9 Hydrology

This chapter summarises the impact of the proposed upgrade on surface water flows. In particular it assesses whether there would be any potential worsening of the impacts of flooding that may be caused by the obstruction of water flows by bridges and culverts. The chapter is based on a detailed study that is included *Working Paper 1 - Hydrology assessment*.

Environmental assessment requirement	Where addressed
Flooding impacts, identifying changes to existing flood regimes, in accordance with the *Floodplain Development Manual* (former Department of Natural Resources, 2005) including impacts to existing receivers and infrastructure and the future development potential of affected land	Section 9.5
Impacts to waterways to be modified as a result of the project, including ecological, hydrological and geomorphic impacts (as relevant) and measures to rehabilitate the waterways to pre-construction conditions or better	Sections 9.6 and 9.7 (except for ecological impacts which are addressed in Chapter 12).

9.1 Assessment approach

A study of the hydrologic impacts of the proposed upgrade was undertaken generally in accordance with the Floodplain Development Manual. The study involved.

> Calculation of peak flows for major creeks at key locations.
> Identification of the probable extent of the 1 percent annual exceedance probability (AEP) flood event for each major creek.
> Assessment of the waterway opening required for bridge spans to provide adequate capacity to convey the 1 percent AEP peak flood flow.
> Identification of any residual flooding impacts.
> Identification of impacts to surface water flows and effects of proposed waterway diversions.

The hydrologic studies have been undertaken to a preliminary level for the purposes of the environmental assessment. They are at an adequate level of detail for the concept design of bridges and culverts and to identify likely impacts. Detailed design of the proposed upgrade will require further hydrologic analysis.

9.2 Existing creek network

The following named creeks are crossed by the proposed upgrade:

> Emigrant Creek.
> Skinners Creek.
> Byron Creek (downstream of the confluence with Tinderbox Creek).

A number of unnamed creeks and tributaries are also traversed by the proposed upgrade.

All these creeks originate on the plateau on which the proposed upgrade would be located and flow generally to the southwest. These are described in more detail overleaf.

9.2.1 Emigrant Creek

The source of Emigrant Creek is just south of the junction of Piccadilly Hill Road and Broken Head Road. It has a catchment area of 4.1 km^2 where it is crossed by the proposed upgrade, about 6 km upstream of the Emigrant Creek Dam. The dam and drinking water catchment is discussed in more detail in **Chapter 10 – Water quality.**

The creek passes beneath the existing highway in four 1800 mm wide by 2000 mm high reinforced concrete box culverts, immediately upstream of the proposed upgrade crossing. Beyond this, Emigrant Creek continues flowing southwards where it outfalls to the Richmond River near West Ballina.

The Emigrant Creek catchment upstream and in the vicinity of the proposed crossing is characterised by gentler sloping hills than the Byron and Tinderbox catchments, with numerous small dams and water bodies, both on the creek and its tributaries, and numerous changes of direction. The approximate tidal limit of Emigrant Creek is near the Tintenbar Road bridge.

9.2.2 Skinners Creek

Skinners Creek is the smallest of the named creeks. It has its source near Piccadilly Hill. Where it would be crossed by the proposed upgrade it has a catchment area of 2.3 km^2. Downstream of the crossing, Skinners Creek flows into Pearces Creek, which joins the Wilson River at Booyong. It crosses the existing Pacific Highway approximately 1 km north of Newrybar, where it passes beneath the highway in six 1800 mm circular concrete conduits.

The catchment is less steep than those of Tinderbox and Byron Creeks. Along with Byron and Tinderbox Creeks, this catchment forms part of the drinking water catchment of the proposed Lismore source, discussed in more detail in **Chapter 10 – Water quality.**

9.2.3 Byron Creek

The source of Byron Creek is approximately 1 km northeast of Coopers Shoot. Byron Creek has a catchment of approximately 21.6 km^2 at the point where it is crossed by the proposed upgrade. The catchment includes the Tinderbox Creek catchment as the proposed upgrade crosses downstream of the confluence point of these two creeks. West of the proposed upgrade, Byron Creek joins with the Wilson River, before joining the Richmond River. The catchment forms part of the drinking water catchment of the proposed Lismore source.

The existing Pacific Highway crosses Byron Creek approximately 400 m downstream of the crossing point for the proposed upgrade, on a bridge that also passes over the adjacent Casino – Murwillumbah Railway.

At the upstream end of the Byron Creek catchment, the topography is relatively steep, interspersed with isolated small areas of flatter grade. Downstream of the confluence with Tinderbox Creek, and in the vicinity of the existing Pacific Highway crossing, Byron Creek widens significantly. This is potentially the result of a weir located downstream in Bangalow, which appears to have been constructed to provide a swimming facility. Downstream of the weir, the creek returns to a narrow, natural channel.

9.3 Peak flows

Peak flows were determined using the RAFTS modelling software. **Table 9.1** shows peak flows for the 1 percent AEP event at key locations along each creek.

Table 9.1 - Flow at the 1 percent AEP event at key locations

Creek	Location	1% AEP flow (m3/s)
Byron	Location of existing Pacific Highway creek crossing	532
	Just before Tinderbox/Byron junction	251
	Just after Tinderbox/Byron junction (location of proposed upgrade creek crossing)	506
Skinners	Location of proposed upgrade creek crossing	56
	Location of existing Pacific Highway creek crossing	68
Emigrant	Location of existing Pacific Highway and proposed upgrade creek crossing	146

9.4 Existing flood extent

The existing 1 percent AEP flood extent (**Figure 9.1**) in the vicinity of the proposed upgrade reflects the absence of floodplain and the relatively small catchments of the creeks. The flood extent is generally contained to within several hundred metres of the respective centre line of each creek.

9.5 Impact on flood behaviour

9.5.1 Overview

The proposed upgrade would pass through steeply undulating topography with well-defined creeks and valleys, and cross creek lines close to their source. As a result, the proposed upgrade would not pass through areas constituting a floodplain. It would however, traverse creek overbank areas subject to local flooding during large storm events. This includes the Emigrant, Skinners and Byron creeks – as well as a number of smaller unnamed watercourses.

Potential impacts on flood behaviour potentially include:

> Change in flood levels and extents.

> Change in inundation periods and/or the rate of rise of floodwaters.

> Change in flow velocity.

The hydrologic modeling undertaken to date suggests there would be no changes to flood regimes that impact on existing receivers, infrastructure or development potential of land. Impacts on individual creeks are discussed following.

9.5.2 Tributary of Emigrant Creek

The proposed upgrade crosses an unnamed tributary of Emigrant Creek, approximately 300 m south of the crossing of Emigrant Creek. The existing Pacific Highway runs parallel to the proposed upgrade immediately upstream of the new crossing, and the existing waterway opening consists of 2 x 1500 mm diameter pipes. However, despite the relatively minor upstream catchment area, the proposed upgrade incorporates a bridge at this location, in order to span the upstream end of a private dam, and as a result of the steep topography in the area. Given the small catchment area, this creek has not been subject to hydraulic modelling.

9.5.3 Emigrant Creek

Bridge abutments on both sides of Emigrant Creek would be located in a way that minimises increases in flood levels during flood events. Bridge design would also aim to minimise change to inundation periods and flow velocities.

The existing Pacific Highway, located upstream of the proposed new crossing, would be retained as an access road, and existing waterway openings (four 1800 mm wide by 2000 mm high reinforced concrete box culverts) would be retained.

9.5.4 Skinners Creek

Bridge abutments on both sides of Emigrant Creek would be located in a way that minimises increases in flood levels during flood events. Bridge design would also aim to minimise change to inundation periods and flow velocities.

9.5.5 Byron Creek

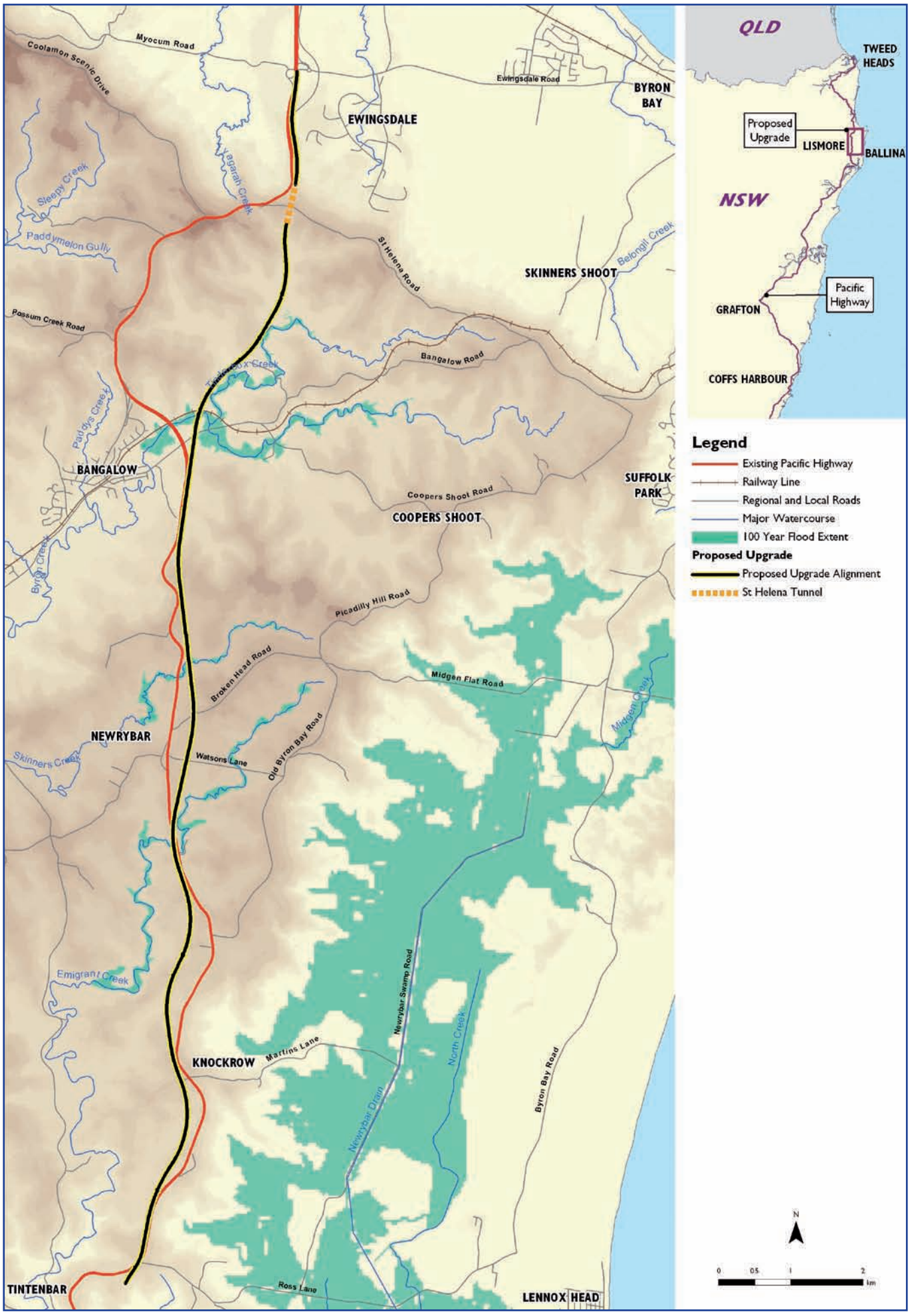
Bridge abutments on both sides of Emigrant Creek would be located in a way that minimises increases in flood levels during flood events. Bridge design would also aim to minimise change to inundation periods and flow velocities.

The position of the northern abutments has been driven by the need to clear the Casino-Murwillumbah railway. The railway is above the 1 percent AEP flood extent, and therefore the abutments are well outside the flood extent. Bridge abutments at the southern end have been angled back where required to reduce impacts on the flood regime.

9.5.6 Minor watercourses

Crossings of minor watercourses have been designed to convey the 1 percent AEP flood event with minimal increase in upstream water levels. There would therefore be minimal impact on the existing flood regime.

Figure 9.1 - 1 percent annual exceedance probability flood extent



9.6 Impacts of waterway modifications

The design of the proposed upgrade would allow the natural flow regimes and existing overland flow paths to be maintained. Accordingly, there would be minimal impact on existing receivers and infrastructure, and on any future development potential.

Culverts would be provided beneath the proposed upgrade to convey surface water runoff, and would be designed with sufficient capacity to convey the 100 year ARI peak flow with:

> No flow on at least one carriageway of the proposed upgrade (predicted performance is well in excess of this requirement).
> Only highly localised increases to water levels upstream of the structure that do not impact on nearby property.
> Minimal disruption to the natural hydrological regime through the diversion of flow onto adjoining catchments.

Waterway diversions have generally been avoided but minor diversions are proposed at a number of situations for one or more of the following reasons:

> Where the proposed upgrade alignment coincides with the existing alignment of a waterway.
> Where the required skew of a culvert would result in a culvert of excessive length.
> Where it would be necessary to direct clean water around a water quality sediment basin.

It is estimated that nine minor waterway diversions would be required, totalling approximately 1.5 km in length. The hydrologic impacts of these diversions would be minimal as they would be specifically designed to maintain the existing hydrologic regime. Similarly, the diversions would be designed to avoid any impacts on downstream morphology of the waterways. Ecological impacts of waterway diversions are discussed in **Chapter 12 - Ecology**. Proposed waterway modifications are shown in **Figures 9.2 a-e.**

9.7 Management of impacts

Because of the minimal nature of impacts on existing waterways, no specific rehabilitation measures are considered necessary. However, the following management measures would be adopted.

9.7.1 Drainage structures

The concept design has incorporated measures such as appropriately sized culverts and diversion drains to limit the extent of changes to the local drainage characteristics so as to maintain existing surface water flow regimes. Drainage structures would be designed to facilitate fish passage in accordance with DPI Fisheries guidelines (Fairfull and Witheridge, 2003)

9.7.2 Scour protection

Appropriate scour protection would be provided on both upstream and downstream ends of all structures where increased velocities have the potential to cause scour. Design of scour protection measures would be undertaken during the detailed design phase based on peak inlet/outlet velocity and applicable fish and fauna friendly requirements. The selection of appropriate scour protection would depend on the characteristics of the culvert flows. Typically, a headwall and apron would be sufficient to protect against scour when the outlet velocities are low. However, watercourses with high velocity flows may require devices to slow the flow prior to entry to the culvert and protect the stream bed.

The topography of the area requires culverts to be laid on a steep grade in a number of locations, to match existing creek alignments. Energy dissipation structures would be provided in these locations to reduce flow velocities and protect against scour.

9.7.3 Modified waterways

Effective hydrologic function and morphological stability would be inherent in the design of diverted waterways. Maximisation of ecological values of these waterways is discussed in **Chapter 12 – Ecology.**

Figure 9.2a - Proposed waterway modifications

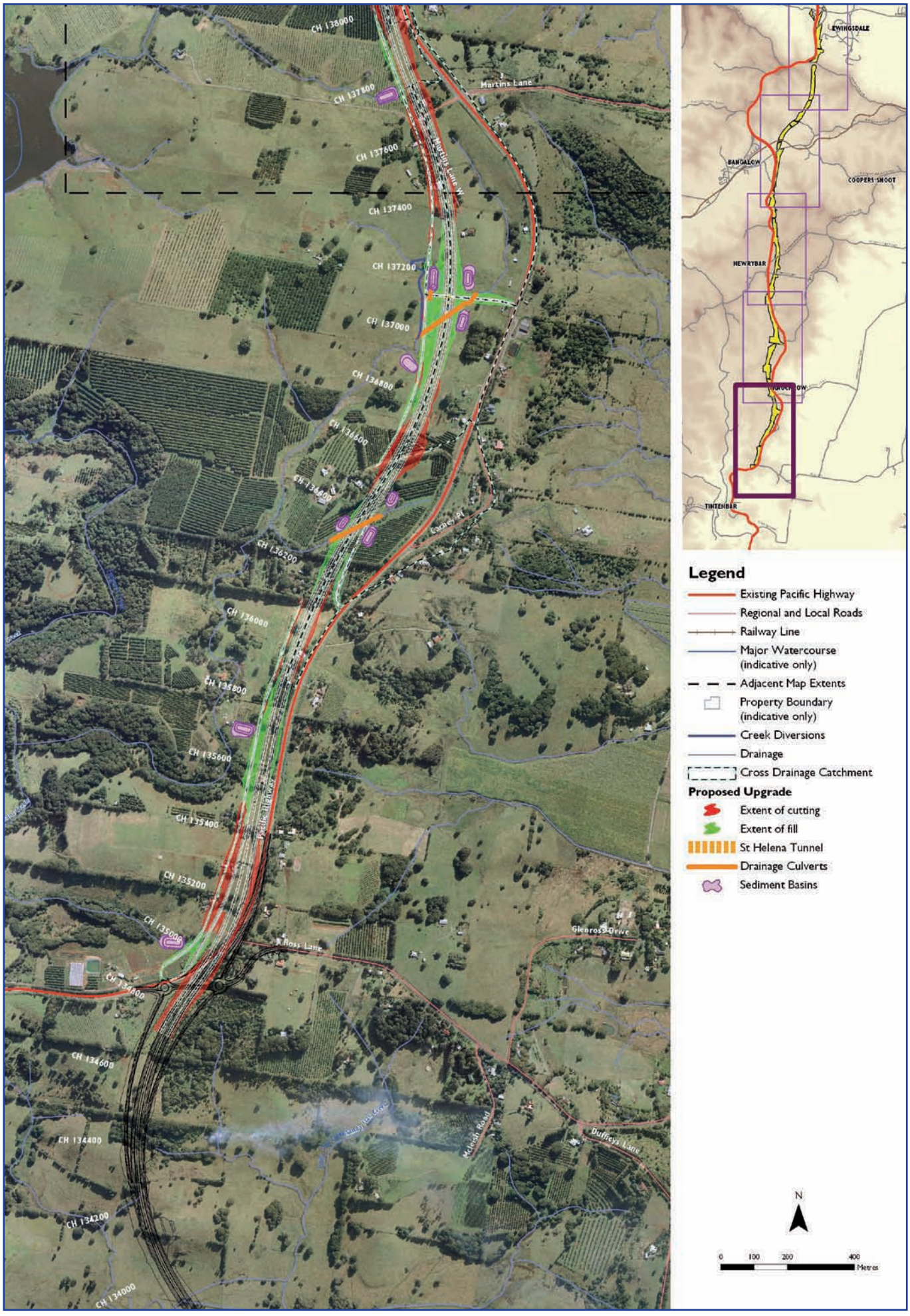


Figure 9.2b - Proposed waterway modifications

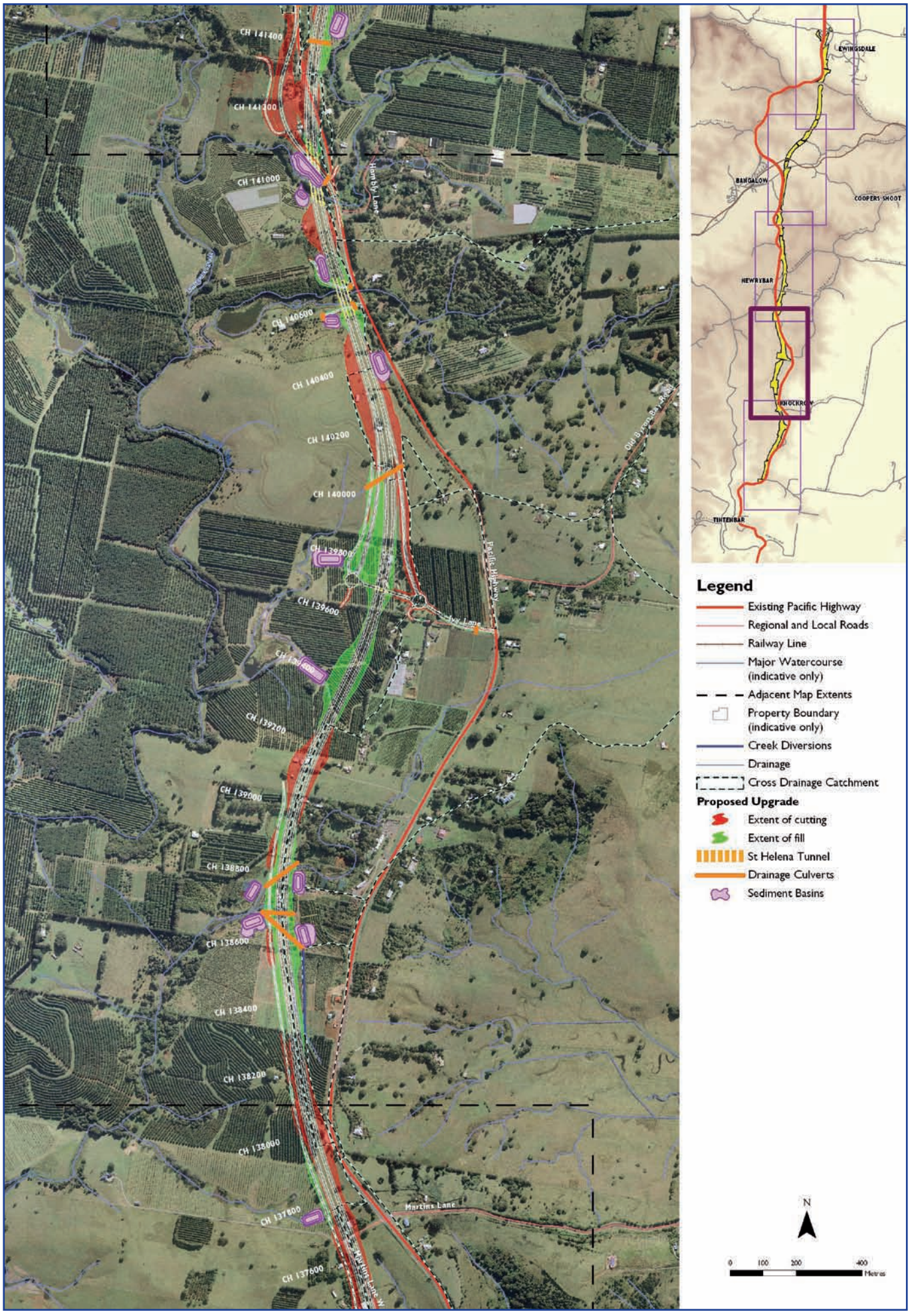


Figure 9.2c - Proposed waterway modifications

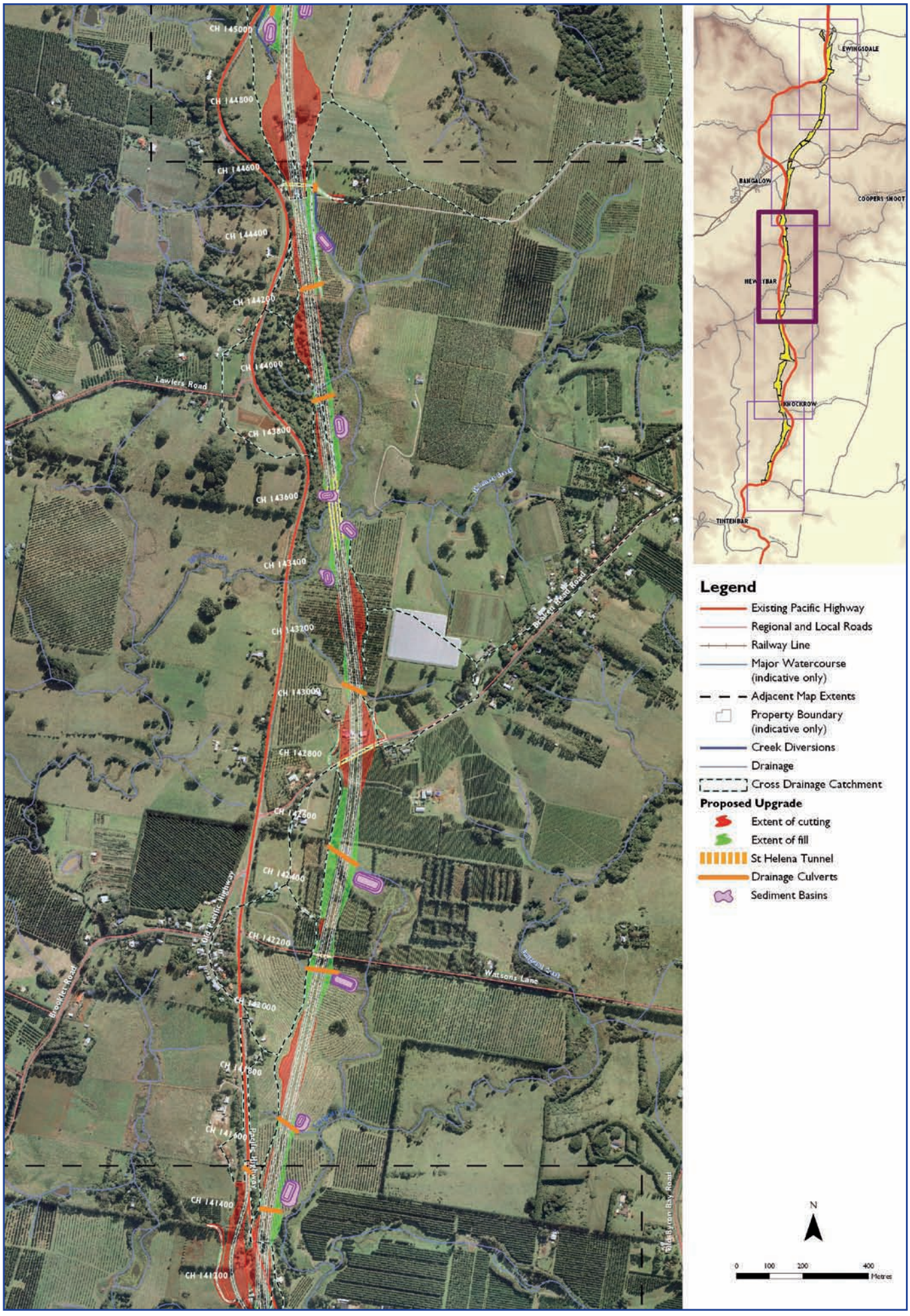


Figure 9.2d - Proposed waterway modifications

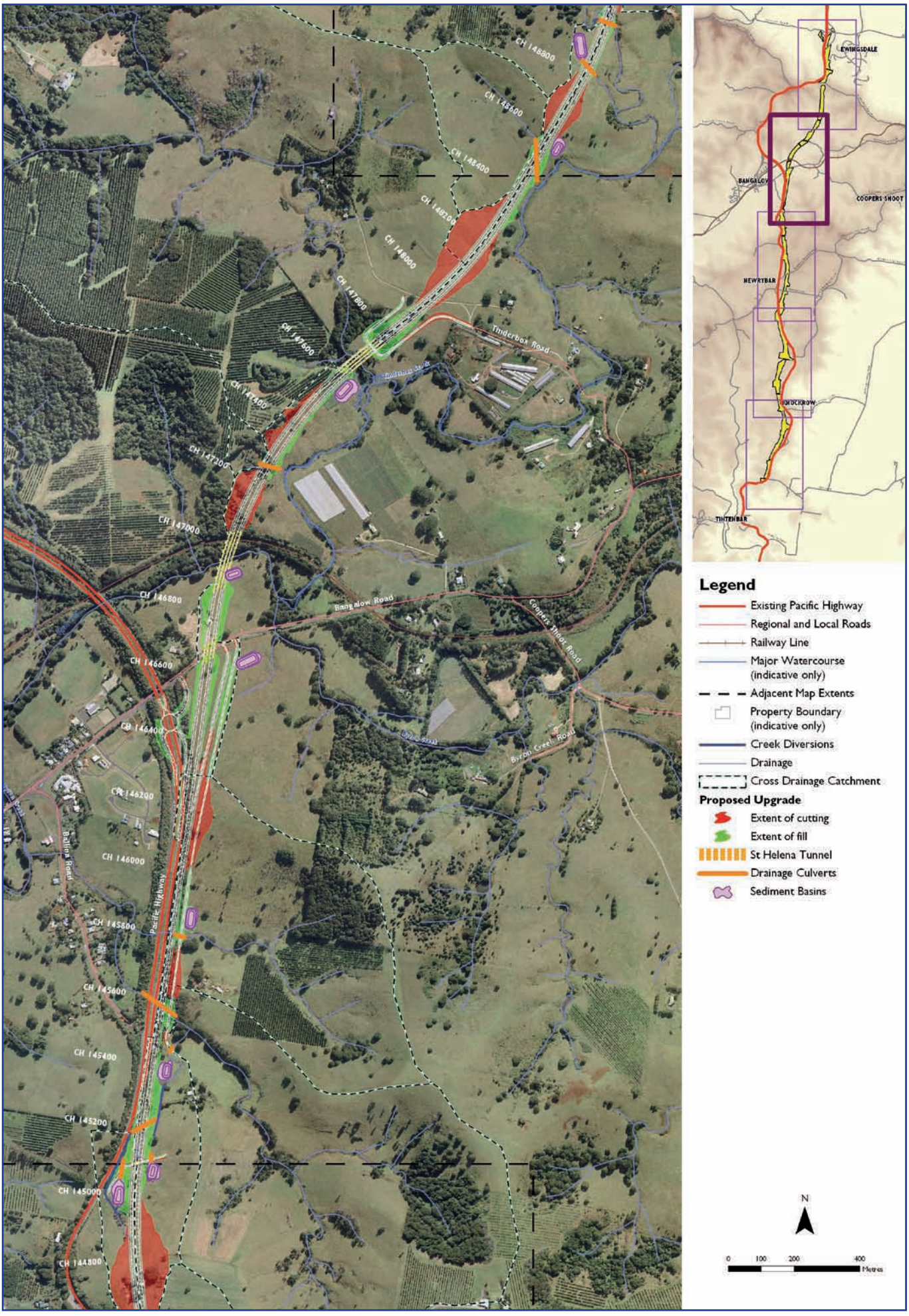


Figure 9.2e - Proposed waterway modifications