no reliable topo survey in this area

ID	Arrangement	Length (m)	US/DS Invert level (mAHD)	Additional comments
ES116	1/0.375 m RCP	8	7.7 / 7.61	CHCC Depth to invert info not used as no reliable topo survey in this area
ES117	1/0.375 m RCP	20	6.5 / 4.8	CHCC Depth to invert info not used as no reliable topo survey in this area
ES118	1/0.6 m RCP	14	7.65 / 7.1	CHCC Depth to invert info not used as no reliable topo survey in this area
ES119	1/0.6 m RCP	10	7.89 / 7.65	CHCC Depth to invert info not used as no reliable topo survey in this area
ES120	1/0.45 m RCP	35	10.83 / 7.89	CHCC Depth to invert info not used as no reliable topo survey in this area
ES121	1/0.375 m RCP	12	13.01 / 12.48	CHCC Depth to invert info not used as no reliable topo survey in this area
ES122	1/0.375 m RCP	29	12.4 / 9.33	CHCC Depth to invert info not used as no reliable topo survey in this area
ES123	1/0.375 m RCP	19	9.33 / 7.53	CHCC Depth to invert info not used as no reliable topo survey in this area
ES124	1/0.375 m RCP	20	7.43 / 6.5	CHCC Depth to invert info not used as no reliable topo survey in this area
ES125	1/1.5 m RCP	6	10.07 / 10.06	ILs assumed from Cadence pit survey
ES126	1/1.5 m RCP	18	12.08 / 10.07	Partial detailed survey - no size or DSIL info provided, Developed removal
ES127	1/1.2 m RCP	11	8.75 / 8.37	Partial detailed survey (US IL only), remaining info requested
ES128	1/0.375 m RCP	31	17.1 / 12.79	CHCC Depth to invert info not used as no reliable topo survey in this area
ES129	1/1.5 m RCP	10	4.43 / 4.3	CHCC Depth to invert info not used as no reliable topo survey in this area
ES130	1/0.45 m RCP	17	7.26 / 7	CHCC Depth to invert info not used as no reliable topo survey in this area
ES131	1/0.375 m RCP	20	13.36 / 12.8	ILs assumed from Cadence pit survey
ES132	1/1.2 m RCP	21	4.68 / 4.04	Partial detailed survey (DS IL only), remaining info requested
ES133	1/1.2 m RCP	77	8.35 / 5.47	CHCC Depth to invert info not used as no reliable topo survey in this area
ES134	1/1.5 m RCP	12	4.46 / 4.34	CHCC Depth to invert info not used as no reliable topo survey in this area
ES135	1/1.2 m RCP	20	5.45 / 4.7	CHCC Depth to invert info not used as no reliable topo survey in this area
ES136	1/0.375 m RCP	23	7.06 / 3.77	CHCC Depth to invert info not used as no reliable topo survey in this area
ES137	1/0.375 m RCP	9	7.72 / 6.4	CHCC Depth to invert info not used as no reliable topo survey in this area
ES138	1/0.375 m RCP	2	6.32 / 5.96	CHCC Depth to invert info not used as no reliable topo survey in this area
ES139	1/0.375 m RCP	8	7.13 / 4.79	CHCC Depth to invert info not used as no reliable topo survey in this area
ES140	1/1.5 m RCP	13	4.77 / 4.46	CHCC Depth to invert info not used as no reliable topo survey in this area
ES141	2/0.75 m RCP	6	26.74 / 24.58	Contradictory size info, IL's assumed from topo
ES142	3/0.6 m RCP	31	34.3 / 26.74	Contradictory size info, IL's assumed from topo
ES143	2/0.9 m RCP	8	15.35 / 14.98	US IL taken from detailed DEM, DS calculated from DS pipe IL, awaiting confirmation
ES144	1/0.375 m RCP	4	6.99 / 6.97	Complete detailed survey, Developed removal
ES145	1/0.9 m RCP	9	14.98 / 14.56	DS IL taken from pipe downstream, US IL interpolated from pipe upstream, awaiting confirmation, Developed removal
ES146	1/0.6 m RCP	8	9 / 7.35	Partial detailed survey (DS IL only), remaining info requested, Developed removal

ID	Arrangement	Length (m)	US/DS Invert level (mAHD)	Additional comments
ES147	3/0.75 m RCP	25	6.78 / 6.57	Partial detailed survey (DS IL only), remaining info requested, Developed removal
ES148	1/0.375 m RCP	10	60.53 / 61.05	Complete Detailed Survey
ES149	1/0.375 m RCP	8	30.08 / 30.5	Complete Detailed Survey, Developed removal
ES150	1/0.375 m RCP	9	56.93 / 56.32	Complete Detailed Survey
ES151	1/0.45 m RCP	14	24.47 / 24.28	Incomplete DS - no size, Developed removal
ES152	3/0.375 m RCP	4	15.35 / 15.3	Complete Detailed Survey
ES153	1/0.225 m RCP	10	50.89 / 50.6	Complete Detailed Survey
ES156	1/0.45 m RCP	7	25.92 / 25.75	No IL info
ES157	1/0.75 m RCP	5	11.06 / 10.85	Complete Detailed Survey
ES158	2/1.35 m RCP	7	9.22 / 9.3	Complete Detailed Survey (DSIL higher than USIL)
ES159	2/1.2 x 0.75 m RCBC	4	36.63 / 36.18	Incomplete DS - no info, only strings in Cadence, Developed removal
ES160	1/0.45 m RCP	29	12.11 / 12.06	Complete Detailed Survey
ES161	1/0.9 m RCP	9	46.38 / 46.25	Complete Detailed Survey, 90% blockage
ES162	1/0.9 m RCP	7	35.93 / 35.83	Complete Detailed Survey, 30% blockage
ES163	1/1.5 m RCP	20	35.82 / 35.17	Complete Detailed Survey, 10% blockage
ES164	1/0.9 m RCP	22	41.39 / 40.93	Complete Detailed Survey, 15% blockage
ES165	1/1.5 m RCP	19	33.57 / 32.74	Complete Detailed Survey, 15% blockage
ES166	1/2.05 m RCP	10	41.9 / 41.85	Complete Detailed Survey, 10% blockage
ES168	1/2.05 m RCP	9	42.04 / 41.99	Complete Detailed Survey, 10% blockage
ES169	1/0.9 m RCP	12	34.72 / 34.62	Incomplete DS - at boundary of request area, USIL only provided, 10% blockage
ES170	1/0.45 m RCP	5	41.89 / 41.75	Complete Detailed Survey, 50% blockage
ES171	1/0.6 m RCP	9	37.18 / 36.7	Complete Detailed Survey
ES172	3/0.45 m RCP	11	43.8 / 43.2	Assumed- DS not requested
ES173	2/0.45 m RCP	9	46.3 / 46.2	Assumed- DS not requested
ES174	2/0.45 m RCP	8	46.4 / 46.3	Assumed- DS not requested
ES175	1/0.45 m RCP	17	100.79 / 99.99	Incomplete Detailed Survey - not clear DSIL/ DS arrangement
ES176	1/0.45 m RCP	8	88.73 / 88.25	Complete Detailed Survey, Developed removal
ES177	1/0.9 m RCP	8	62.13 / 61.65	Complete Detailed Survey, Developed removal
ES178	1/0.45 m RCP	7	68.14 / 67.7	Complete Detailed Survey, Developed removal
ES179	2/1.2 m RCP	8	71.8 / 70.92	Complete Detailed Survey, Developed removal
ES180	1/1.05 m RCP & 1/0.75 m RCP	7	61.04 / 60.78	Complete Detailed Survey, Developed removal
ES181	1/0.9 m RCP	10	39.2 / 39.1	Size info only
ES182	1/0.9 m RCP	34	39.1 / 38.7	Size info only
ES183	1/0.9 m RCP	10	38.7 / 38.5	Size info only
ES184	1/1.2 m RCP	6	38.5 / 38.4	Size info only
ES185	1/1.2 m RCP	36	38.4 / 36.3	Size info from CHCC data
ES186	1/0.375 m RCP	10	36.5 / 36.4	Size info only
ES187	1/0.375 m RCP	11	35.3 / 35.2	Size info only
ES188	1/0.45 m RCP	7	36.4 / 36.3	Size info only
ES189	1/1.2 m RCP	19	36.3 / 35.2	Size info only
ES190	1/1.2 m RCP	78	35.2 / 31.7	Size info only
ES191	1/0.375 m RCP	9	31.8 / 31.7	Size info only
ES192	1/1.2 m RCP	24	31.7 / 30.3	Size info only
ES193	1/1.2 m RCP	15	30.3 / 29.4	Size given as 1050 but updated to 1200 to match US pipes

ID	Arrangement	Length (m)	US/DS Invert level (mAHD)	Additional comments
ES194	1/1.2 m RCP	14	29.4 / 28.6	Size info only
ES195	1/0.45 m RCP	15	28.8 / 28.7	Size info only
ES196	1/0.6 m RCP	9	28.7 / 28.6	Size info only
ES197	1/1.35 m RCP	44	28.6 / 25.1	Size info only
ES198	1/1.35 m RCP	39	25.1 / 23.9	Size updated to match US culvert (larger)
ES199	2/0.825 m RCP	10	23.9 / 23.5	Barrels updated to match US culverts
ES200	2/0.825 m RCP	12	23.5 / 23.2	Size updated to match US culvert
ES201	1/0.375 m RCP	10	23.3 / 23.2	Size info only
ES202	2/0.9 m RCP	31	23.2 / 22.2	Updated barrel no. to match with US
ES203	2/0.9 m RCP	46	22.2 / 20.8	Size info only
ES204	1/0.375 m RCP	9	20.9 / 20.8	Size info only
ES205	2/0.9 m RCP	8	20.8 / 20.6	Barrels updated to match US network
ES206	1/0.9 m RCP	11	22.3 / 22.1	Size info only
ES207	1/0.9 m RCP	3	22.1 / 22	Size info only
ES208	1/0.9 m RCP	25	22 / 21.7	Size info only
ES209	1/0.9 m RCP	13	21.7 / 21.5	Size info only
ES210	1/0.9 m RCP	9	21.5 / 21.3	Size info only
ES211	1/0.9 m RCP	14	21.3 / 21.1	Size info only
ES212	1/0.9 m RCP	11	21.1 / 20.9	Size info only
ES213	1/1.05 m RCP	33	20.9 / 20.4	Size info only
ES214	1/1.05 m RCP	46	20.4 / 19.7	Size info only
ES215	1/1.05 m RCP	10	19.7 / 19.5	Size info only
ES216	1/1.35 m RCP	13	33.01 / 31.02	Complete Detailed Survey
ES217	1/1.5 m RCP	50	30.67 / 30.04	Complete Detailed Survey
ES218	2/0.75 m RCP	5	22.93 / 22.8	Complete Detailed Survey
ES219	1/1.2 m RCP	6	12.87 / 12.52	Complete Detailed Survey
ES220	2/0.6 m RCP	12	14.64 / 14.53	Complete Detailed Survey
ES221	1/0.6 m RCP	52	14.4 / 13.35	Incomplete DS Survey of inlet only, no alignment and inconclusive outlet survey
ES222	1/1.2 m RCP	20	13.73 / 13.12	Complete Detailed Survey
ES223	1/0.45 m RCP	8	14.97 / 14.74	Complete Detailed Survey
ES224	1/0.45 m RCP	8	15.23 / 14.97	Complete Detailed Survey
ES225	1/1.2 m RCP	14	14.29 / 14.16	Complete Detailed Survey
ES226	1/1.2 m RCP	5	15.83 / 15.82	Complete Detailed Survey
ES227	1/0.45 m RCP	5	26.63 / 26.53	Complete Detailed Survey, Developed removal
ES228	2/0.6 m RCP	5	8.76 / 8.73	Developed removal
ES229	1/1.35 m RCP	12	7.22 / 7.1	
ES230	1/1.35 m RCP	9	7.43 / 7.22	
ES231	1/1.05 m RCP	13	7.57 / 7.43	
ES232	1/0.75 m RCP	8	7.61 / 7.57	
ES233	1/0.75 m RCP	28	9.17 / 7.64	
ES234	1/1.2 m RCP	26	8.52 / 8.22	
ES235	2/0.45 m RCP	21	8.44 / 8.21	50% blockage
ES236	1/1.8 x 0.45 m RCBC	32	8.21 / 7.91	50% blockage
ES237	1/1.8 x 0.45 m RCBC	8	7.88 / 7.82	50% blockage
ES238	1/1.8 x 0.45 m RCBC	21	7.79 / 7.75	50% blockage
ES239	2/0.825 m RCP	48	7.54 / 7.3	50% blockage
ES240	2/0.825 m RCP	30	7.27 / 7	50% blockage
ES241	3/3.6 x 1.2 m RCBC	23	7.21 / 7.21	50% blockage

ID	Arrangement	Length (m)	US/DS Invert level (mAHD)	Additional comments
ES242	3/3.6 x 1.2 m RCBC	18	7.21 / 7.02	50% blockage
ES243	4/3.6 x 1.8 m RCBC	23	7.02 / 7.02	50% blockage
ES244	1/0.6 m RCP	155	7.13 / 6.58	50% blockage
ES245	3/3.6 x 0.9 m RCBC	7	5.96 / 5.96	50% blockage
ES246	1/0.3 m RCP	5	8.33 / 8.31	Developed removal
ES247	3/3.6 x 1.2 m RCBC	11	5.27 / 5.26	50% blockage
ES248	1/1.05 m RCP	10	3.71 / 3.65	
ES249	2/1.05 m RCP	10	3.71 / 3.65	
ES250	2/1 m RCP	10	3.71 / 3.65	
ES251	3/1.5 x 1.2 m RCBC	20	3.34 / 3.25	
ES252	3/1.05 m RCP	50	4.75 / 3.71	
ES253	3/1.05 m RCP	102	3.71 / 3.25	
ES254	3/1.05 m RCP	97	3.25 / 2.78	
ES255	1/1.05 m RCP	12	2.78 / 2.73	
ES256	2/0.9 m RCP	29	3.2 / 3	
ES257	7/2.1 x 1.2 m RCBC	15	4.17 / 4.04	
ES258	1/1.05 m RCP	8	3.45 / 3.41	Developed removal
ES259	1/0.6 m RCP	15	5 / 4.97	Developed removal
ES260	1/0.6 m RCP	73	4.96 / 4.78	Developed removal
ES261	1/0.9 m RCP	16	4.73 / 4.26	Developed removal
ES262	1/0.9 m RCP	11	4.7 / 4.63	Developed removal
ES263	1/0.9 m RCP	48	4.53 / 3.35	Developed removal
ES264	2/0.75 m RCP	9	0.97 / 0.94	
ES265	1/3 x 3 m RCBC	36	17.37 / 17.02	Developed removal
ES266	1/0.45 m RCP	5	3.74 / 3.68	Developed removal
ES267	1/1.5 m RCP	10	36.55 / 36.5	
ES268	1/1.2 m RCP	14	38.45 / 38.35	
ES269	1/0.9 m RCP	53	2.55 / 2.49	
ES270	2/12 m spans	25	5.96	Newports Creek Bridge, loss coefficient 0.3
ES271	1/0.225 m RCP	7	55.69 / 55.3	Complete Detailed Survey
ES272	1/0.75 m RCP	7	52.22 / 52.05	Complete Detailed Survey
ES273	1/0.45 m RCP	10	52.76 / 52.38	Complete Detailed Survey
ES274	3/0.9 m RCP	7	47.21 / 47.14	Complete Detailed Survey
ES275	1/0.45 m RCP	17	47.3 / 46.87	Complete Detailed Survey
ES276	1/0.375 m RCP	14		
ES277	1/0.45 m RCP	13		
ES278	1/0.45 m RCP	14		
ES279	1/0.6 m RCP	73		
ES280	1/0.6 m RCP	30		
ES281	1/0.6 m RCP	72		
ES282	1/0.6 m RCP	70		
ES283	1/0.6 m RCP	62		
ES284	1/0.6 m RCP	62		
ES285	1/0.675 m RCP	36		
ES286	1/0.675 m RCP	7		

Table 35: Hydraulic structures – developed

ID	Arrangement	Length (m)	US/DS Invert level (mAHD)	Additional comments
DS01	6/1.8 x 0.6 m RCBC	9	1.4 / 1.35	
DS02	2/1.5 m RCP	70	3.25 / 2.02	
DS03	2/0.6 x 0.6 m RCBC	12	4.0 / 3.94	
DS04	1/0.9 m RCP	117	7.2 / 5.24	25% blockage
DS05	1/1.2 m RCP	58	4.9 / 4.5	
DS06	1/41.5 m bridge span	41.5	17.19	BR02, loss coefficient 0.00
DS07	8/1.05 m RCP	37	2.8 / 2.68	
DS08	4/4.2 x 0.9 m RCBC	35	2.96 / 2.64	
DS09	5/2.7 x 1.5 m RCBC, 1/3 x 3.3 RCBC	83	4.67 / 4.26 5.25 / 4.86	
DS10	3/27 m bridge spans	81	11.08	BR03NB&SB, loss coefficient 0.11
DS11	3/3 x 2.4 m RCBC	57	8.56 / 8.35	
DS12	3/30 m bridge spans	90	12.98	BR23, loss coefficient 0.22
DS13	1/37m bridge span	37	13.65	BR04, loss coefficient 0.07
DS14	6/2.4 x 2.4 m RCBC	45	7.19 / 7.14	
DS15	Not used			
DS16	1/0.9 m RCP	75	20.64 / 16.06	25% blockage
DS17	1/0.9 m RCP	21	29.04 / 20.66	25% blockage
DS18	1/0.9 m RCP	79	23.68 / 23.28	25% blockage
DS19	1/0.9 m RCP	14	29.05 / 24.27	25% blockage
DS20	3/1.5 m RCP	90	28.92 / 26.8	
DS21	1/3 x 3 m RCBC	61	34.17 / 33.84	25% blockage
DS27	1/1.05 m RCP	94	33.2 / 29.81	15% blockage
DS28	3/1.2 x 0.6 m RCBC	21	29.58 / 28.94	15% blockage
DS29	1/1.2 x 0.6 m RCBC	9	30 / 29.93	
DS30	2/1.2 x 0.6 m RCBC	7	25.5 / 25.44	
DS31	2/1.2 x 0.6 m RCBC	7	26.52 / 26.48	
DS32	3/(16, 32, 16) m bridge spans	64	26.86	BR07, loss coefficient 0.1
DS33	4/16 m bridge spans	64	23	BR06NB, loss coefficient 0.2
DS34	4/16 m bridge spans	64	23	BR06SB, loss coefficient 0.2
DS35	3/(20, 32, 20) m bridge spans	72	26.32	BR08 loss coefficient 0.13
DS36	1/0.6 m RCP	27	23.41 / 23.28	
DS38	3/1.2 m RCP	125	24.31 / 22.33	
DS39	3/1.35 m RCP	145	39.28 / 33.85	
DS40	1/1.2 x 0.45 m RCBC	18	53.79 / 53.7	
DS41	1/1.05 m RCP	143	46.29 / 43.15	15% blockage
DS42	2/1.2 m RCP	128	52.96 / 52.32	
DS43	2/42 m bridge spans	84	85.89	BR11, loss coefficient 0.00
DS44	3/(45, 90, 45) m bridge spans	180	76.3	BR12SB, loss coefficient 0.00
DS45	3/(45, 90, 45) m bridge spans	180	76.3	BR12NB, loss coefficient 0.00
DS46	3/1.5 m RCP	80	82 / 77.75	15% blockage
DS47	3/1.2 x 0.6 m RCBC	17	89.02 / 88.65	
DS48	2/1.5 m RCP	87	77.82 / 75.9	
DS49	2/1.5 x 1.5 m RCBC	26	65.01 / 64.27	
DS50	1/32 m bridge span	32	72.4	BR13SB, loss coefficient 0.00
DS51	1/32 m bridge span	32	73.1	BR13NB, loss coefficient 0.00
DS52	2/0.525 m RCP	10	68.46 / 68.24	

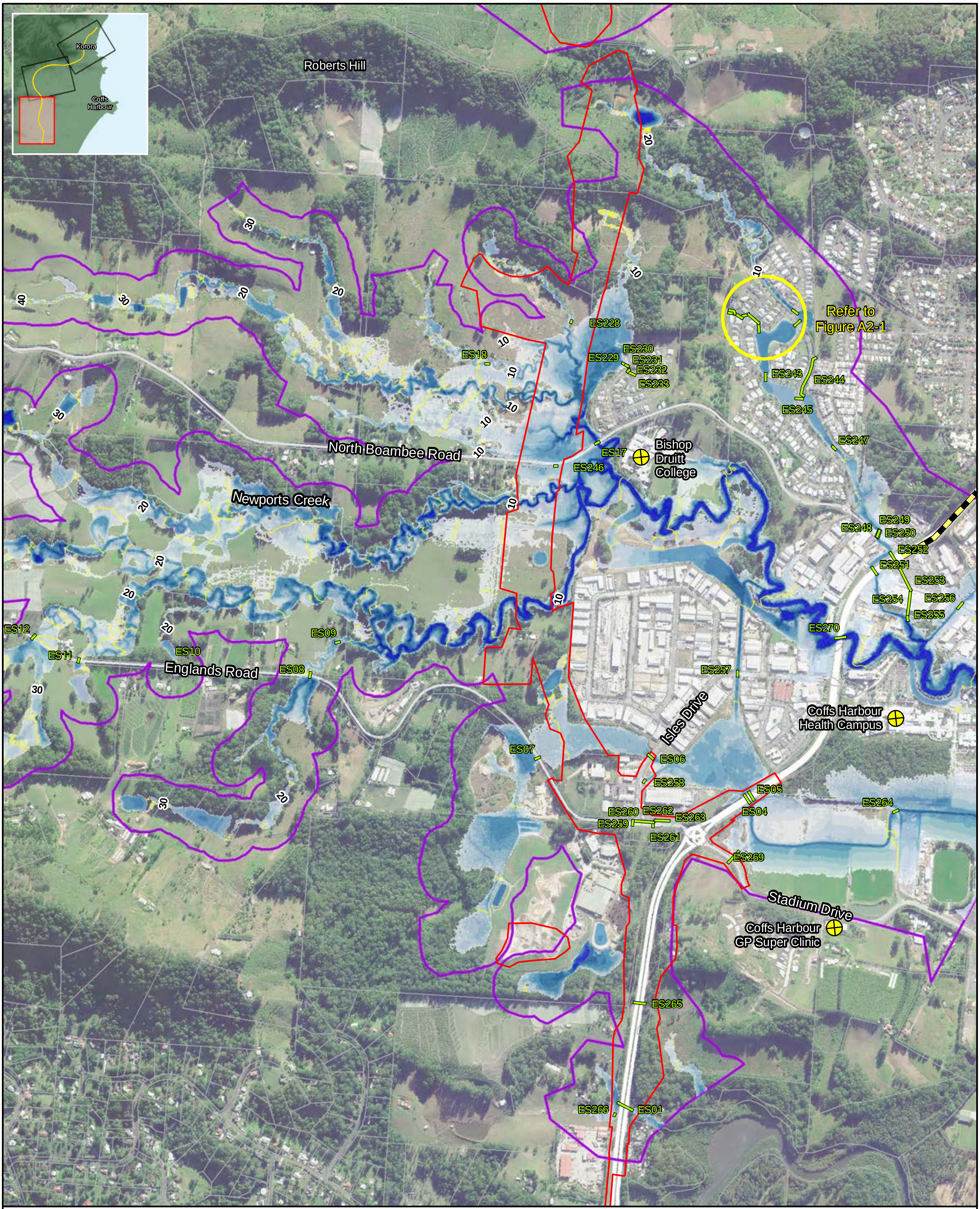
ID	Arrangement	Length (m)	US/DS Invert level (mAHD)	Additional comments
DS53	3/1.8 m RCP	16	58.4 / 58	
DS54	1/1.2 x 0.6 m RCBC	6	74.2 / 74.13	
DS55	2/1.35 m RCP	125	63.39 / 60.63	15% blockage
DS57	1/1.2 x 0.6 m RCBC	9	73.68 / 73.26	
DS58	2/1.2 m RCP	76	61.72 / 60.06	15% blockage
DS59	2/1.2 m RCP	40	66.62 / 61.74	15% blockage
DS60	2/1.2 m RCP	32	69.28 / 66.55	
DS61	1/0.9 m RCP	134	63.64 / 59.05	
DS62	1/0.45 m RCP	9	71.96 / 71.55	
DS63	1/1.2 m RCP	103	63.5 / 61.22	15% blockage
DS64	1/0.6 m RCP	15	71.38 / 71.02	
DS65	4/1.5 m RCP	122	51.8 / 49.13	
DS66	1/33 m bridge span	33	55.88	BR16NB, loss coefficient 0.00
DS67	1/33 m bridge span	33	55.88	BR16SB, loss coefficient 0.00
DS68	4/2.7 x 1.2 m RCBC	40	42.55 / 42.16	
DS69	3/1.2 m RCP	76	42.32 / 40.04	15% blockage
DS70	1/3 x 3 m RCBC	54	38.25 / 35.97	
DS71	1/1.05 m RCP	38	27.22 / 25.87	
DS72	3/1.5 m RCP	86	33.2 / 31.3	
DS74	2/1.5 m RCP	40	29.59 / 28.7	
DS76	2/1.8 m RCP	108	24.3 / 22.46	
DS77	2/1.5 m RCP	73	37.62 / 36.07	
DS78	1/1.35 m RCP	143	33.65 / 30.34	
DS79	2/1.2 m RCP	39	31.18 / 30.99	
DS80	2/1.35 m RCP	36	24.46 / 24.03	15% blockage
DS83	1/1.5 m RCP	50	41 / 39.89	
DS85	1/37.9 m bridge span	37.9	13	B21, loss coefficient 0.08
DS86	7/0.75 m RCP	101	9.66 / 9.16	
DS87	2/1.2 m RCP	36	8 / 7.08	
DS88	1/1.5 m RCP	68	9.75 / 9.19	
DS89	1/1.05 m RCP	31	14.49 / 14.15	
DS90	1/1.05 m RCP	43	14.02 / 12.92	
DS91	1/1.05 m RCP	15	12.9 / 12.59	
DS92	1/1.5 m RCP	124	12.26 / 11.65	
DS93	1/1.5 m RCP	44	12.5 / 12.28	
DS94	1/0.75 m RCP	13	13.58 / 13.45	
DS95	1/0.75 m RCP	18	14.64 / 13.6	
DS96	1/1.5 m RCP	43	13.5 / 12.52	
DS97	1/0.9 m RCP	14	14.28 / 14.2	
DS98	1/1.2 m RCP	15	14.98 / 14.26	
DS99	1/1.2 m RCP	14	15.2 / 15.13	
DS100	1/1.05 m RCP	21	15.58 / 15.15	
DS101	1/0.9 m RCP	14	16.02 / 15.88	
DS102	1/36 m bridge span	36	20.68	BR22NB, loss coefficient 0.0
DS103	1/36 m bridge span	36	20.96	BR22SB, loss coefficient 0.0
DS104	2/1.5 m RCP	21	38.24 / 37.92	
DS105	3/(37.2, 37.8, 37.4) m bridge spans	112.2	34.2	B19, loss coefficient 0.0
DS106	3/1.5 m RCP	27	36.47 / 35.9	

ID	Arrangement	Length (m)	US/DS Invert level (mAHD)	Additional comments
DS107	2/1.8 m RCP	20	38.71 / 38.36	25% blockage
DS108	2/1.8 m RCP	7	56.5 / 56.4	15% blockage
DS109	1/1.65 m RCP	7	56.5 / 56.4	15% blockage
DS110	1/1.2 x 0.6 m RCBC	8	79.61 / 79.31	
DS111	2/1.2 x 0.6 m RCBC	12	28.35 / 27.69	
DS112	3/0.75 m RCP	16	28.99 / 28.12	
DS113	1/3 x 3 m RCBC	89	10.01 / 9.92	
DS114	1/6 x 3.05 m RCBC	74	14.91 / 14.54	
DS115	1/0.9 m RCP	73	14.83 / 11.54	
DS116	3/1.8 m RCP	127	65.8 / 63.64	

Appendix B

Existing flood maps

B1 Peak flood level and depth



Legend

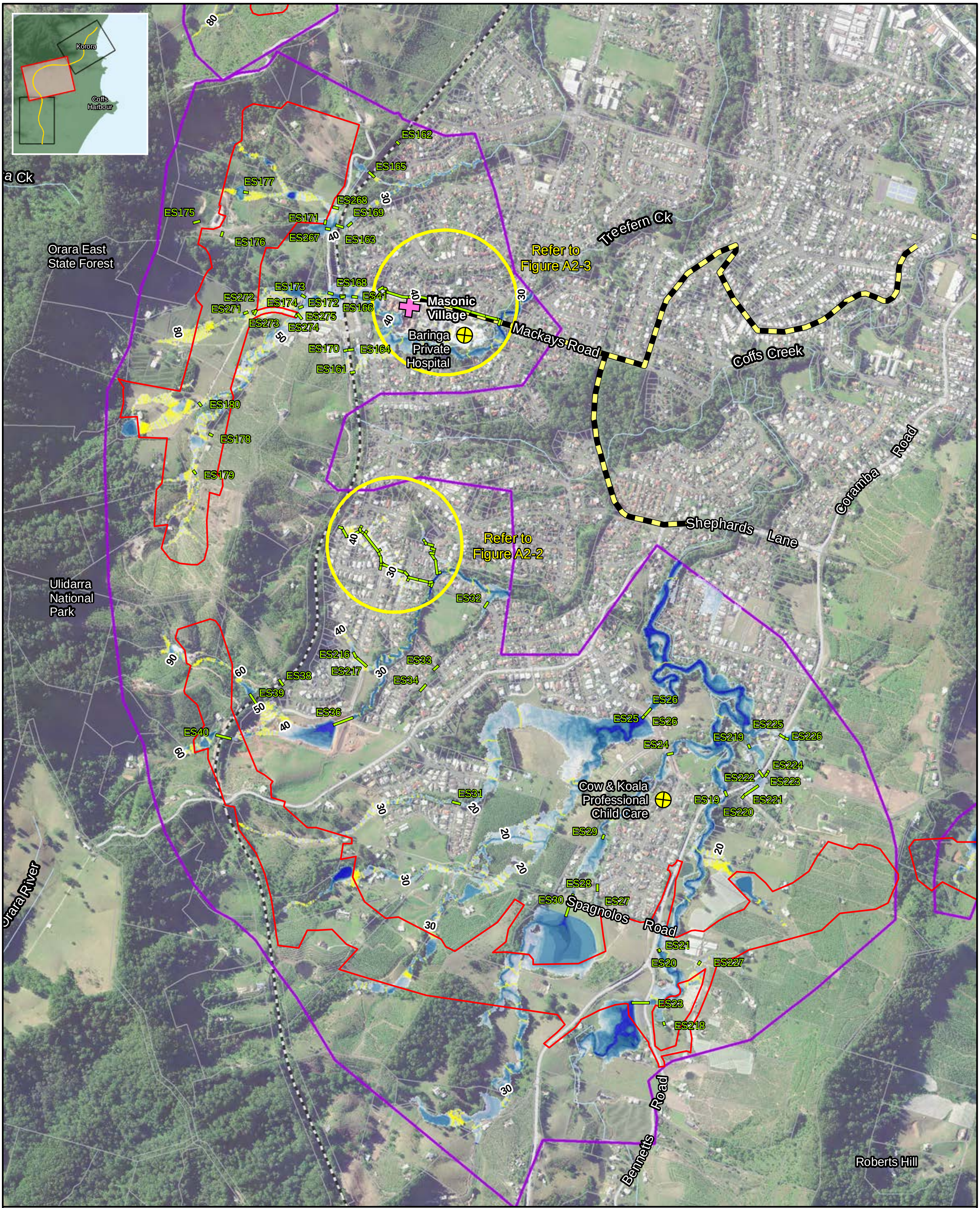
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Peak flood level (mAHD at 1m contours)
Modelled structures
Critical Infrastructure
Assembly areas

Peak flood depth (m)

0.00 - 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
> 2.50

Coffs Harbour Bypass
North Boambee Valley 18 % AEP peak flood level and depth
Figure B1-1-1

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

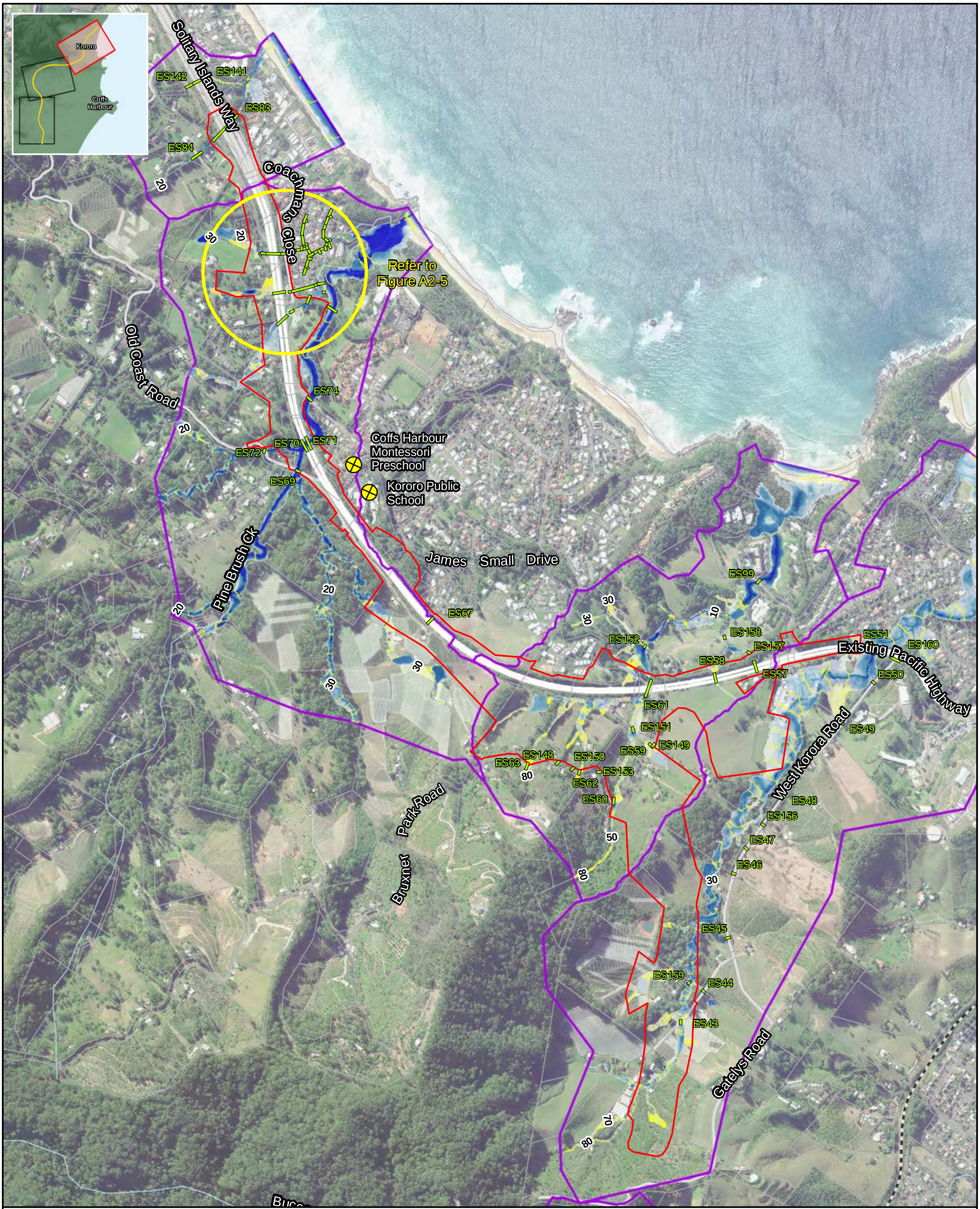
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Coffs Creek 18 % AEP peak flood level and depth
Figure B1-2-1

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

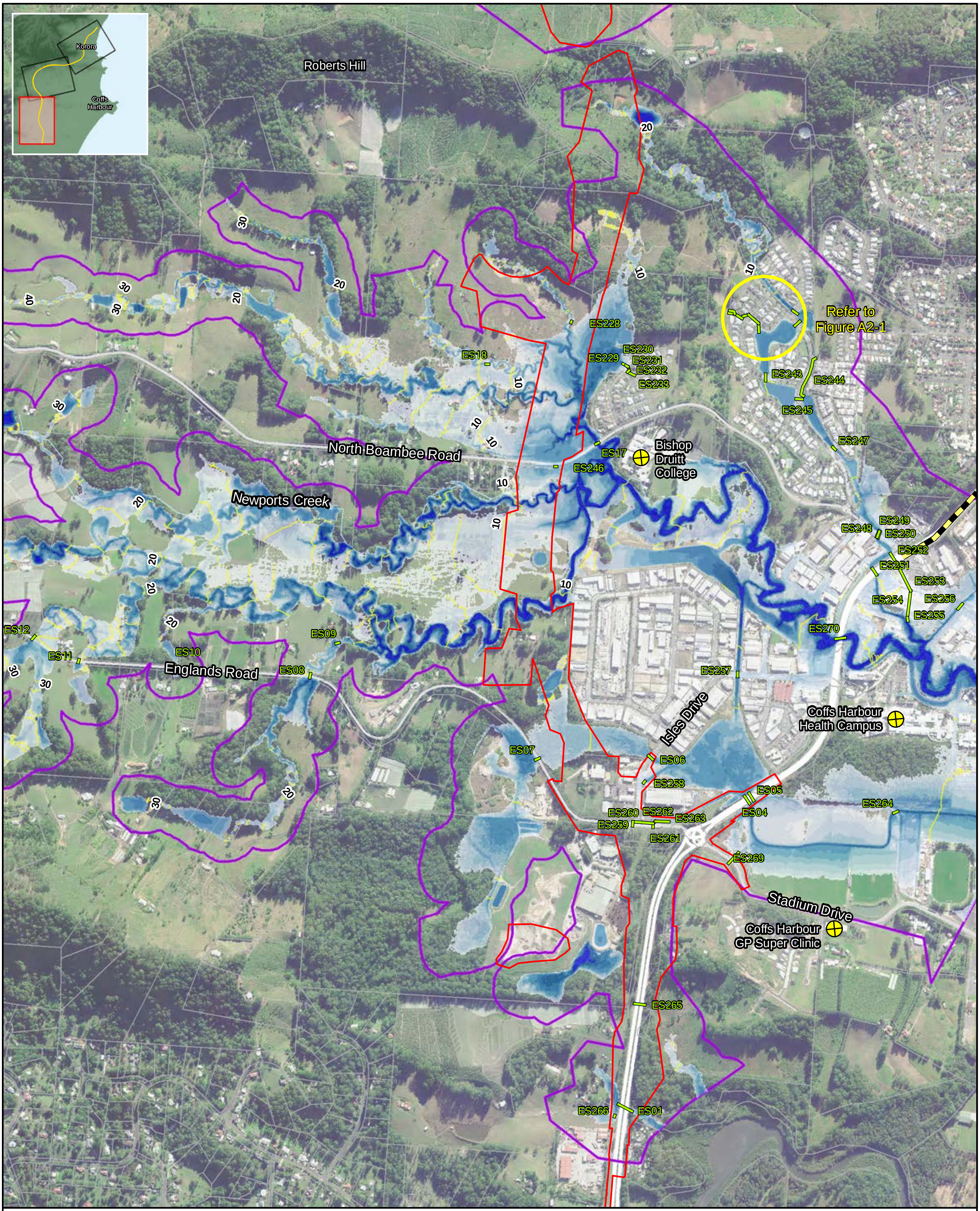
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Peak flood level (mAHD at 1m contours)
Modelled structures
Critical Infrastructure
Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Northern creeks 18 % AEP peak flood level and depth
Figure B1-3-1

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

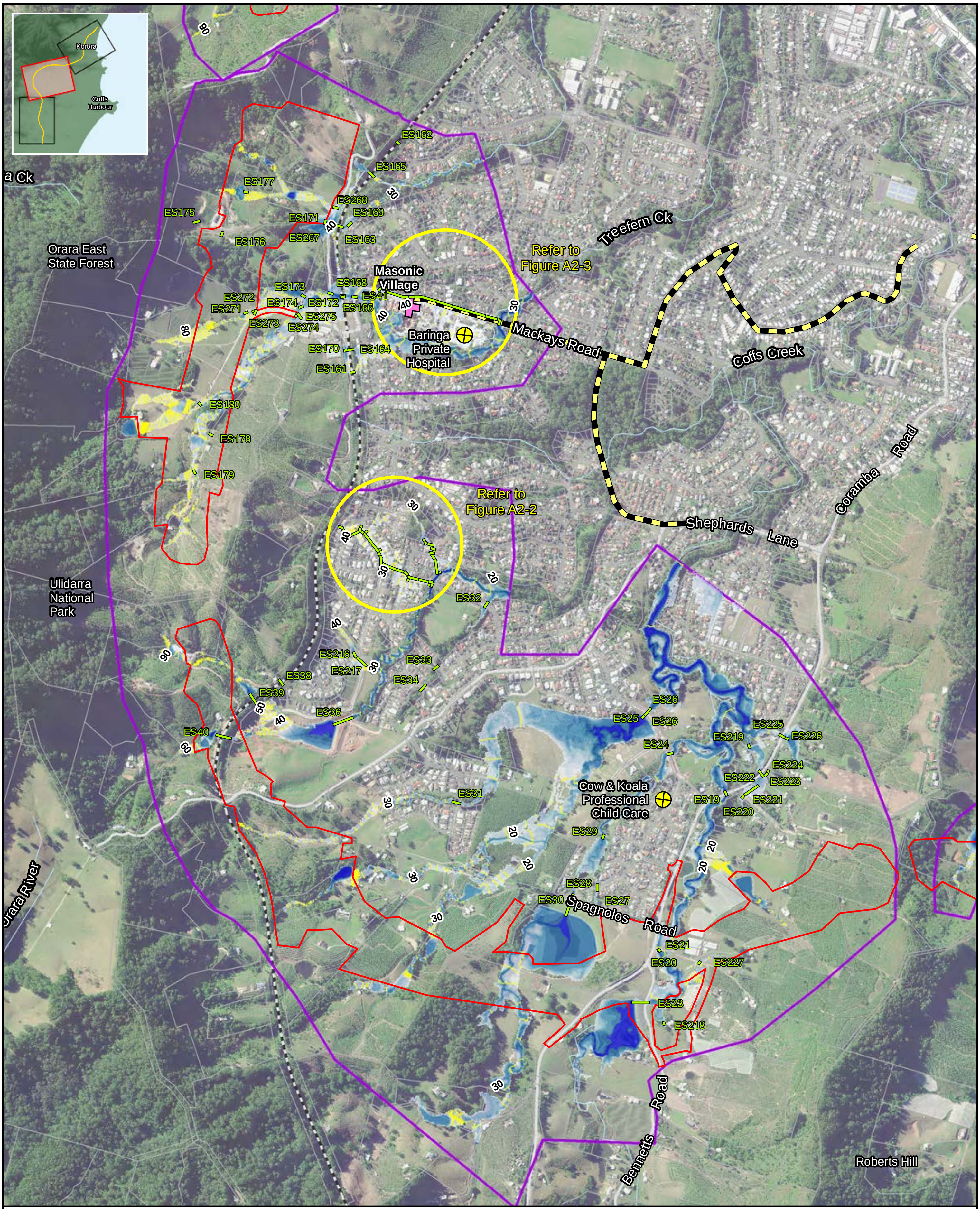
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Peak flood level (mAHD at 1m contours)
Modelled structures
Critical Infrastructure
Assembly areas

Peak flood depth (m)

0.00 - 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
> 2.50

Coffs Harbour Bypass
North Boambee Valley 10 % AEP peak flood level and depth
Figure B1-1-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

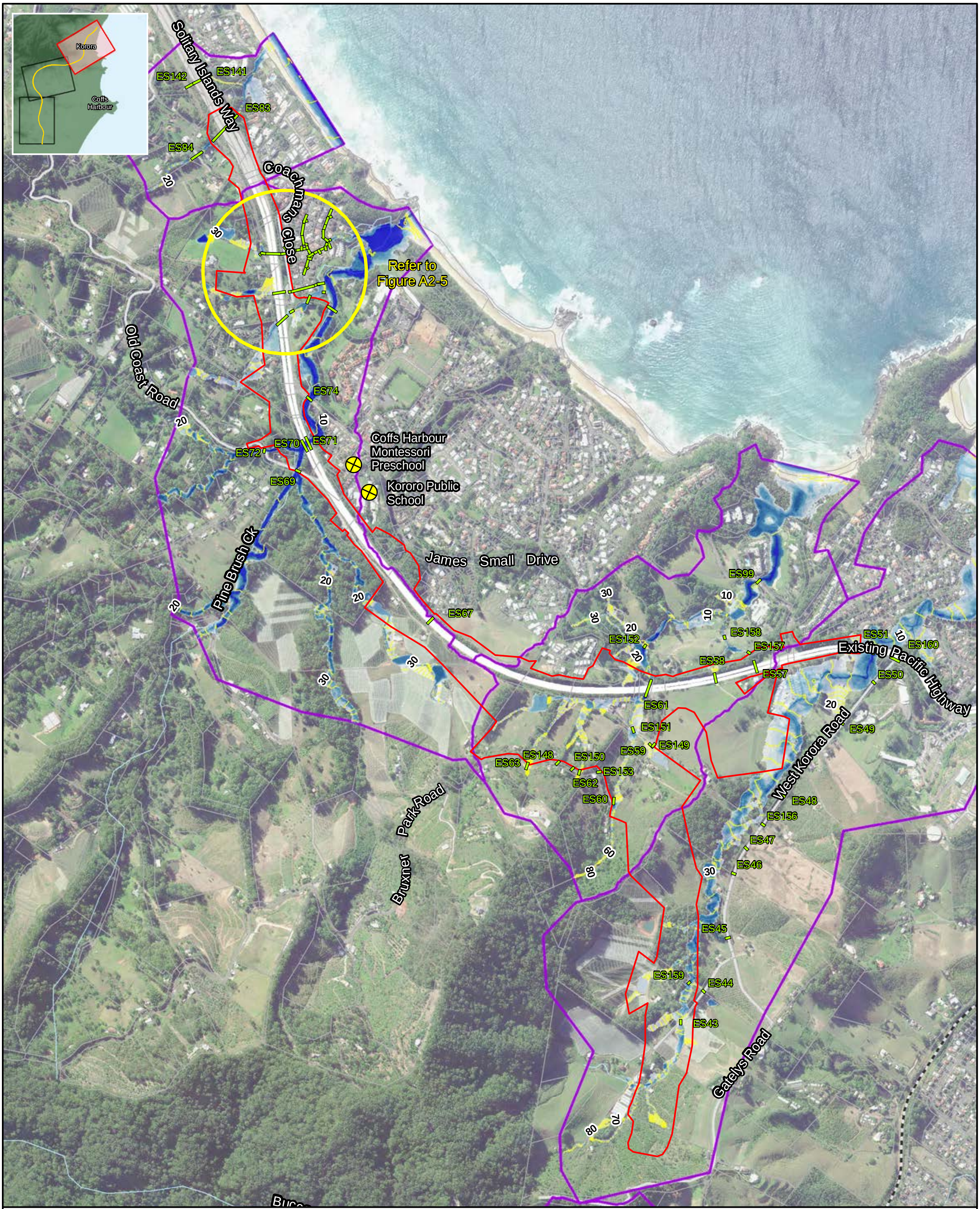
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Coffs Creek 10 % AEP peak flood level and depth
Figure B1-2-2

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

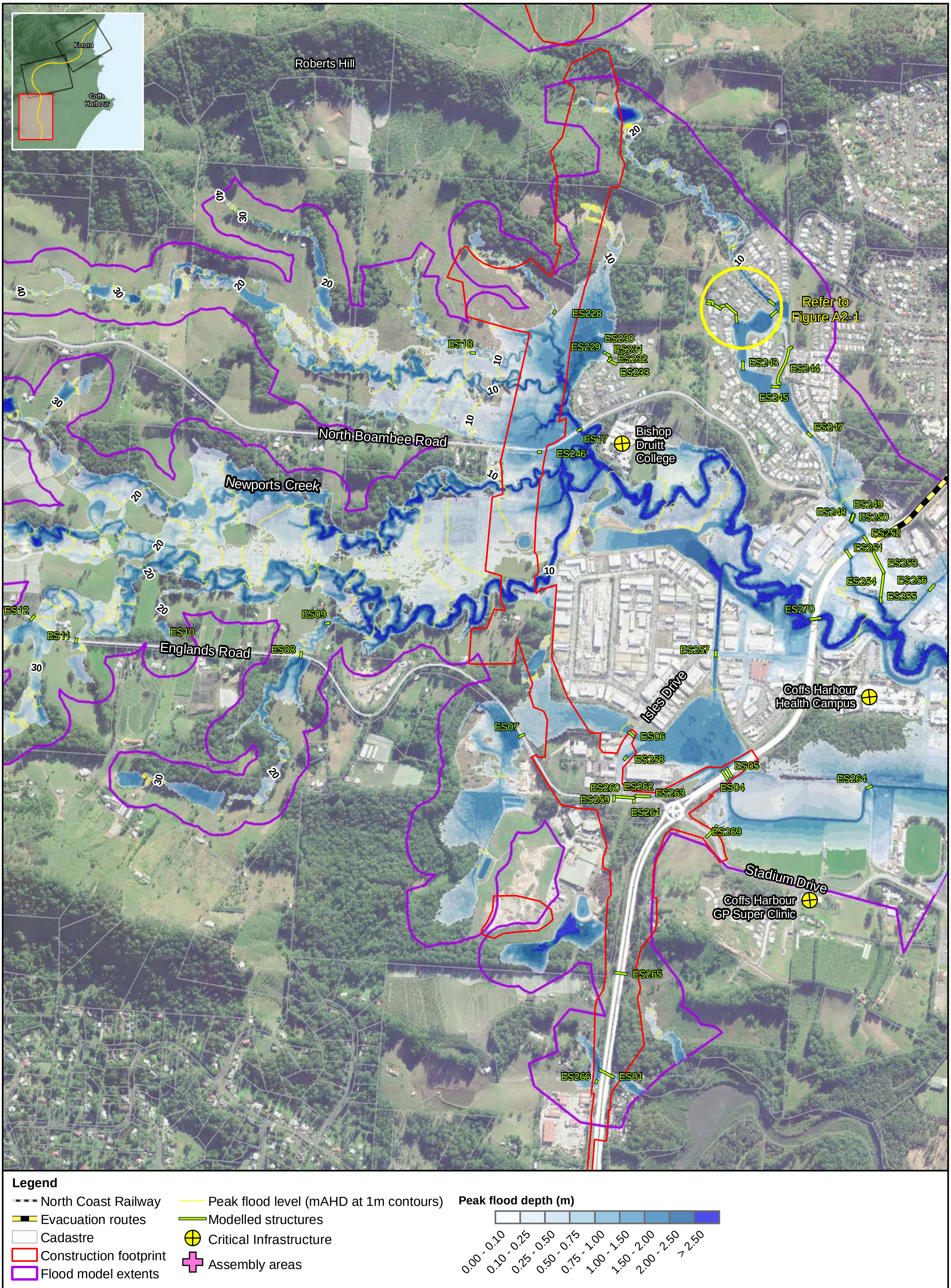
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Peak flood level (mAHD at 1m contours)
Modelled structures
Critical Infrastructure
Assembly areas

Peak flood depth (m)

0.00 - 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
> 2.50

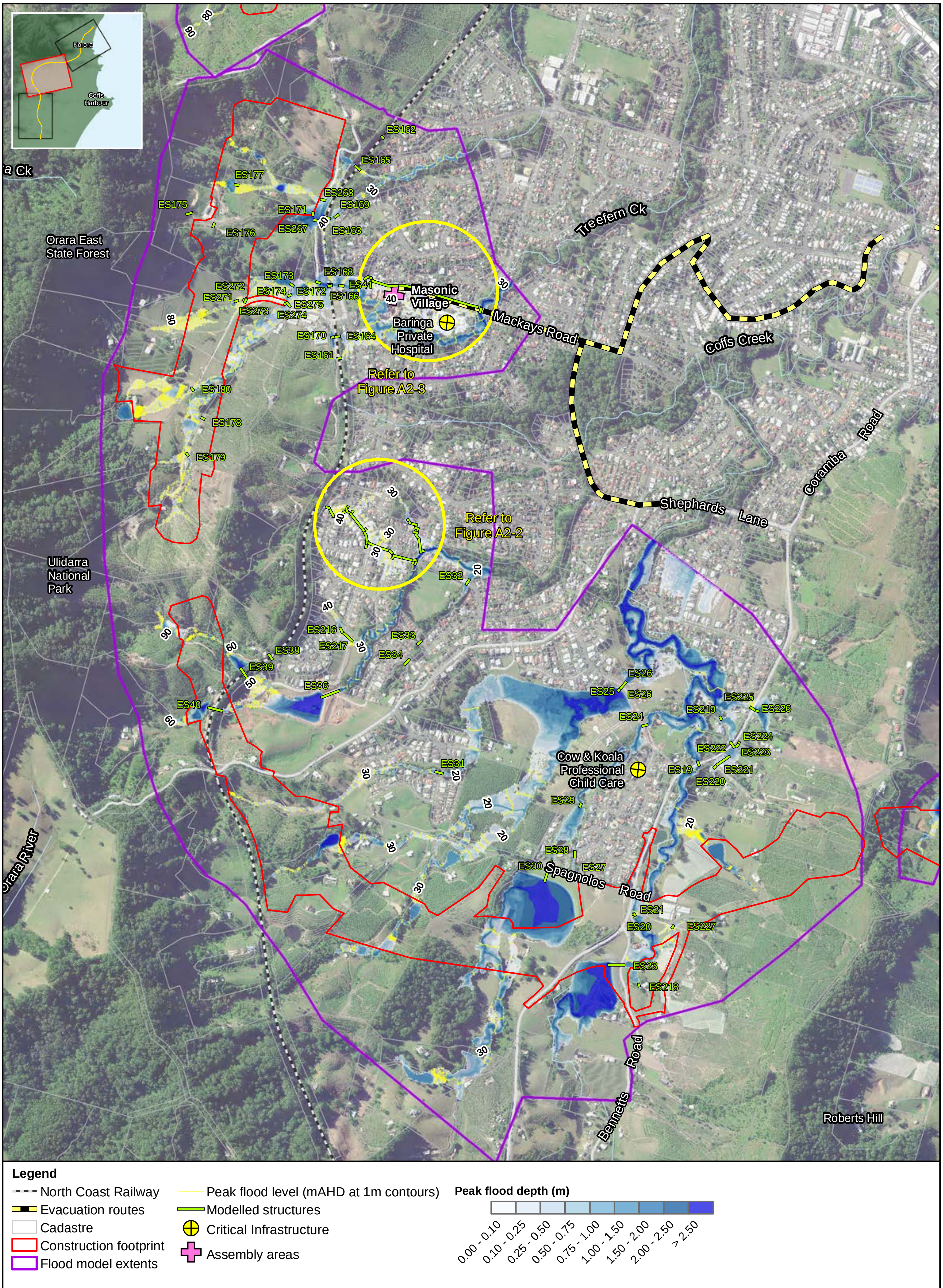
Coffs Harbour Bypass
Northern creeks 10 % AEP peak flood level and depth
Figure B1-3-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Coffs Harbour Bypass
North Boambee Valley 5 % AEP peak flood level and depth
Figure B1-1-3

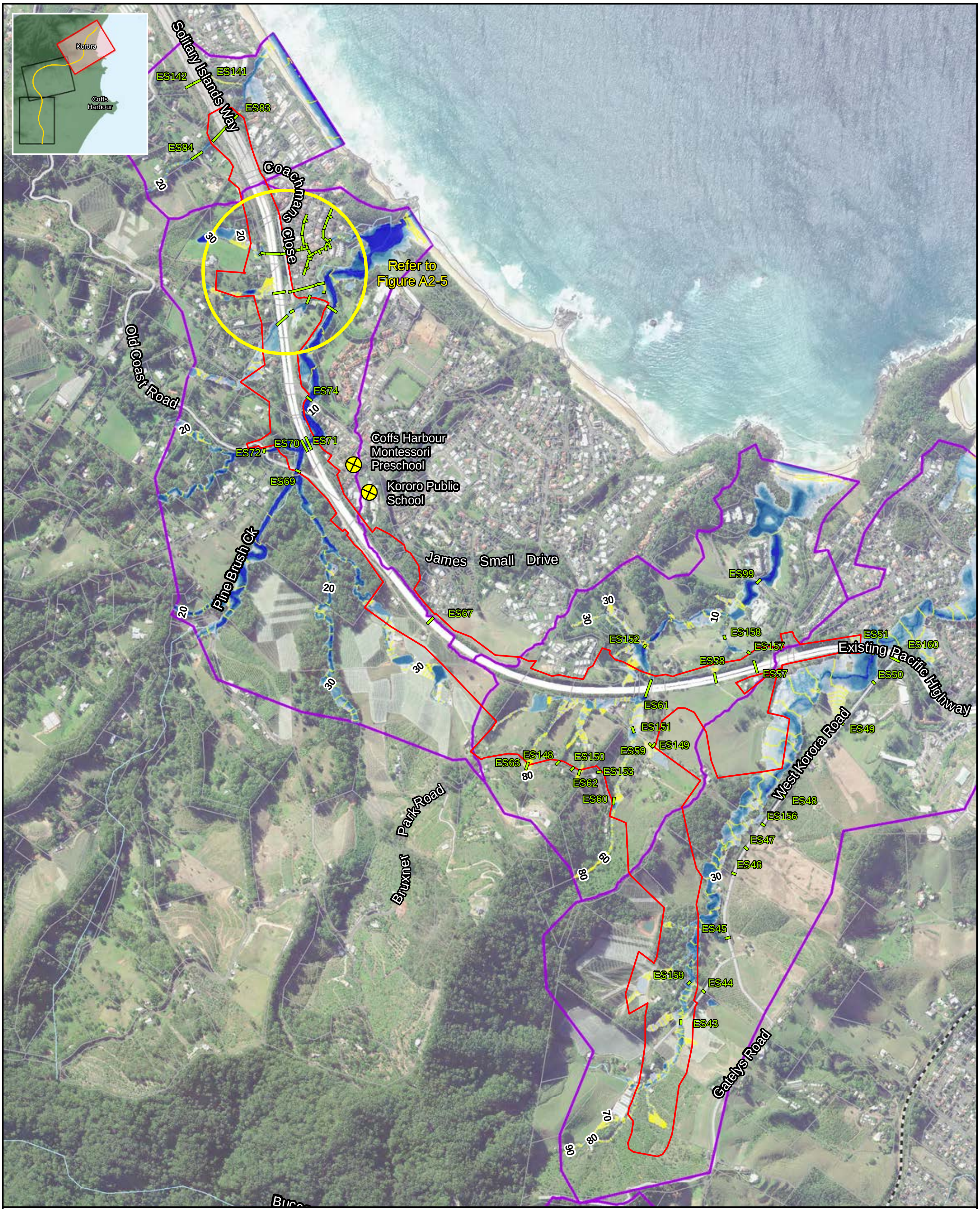
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Coffs Harbour Bypass

Coffs Creek 5 % AEP peak flood level and depth

Figure B1-2-3



Legend

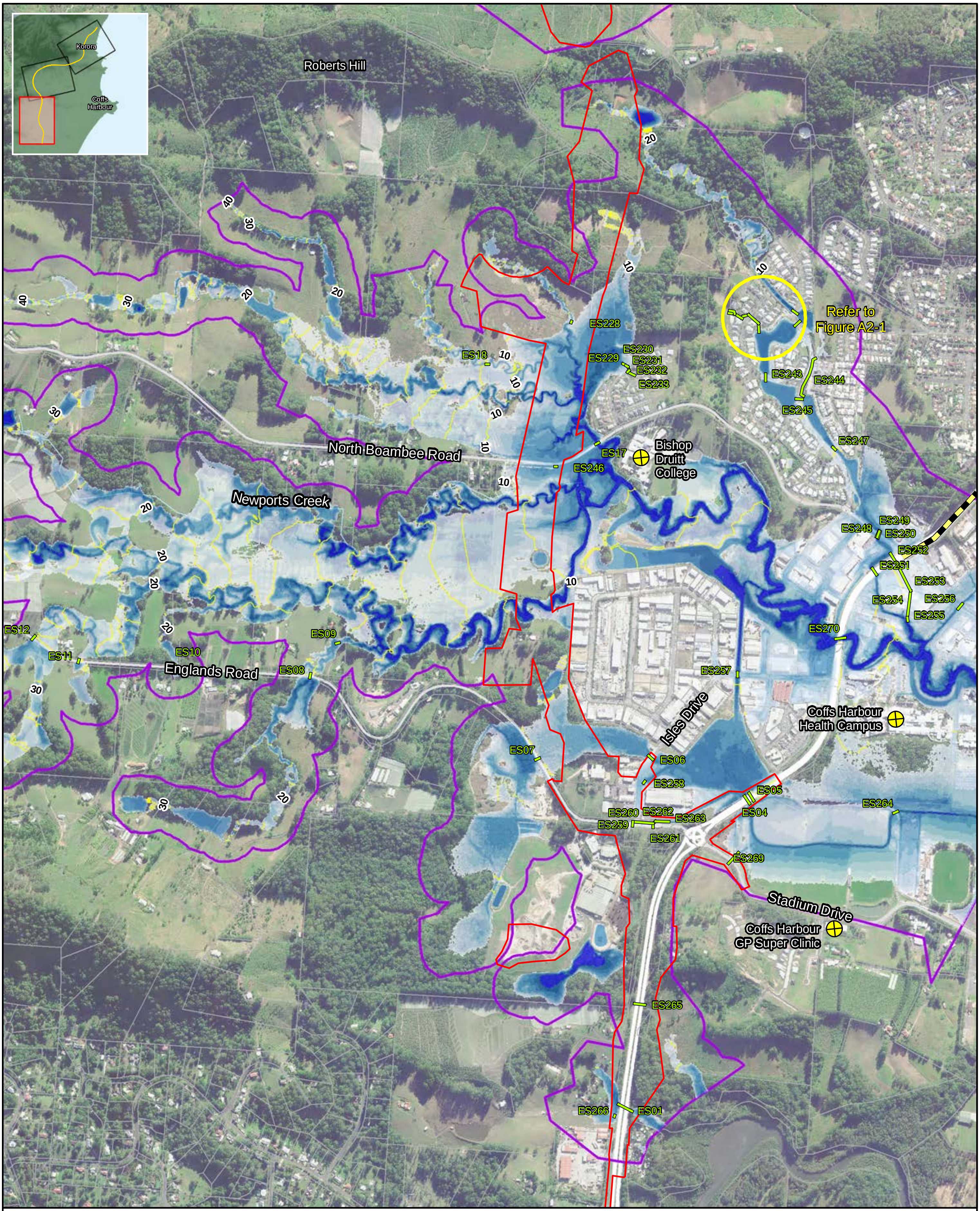
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Northern creeks 5 % AEP peak flood level and depth
Figure B1-3-3

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

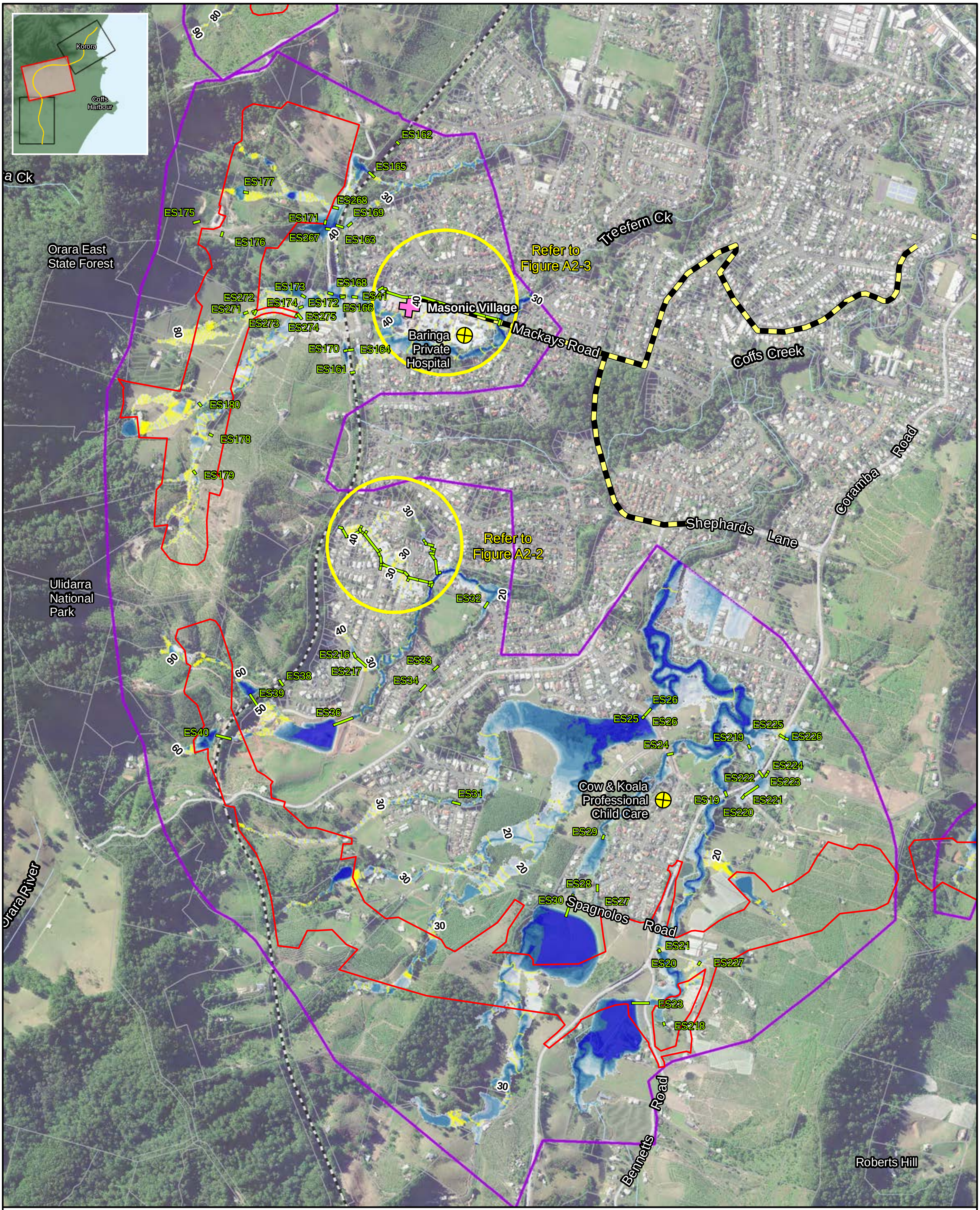
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
North Boambee Valley 2 % AEP peak flood level and depth
Figure B1-1-4

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

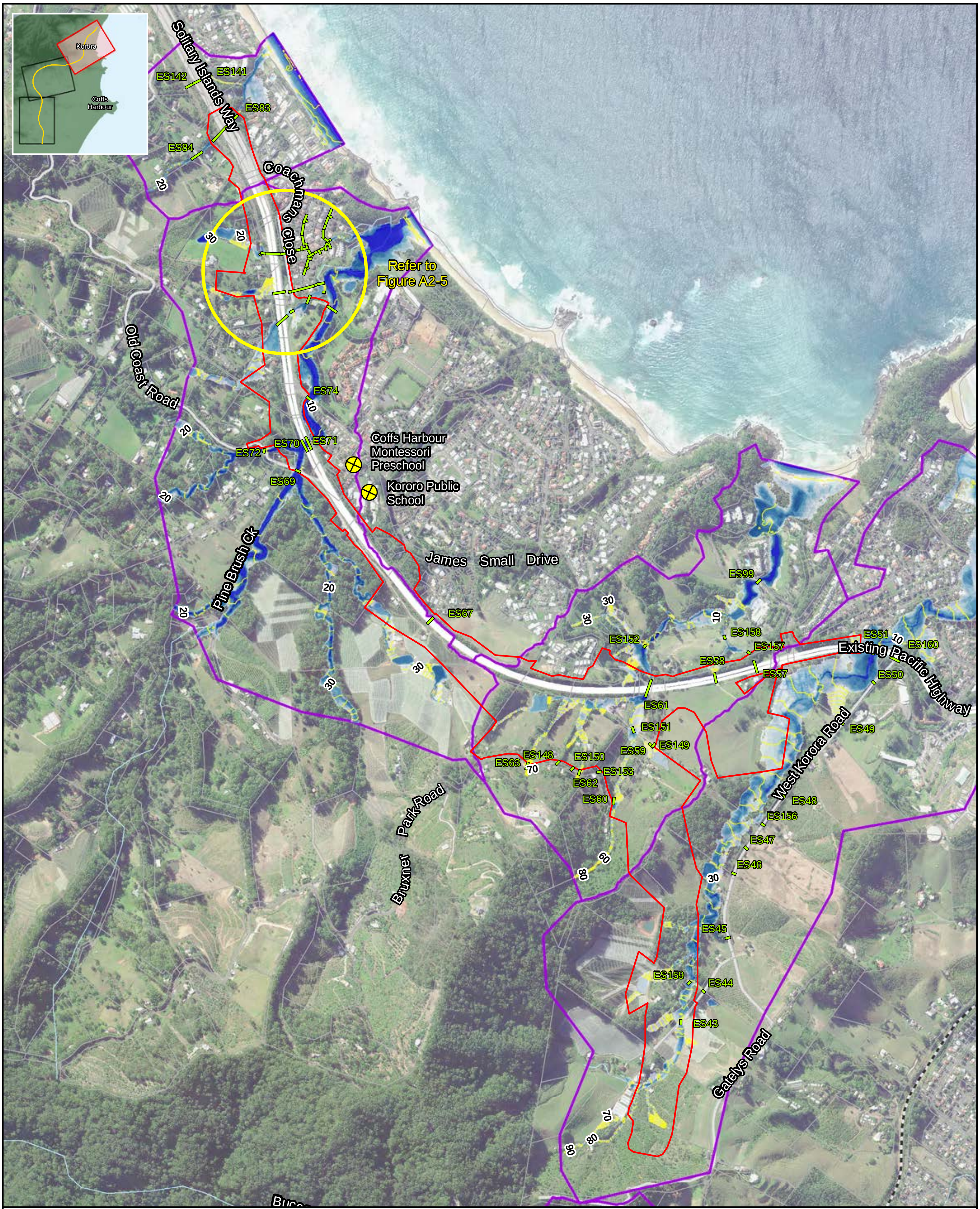
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Coffs Creek 2 % AEP peak flood level and depth
Figure B1-2-4

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

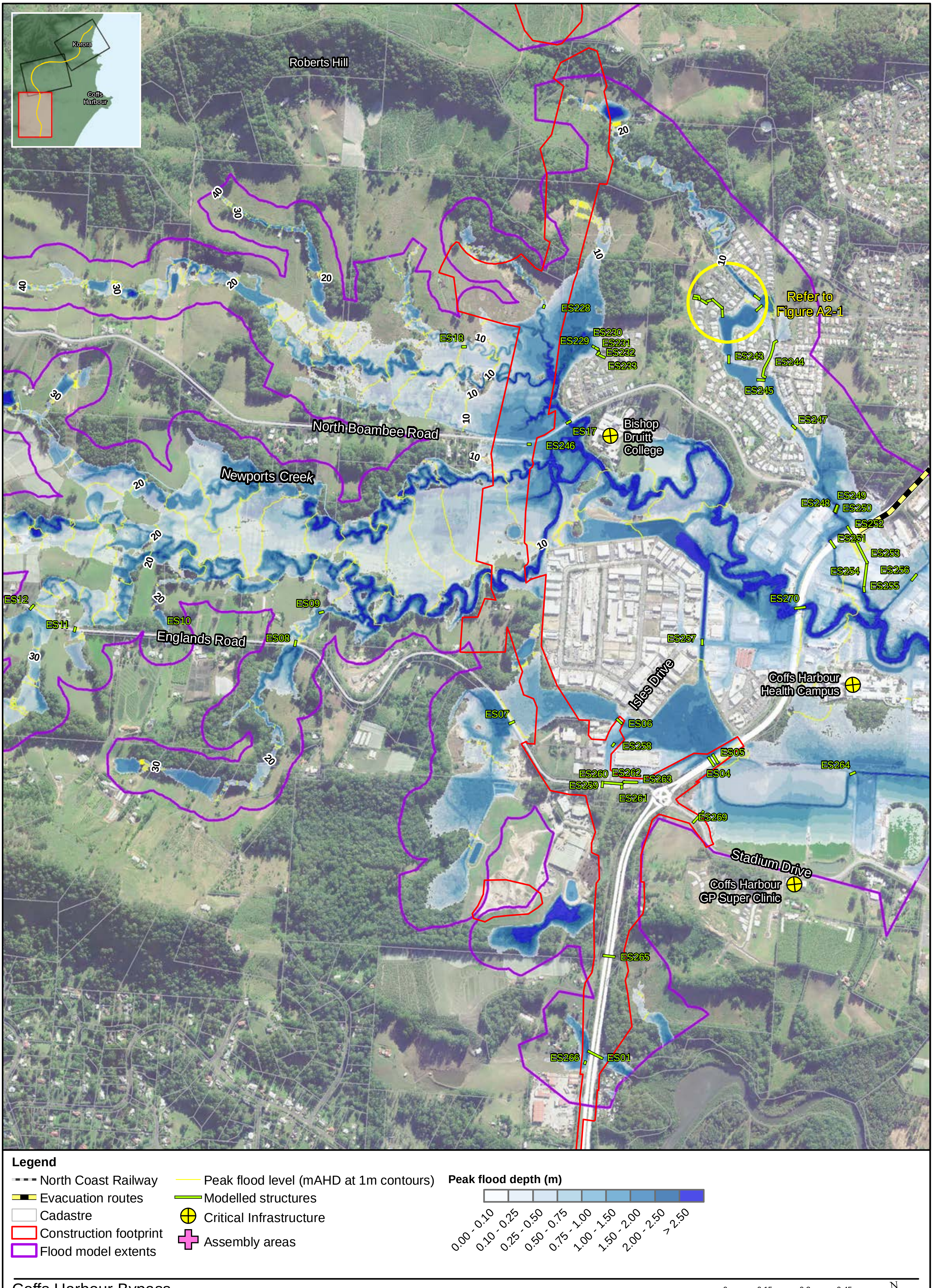
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

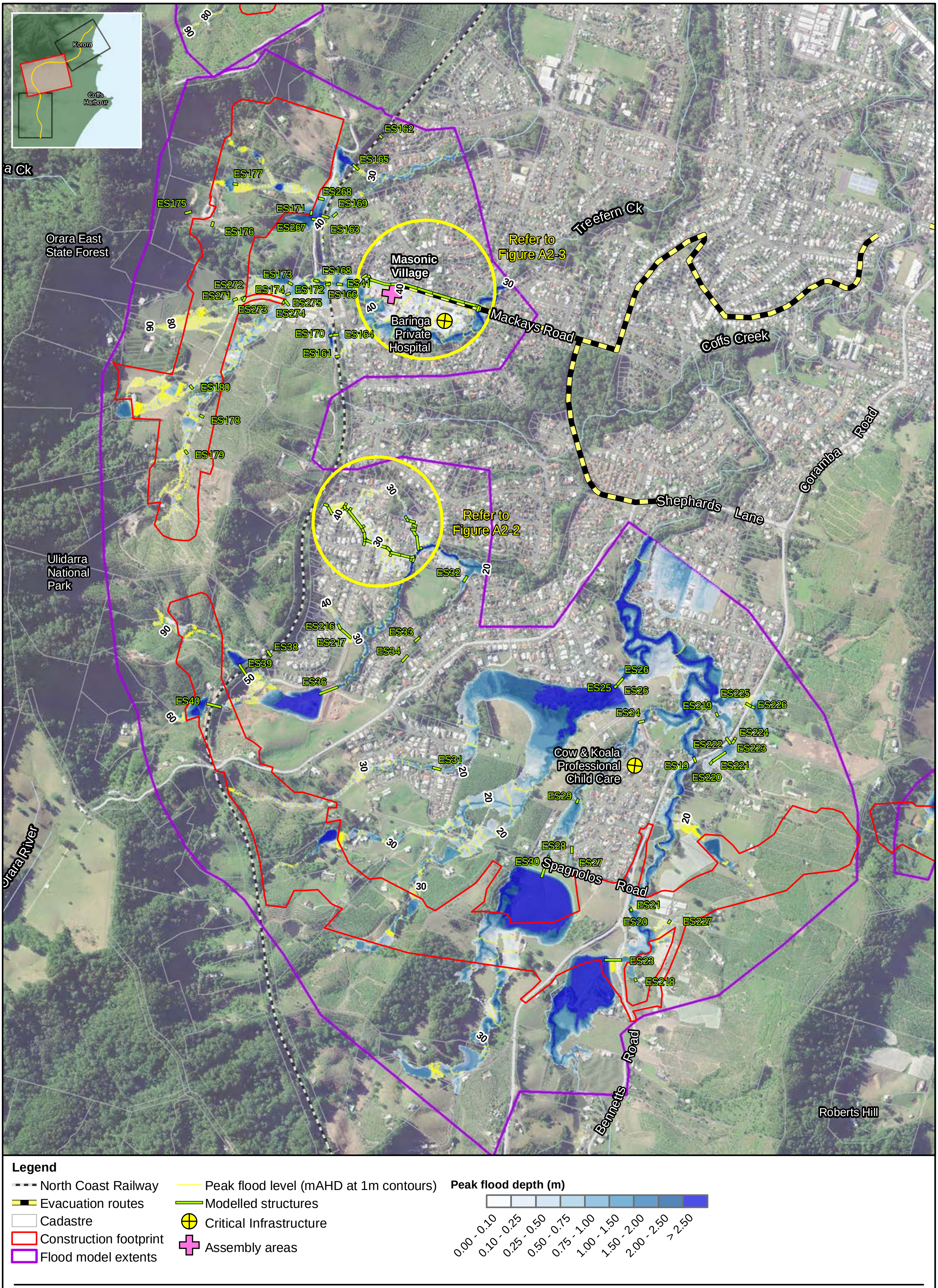
0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Northern creeks 2 % AEP peak flood level and depth
Figure B1-3-4

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



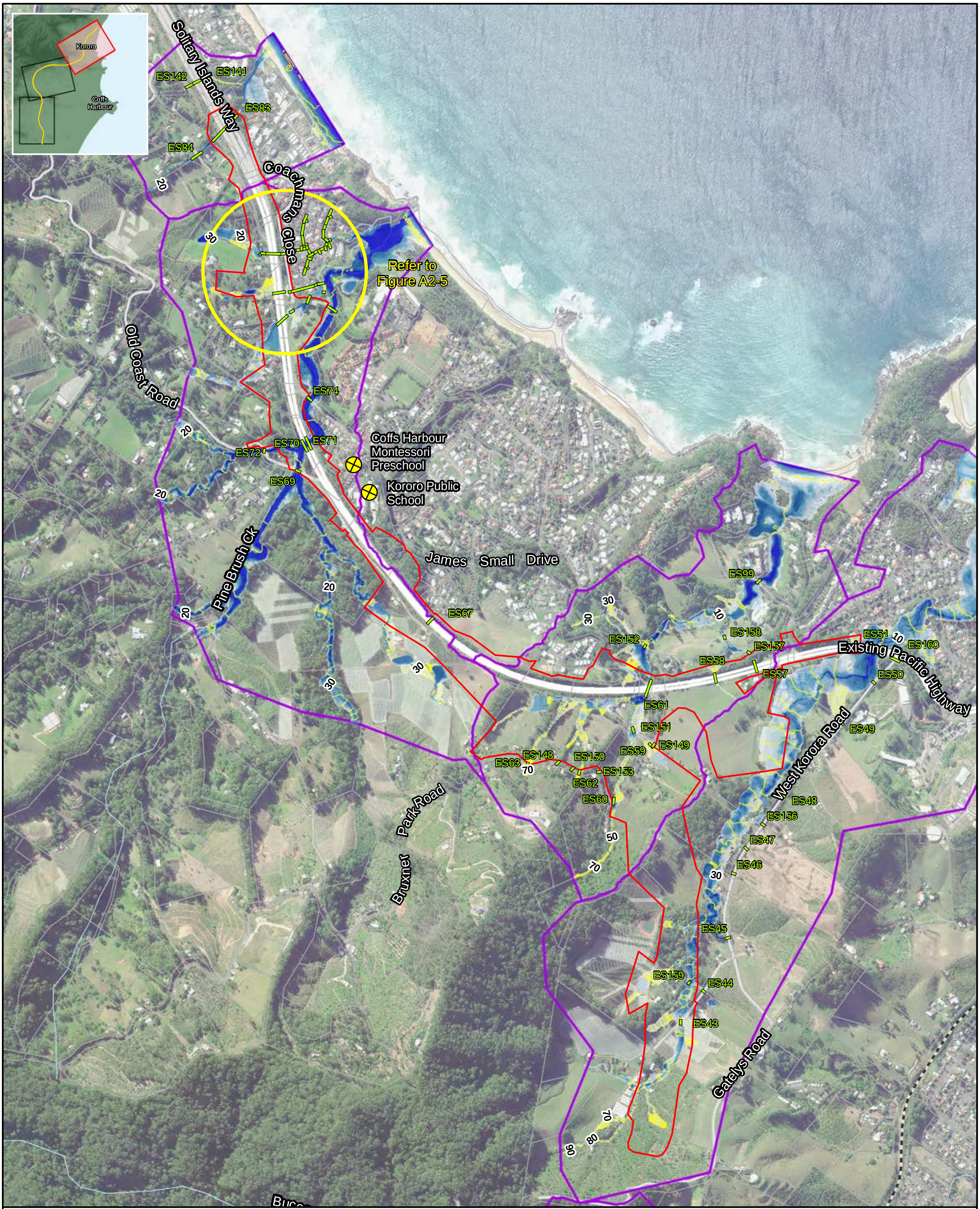
Coffs Harbour Bypass
North Boambee Valley 1 % AEP peak flood level and depth
Figure B1-1-5



Coffs Harbour Bypass

Coffs Creek 1 % AEP peak flood level and depth

Figure B1-2-5



Legend

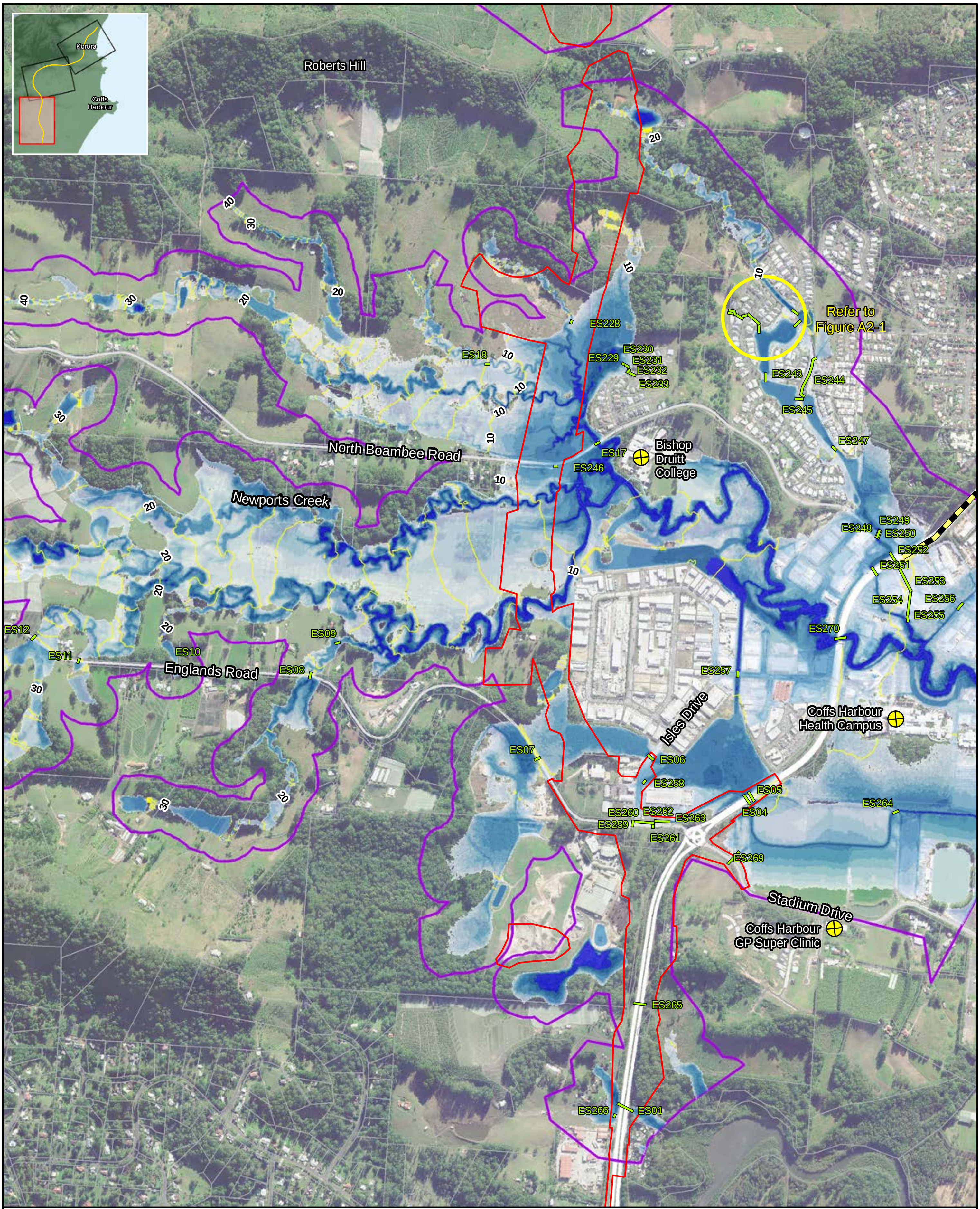
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Peak flood level (mAHD at 1m contours)
Modelled structures
Critical Infrastructure
Assembly areas

Peak flood depth (m)

0.00 - 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
> 2.50

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Coffs Harbour Bypass
Northern creeks 1 % AEP peak flood level and depth
Figure B1-3-5



Legend

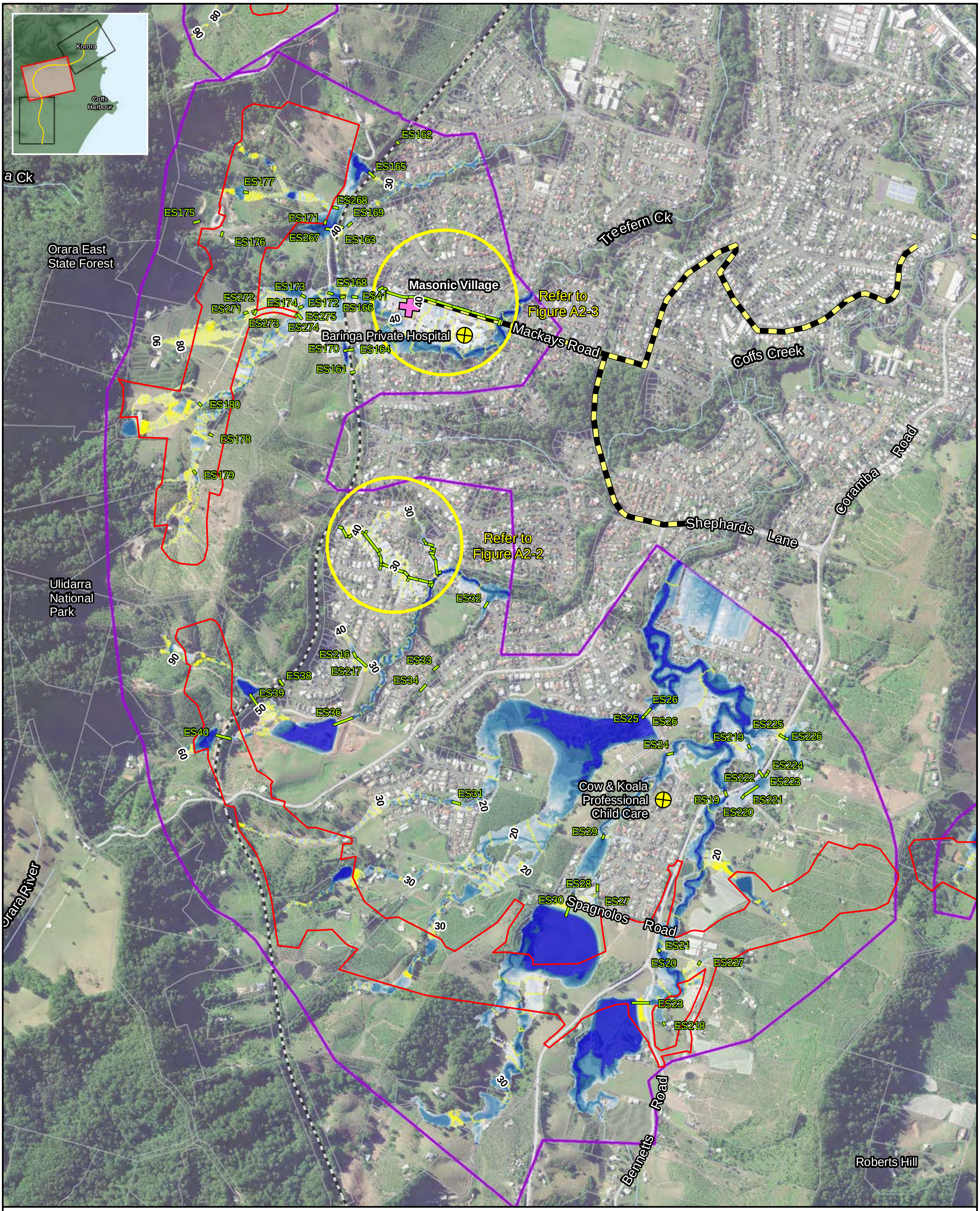
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Peak flood level (mAHD at 1m contours)
Modelled structures
Critical Infrastructure
Assembly areas

Peak flood depth (m)

0.00 - 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
> 2.50

Coffs Harbour Bypass
North Boambee Valley 1 % AEP 2050 climate peak flood level and depth
Figure B1-1-6

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

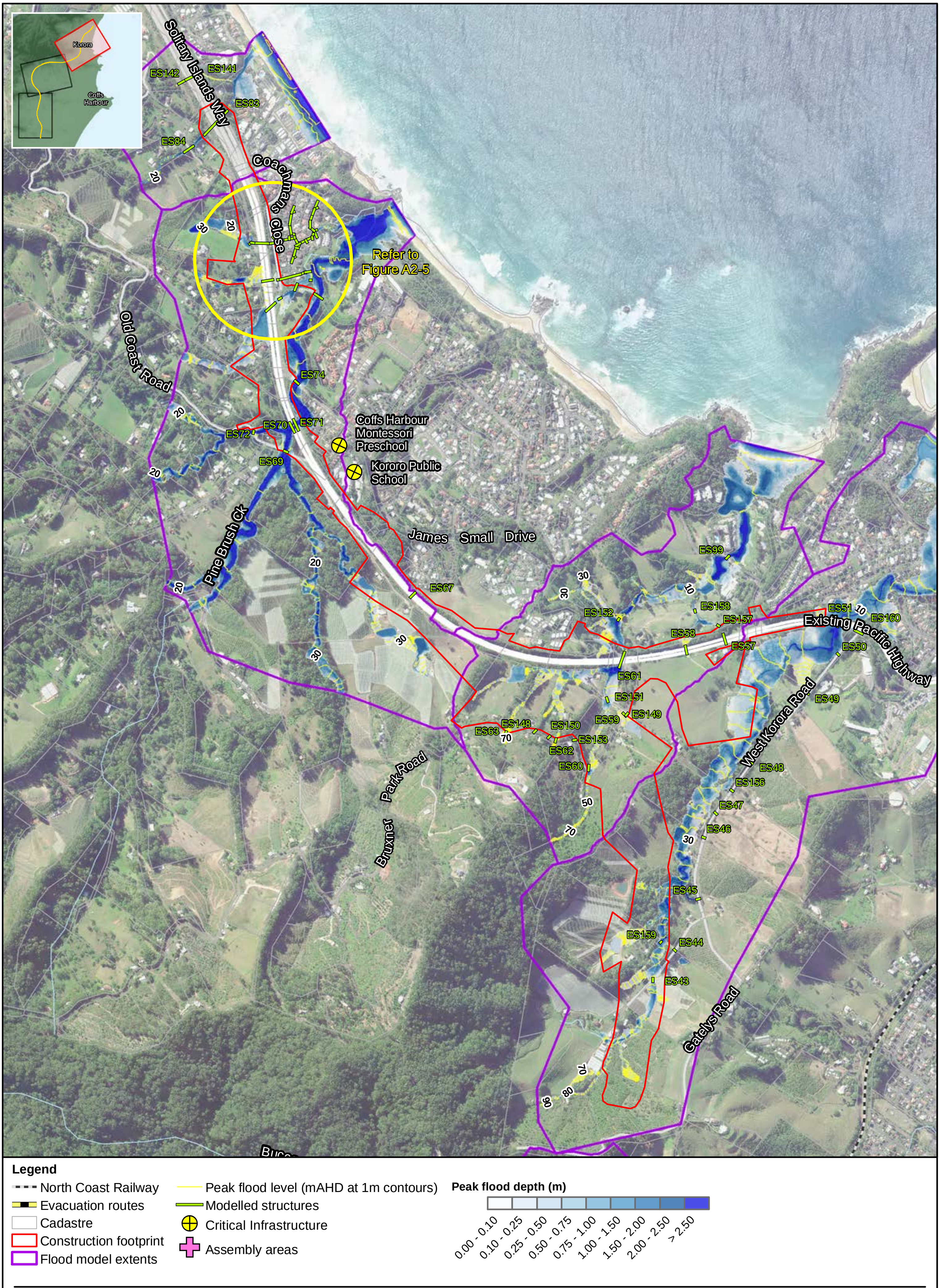
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

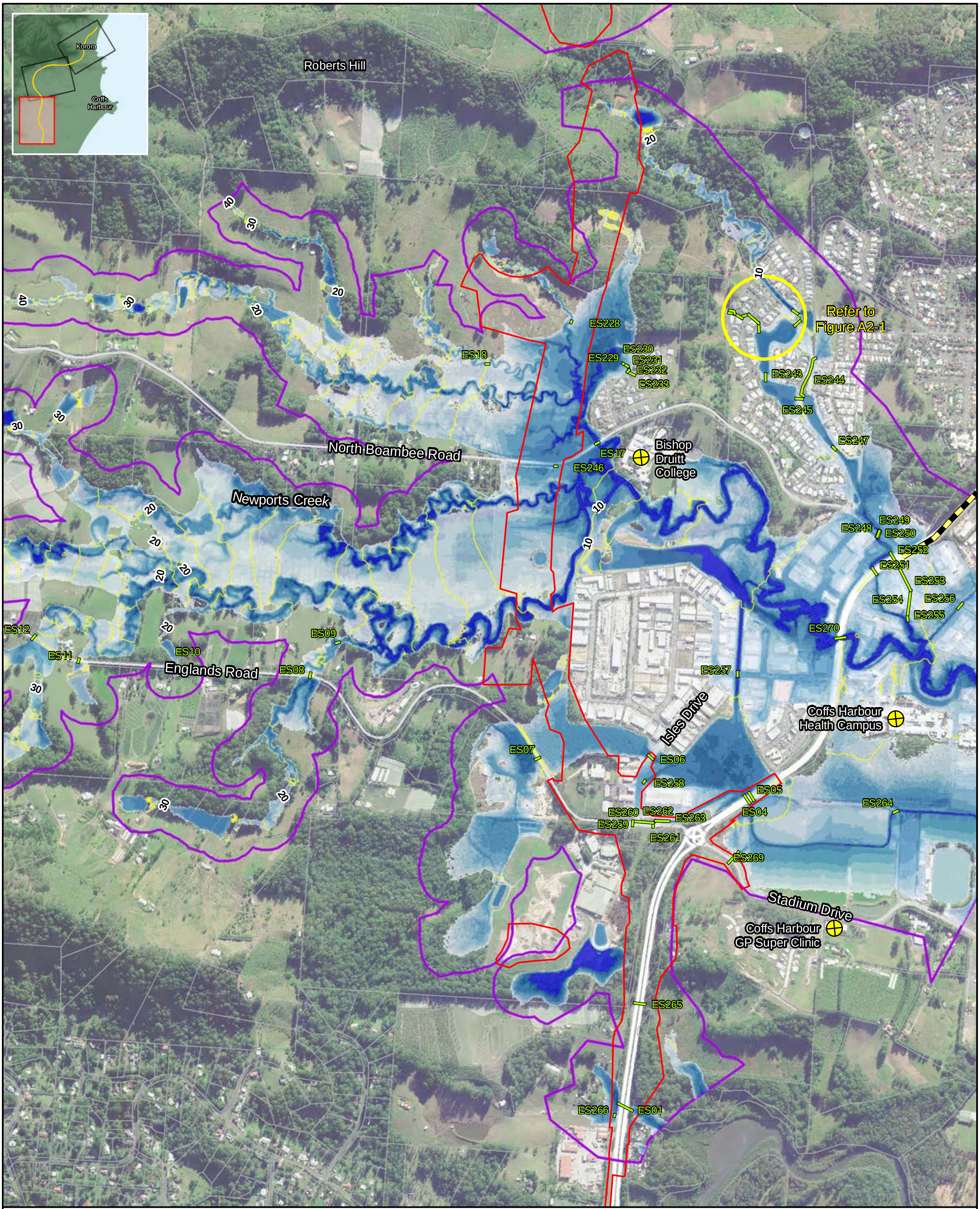
0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Coffs Creek 1 % AEP 2050 climate peak flood level and depth
Figure B1-2-6

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Coffs Harbour Bypass
Northern creeks 1 % AEP 2050 climate peak flood level and depth
Figure B1-3-6



Legend

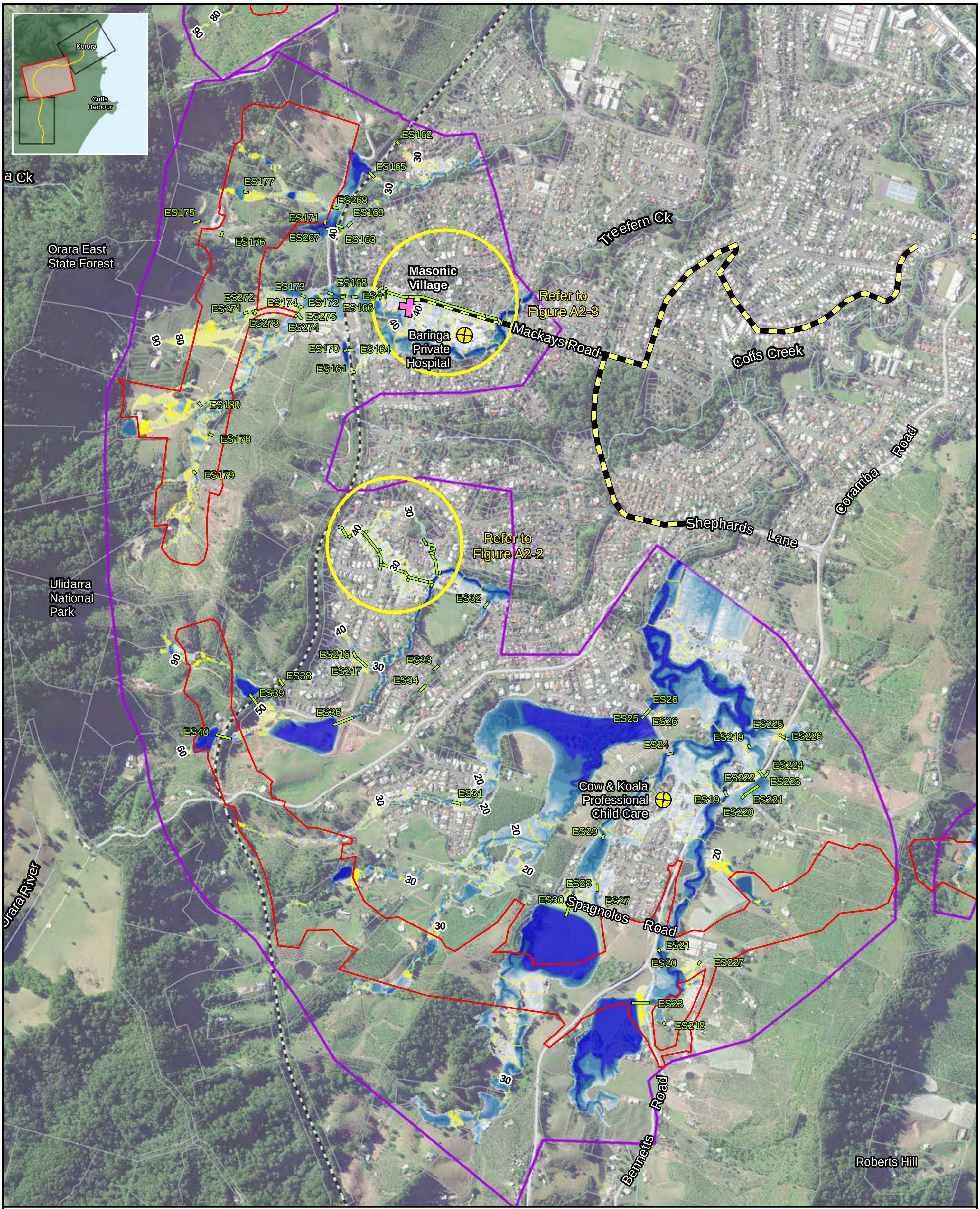
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
North Boambee Valley 1 % AEP 2100 climate peak flood level and depth
Figure B1-1-7

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

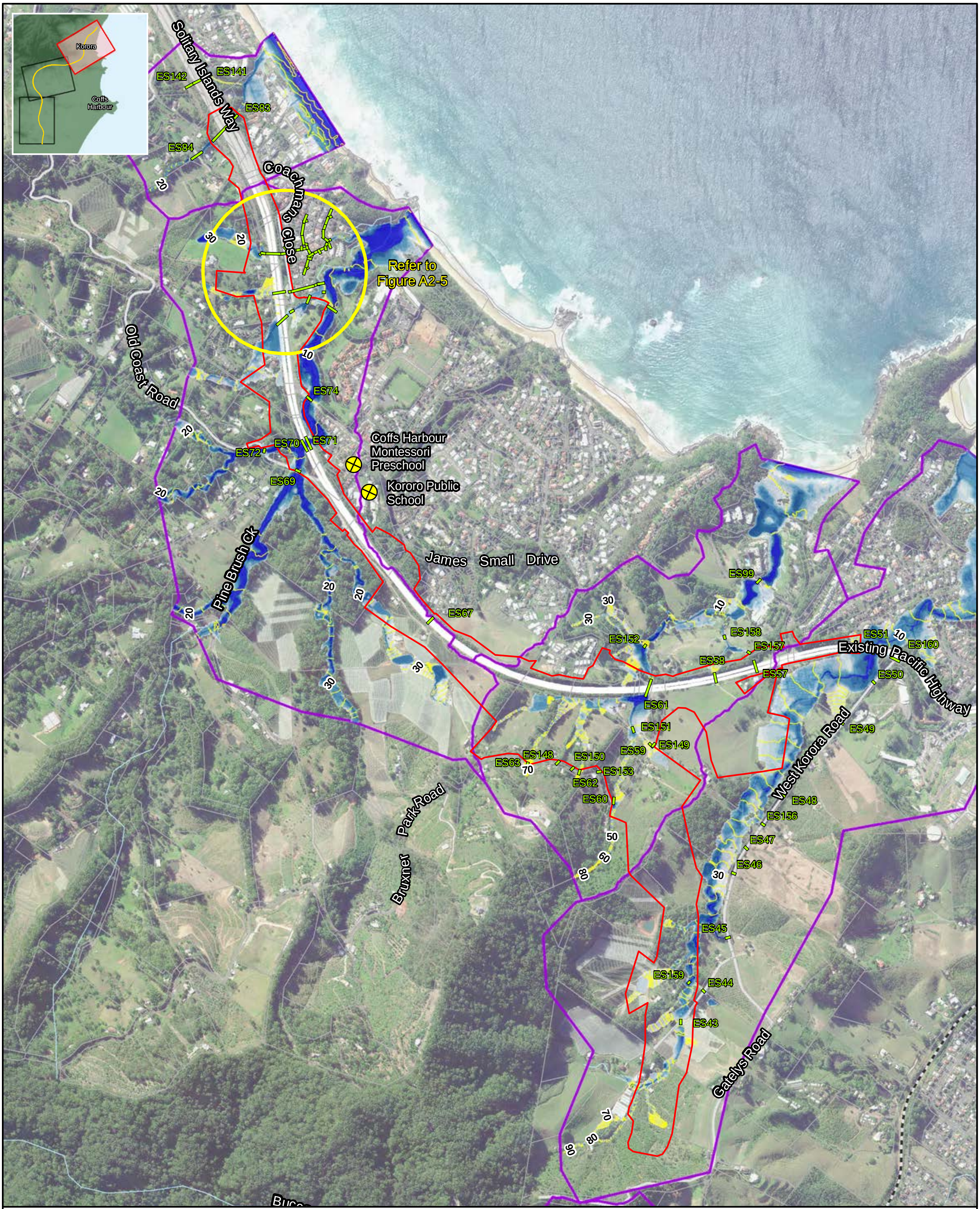
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Coffs Creek 1 % AEP 2100 climate peak flood level and depth
Figure B1-2-7

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

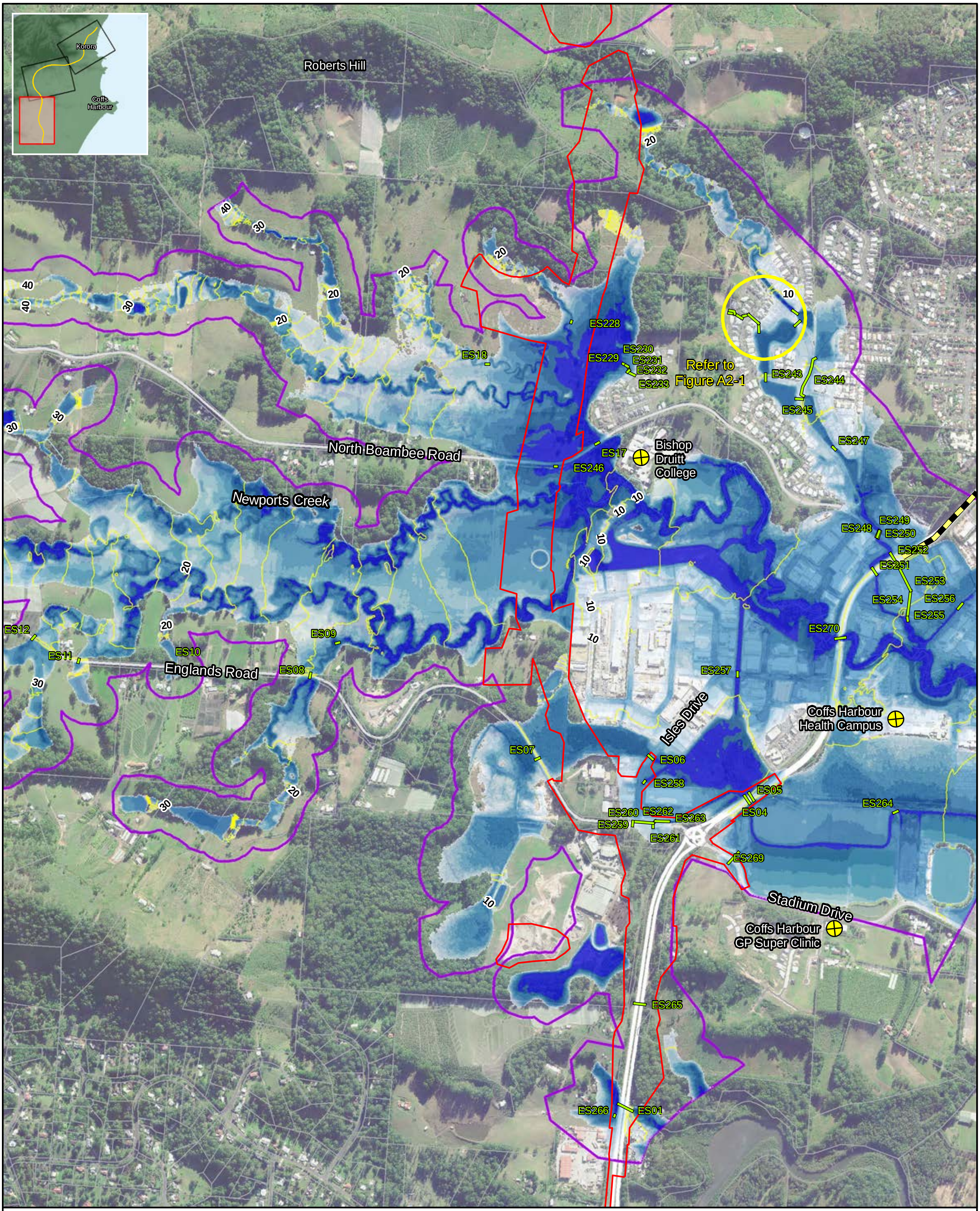
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Northern creeks 1 % AEP 2100 climate peak flood level and depth
Figure B1-3-7

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

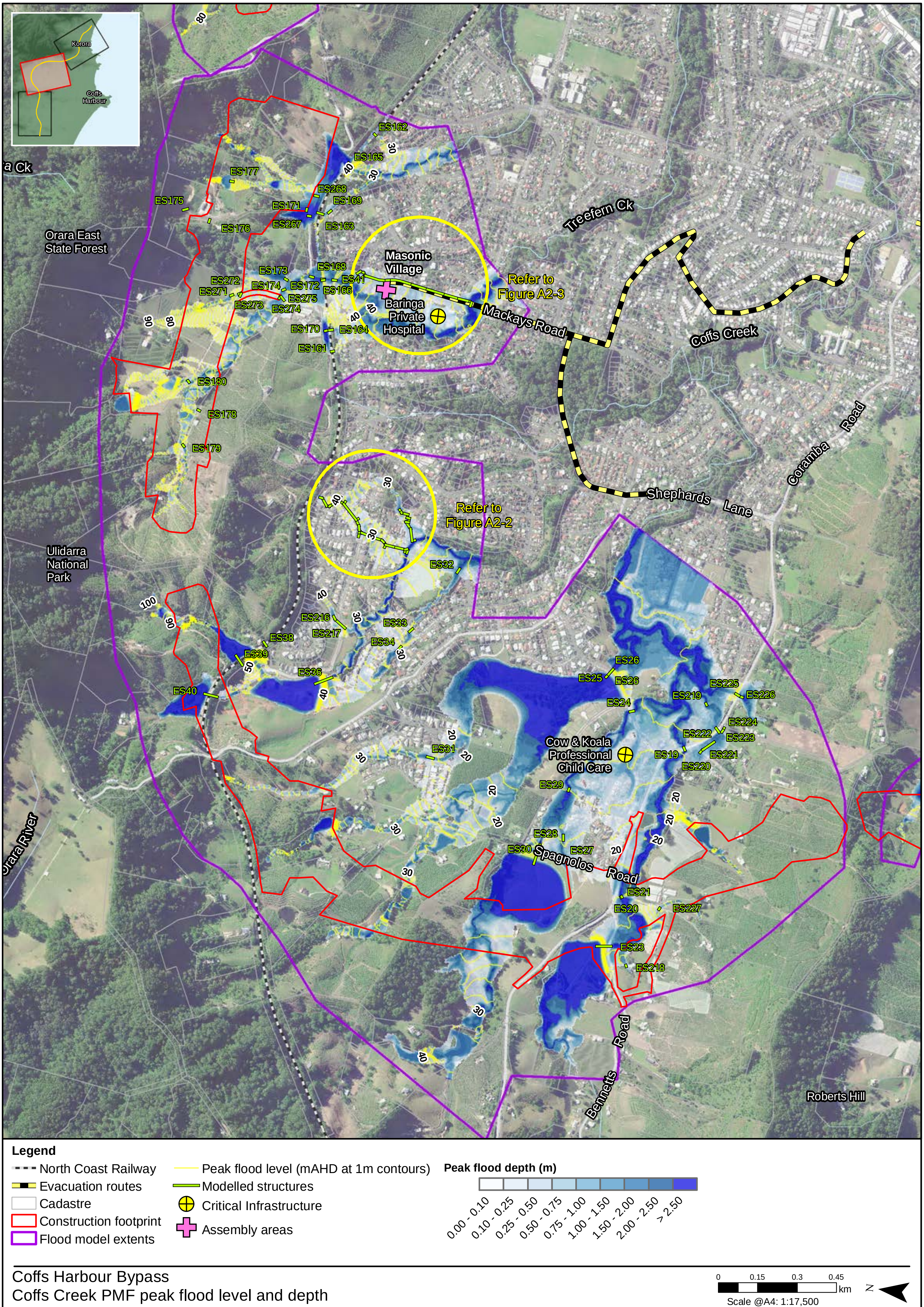
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood depth (m)

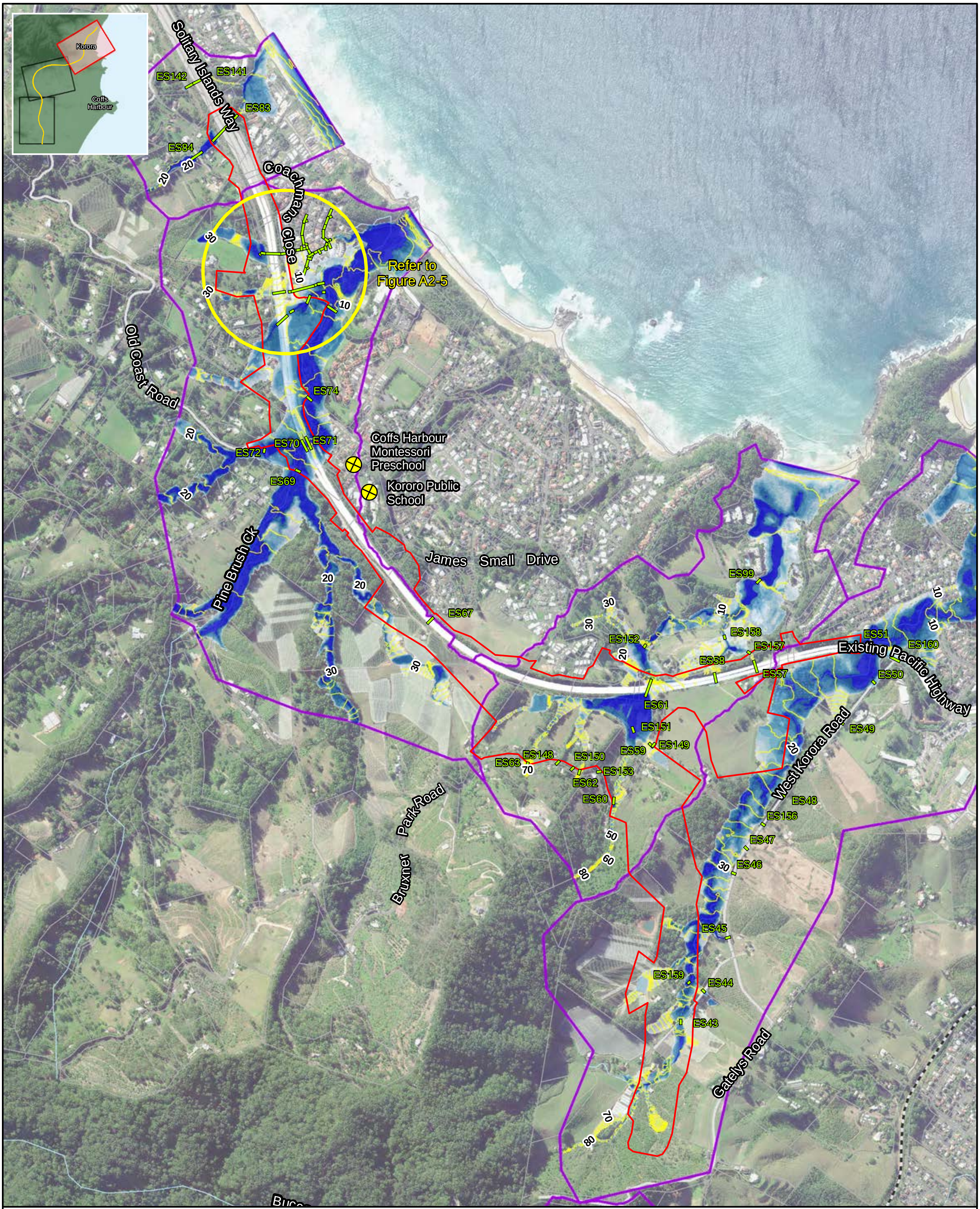
0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
North Boambee Valley PMF peak flood level and depth
Figure B1-1-8

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Coffs Harbour Bypass
Coffs Creek PMF peak flood level and depth
Figure B1-2-8



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Peak flood level (mAHD at 1m contours)
- Modelled structures
- Critical Infrastructure
- Assembly areas

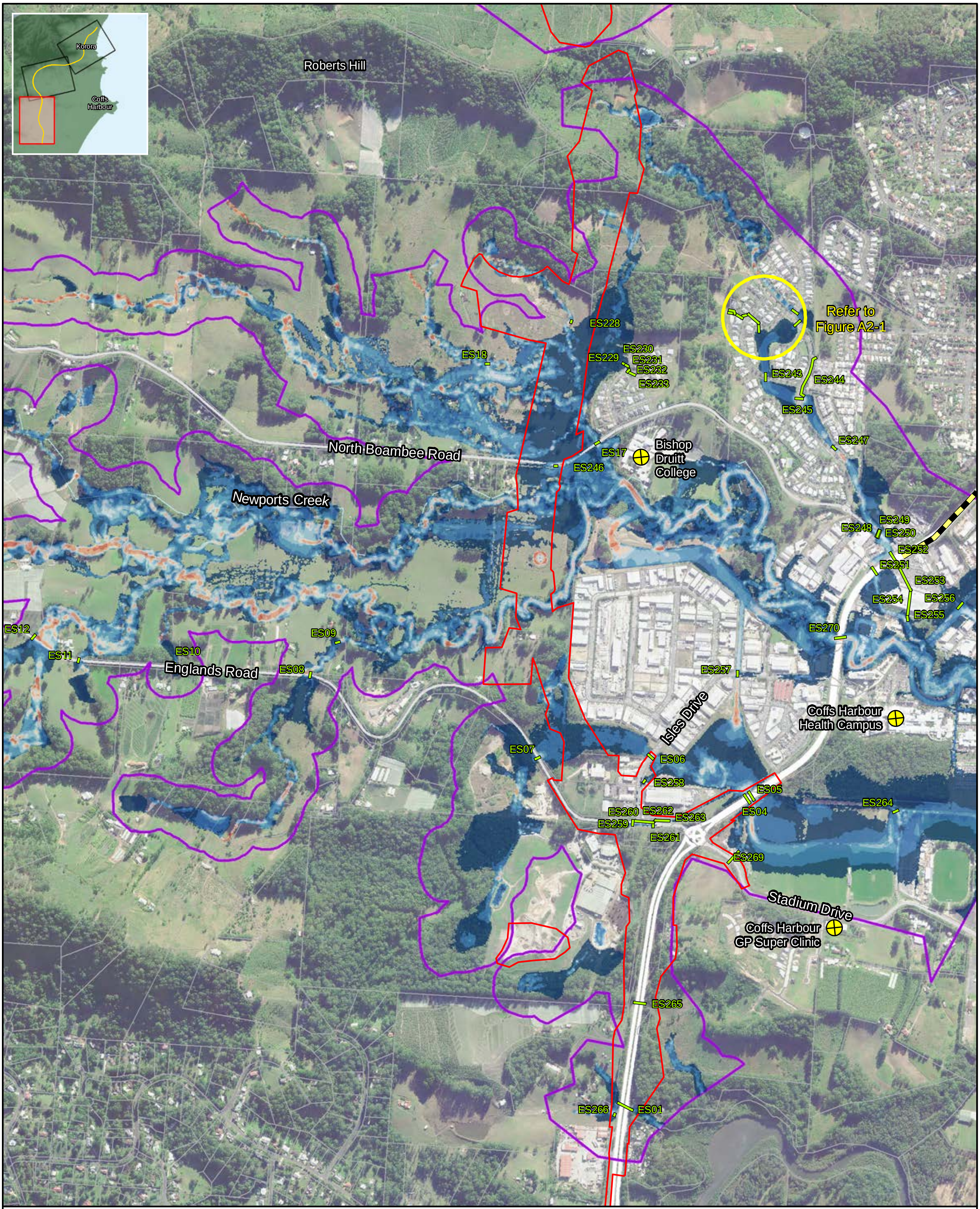
Peak flood depth (m)

0.00 - 0.10, 0.10 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.50, 1.50 - 2.00, 2.00 - 2.50, > 2.50

Coffs Harbour Bypass
Northern creeks PMF peak flood level and depth
Figure B1-3-8

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

B2 Peak flood velocity



Legend

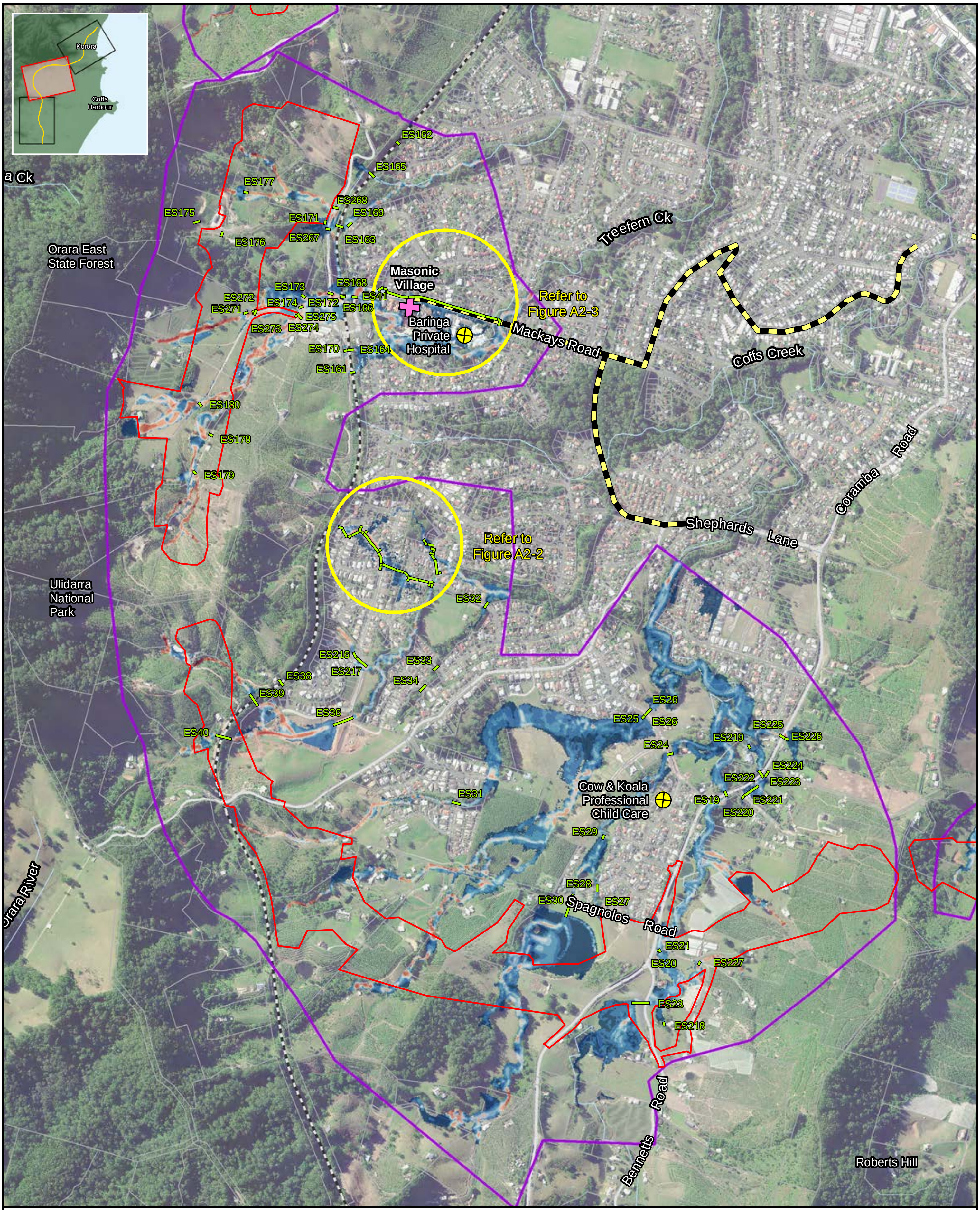
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
North Boambee Valley 18 % AEP peak flood velocity
Figure B2-1-1

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

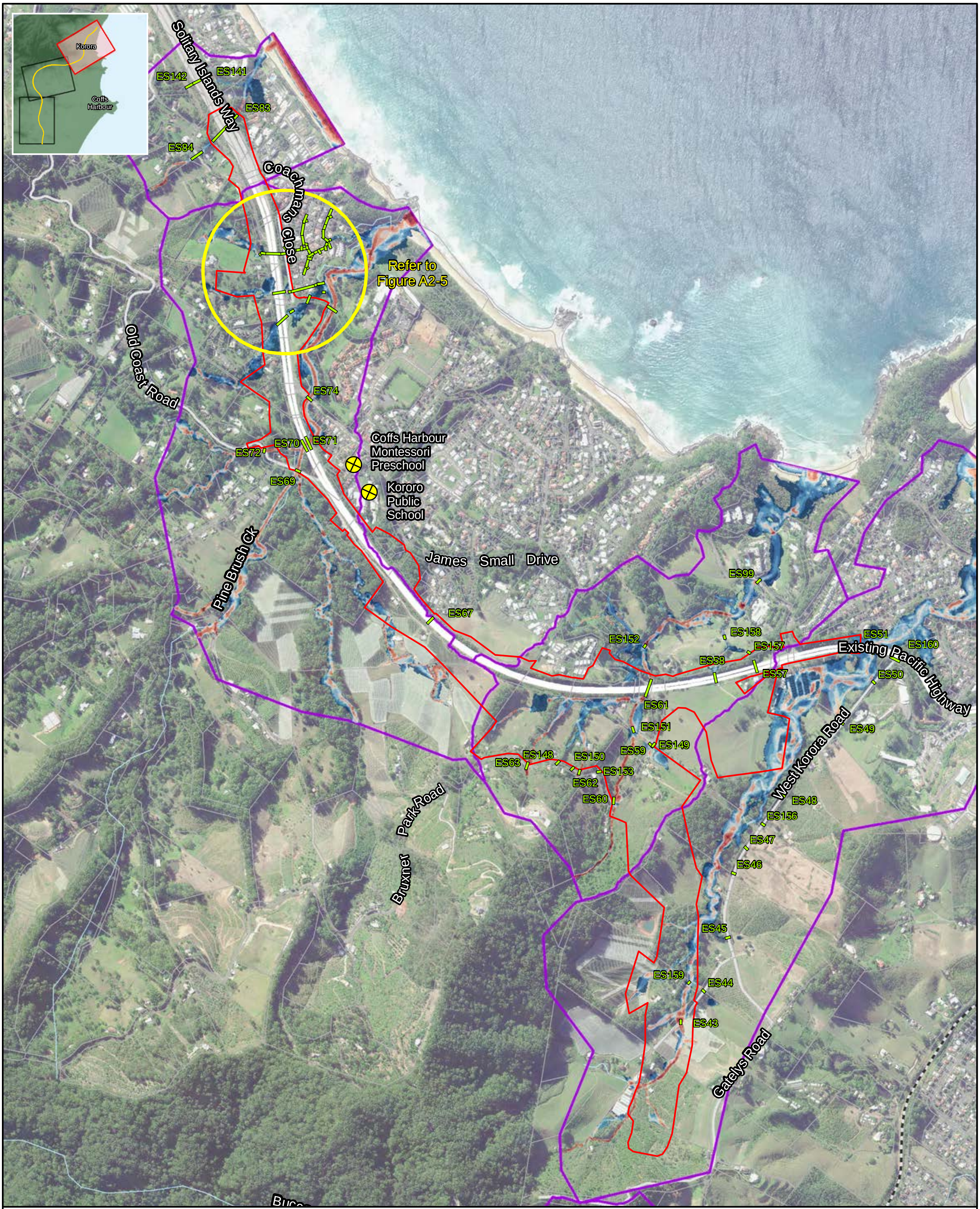
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Coffs Creek 18 % AEP peak flood velocity
Figure B2-2-1

0 0.15 0.3 0.45 km N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

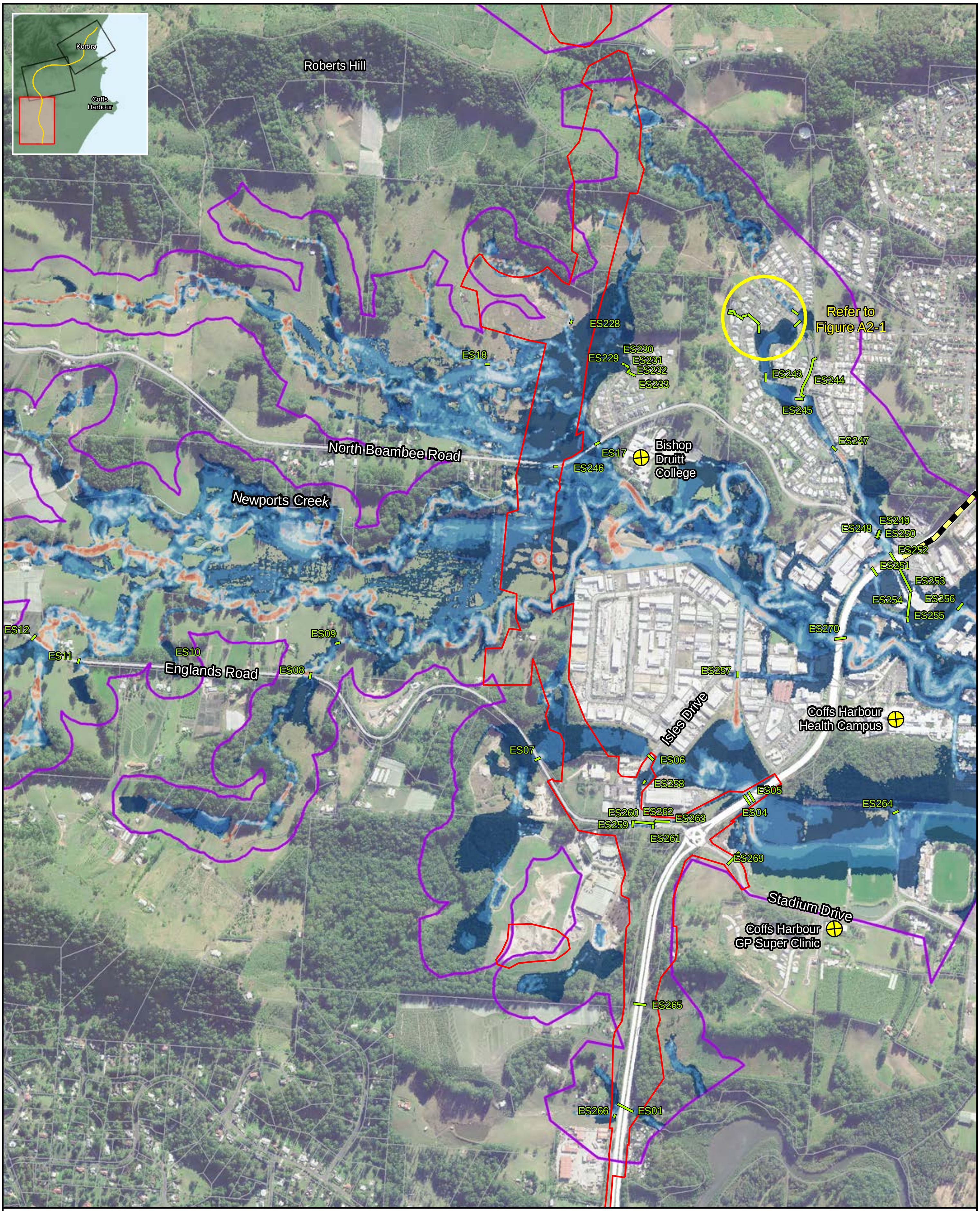
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Northern creeks 18 % AEP peak flood velocity
Figure B2-3-1

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

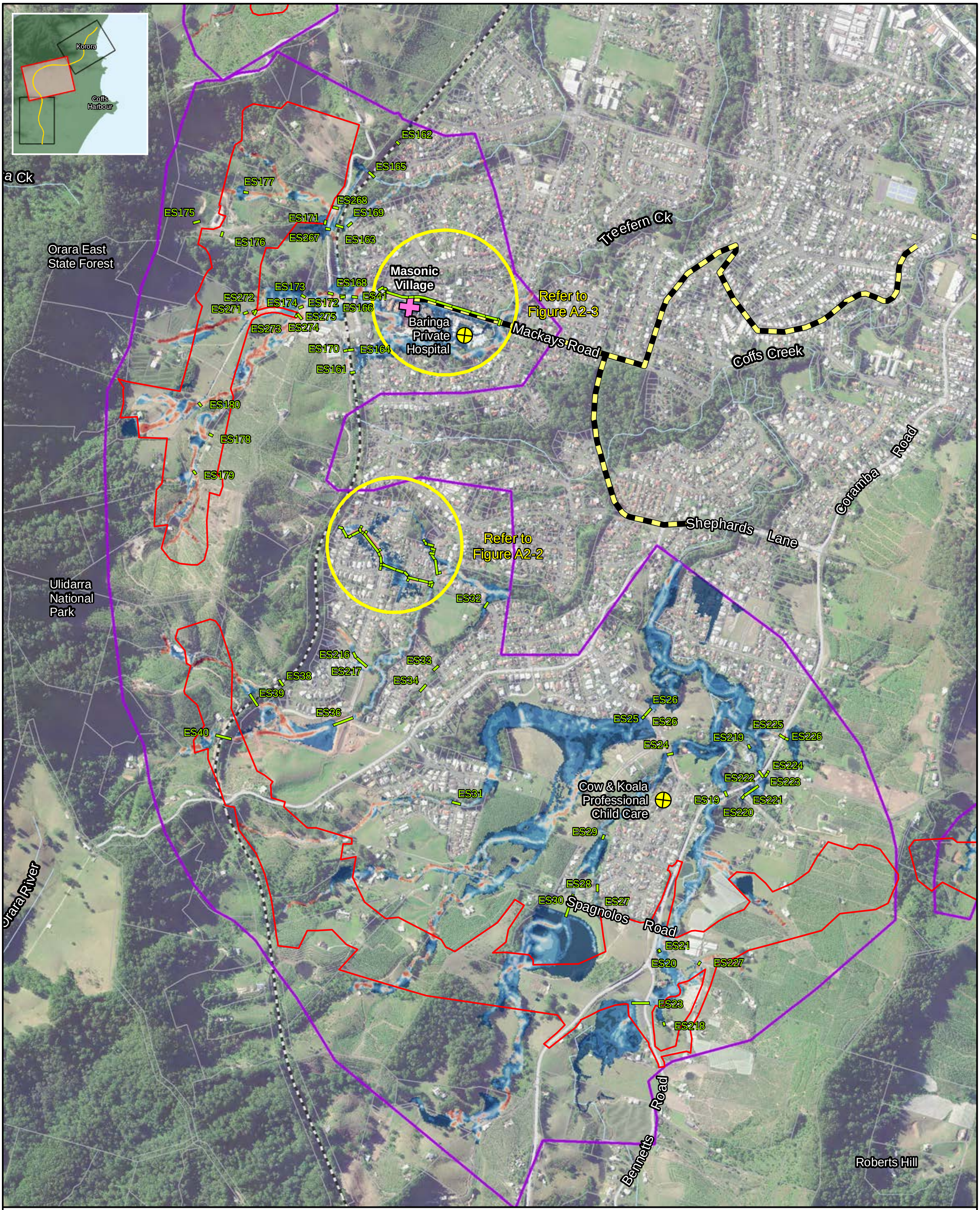
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
North Boambee Valley 10 % AEP peak flood velocity
Figure B2-1-2

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

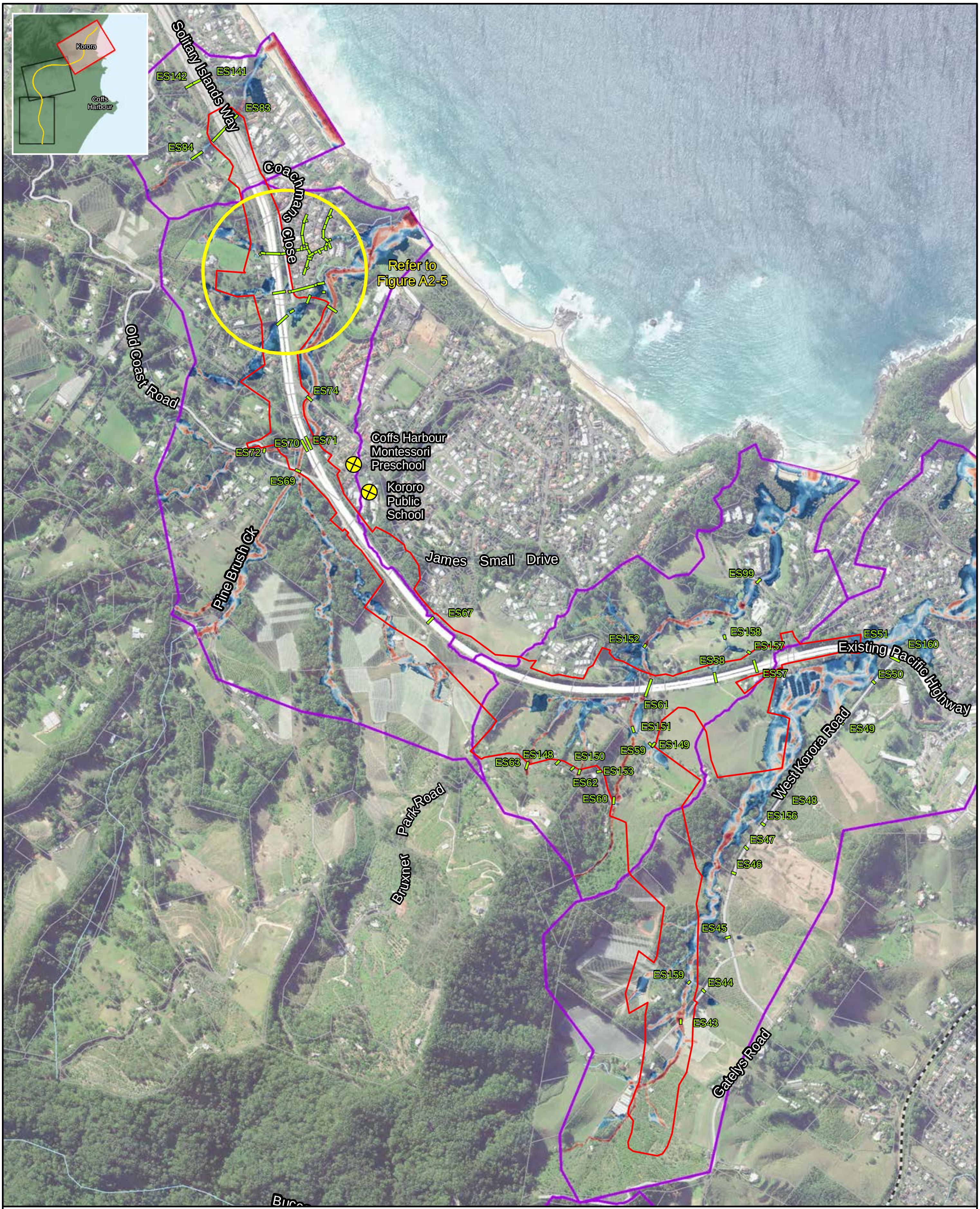
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Coffs Creek 10 % AEP peak flood velocity
Figure B2-2-2

0 0.15 0.3 0.45 km N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

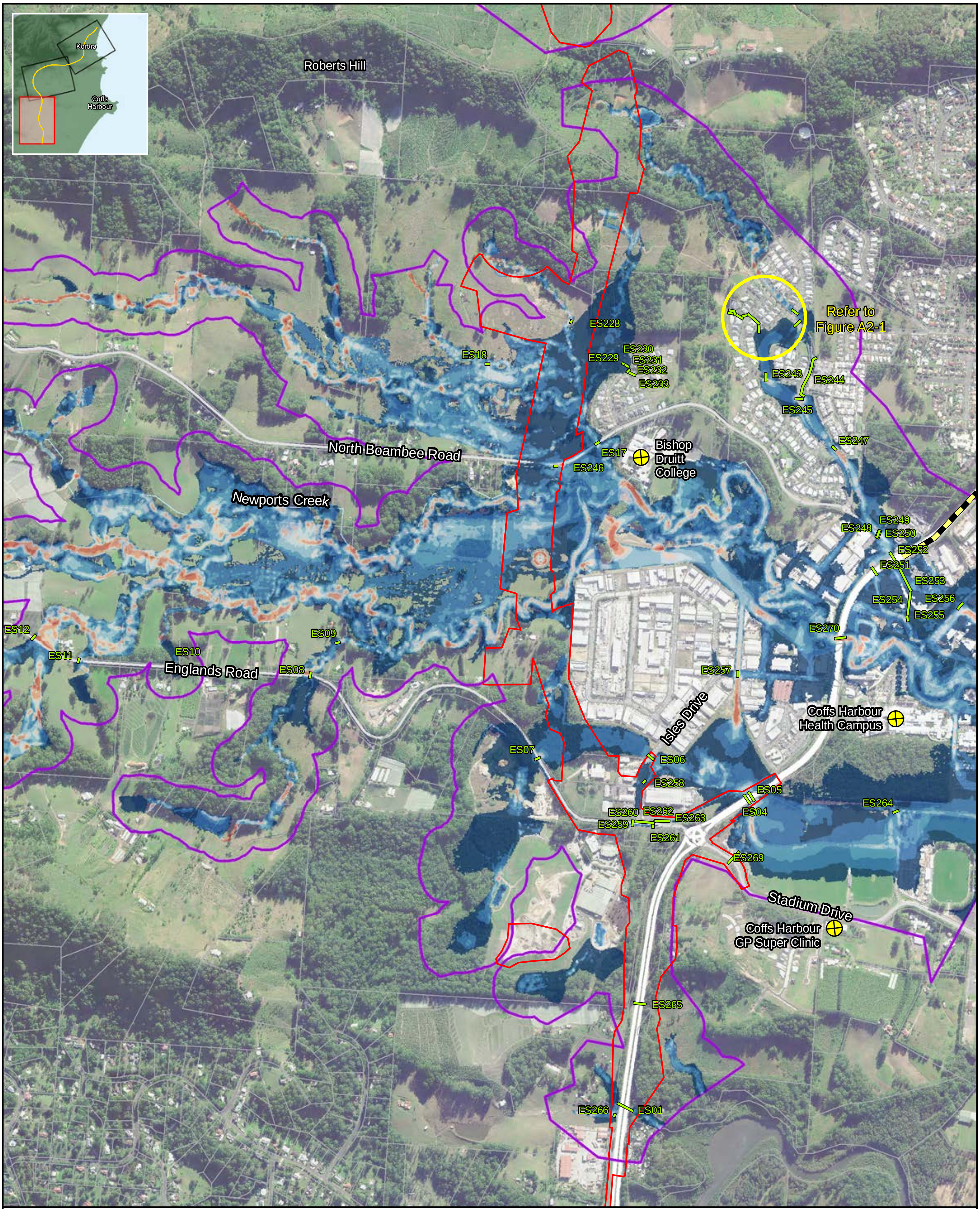
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Northern creeks 10 % AEP peak flood velocity
Figure B2-3-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

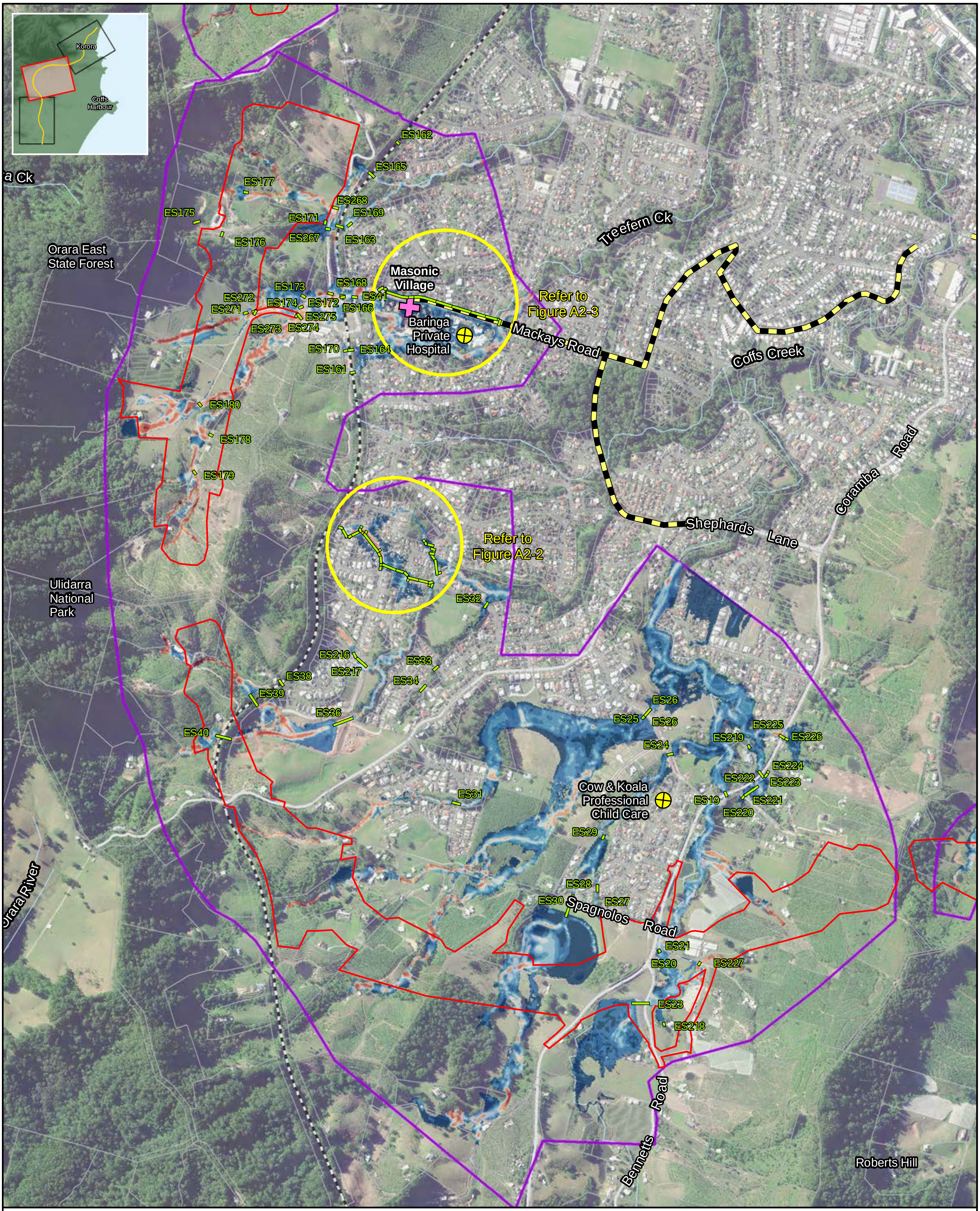
Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
North Boambee Valley 5 % AEP peak flood velocity
Figure B2-1-3

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

N



Legend

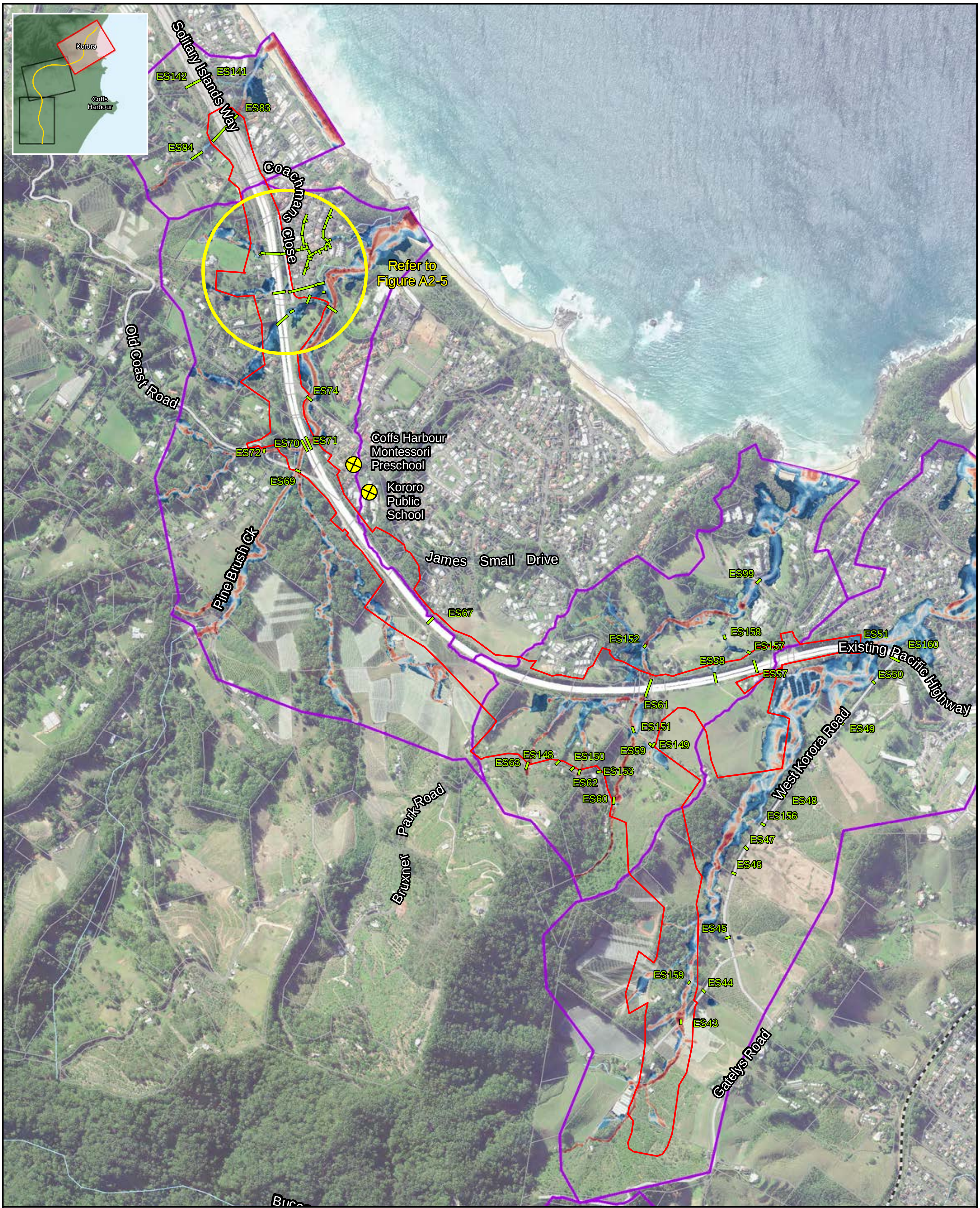
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Coffs Creek 5 % AEP peak flood velocity
Figure B2-2-3

0 0.15 0.3 0.45 km N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

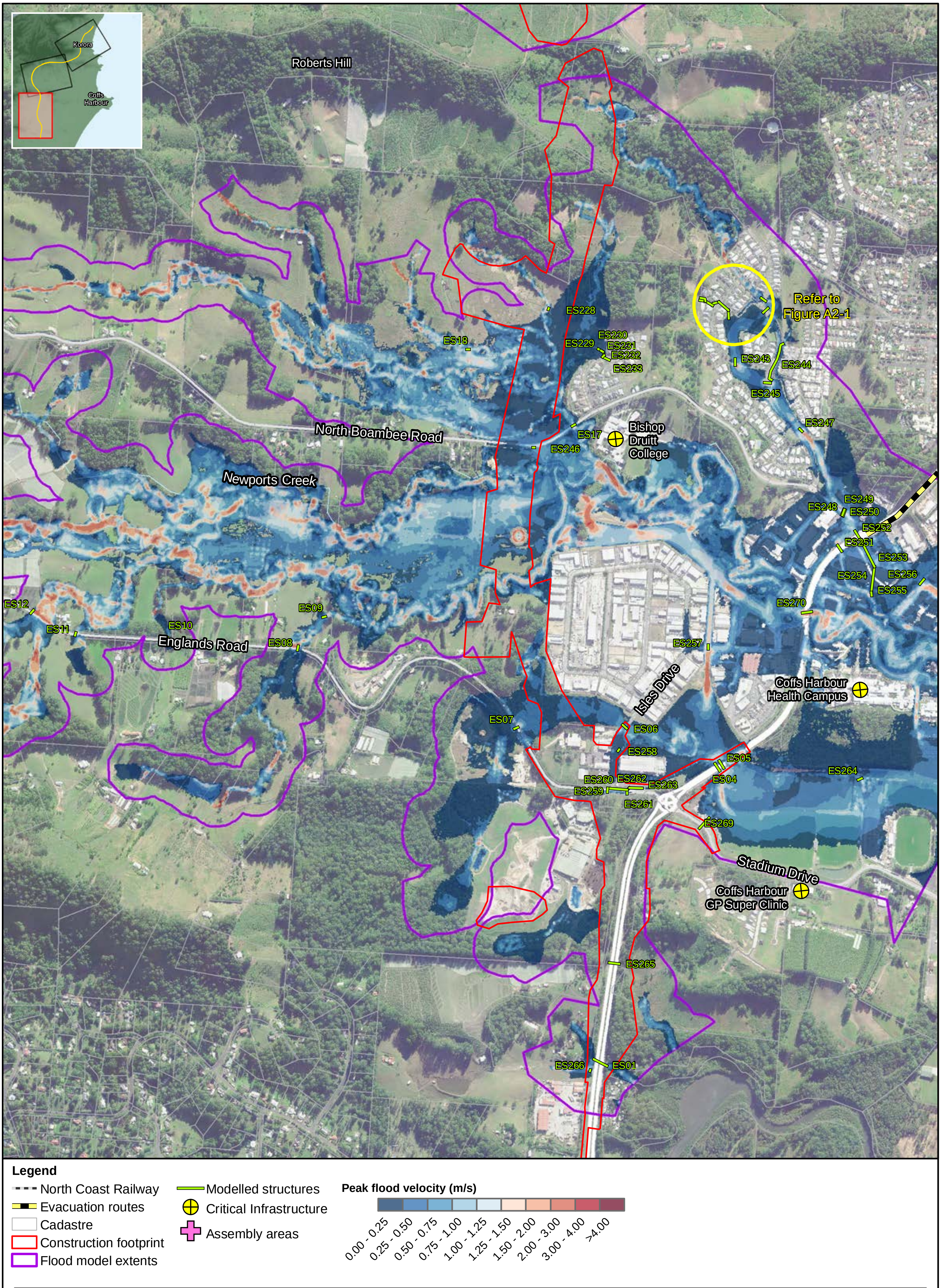
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

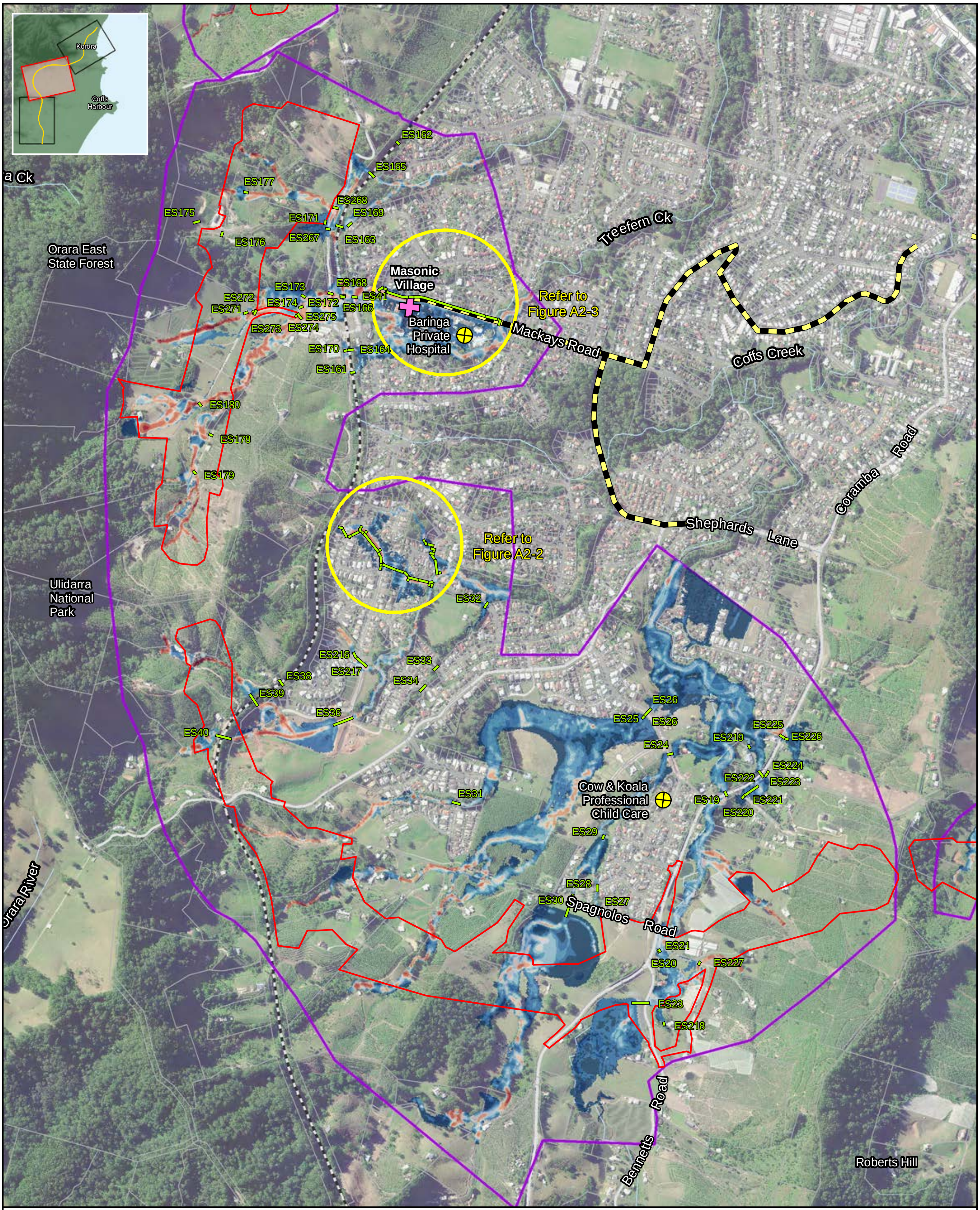
0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Northern creeks 5 % AEP peak flood velocity
Figure B2-3-3

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Coffs Harbour Bypass
North Boambee Valley 2 % AEP peak flood velocity
Figure B2-1-4



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Coffs Creek 2 % AEP peak flood velocity
Figure B2-2-4

0 0.15 0.3 0.45 km N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Legend

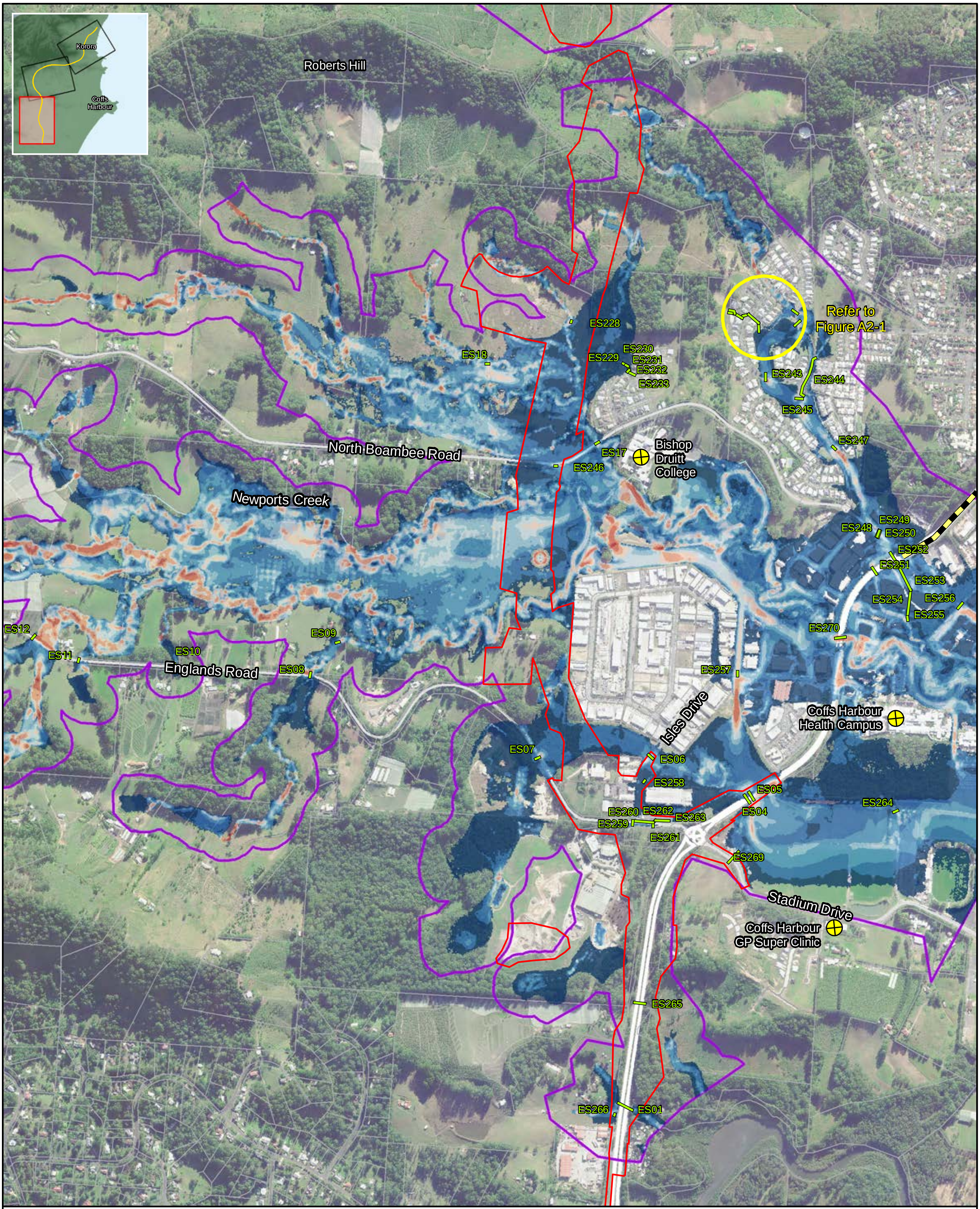
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Northern creeks 2 % AEP peak flood velocity
Figure B2-3-4

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

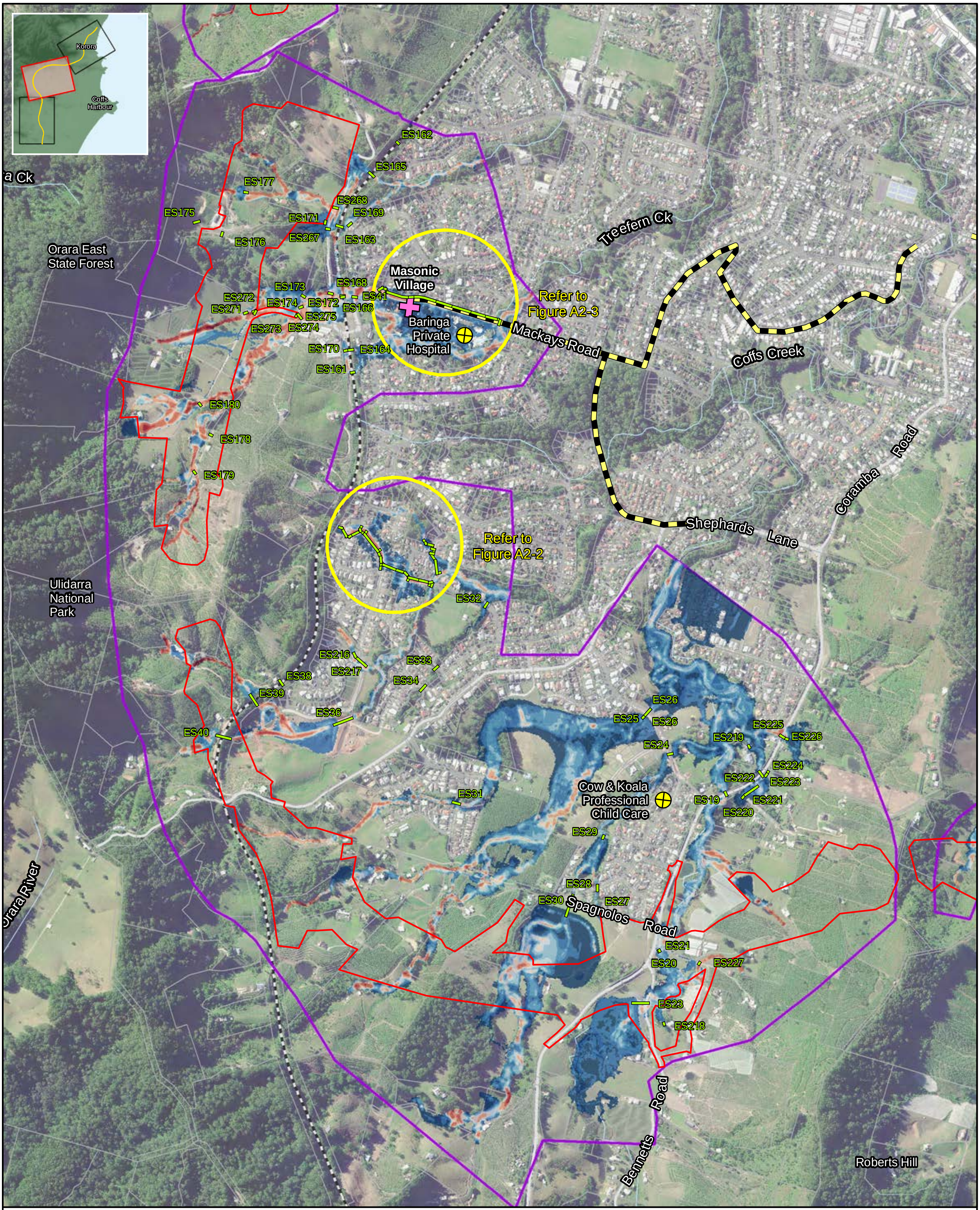
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
North Boambee Valley 1 % AEP peak flood velocity
Figure B2-1-5

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Coffs Creek 1 % AEP peak flood velocity
Figure B2-2-5

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Legend

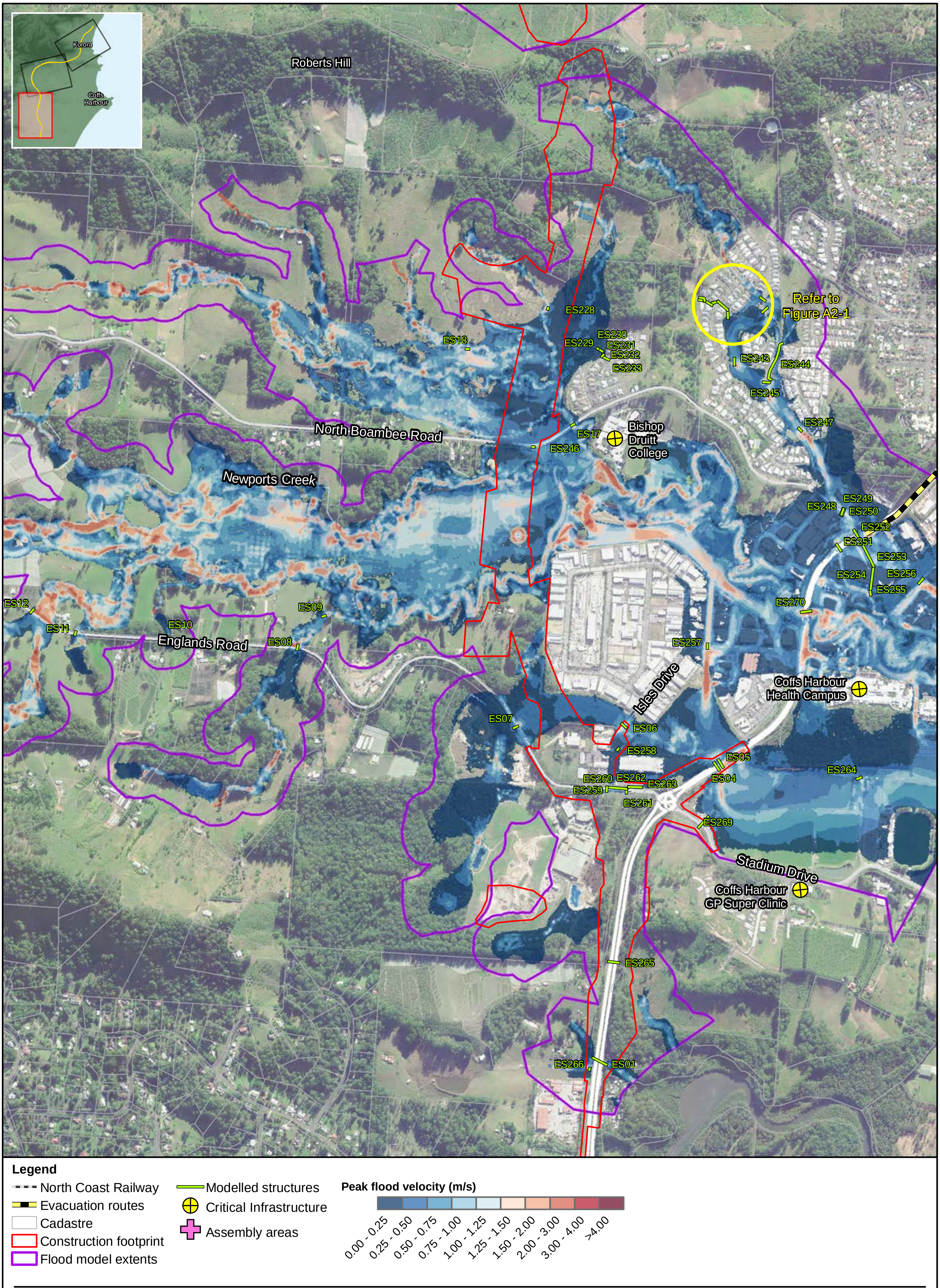
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Modelled structures
Critical Infrastructure
Assembly areas

Peak flood velocity (m/s)

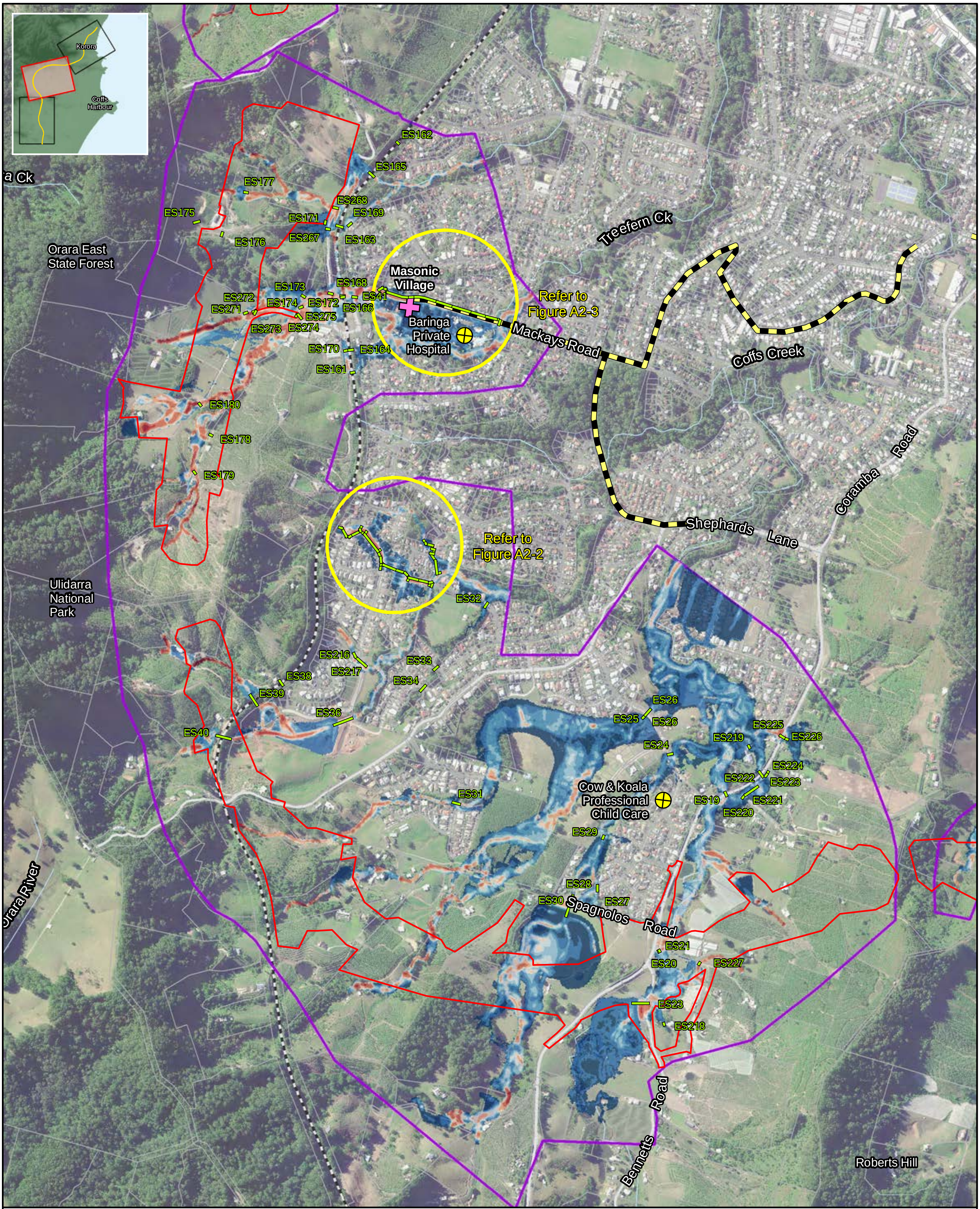
0.00 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.25
1.25 - 1.50
1.50 - 2.00
2.00 - 3.00
3.00 - 4.00
>4.00

Coffs Harbour Bypass
Northern creeks 1 % AEP peak flood velocity
Figure B2-3-5

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Coffs Harbour Bypass
North Boambee Valley 1 % AEP 2050 climate peak flood velocity
Figure B2-1-6



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

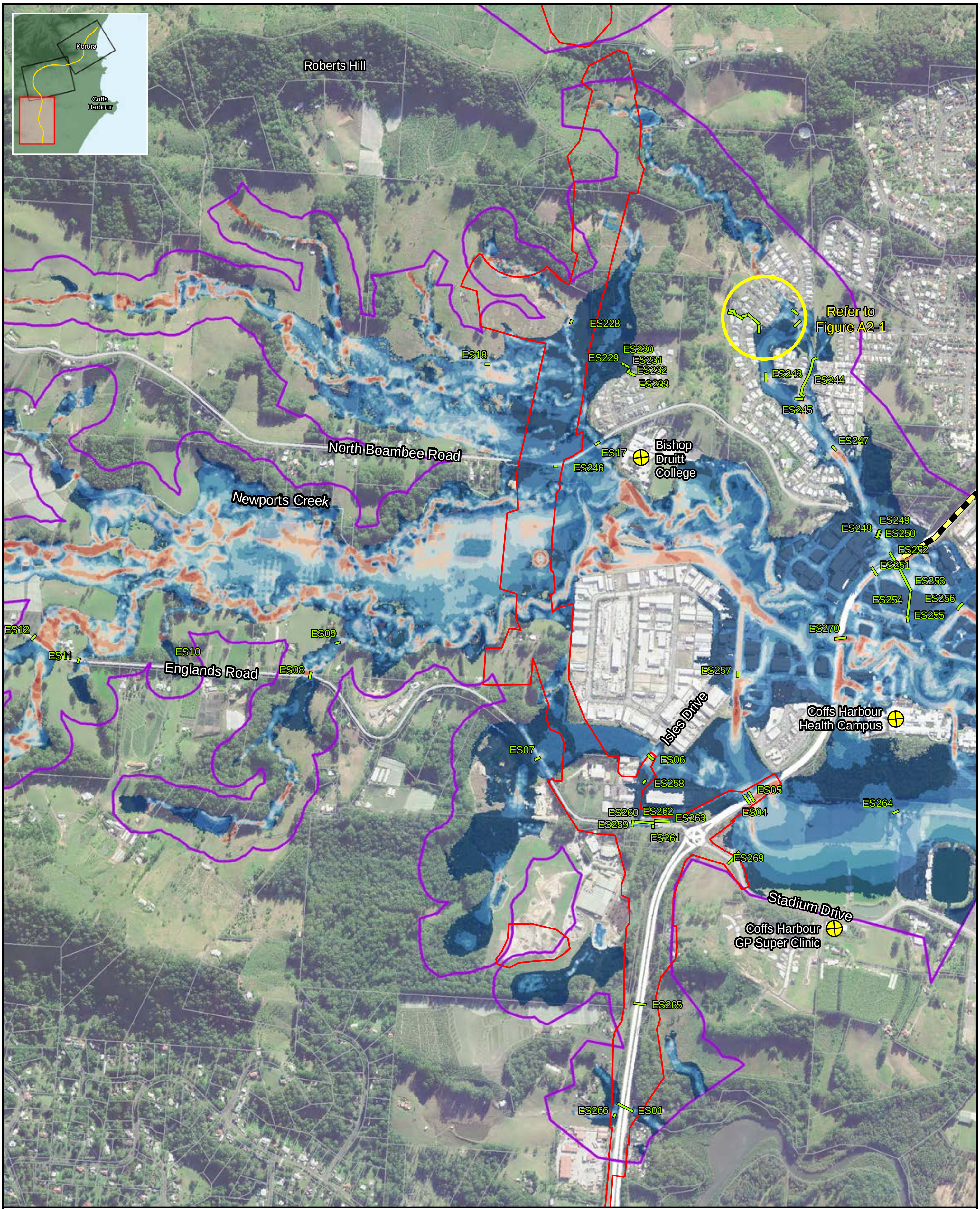
0.00 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.25
1.25 - 1.50
1.50 - 2.00
2.00 - 3.00
3.00 - 4.00
>4.00

0 0.15 0.3 0.45 km N

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Coffs Harbour Bypass
Coffs Creek 1 % AEP 2050 climate peak flood velocity
Figure B2-2-6

Coffs Harbour Bypass
Northern creeks 1 % AEP 2050 climate peak flood velocity
Figure B2-3-6



Legend

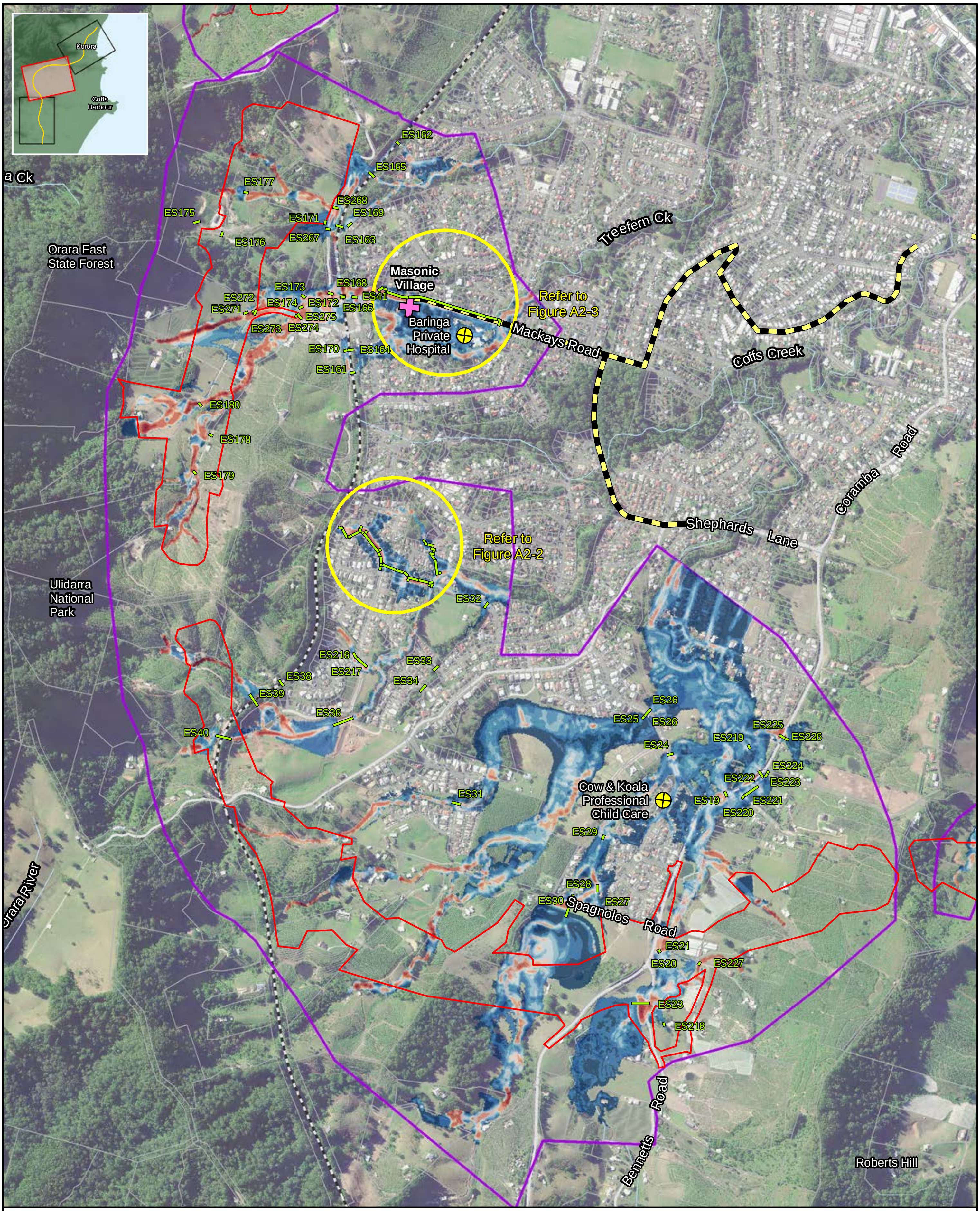
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
North Boambee Valley 1 % AEP 2100 climate peak flood velocity
Figure B2-1-7

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

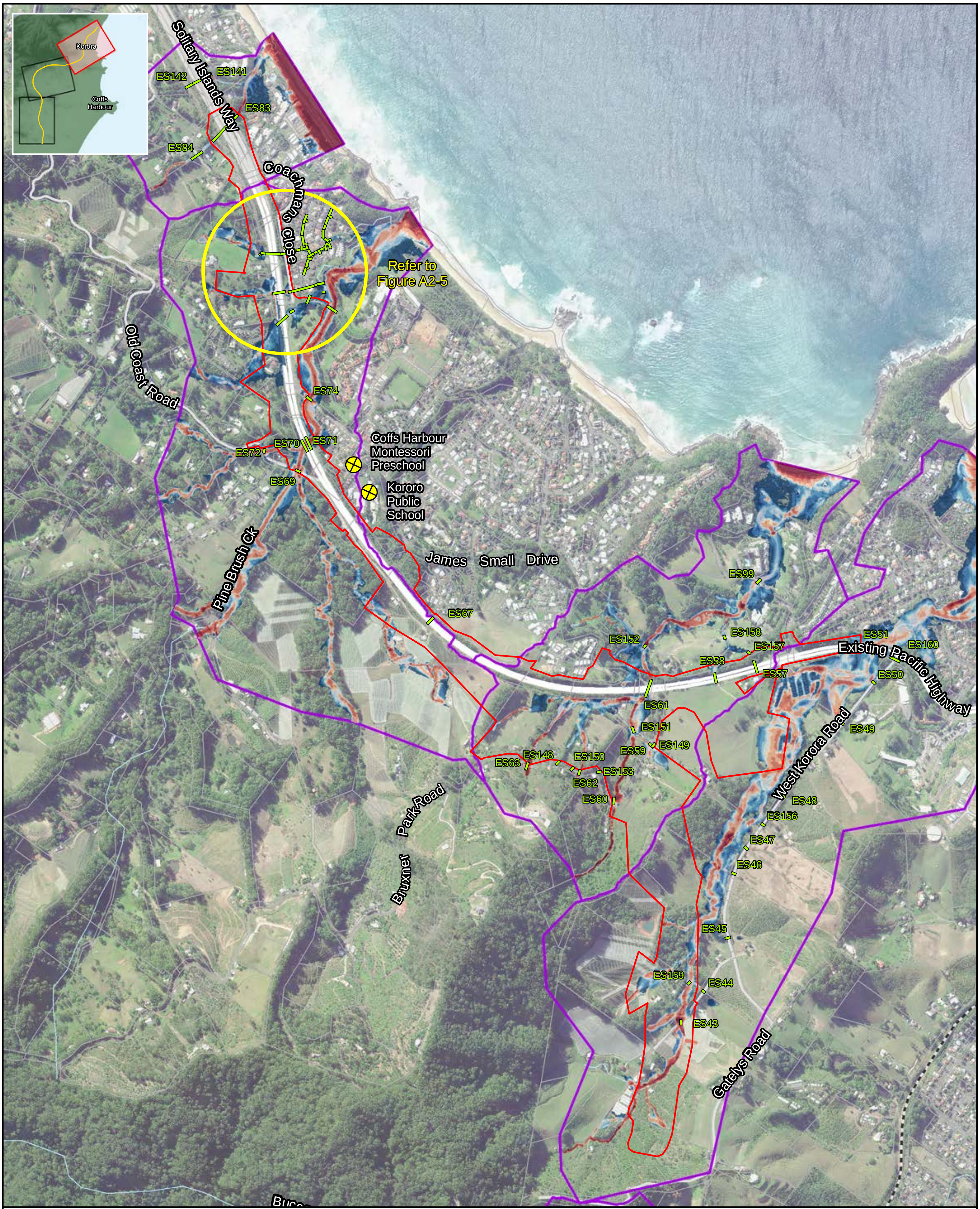
Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

0 0.15 0.3 0.45 km N

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Coffs Harbour Bypass
Coffs Creek 1 % AEP 2100 climate peak flood velocity
Figure B2-2-7



Legend

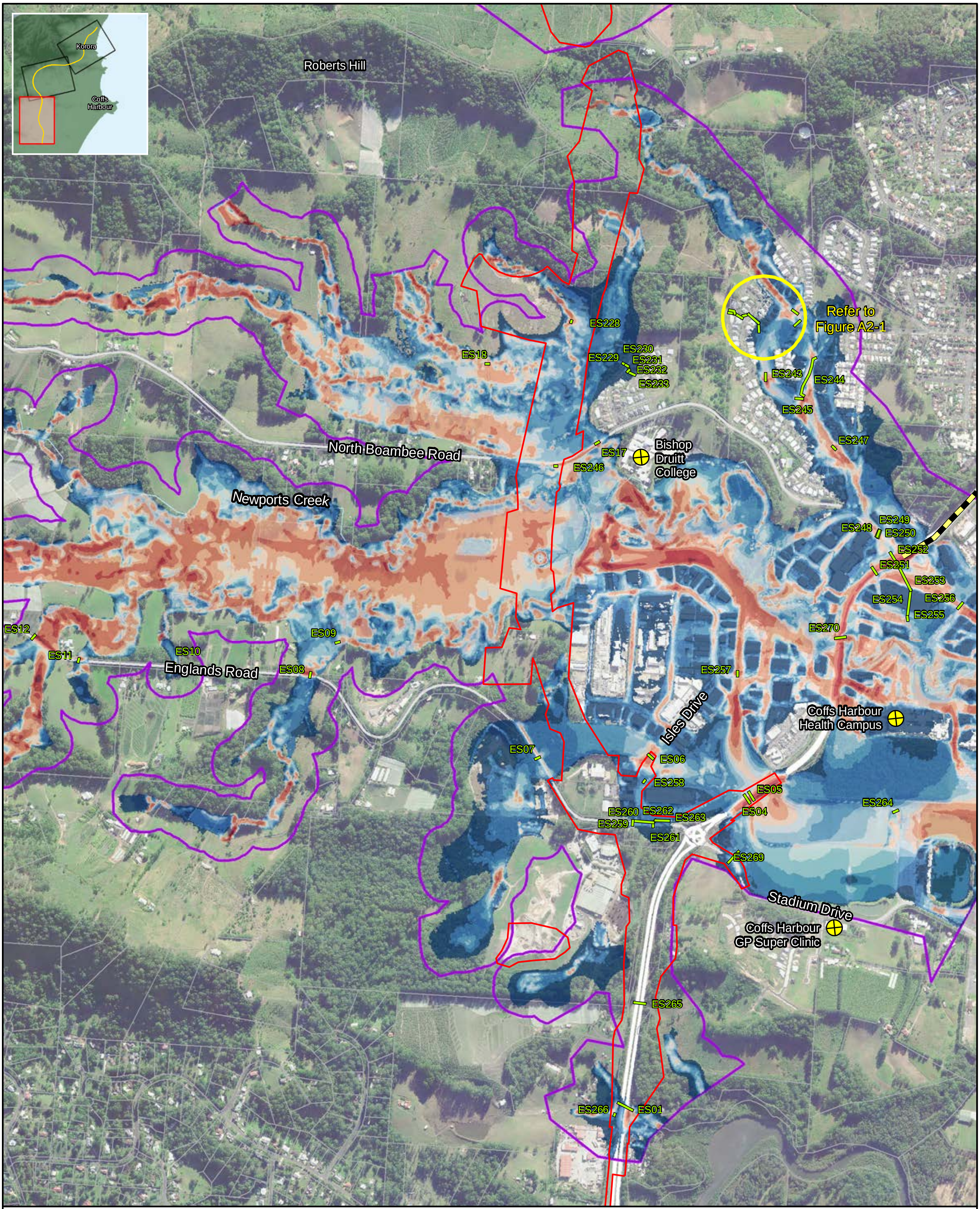
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Northern creeks 1 % AEP 2100 climate peak flood velocity
Figure B2-3-7

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

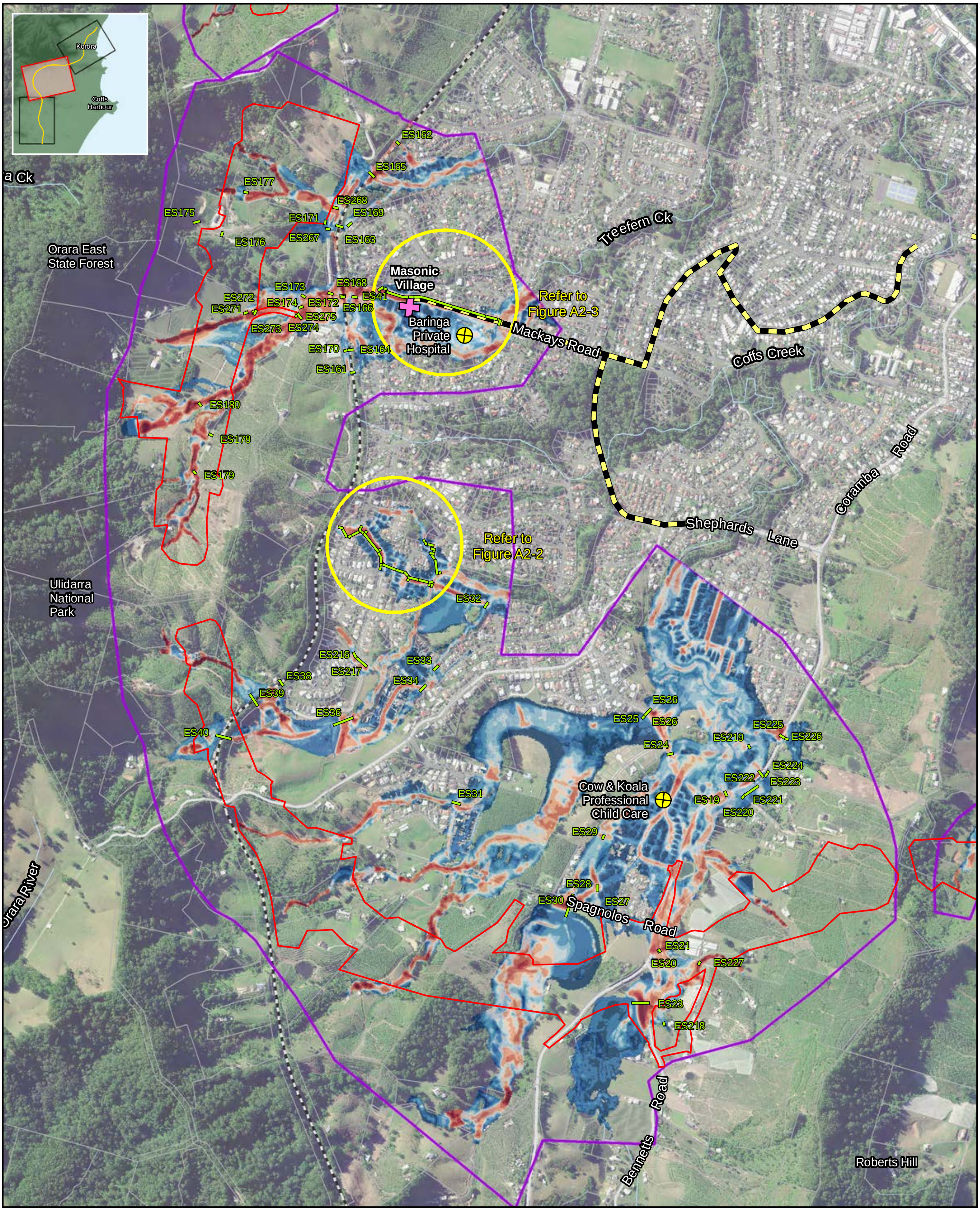
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Modelled structures
Critical Infrastructure
Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.25
1.25 - 1.50
1.50 - 2.00
2.00 - 3.00
3.00 - 4.00
>4.00

Coffs Harbour Bypass
North Boambee Valley PMF peak flood velocity
Figure B2-1-8

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

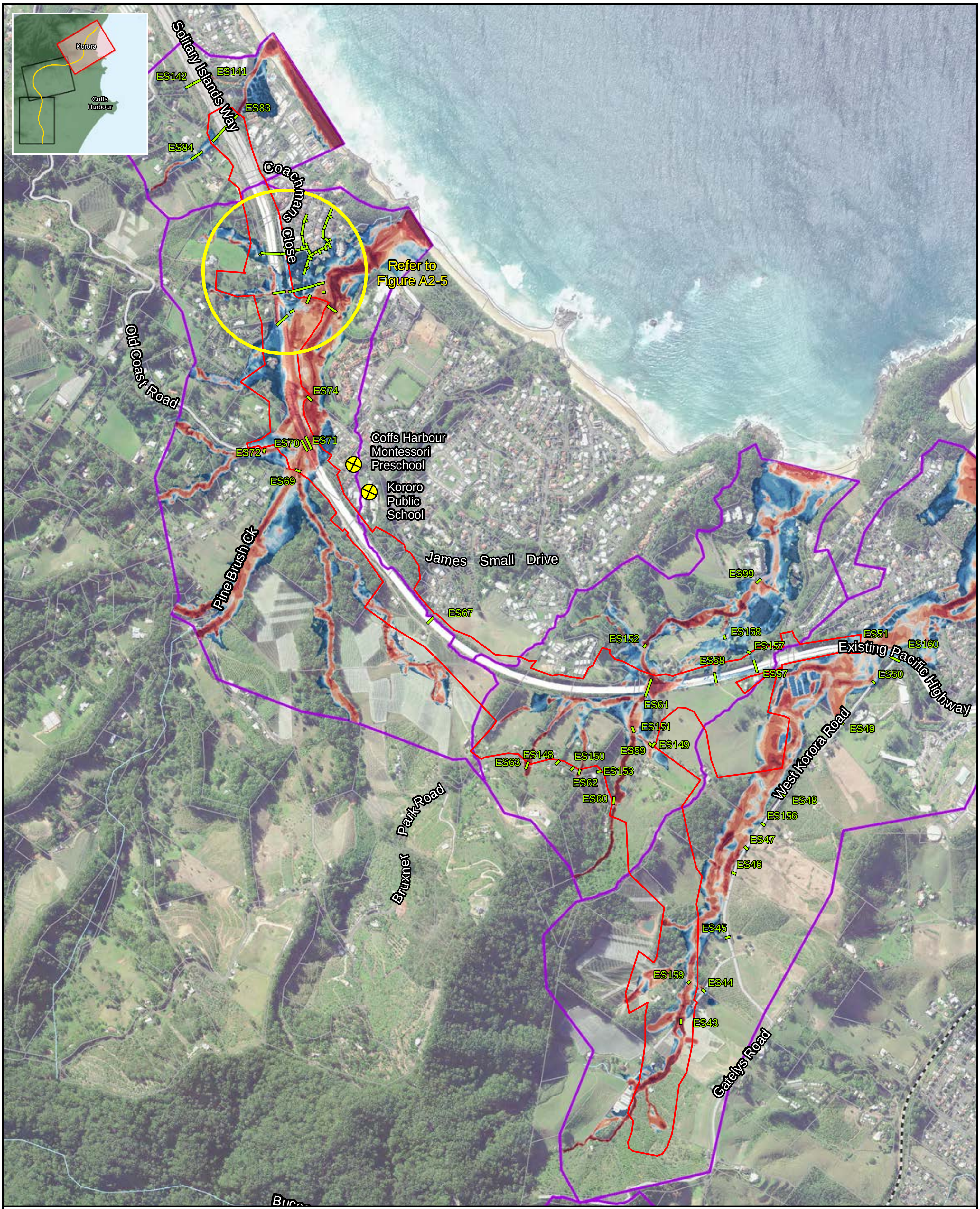
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood velocity (m/s)

0.00 - 0.25, 0.25 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 2.00, 2.00 - 3.00, 3.00 - 4.00, >4.00

Coffs Harbour Bypass
Coffs Creek PMF peak flood velocity
Figure B2-2-8

0 0.15 0.3 0.45 km N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

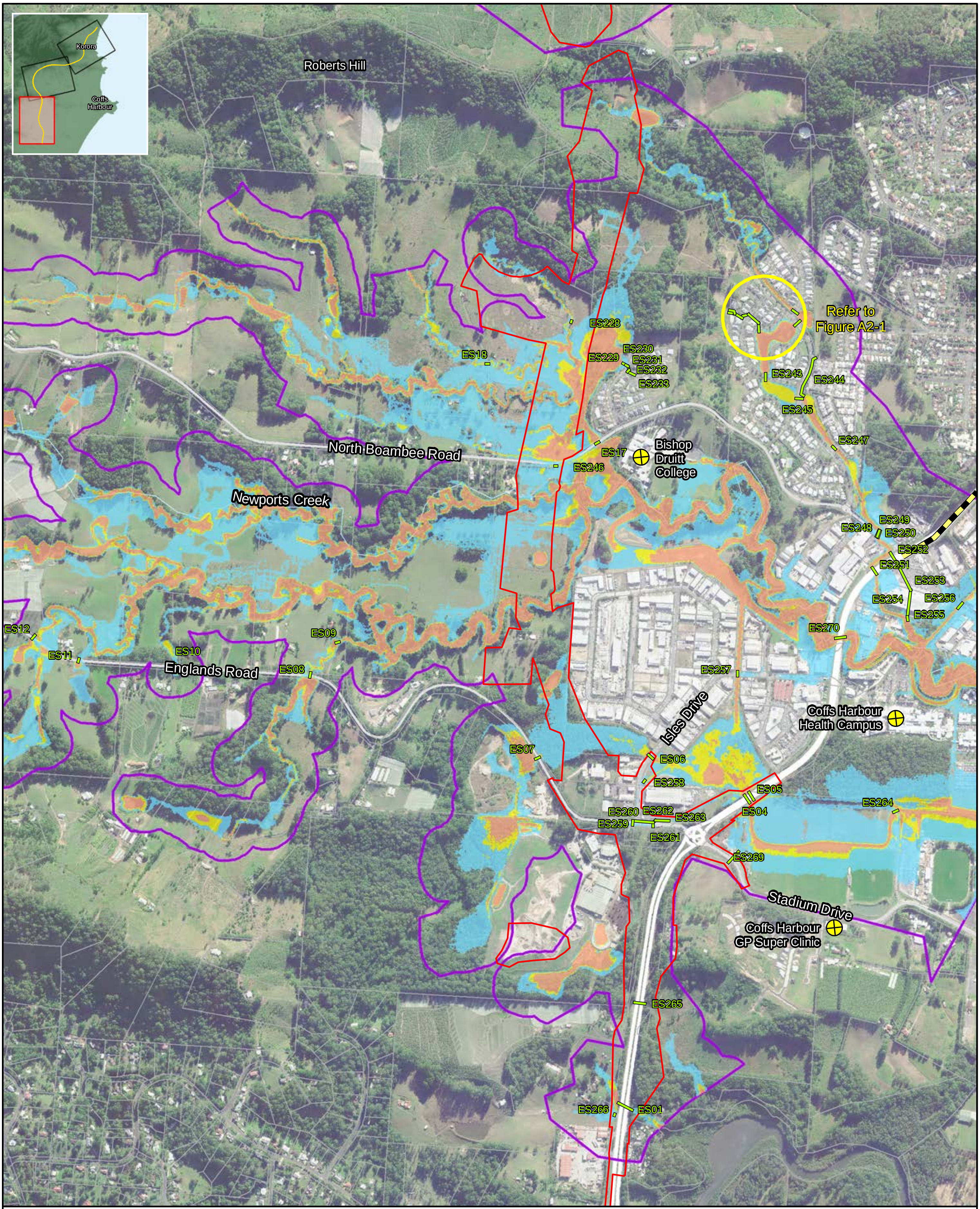
Peak flood velocity (m/s)

0.00 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.25
1.25 - 1.50
1.50 - 2.00
2.00 - 3.00
3.00 - 4.00
>4.00

Coffs Harbour Bypass
Northern creeks PMF peak flood velocity
Figure B2-3-8

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

B3 Peak flood hazard



Legend

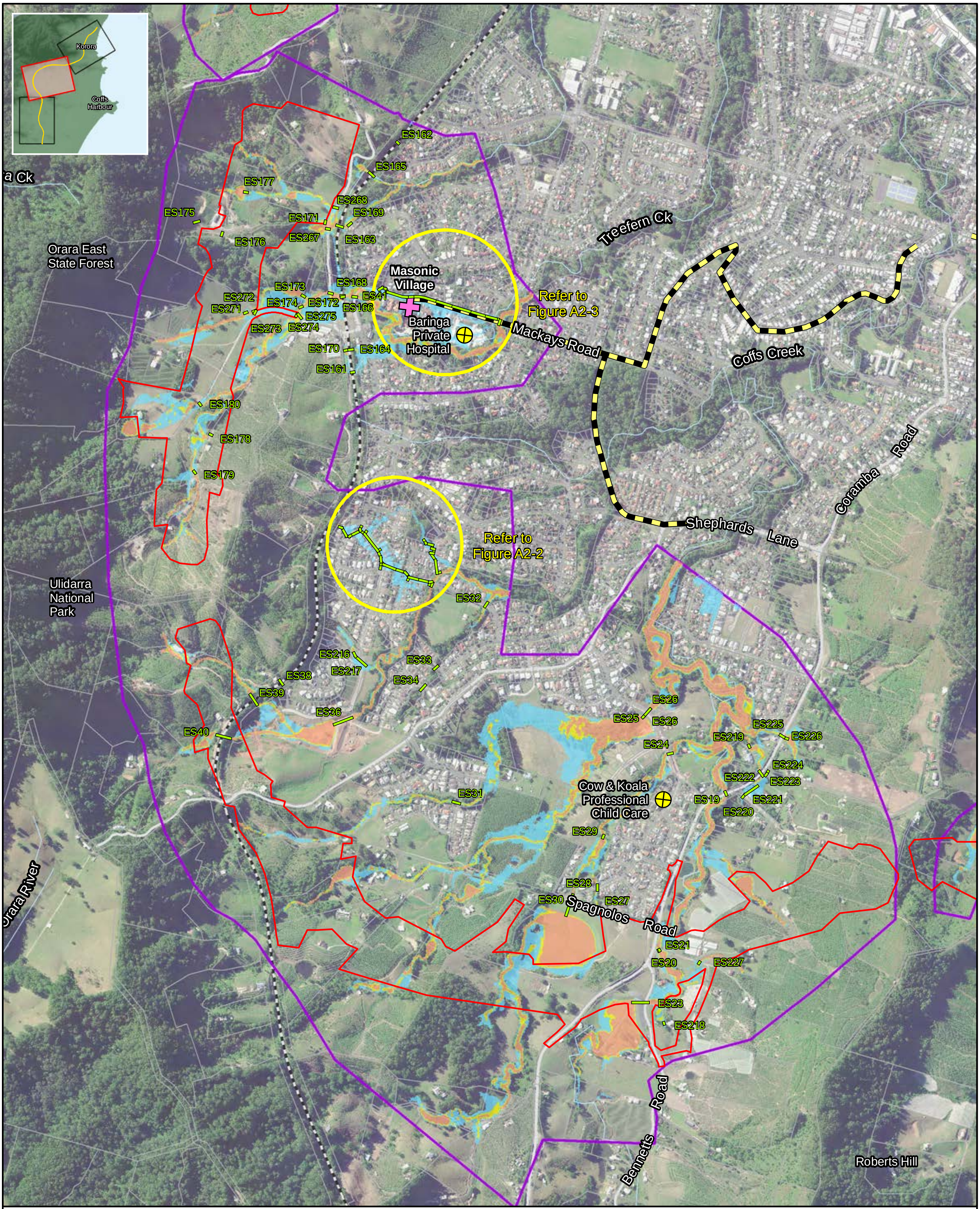
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low, Intermediate, High

Coffs Harbour Bypass
North Boambee Valley 18 % AEP peak flood hazard
Figure B3-1-1

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low | Intermediate | High

Coffs Harbour Bypass
Coffs Creek 18 % AEP peak flood hazard
Figure B3-2-1

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low Intermediate High

Coffs Harbour Bypass

Northern creeks 18 % AEP peak flood hazard

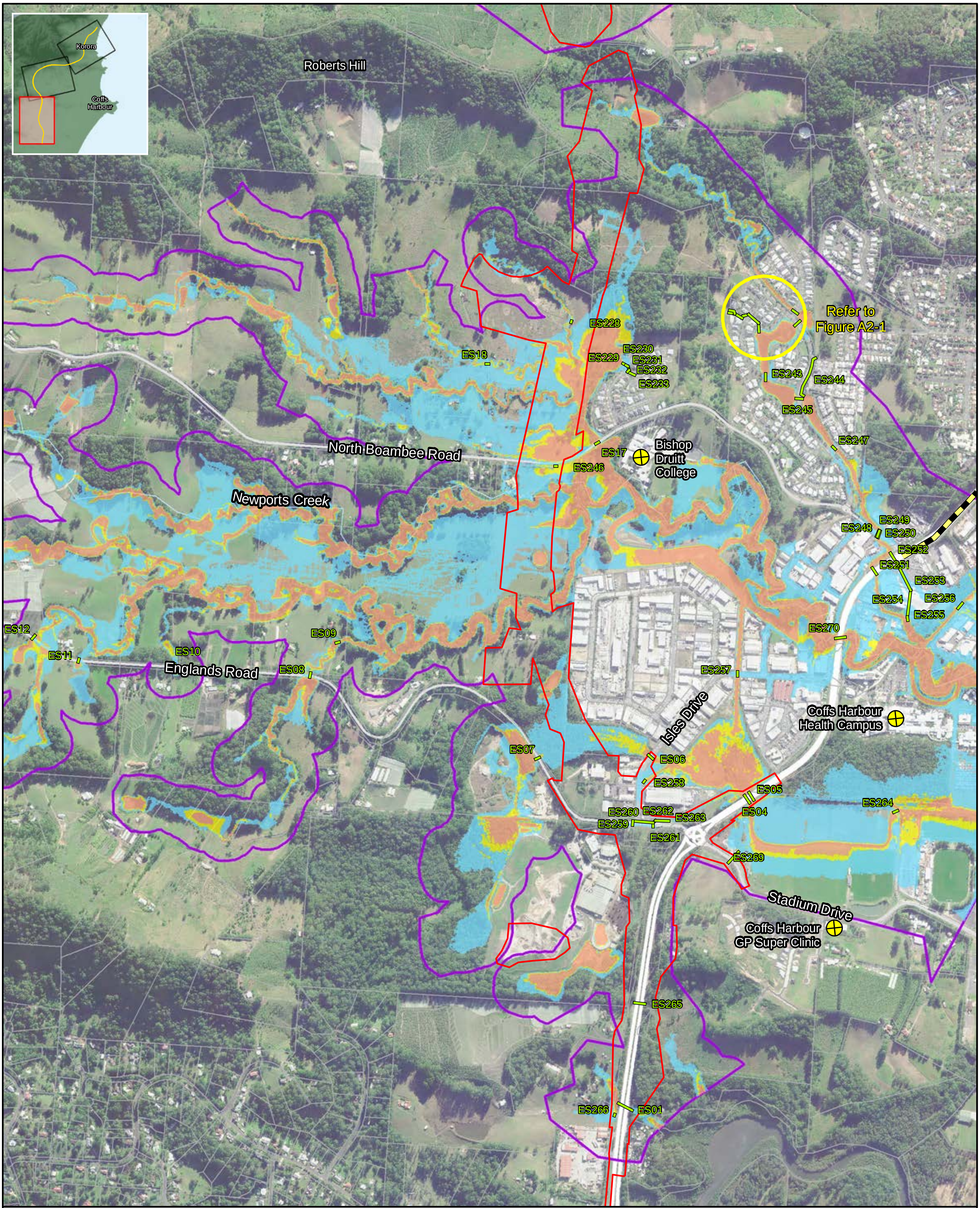
Figure B3-3-1

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500

GDA 1994 MGA Zone 56

N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

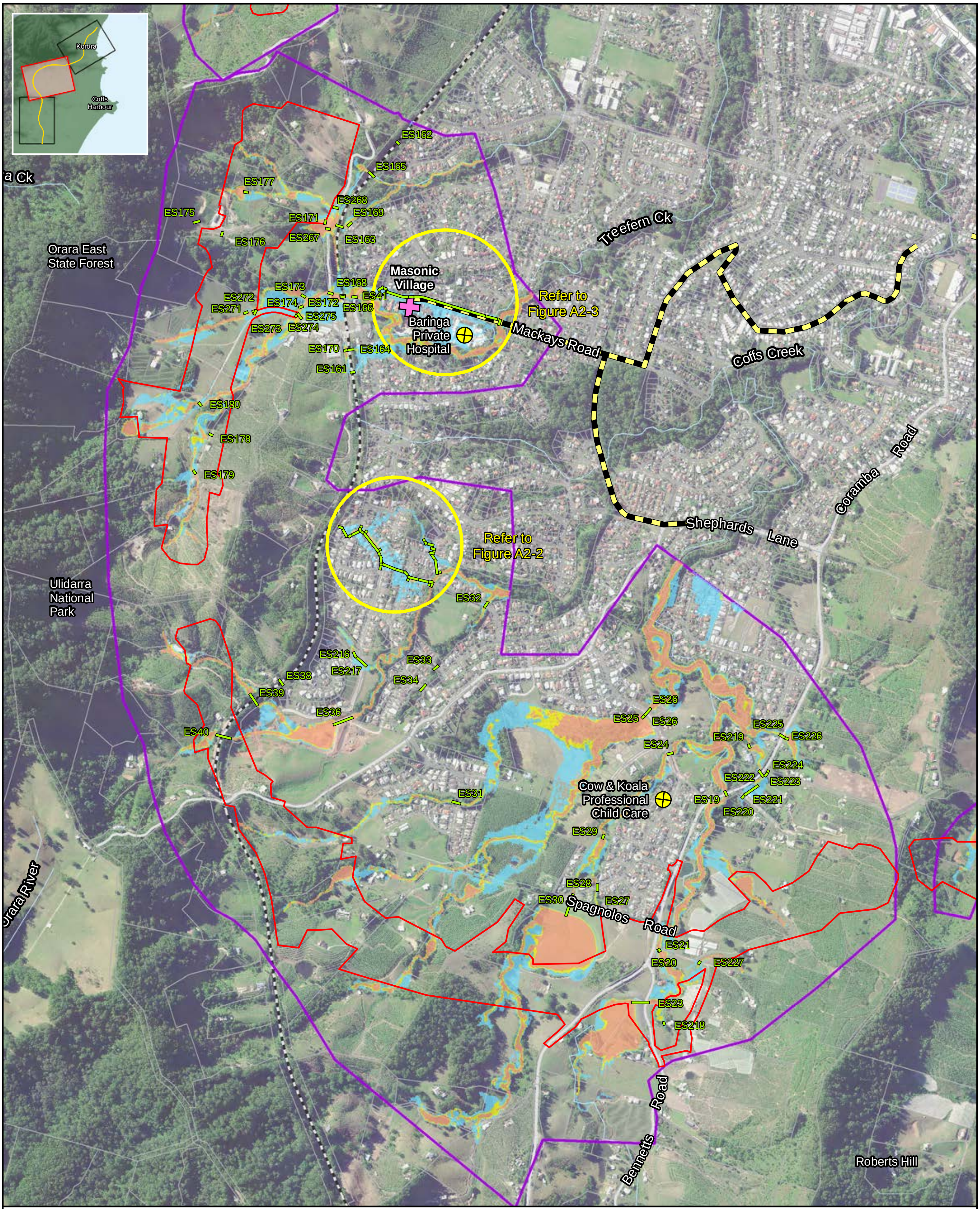
Low | Intermediate | High

Coffs Harbour Bypass
North Boambee Valley 10 % AEP peak flood hazard
Figure B3-1-2

0 | 0.15 | 0.3 | 0.45 km

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low / Intermediate / High

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Coffs Harbour Bypass
Coffs Creek 10 % AEP peak flood hazard
Figure B3-2-2

Legend

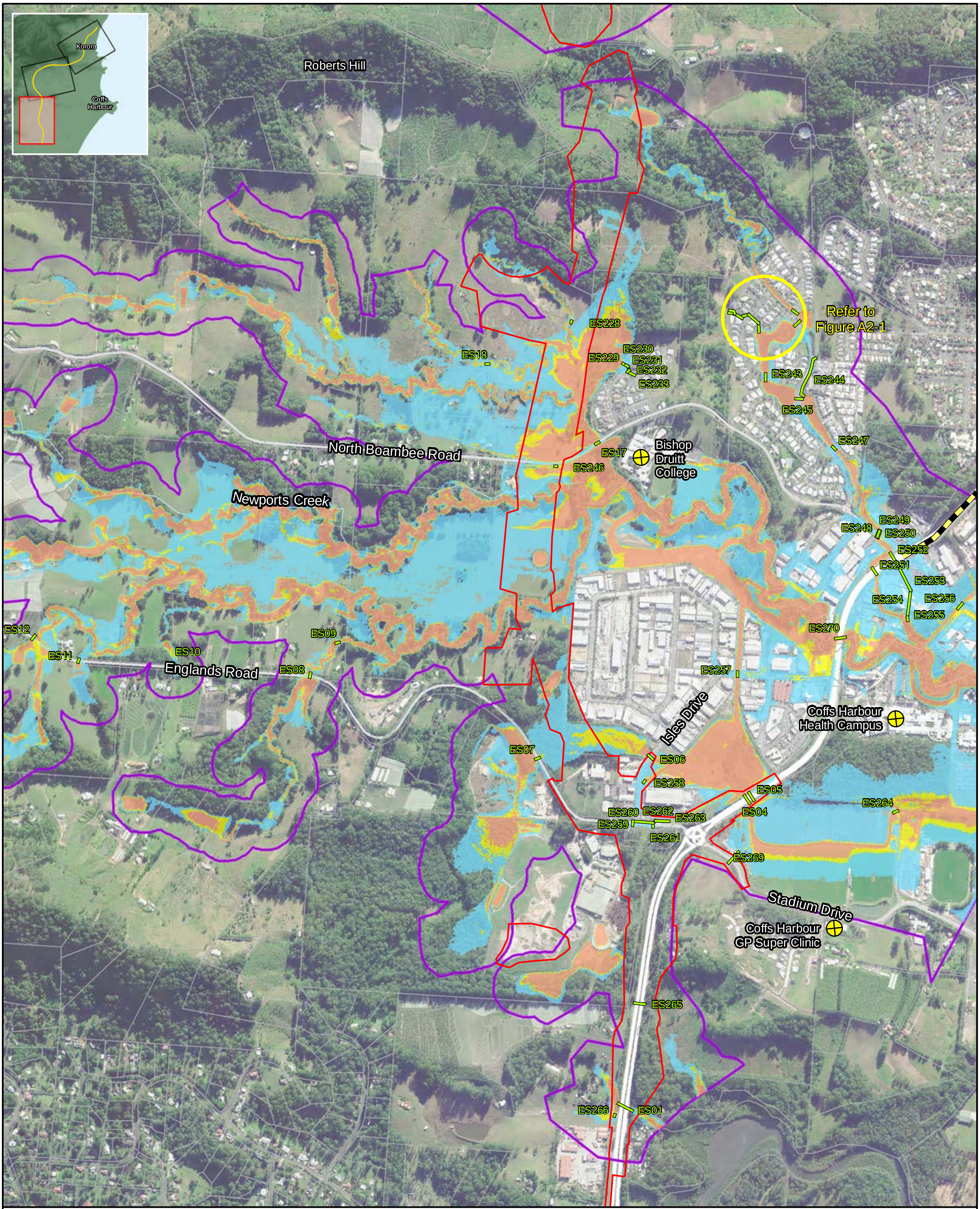
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low | Intermediate | High

Coffs Harbour Bypass
Northern creeks 10 % AEP peak flood hazard
Figure B3-3-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

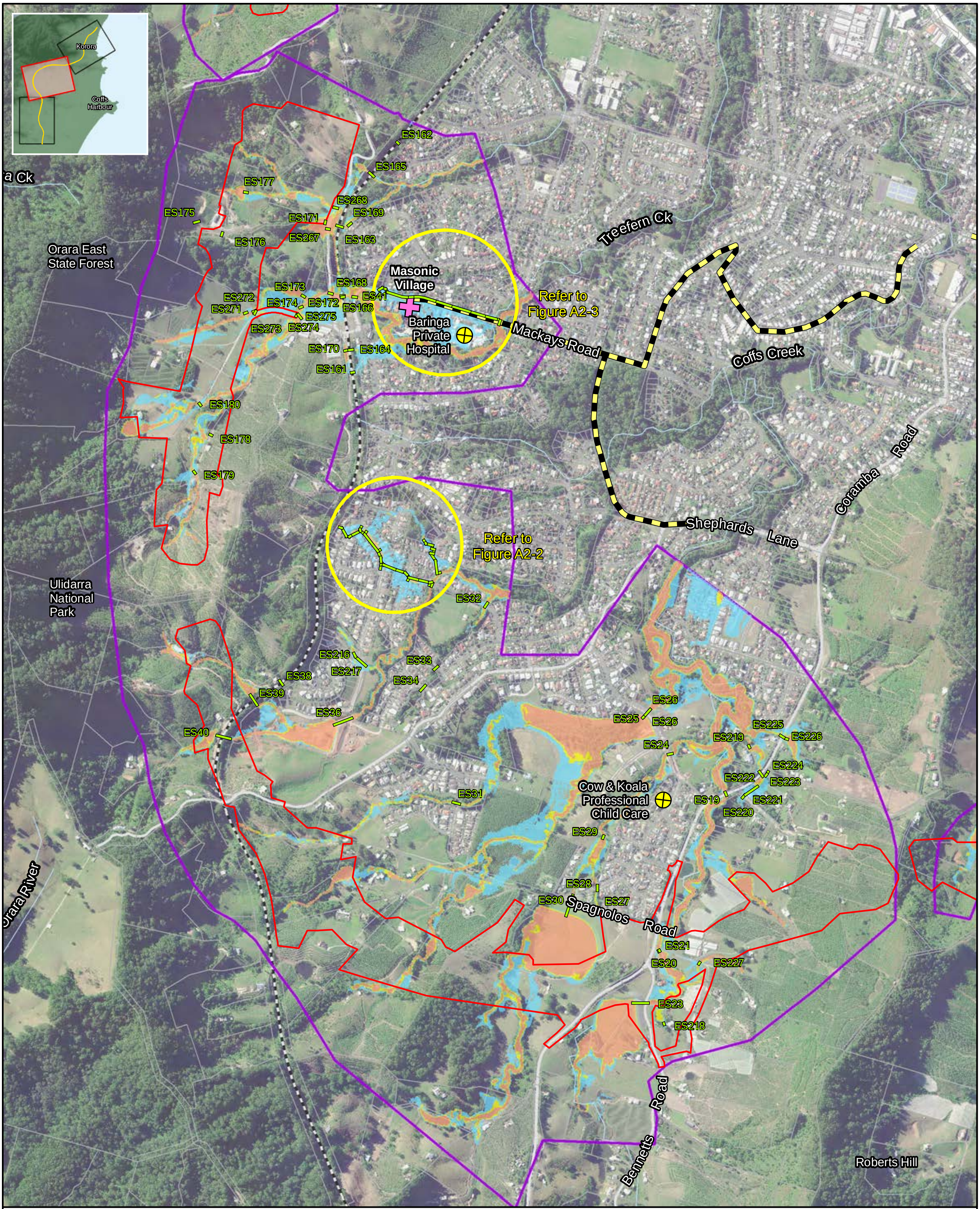
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low
Intermediate
High

Coffs Harbour Bypass
North Boambee Valley 5 % AEP peak flood hazard
Figure B3-1-3

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low | Intermediate | High

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Coffs Harbour Bypass
Coffs Creek 5 % AEP peak flood hazard
Figure B3-2-3

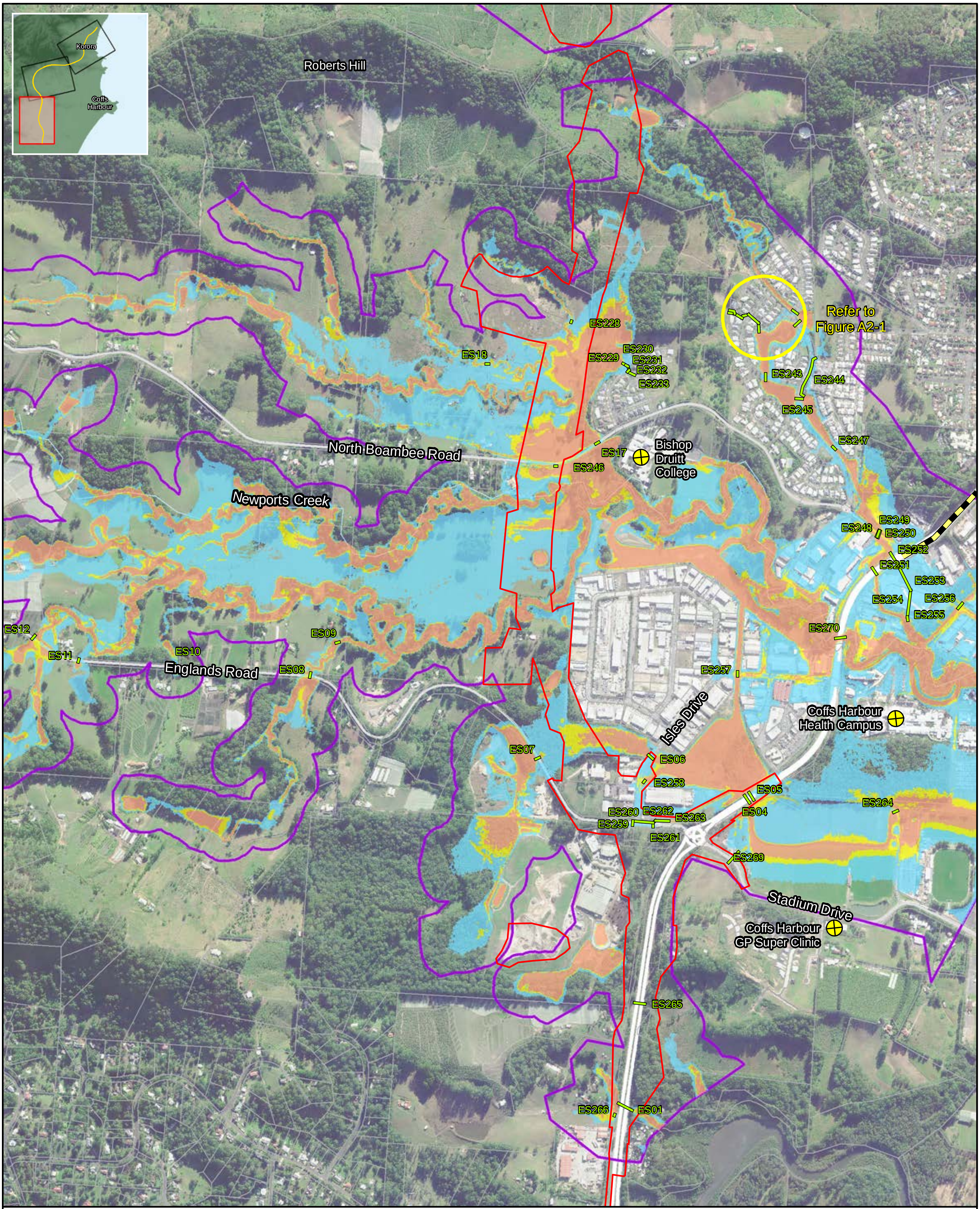
Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard: Low, Intermediate, High

Coffs Harbour Bypass
Northern creeks 5 % AEP peak flood hazard
Figure B3-3-3

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

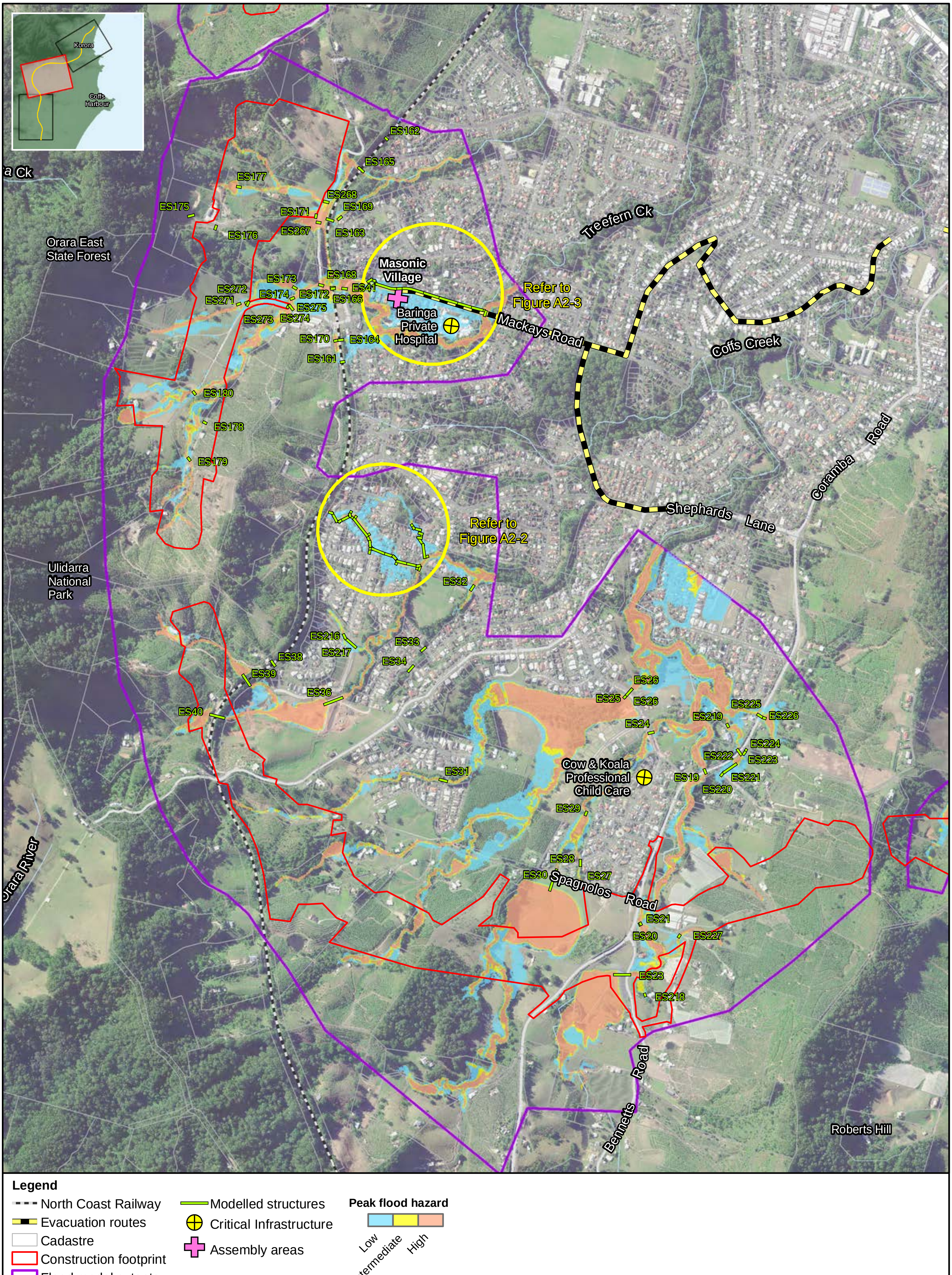
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Modelled structures
Critical Infrastructure
Assembly areas

Peak flood hazard

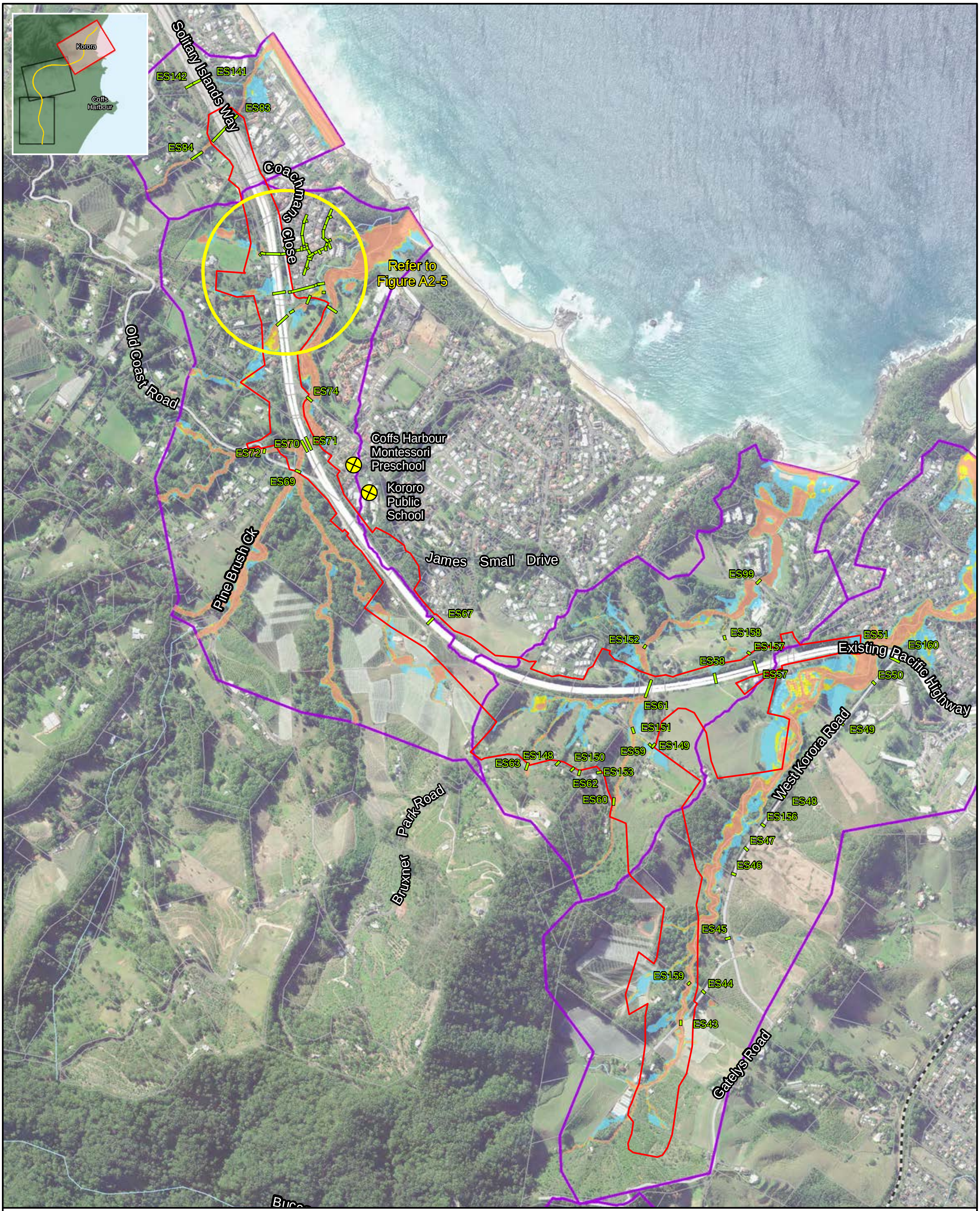
Low
Intermediate
High

Coffs Harbour Bypass
North Boambee Valley 2 % AEP peak flood hazard
Figure B3-1-4

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Coffs Harbour Bypass
Coffs Creek 2 % AEP peak flood hazard
Figure B3-2-4



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low | Intermediate | High

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500

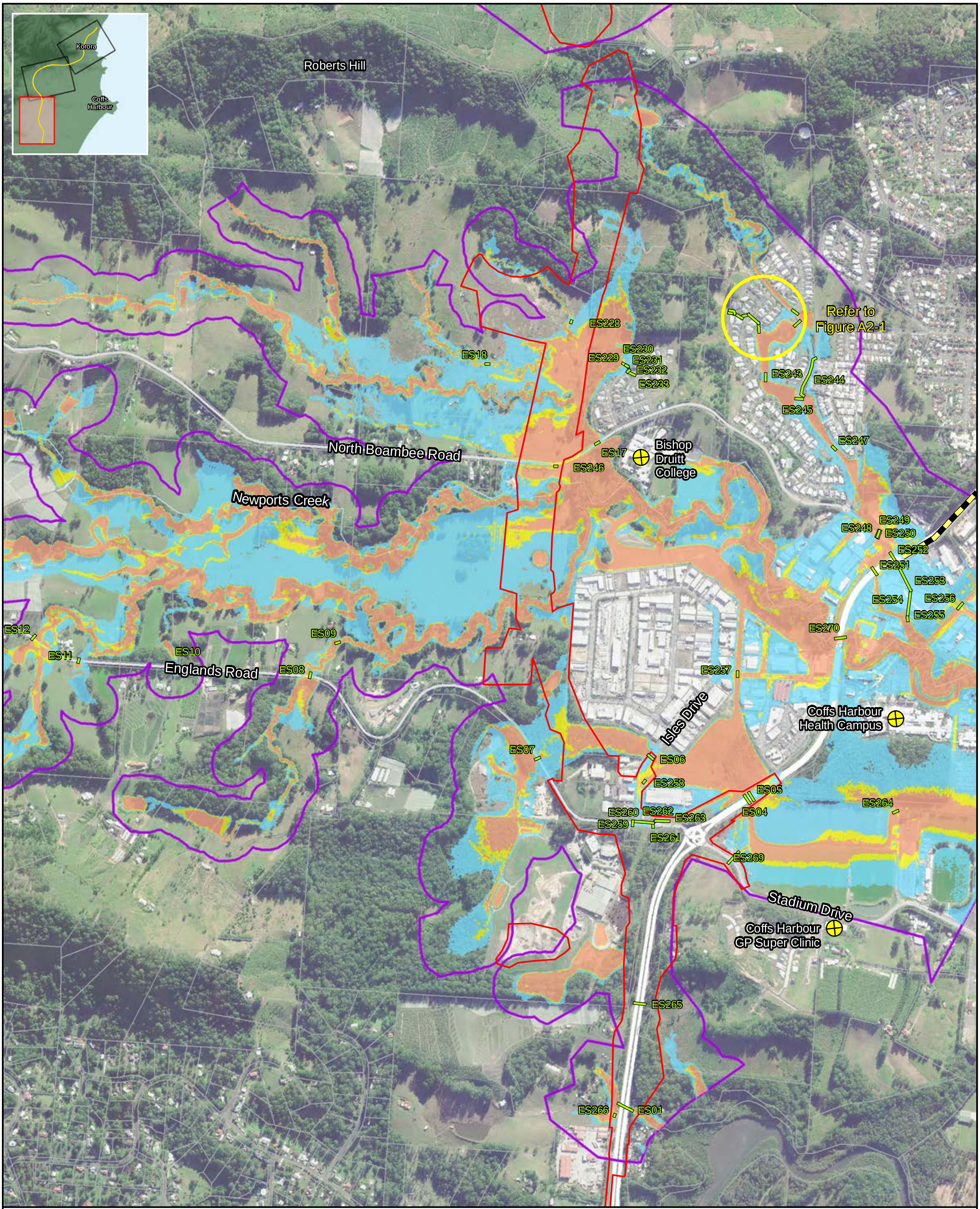
GDA 1994 MGA Zone 56

N

Coffs Harbour Bypass

Northern creeks 2 % AEP peak flood hazard

Figure B3-3-4



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low / Intermediate / High

Coffs Harbour Bypass

North Boambee Valley 1 % AEP peak flood hazard

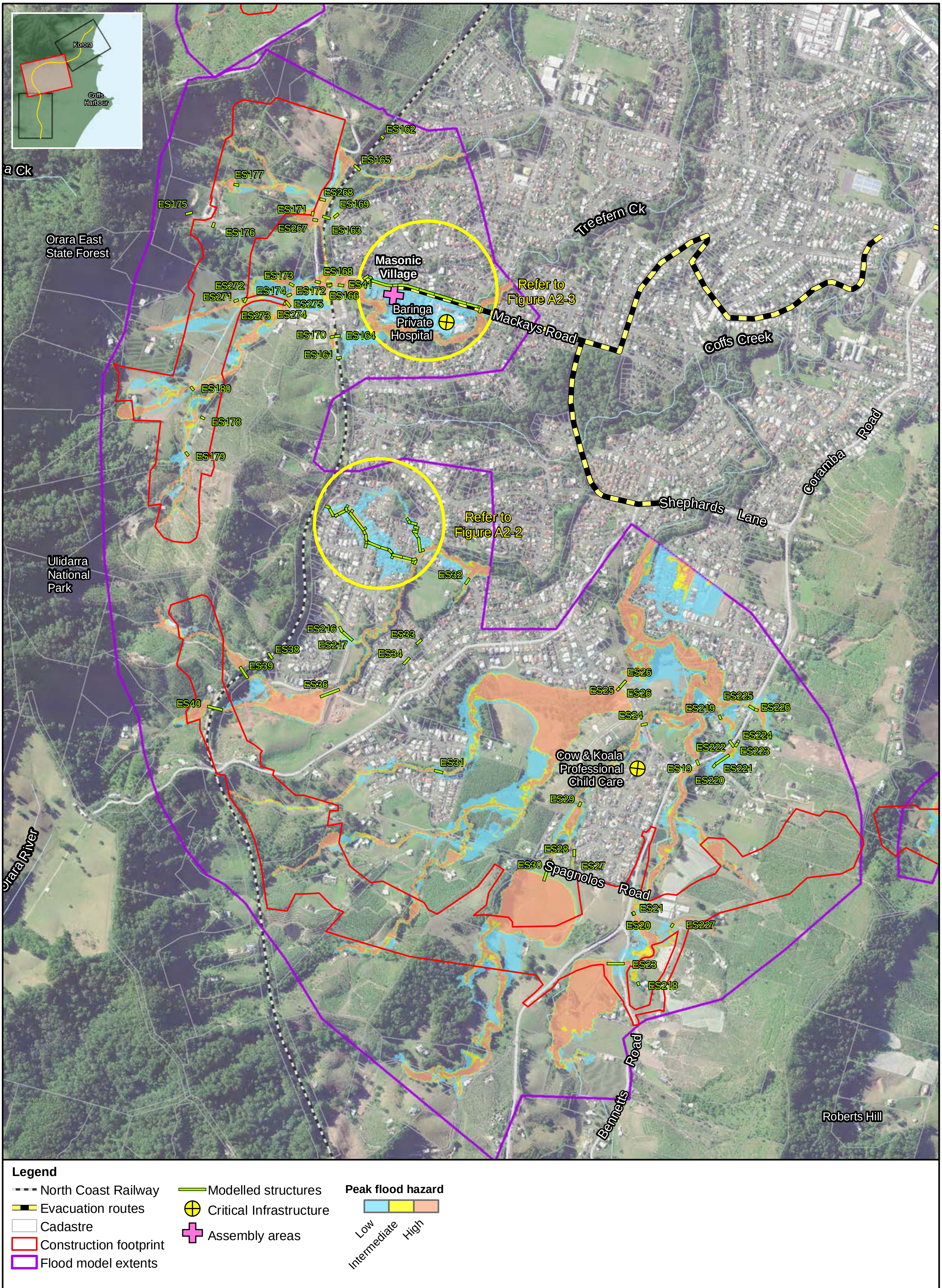
Figure B3-1-5

0 0.15 0.3 0.45 km

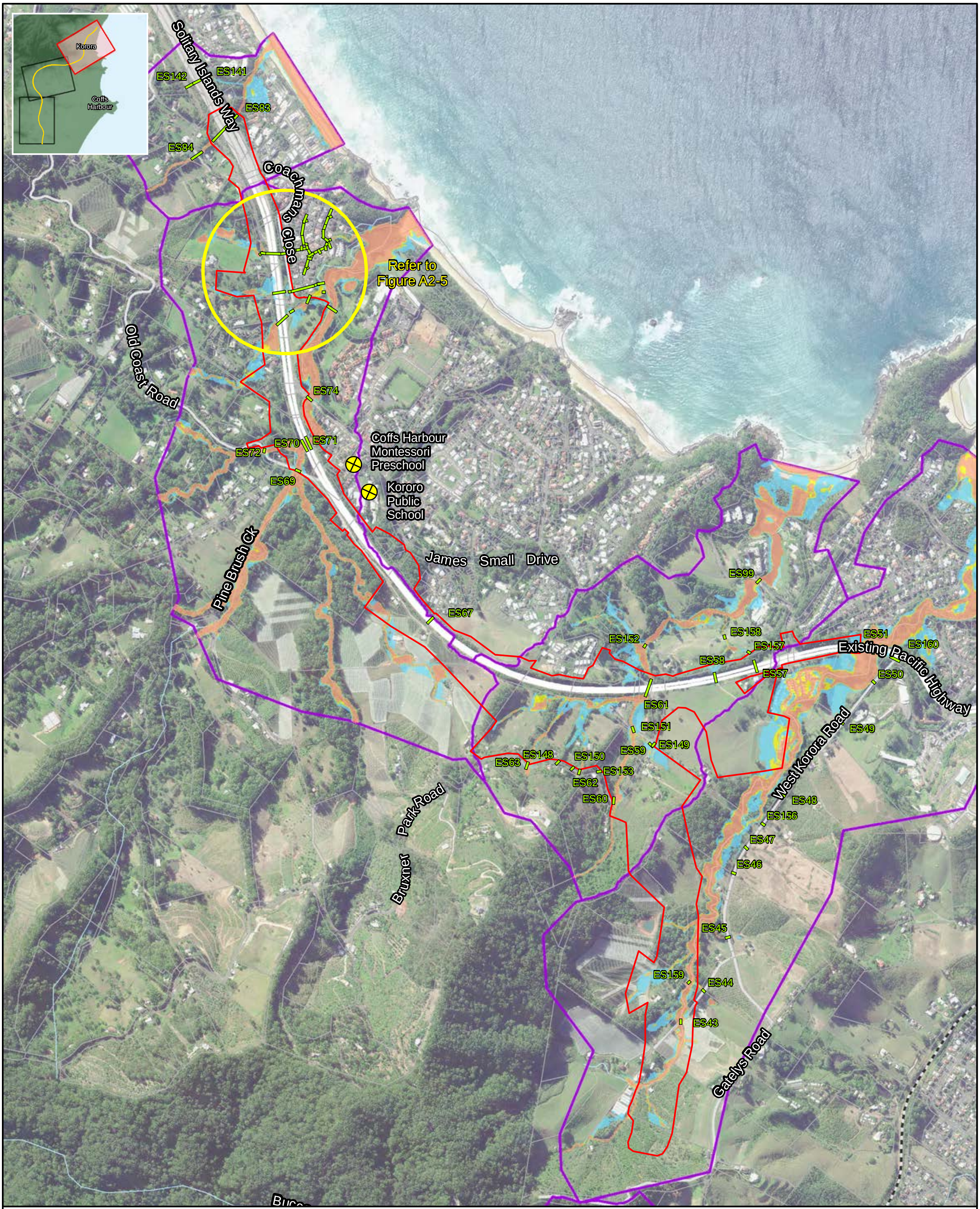
Scale @A4: 1:17,500

GDA 1994 MGA Zone 56

N



Coffs Harbour Bypass
Coffs Creek 1 % AEP peak flood hazard
Figure B3-2-5



Legend

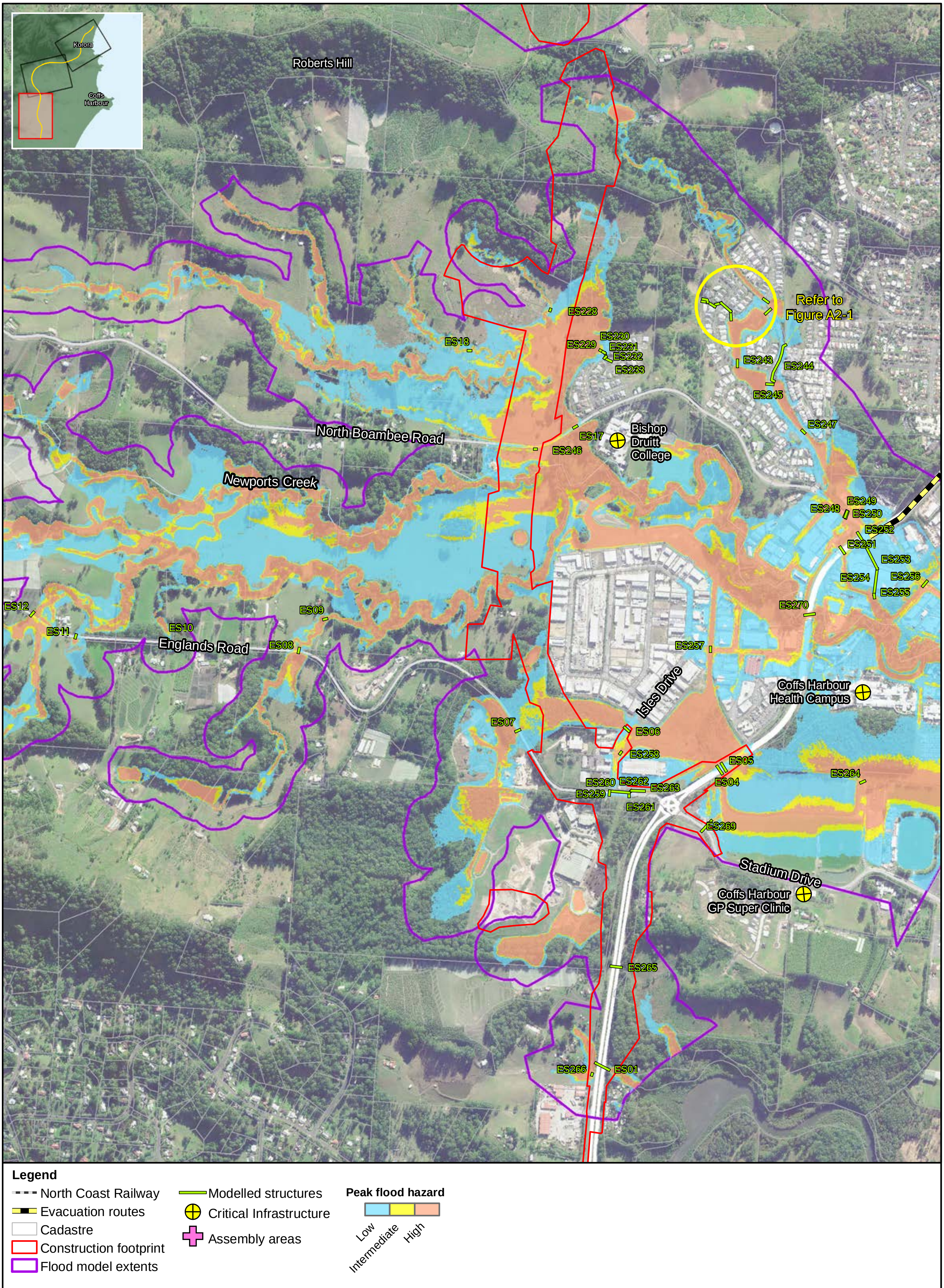
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low | Intermediate | High

Coffs Harbour Bypass
Northern creeks 1 % AEP peak flood hazard
Figure B3-3-5

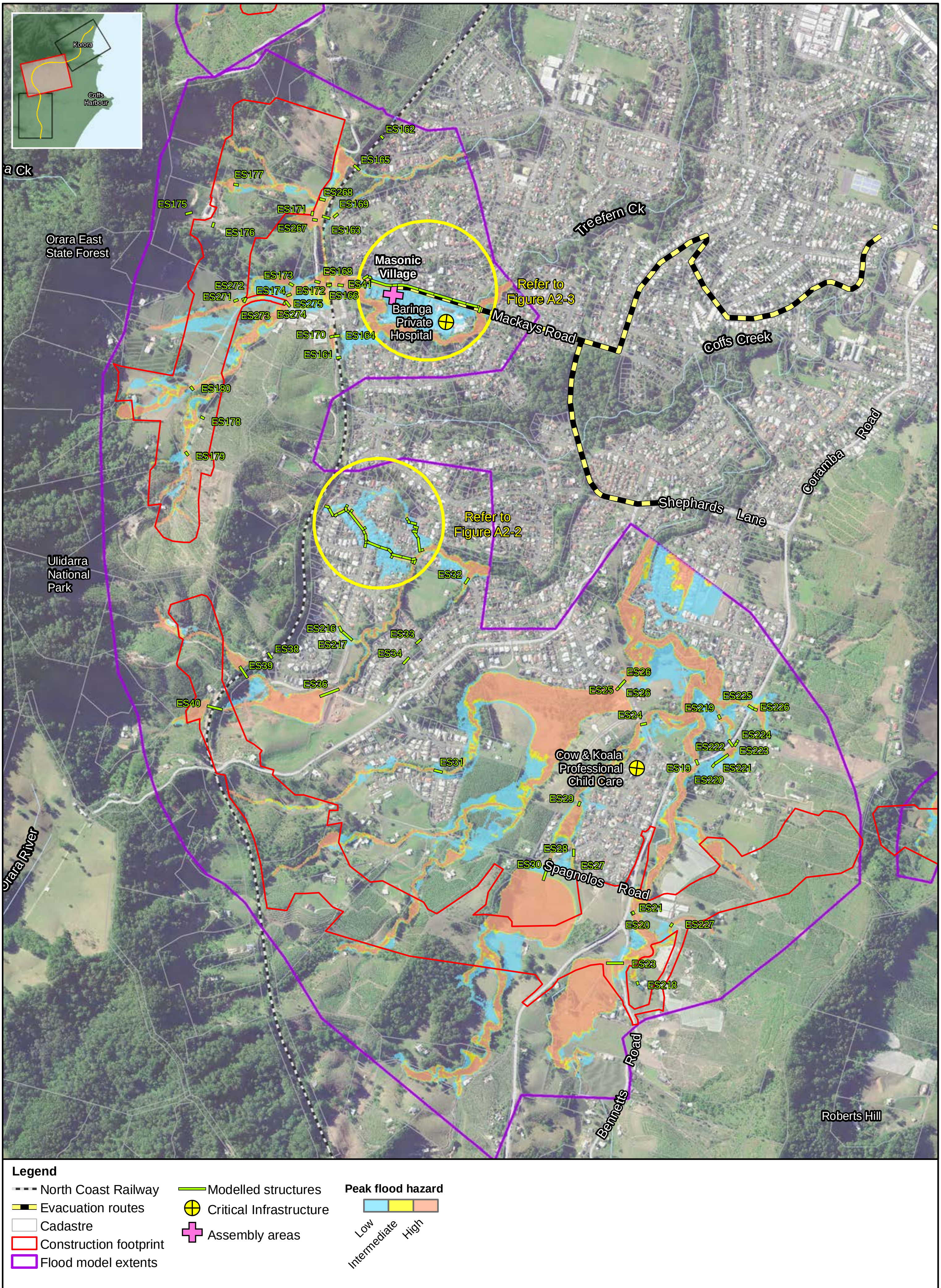
0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



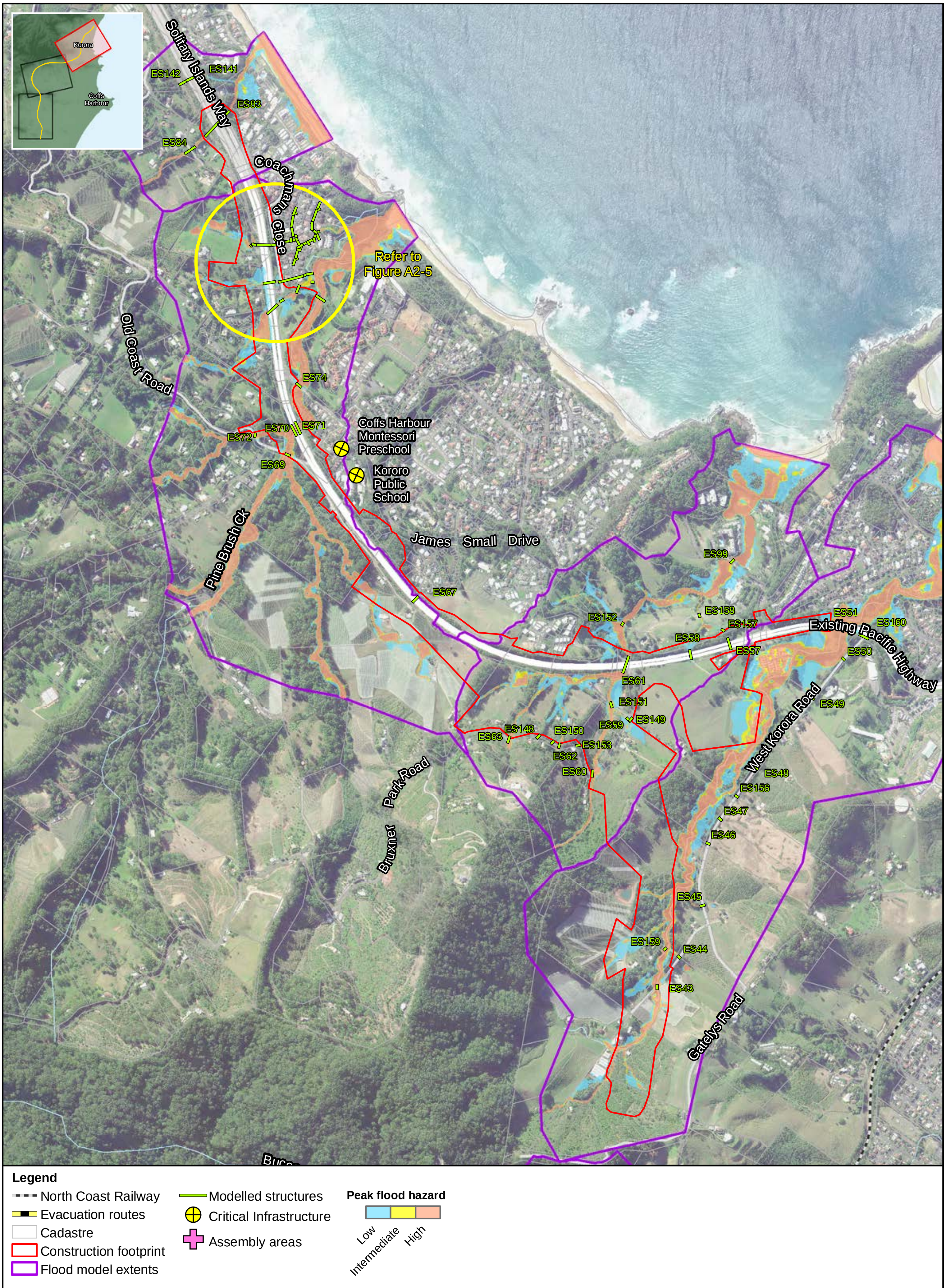
Coffs Harbour Bypass

North Boambee Valley 1 % AEP 2050 climate peak flood hazard

Figure B3-1-6



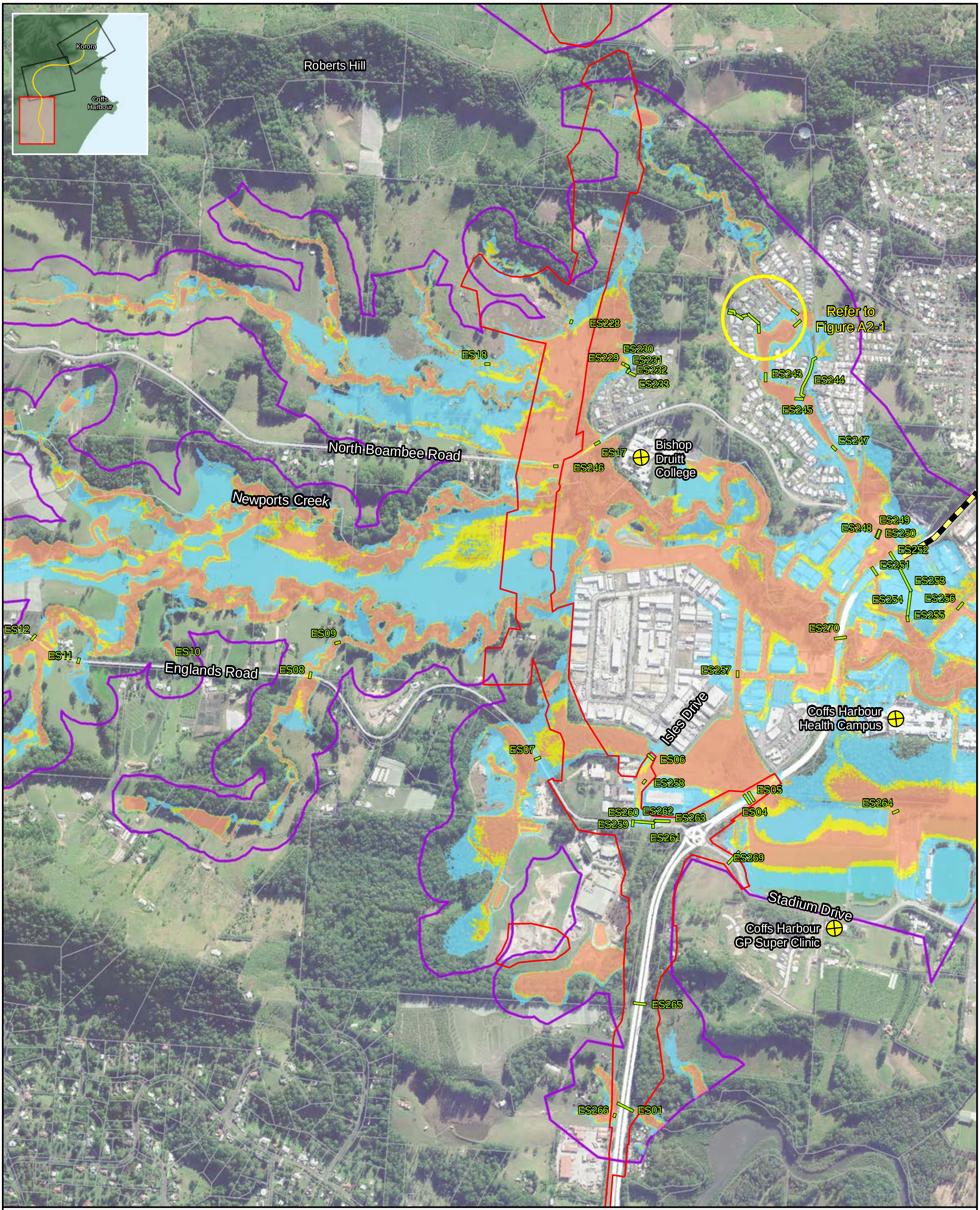
Coffs Harbour Bypass
Coffs Creek 1 % AEP 2050 climate peak flood hazard
Figure B3-2-6



Coffs Harbour Bypass

Northern creeks 1 % AEP 2050 climate peak flood hazard

Figure B3-3-6



Legend

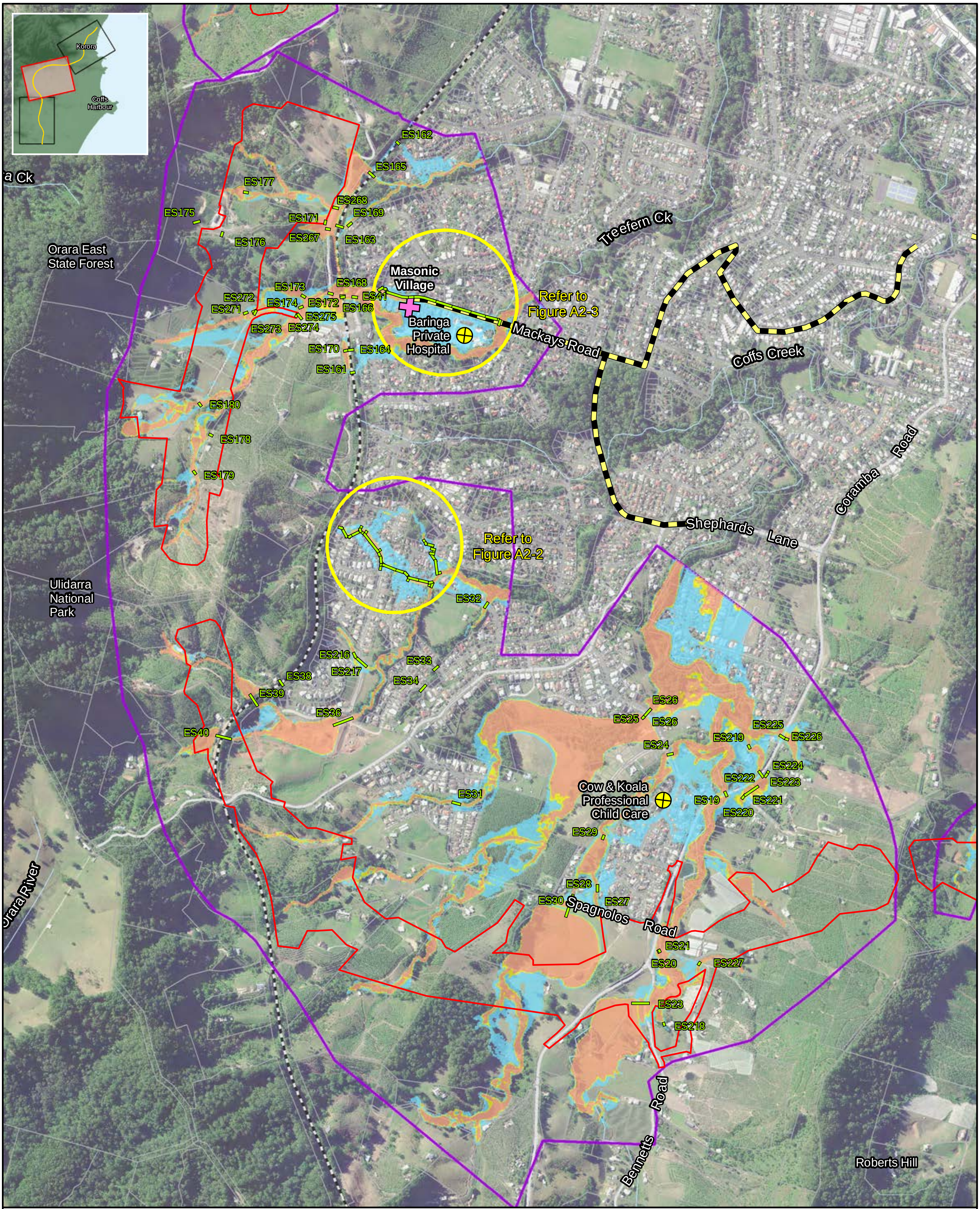
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

Peak flood hazard

Low, Intermediate, High

Coffs Harbour Bypass
North Boambee Valley 1 % AEP 2100 climate peak flood hazard
Figure B3-1-7

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

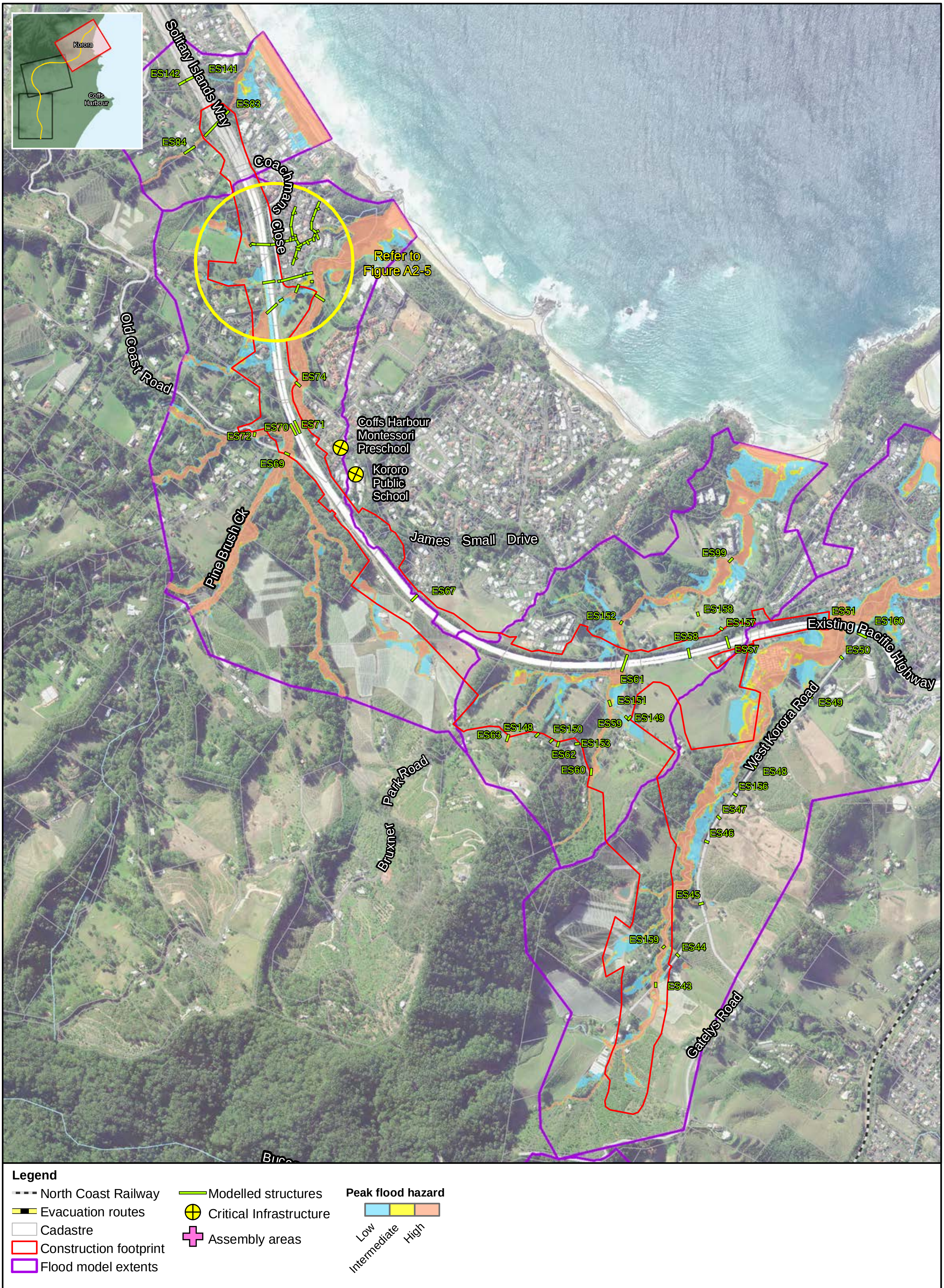
Peak flood hazard

Low | Intermediate | High

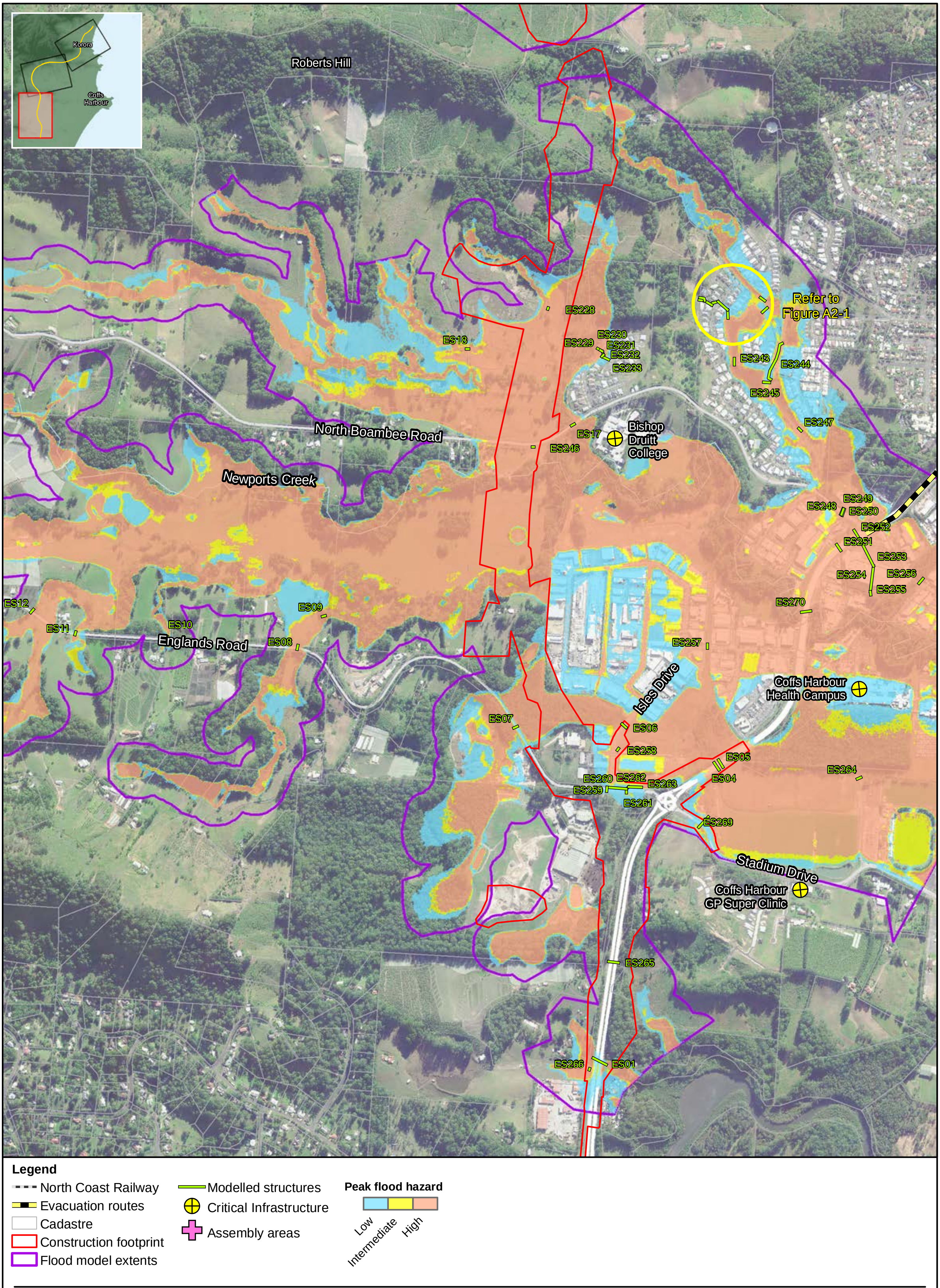
0 0.15 0.3 0.45 km

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

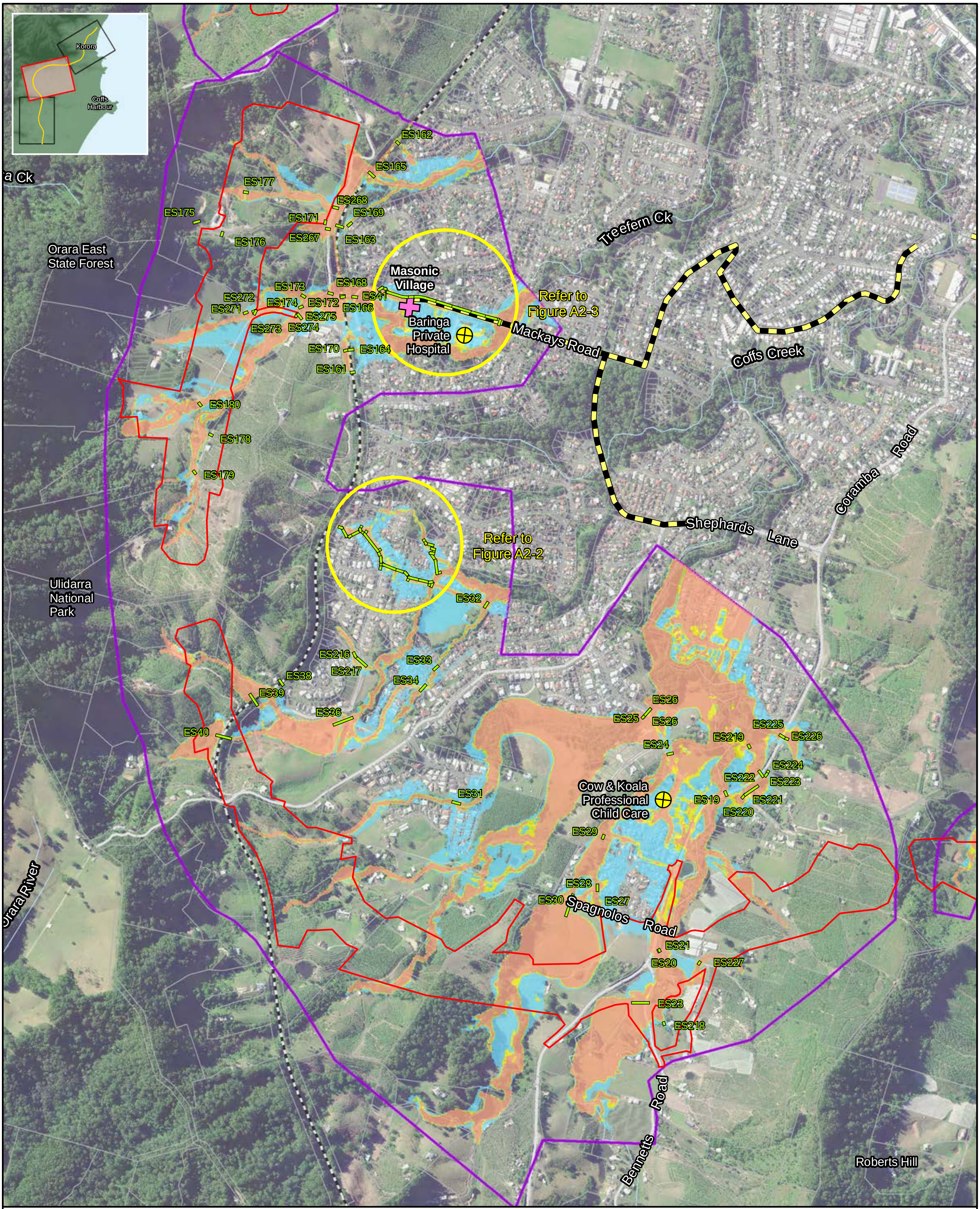
Coffs Harbour Bypass
Coffs Creek 1 % AEP 2100 climate peak flood hazard
Figure B3-2-7



Coffs Harbour Bypass
Northern creeks 1 % AEP 2100 climate peak flood hazard
Figure B3-3-7



Coffs Harbour Bypass
North Boambee Valley PMF peak flood hazard
Figure B3-1-8



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas

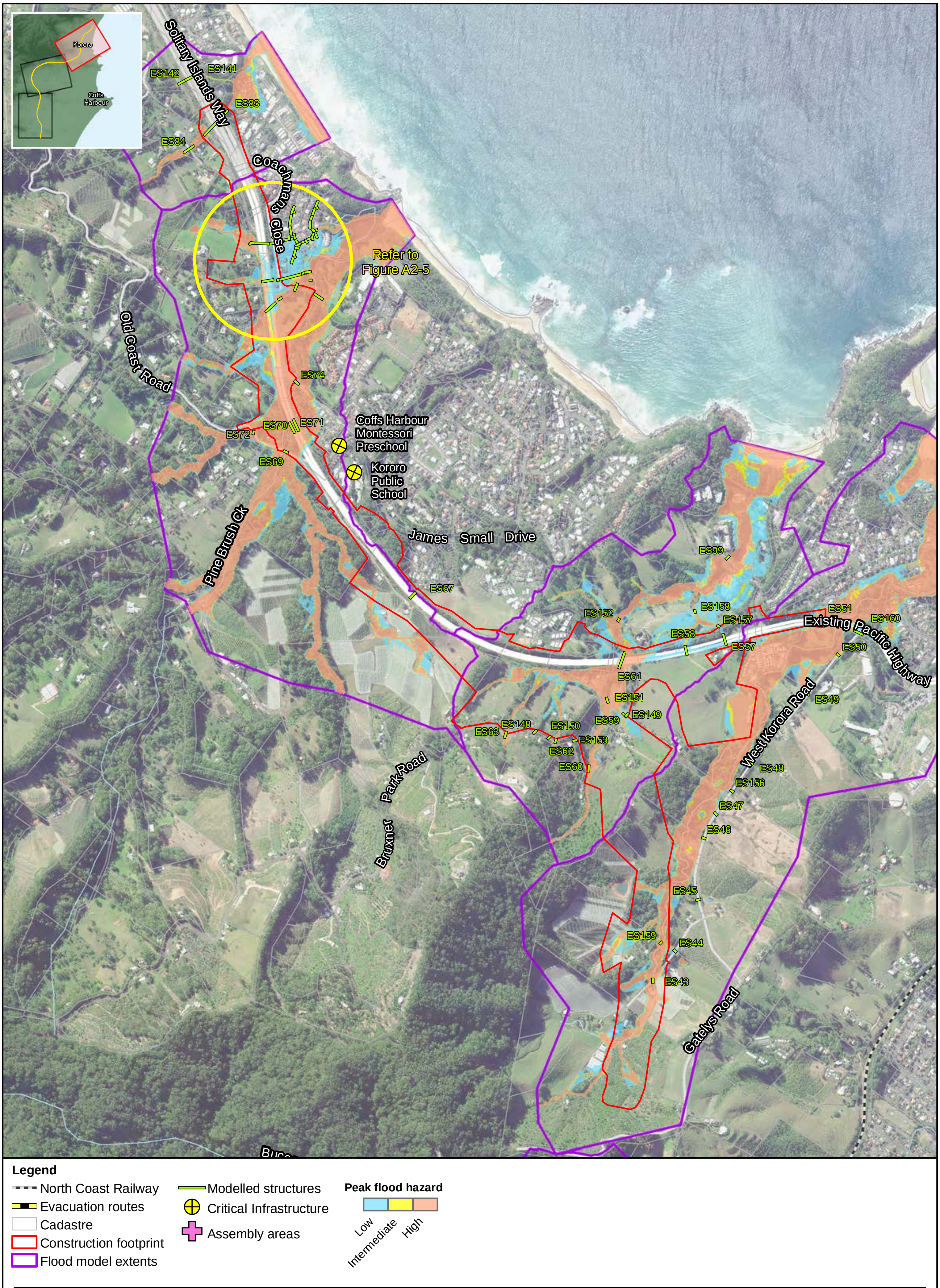
Peak flood hazard

Low, Intermediate, High

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

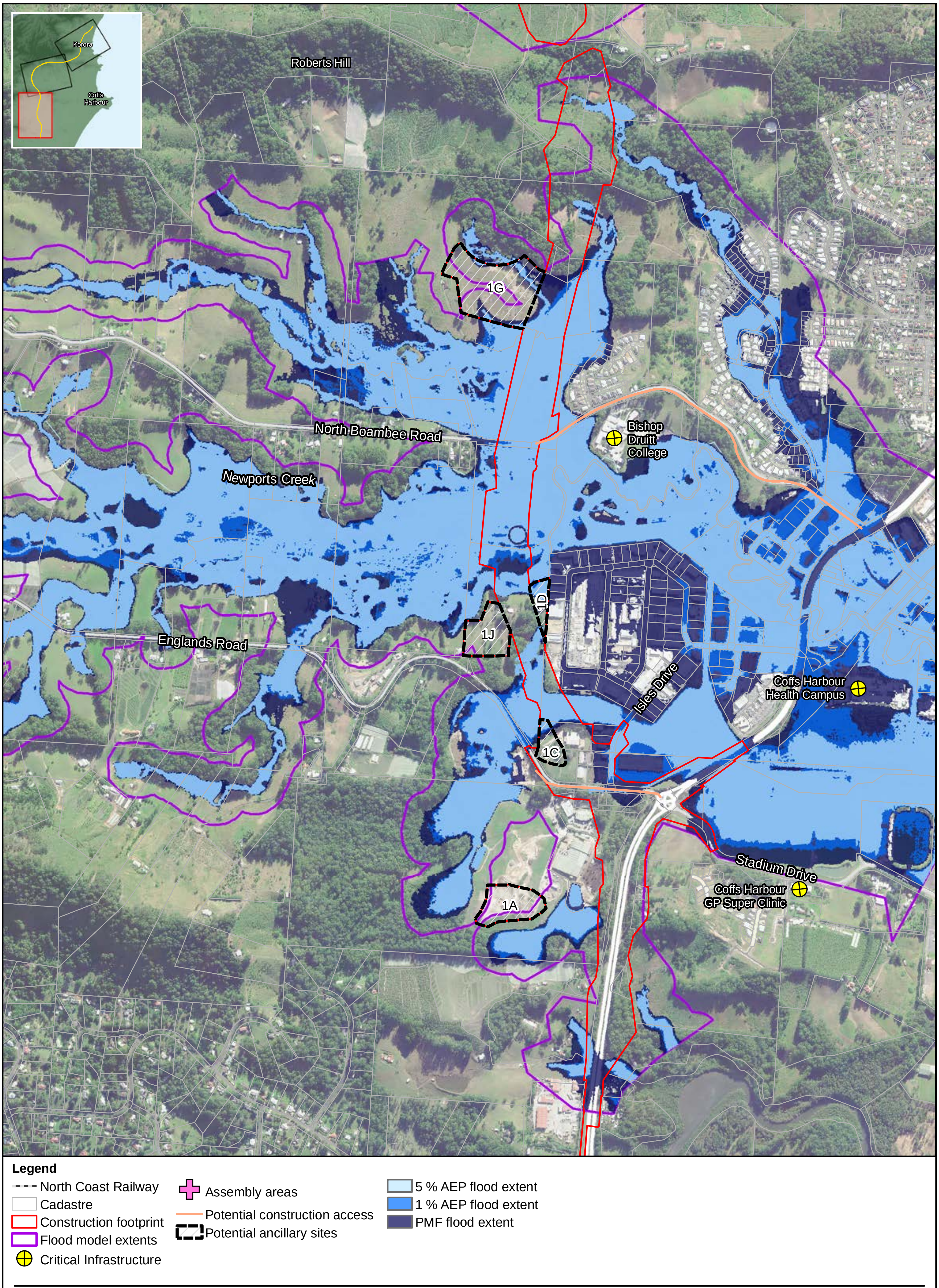
Coffs Harbour Bypass
Coffs Creek PMF peak flood hazard
Figure B3-2-8



Coffs Harbour Bypass
Northern creeks PMF peak flood hazard
Figure B3-3-8

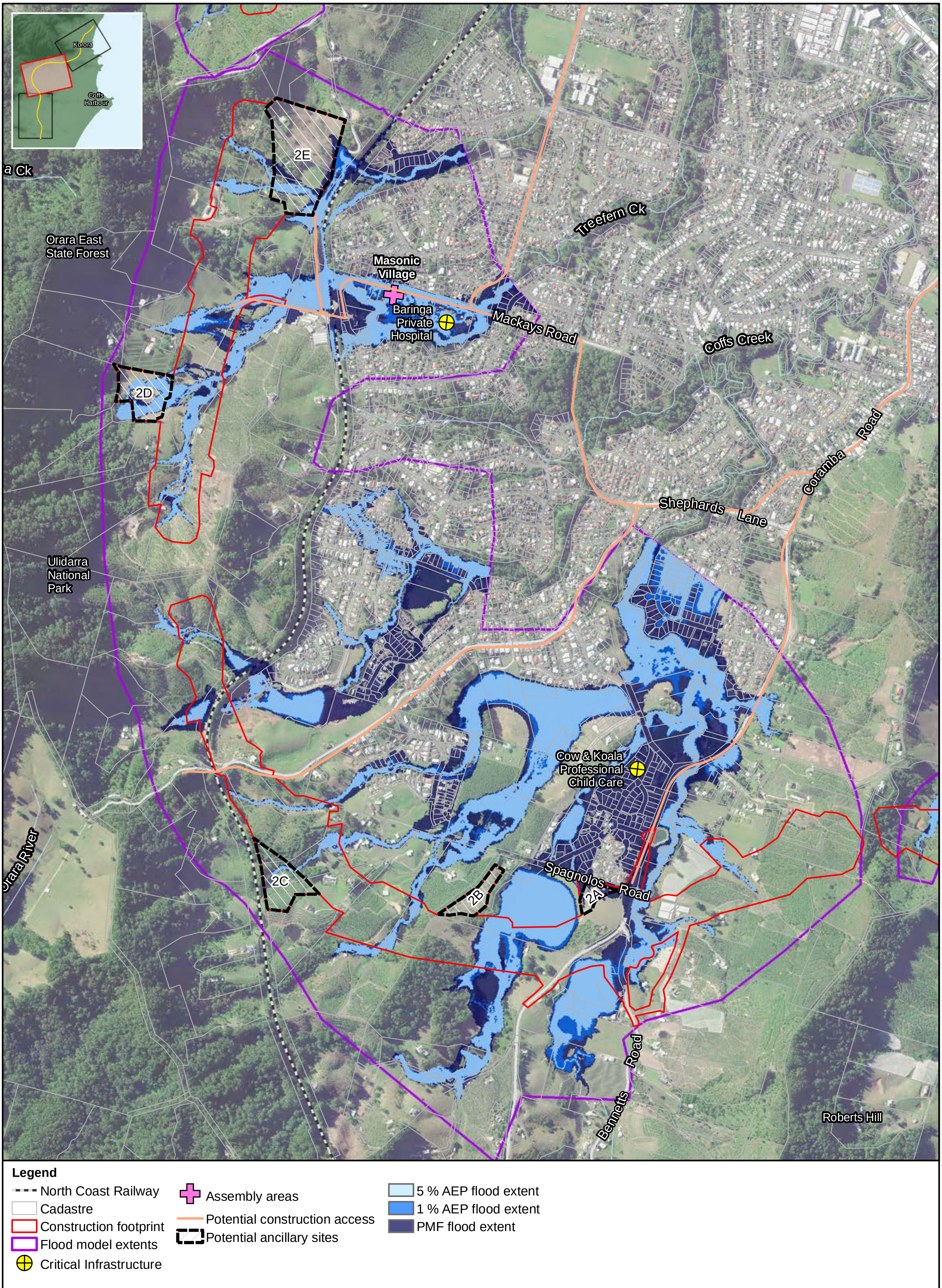
Appendix C

Conceptual construction flood maps

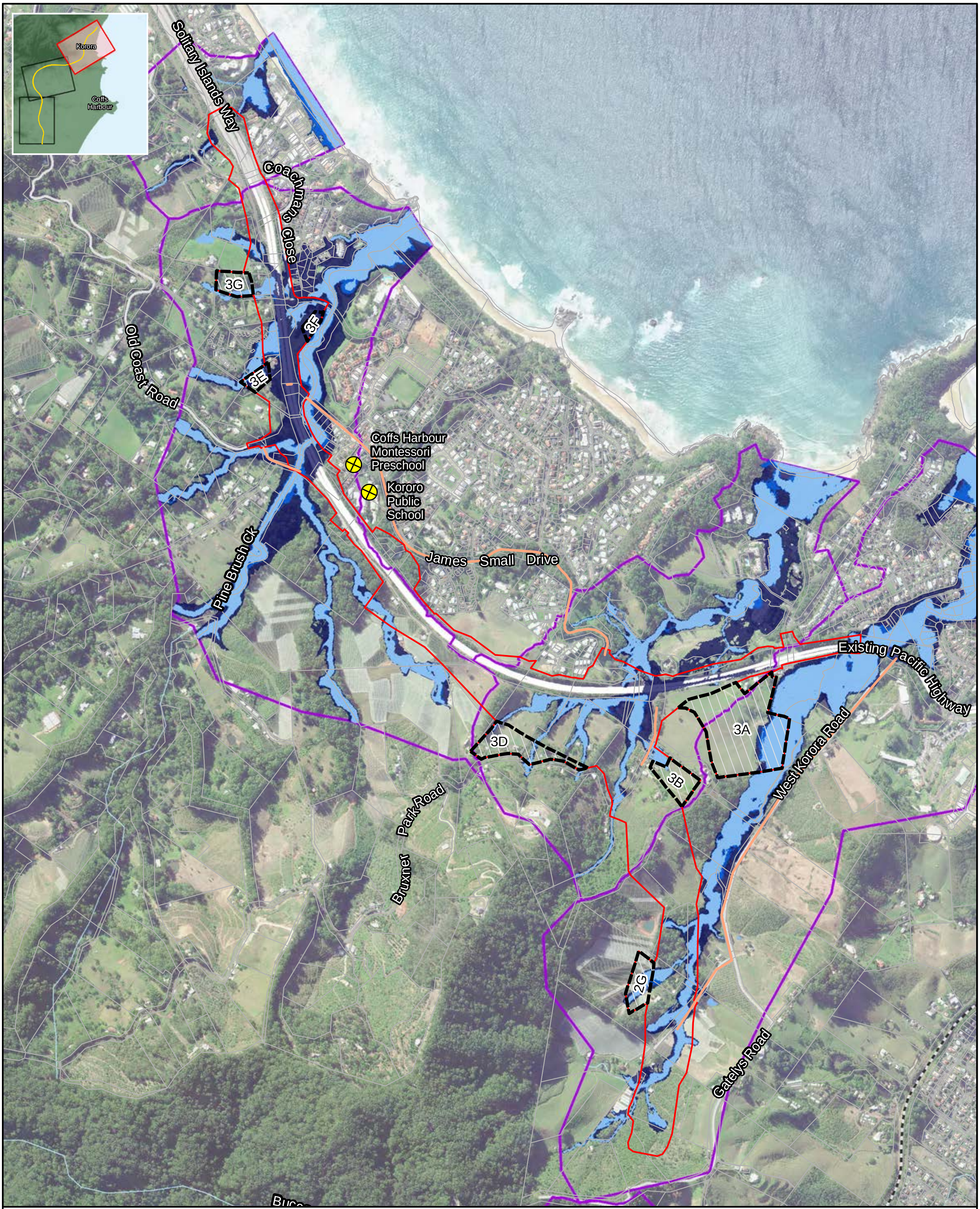


Coffs Harbour Bypass
North Boambee Valley ancillary sites peak flood inundation
C1

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Coffs Harbour Bypass
Coffs Creek ancillary sites peak flood inundation
C2



Legend

- North Coast Railway
- Cadastre
- Construction footprint
- Flood model extents
- Critical Infrastructure
- Assembly areas
- Potential construction access
- Potential ancillary sites
- 5 % AEP flood extent
- 1 % AEP flood extent
- PMF flood extent

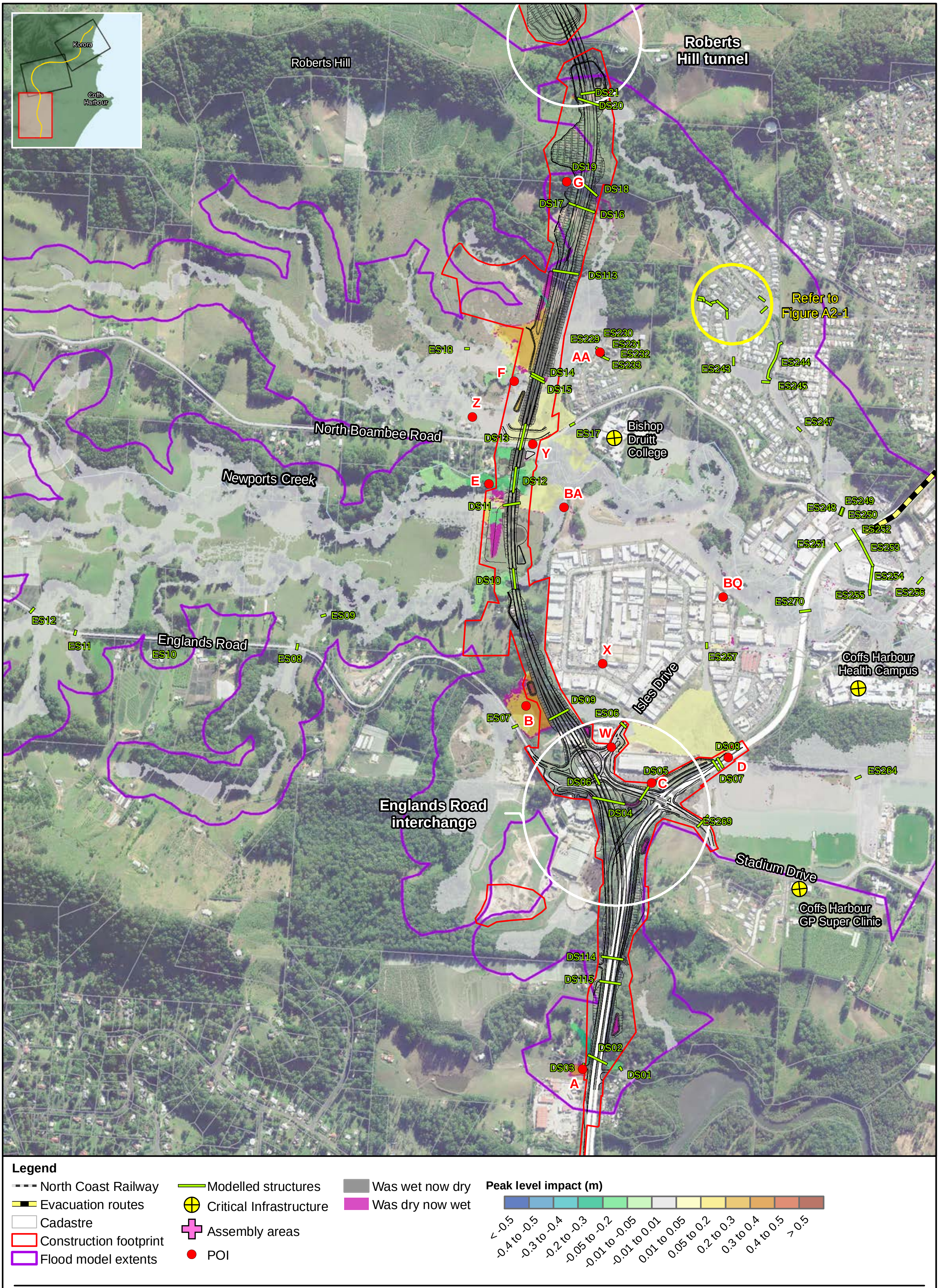
Coffs Harbour Bypass
Northern creeks ancillary sites peak flood inundation
C3

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Appendix D

Developed flood maps

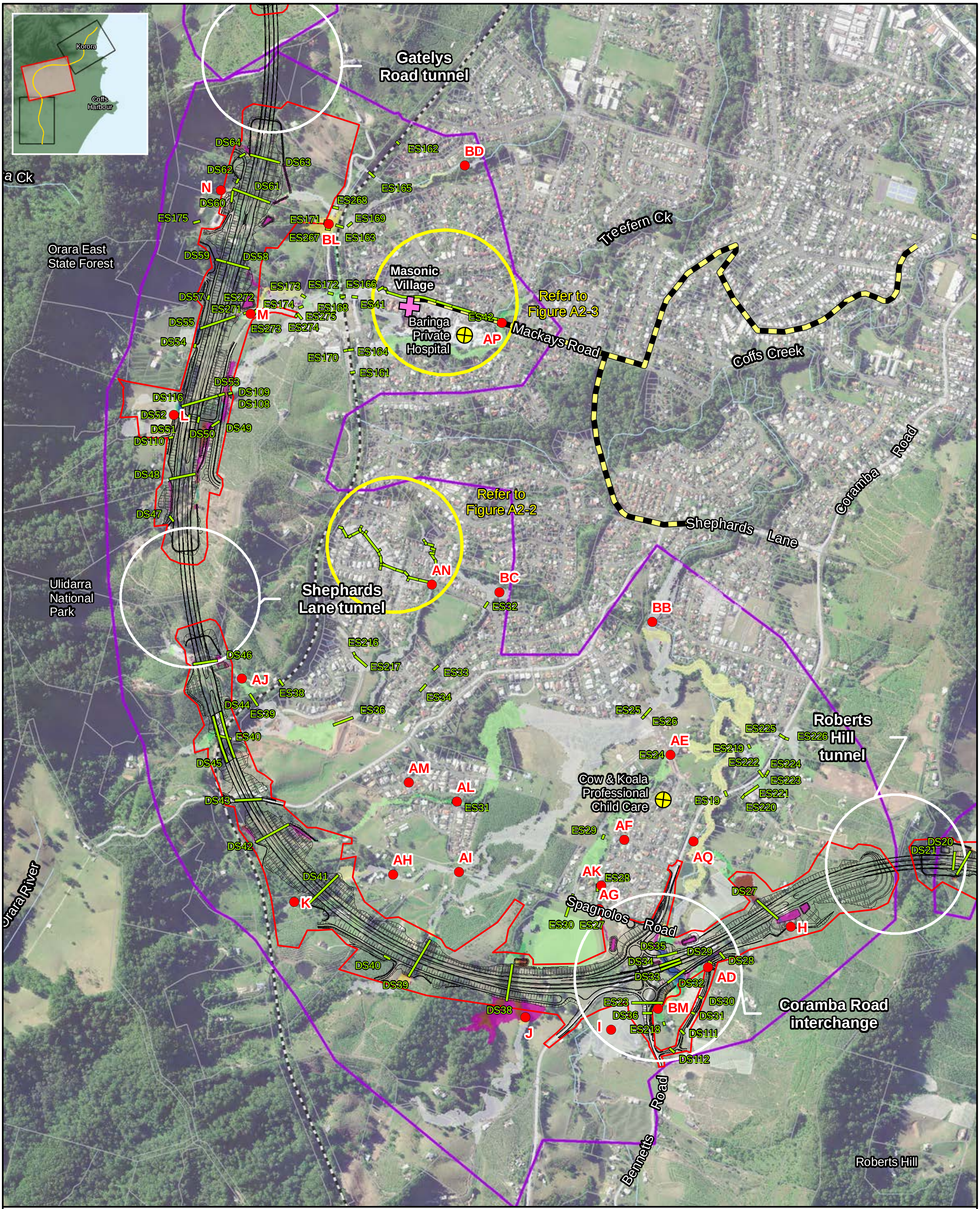
D1 Peak flood level difference



Coffs Harbour Bypass

North Boambee Valley 18 % AEP peak flood level difference

Figure D1-1-1



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5 | -0.4 to -0.5 | -0.3 to -0.4 | -0.2 to -0.3 | -0.05 to -0.2 | -0.01 to -0.05 | -0.01 to 0.01 | 0.01 to 0.05 | 0.05 to 0.2 | 0.2 to 0.3 | 0.3 to 0.4 | 0.4 to 0.5 | > 0.5

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500

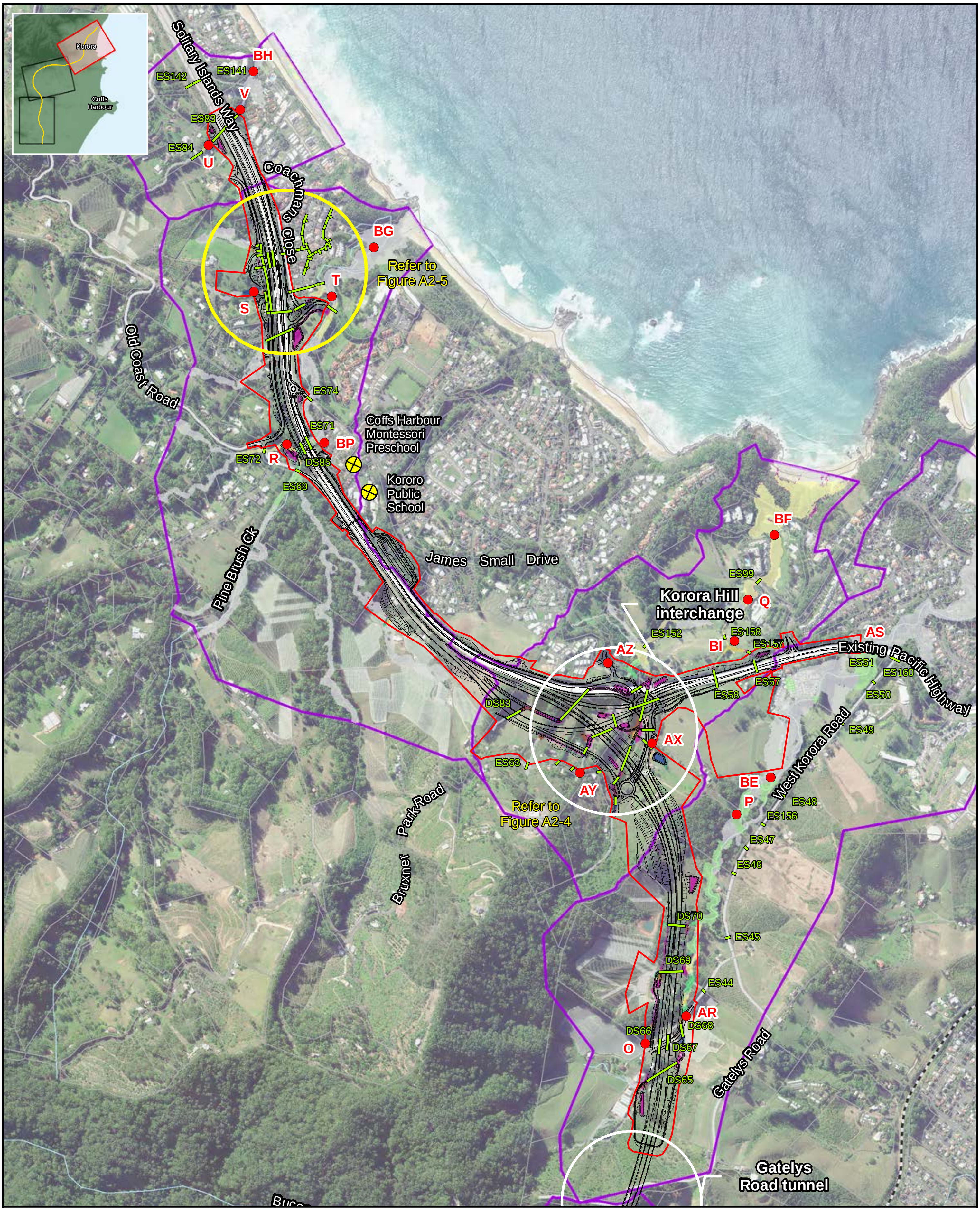
GDA 1994 MGA Zone 56

N

Coffs Harbour Bypass

Coffs Creek 18 % AEP peak flood level difference

Figure D1-2-1



Legend

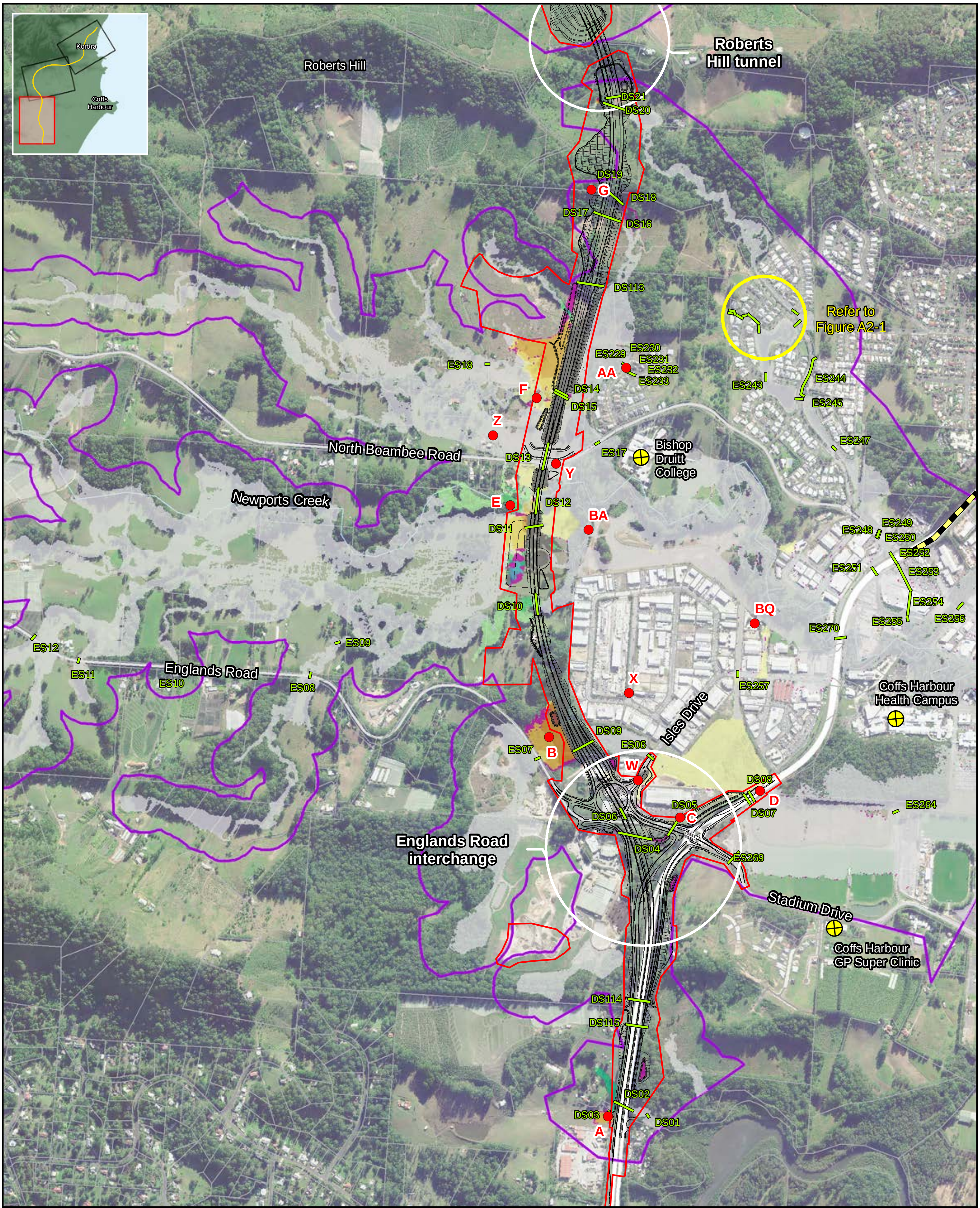
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
Northern creeks 18 % AEP peak flood level difference
Figure D1-3-1

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

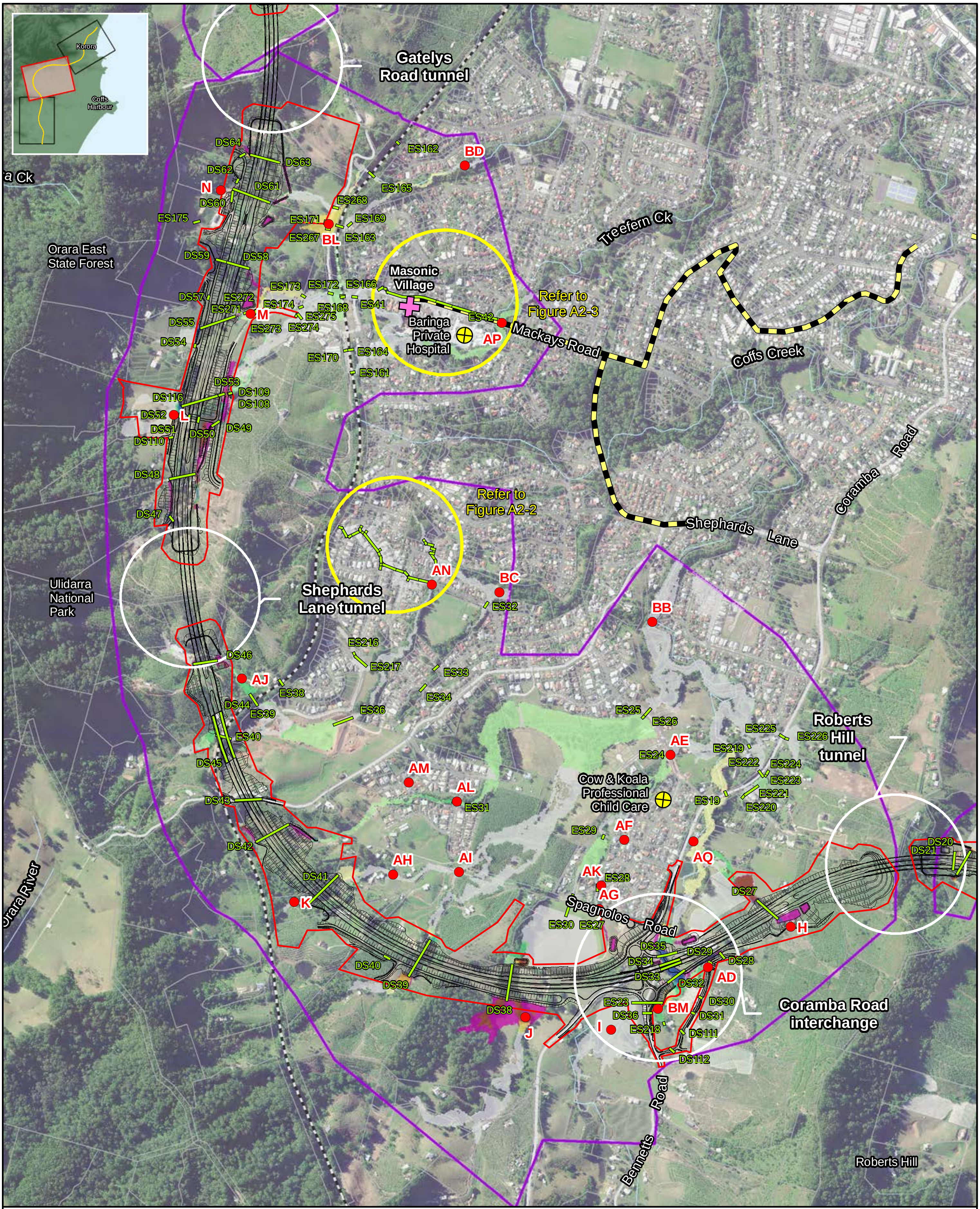
North Coast Railway
Evacuation routes
Cadastre
Construction footprint
Flood model extents
Modelled structures
Critical Infrastructure
Assembly areas
POI
Was wet now dry
Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
North Boambee Valley 10 % AEP peak flood level difference
Figure D1-1-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

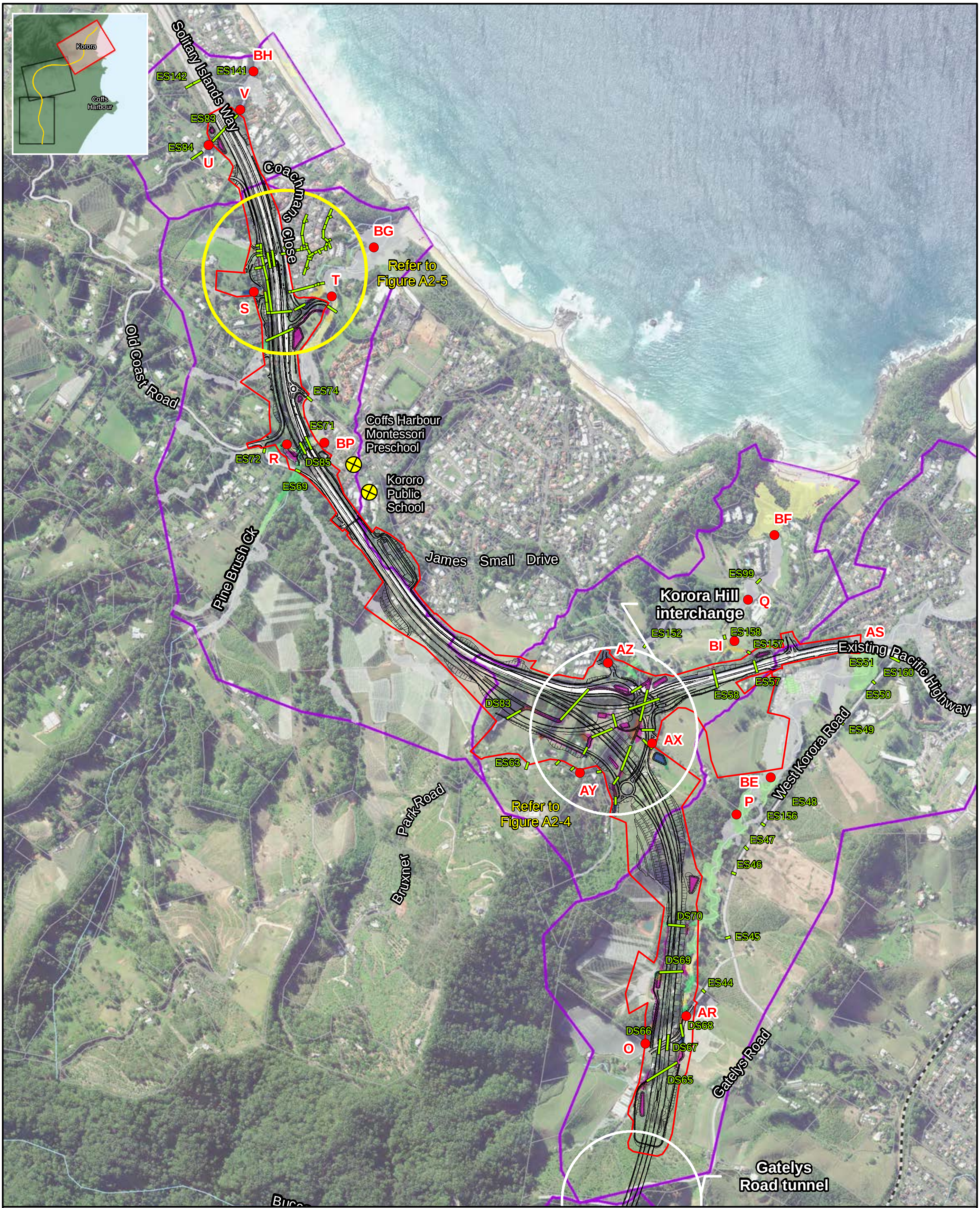
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
Coffs Creek 10 % AEP peak flood level difference
Figure D1-2-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

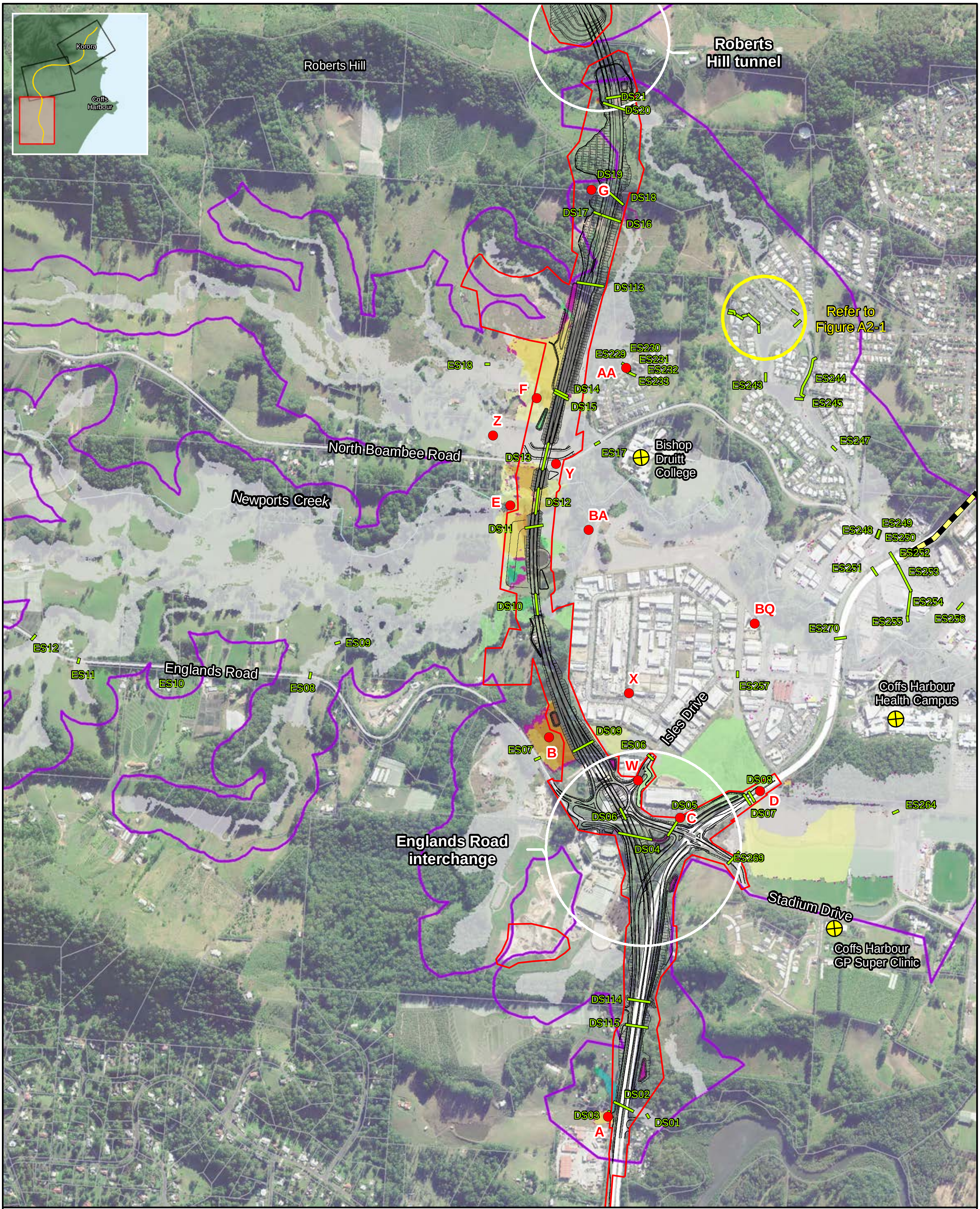
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
Northern creeks 10 % AEP peak flood level difference
Figure D1-3-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass

North Boambee Valley 5 % AEP peak flood level difference

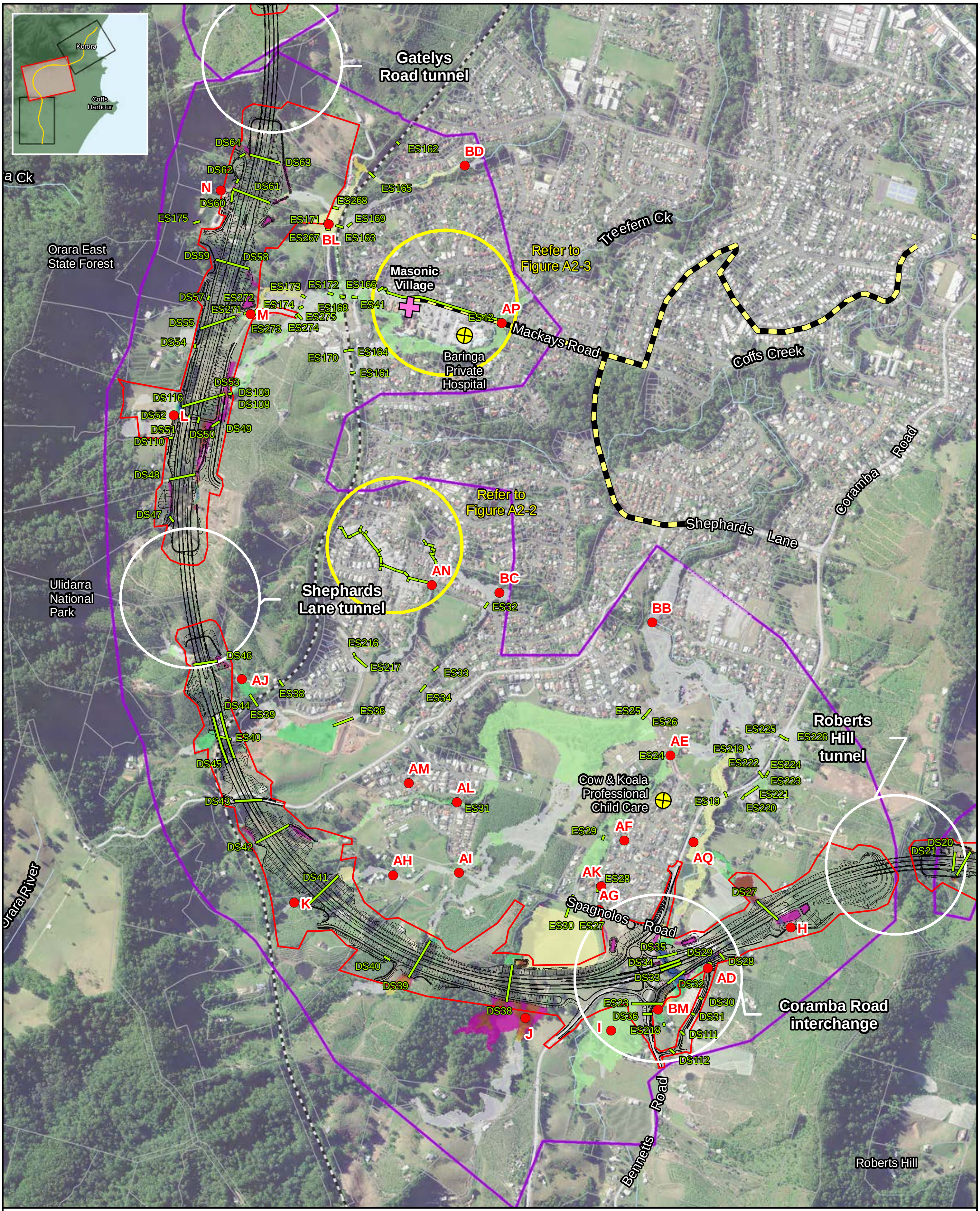
Figure D1-1-3

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500

GDA 1994 MGA Zone 56

N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500

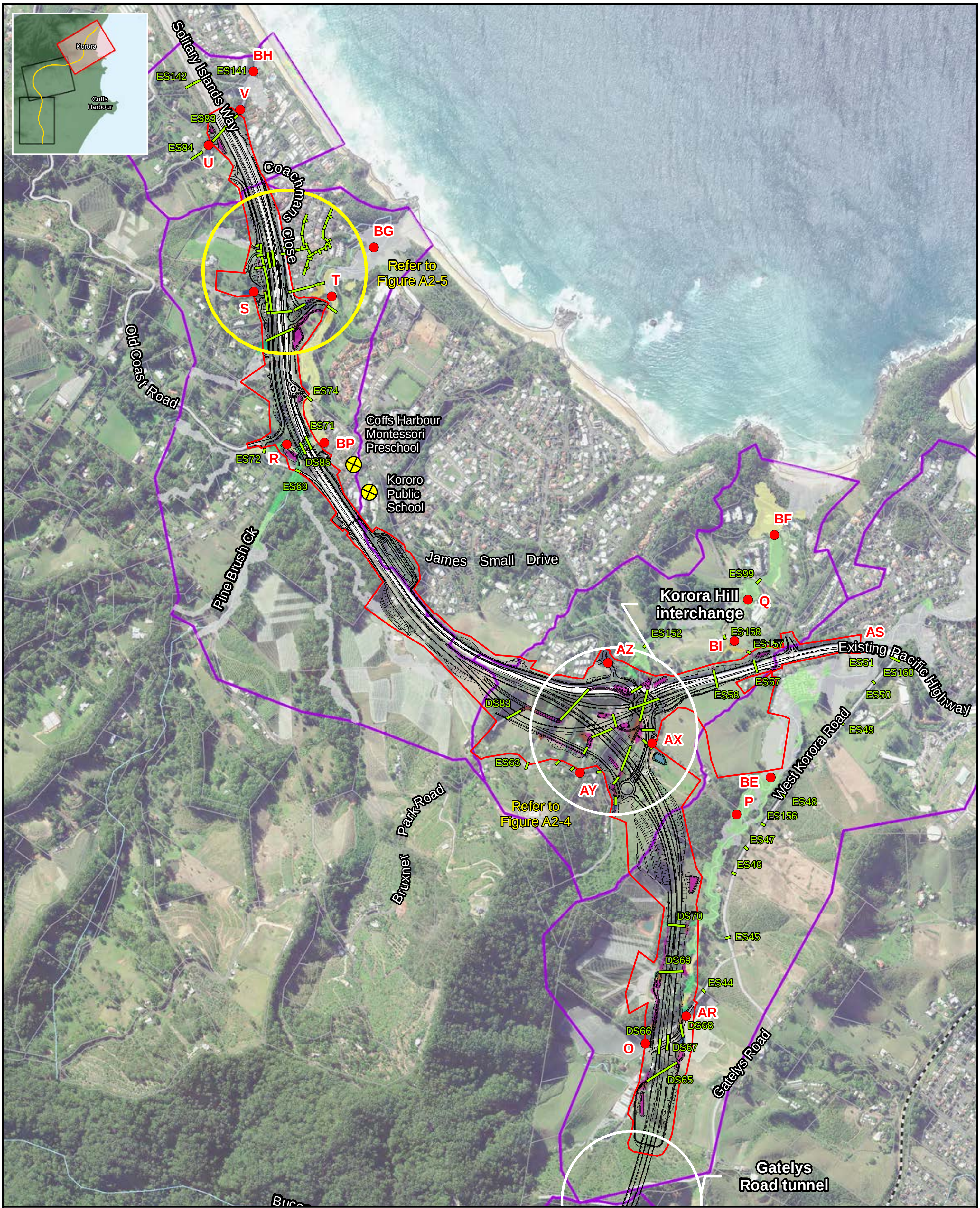
GDA 1994 MGA Zone 56

N

Coffs Harbour Bypass

Coffs Creek 5 % AEP peak flood level difference

Figure D1-2-3



Legend

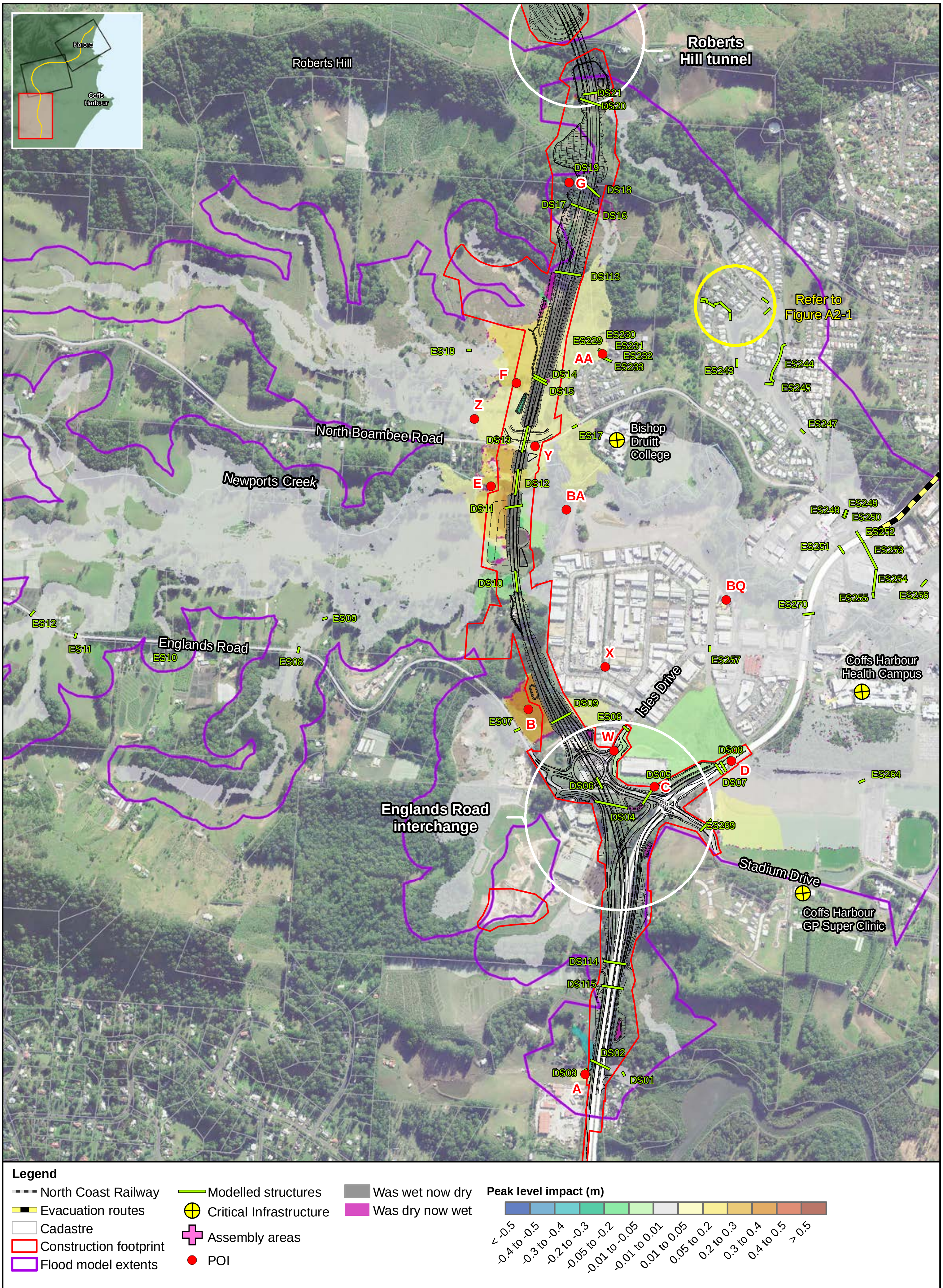
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
Northern creeks 5 % AEP peak flood level difference
Figure D1-3-3

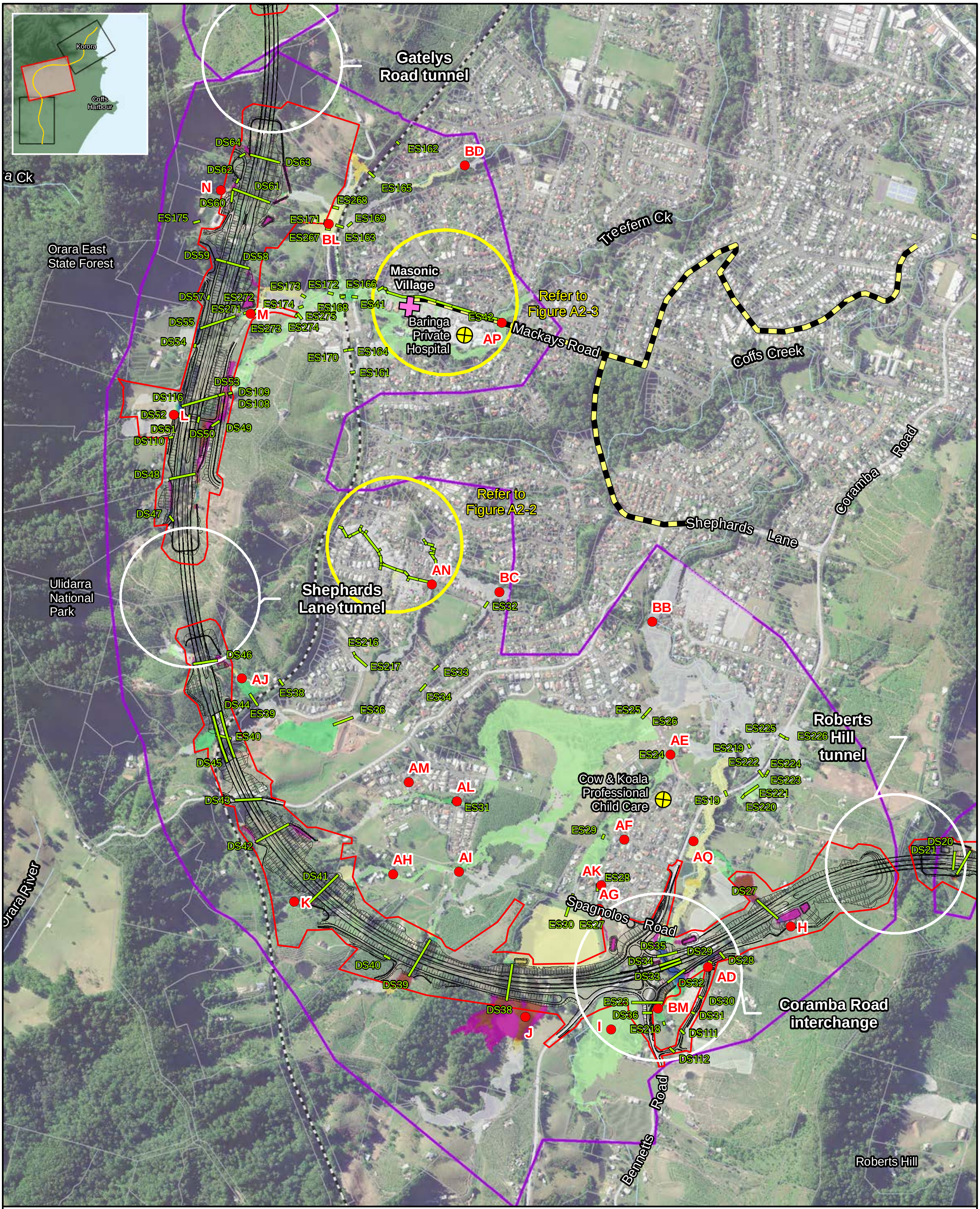
0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Coffs Harbour Bypass

North Boambee Valley 2 % AEP peak flood level difference

Figure D1-1-4



Legend

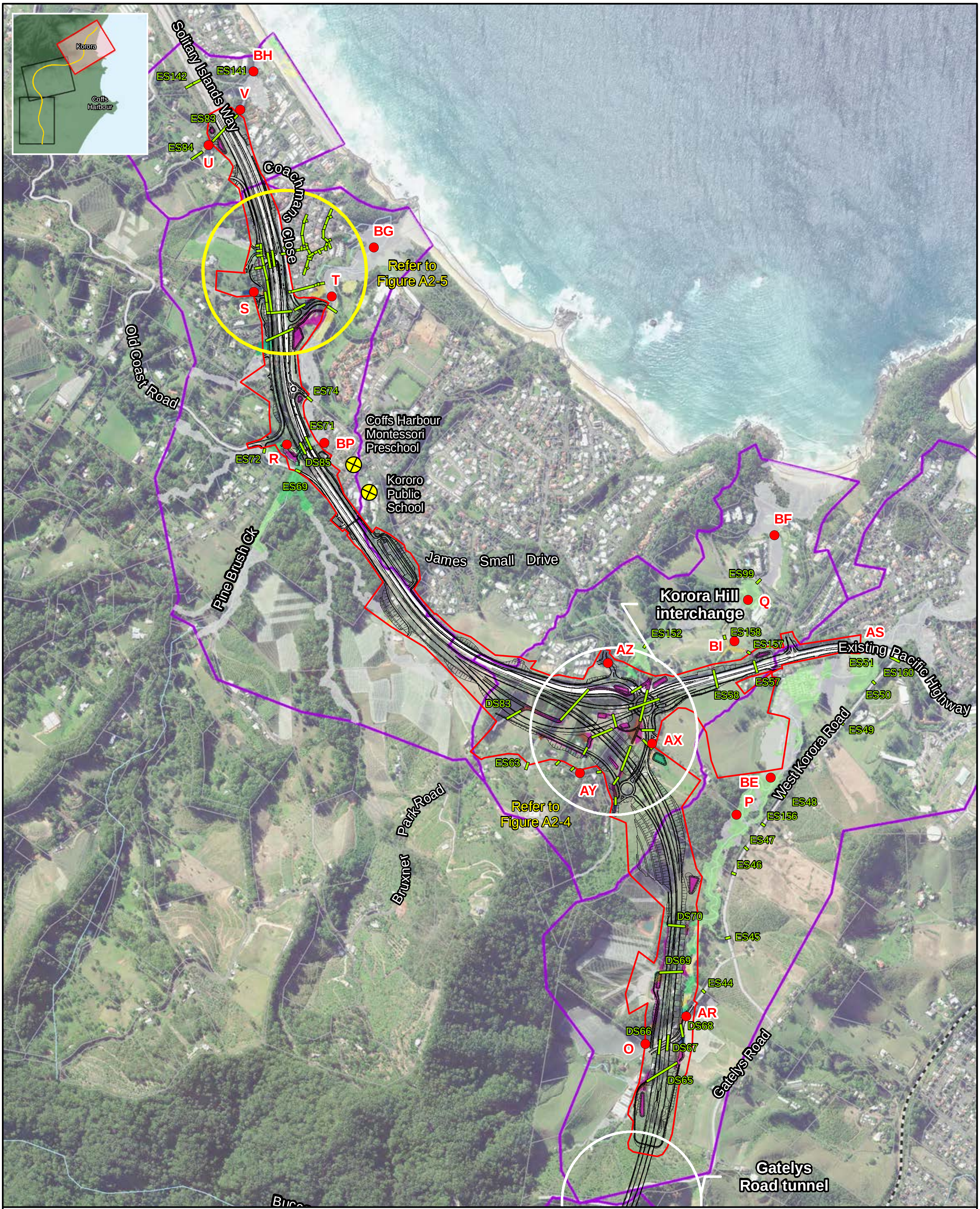
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
Coffs Creek 2 % AEP peak flood level difference
Figure D1-2-4

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

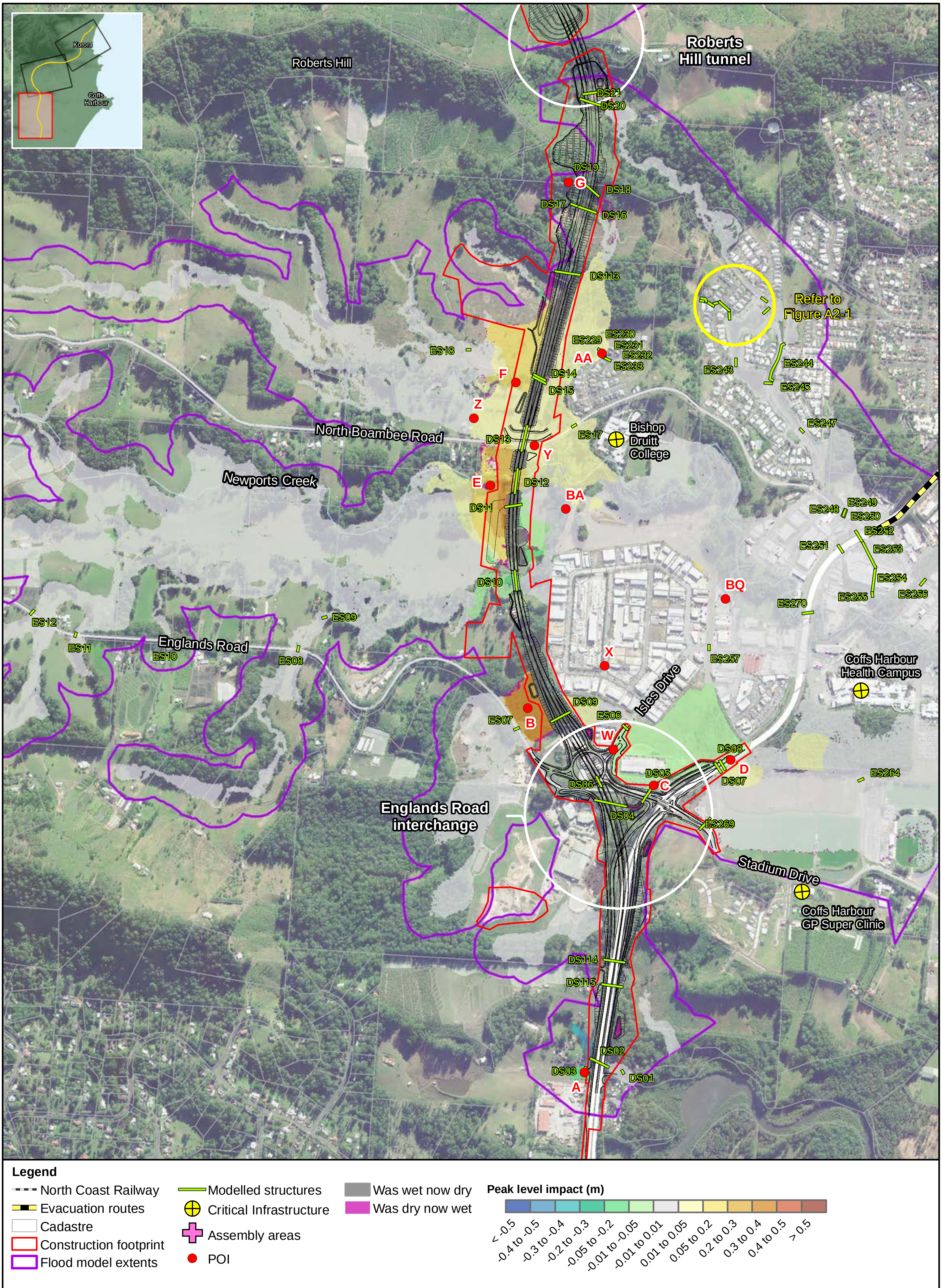
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

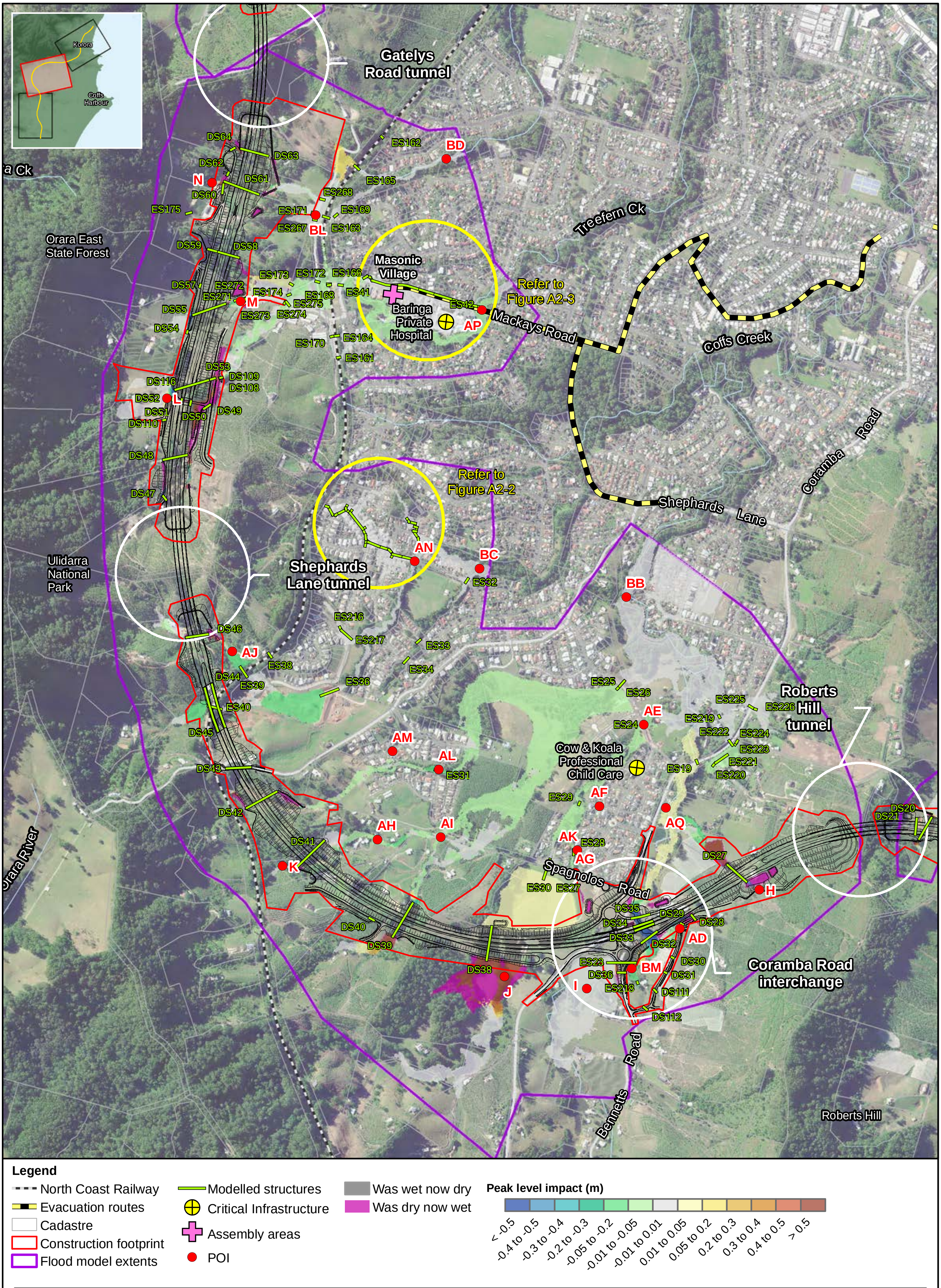
Coffs Harbour Bypass
Northern creeks 2 % AEP peak flood level difference
Figure D1-3-4

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N

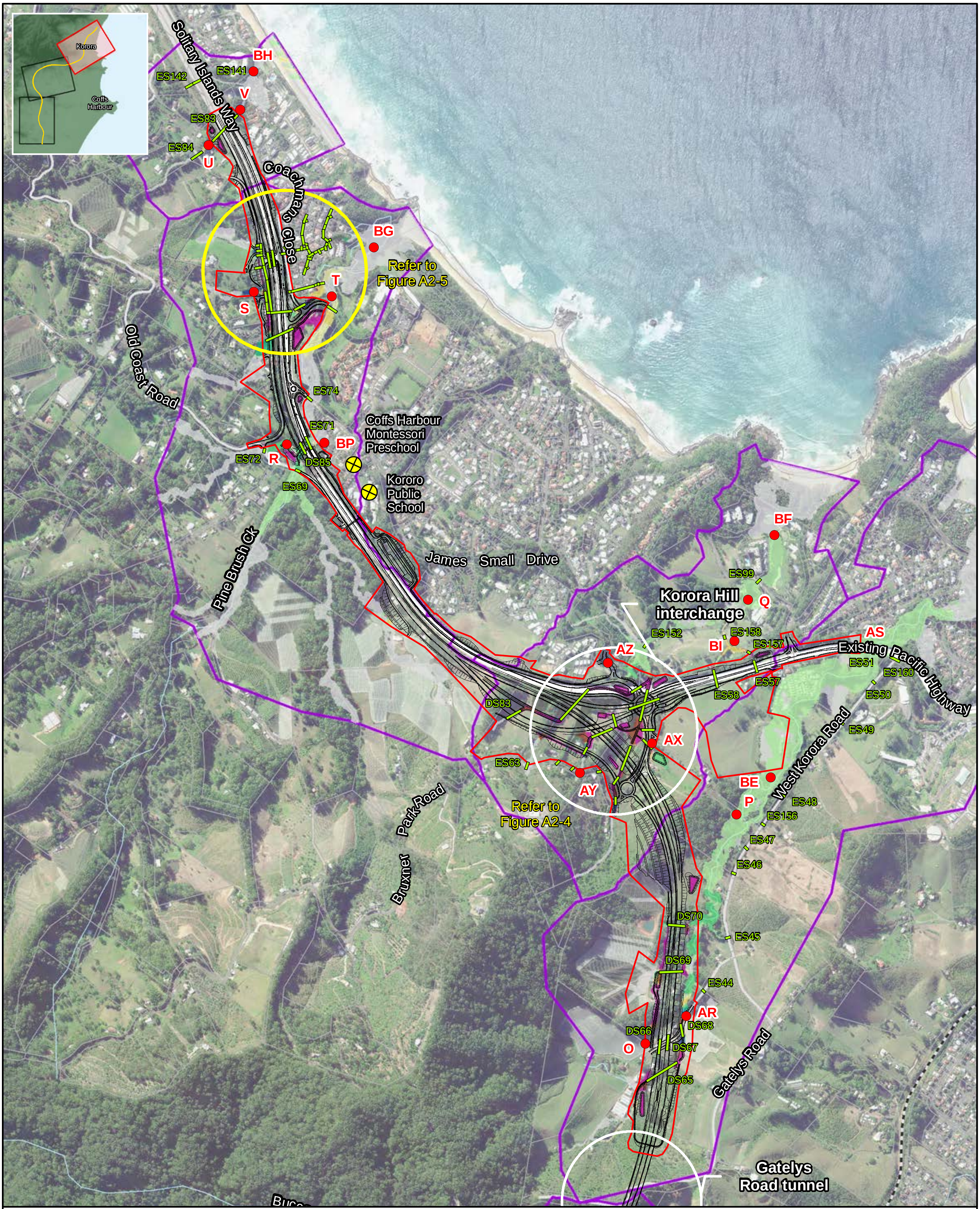


Coffs Harbour Bypass
North Boambee Valley 1 % AEP peak flood level difference
Figure D1-1-5

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Coffs Harbour Bypass
Coffs Creek 1 % AEP peak flood level difference
Figure D1-2-5



Legend

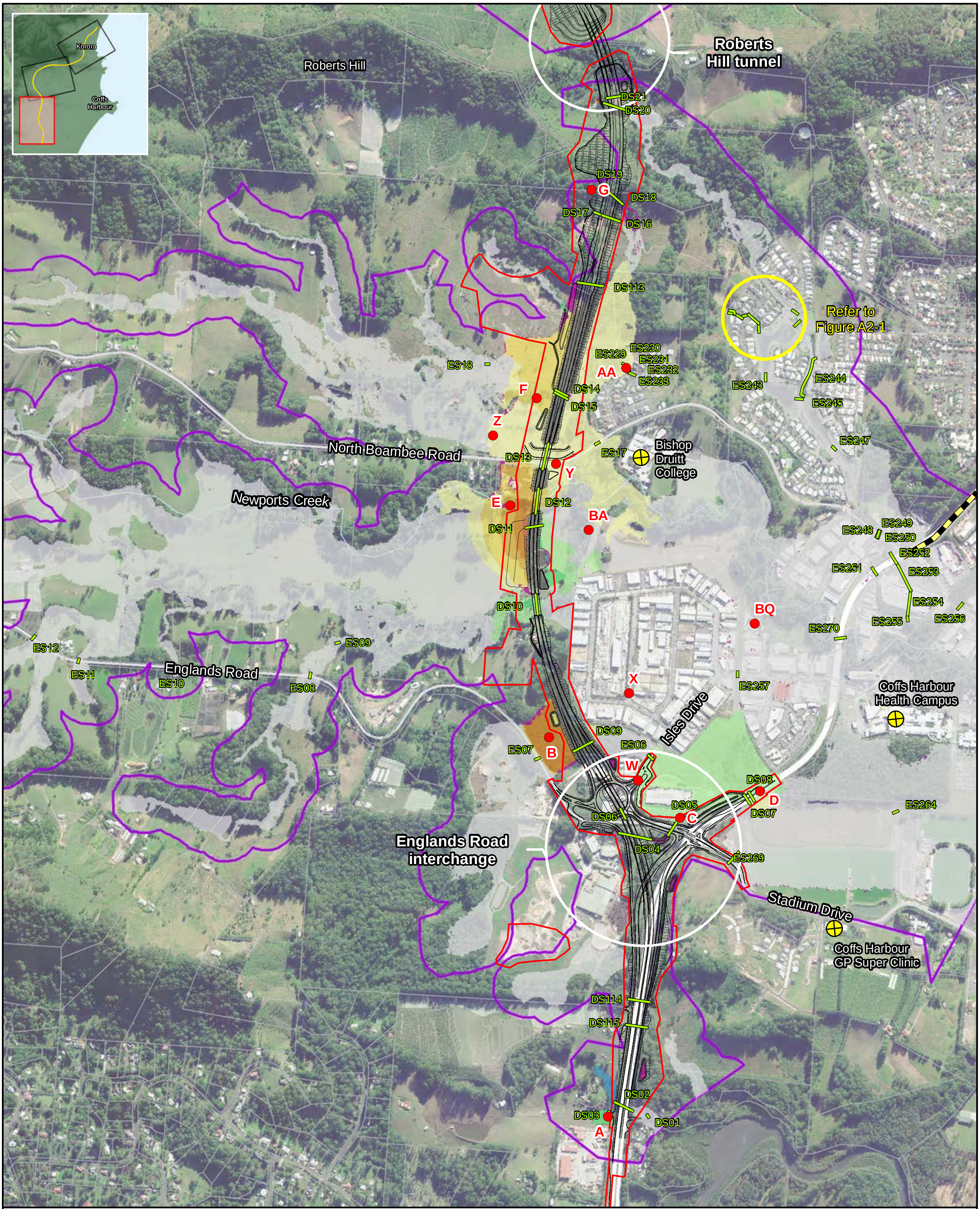
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
Northern creeks 1 % AEP peak flood level difference
Figure D1-3-5

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

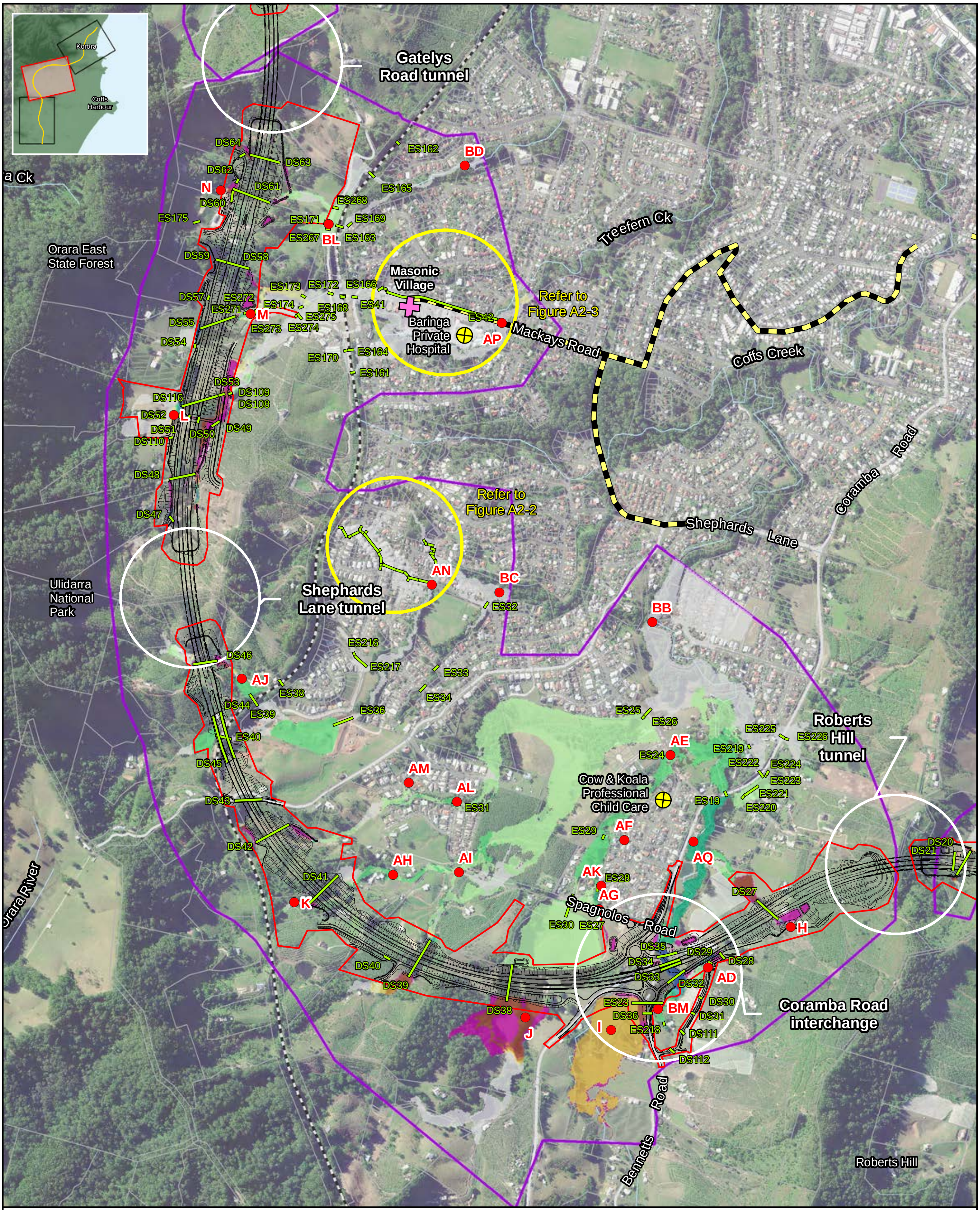
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
North Boambee Valley 1 % AEP 2050 climate peak flood level difference
Figure D1-1-6

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500

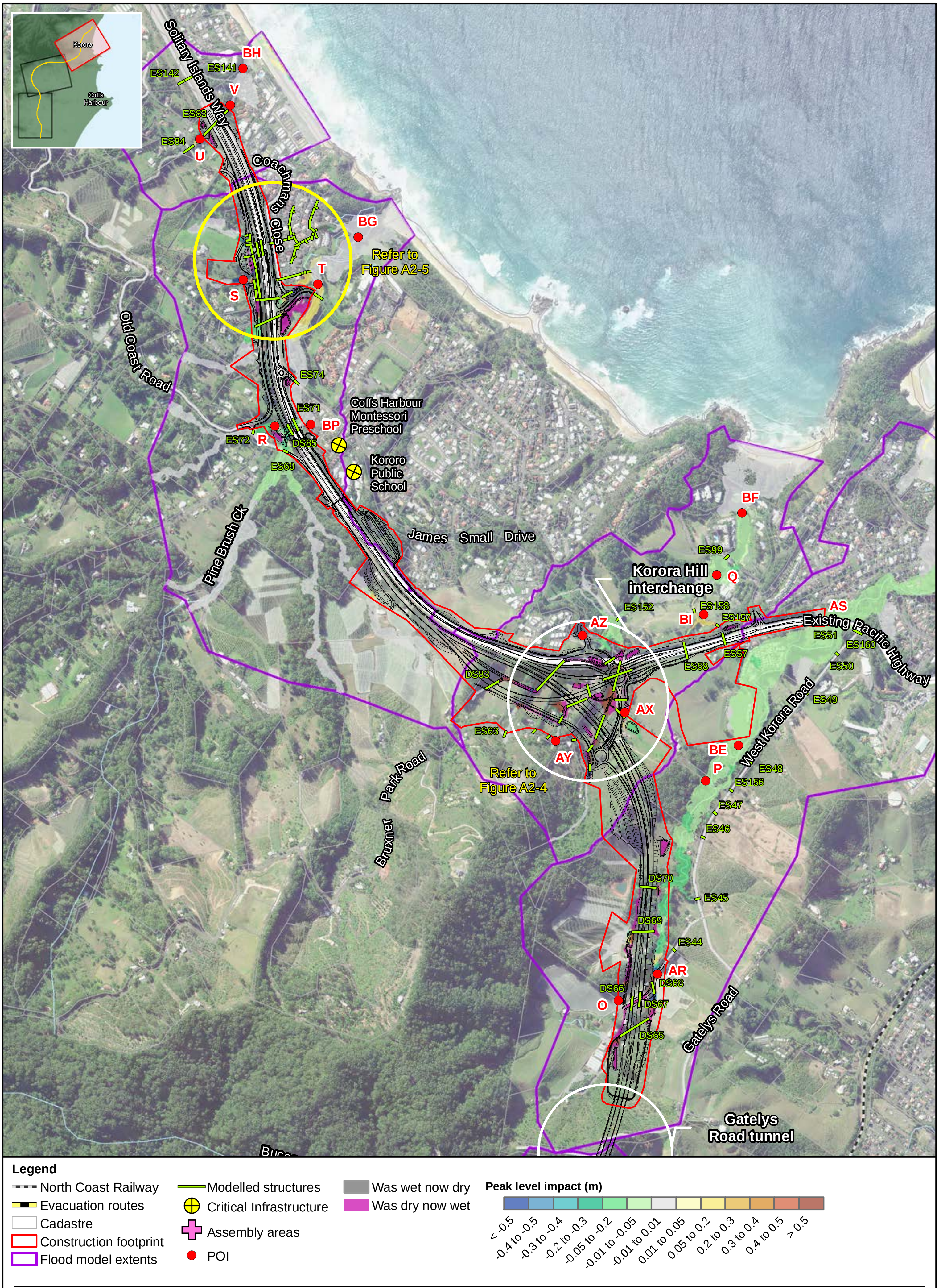
GDA 1994 MGA Zone 56

N

Coffs Harbour Bypass

Coffs Creek 1 % AEP 2050 climate peak flood level difference

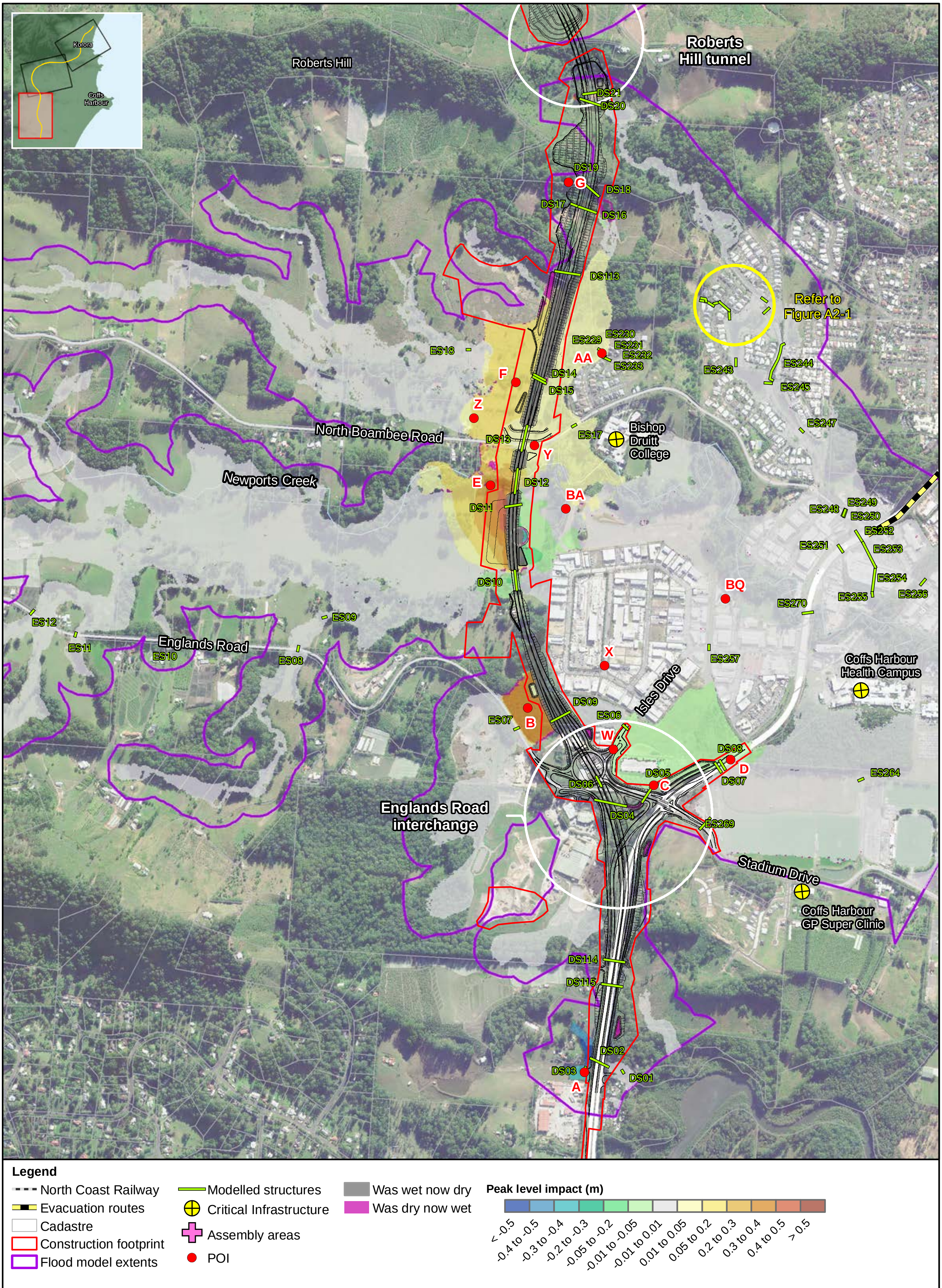
Figure D1-2-6



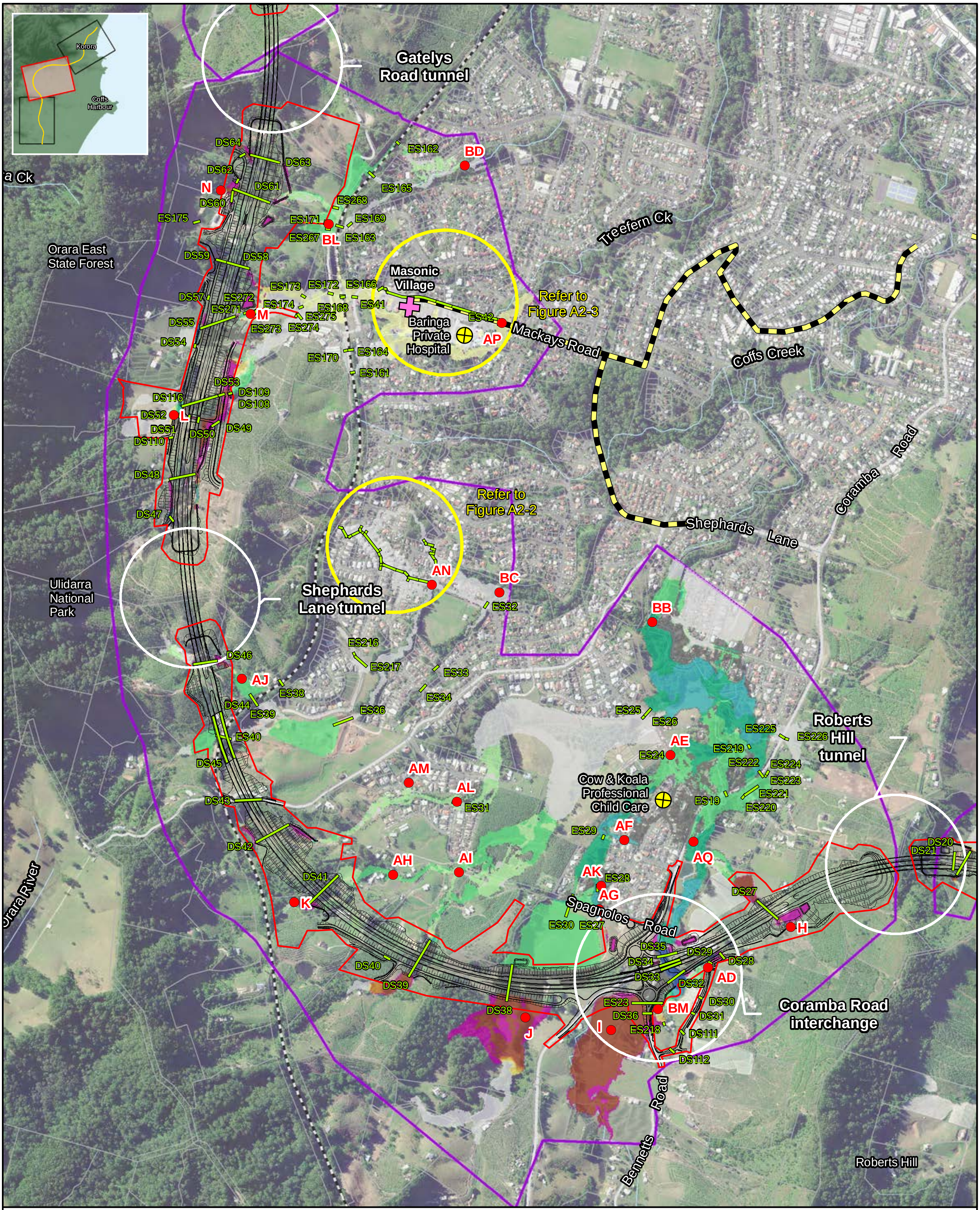
Coffs Harbour Bypass

Northern creeks 1 % AEP 2050 climate peak flood level difference

Figure D1-3-6



Coffs Harbour Bypass
North Boambee Valley 1 % AEP 2100 climate peak flood level difference
Figure D1-1-7



Legend

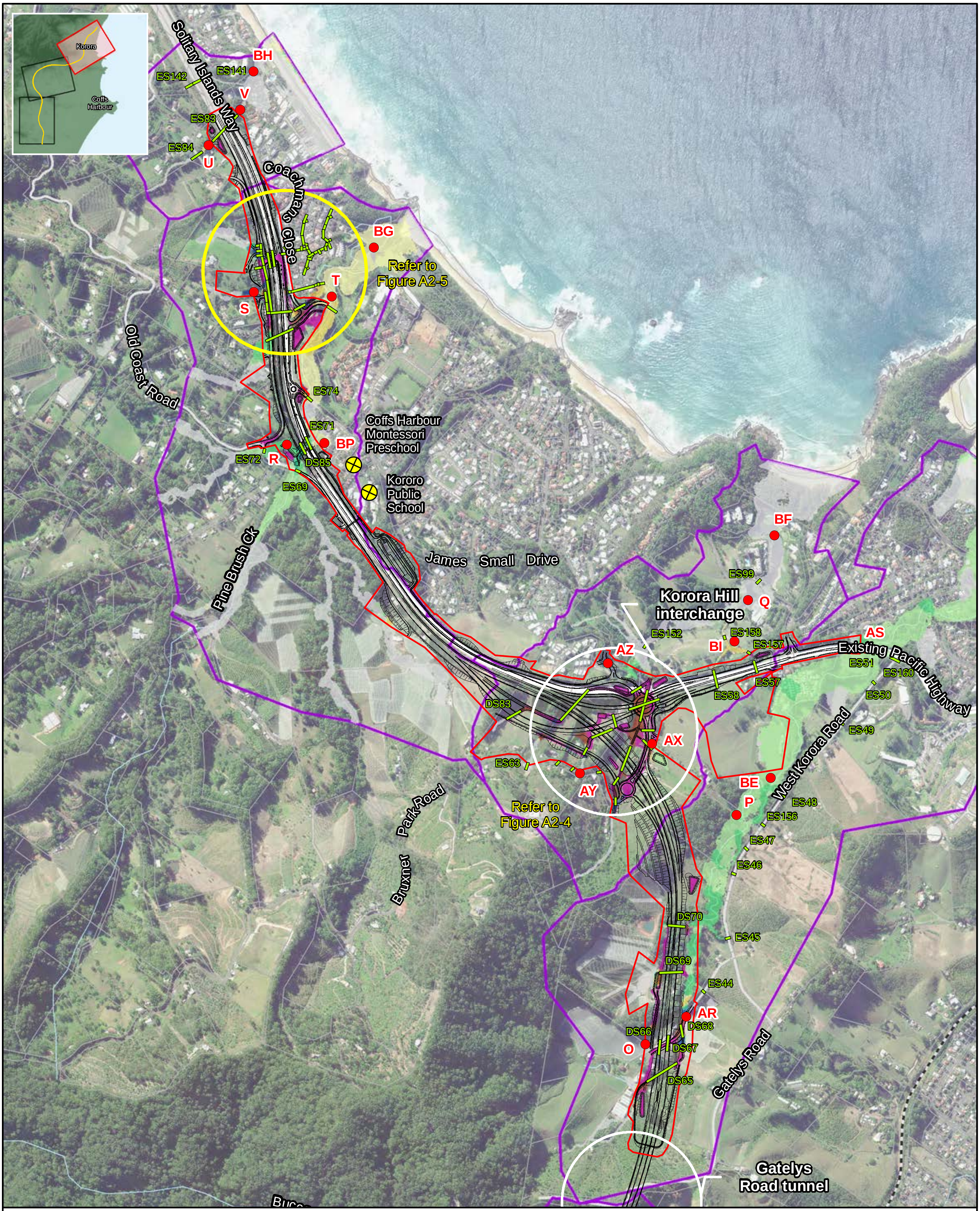
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
Coffs Creek 1 % AEP 2100 climate peak flood level difference
Figure D1-2-7

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

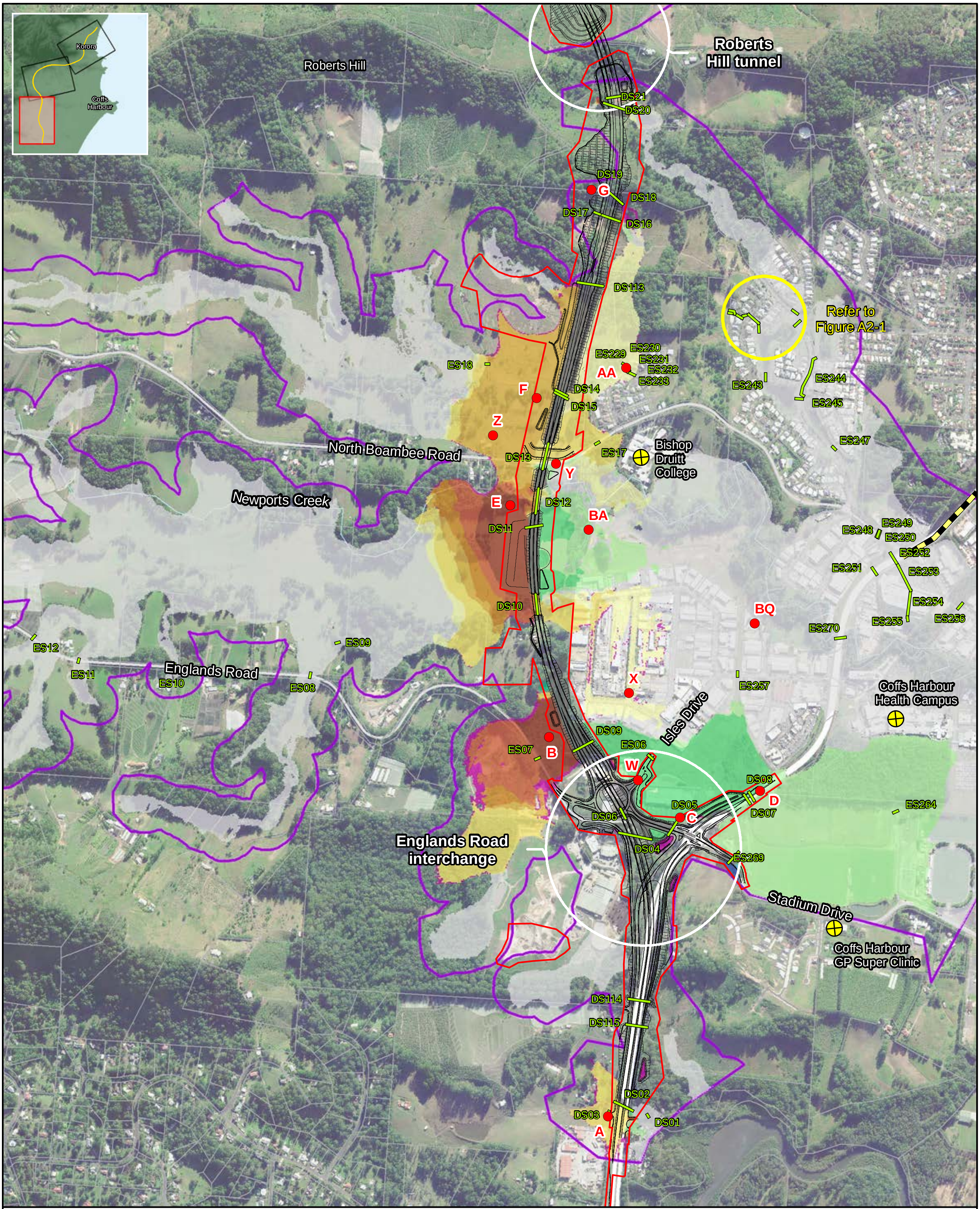
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5 | -0.4 to -0.5 | -0.3 to -0.4 | -0.2 to -0.3 | -0.05 to -0.2 | -0.01 to -0.05 | -0.01 to 0.01 | 0.01 to 0.05 | 0.05 to 0.2 | 0.2 to 0.3 | 0.3 to 0.4 | 0.4 to 0.5 | > 0.5

Coffs Harbour Bypass
Northern creeks 1 % AEP 2100 climate peak flood level difference
Figure D1-3-7

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

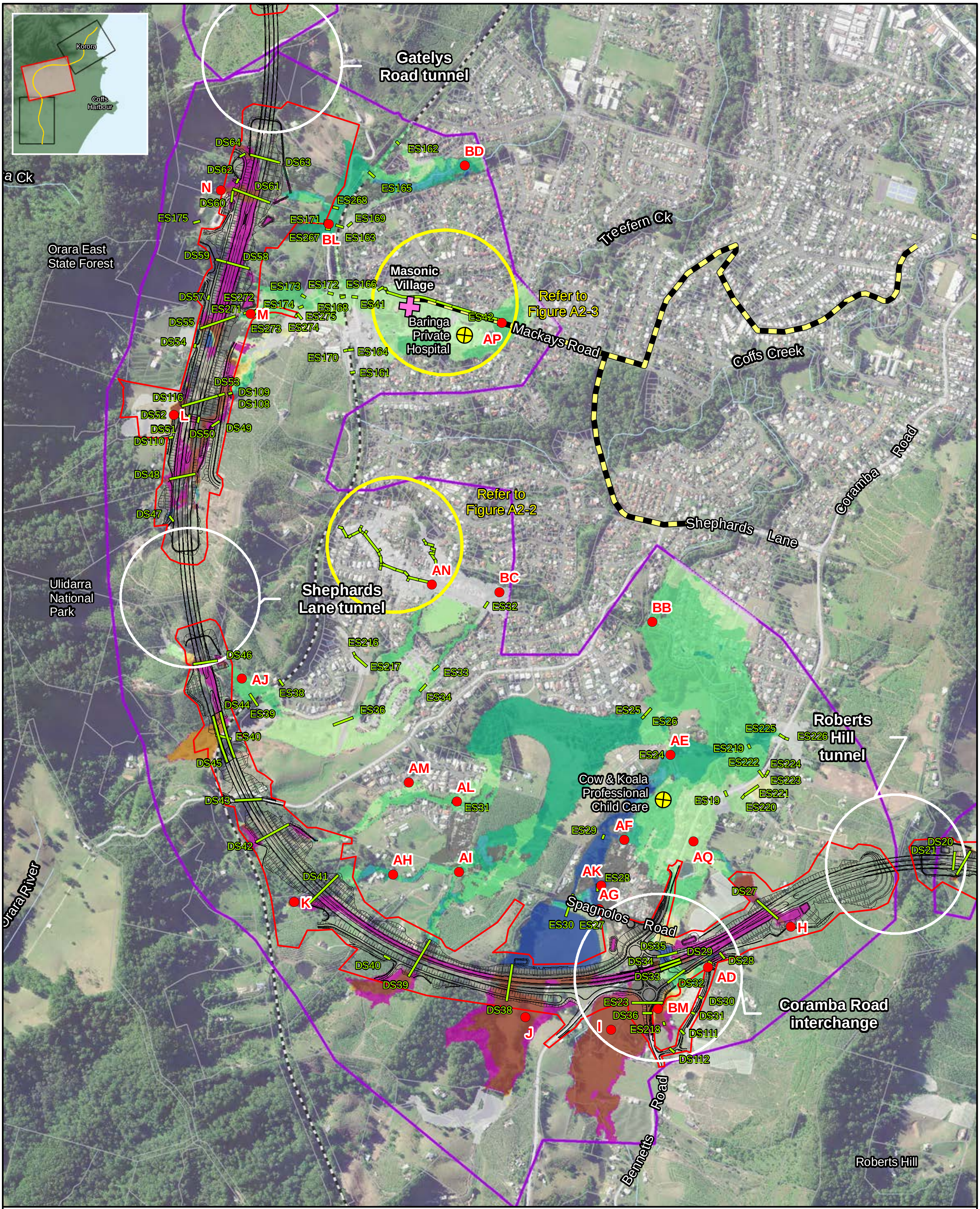
< -0.5 | -0.4 to -0.5 | -0.3 to -0.4 | -0.2 to -0.3 | -0.05 to -0.2 | -0.01 to -0.05 | -0.01 to 0.01 | 0.01 to 0.05 | 0.05 to 0.2 | 0.2 to 0.3 | 0.3 to 0.4 | 0.4 to 0.5 | > 0.5

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

N

Coffs Harbour Bypass
North Boambee Valley PMF peak flood level difference
Figure D1-1-8



Legend

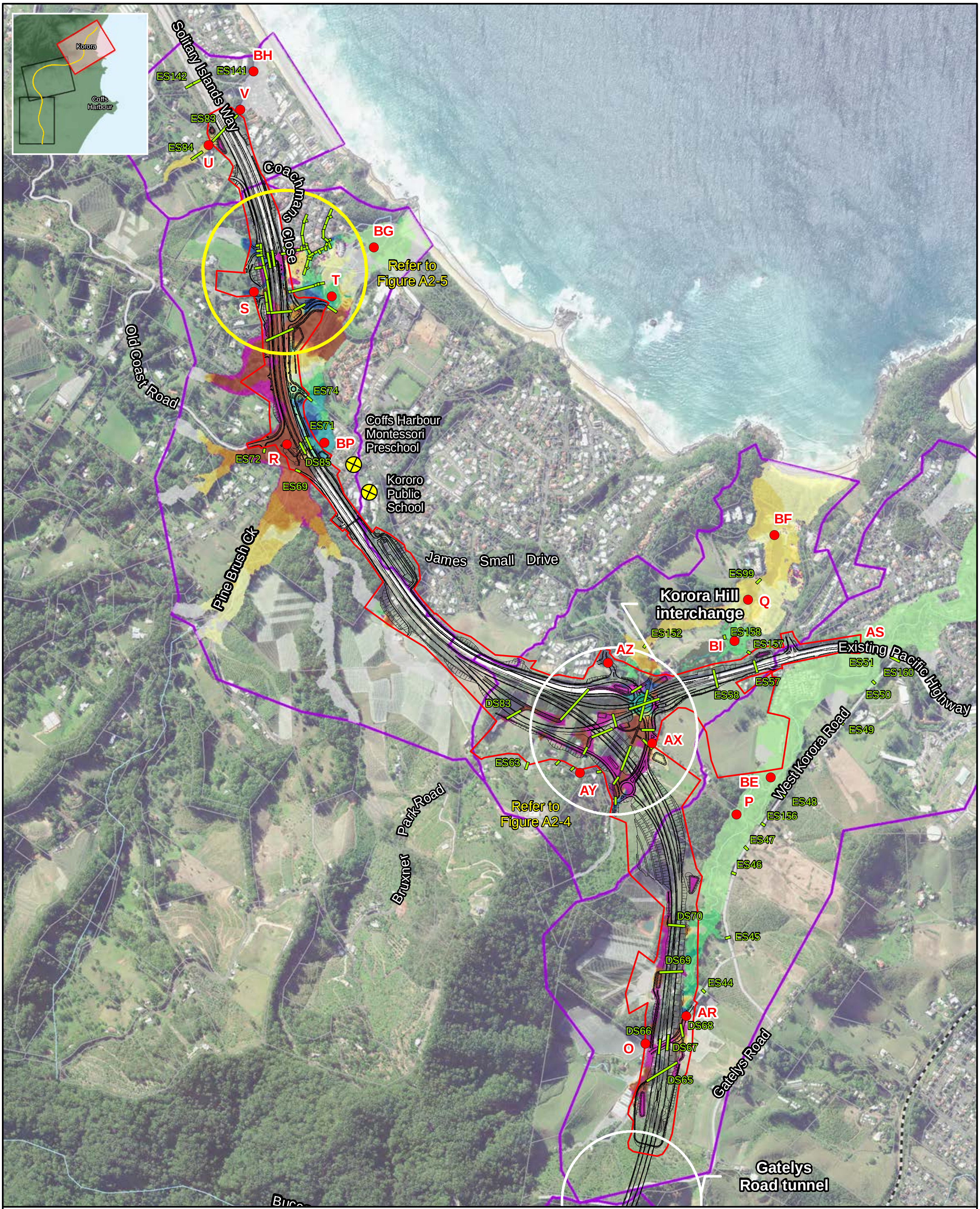
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
Coffs Creek PMF peak flood level difference
Figure D1-2-8

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

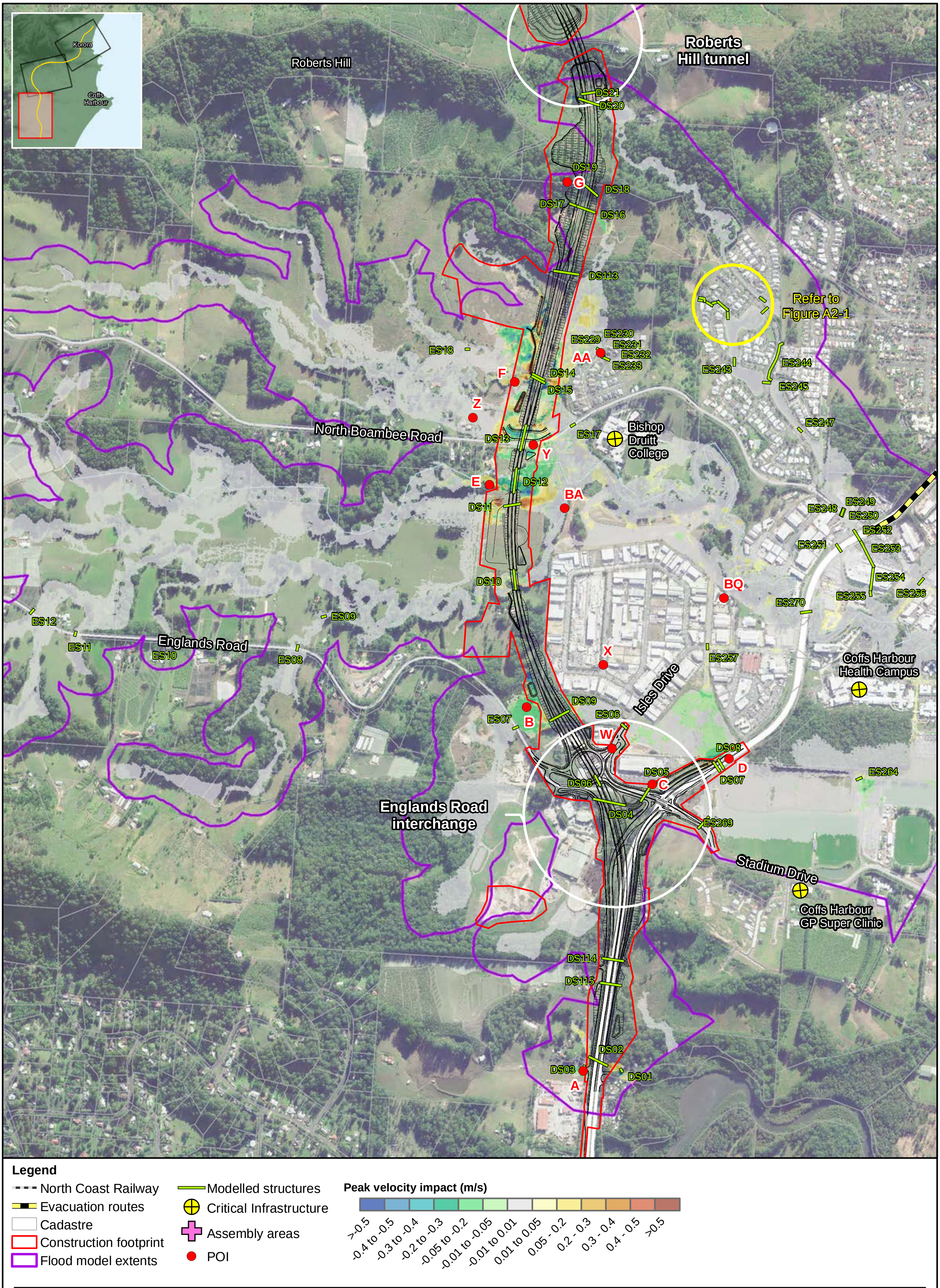
Peak level impact (m)

< -0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 to 0.2, 0.2 to 0.3, 0.3 to 0.4, 0.4 to 0.5, > 0.5

Coffs Harbour Bypass
Northern creeks PMF peak flood level difference
Figure D1-3-8

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N

D2 Peak flood velocity difference



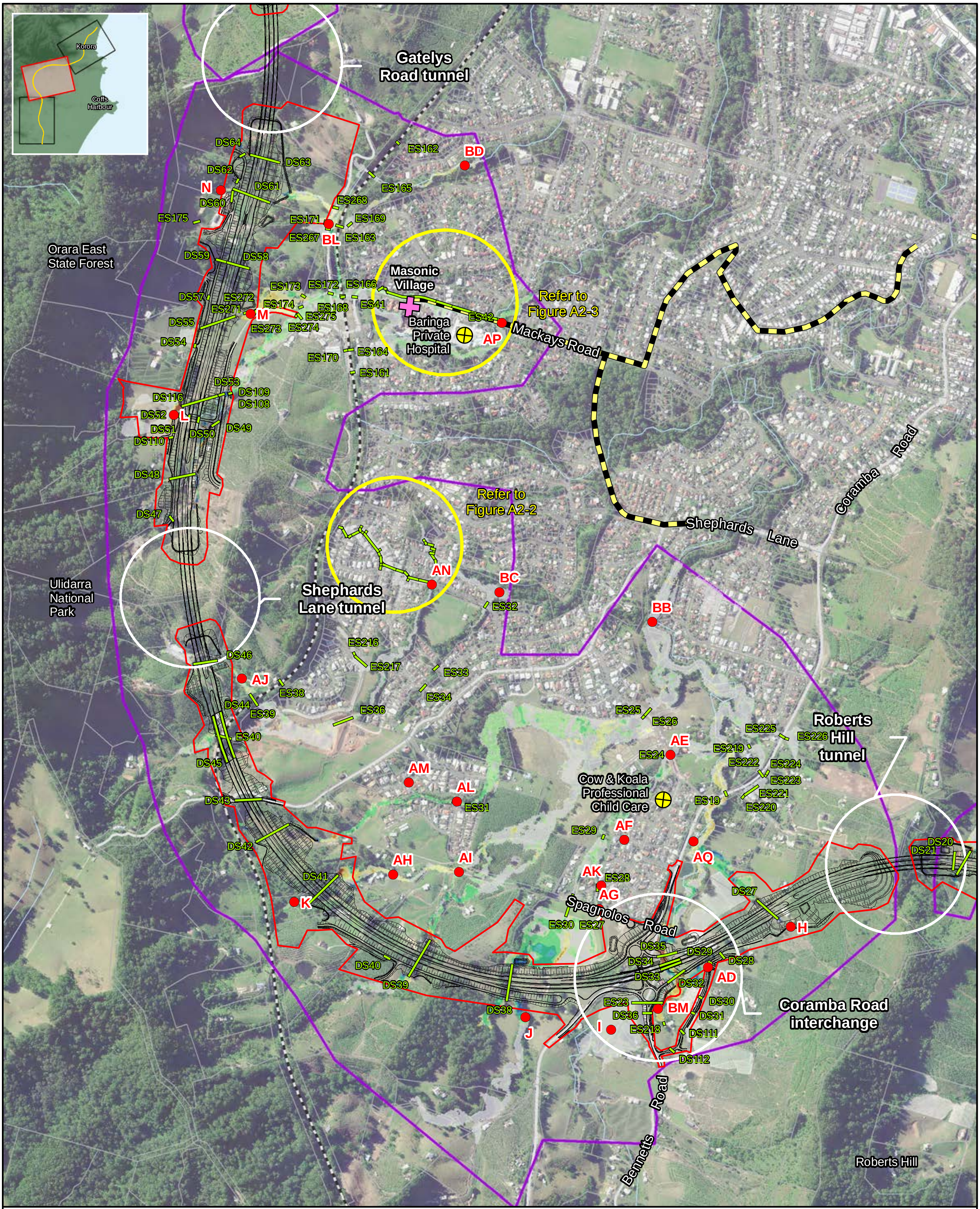
Coffs Harbour Bypass

North Boambee Valley 18 % AEP peak flood velocity difference

Figure D2-1-1

Scale @A4: 1:17,500

GDA 1994 MGA Zone 56



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

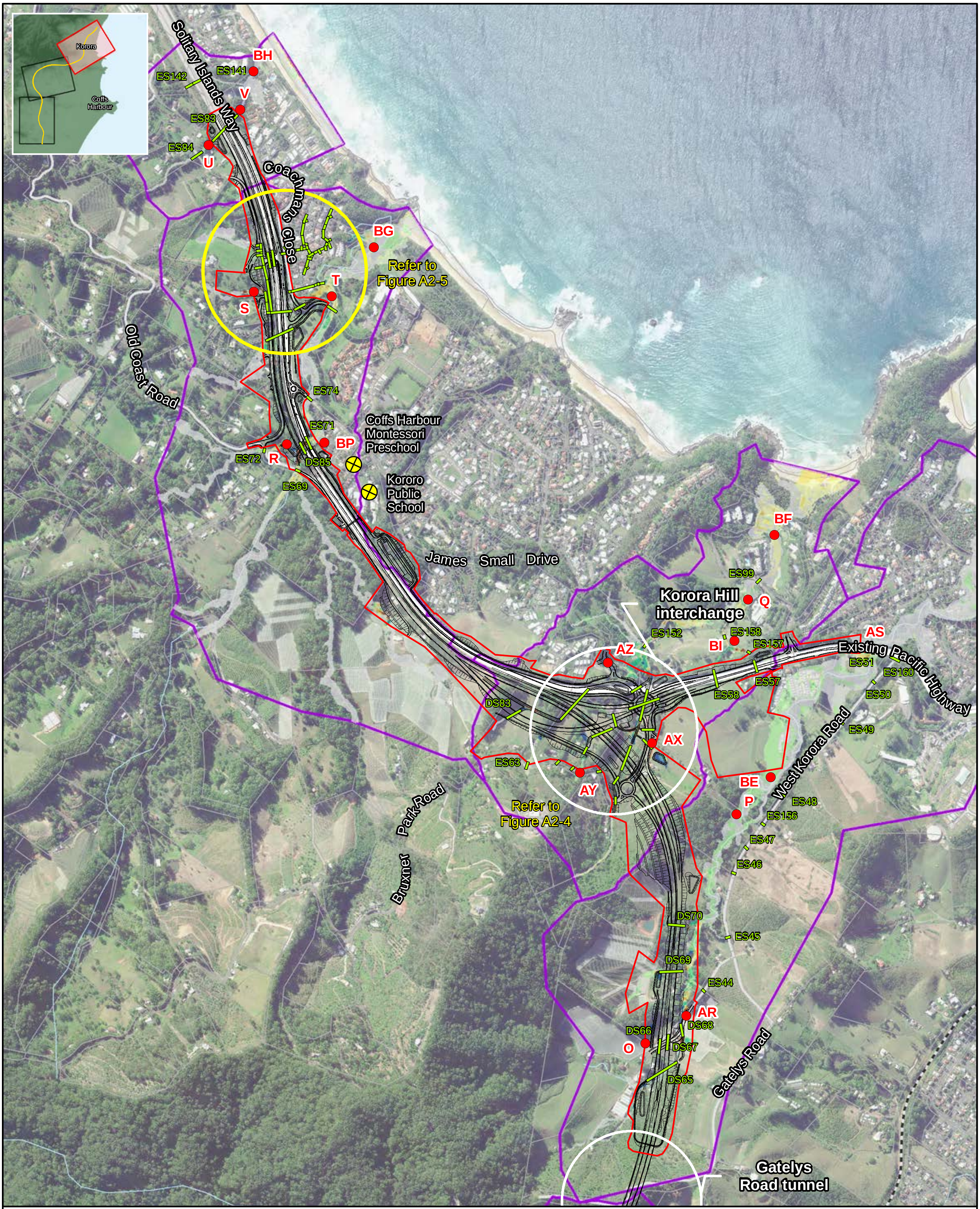
- >-0.5
- -0.4 to -0.5
- -0.3 to -0.4
- -0.2 to -0.3
- -0.05 to -0.2
- -0.01 to -0.05
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- >0.5

Coffs Harbour Bypass
Coffs Creek 18 % AEP peak flood velocity difference
Figure D2-2-1

0 0.15 0.3 0.45 km

N

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

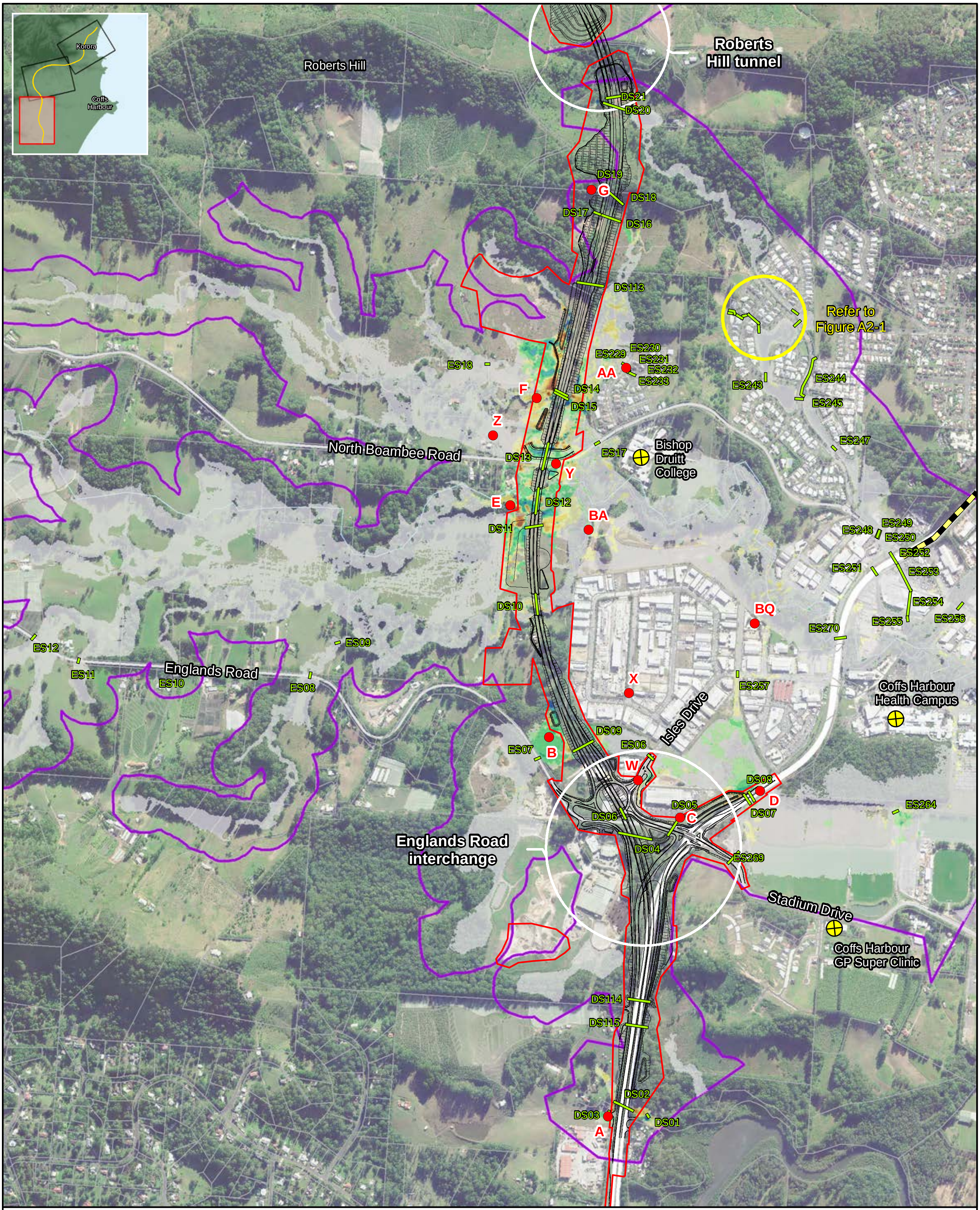
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Northern creeks 18 % AEP peak flood velocity difference
Figure D2-3-1

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

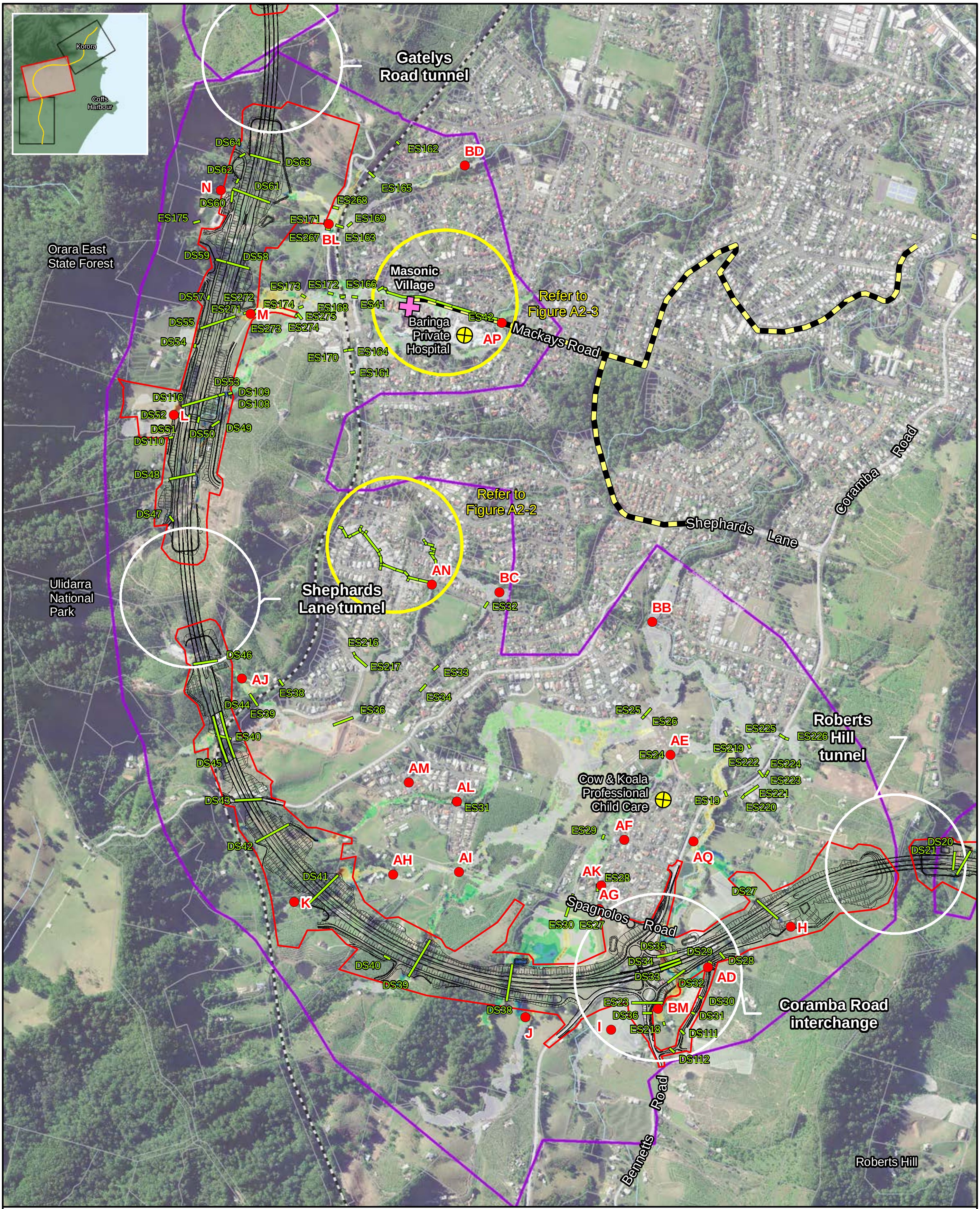
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
North Boambee Valley 10 % AEP peak flood velocity difference
Figure D2-1-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

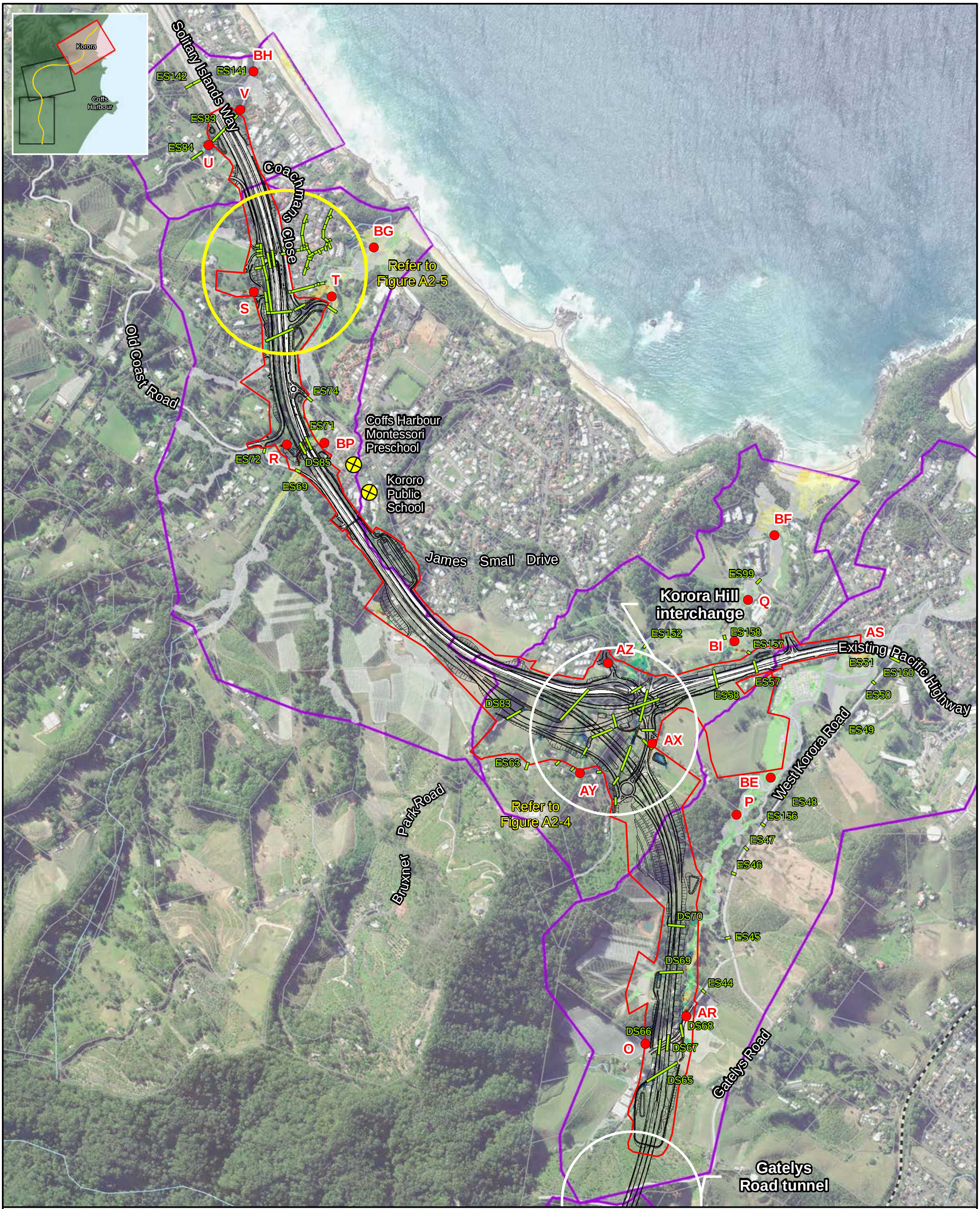
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

<-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Coffs Creek 10 % AEP peak flood velocity difference
Figure D2-2-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

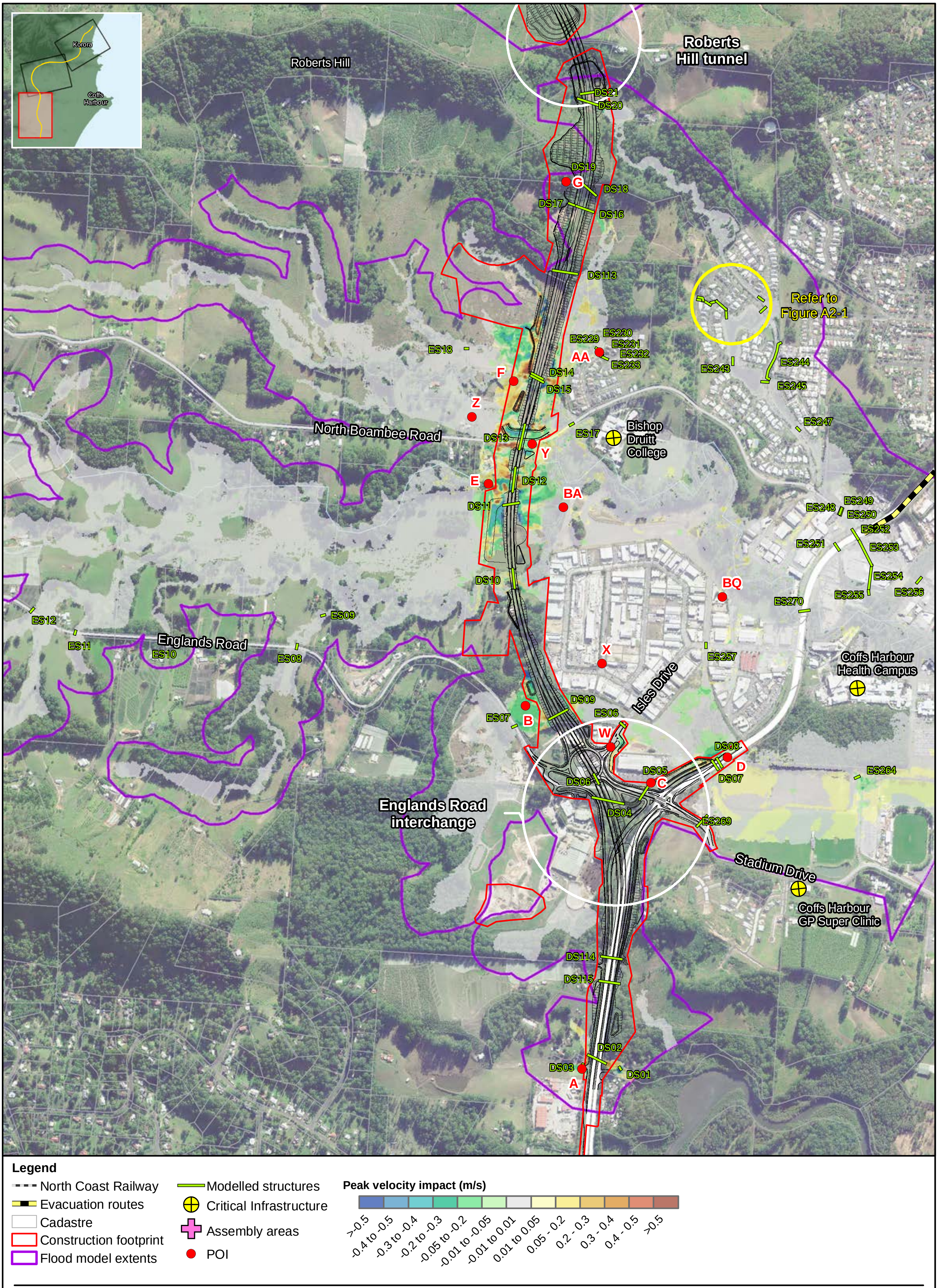
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

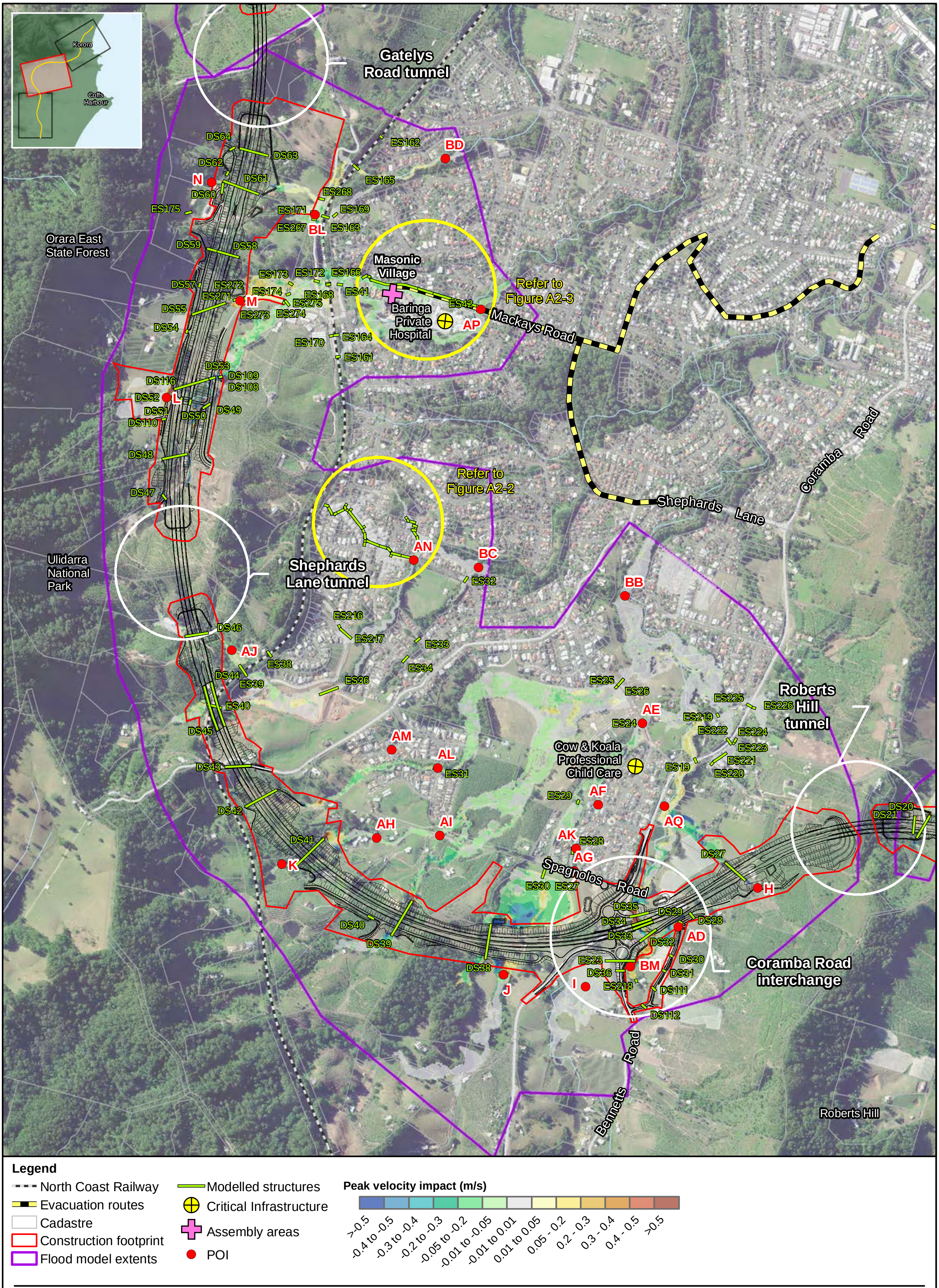
>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Northern creeks 10 % AEP peak flood velocity difference
Figure D2-3-2

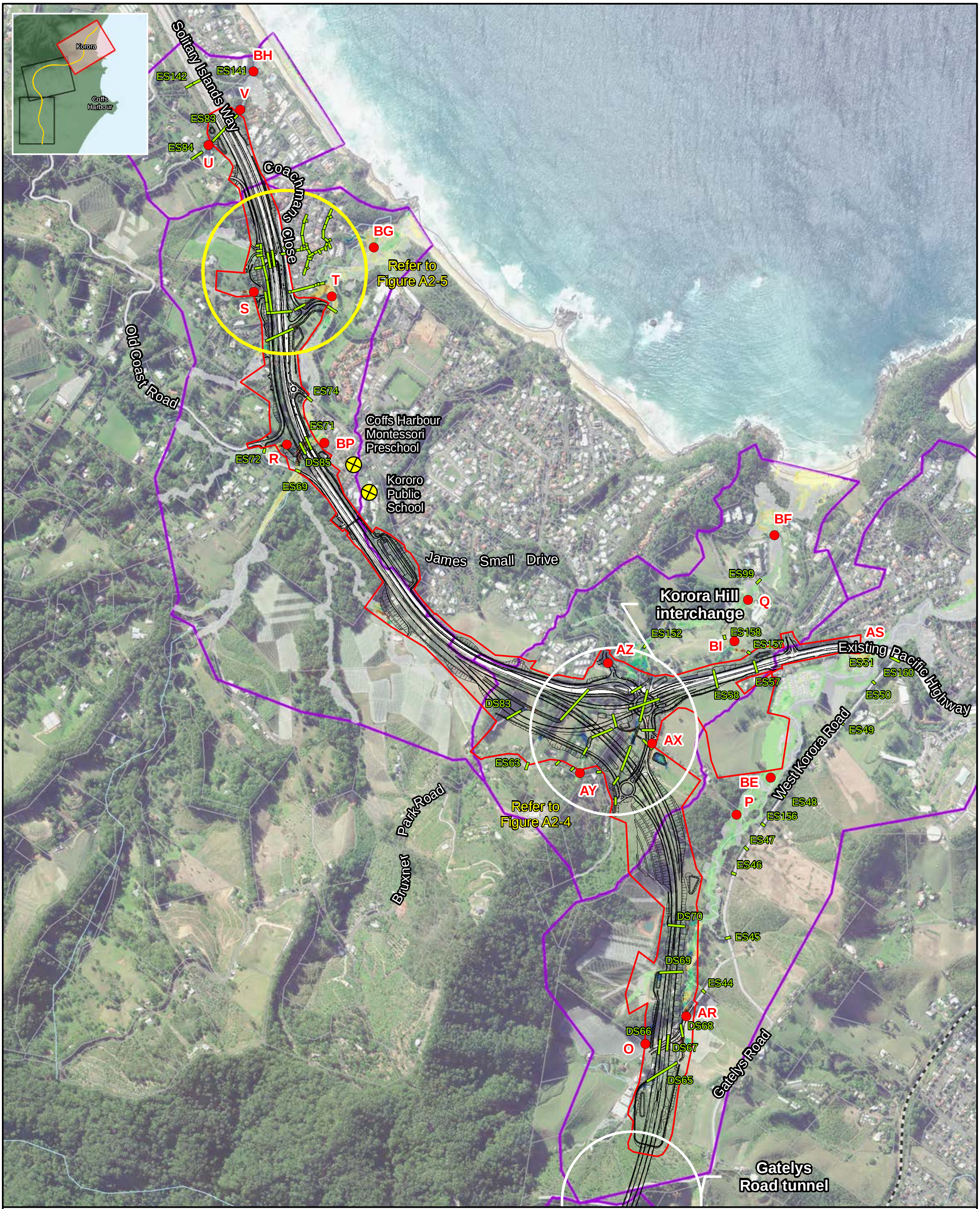
0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Coffs Harbour Bypass
North Boambee Valley 5 % AEP peak flood velocity difference
Figure D2-1-3



Coffs Harbour Bypass
Coffs Creek 5 % AEP peak flood velocity difference
Figure D2-2-3



Legend

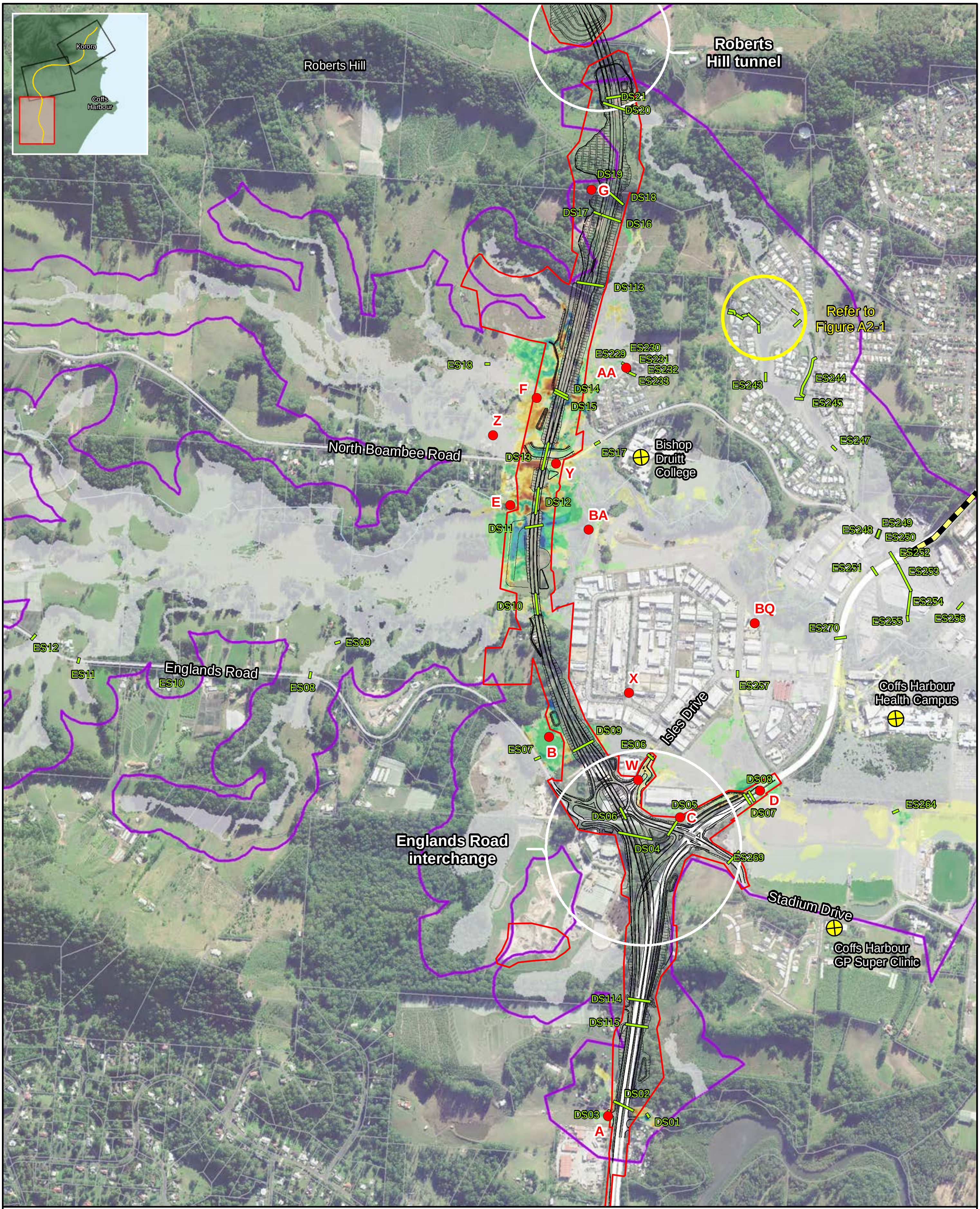
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Northern creeks 5 % AEP peak flood velocity difference
Figure D2-3-3

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

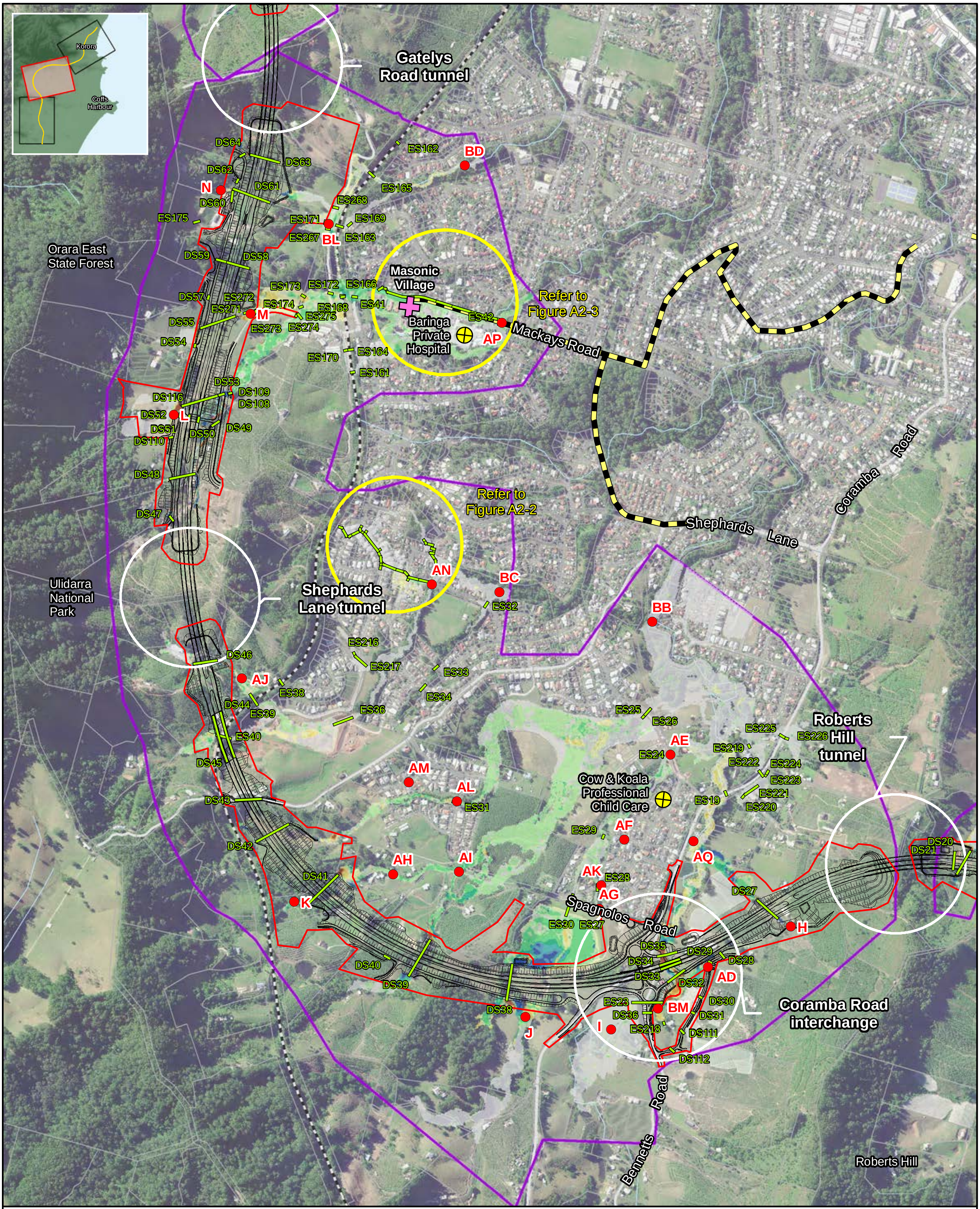
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
North Boambee Valley 2 % AEP peak flood velocity difference
Figure D2-1-4

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

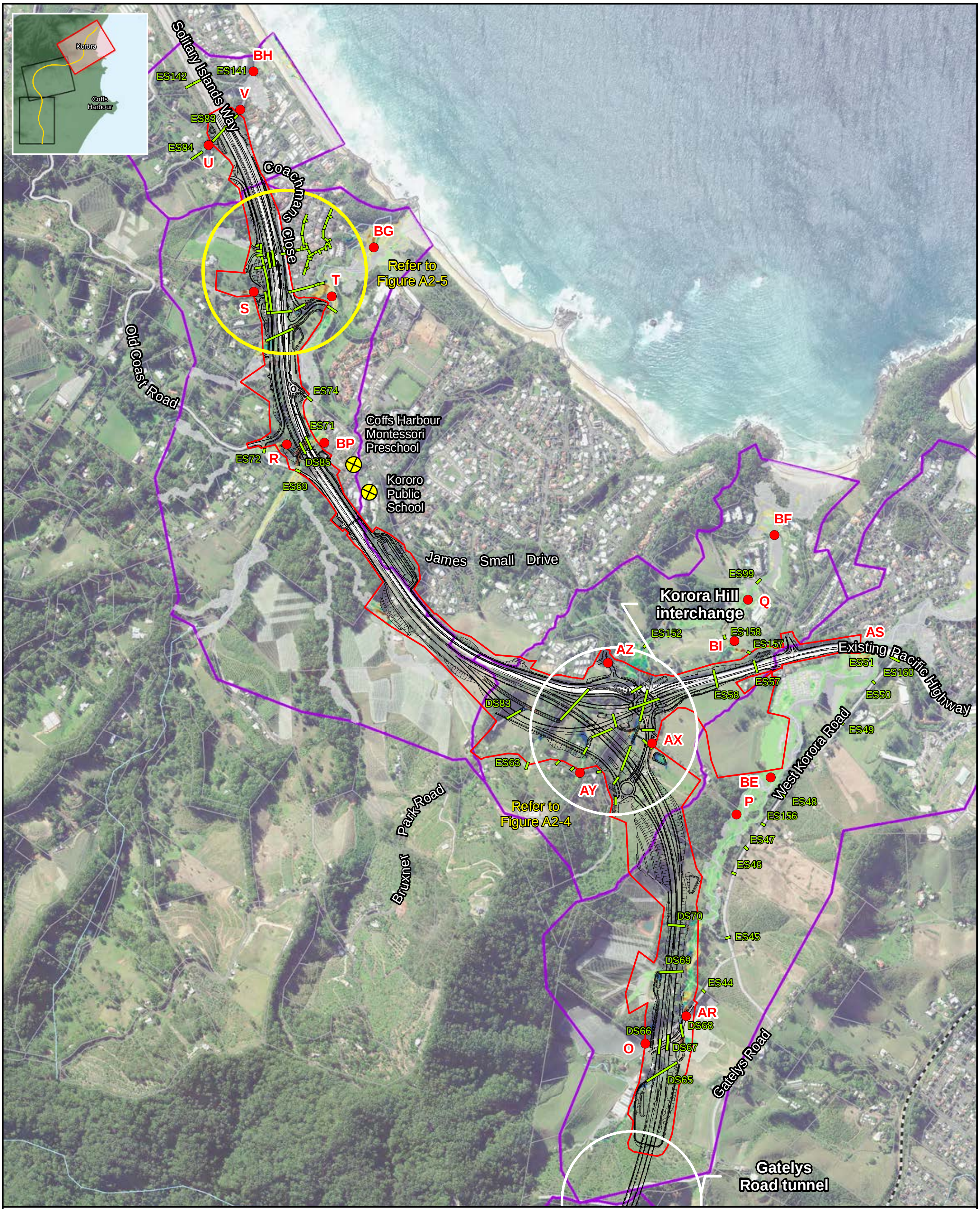
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5 | -0.4 to -0.5 | -0.3 to -0.4 | -0.2 to -0.3 | -0.05 to -0.2 | -0.01 to -0.05 | -0.01 to 0.01 | 0.01 to 0.05 | 0.05 - 0.2 | 0.2 - 0.3 | 0.3 - 0.4 | 0.4 - 0.5 | >0.5

Coffs Harbour Bypass
Coffs Creek 2 % AEP peak flood velocity difference
Figure D2-2-4

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

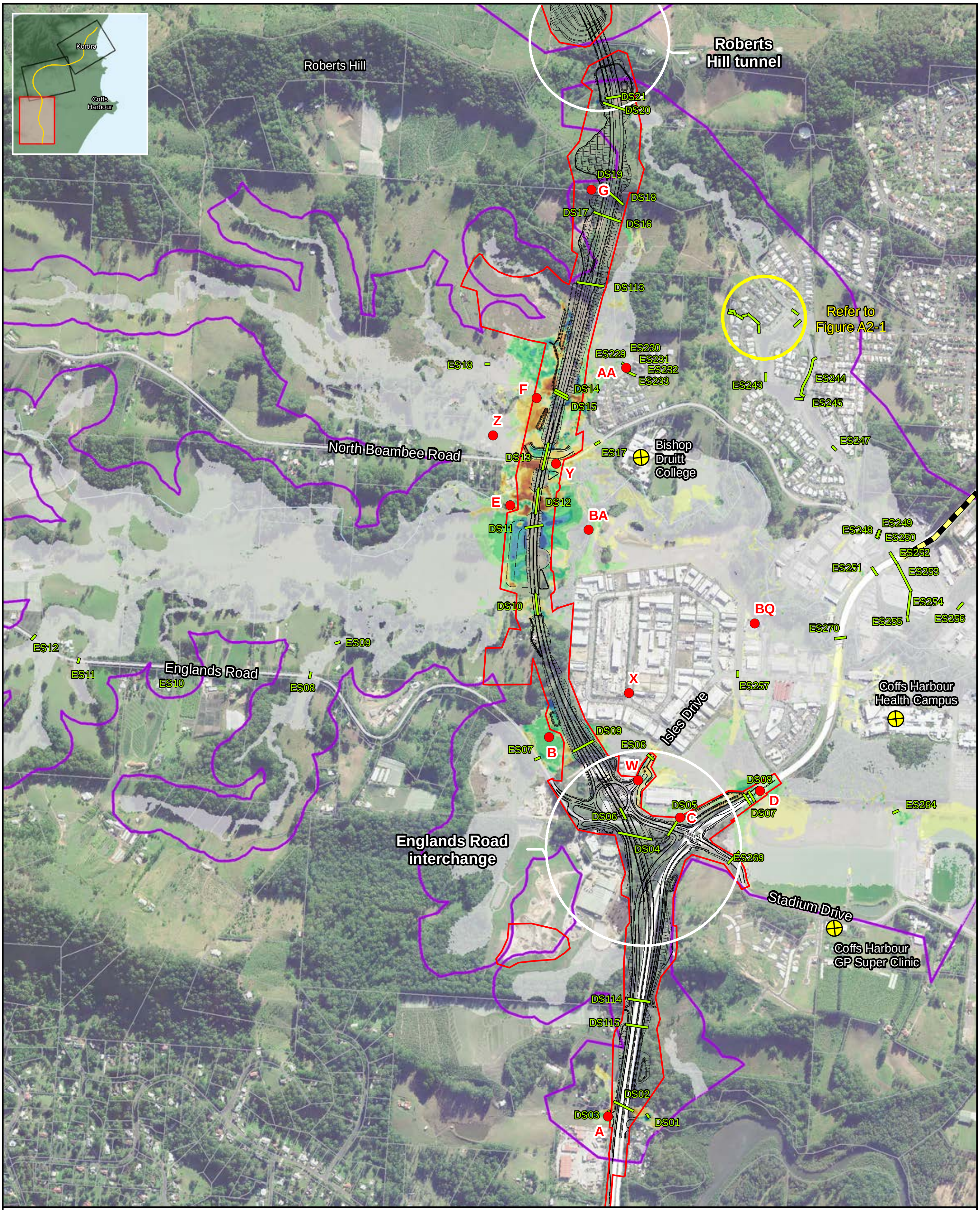
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

<-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Northern creeks 2 % AEP peak flood velocity difference
Figure D2-3-4

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

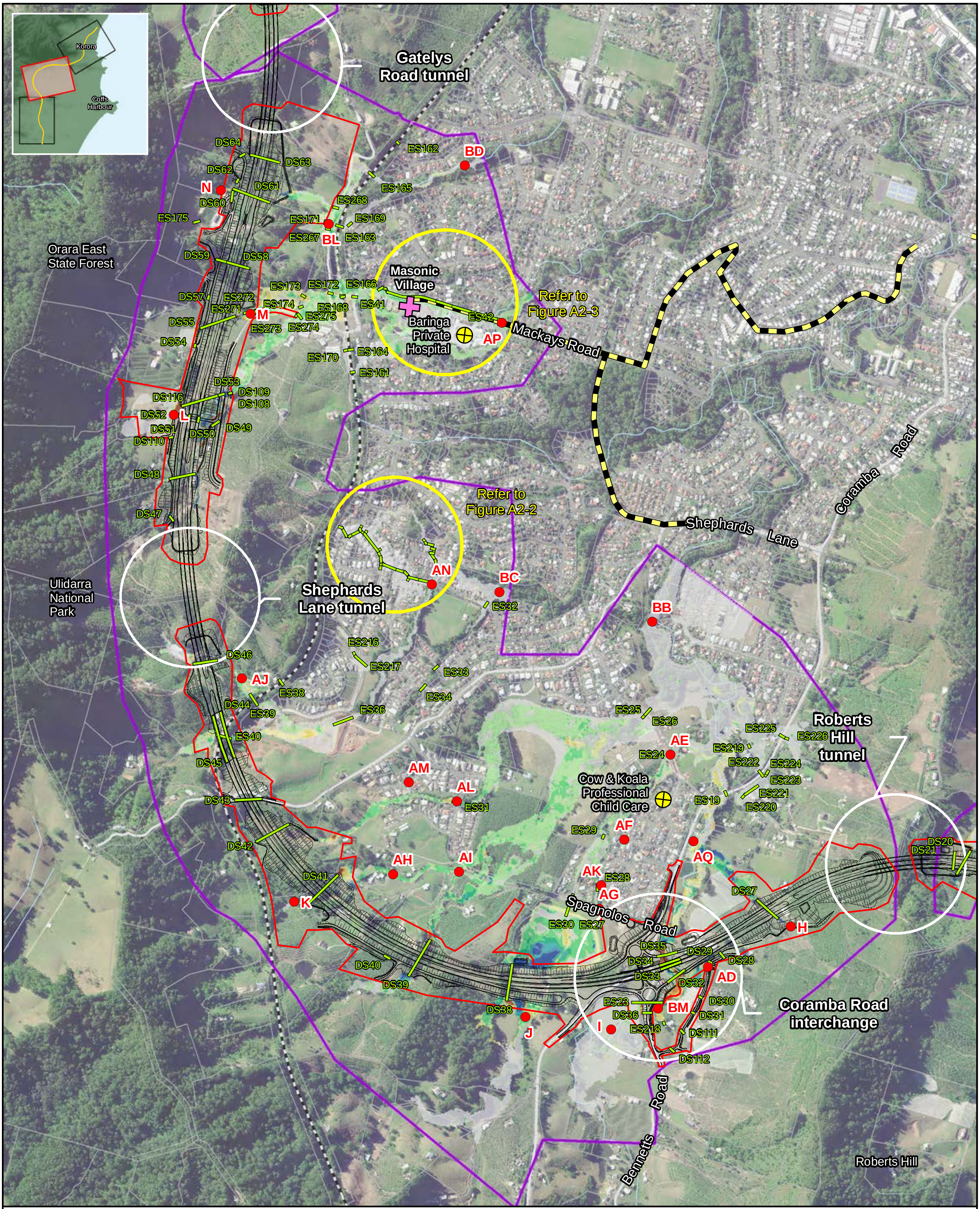
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
North Boambee Valley 1 % AEP peak flood velocity difference
Figure D2-1-5

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Legend

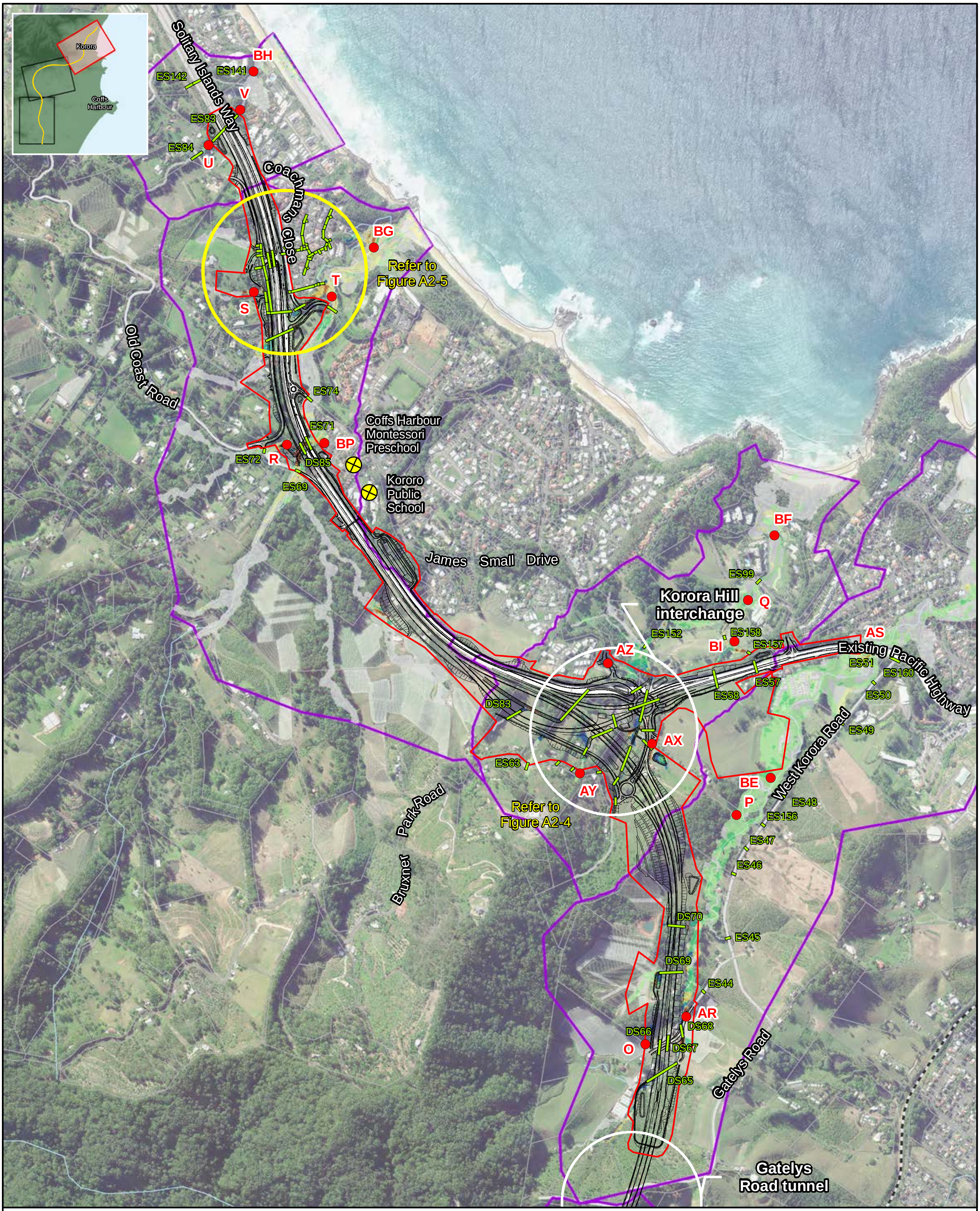
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Coffs Creek 1 % AEP peak flood velocity difference
Figure D2-2-5

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

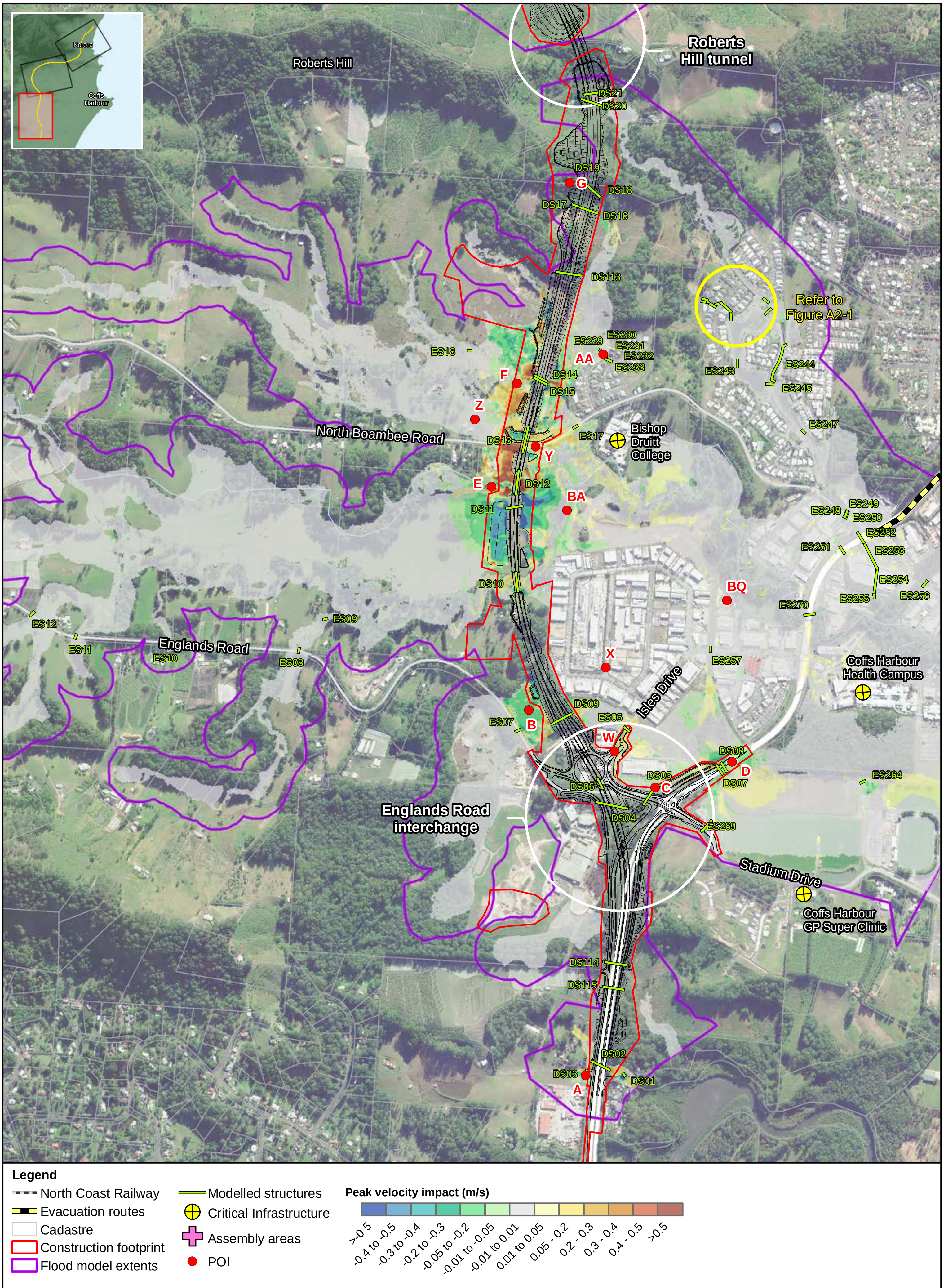
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

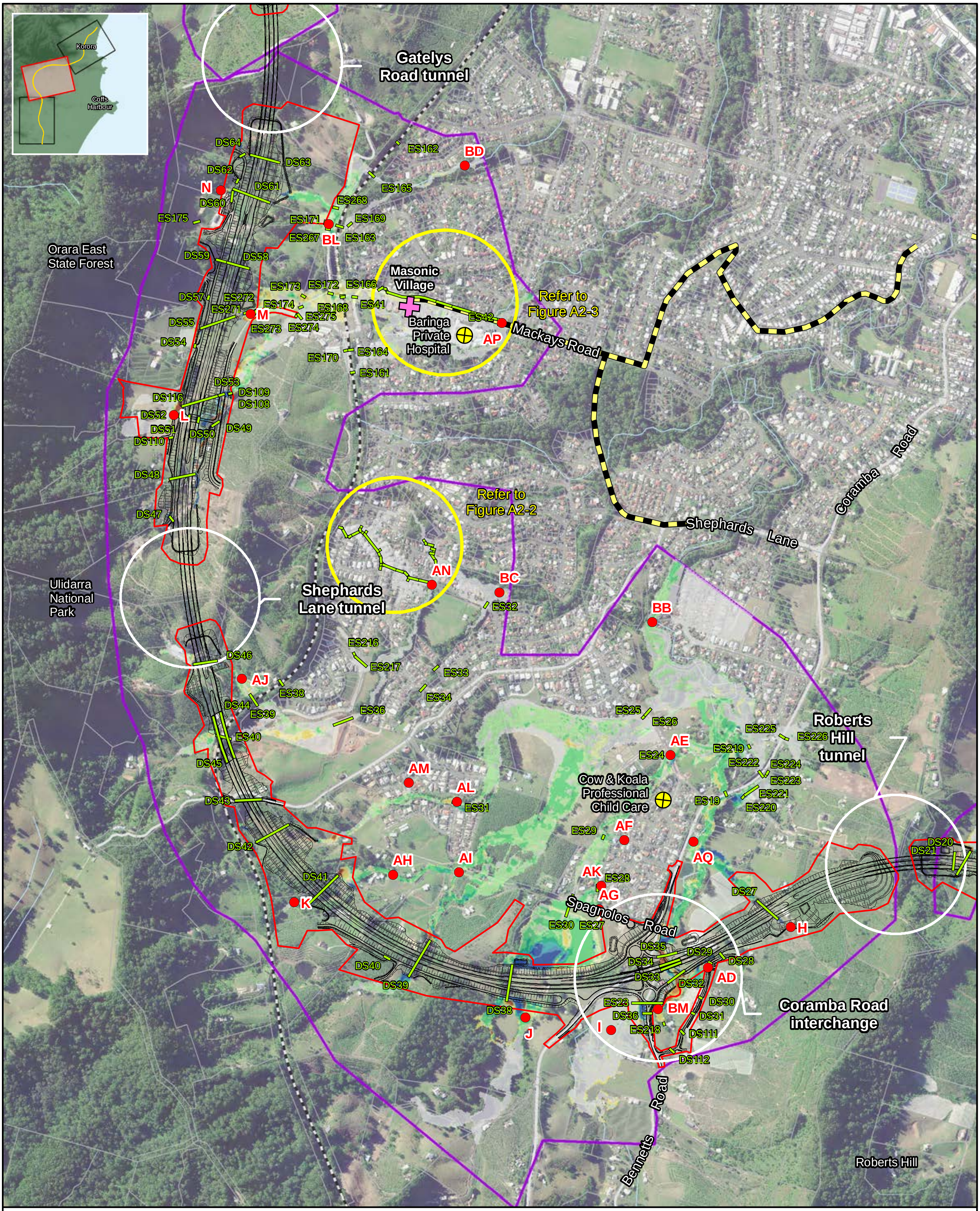
Coffs Harbour Bypass
Northern creeks 1 % AEP peak flood velocity difference
Figure D2-3-5



Coffs Harbour Bypass

North Boambee Valley 1 % AEP 2050 climate peak flood velocity difference

Figure D2-1-6



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

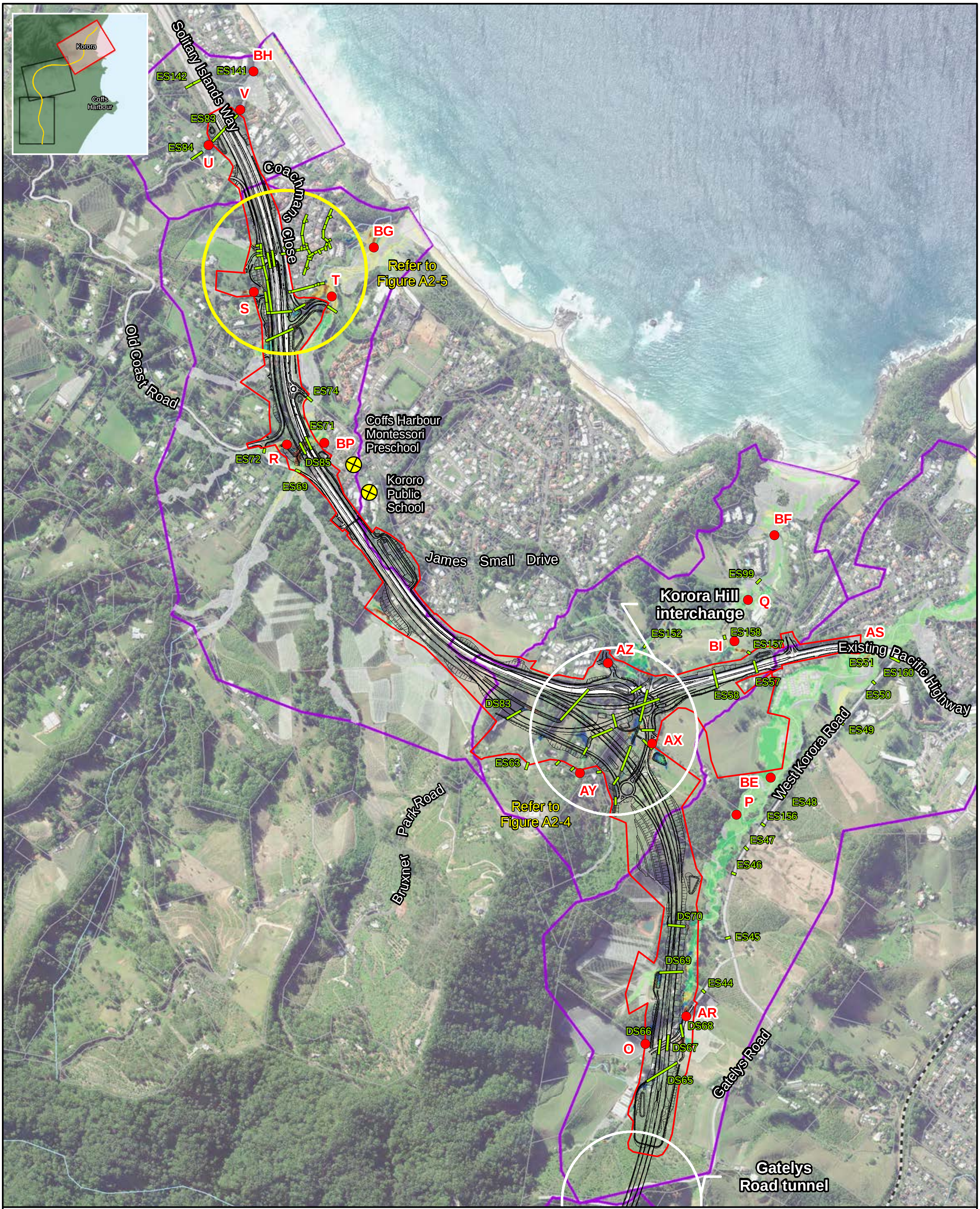
>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

0 0.15 0.3 0.45 km

N

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Coffs Harbour Bypass
Coffs Creek 1 % AEP 2050 climate peak flood velocity difference
Figure D2-2-6



Legend

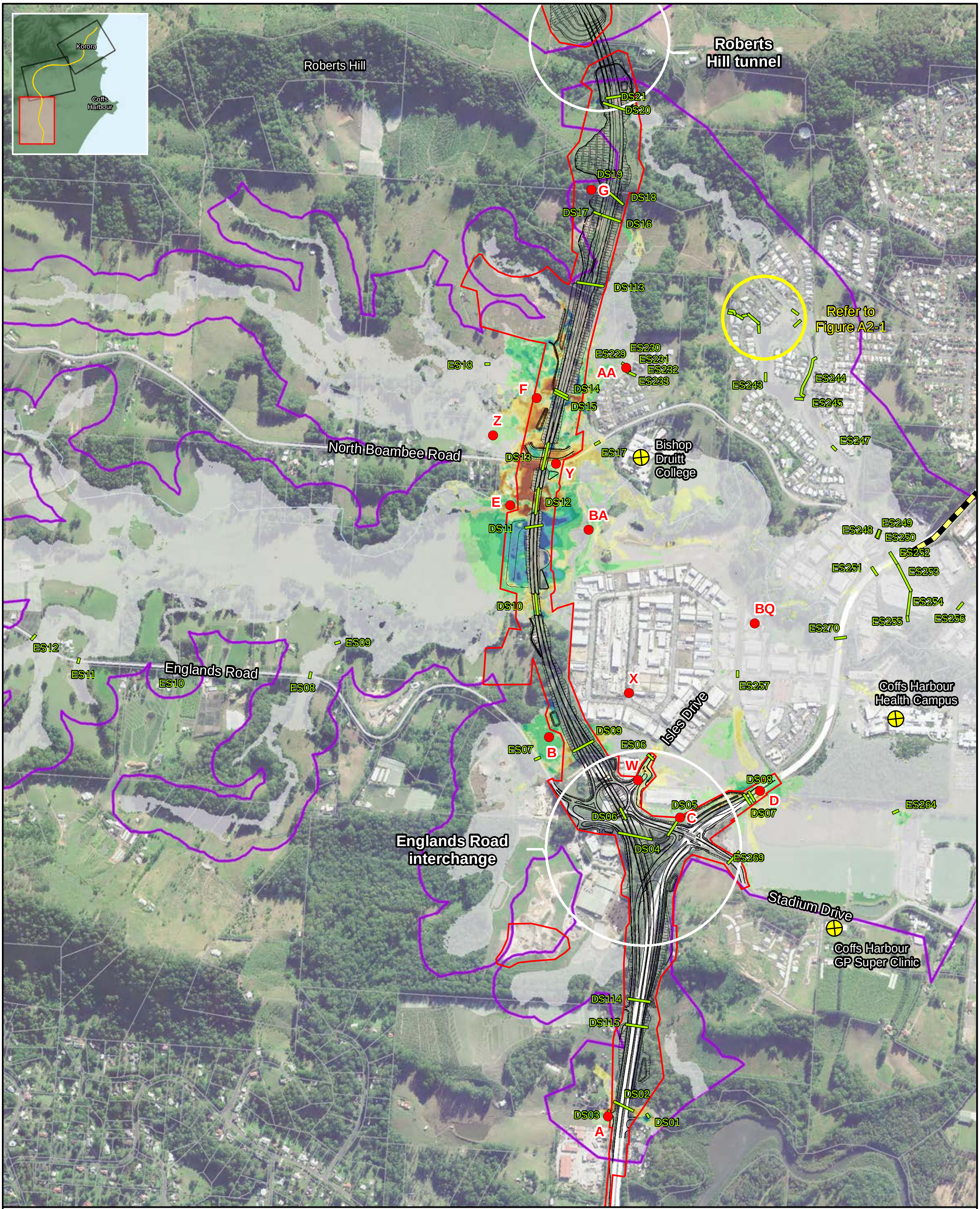
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Northern creeks 1 % AEP 2050 climate peak flood velocity difference
Figure D2-3-6

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

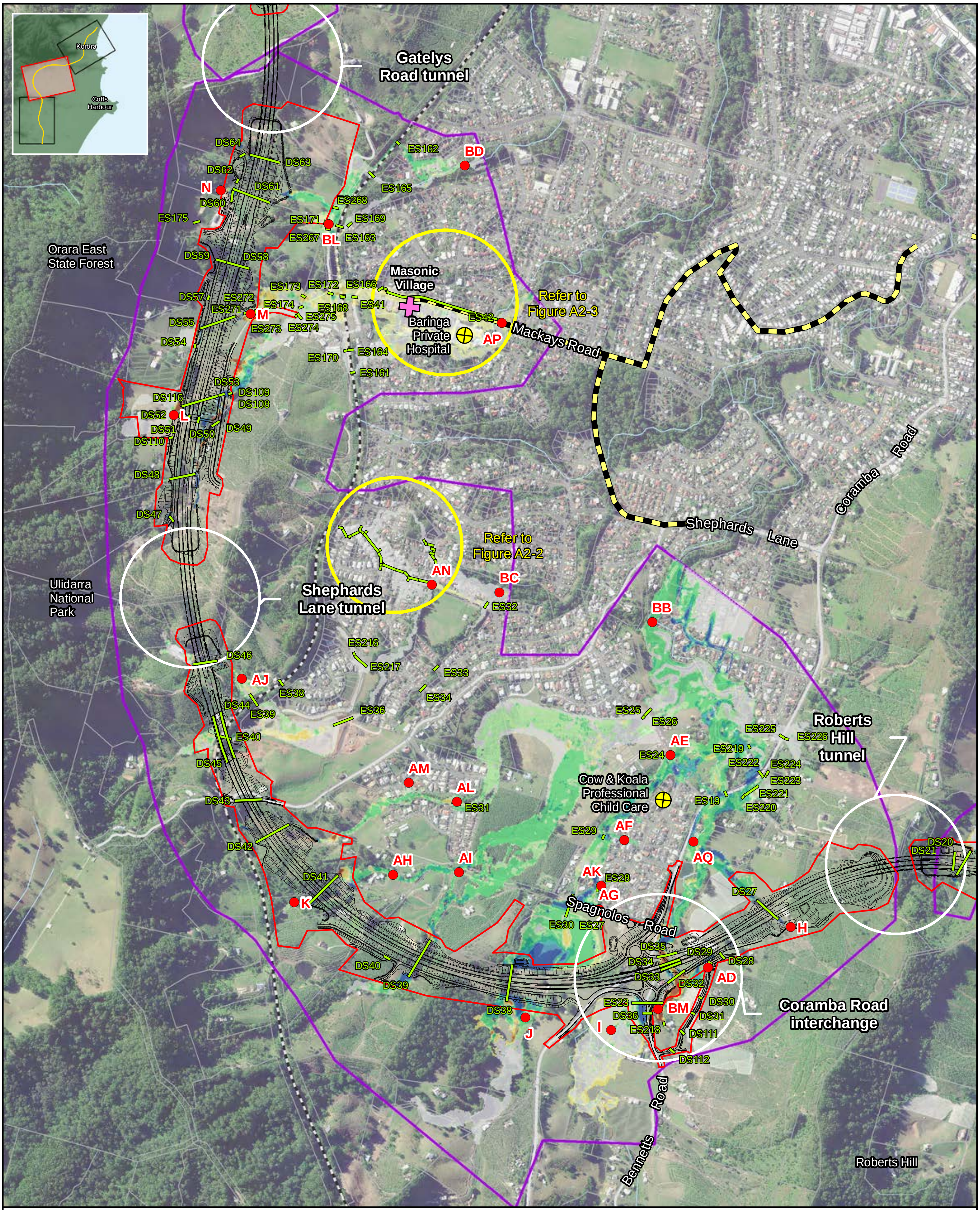
>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

N

Coffs Harbour Bypass
North Boambee Valley 1 % AEP 2100 climate peak flood velocity difference
Figure D2-1-7



Legend

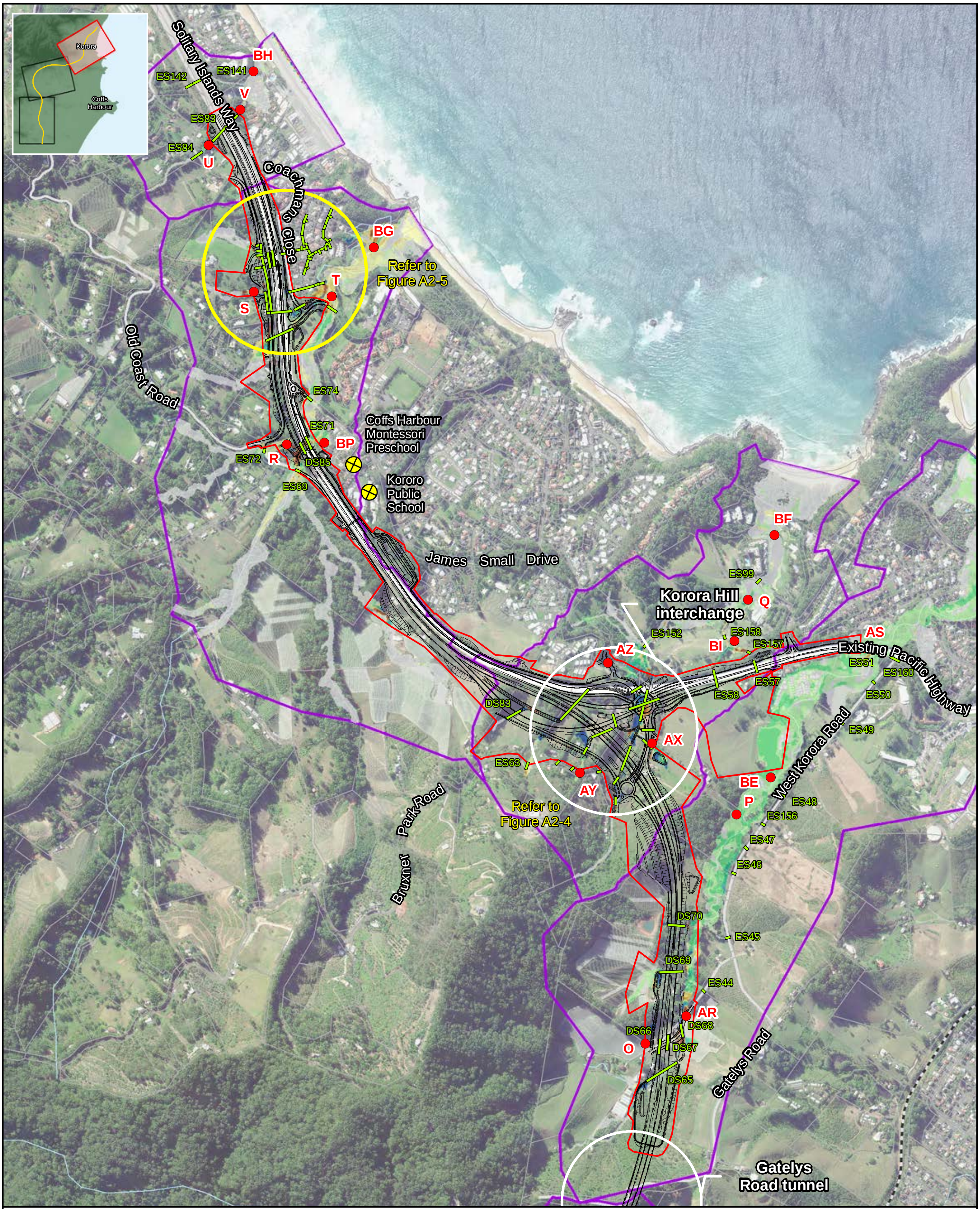
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Coffs Creek 1 % AEP 2100 climate peak flood velocity difference
Figure D2-2-7

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

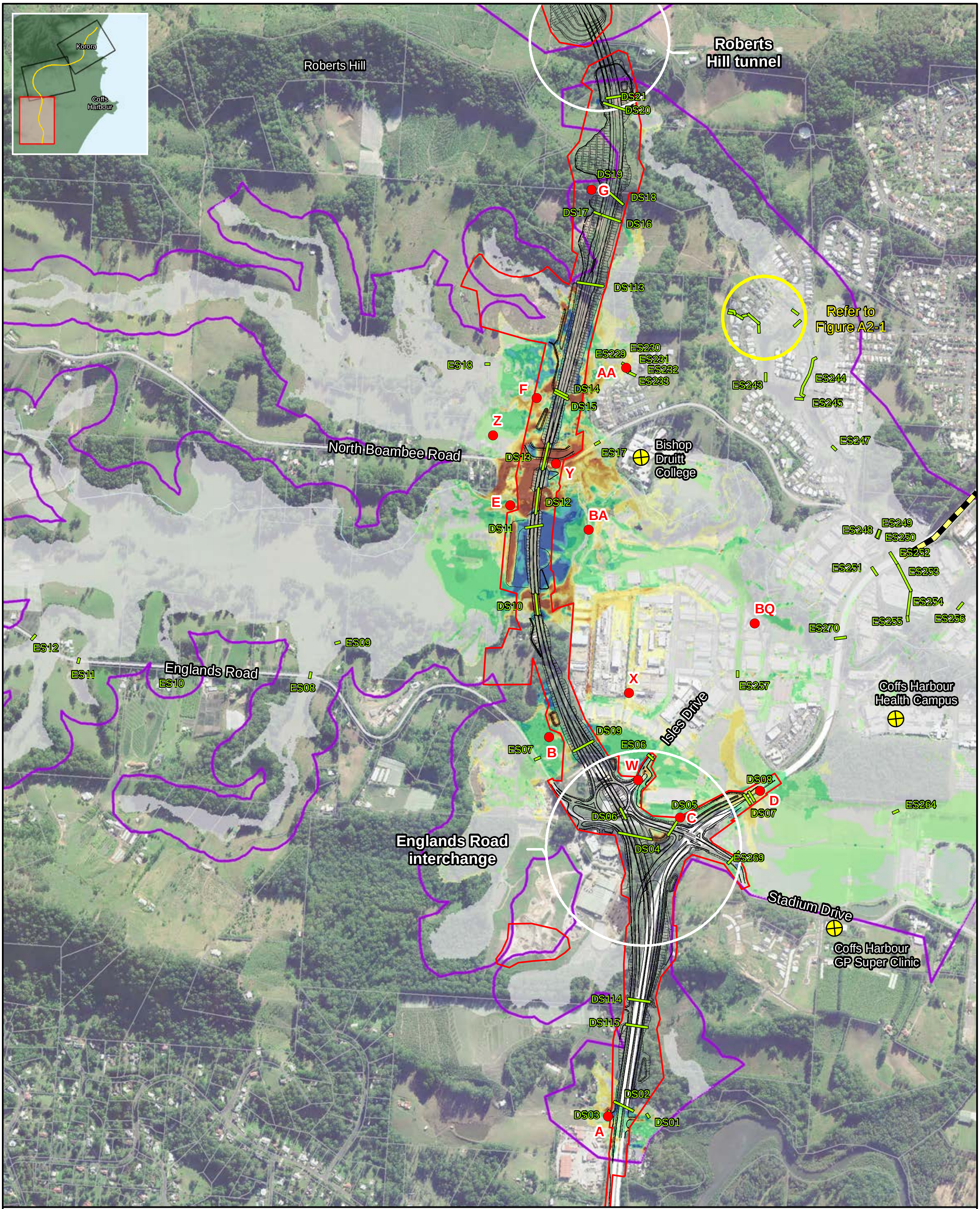
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N

Coffs Harbour Bypass
Northern creeks 1 % AEP 2100 climate peak flood velocity difference
Figure D2-3-7



Legend

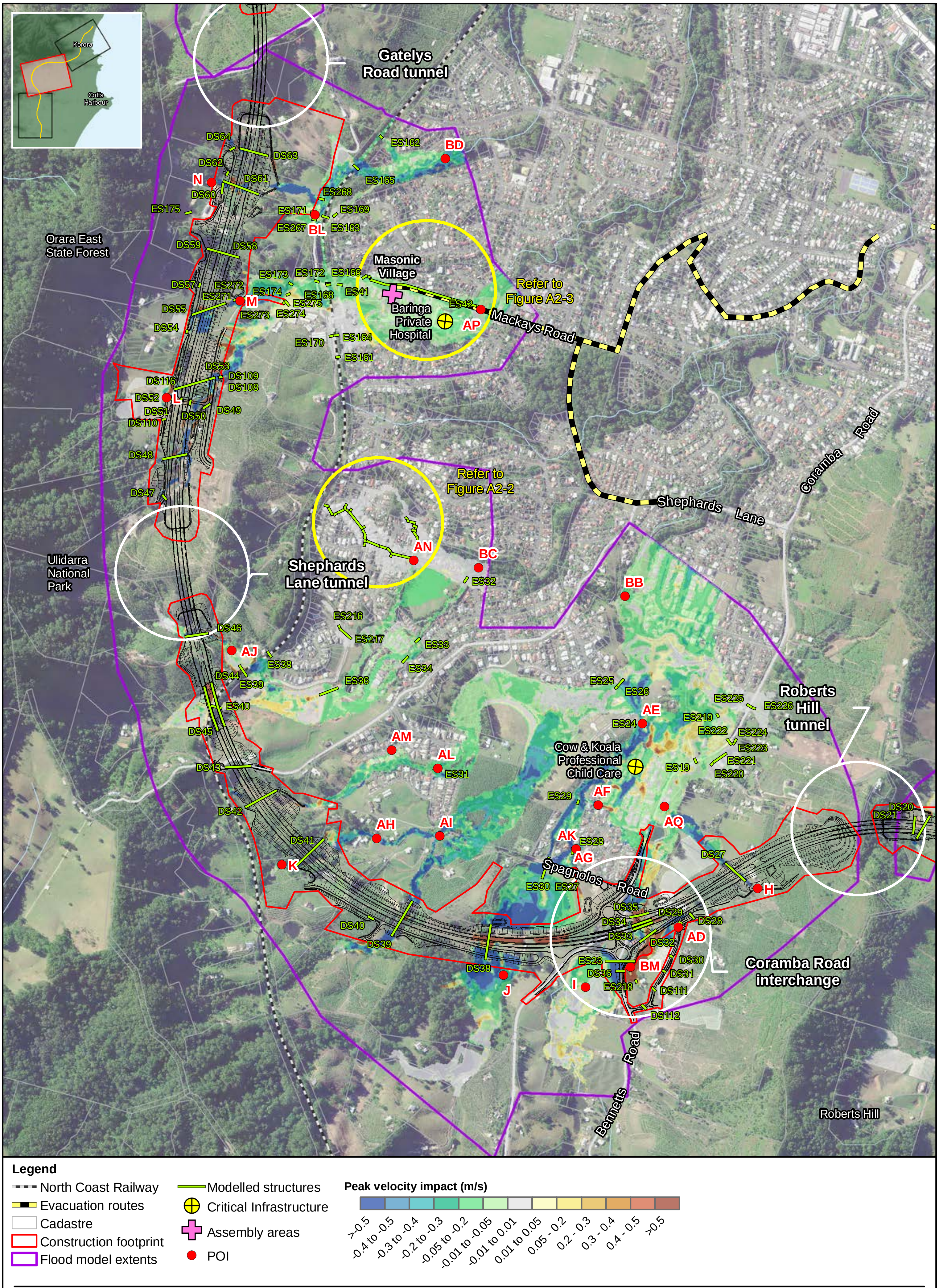
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI

Peak velocity impact (m/s)

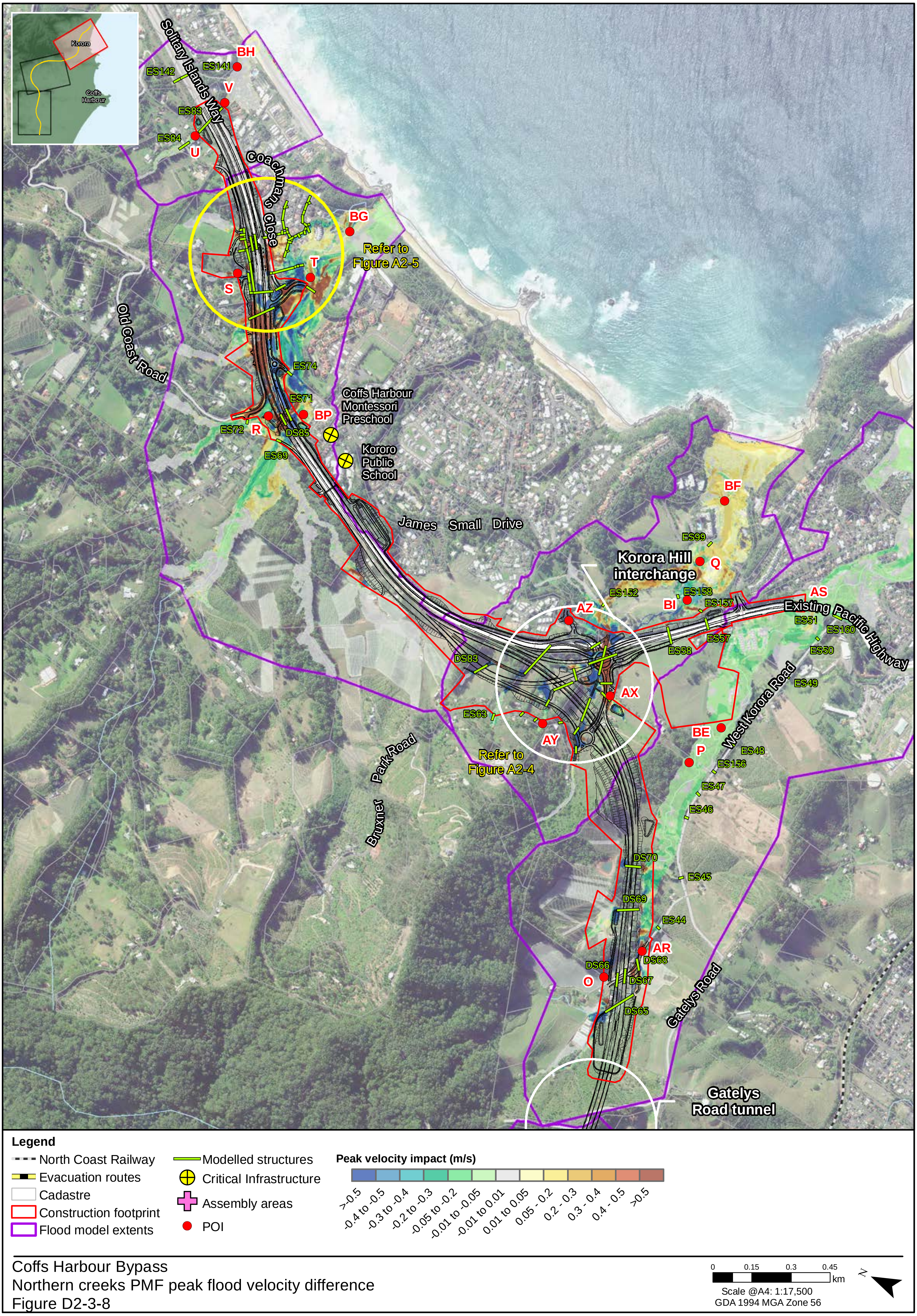
>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
North Boambee Valley PMF peak flood velocity difference
Figure D2-1-8

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N



Coffs Harbour Bypass
Coffs Creek PMF peak flood velocity difference
Figure D2-2-8



Coffs Harbour Bypass

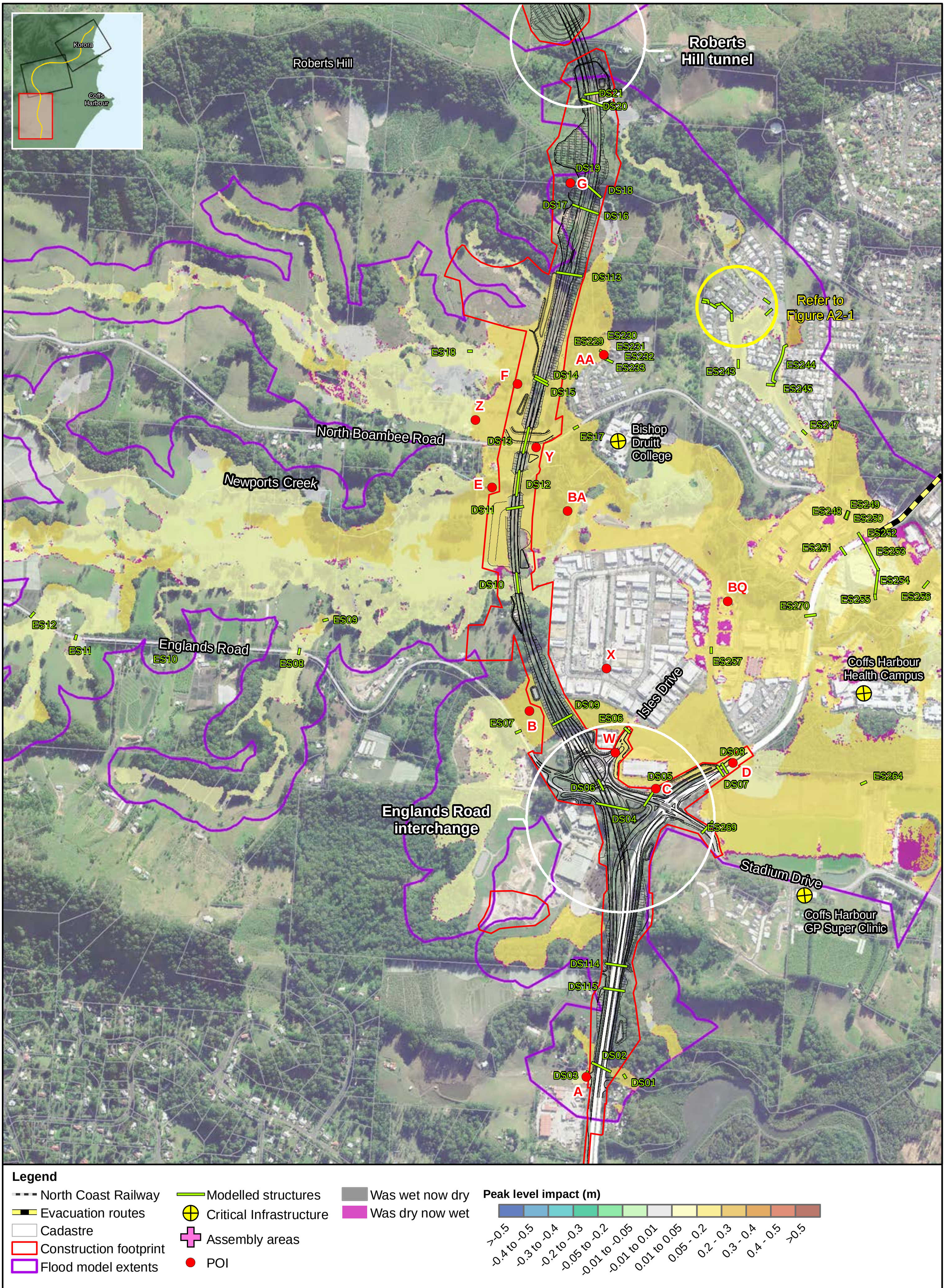
Northern creeks PMF peak flood velocity difference

Figure D2-3-8

Appendix E

Climate change flood maps

E1 Climate change maps



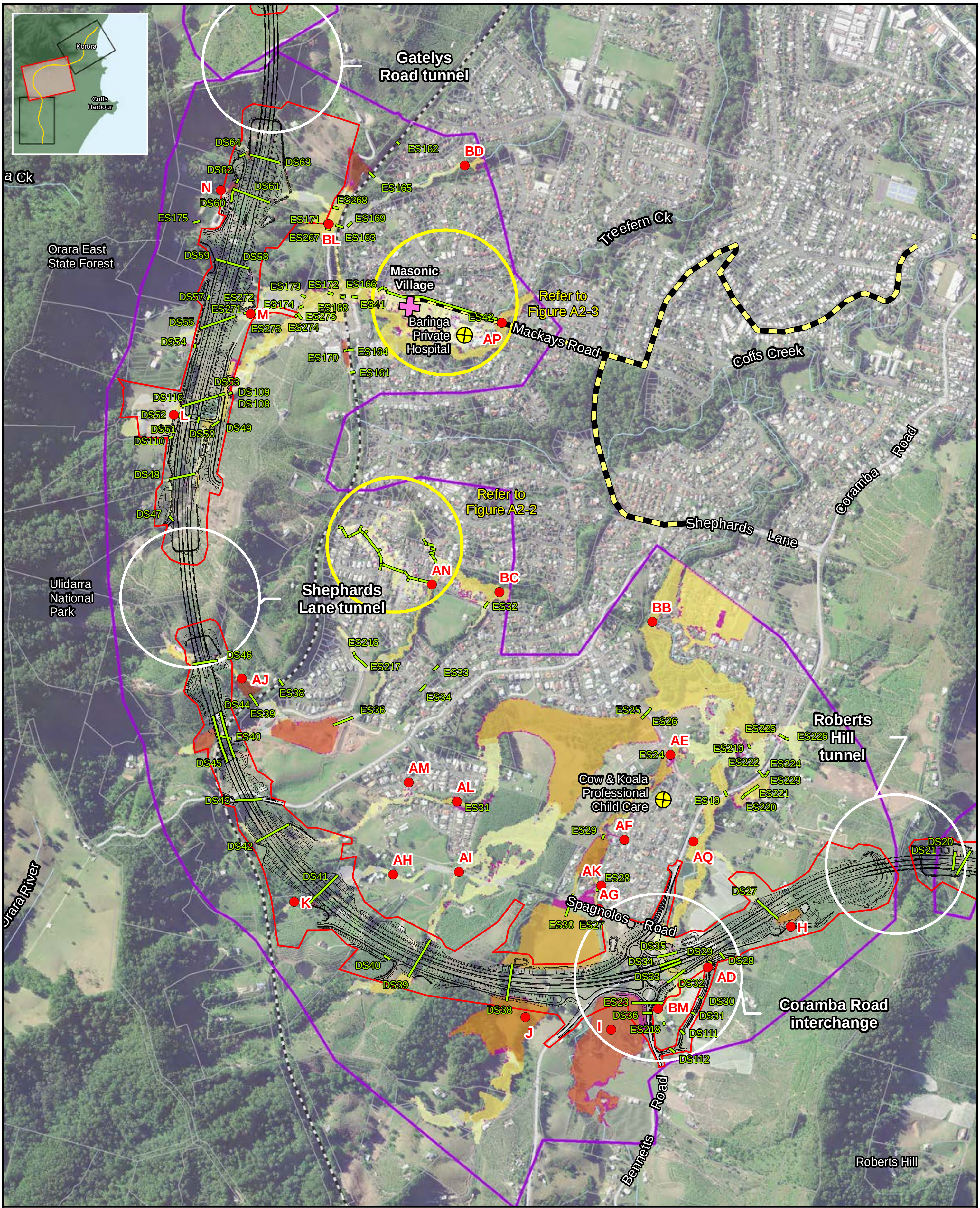
Coffs Harbour Bypass

North Boambee Valley 1 % AEP 2050 climate peak flood level difference from climate change

Figure E1-1

Scale @A4: 1:17,500

GDA 1994 MGA Zone 56



Legend

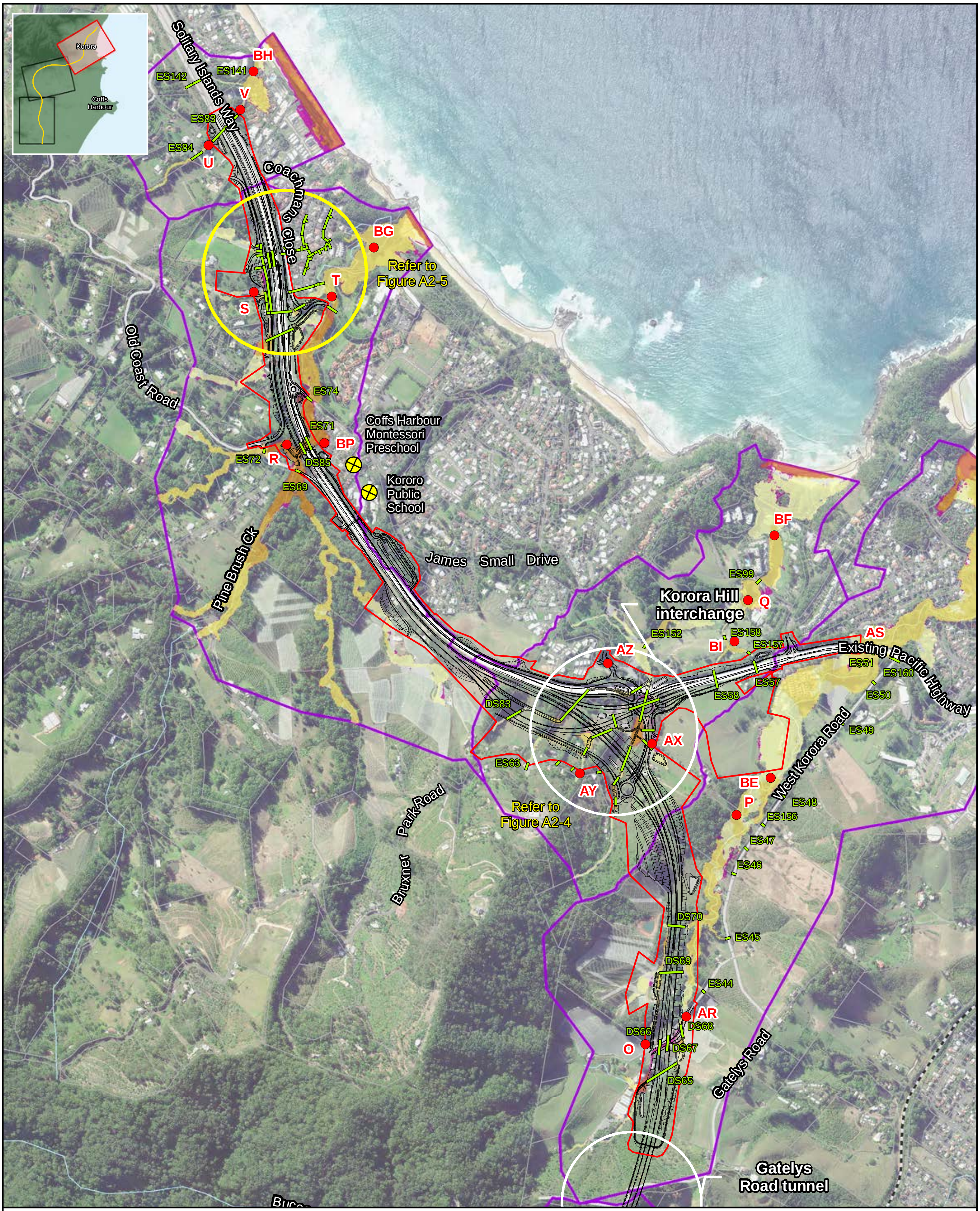
- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

Coffs Harbour Bypass
Coffs Creek 1 % AEP 2050 climate peak flood level difference from climate change
Figure E2-1

0 0.15 0.3 0.45 km
N
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500

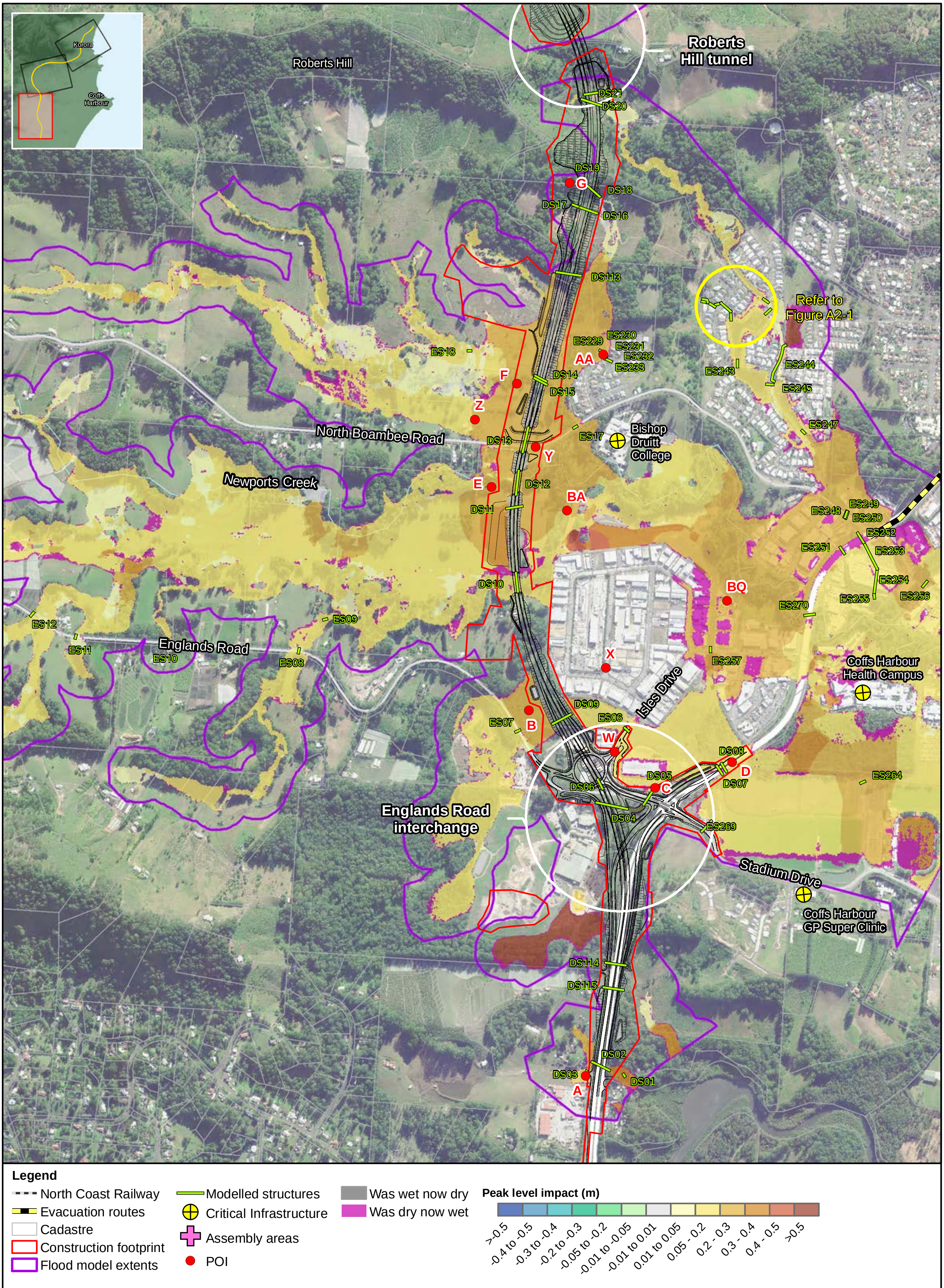
GDA 1994 MGA Zone 56

N

Coffs Harbour Bypass

Northern creeks 1 % AEP 2050 climate peak flood level difference from climate change

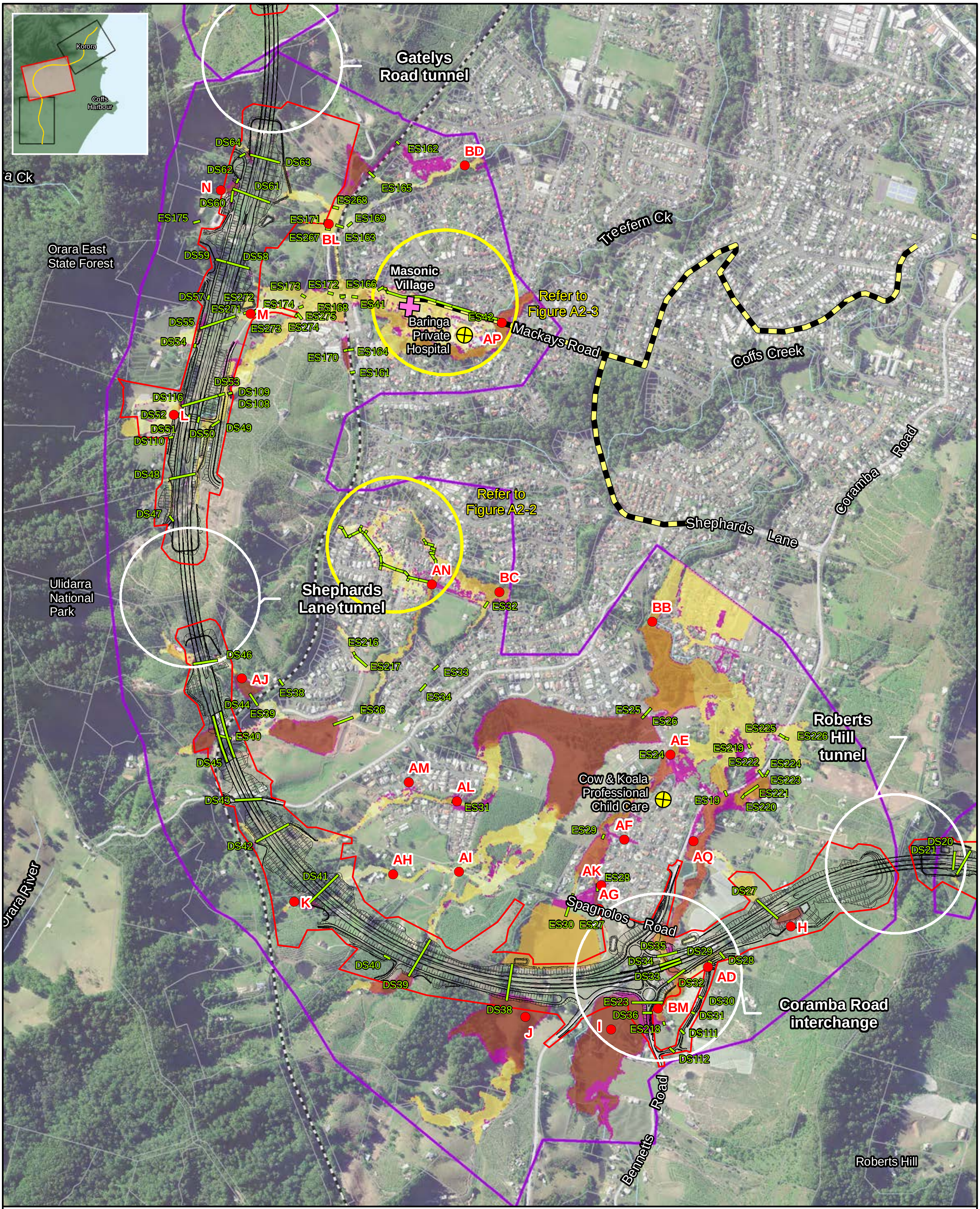
Figure E3-1



Coffs Harbour Bypass

North Boambee Valley 1 % AEP 2100 climate peak flood level difference from climate change

Figure E1-2



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

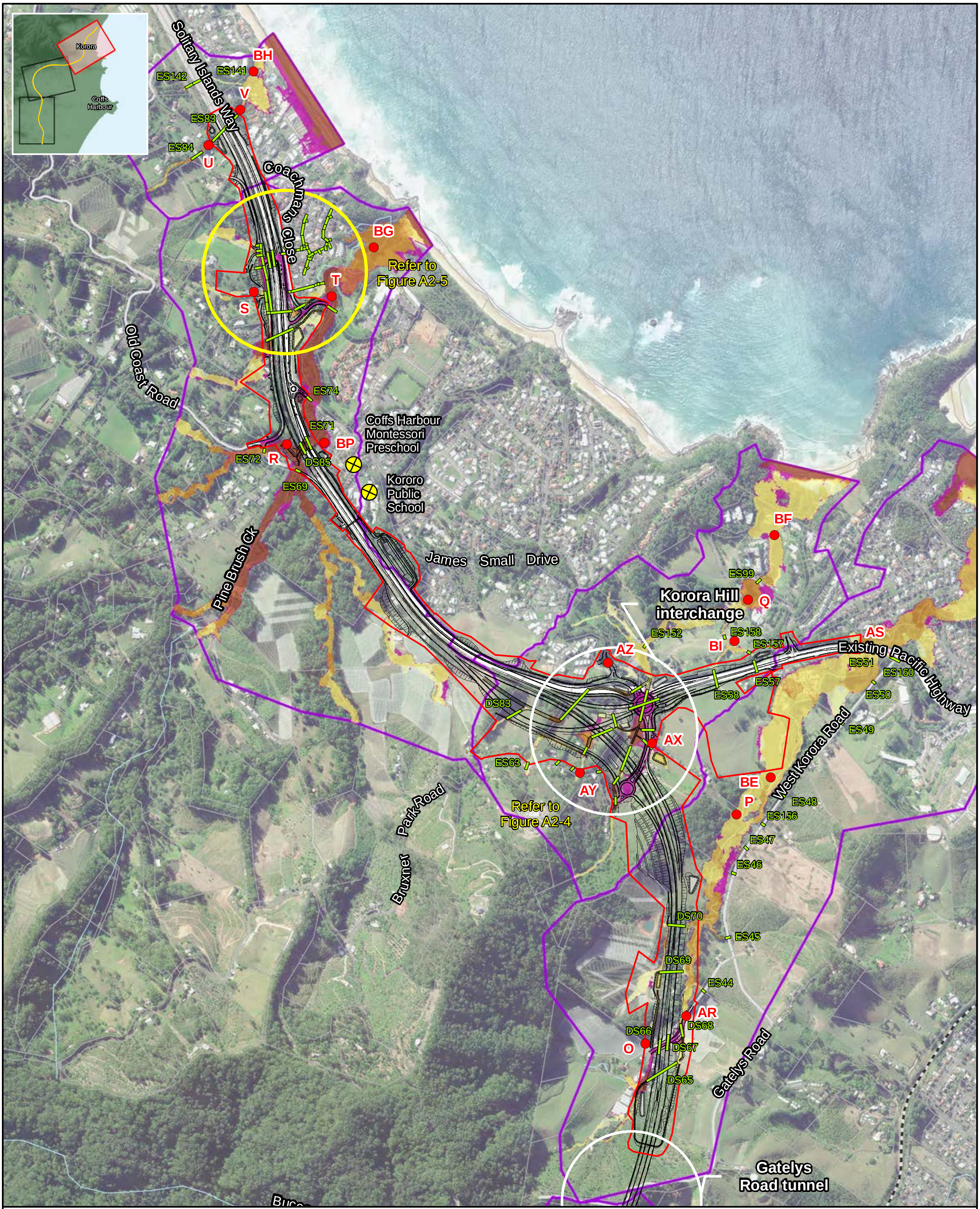
Peak level impact (m)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

0 0.15 0.3 0.45 km

Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

Coffs Harbour Bypass
Coffs Creek 1 % AEP 2100 climate peak flood level difference from climate change
Figure E2-2



Legend

- North Coast Railway
- Evacuation routes
- Cadastre
- Construction footprint
- Flood model extents
- Modelled structures
- Critical Infrastructure
- Assembly areas
- POI
- Was wet now dry
- Was dry now wet

Peak level impact (m)

>-0.5, -0.4 to -0.5, -0.3 to -0.4, -0.2 to -0.3, -0.05 to -0.2, -0.01 to -0.05, -0.01 to 0.01, 0.01 to 0.05, 0.05 - 0.2, 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5, >0.5

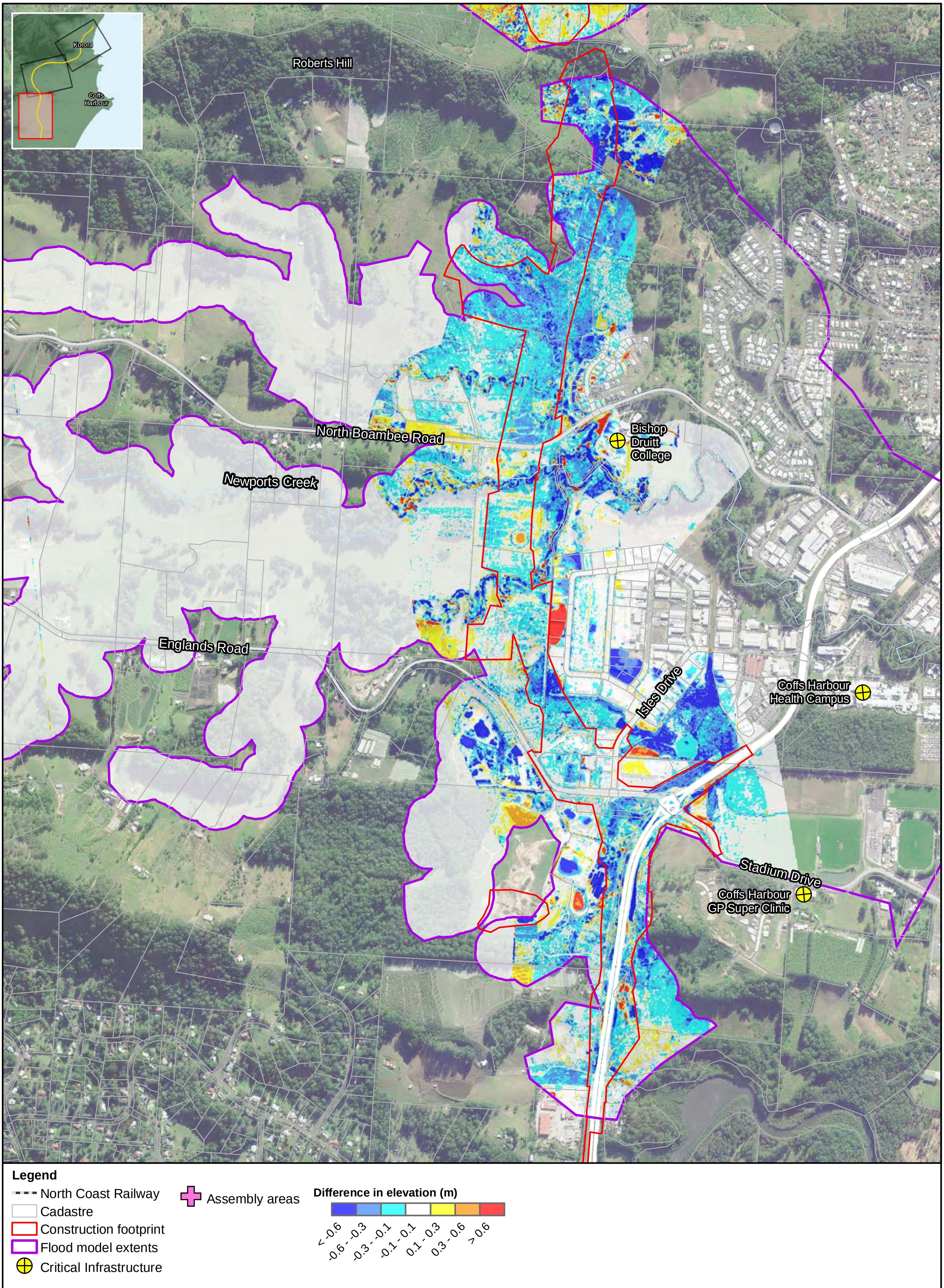
Coffs Harbour Bypass
Northern creeks 1 % AEP 2100 climate peak flood level difference from climate change
Figure E3-2

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56

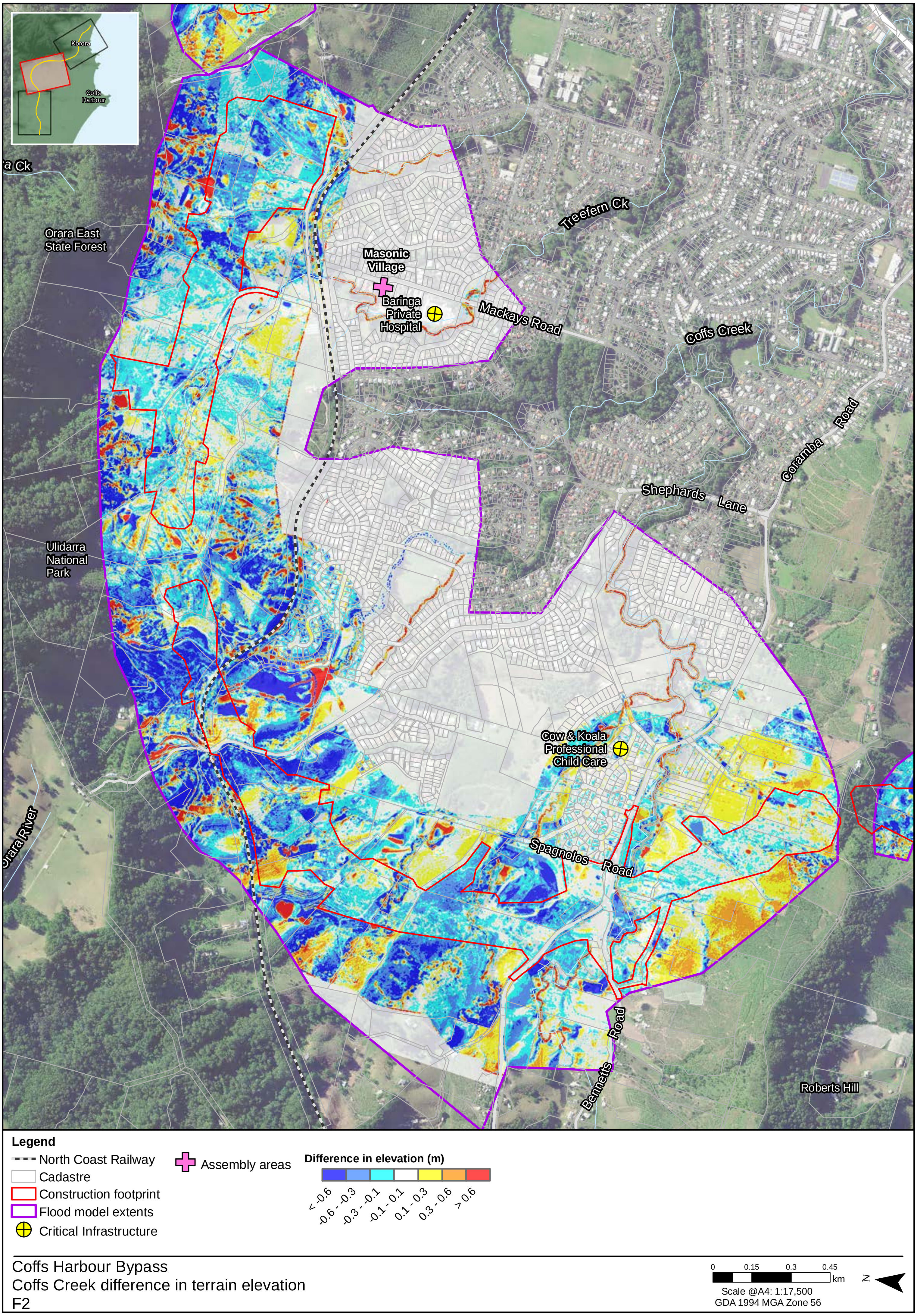
Appendix F

Change in existing terrain maps

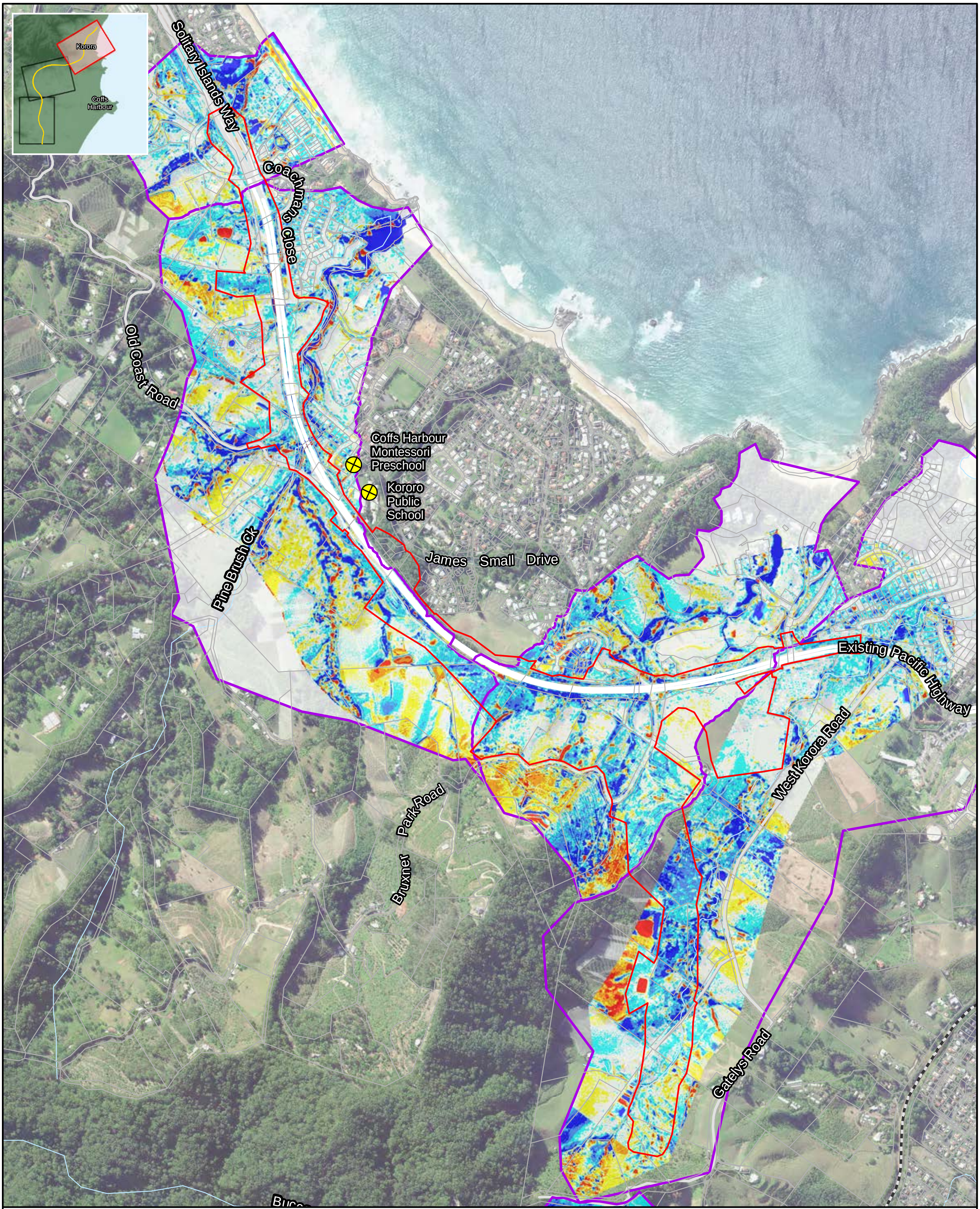
F1 Change in terrain maps



Coffs Harbour Bypass
North Boambee Valley difference in terrain elevation
F1



Coffs Harbour Bypass
Coffs Creek difference in terrain elevation
F2



Legend

- North Coast Railway
- Cadastre
- Construction footprint
- Flood model extents
- Critical Infrastructure
- Assembly areas

Difference in elevation (m)

< -0.6; -0.6 - -0.3; -0.3 - -0.1; -0.1 - 0.1; 0.1 - 0.3; 0.3 - 0.6; > 0.6

Coffs Harbour Bypass
Northern creeks difference in terrain elevation
F3

0 0.15 0.3 0.45 km
Scale @A4: 1:17,500
GDA 1994 MGA Zone 56
N

Appendix G

Operational impacts comparison with the EIS

G1 Operational impacts comparison with the EIS

The documentation of impacts of the amended design below includes a comparison with the impacts presented in the EIS. In the comparison of impacts, some locations are listed as having impacts 'consistent' with those in the EIS. This does not imply that the impacts are exactly the same. It does imply that:

- Where the impacts in the EIS were compliant with the flood management objectives, then 'consistent' means that the impacts are also compliant for the amended design.
- Where the impacts in the EIS were not compliant with the flood management objectives, then any change (either improvement or worsening) to these impacts is documented.
- If the impacts in the EIS were indicating an improvement and that improvement is no longer predicted for the amended design (but the impacts for the amended design are compliant), then this is noted but not considered to be worsening.

G1.1 North Boambee Valley

Level

Potential flood level impacts for the North Boambee Valley catchment for the amended design are discussed in **Section 5.2.1**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 36.**

Table 36: Comparison of predicted flood level impacts in the North Boambee Valley catchment

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
A	The project widens the road embankment into the low-lying area currently drained by the existing culvert (ES01) and the driveway access of Lot 232 DP740659. Afflux up to 120 mm in the 1% AEP event was noted over the current dam.	The project widens the road embankment into the low-lying area currently drained by the existing culvert (ES01) causing the following flood impacts: • Increase in peak water level in events up to the 2% AEP over the current dam, with a maximum increase of 380 mm predicted in the 18% AEP event • Peak water level is reduced (i.e. negative afflux) from 5.1 mAHD to 5.0 mAHD in the 1% AEP event on Lot 232 DP740659. It is noted that the flood extent does not extend to the residential building.	Impacts have increased for the amended design. The maximum afflux on the farm dam has increased. Note the residential property is not adversely impacted, which is consistent with the EIS. These changes are because of new data and design refinements which include widening of the highway embankment and filling of the adjacent storage area.
B	The project has the potential to impact the tributary adjacent to Englands Road at point of interest B. Afflux up to 850 mm was predicted in the 1% AEP event. The afflux was contained on land owned by TfNSW between the project and Englands Road. The afflux was contained to the heavily vegetated floodplain with no impact to Englands Road flood immunity. Time of inundation was predicted to increase from 10 hours 35 minutes to 10 hours 40 minutes and as such this minor increase in duration of 5 minutes was not expected to impact environmental processes.	The project has the potential to impact the tributary adjacent to Englands Road at point of interest B. Afflux up to 350 mm is predicted in the 1% AEP event which would be contained on land owned by TfNSW between the project and Englands Road. The afflux is contained to the heavily vegetated floodplain with no impact to Englands Road flood immunity. Time of inundation is predicted to increase by 5 minutes. This minor increase in duration is not expected to impact environmental processes.	Impacts have improved with the amended design. Afflux in the 1% AEP event is reduced from 850 mm for the EIS design to 350 mm for the amended design. The increase in duration of inundation is consistent with what was predicted in the EIS. This is because of new data, design refinements and water quality basins design changes.
C	Stormwater drainage from the Englands Road interchange discharges to the existing drainage channel adjacent to the existing Pacific Highway, this resulted in a change in flow distribution over Lot 61 DP1026815.	Stormwater drainage from the Englands Road interchange discharges to the existing drainage channel adjacent to the existing Pacific Highway, resulting in a change in flow distribution over Lot 61 DP1026815.	Impacts from the amended design are consistent with the EIS design impacts.

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
D	The tie-in with the existing Pacific Highway slightly modifies the road profile and embankment width affecting flood conveyance. There was a localised increase in flow velocities downstream of the culverts because of the project.	The tie-in with the existing Pacific Highway slightly modifies the road profile and embankment width affecting flood conveyance and storage causing the following impacts in the 1% AEP event: • Decreases in peak water level on the northbound lanes of up to 22 mm • Increases in peak water level of up to 17 mm on vegetated recreational areas downstream of design structures (DS07, DS08).	The EIS showed the existing Pacific Highway as 'flood free' (up to the 1% AEP flood). Modelling now predicts the existing Pacific Highway to be affected at POI D in several events. This is because of new data, improvements to modelling methodologies and outcomes of consultation with CHCC. The amended design is predicted to slightly reduce peak water levels on the existing Pacific Highway. This is because design refinements, which include the addition of another 4 x 1050mm culverts, have been made to mitigate adverse impacts to the existing Pacific Highway caused by project.
E	The project traverses the Newports Creek floodplain at this location and the project embankments affect flood storage and conveyance to the main creek channels. Localised afflux of up to 0.5 m in the 1% AEP event was predicted immediately upstream of the project. Afflux reduced to around 0.2 m as the extent of flood depth increase extended upstream to: • The existing agricultural/forested areas • The residential property adjacent to North Boambee Road (property is owned by TfNSW). Flood depth increased by 0.2 m in the 1% AEP event • Towards North Boambee Road. There was no change to the PMF flood hazard category upstream of the project throughout the North Boambee Valley (West) urban release area.	The project traverses the Newports Creek floodplain at this location and the project embankments affect flood storage and conveyance to the main creek channels. Localised afflux of up to 380 mm in the 1% AEP event is predicted immediately upstream of the project. Afflux reduces to around 65 mm as the flood extends upstream to: • The existing agricultural/forested areas • The residential property adjacent to North Boambee Road (property is owned by TfNSW). Flood depth increases by 180 mm in the 1% AEP event • Towards North Boambee Road.	Impacts have improved with the amended design. Localised afflux immediately upstream of the project is reduced from 500 mm in the EIS design to 380 mm for the amended design. Afflux on agricultural/forested areas and the residential property is reduced from 200 mm to 65 mm. Afflux towards North Boambee Road is reduced from 200 mm to 180 mm. These improvements are because of new data, improved modelling methodologies and the North Boambee Valley vertical alignment design change.

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
F / Z / AA / Y	The project traverses the Newports Creek floodplain. Embankments reduce floodplain storage in this area which resulted in afflux up to 35 mm in the 1% AEP event on the surrounding pastural/forested areas and the northern extent of Highlander Drive. Afflux of up to 18 mm was predicted at the residential property of Lot 1 DP711234 – on the north side of North Boambee Road near point of interest Z.	The project traverses the Newports Creek floodplain. Embankments reduce floodplain storage in this area (point of interest F) resulting in afflux up to 110 mm in the 1% AEP event on the surrounding pastural/forested areas. Within the northern extent of Highlander Drive (point of interest AA) afflux of up to 16 mm is predicted on the road in the 1% AEP event. No residential buildings are impacted at point of interest AA. Afflux of up to 25 mm is predicted at the residential property of Lot 1 DP711234 – on the north side of North Boambee Road (point of interest Z). Survey of the residential building determined that the floor level is about 450 mm above the predicted 1% AEP flood levels.	Impacts from the amended design are greater than the EIS design impacts. Afflux on the pastural/forested areas is increased from 35 mm to 110 mm for the amended design. Afflux on the residential property is increased by 7 mm from 18 mm to 25 mm in the amended design. Note that the 1% AEP peak water level is below floor level of the house. Afflux on Highlander Drive is increased by 1 mm at POI AA. These changes are because of new data, improved modelling methodologies and the North Boambee Valley vertical alignment design change.
G	The project traverses the northern upper sub-catchments of Newports Creek requiring conveyance.	The project traverses the northern upper sub-catchments of Newports Creek requiring conveyance.	Impacts from the amended design are consistent with the EIS design impacts.

Scour and velocity

Potential scour and velocity impacts for the North Boambee Valley catchment for the amended design are discussed in **Section 5.2.1**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 37.**

Table 37: Comparison of predicted velocity impacts in the North Boambee Valley catchment

Location	EIS potential flood impact	Amended potential flood impact	Change in impact
Bridges: DS12 (BR23), DS13 (BR04), DS14 (BR05)	The flows upstream of proposed bridge structures DS12 (BR23), DS13 (BR04) and DS14 (BR05) increased by approximately 0.8 m/s in the 1 per cent AEP event.	Flow velocities near proposed bridge structures DS12 (BR23) and DS13 (BR04) are predicted to increase by up to 1.0 m/s to peak velocities of 1.5 m/s in the 1 per cent AEP event. These increases are within the construction footprint.	Impacts for the amended design are consistent with those presented in the EIS, noting the removal of a bridge (BR05) and replacement with culverts at DS14 as part of the North Boambee Valley vertical alignment design change.

Location	EIS potential flood impact	Amended potential flood impact	Change in impact
Minor tributaries	Increase in velocity of approximately 0.5 m/s was also forecast downstream of proposed culverts DS07, DS08 and DS20 in events above the 5 per cent AEP.	Localised increases in velocities at drainage structure outlets. Downstream of DS03 (POI A) velocities increase to up to 2 m/s in the 1% AEP event. This increase is localised and does not affect the nearby residential building. At all other locations velocity increases are less than 0.2 m/s outside the construction footprint in the 1% AEP.	Impacts for the amended design have increased at POI A from the EIS. This is because of new data and design refinements. At all other locations, impacts for the amended design are consistent with those presented in the EIS.

Access

Potential access impacts for the North Boambee Valley catchment for the amended design are discussed in **Section 5.2.1**. A comparison of these impacts with the impacts presented in the EIS is outlined in

Table 38**.**

Table 38: Comparison of predicted access impacts in the North Boambee Valley catchment

		EIS minimum event closure (AEP) / crest depth (mm)			Amended minimum event closure (AEP) / crest depth (mm)			
POI	Affected road / driveway	Existing	Developed	Impact	Existing	Developed	Impact	Change in impact
A	Lot 232 DP740659	<18% / 0.52	>1% / 0	Increased	<18% / 330	<18% / 240	Maintained	New data and design refinements have reduced peak water level reductions on the driveway. The amended design does not impact this access location.
B	Englands Road	<18% / 130	<18% / 130	Maintained	<2% / 280	<2% / 280	Maintained	No change
D	Pacific Highway Newports Creek	>1% / 0	>1% / 0	Maintained	<2% / 250	<2% / 240	Maintained	No change
W	Isles Drive	<18% / 0.57	<18% / 0.16	Maintained	<10% / 330	<2% / 400	Increased	New data and design refinements have increased the existing level of access at this location. The Englands Interchange

		EIS minimum event closure (AEP) / crest depth (mm)			Amended minimum event closure (AEP) / crest depth (mm)			
								design change improves the level of access.
X	Engineering Drive	2% / 0.11	2% / 0.11	Maintained	>1% / 0	>1% / 0	Maintained	No change
Y	North Boambee Road	<18% / 0.78	<18% / 0.78	Maintained	<18% / 580	<18% / 580	Maintained	No change
AA	Highlander Drive North	<18% / 0.54	<18% / 0.55	Maintained	<18% / 110	<18% / 120	Maintained	No change
AA	Glengyle Close	<18% / 0.51	<18% / 0.52	Maintained	<10% / 140	<10% / 170	Maintained	No change
Z	Lot 2 DP711234	<18% / 0.28	<18% / 0.28	Maintained	<18% / 300	<18% / 300	Maintained	No change
Z	Lot 100 DP1145073	<18% / 0.19	<18% / 0.20	Maintained	<18% / 250	<18% / 250	Maintained	No change

Direction

Realignment of a northern tributary of Newports Creek is required as it passes beneath the project north of North Boambe Road. In the EIS design, approximately 130m of realignment was required as the tributary was redirected through bridge BR05. As part of the North Boambee Valley vertical alignment design change, BR05 has been replaced with culverts (DS14). This has increased the length of creek realignment required at this crossing by approximately 15m.

At all other locations in both the EIS design and the amended design, the project results in minimal changes to surface water source and direction where possible, except for constriction into and expansion out of structures and constructed diversions, in line with the project floodplain management objectives.

Hazard

Potential flood hazard impacts for the North Boambee Valley catchment for the amended design are discussed in **Section 5.2.1**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 39**.

Table 39: Comparison of predicted hazard impacts in the North Boambee Valley catchment

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
E	The project was predicted to increase the flood hazard to high, over an area of around 1.5 hectares for design flood events.	The project is predicted to increase the flood hazard to high, over an area of less than one hectare for all design AEP flood events.	The extent of hazard impacts has been reduced for the amended design. This is because of new data and improved modelling methodologies as well as the North Boambee Valley vertical alignment design change.
B	An increase of flood hazard was also predicted on the upstream side of Englands Road within pasture and forested land during the PMF event.	An increase of flood hazard is also predicted within forested land in events greater than the 5% AEP. An increase in flood hazard is predicted on Englands Road during the PMF.	Impacts to hazard classification at this location have increased for the amended design. This is because of new data and improved modelling methodologies as well as design refinements adopted to mitigate potential impacts of the project.
General	Not reported.	No changes to flood hazard classifications are predicted over existing buildings and upstream of the project throughout the North Boambee Valley (West) urban release area.	Impacts for the amended design are consistent with those presented in the EIS however this point was not explicitly documented in the EIS.

Critical infrastructure

Potential impacts to critical infrastructure for the North Boambee Valley catchment for the amended design are discussed in **Section 5.2.1**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 40**.

Table 40: Comparison of predicted impacts to critical infrastructure in the North Boambee Valley catchment

Location	EIS potential flood impact	Amended potential flood impact	Change in impact
Bishop Druitt College	All buildings were outside flood extents. A portion of carpark and sporting fields were inundated but not impacted by the project. No change anticipated.	All buildings are outside flood extents. A portion of carpark and sporting fields are inundated but not impacted by the project. No impact predicted.	No change
Coffs Harbour GP Super Clinic	Outside flood extents. No change anticipated.	Outside flood extents. No impact predicted.	No change
Coffs Harbour Health Campus	Not within model extents.	At least one building is within the 10% AEP existing flood extents. Several buildings are within the 1% AEP flood extents. No impact predicted.	No change

Emergency management

Impacts to evacuation routes in the North Boambee Valley catchment are consistent with those presented in the EIS. That is, there are no adverse impacts to all identified evacuation routes. It is important to note that the modelled existing flooding behaviour on the existing Pacific Highway (near the Coffs Harbour Health Campus) has changed because of the downstream extension of the flood model. This is discussed in detail in **Section 2.6.1**. The amended design is predicted to maintain the current level of access to the Coffs Harbour Health Campus and cause slight reductions, in the order of 10 to 30 mm, in peak water level on the existing Pacific Highway in the 1% AEP event.

Boambee Newports Creek Floodplain Risk Management Plan

Impacts relating to the Boambee Newports Creek Floodplain Risk Management Plan are consistent with those presented in the EIS.

G1.2 Coffs Creek

Level

Potential flood level impacts for the Coffs Creek catchment for the amended design are discussed in **Section 5.2.2**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 41**.

Table 41: Comparison of predicted flood level impacts in the Coffs Creek catchment

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
H	The project traverses the southern upper sub-catchment of Coffs Creek requiring conveyance.	The project traverses the southern upper sub-catchment of Coffs Creek requiring conveyance. The increase in flood extent, which is within the construction footprint, is because additional storage has been provided to retain flows upstream of the project.	Impacts from the amended design are consistent to those presented in the EIS. The flood extent has increased (within the project boundary) for the amended design. These changes are because of the additional storage provided at POI H which is part of the Coffs Creek flood mitigation design change.

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
I	Predicted afflux in the 1% AEP flood event was 18 mm within the Bennetts Road detention basin because of the Coramba Road interchange immediately downstream of the basin and the impact this had on the outlet from the basin.	No adverse impact is predicted within the Bennetts Road detention basin.	Impacts have improved with the amended design. Afflux within the basin is no longer predicted for the amended design. These changes are because of new data and improved modelling methodologies and the removal of originally proposed additional excavation within the Bennetts Road detention basin which is part of the Coffs Creek flood mitigation design change.
BM	Location not reported in EIS.	Afflux of up to 190 mm during the 1% AEP flood event is predicted within Coffs Creek upstream of the Coramba Road interchange bridge crossing.	POI BM was not reported on in the EIS but has now been appointed a POI. Afflux in the EIS was up to 170 mm within the waterway. Afflux for the amended design is both within the waterway and adjacent farmland but is within the flood management objectives. Impacts at this location are influenced by new data, improved modelling methodologies and outcomes of community consultation.
AQ	Predicted afflux in the 1% AEP flood event was 50 mm within Coffs Creek downstream of the project. The increase in flood level at this location was because of the increased area of impervious surfaces (the project pavement), which resulted in additional stormwater runoff entering the creek. Afflux of up to 50 mm was predicted at the residential building. It was unconfirmed if the predicted afflux affected existing structures. A finished floor level survey will be carried out during detailed design to confirm whether predicted afflux would affect the existing structure.	Predicted afflux in the 1% AEP flood event is 30 mm within Coffs Creek downstream of the project. The increase in flood level at this location is because of the increased area of impervious surfaces (the project pavement), resulting in additional stormwater runoff entering the creek. Afflux of up to 26 mm is predicted at the residential building. Survey of the residential building (Lot B DP363629) determined that the floor level was 900 mm above the predicted 1% AEP flood event.	Impacts have improved with the amended design. Afflux on the residential property has been reduced from 50 mm to 26 mm for the amended design. Predicted afflux within the waterway has been reduced from 50mm to 30mm. These changes are because of new data, improved modelling methodologies and because of the additional storage provided at POI H and at the outlet of DS27. These detention areas are part of the Coffs Creek flood mitigation design change. Note the additional excavation within the Bennetts Road Detention Basin (used for mitigation in the EIS) is no longer proposed.

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
J	The project extends into the existing Spagnolos Road detention basin, decreasing storage volume and attenuation effectiveness. Predicted afflux upstream of the project and the Spagnolos Road detention basin in the 1% AEP flood event was up to 4000 mm. This afflux was contained to the heavily vegetated areas on land owned by TfNSW. There was a decrease in flood levels predicted within the Spagnolos Road detention basin in the 1% AEP flood event.	The project extends into the existing Spagnolos Road detention basin, decreasing storage volume and attenuation effectiveness. Predicted afflux upstream of the project and the Spagnolos Road detention basin in the 1% AEP flood event would be up to 3650 mm. This afflux is contained to the heavily vegetated areas on land owned by TfNSW. Downstream of the project, afflux of up to 40mm is predicted in Spagnolos Road detention basin for events up to the 1% AEP flood event.	Impacts have improved with the amended design. While the afflux is still significant, a better balance between impacts downstream in Spagnolos Road detention basin and upstream of the project has been achieved. Afflux has been reduced by 350 mm for the amended design. These changes are because of design refinements.
K	The project traverses the upper sub-catchments of Coffs Creek requiring conveyance.	The project traverses the upper sub-catchments of Coffs Creek requiring conveyance.	Impacts from the amended design are consistent with the EIS design impacts.
L	It is proposed to reconfigure the access road resulting in modification of flood flow distribution.	The reconfiguration of access roads resulted in modification of flood flow distribution.	Impacts from the amended design are consistent with the EIS design impacts.
M	Afflux of up to 400 mm during the 1% AEP flood event was predicted within the Treefern Creek area downstream of project near point of interest M. The concept design for the project included measures to direct flows crossing the main carriageway (via a proposed culvert DS55) away from Mackays Road to improve local access and reduce potential scour effects. Afflux was contained to vegetated creek areas and the proposed design resulted in no adverse flood impact to access.	Afflux of up to 100 mm during the 1% AEP flood event is predicted within the Treefern Creek area downstream of project near point of interest M. Afflux is contained to vegetated creek areas and the proposed design results in no adverse flood impact to access.	Impacts have improved with the amended design. Afflux is reduced from 400 mm to 100 mm. These changes are because of new data and design refinements including the additional localised detention area downstream of POI L.
N	The project traverses the upper sub-catchments of Coffs Creek requiring conveyance.	The project traverses the upper sub-catchments of Coffs Creek requiring conveyance.	Impacts from the amended design are consistent with the EIS design impacts.

Scour and velocity

Potential scour and velocity impacts for the Coffs Creek catchment for the amended design are discussed in **Section 5.2.2**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 42**.

Table 42: Comparison of predicted velocity impacts in the Coffs Creek catchment

Location	EIS design potential flood impact	Amended design potential flood impact	Change in impact
Coffs Creek	Minor (up to +0.2 m/s) peak velocity increases were predicted within Coffs Creek downstream of Bennetts Road basin that may have resulted in localised scour instances during peak events.	Peak velocity increases (up to +1.5 m/s in the 1 per cent AEP event) are predicted within Coffs Creek downstream of Bennetts Road detention basin that may increase scour potential during flood events. Predicted peak velocity increases are less than 0.5 m/s downstream of the construction footprint.	Impacts for the amended design are increased. These changes are because of new data and improved modelling methodologies.
Treefern Creek	The proposed Mackays Road bund (POI: M) redistributes flows and hence increased peak flood velocities (up to 0.5 m/s) were predicted to the vegetated area to the east. Absolute velocities were still relatively low in the 18 per cent AEP event, increasing from 1.4 m/s in existing conditions to 2.1 m/s post-project conditions.	No adverse impact is predicted for Treefern Creek.	Impacts for the amended design are reduced. These changes are because of new data, including the detailed survey of culverts under the North Coast Railway (ES166 and ES168).
Minor tributaries	Downstream of design culverts DS41 and DS61, increases were observed of up to 0.3 m/s in events above the 5 per cent AEP. As is noted in other areas of increased velocity downstream of culverts outlet scour protection is to be refined in the detailed design stage.	Localised increases in velocity at drainage structure outlets. At the outlet of design culverts DS41, DS55 and DS61, localised increases in velocity of up to 0.5 m/s in events larger than the 5 per cent AEP is predicted. At all locations velocity increases are less than 0.4 m/s outside the construction footprint in the 1% AEP.	Impacts for the amended design are consistent with those presented in the EIS.

Access

Potential access impacts for the Coffs Creek catchment for the amended design are discussed in **Section 5.2.2**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 43**.

Table 43: Comparison of predicted access impacts in the Coffs Creek catchment

		EIS minimum event closure (AEP) / crest depth (mm)			Amended minimum event closure (AEP) / crest depth (mm)			
POI	**Affected road / driveway**	**Existing**	**Developed**	**Impact**	**Existing**	**Developed**	**Impact**	**Change in impact**
AD	Lot 60 DP586574	<18% / 0.33	>1% / 0.05	Increased	<18% / 220	>1% / 0	Increased	No change
AD	Lot 730 DP1066743	<18% / 0.36	10% / 0.13	Increased	<18% / 200	<1% / 120	Increased	No change
AE	William Sharp Drive West	<18% / 0.11	10% / 0.19	Increased	>1% / 0	>1% / 0	Maintained	New data and improved modelling methodologies increased the existing level of access from not being trafficable in any modelled events to being trafficable in the 1% AEP event. The amended design does not impact access at this location.
AF	Rosalee Close	<18% / 0.43	<18% / 0.41	Maintained	>1% / 0	>1% / 0	Maintained	No change
AK	Roselands Drive near Spagnolos Road	10% / 0.13	5% / 0.12	Increased	>1% / 0	>1% / 0	Maintained	New data and improved modelling methodologies increased the existing level of access from being trafficable in the 10% AEP event to being trafficable in the 1% AEP event. The amended design does not impact access at this location.
AL	Roselands Drive near Barnet Street	5% / 0.14	5% / 0.11	Maintained	>1% / 0	>1% / 0	Maintained	No change
AM	Gillon Street	5% / 0.16	1% / 0.18	Increased	>1% / 0	>1% / 0	Maintained	New data and improved modelling methodologies increased the existing level of access from being trafficable in the 5% AEP event to being trafficable in the 1% AEP event. The amended design does not impact access at this location.

		EIS minimum event closure (AEP) / crest depth (mm)			Amended minimum event closure (AEP) / crest depth (mm)			
AN	Polwarth Drive	<18% / 0.18	<18% / 0.16	Maintained	<18% / 140	<18% / 140	Maintained	No change
AG	Spagnolos Road	1% / 0.12	>1% / 0.02	Increased	>1% / 0	>1% / 0	Maintained	New data and improved modelling methodologies increased the existing level of access from being trafficable in the 2% AEP event to being trafficable in the 1% AEP event. The amended design does not impact access at this location.
AI	Lot 5 DP1104404	<18% / 0.23	<18% / 0.21	Maintained	<1% / 120	<1% / 110	Maintained	No change
AH	Lot 102 DP1150637	<18% / 0.64	<18% / 0.60	Maintained	<18% / 820	<18% / 820	Maintained	No change
AJ	Lot 4 DP1157157	<18% / 0.59	<18% / 0.59	Maintained	<18% / 300	<18% / 300	Maintained	No change
M	Mackays Road Treefern Creek North	<18% / 0.52	<18% / 0.42	Maintained	<18% / 300	<18% / 300	Maintained	No change
L	Mackays Road Treefern Creek North	Not impacted in EIS			1% / 0	1% / 90	Maintained	This location was not impacted in the EIS. Modelling now predicts this location to be impacted as a result of design refinements in this area however, the amended project design maintains the existing level of access.
AP	Mackays Road Treefern Creek South (Bray Street)	<18% / 0.26	<18% / 0.15	Maintained	<18% / 310	<18% / 280	Maintained	No change
BL	Mackays Road	Not impacted in EIS			<18% / 1640	<18% / 1700	Maintained	This location was not impacted in the EIS. New data in this area modified the existing flooding behaviour. Note that the amended project maintains the existing level of access.

Direction

In both the EIS design and the amended design, the project results in minimal changes to surface water source and direction where possible, except for constriction into and expansion out of structures and constructed diversions, in line with the project floodplain management objectives.

Hazard

Potential flood hazard impacts for the Coffs Creek catchment for the amended design are discussed in **Section 5.2.2**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 44.**

Table 44: Comparison of predicted hazard impacts in the Coffs Creek catchment

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
General	Increases in hazard classification in vegetated and open pasture areas in events between 5 per cent AEP and PMF near POI L and east of POI M were predicted.	Localised increases in hazard levels in areas of increased flood extent, including on the main carriageway in the PMF event	Impacts for the amended design are reduced when compared to those presented in the EIS. Impacts at POI L and POI M are now predicted to be fully contained within the construction footprint. These changes are because of new data, design refinements, and improved modelled methodologies. Note increased hazard levels were predicted on the main carriageway in the PMF for the EIS design but this was not explicitly stated.

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
J	Hazard levels were adversely impacted upstream of the existing Spagnolos Road detention basin (near point of interest J). Under current conditions, the existing Spagnolos Road detention basin provides a level of flood storage. With the project in place this flood storage is reduced. The project as proposed would hold back flood waters upstream of the project (point of interest J), on heavily vegetated areas on land currently owned by Roads and Maritime. This would cause the road formation to act as a detention basin and potentially result in a decrease in flood levels within the Spagnolos Road detention basin in the 1 per cent AEP flood event. While this would potentially improve flood conditions downstream of the project, there would be greater operational and management risks for the main carriageway as well as ongoing maintenance and management requirements for this location. Refinement of the cross-drainage design in this location will be carried out during detailed design in consultation with CHCC and DPIE (Environment, Energy and Science Group). Refinement of the cross-drainage design would aim to maintain the existing flooding / hydrological regime by providing a better balance between holding water upstream of the project and managing downstream flood levels consistent with the floodplain management objectives in Section 1.7	Hazard levels have been adversely impacted upstream of the existing Spagnolos Road detention basin (near point of interest J). Under current conditions, the existing Spagnolos Road detention basin provides a level of flood storage. With the project in place this flood storage is reduced. The project as proposed would hold back flood waters upstream of the project (point of interest J), on heavily vegetated areas on land currently owned by TfNSW. This would cause the road formation to act as a detention basin. While this is forecast to improve flood conditions downstream of the project, there would be greater operational and management risks for the main carriageway as well as ongoing maintenance and management requirements for this location. Further considerations of risks created by the design in this location will be carried out during detailed design in consultation with CHCC and DPIE (Environment, Energy and Science Group). This may include consideration of the road formation under the Dam Safety Act 2015 in consultation with Dam Safety NSW. Refinement of the cross-drainage design would aim to maintain the existing flooding / hydrological regime by providing a better balance between holding water upstream of the project and managing downstream flood levels consistent with the floodplain management objectives in Section 1.9.	Impacts for the amended design are consistent with those presented in the EIS.
Baringa Private Hospital	Increases in hazard in localised areas within Baringa Private Hospital in the PMF event were predicted, however there were no changes to hazard in smaller rainfall events	Impacts are no longer predicted for the Baringa Private Hospital.	Impacts for the amended design are no longer predicted for this location in any modelled event. These changes are because of new data, including the detailed survey of culverts under the North Coast Railway (ES166

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
			and ES168) and upstream design refinements including the provision of an additional localised flood detention areas within the construction footprint (downstream of point of interest L).
Cow & Koala Professional Child Care	A decrease in hazard in the PMF event only was predicted, other events remained unchanged	Impacts are no longer predicted for the Cow & Koala Professional Child Care infrastructure.	Impacts for the amended design are no longer predicted for this location in any modelled event. These changes are because of new data and upstream design refinements.

Critical infrastructure

Potential impacts to critical infrastructure for the Coffs Creek catchment for the amended design are discussed in **Section 5.2.2**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 45**.

Table 45: Comparison of predicted impacts to critical infrastructure in the Coffs Creek catchment

Location	EIS potential flood impact	Amended potential flood impact	Change in impact
Baringa Private Hospital	Peak flood level reductions for all events except minor PMF increases of up to 18 mm, with a peak flood depth 954 mm. It is noted the accuracy of this location is limited without the upstream railway cross-drainage (refer Section 3.2).	No change to peak flood levels for all design events. Minor peak flood level reductions are predicted for the PMF event.	As a result of collecting detailed survey of the upstream North Coast Railway culverts (ES166 and ES168), the flooding conditions at the hospital have changed following exhibition of the EIS. The hospital is not predicted to be adversely impacted with the amended design. This is consistent with the EIS. These changes are because of new data and design refinements including the provision of an additional localised flood detention area within the construction footprint (downstream of point of interest L).
Cow & Koala Professional Child Care	Cow & Koala Professional Child Care remained immune in events up to and including the 1% AEP event. Peak flood levels were reduced in the PMF event by up to 11 mm.	Cow & Koala Professional Child Care remains immune in design events up to and including the 1% AEP. Peak flood level reductions of up to 120 mm are predicted in the PMF event.	Impacts for the amended design are consistent with those presented in the EIS, except there are greater peak water level reductions predicted in the PMF event. This change is because of new data and design refinements to upstream drainage structures.

Emergency management

Impacts to evacuation routes in the Coffs Creek catchment are consistent with those presented in the EIS. That is, there are no adverse impacts to all identified evacuation routes.

Coffs Creek Floodplain Risk Management Plan

Impacts relating to the Coffs Creek Floodplain Risk Management Plan are consistent with those presented in the EIS.

G1.3 Northern creeks

Level

Potential flood level impacts for the northern creeks catchment for the amended design are discussed in **Section 5.2.3**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 46**.

Table 46: Comparison of predicted flood level impacts in the northern creeks catchment

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
O	The project and revised local access road traverses the northern sub-catchments of Jordans Creek requiring conveyance.	The project and revised local access road traverses the northern sub-catchments of Jordans Creek requiring conveyance.	Impacts from the amended design are consistent with the EIS design impacts.
P	Existing access to Lot 19 DP771618 via Bruxner Park Road is proposed to be provided via West Korora Road with a new connection provided across Jordans Creek. Predicted afflux in the 1% AEP flood event was 1200 mm within Jordans Creek next to the proposed access crossing.	No impact is predicted at this location.	Impacts have improved with the amended design. Afflux at POI P is no longer predicted. These changes are because of new data and relocated property access which is part of the Korora Hill interchange design change.

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
Q	The Korora Hill interchange results in the removal of the Bruxner Park Road intersection detention, increased road runoff and redistribution of flood flows to the downstream Pacific Bay Resort. Predicted afflux in the 1% AEP flood event was up to 200 mm within the vegetated creek and lakes, golf course and carpark areas.	The Korora Hill interchange results in the removal of the Bruxner Park Road intersection detention, increased road runoff and redistribution of flood flows to the downstream Pacific Bay Resort. Afflux of 35 mm is predicted in the 18% AEP flood event within the vegetated creek and lakes, golf course and carpark areas. No adverse impacts are predicted in other events up to the 1% AEP flood event. Peak water level reductions of up to 40 mm are predicted in the 1% AEP event.	Impacts have improved with the amended design. Afflux is reduced from 200 mm to 35 mm. These changes are because of new data and the redesigned interchange which is part of the Korora Hill interchange design change.
BI	Increased runoff was predicted with the approved development area of Pacific Bay Eastern Lands from the interchange at Korora Hill. Predicted afflux in the 1% AEP flood event was up to 100 mm on Lot 14 of the approved development. New flow paths were predicted through Lots 14 to 16 and Lots 18 to 21 with depths of 30 mm and 50 mm respectively in the 1% AEP flood event. Previous consultation with the proponent of the Pacific Bay Eastern Lands during preparation of the EIS had indicated that the future proposals are also being investigated within the area subject to flooding impact.	No impact is predicted for the approved development area of Pacific Bay Eastern Lands.	Impacts have decreased with the amended design. Afflux at POI BI is no longer predicted. These changes are because of new data and the redesigned interchange which is part of the Korora Hill interchange design change.

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
R	The project reconfigures the existing Pacific Highway Pine Brush Creek crossings (ES71) including additional bridges and embankment work. Predicted afflux in the 1% AEP flood event was up to 200 mm over heavily vegetated creek areas. No adverse flood impact was predicted to the existing Old Coast Road (ES69 and ES72) bridges. *Note that impacts downstream of the Pine Brush Creek crossings (ES71) were reported under POI R in the EIS. Impacts downstream of the bridges have now been separated for clarity and are reported in POI BP.*	The project reconfigures the existing Pacific Highway Pine Brush Creek crossings (ES71) including additional twin bridges (DS85 (BR21)), embankment work and creek realignments. Localised peak water level reductions of up to 200 mm are predicted within the waterway in the 1% AEP flood event. No adverse flood impact is predicted to the existing Old Coast Road (ES69 and ES72) bridges.	Peak water level impacts of up to 200 mm were predicted in the EIS. Peak water level reductions of up to 200 mm are now predicted in the 1% AEP event. These changes are because of new data, improved modelling methodologies and modifications which are part of the Pine Brush Creek and Williams Creek realignment design change.
BP	The project reconfigures the existing Pacific Highway Pine Brush Creek crossings (ES71) including additional bridges and embankment work. Predicted afflux in the 1% AEP flood event was up to 70 mm over heavily vegetated creek areas. No adverse flood impact was predicted to the existing James Small Drive (ES74) bridges. *Note that these impacts (downstream of the Pine Brush Creek crossings (ES71) were reported under POI R in the EIS. Impacts downstream of the bridges have now been separated for clarity.*	Predicted afflux in the 1% AEP flood event is up to 13 mm over heavily vegetated creek areas (outside the project boundary). No adverse flood impact is predicted to the existing James Small Drive (ES74) bridges. Survey of the residential building (Lot 20 DP841807) determined that the floor level was at 11.14 mAHD. Afflux is predicted in events up to and including the 5% AEP. The peak water level in these events is below the floor level. The peak water level for the 1% AEP event under existing conditions is observed to be 11.39 mAHD. Afflux is not predicted in the 1% AEP event. This building is owned by TfNSW.	Impacts have decreased with the amended design. Afflux in the creek (downstream of the bridges) is reduced to 13 mm. The floor level of the residential building is above the peak water levels predicted in events up to and including the 5% AEP event. Afflux in events greater than the 5% AEP event are no longer observed. These changes are because of new data, improved modelling methodologies and modifications which are part of the Pine Brush Creek and Williams Creek realignment design change.
S	The project and revised local access road traverses the northern sub-catchments of Pine Brush Creek requiring conveyance.	The project and revised local access road traverses the northern sub-catchments of Pine Brush Creek requiring conveyance.	Impacts from the amended design are consistent with the EIS design impacts.

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
T	The Opal Boulevard access has been reconfigured, resulting in a modified flood distribution. Localised afflux of up to 300 mm was predicted in the 1% AEP event immediately upstream and downstream of the Opal Boulevard crossing of Pine Brush Creek.	The project reconfigures the existing Opal Boulevard access, resulting in a modified flood distribution. Localised afflux of up to 85 mm is predicted in the 1% AEP event immediately upstream and downstream of the Opal Boulevard crossing of Pine Brush Creek.	Impacts have been improved with the amended design. Afflux is reduced from 300 mm to 85 mm in the amended report. These changes are because of new data, improvements to modelling methodologies and design refinements such as reconfigurations of upstream drainage channels and structures. There have been no changes to the road design following exhibition of the EIS.
U	The proposed water quality basins extend into the waterway of the main Sapphire Beach tributary. This resulted in predicted localised afflux of up to 200 mm over vegetated areas of a residential property located on Campbell Close, Korora. Existing buildings were not affected.	The proposed water quality basins extend into the waterway of the main Sapphire Beach tributary, resulting in localised afflux of up to 90 mm within the waterway. No change to the existing flood extents is predicted.	Impacts have been improved with the amended design. Afflux is reduced from 200 mm to 90 mm in the amended report. These changes are because of new data, improvements to modelling methodologies and design refinements.
V	The project tie-in was predicted to result in up to 11 mm of afflux to the downstream area of Nautilus Villas. Greater peak level impacts of up 28 mm were predicted on three residential properties immediately adjacent to the waterway.	No impact is predicted for the Nautilus Villas.	Impacts have improved with the amended design. Afflux at POI V is no longer predicted. These changes are because of new data and improvements to the modelling methodologies.

Scour and velocity

Potential scour and velocity impacts for the northern creeks catchment for the amended design are discussed in **Section 5.2.3**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 47**.

Table 47: Comparison of predicted velocity impacts in the northern creeks catchment

Location	EIS potential flood impact	Amended potential flood impact	Change in impact
Pacific Bay Resort	Minor (up to +0.2 m/s) peak velocity increases were predicted within the current course flow-paths and lakes. Increases were generally limited to existing vegetated creeks and paved areas, except the new flow path downstream of ES57, subject to predicted velocities of around 0.5 and 0.7 m/s in the 18 and 1 per cent AEP events respectively. It was noted that this will be reviewed during detailed design with a focus on water quality basin outlet location and possible outlet scour protection.	Minor (up to +0.2 m/s) peak velocity increases are predicted within the existing course flow paths and lakes. Peak velocity increases of up to 1.0 m/s are predicted downstream of ES57 and ES157 (POI BI), within the existing flow path.	Impacts for the amended design are within existing waterways and flow paths. The spatial extent of flooding and consequently the extent of velocity increases have reduced. However, there has been a minor worsening of the magnitude of the velocity increase. These changes are because of new data including detailed survey of nearby terrain and drainage structures. The design scenario flooding behaviour is also influenced by the Korora Hill interchange design change.
Pacific Bay Eastern Lands	Minor increases in peak velocity on Lot 14 in the 1 per cent AEP of up to 0.2 m/s were predicted. Increases were also predicted in the PMF event of up to 0.3 m/s on lots 14-22.	No impact is predicted for the approved development area of Pacific Bay Eastern Lands.	Impacts for the amended design are no longer predicted for this location. This is because of new data including detailed survey of nearby terrain and drainage structures. The design scenario flooding behaviour is also influenced by the Korora Hill interchange design change.
Minor tributaries	Localised velocity increases were also predicted downstream of design culverts DS70, DS71 and DS72 of up to 0.5 m/s in events above the 5 per cent AEP.	Localised increases in velocity are predicted at drainage structure outlets. Downstream of DS87 (POI T) an increase of up to 1.0 m/s is predicted in the 1% AEP event. This increase is localised and is contained within the waterway. At all other locations velocity increases are less than 0.2 m/s outside the construction footprint in the 1% AEP.	Impacts for the amended design have increased at POI T from the impacts reported in the EIS. These changes are because of new data and design refinements to nearby drainage features.
Pine Brush Creek	Not impacted.	Existing peak velocities reach approximately 3.5m/s in Pine Brush Creek and 2.9m/s in Williams Creek in the 1% AEP event. Peak velocity increases of up to 0.6 m/s are predicted through the waterway realignment of Williams Creek in the 1% AEP event. Peak velocities for the amended design are predicted to reach 3.5m/s in Pine Brush Creek and 3.5m/s in Williams Creek in the 1% AEP event. Impacts are generally contained within the construction footprint and do not affect any residential buildings.	Impacts at the waterway realignment have increased within Williams Creek from the EIS. This change is because of new data and the Pine Brush Creek and Williams Creek waterway realignment design change.

Access

Potential access impacts for the northern creeks catchment for the amended design are discussed in **Section 5.2.3**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 48**.

Table 48: Comparison of predicted access impacts in the northern creeks catchment

		EIS minimum event closure (AEP) / crest depth (mm)			Amended minimum event closure (AEP) / crest depth (mm)			
POI	Affected road / driveway	Existing	Developed	Impact	Existing	Developed	Impact	Change in impact
AR	West Korora Road, Jordans Creek^	<18% / 1020	<18% / 1380	Maintained	<18% / 540	1% / 70	Increased	Impacts to access have been improved with the amended design. This is because of improved modelling methodologies, new data and design refinements to nearby drainage structures. A greater level of access is predicted with the amended design.
AX/P	Lot 19 DP771618	>1% / 58	5% / 190^	Decreased	5% / 110	1% / 0	Increased	Impacts to access have been improved with the amended design. Access for the EIS design was provided via West Korora Road. Access is provided from Bruxner Park Road in the amended design. This is part of the Korora Hill interchange design change. A greater level of access is predicted with the amended design.
AS	Pacific Highway, Jordans Creek	<18% / 590	<18% / 590	Maintained	<5% / 250	<5% / 250	Maintained	No change
AY	Bruxner Park Road	<18% / 130	<18% / 110	Maintained	<18% / 110	<18% / 100	Maintained	No change

		EIS minimum event closure (AEP) / crest depth (mm)			Amended minimum event closure (AEP) / crest depth (mm)			
POI	**Affected road / driveway**	**Existing**	**Developed**	**Impact**	**Existing**	**Developed**	**Impact**	**Change in impact**
AZ	James Small Drive	>1% / 75	<18% / 130	Decreased	>1% / 0	>1% / 0	Maintained	Impacts to access have been improved with the amended design. This is because of the improvements to modelling methodologies. Modelling now shows this access location to be outside the flood extents in the existing case. The amended design does not impact access at this location.
Q	Resort Drive	<18% / 580	<18% / 580	Maintained	>1% / 0	>1% / 0	Maintained	No change
AU	Langley Close	<18% / 680	<18% / 670	Maintained	<18% / 300	<18% / 300	Maintained	No change
AT	Driftwood Court	<18% / 760	<18% / 760	Maintained	<18% / 660	<18% / 660	Maintained	No change
AU	Cutter Drive	<18% / 520	<18% / 510	Maintained	<18% / 270	<18% / 270	Maintained	No change
AT	Firman Drive	<18% / 830	< 18% / 820	Maintained	<18% / 770	<18% / 770	Maintained	No change
AZ	Ballantine Drive	>1% / 22	>1% / 49	Maintained	>1% / 0	>1% / 0	Maintained	No change
R	Old Coast Road, Pine Brush Creek	10% / 130	10% / 140	Maintained	<5% / 340	<5% / 330	Maintained	No change
T	Opal Boulevard	5% / 110	10% / 100	Decreased	2% / 120	1% / 0	Increased	Impacts to access have been improved with the amended design. New data and improved modelling methodologies increased the existing level of access from being trafficable in the 5% AEP event to being trafficable in the 2% AEP event. The amended design increases the level of access at this location because of nearby drainage design refinements.

		EIS minimum event closure (AEP) / crest depth (mm)			Amended minimum event closure (AEP) / crest depth (mm)			
POI	Affected road / driveway	Existing	Developed	Impact	Existing	Developed	Impact	Change in impact
S	Lot 1 DP270147	<18% / 130	10% / 120	Increased	<18% / 140	<18% / 140	Maintained	The EIS design predicted improvements to access at this location. The amended design does not impact access at this location. These changes are because of new data and improved modelling methodologies.
S	Lot 100 DP1112799	<18% / 170	>1% / 27	Increased	>1% / 0	>1% / 0	Maintained	Improvements to modelling methodologies have reduced the flood extents in this area. Modelling now shows this access location to be outside the flood extents in the existing case. The amended design does not impact access at this location.
S	Lot 1 DP527497	>1% / 37	<18% / 220	Decreased	<2% / 130	<2% / 130	Maintained	Impacts to access have been improved with the amended design. New data and improved modelling methodologies reduced the predicted level of access from being trafficable in the 1% AEP event to not being trafficable in the 18% AEP event under existing conditions. The amended design maintains the level of access at this location because of nearby drainage design refinements.
V	Ocean Dream	<18% / 510	<18% / 520	Maintained	<18% / 640	<18% / 640	Maintained	No change

^Points of interest AU and AT are located approximately 500 m and 650 m downstream of point of interest AS. This is not within the mapping extent shown in the figures. However, these locations are not impacted by the project.

Direction

As part of the Pine Brush Creek and Williams Creek realignment design change, additional creek realignment is required at DS85 (BR21). The realignment includes the relocation of the confluence of the two creeks to approximately 20 m upstream of the existing confluence location. In addition to this, Williams Creek and Pine Brush Creek have been realigned by approximately 90 m and 85 m respectively to maintain existing velocities and hydraulic grades upstream of the confluence. These changes result in improved flood flow management through the three bridges. At all other waterway crossings, the EIS design and the amended design both result in minimal changes to surface water source and direction where possible, except for constriction into and expansion out of structures and constructed diversions, in line with the project floodplain management objectives.

Hazard

Potential flood hazard impacts for the northern creeks catchment for the amended design are discussed in **Section 5.2.3**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table** 49.

Table 49: Comparison of predicted hazard impacts in the northern creeks catchment

POI	EIS potential flood impact	Amended potential flood impact	Change in impact
Minor tributaries	Increases in flood hazard classifications were predicted over some areas immediately upstream of the project (DS67, DS69, DS70, DS86).	Increases in flood hazard classifications are predicted over the area immediately upstream of the culvert DS86 in the PMF event.	Impacts for the amended design are reduced when compared to those presented in the EIS. These changes are because of new data, design refinements, and improved modelled methodologies.
Pacific Bay Resort	Localised increases were predicted around the Pacific Bay Resort and golf course (downstream of culverts ES57 and ES58) during the five and 1 per cent AEP events.	Impacts are no longer predicted for the Pacific Bay Resort.	Impacts are no longer predicted for the amended design. This is because of new data including detailed survey of nearby terrain and drainage structures. The design scenario flooding behaviour is also influenced by the Korora Hill interchange design change.

Critical infrastructure

Potential impacts to critical infrastructure in the northern creeks catchment for the amended design are discussed in **Section 5.2.3**. A comparison of these impacts with the impacts presented in the EIS is outlined in **Table 50**.

Table 50: Comparison of predicted impacts to critical infrastructure in the northern creeks catchment

Location	EIS potential flood impact	Amended potential flood impact	Change in impact
Kororo Public School	Outside flood extents. No change anticipated.	Outside flood extents. No impact predicted.	No change
Coffs Harbour Montessori Preschool	Outside flood extents. No change anticipated.	Outside flood extents. No impact predicted.	No change

Emergency management

Impacts to evacuation routes in the northern creeks catchment are consistent with those presented in the EIS. That is, there are no adverse impacts to all identified evacuation routes.