Urban Design and Landscape Report (Sections 1 & 2)

Woolgoolga to Ballina Pacific Highway upgrade

March 2015

Prepared for

Transport Roads & Maritime Services

Grafton, NSW

Prepared by

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1 Introduction

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1.1 Upgrade overview

Current upgrade overview

The proposed upgrade of the Pacific Highway between Woolgoolga and Glenugie forms part of the Pacific Highway upgrade program between Woolgoolga and Ballina, on the north coast of New South Wales.

The proposed upgrade extends over approximately 31 kilometres from the Sapphire to Woolgoolga Pacific Highway upgrade, about 32 kilometres north of Coffs Harbour (currently under construction) to the Glenugie upgrade project (approximately 64 kilometres north of Coffs Harbour, opened to traffic in October 2011).

The Arup Parsons Brinckerhoff Joint Venture (APBJV) was established for the purpose of preparing the detailed design and documentation for the construction of this upgrade. Spackman Mossop Michaels (SMM) has been engaged by APBJV to provide urban design and landscape design.

The purpose of this report

The purpose of this Urban design and landscape report is to:

- Provide an overview of the urban design and landscape concept design provided by the Woolgoolga to Ballina Alliance
- Analyse design and environmental-related issues and recommend responses
- Enable the project delivery to be better informed about urban design and landscape objectives, principles and recommendations
- Encourage adherence with the over arching Roads and Maritime guidelines, Director General Requirements and other relevant guidelines, codes and standards.

The processes and outcomes of this report will guide the Roads and Maritime during the implementation of urban design and landscape recommendations as the project progresses and offer alternative strategies where unexpected conditions are encountered during construction.

Background and limitations

This report is based on concept reports released by Roads and Maritime Services (Roads and Maritime) that have been prepared by the Woolgoolga to Ballina Planning Alliance, of which the Woolgoolga to Glenugie upgrade comprises two out of eleven upgrade sections. The report is also based on limited site investigation and discussions with APBJV design team leaders and Roads and Maritime peer reviewers.

Urban design framework

The principles of the upgrade have been developed in accordance with the Pacific Highway Urban Design Framework (Roads and Maritime, 2005), as follows:

- Provide a flowing road alignment that is responsive and integrated with the landscape
- Provide a well-vegetated, natural road corridor
- Provide an enjoyable and interesting highway experience for road users
- Value the communities and towns along the road
- Provide consistency-with-variety in road elements
- Provide a simplified and unobtrusive road design.

Urban and landscape design principles and objectives are expanded in **Section 5** of this report.

Development of the preferred upgrade

After consideration of the Project Environmental Impact Statement (EIS) and Preferred Infrastructure Report (PIR), the Minister for Planning approved the Woolgoolga to Ballina Pacific Highway Upgrade under Part 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act) on 24 June 2014, subject to the Minister's Conditions of Approval (CoA) being met. The approved project was referred to the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (now the Department of the Environment) in accordance with the requirements of the EPBC Act. The Minister's approval was received on 14 August 2014 subject to a number of conditions being met.

The Woolgoolga to Glenugie upgrade was formally known as two separate upgrades, being the Woolgoolga to Wells Crossing, and Wells Crossing to Iluka Road upgrades. The Woolgoolga to Glenugie project as it currently stands, includes the southern nine kilometres of the Woolgoolga to Wells Crossing project, with the remainder comprising a new alignment towards Glenugie.

A brief outline of the project history for Woolgoolga to Wells Crossing is:

- November 2004: Investigations commenced into the upgrade including community consultation to identify a study area and route options.
- October 2005: Route options announced and displayed for community comment.
- August 2006: Preferred route announced and displayed for community comment.
- May 2007: Preferred routes identified for the Barcoongere Way and Luthers Road areas following further community, agricultural and environmental investigations.
- April 2008: Concept design announced and on displayed for community comment.

A brief outline of the project history for Wells Crossing to Iluka Road is:

- November 2004: Investigations commenced into the upgrade of the Pacific Highway including community consultation to identify a study area and route options.
- October 2005: Route options announced and display for community comment.
- May 2006: Outcomes of value management workshop announced.
- September 2006: Preferred route announced and displayed for community comment.
- January 2009: Concept design announced and displayed for community comment.
- May 2009: The Minister for Roads asked Roads and Maritime Services (formerly Roads and Traffic Authority) to work with local cane growers and affected landowners to investigate the feasibility of an alternative option that avoids the high value cane land along the south arm of the Clarence River between Tyndale and Maclean.
- June 2010: The projects were combined when the Woolgoolga to Ballina Planning Alliance was formed. Since that time, a refined concept design was announced and displayed for community comment in October 2011. The Environmental Assessment was subsequently undertaken and is currently awaiting planning approval.
- The highway design presented in this report is based on the road alignment concept design developed by the Woolgoolga to Ballina Planning Alliance in early to mid 2012 with subsequent detailed design provided by the APBJV from mid 2012 to late 2013.

Upgrade Staging

Section 1: Arrawarra to Halfway Creek

Commencing at the northern extent of the Pacific Highway upgrade Sapphire to Woolgoolga, the first two kilometres of Section 1 passes through low-lying swamp forests with dense vegetation screening the highway from the nearby settlements of Arrawarra and Corindi Beach. At chainage 2,000 the upgrade deviates into the visually more exposed off-line route traversing the Corindi floodplain, where it is visible from a scattered handful of local residences and from the existing highway. In the vicinity of Cassons Creek, the upgrade re-enters a densely forested environment before reconnecting with the existing highway at the Range Road interchange and continuing to follow the existing highway for the remainder of the Section until the existing Halfway Creek upgrade.

The visual impact of the proposal was assessed by the Woolgoolga to Ballina Planning Alliance as moderate to low throughout this section, with the alignment screened from existing townships by dense forest and only passing within 300 metres of local residences or commercial sites on a handful of occasions. Changes to the alignment during detailed design have not impacted this rating.

Road user views of the proposed upgrade will be greatly impacted throughout this section due to the significant proportion of off-line sections of highway and sweeping views afforded over the Corindi floodplain from elevated levels associated with the new twin bridges over the floodplain.

Urban design considerations in this section focus on the form and proportion of highway bridges, particularly at the 300 metre long Corindi floodplain bridge, as well as the three overbridges at Sherwood Creek Road, Kangaroo Trail Road and Range Road interchange. Large landscape formations will be located at the main cutting at Dirty Creek Range and the large fill embankments on approach to the Range Road Interchange. These have been the subject of urban and landscape design considerations in order to integrate the formations with the existing landscape topography.

Landscape techniques consist of a combination of planting, revegetation and bushland reconstruction, in locations determined as most suitable. Suitability was assessed in terms of vertical alignment ie cut or fill, adjacent landscape character and vegetation communities, as well as whether the alignment is off-line, thus lending itself to bushland reconstruction.

Section 2: Halfway Creek to Glenugie

Commencing at the existing Halfway Creek upgrade and tying-in at the existing Glenugie upgrade, Section 2 generally follows the existing highway and crosses it in several locations. This section of the upgrade is situated within a mosaic of dense forest and partially cleared agricultural lands and passes a scattering of rural-residential residences on large allotments.

The visual impact of the proposal was assessed by the Woolgoolga to Ballina Planning Alliance as moderate to low in this section apart from a few locations closer to the alignment where higher impacts can be expected. Primarily, these locations with higher impacts are adjacent to bridges, which have been designed to a higher level of quality as a result. Changes to the alignment during detailed design have not impacted this rating.

Road user views of this Section of the proposed upgrade will not be substantially impacted as whilst the section is predominantly offline, views screened by dense forest will be similar in nature to the existing experience. Urban design input into the design in this section, has focused on the streamlined form of highway bridges, particularly the twin bridges over Halfway Creek, which are visible from a nearby commercial site.

Landscape techniques have primarily focused on the implementation of bushland reconstruction due to the proximity of dense, dry forest and the off-line nature of the alignment. The use of this methodology will build upon the success of bushland reconstruction implemented at the Glenugie upgrade in 2010-11.

Urban and Landscape Design Strategy and mitigation measures

Building upon the high level visual assessment and mitigation strategies developed for the entire Pacific Highway Woolgoolga to Ballina upgrade by Woolgoolga to Ballina Planning Alliance, strategies have been further developed and are outlined in this report. These strategies maintain a consistency with the **Pacific Highway Urban Design Framework**.

The mitigation measures that have been developed for the Woolgoolga to Glenugie upgrade are:

- Urban design input into an integrated design approach that utilises the collaborative skills of designers, engineers and environmental specialists in order to provide a solution that balances the critical aspects of each discipline in accordance with Roads and Maritime document **Beyond the Pavement**.
- Urban design input into the design of major structures to ensure consistency with the intent of Roads and Maritime document **Bridge Aesthetics** and previous bridge design along this section of the highway.
- Urban and landscape design input into the design of major earthworks formations such as large cuttings and fill embankments to provide a well-integrated landscape intervention with reduced visual impacts on road users and road viewers.
- Development of a combination of landscape techniques to provide the best suited revegetation response based on the intrinsic characteristics of the landscape and to allow for contingencies should seasonal or other constraints impact the success of any one technique in accordance with the Roads and Maritime document **Landscape Guidelines**.

Key References

Refer to the **Urban Design Report and Landscape Character and Visual Impact Assessment** (W2BPA, 2012) for further information regarding visual and character impacts.

Refer to **Section 5** and **6** of this report for expansion of urban design and landscape strategies.

1.2 Minister's conditions of approval

Minister's conditions of approval - urban design

The Minister's Conditions of Approval (MCoA) granted by the Minister for Planning on 24 June 2014 for the Woolgoolga to Ballina Pacific Highway Upgrade includes the following Condition D20 with respect to Urban Design and Landscaping (refer **Table 1-1**).

Table 1.1: Minister's conditions of approval - D20: urban design

	URBAN DESIGN REQUIREMENT	URBAN DESIGN RESPONSE	DOCUMENT REFERENCE
D20	The Applicant shall prepare and implement an Urban Design and Landscape Plan prior to the commencement of permanent built works and/or landscaping, unless otherwise agreed by the Secretary, to present an integrated landscape and design for the SSI. The Plan shall be prepared in accordance with the Roads and Maritime Services urban design and visual guidelines, the design principles outlined in the EIS, and the revegetation principles outlined in the EIS Working Paper—Biodiversity. The Plan shall be prepared by an appropriately qualified expert in consultation with the relevant council and community, to the satisfaction of the Secretary. The Plan shall include, but not necessarily be limited to:	¬ An urban design and landscape plan has been prepared by consultants registered with Roads and Maritime and in accordance with Roads and Maritime urban design and visual guidelines. ¬ The Woolgoolga to Ballina EIS prepared by the W2B Planning Alliance has provided the environmental framework for the project. Of particular relevance to urban design and landscape are the **Working paper: biodiversity assessment** (Aurecon, SKM, November 2012) and **Working paper: urban design, landscape character and visual impact assessment**, (Hassell, May 2012), which have been referenced numerous times in this report.	¬ Throughout this report
(a)	identification of design principles and standards based on:		
(i)	¬ local environmental values,	¬ A landscape context and character study has been undertaken in order to identify environmental and cultural values as well as an assessment of vegetation. The outcomes of this study are reflected in the development of urban and landscape design objectives, principles and mitigation measures	¬ Sections 2, 4 and 5 of this report
(ii)	¬ heritage values;	¬ A review of regional aboriginal and non-aboriginal history and heritage features has been undertaken, with very few sites of significance being identified. Impacts to known heritage sites have been identified, detailed assessment and impact mitigation strategies are outlined in the **Environmental Impact Statement and Historical Heritage Assessment** (W2BPA, 2012).	¬ Section 2.10 of this report
(iii)	¬ urban design context;	¬ A project precedent and landscape character study has been undertaken along the Pacific Highway in this region, focusing on recent upgrade stages. The outcomes of this study are reflected in the development of urban and landscape design objectives, principles and mitigation measures	¬ Sections 4 and 5 of this report
(iv)	¬ sustainable design and maintenance;	¬ Structures involving urban design input have been designed in accordance with Roads and Maritime's **Beyond the Pavement** guidelines and **Pacific Highway Urban Design Framework,** particularly in relation to robust and long-lasting materials ¬ Landscape design has involved the development of landscape implementation methods that aim to provide a long-lasting and self-regenerating, well-vegetated landscape. Particular focus here is the design and specification of bushland reconstruction to be employed primarily in the off-line forested areas of Section 2. This method has been successfully employed on the nearby Glenugie Upgrade stage (undertaken by consultant team members).	¬ Sections 5 and 6 of this report

	URBAN DESIGN REQUIREMENT	URBAN DESIGN RESPONSE	DOCUMENT REFERENCE
(v)	¬ community amenity and privacy;	¬ A landscape context, character and urban design precedent study has been undertaken in order to ensure that the upgrade is well integrated into the regional environment ¬ Retention of large sections of the existing highway has been designed in order to facilitate connectivity and to enable local connections to the highway ¬ Structures, roadside furniture and landscape treatments have been designed to be robust and of a high quality in accordance with Roads and Maritime guidelines ¬ All disturbed areas of the road corridor have been designed to employ a revegetation method that will provide a well-vegetated roadside environment. As a consequence of this, local residents and businesses will benefit from screening from the road, increasingly so as the landscape establishes over time	¬ Throughout this report
(vi)	¬ relevant design standards and guidelines; and	¬ Relevant Roads and Maritime standards and guidelines have informed the plan	¬ **Section 1.3** of this report
(vii)	¬ the urban design objectives outlined in Section 4.2 of the EIS Working Paper—Urban Design Landscape Character and Visual Impact ;	¬ Urban design principles and objectives contained in the W2B EIS working paper have informed the development of objectives and principles specific to the W2G stage	¬ **Section 5** of this report
(b)	the location of existing vegetation and proposed landscaping (including use of indigenous and endemic species where possible). Details of species to be replanted/revegetated shall be provided, including their appropriateness to the area and habitat for threatened species;	¬ The landscape design including design of revegetation methodologies and specification of species, has been developed following review the EIS working paper: biodiversity assessment and is 100% comprised of regionally native species ¬ Where species can not be procured from within the road corridor or immediate area, species will be sourced from the NNC/SEQ bioregions as outlined in this report and Roads and Maritime specification ¬ Use of these species has been based on habitat requirements for threatened species, primarily Squirrel Glider and Yellow-bellied Glider	¬ **Section 6** of this report ¬ RMS specification R178
(c)	a description of locations along the corridor directly or indirectly impacted by the construction of the SSI (e.g. temporary ancillary facilities, access tracks, watercourse crossings, etc.) and details of the strategies to progressively rehabilitate regenerate and/or revegetate the locations with the objective of promoting biodiversity outcomes and visual integration;	¬ All areas disturbed by the upgrade construction activities are to be revegetated, these areas have been identified in the urban design and landscape documentation plans ¬ Landscape implementation methods and species procurement guidelines are outlined in this report and in detail in Roads and Maritime W2G upgrade specifications	¬ **Sections 4** and **6** of this report ¬ Landscape drawings W2G-1-UL-DG-0000 to 0129 and W2G-2-UL-DG-0000 to 123 ¬ RMS specifications R178 and R179
(d)	take into account appropriate roadside plantings and landscaping in the vicinity of heritage items and ensure no additional heritage impacts;	¬ All roadside areas are to be revegetated where disturbed by construction activities in accordance with environmental objectives. There are no existing cultural, or landmark plantings associated with heritage items next to the upgrade that would form a precedent for cultural planting to be used on the upgrade	¬ **Sections 4** and **6** of this report
(e)	a description of disturbed areas (including borrow sites) and details of the strategies to progressively rehabilitate, regenerate and/or revegetate these areas, including clear objectives and timeframes for rehabilitation works, procedures for monitoring success of regeneration or revegetation, and corrective actions should regeneration or revegetation not conform to the objectives adopted;	¬ The landscape implementation developed as part of the plan as outlined in this report and Roads and Maritime specifications outlines requirements for progressive and rapid revegetation as well as maintenance and monitoring ¬ The landscape implementation strategy comprises several revegetation methods, including provisional treatments, in order to allow use of alternative methods where required	¬ **Section 6** of this report ¬ Landscape drawings W2G-1-UL-DG-0000 to 0129 and W2G-2-UL-DG-0000 to 123 ¬ RMS specifications R178 and R179

	URBAN DESIGN REQUIREMENT	URBAN DESIGN RESPONSE	DOCUMENT REFERENCE
(f)	location and design treatments for any associated footpaths and cyclist elements, and other features such as seating, lighting (in accordance with AS 4282-1997 Control of the Obtrusive Effect of Outdoor Lighting), fencing, materials and signs;	¬ Limited footpath access is required on or over the upgrade due to the relatively low local population, combined with the retention of large sections of the existing highway in order to facilitate local motorist, cyclist and in relatively few cases, pedestrian connectivity. ¬ Roads and Maritime, in conjunction with the design team, have undertaken consultation with regards to community impacts and requirements with stakeholders including Coffs Harbour City and Clarence Valley councils, as well as local residents. The outcomes of this are reflected in the design ¬ Rest areas and seating were not required as part of the design scope for the upgrade ¬ A minimum of lighting has been provided in accordance with Roads and Maritime objectives and in accordance with AS4282 ¬ Fencing is required for the full length of the upgrade in order to provide a safe highway environment and to provide controlled access for fauna. Where possible fencing is located away from view from the highway and hybridised with cadastral and fauna management requirements in order to reduce the layers of fencing required. Materials selected are rural in character, robust and cost efficient ¬ Signage has been design in order to provide efficient and highly visible wayfinding and other information to road users. An urban design review has been undertaken in order to minimise signage clutter and to integrate signage with other furniture elements and to prevent incompatible landscape treatments	¬ Refer to road alignment and road furniture drawing packages
(g)	an assessment of the visual screening effects of existing vegetation and the proposed landscaping and built elements. Where properties have been identified as likely to experience high visual impact as a result of the SSI and high residual impacts are likely to remain, the Applicant shall, in consultation with affected landowners, identify opportunities for providing at-property landscaping to further screen views of the SSI. Where agreed with the landowner, these measures shall be implemented during the construction of the SSI;	¬ No properties were identified in the EIS Working paper as having high visual impact, ratings ranged from moderate-low to high-moderate. All properties with potential impacts were reviewed for consistency with the detailed design and for mitigation measures, the outcome of which, in all cases, is to ensure the retention of existing vegetation wherever possible, provide revegetation that suits the existing landscape character and to provide revegetation of all roadside areas impacted by construction activities, including trees. Some visual impacts have been mitigated through horizontal or vertical realignment, such that the highway is in cut (below the viewing line) or moved further away from the viewer. ¬ Roads and Maritime has undertaken consultation with regards to community impacts with local residents. The outcomes of this are summarised in this report and reflected in the design.	¬ Refer **Working paper: urban design, landscape character and visual impact assessment**, (Hassell, May 2012) ¬ **Sections 1.4** and **4** of this report
(h)	graphics such as sections, perspective views and sketches for key elements of the SSI, including, but not limited to built elements of the SSI;	¬ Urban design drawings have been prepared for key structures including bridges. These followed a bridge options review undertaken for each bridge, in order to ensure the most cost efficient design was provided and that urban design objectives were maintained and visual impacts mitigated	¬ **Section 6** of this report

	URBAN DESIGN REQUIREMENT	URBAN DESIGN RESPONSE	DOCUMENT REFERENCE
(i)	strategies for progressive landscaping and other environmental controls such as erosion and sedimentation controls, drainage and noise mitigation;	¬ Progressive revegetation, erosion control, riparian restoration and sedimentation control all form part of the complete landscape design methodology ¬ Noise mitigation and treatments is addressed in detail in other reports and was not a specific urban design requirement	¬ **Section 6** of this report ¬ RMS specification R178
(j)	monitoring and maintenance procedures for the built elements, rehabilitated vegetation and landscaping (including weed control). including performance indicators, responsibilities, timing and duration and contingencies where rehabilitation of vegetation and landscaping measures fail; and	¬ Monitoring and maintenance is crucial to the success of the landscape methods designed for the upgrade and is a Roads and Maritime requirement.	¬ **Section 6** of this report ¬ RMS specification R178
(k)	evidence of consultation with the relevant council and community on the proposed urban design and landscape measures prior to its finalisation.	¬ Local stakeholders and residents have been consulted throughout the design process, with regular updates provided to Coffs Harbour City and Clarence Valley councils for the purpose of encouraging input and comment ¬ Community and council engagement has resulted in relatively few responses from the community and no formal comments from council. Council comments were received at several meetings and fed back to the designers ¬ Community engagement was undertaken between 29/09/14 to 24/10/14.	¬ **Section 1.4** of this report

1.3 Urban design guidance

Roads and Maritime guidance documents

The following documents, guidelines and policy framework have been considered in the preparation of this urban design report and associated detailed design (refer **Figure 1-1**):

- *Pacific Highway Urban Design Framework, Hexham to Tweed Heads* (Roads and Maririme, 2013)
- *Beyond the Pavement* (Roads and Maritime, 2014)
- *EIA N04 Practice Note: Guidelines for Landscape Character and Visual Impact Assessment V2.0* (Roads and Maritime, 2013)
- *Bridge Aesthetics* (Roads and Maritime, 2012)
- *Noise Wall Guidelines* (Roads and Maritime, 2006)
- *Shotcrete Design Guidelines* (Roads and Maritime, 2005)
- *Landscape Guidelines* (Roads and Maritime, 2008)

Project documents

The following project documents have been considered in the preparation of this urban design report and associated detailed design (refer **Figure 1-2**):

- Pacific Highway upgrade: Woolgoolga to Ballina, urban design report, landscape character and visual impact assessment (2012)
- Upgrading the Pacific Highway, Woolgoolga to Ballina upgrade, Biodiversity assessment
- Woolgoolga to Wells Crossing, landscape and visual assessment working paper (2006)

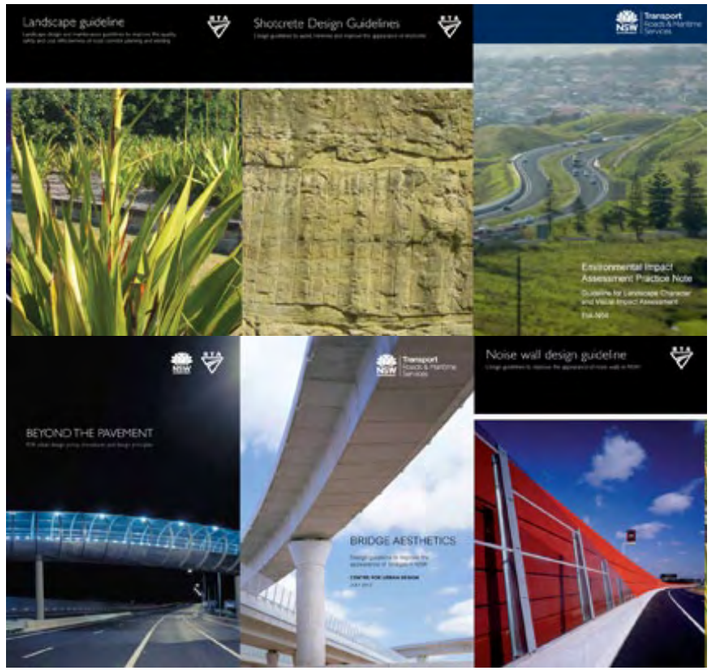

Figure 1.1: Roads and Maritime guidance documents

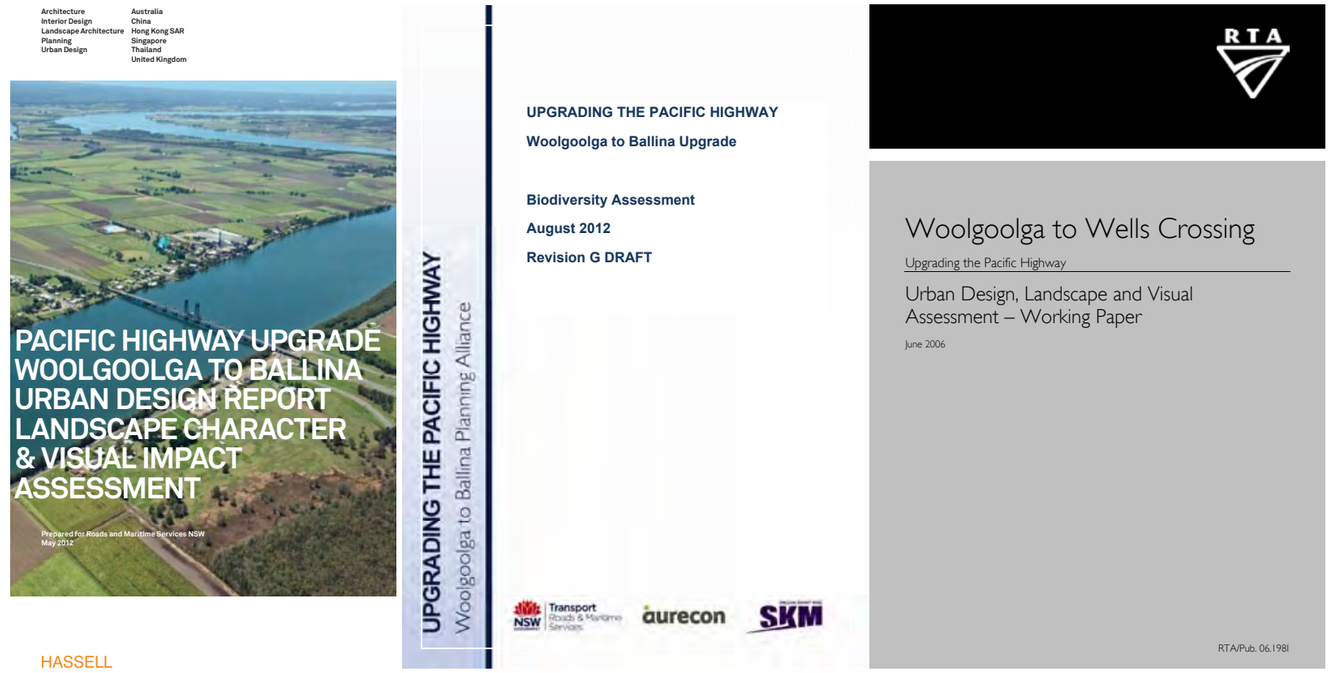

Figure 1.2: Roads and Maritime project documents

1.4 Community and stakeholder consultation

Local stakeholders and residents have been consulted throughout the design process, with regular updates provided to Coffs Harbour City and Clarence Valley councils for the purpose of encouraging input and comment.

Community and stakeholder engagement has resulted in relatively few responses from the community and no formal comments from council. Council comments were received at several meetings and fed back to the designers.

Community and stakeholder engagement was undertaken between 29/09/14 to 24/10/14. Consultation activities included:

- Static displays at Coffs Harbours City Council, Woolgoolga Library, Clarence Valley Council and Roads and Maritime's Pacific Highway office in Grafton
- Media release including advertisments in local papers
- Letterbox drops to residents between Woolgoolga and Glenugie
- Community drop in sessions, held in Corindi on 14/10/14, which provided an opportunity for members of the public to review the plans and discuss impacts with the project team and fill out a feedback form
- Roads and Maritime project website
- Consultation with NSW Environment Protection Authority was undertaken during the 100% Detailed Design phase August 2013 and also during the Pre-Issue for Construction phase November 2013.

Typical comments

Comments received during this consultation period have been identified and addressed where appropriate. A sample of these comments is as follows:

- Vegetation should be native and growing in the local area. Inappropriate plants have been used in areas on the recently completed highway i.e. Mooney and Sapphire.
- Important to use native vegetation indigenous to the site. No birds of paradise please.

Comment summary

To date no submissions have come from either of the two local Councils, Coffs Harbour City Council and Clarence Valley Council.

To date there have been no formal written submissions from the public relating the W2G UDLP.

The responses from the community working group sessions are summarised as follows (refer **Table 1-2**):

Table 1.2: **Community working group response table**

COMMENT	VERY IMPORTANT	IMPORTANT	NEUTRAL	NOT IMPORTANT	NOT AT ALL IMPORTANT	TOTAL NO. OF RESPONSES
Location of existing vegetation and proposed landscaping	6	0	2	0	0	8
Type of plants being used	5	1	1	0	0	7
Monitoring and maintenance for vegetation and landscaping	5	3	1	0	0	9
Location and design for lighting fencing and signs	5	3	2	0	0	10

2 Existing context

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Figure 2.1: Location map, eastern Australia (Source: Open Streetmap Contributors)

Figure 2.2: Location map, north coast of New South Wales (Source: Open Streetmap Contributors)

2.1 Location

The upgrade is located on the mid and far north coast of NSW and is situated between the regional centres of Coffs Harbour on the coast and Grafton to the west in the Clarence Valley. The upgrade forms two sections out of the 12-section upgrade between Woolgoolga and Ballina (refer **Figures 2.1** and **2.2**).

The upgrade, commencing near the townships of Arrawarra and Corindi Beach, approximately 560 kilometres north of Sydney, will form the next stage of the Pacific Highway Sapphire to Woolgoolga upgrade (currently under construction). After passing through the existing Halfway Creek upgrade (completed 2004), the upgrade continues on to tie-in at the existing Glenugie upgrade (open to traffic 2010) (refer **Figure 2.3**).

2.2 The study area

The alignment for the proposed upgrade extends 31 kilometres along the Pacific Highway – from Arrawarra/Corindi Beach (north of Woolgoolga) to the Glenugie upgrade tie-in (south of Grafton) (refer **Figure 2.3**).

The alignment is largely restricted to a route corridor that is adjacent the existing highway, except for a new section of highway that crosses the Corindi Floodplain and traverses the Dirty Creek Range between Kangaroo Trail Road and Range Road. The corridor averages 80 to100 metres wide, with some wider areas of 150 to190 metres (chainage 7,940 and 9,600). The minimum corridor width is 40 metres (chainage 4,900)

The landscape and urban design study area encompasses the route corridor and includes the wider landscape that surrounds the corridor. The study area crosses two local government areas, being Coffs Harbour City Council in the southeast and Clarence Valley Council in the northwest (refer **Inset**).

Following is a summary of the study area's key environmental factors that would affect the design of the highway upgrade. Further detail on each of these topics can be found in the related specialist environmental corridor studies for the proposed route corridor.

Inset: local government areas (Source: Clarence Valley Council)

Figure 2.3: Study area and local government areas (Source: Open Streetmap Contributors)

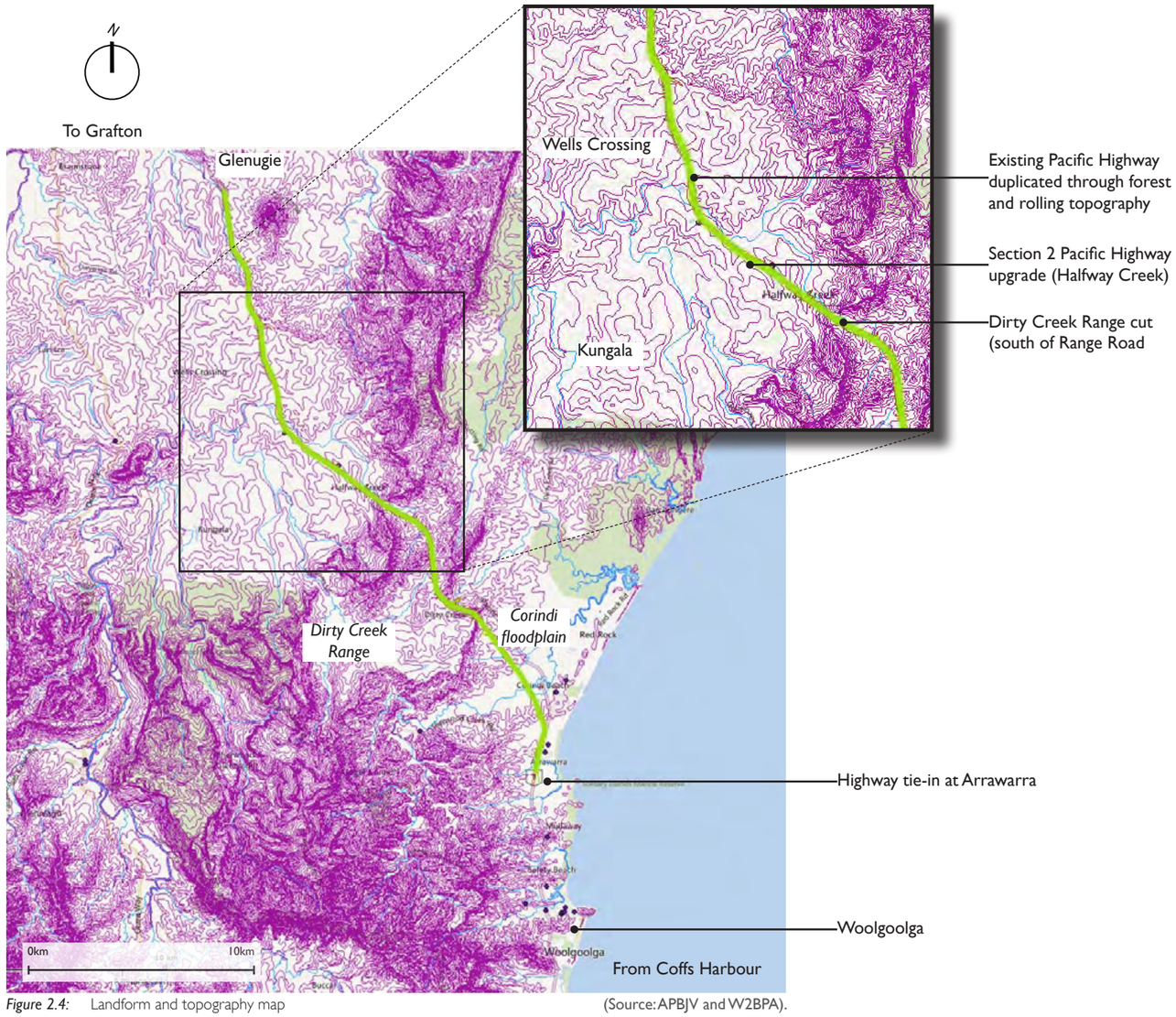


Figure 2.4: Landform and topography map (Source: APBJV and W2BPA).

2.3 Landform and topography

The terrain within the region is predominantly characterised by two major landscape types, being an undulating coastal river valley associated with the Clarence River system, with a surrounding formation of local ranges connected with the Great Dividing Range to the west (300 to 380 metres above sea level) (refer **Figure 2.4**).

The major topography of the study area runs in a north-south band with the highest point within the Section 1 corridor being 147 metres above sea level on approach to the Halfway Creek upgrade, however the top of the Dirty Creek range cutting at 120 metres a.s.l is more noticeable due to the steeper terrain. Heights of 60 to 80 metres above sea level are typical for Section 2.

Design considerations

- The distinctive landform and topography of the area provides a strong landscape character consistent with the northern New South Wales coast. The relationship between the proposed highway alignment and the existing terrain has been carefully considered to ensure that the essential qualities of the 'topographic experience' are preserved for the road user.
- In Section 1, the steep terrain intersected by the highway at Dirty Creek will require substantial earthworks (cuttings and fill embankments) and structures (bridges and walls) in order to reconcile the geometric requirements of an upgraded highway alignment with the natural terrain.
- While the topography of Section 2 is not as dramatic by comparison, the rolling terrain from Halfway Creek westwards also requires substantial earthworks and bridges in some locations.
- The design of structures such as bridges requires urban design input, in order to ensure that they are sensitively integrated with their surroundings.
- Additionally, the design of the cuttings and fill embankments have been carefully considered in order to integrate them with the form and character of the existing terrain.

2.4 Geology and soils

The geology of the study area generally comprises two distinct parts, deep alluvial plains that overlay rocks of the New England Fold Belt (comprising mostly of steeply bedded metasandstones and metasiltstones) and the Clarence Moreton Basin (comprising mostly of relatively flat lying conglomerate, sandstone, and siltstone strata), both containing bands of undifferentiated deposited material in gullies.

Deep alluvial plains are predominantly located in Section 1, in the low-lying areas of Arrawarra and Corindi, whilst varying rock types are generally located in areas of higher ground in Sections 1 and 2.

These geological types have a direct relationship with the overlying topsoils, with the alluvial plains producing relatively stable sandy/ silty/ gravelly topsoils with low fertility and the higher ground producing more erosive sandy or stiff clays with higher fertility. Most soils encountered on the project, apart from those modified through agricultural practices, will be shallow, low in pH and therefore more suited to native vegetation.

Generally the underlying bedrock formations are a key contributor to topographical variations encountered to the west of Section 1 and throughout Section 2. The ability of exposed rock to stand at steeper grades varies throughout the study area (refer **Plate 2.1**).

For a detailed discussion of the geology of the study area, refer to the **Pacific Highway upgrade, Woolgoolga to Glenugie Geotechnical Report** (APBJV 2013).

Design considerations

- Views to geological landmarks have been incorporated into the proposed highway alignment where possible, in order to reinforce a sense of place to the highway experience.
- The design of cuttings aims to maintain steep faces wherever possible in order to minimise the footprint of the highway upgrade. Additionally, it is important to retain a natural rock finish to the cuttings, in order to maintain the visual connection to the geological character of the local area.
- Where rock material exposed during construction can not be cut to steeper grades batters will be laid back and in some instances revegetated. Generally the cut rock faces will remain exposed regardless of slope.
- Topsoil from cleared areas will be stripped and reused in revegetation areas and will require amelioration depending on from where it has been sourced.

Cutting at Glenugie exhibiting weathering along the strata formation

Cutting at Glenugie exhibiting strong verticality and minimal weathering.

Cutting south of Arrawarra being prepared exhibiting strong verticality.

Small excavation at Dirty Creek Range exposing shallow topsoils and rocky subsoils.

Plate 2.1: Images 1-4 of nearby Pacific Highway cuttings. (Source: SMM)

2.5 Hydrology and drainage

The majority of the study area is located within the Clarence River catchment, which comprises a series of rivers, creeks and floodplains surrounding by higher elevations. Rivers and creeks provide a broad range of habitat for a wide diversity of aquatic plant and animal species, as well as supporting a range of ecological processes. Many of the freshwater rivers and creeks in the region, specifically Corindi River in Section 1, are influenced by tidal flows that support freshwater and estuarine flora and fauna (refer **Figures 2.5 and 2.6**).

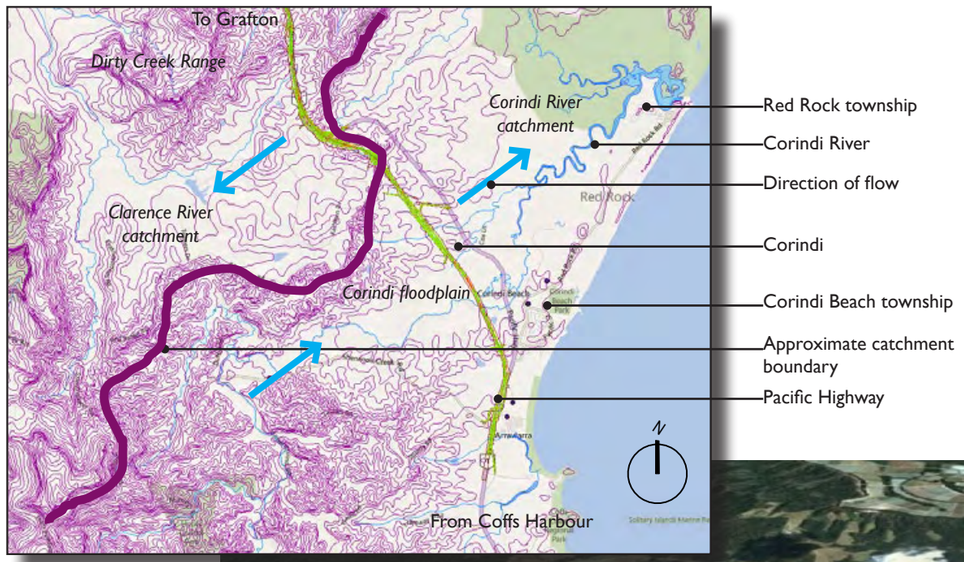
The hydrological pattern of the study area can be defined in two distinct sections - Section 1 comprising the Corindi Creek floodplain (refer **Plate 2.2**) which is drained in an easterly direction by Corindi, Cassons and Blackadder Creeks into the Corindi River, and Section 2, which sees the proposed upgrade traverse Halfway Creek, Wells Crossing and numerous incidental culvert crossings, a majority of which flow in a westerly direction into the Clarence River catchment.

For a detailed discussion of the hydrology of the study area, refer to the **Pacific Highway upgrade, Woolgoolga to Glenugie Longitudinal and Cross-drainage reports** (APBJV, 2013).

Design considerations

- Six waterway bridges and numerous culverts are required as part of the highway upgrade.
- The design of these bridges and culverts responds to hydrological requirements as well as other ecological considerations such as aquatic and terrestrial fauna passage.
- Vegetation communities generally correspond with drainage patterns across the landscape, which in-turn input into revegetation techniques and flora species used on the project.

Figure 2.5: Hydrology and drainage context map (Source: APBJV and W2BPA).



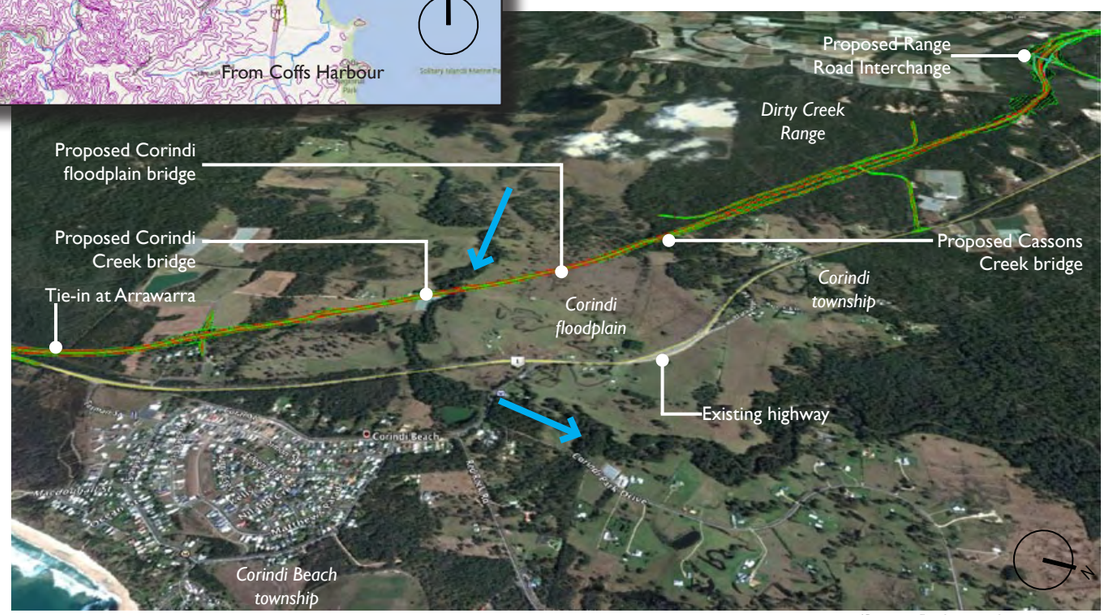


Figure 2.6: Corindi floodplain aerial image (Source: Background terrain image: Copyright Google, Digital Globe, 2010)

Plate 2.2: Corindi floodplain (Source: SMM)

2.6 Climatic factors

At Coffs Harbour the mean winter temperature is approximately 8° celsius (C), while in summer the mean temperature is around 27°C. Mean rainfall is approximately 1693 millimetres per year with the higher rainfalls occurring in the summer months. By contrast in Grafton to the west, the mean winter temperature is approximately 7°C, while in summer the mean temperature is around 30.°C. Mean rainfall is approximately 1,074 millimetres per year with the higher rainfalls occurring in the summer months. It is likely that a majority of the road upgrade will experience conditions similar to these figures.

Design considerations

- Endemic and other indigenous, commercially available vegetation will be used on the project. These species are accustomed to local conditions and will subtly change along the route to target minor variations in conditions.
- Care will need to be taken with regards to the aspect of cut and fill batters to ensure adequate light and temperature is provided. Shaded areas will also occur along the edges of the upgrade, where in close proximity to dense forest.
- Timing of installation of seed and plant material may result in watering being required for establishment.

Banana plantations are common in the region, shown here adjacent the Sapphire to Woolgoolga upgrade, and are indicative of climates achieving a mean temperature of 26°C and mean rainfall of 100mm per month. The ocean is visible in the background, some 25 kilometres away.

Plate 2.3: Overview of surrounding landscape at the southern end of the project (Source: SMM)

2.7 Cultural and scenic values

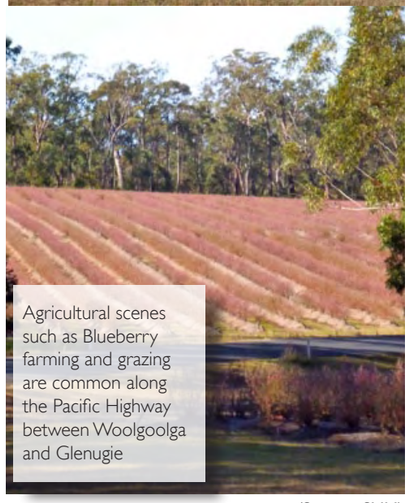
The upgrade of sections 1 and 2, is comprised of two distinct areas as a result of the combinations of landscape types, the vegetation formations present and the way these have been affected by human activities eg agriculture (refer **Plate 2.3** and **2.4**), timber-getting and urban settlement. As a result, views of the surrounding landscape experienced by the road-user, will be driven by these landscape types and cultural influences.

Heading northbound, significant views won't be evident to the road-user until the Corindi floodplain due to the low-lying nature of the alignment. At the floodplain, views to the ranges to the west and across the floodplain to the east will be experienced. Following this there will be limited viewing opportunities through open woodland. Southbound road users will experience viewing opportunities at Dirty Creek and Corindi floodplain from fill embankments. The next significant view will be on approach to the Kangaroo Trail Road overbridge, where views across coastal hinterland to ocean glimpses will be present.

The upgraded highway will only be visible from a limited number of locations, as much of it is low-lying or enclosed by open woodland or forest. Potential views of the Dirty Creek cutting from commercial sites will be limited by minimising the construction footprint and revegetation of exposed batters. Views of the upgrade from the existing highway at Corindi Floodplain will be mitigated by flattening of fill batters and revegetation with pasture grasses. Other views of the upgrade will be possible from rural homesteads, where visual impact will be mitigated through setbacks and revegetation.

The combination of the natural and cultural scenic qualities combined with local heritage values establishes a unique identity to the area. These values have a special meaning and provide a sense of place for the local inhabitants, as well as visitors and through traffic. These values are somewhat lesser when compared to the stronger natural and cultural scenic values to the south and north of the upgrade to which, this section of the Pacific Highway provides an important link.

For a detailed discussion of the Landscape Character and Visual Impacts of the study area, refer to the **Pacific Highway upgrade, Woolgoolga to Ballina Urban Design Report and Landscape Character and Visual Impact Assessment** (W2BPA+Hassell, May 2012).



Agricultural scenes such as Blueberry farming and grazing are common along the Pacific Highway between Woolgoolga and Glenugie

Plate 2.4: Agricultural land uses adjoining the study area (Source: SMM)

Design considerations

- Careful consideration must be given to the relationship between the form and character of the upgraded highway alignment, its associated structures and earthworks, and the form and character of the existing landscape.
- As the highway would be visible from several locations, it is important that the overall highway upgrade is designed to 'fit' visually with the surrounding landscape character.

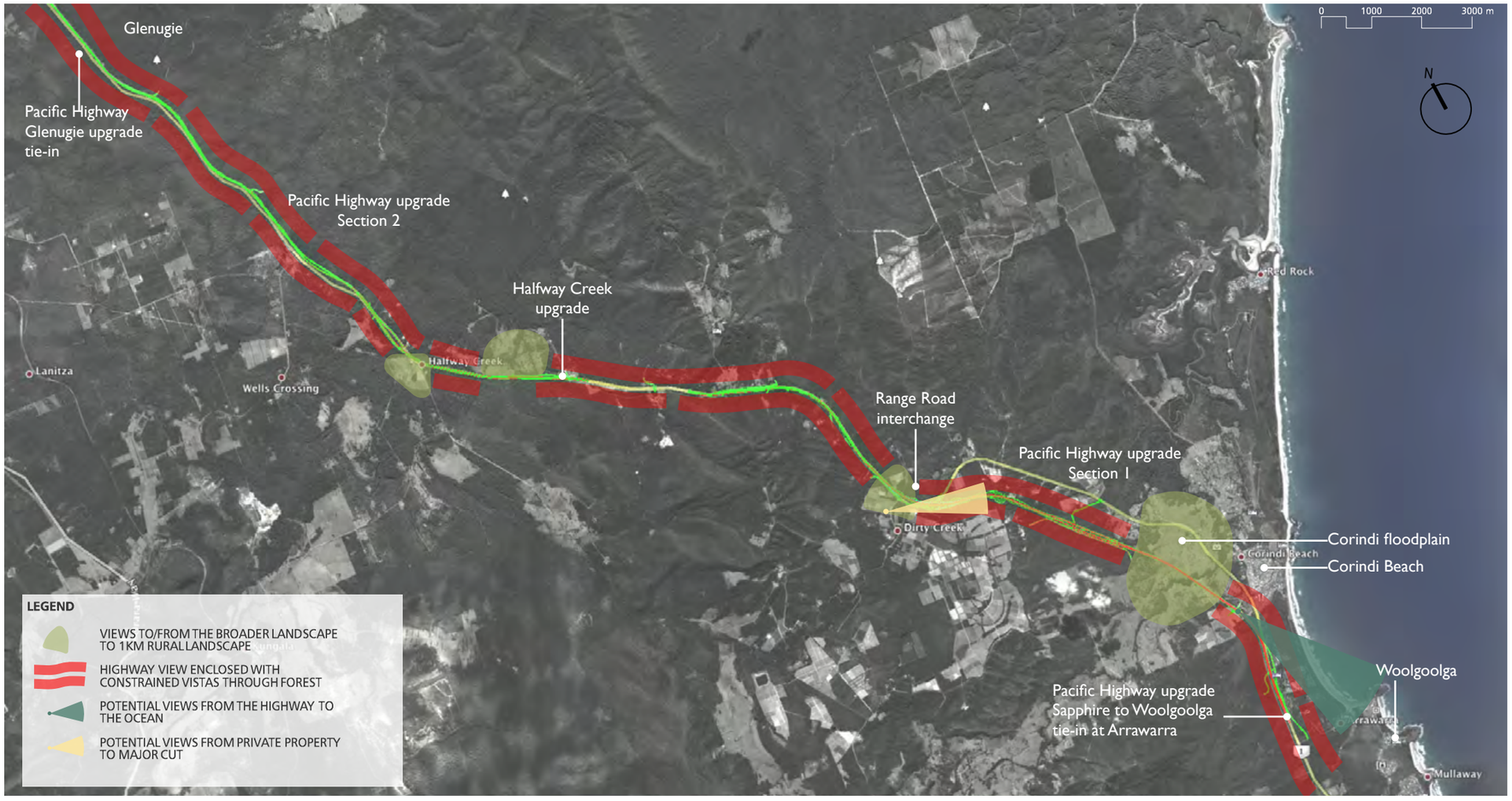


Figure 2.7: Existing character and views map

(Source: Background terrain image: Copyright Google, Digital Globe, 2010)

2.8 Land use and settlement patterns

Land use in the region since European settlement in the 1830s to 1840s, has consisted primarily of timber getting and later agriculture and fisheries. Prior to this the region supported relatively dense populations of Aboriginal people living in productive floodplain habitats. Agricultural activities have led to a decline of aquatic and terrestrial habitats and in water quality. There has also been an increase of pest and weed species and acid sulphate soils. In more recent times, tourism and urban and industrial development have developed in the region supported by increases in population.

Forested lands make up around 50 per cent of the entire Woolgoolga to Glenugie project study area. Around 26 per cent is contained within national parks and state forests and 24 per cent in private ownership. Wetlands make up only four per cent of the study area. Cleared agricultural (refer **Plate 2.5**) and urban land make up 38 per cent of the area and remaining one per cent being transport corridors including the existing Pacific Highway, rail corridors, and other easements and corridors which contain forest (Source: **Biodiversity Assessment** (W2BPA, 2012).

Residential areas are located sporadically along the road corridor and include townships, caravan parks and clusters of rural homesteads at Arrawarra, Corindi Beach and Corindi floodplain. The area northwest of Corindi is characterised by fewer homesteads and denser bushland. Agricultural uses such as blueberry farming (refer **Plate 2.4**) occur in cleared areas of forest.

Design considerations

- Maintaining and enhancing local and regional connectivity are important considerations in relation to land use and settlement. Any areas of residual land resulting from the upgrade works need to be carefully integrated, and revegetated where appropriate and with proposed/future land uses

Plate 2.5: Existing residence on the Corindi floodplain (Source: SMM)

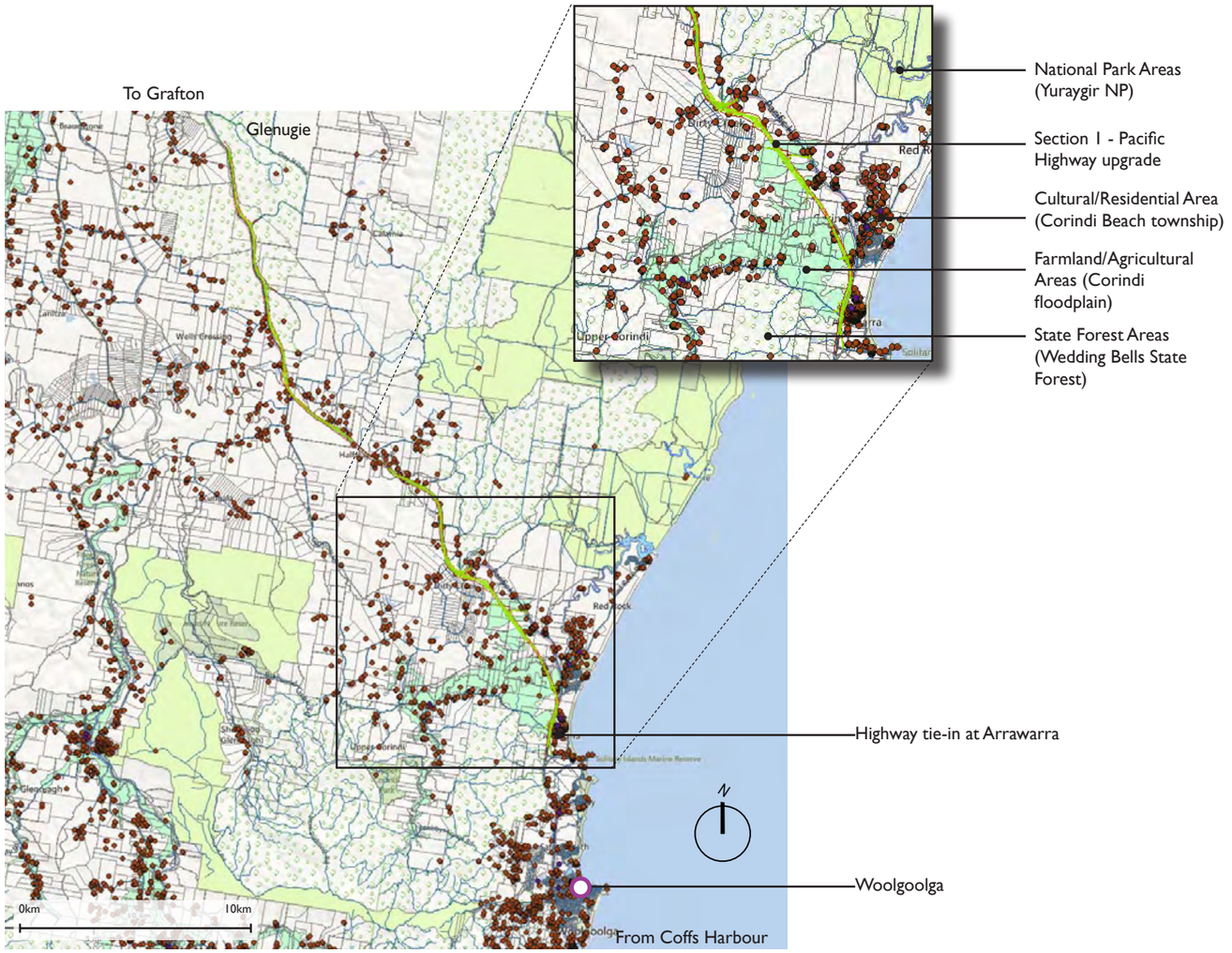


Figure 2.8: Settlement patterns map (Source: APBJV and W2BPA).

- Fauna habitat plants shall be included in specific locations to facilitate use of fauna crossing structures and riparian areas
- Consistent with the objectives of the Urban Design Landscape Management Plan, native vegetation shall be established in disturbed areas existing between the project boundary and planned fauna fencing. This shall occur in locations that provide a connectivity benefit to fauna following the completion of construction and will also not create a visual obstruction to scenic vistas.

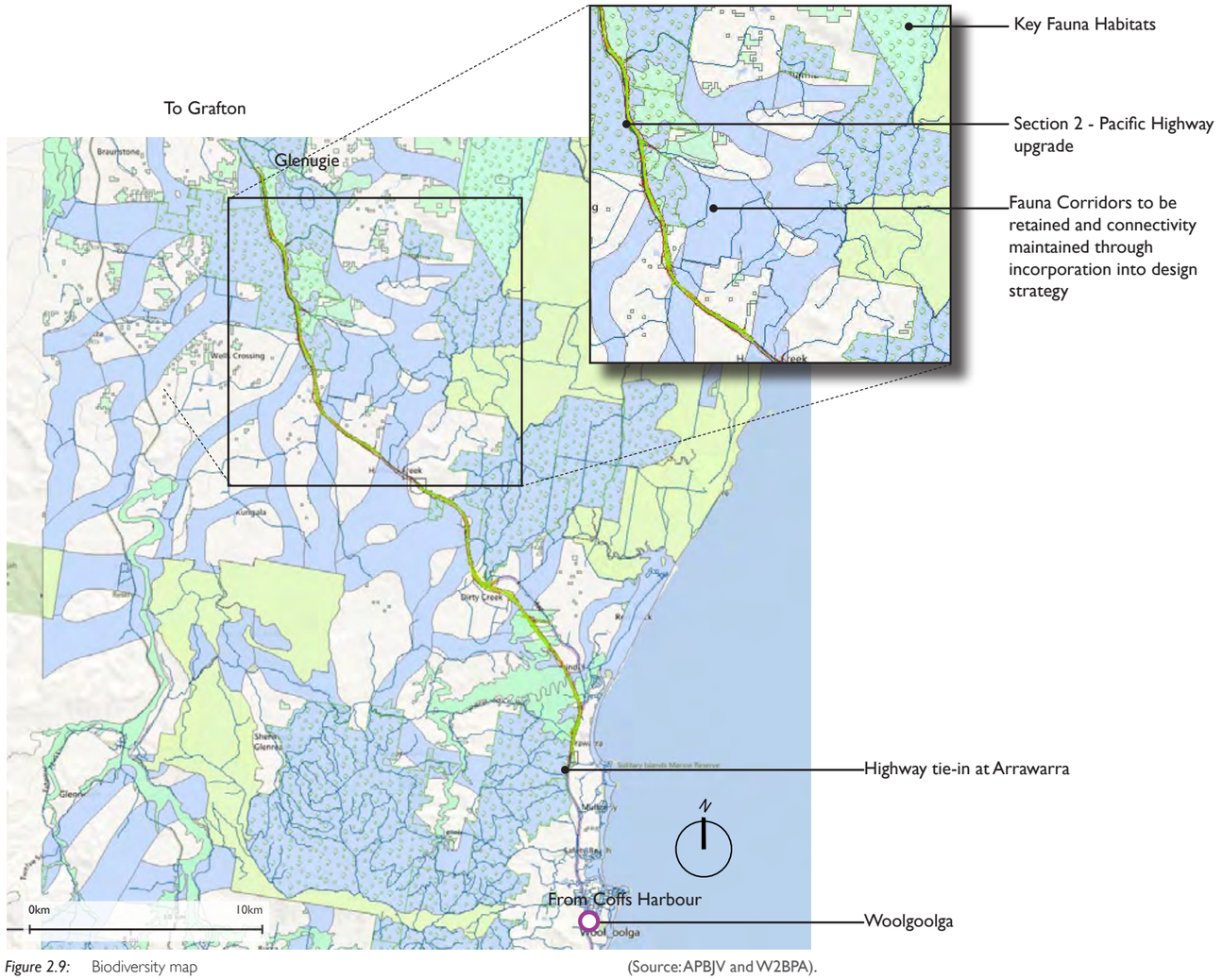


Figure 2.9: Biodiversity map (Source: APBJV and W2BPA).

2.9 Biodiversity

The corridor is located near the boundary of the NSW North Coast (NNC) and South Eastern Queensland (SEQ) Bioregions (under the Interim **Biogeographic Regionlisation for Australia Version 7**). A number of national parks, state forests and nature reserves occur within and in close proximity to the works.

Flora

Six endangered communities and one critically endangered community exist in the project area, as well as 123 threatened or endangered flora and fauna. Several threatened flora listed under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act - Cmwlth) and/or the Threatened Species Conservation Act 1995 (TCS Act - NSW) are known to exist in the study area. Refer to **Table 2.1**. Note: * indicates species proposed to be used on the project.

SPECIES	COMMON NAME	EPBC ACT	TSC ACT
*Angophora robur**	Sandstone Rough-barked Apple	Vulnerable	Vulnerable
Cyperus aquatilis	Water Nutgrass	-	Endangered
Eucalyptus tetrapleura	Square-fruited Ironbark	Vulnerable	Vulnerable
Grevillea quadricauda	Four-tailed Grevillea	Vulnerable	Vulnerable
Lindsaea incisa	Slender Screw Fern	-	Endangered
Maundia triglochinoides	Maundia	-	Vulnerable
Melaleuca irbyana	Weeping Paperbark	-	Endangered
Olax angulata	Square-stemmed Olax	Vulnerable	Vulnerable
Prostanthera palustris	Swamp Mint Bush	Vulnerable	Vulnerable
Quassia sp. Mooney Creek	Moonee Quassia	Endangered	Endangered

Table 2.1: **Endangered and threatened flora within the study area**

Fauna

Many native fauna species are known to exist in the vicinity of the road corridor, including Grey-headed Flying-fox, Koala, Brush-tailed phascogale, Yellow-bellied Glider, and *Rufous Bettong* (Rat-kangaroo). In order to minimise impacts, key habitat and connective corridors have been identified and incorporated into a fauna connectivity strategy (Source: **Biodiversity Assessment** (W2BPA 2012).

For a detailed discussion of the biodiversity strategy, refer to the **Biodiversity Assessment** (W2BPA, 2012). For further discussion on vegetation refer **Section 2.12** of this report.

Design considerations

- Clearance of native vegetation associated with this road corridor is to be minimised in order to maintain the connectivity of existing habitats and minimise habitat fragmentation
- Endangered Ecological Communities and corridors will be connected with additional revegetation areas (refer **Figure 2.9**)
- Remnant vegetation shall be retained between the project boundary and the construction footprint where feasible and reasonable."

2.10 Heritage

Several Aboriginal populations are known to have inhabited the area, utilising the rich terrestrial and aquatic habitats as a food source and for shelter. Whilst there is the potential for a rich and highly valued Aboriginal history throughout the study area, there are few known Aboriginal sites within the road corridor. The areas likely to contain these archaeological sites include ridges, spurs, crests and saddles, and watercourses such as Halfway Creek and Wells Crossing. The Corindi floodplain would have at one stage seen Aboriginal activity and is also reported to be a massacre site, however agricultural practices have largely removed evidence of this history.

The arrival of Europeans to the North Coast in the 1830s-40s was primarily to source timber for the expanding construction industry. This had an immediate impact on the Aboriginal way of life and brought about conflict. The area was initially logged for Hoop Pine and Cedar, followed by Mahogany, Tallowwood, Spotted Gum and Brushbox. Small settlements were set up, with river transportation on the Clarence and Richmond Rivers, while tramways and road systems followed soon after. Once the land had been cleared, agriculture commenced, initially focusing on maize, cane sugar and dairying followed by banana and blue berry plantations. The town of Woolgoolga was established circa 1870 around the same time as Coffs Harbour and immigrants from Europe and the sub-continent settled in the area from the 1940s onwards

Due to the low expenditure and rapidity of these early activities, the legacy of historical development has little in the way of physical evidence apart from in the larger towns. Of the 11 sites within the road corridor identified to have potential significance, only 5 meet the criteria to be registered as having local significance. Two sites in Section 2 with potential local significance, being the remains of the *Six Mile Tick Gate* and *North Coast Tramway*, will be significantly impacted.

The highway itself is an important record of movement in the area and its existing route was created from local roads in operation from around 1895. A continuous route was formed in 1909, while the highway itself was formalised by 1928 and was known as the 'North Coast Road'. The bridge at Wells Crossing is seen as a significant road artefact and will be maintained as part of the old highway local access route. The stockyards and sheds known as *Mileara* are also of local significance and are located to the east of the proposed alignment at approximate Chainage 12,320.

For detailed discussion of Aboriginal and non-Aboriginal heritage, refer to the **Environmental Impact Statement and Historical Heritage Assessment** (W2BPA, 2012)

Design considerations

- The study area has only limited physical remnants of cultural heritage and these sites will be carefully considered and adverse visual and physical impacts minimised (refer **Figure 2.10**).
- Cleared agricultural areas offer significant views.

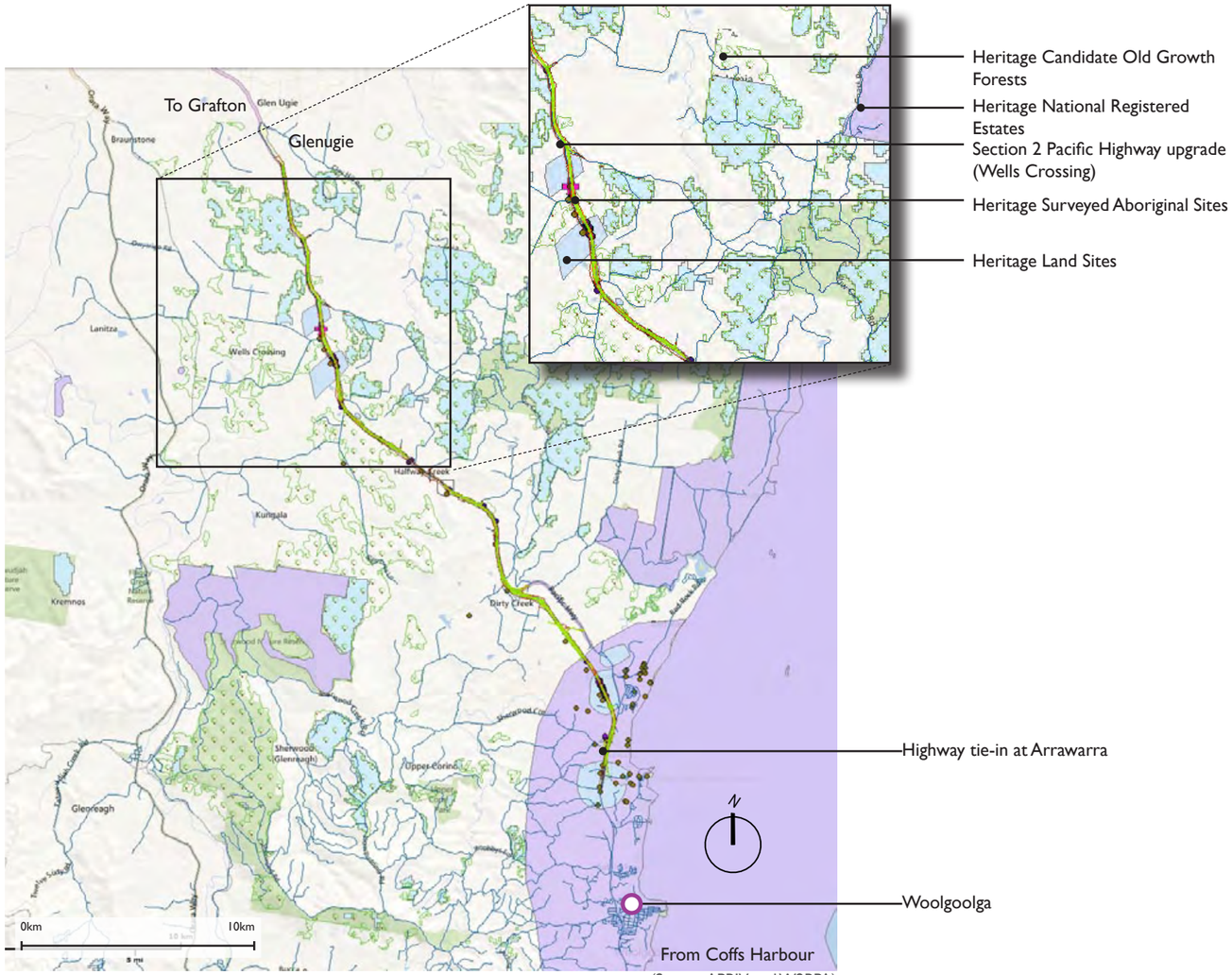


Figure 2.10: Heritage map
(Source: APBJV and W2BPA)

Figure 2.11: Transport network map

(Source: APBJV and W2BPA)

2.11 Transport network

The Pacific Highway (refer **Plate 2.6**) and the North Coast Railway Line form the primary land transport corridors connecting Sydney to Brisbane via the eastern seaboard of New South Wales. Between Coffs Harbour and Grafton, the highway is the major road freight, tourist and commercial link in the region and is the principal road access between the towns and villages along its route (refer **Figure 2.11**). Orara Way is the only other regional road connection between Coffs Harbour and Grafton following a route further inland to the west of the highway.

Both Coffs Harbour and Grafton are serviced by domestic airports, with Coffs Harbour being the most regularly serviced.

Design considerations

- Along with improving safety along the highway itself, there is an opportunity to improve the local road network as part of the highway upgrade. This will be achieved by service roads to provide greater connectivity within the local road network and to provide controlled access points to the highway.

Plate 2.6: Pacific Highway, Glenugie upgrade

(Source SMM)

2.12 Vegetation

Vegetation Communities

The upgrade comprises a diverse range of vegetation communities, landscape types and vegetation formations that have been fragmented and modified by human activities eg Aboriginal land practices, agriculture, timber-getting and urban settlement.

In Section 1, a variety of landscape types and vegetation formations are encountered along the upgrade, including coastal lowlands, forest, open woodland and floodplain. These formations comprise a number of vegetation communities, many which share similar species. The greatest diversity in Section 1 is located in the rugged terrain of the Dirty Creek Range, which supports a variety of heath plants (refer **Plate 2.7**). In Section 2, a majority of the upgrade is located within Glenugie State Forest, which supports habitat for a diversity of native flora and fauna species, including threatened and rare species. This section of the upgrade, is consistent for most of its length due to reduced human impacts, largely intact soil profiles, regrowth of the forest and as a result has higher biodiversity than other sections of the upgrade.

Vegetation Mapping

The vegetation mapping prepared by the Woolgoolga to Ballina Planning Alliance (refer **Figure 2.12**) is based on previous ecological studies carried out from 2006 onwards as well as project-specific mapping. It has therefore been necessary to use previously classified communities as the basis for identifying the vegetation communities located along the upgrade corridor. These species and communities have been used to generate plant species mixes for use in the upgrade. Refer **Section 06** of this report for species mixes and extent of treatments.

Design considerations

- Vegetation communities will inform planting and revegetation mixes used on the upgrade.

Plate 2.7: Native vegetation at Dirty Creek Range. (Source SMM)

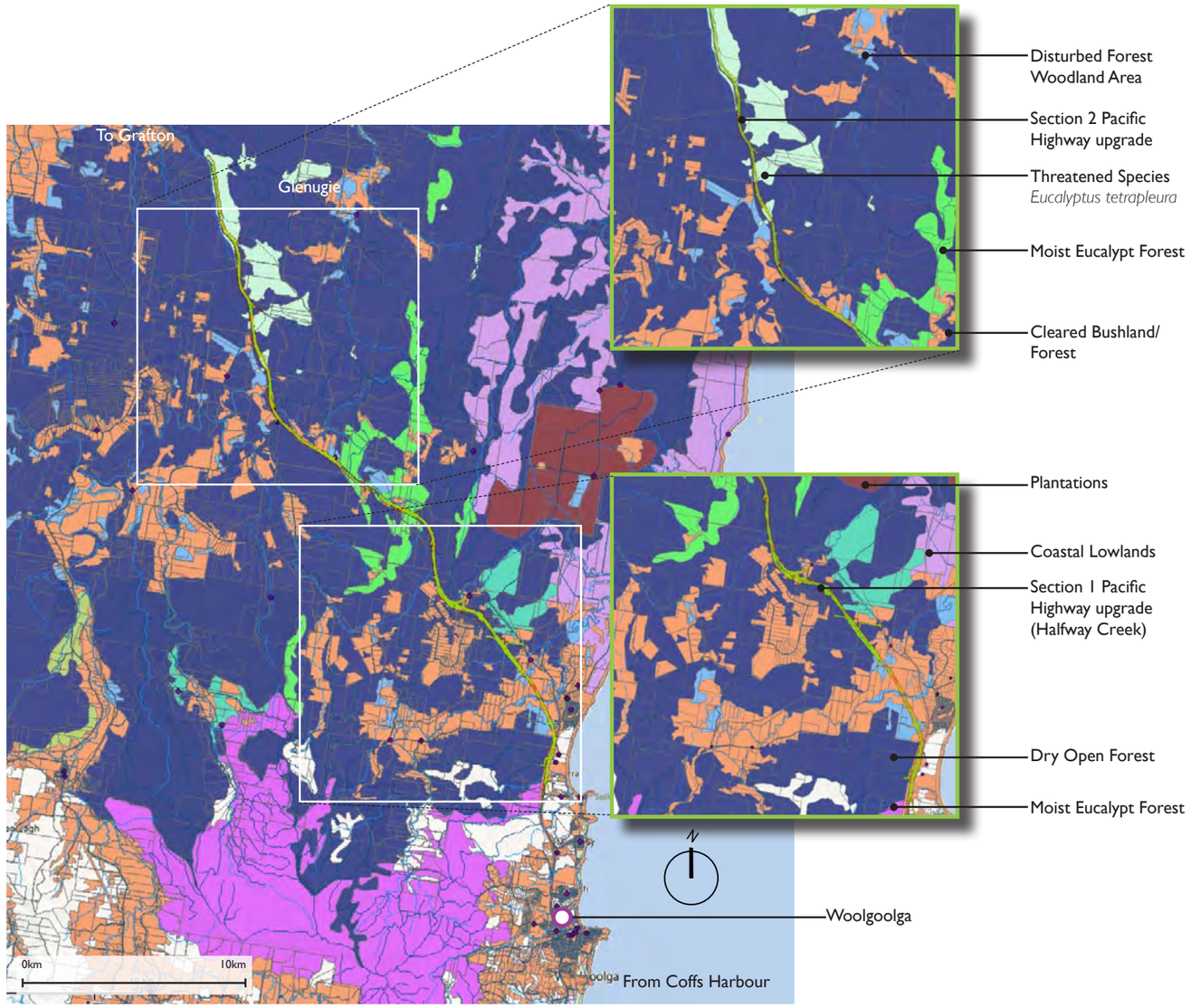


Figure 2.12: Vegetation formations map (Source: APBJV and W2BPA)

3 Overview of the upgrade

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3.1 Highway design

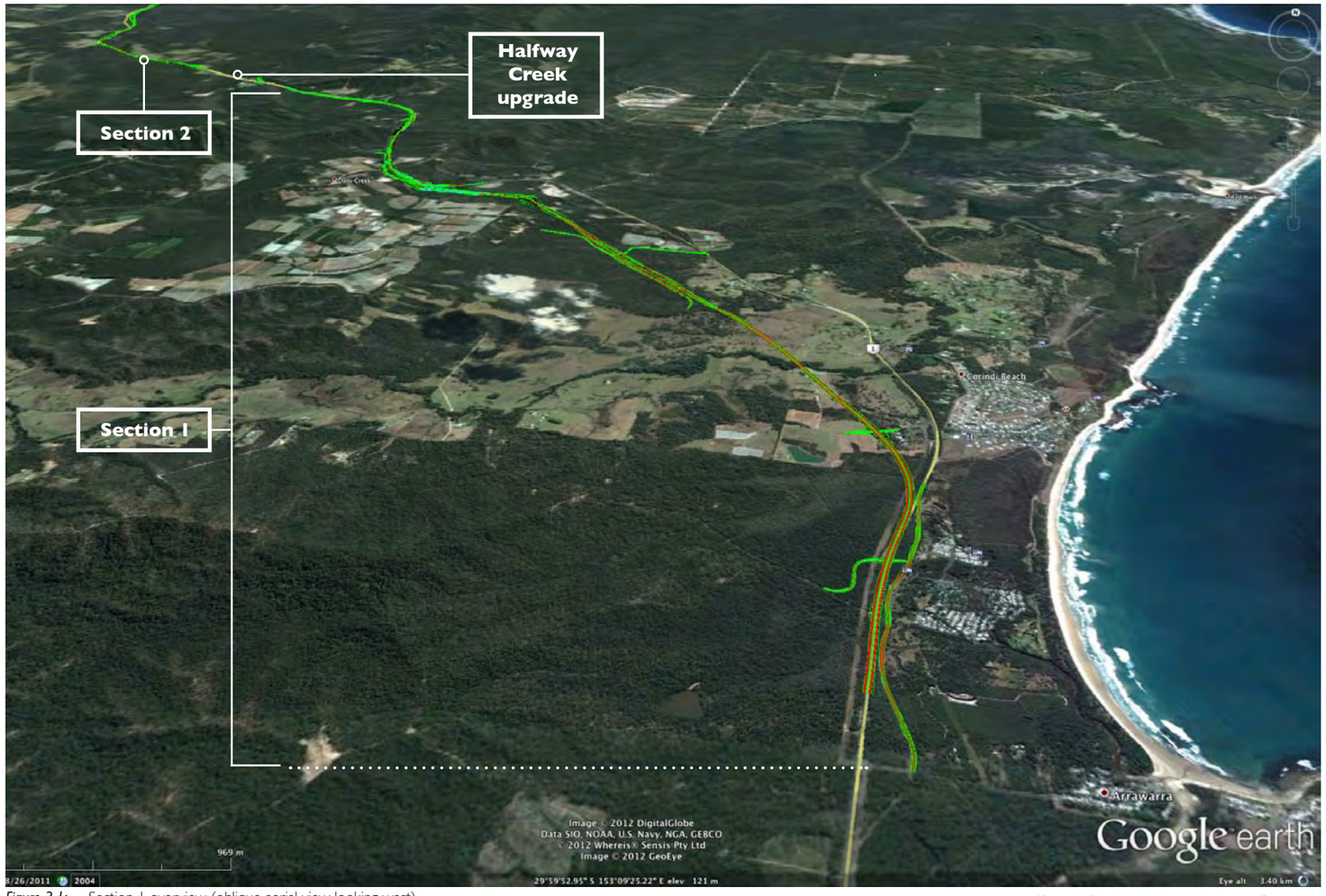

Figure 3.1: Section 1 overview (oblique aerial view looking west).

(Source: Background terrain image: Copyright Google, Digital Globe, 2010)

Overview

The proposed upgrade extends over approximately 31 kilometres from the Sapphire to Woolgoolga Pacific Highway upgrade, about 32 kilometres north of Coffs Harbour, to the Glenugie upgrade project (approximately 64 kilometres north of Coffs Harbour) (refer **Figure 3.1**)

The project is being delivered as one project in two 15 kilometres sections. Section 1 of the upgrade extends from the southern tie-in north of Arrawarra Interchange to chainage 16,500 within the existing 3.4 kilometres Halfway Creek upgrade. Section 2 extends from chainage 16,500 within the Halfway Creek upgrade to the southern extent of the new northbound carriageway within the Glenugie upgrade at chainage 31,400.

The upgrade passes through the following local government areas:

- Coffs Harbour City Council (Section 1);
- Clarence River Council (Sections 1 and 2).

The upgrade passes through or adjacent to the following state reserves:

- Wedding Bells State Forest.
- Newfoundland State Forest.
- Glenugie State Forest

Stages

Section 1 includes:

- Approximately 15 kilometres of main carriageway, from chainage -49 to 16,500;
- Grade separated Interchange at Range Road;
- Realignment of local and access roads;
- Overbridges at Sherwood Creek Road chainage 1,040, Kangaroo Trail Road chainage 2,510 and Range Road chainage 9,822;
- Underpass at Corindi Local Access Road chainage 6,132;
- Bridge crossings at Corindi Creek at chainage 3,600, Corindi floodplain at chainage 4,000 and Cassons Creek at chainage 4,700.

Section 2 includes:

- Approximately 15 kilometres of main carriageway, from chainage 16,500 to 31,400
- Realignment of local and access roads
- Retention of a majority of the existing highway for use as a service road
- Bridge crossings at Halfway Creek chainage 20,718 and Wells Crossing chainage 22,370.

Lane Configuration

Initial Four Lane upgrade - 'A class'

For most of its length, the 'A class' highway upgrade consists of two north-westbound and two south-eastbound lanes separated by a median that varies in width. Generally provision will be made for a 12 metre wide depressed median, however this will be increased at some locations due to physical constraints of the natural environment, sight-line requirements or due to fauna connectivity requirements.

Future Six lane Strategy - 'M class'

The six-lane strategy for the upgrade would see an additional lane in each direction constructed within the 'A class' median leaving a minimum of a 5 metre median (the minimum desirable width for a median with a central wire rope safety barrier (WRSB). In some locations due to future visibility restrictions in tight horizontal curves the median has been widened to achieve sufficient sight-line distances when the future WRSB is installed. An alternative strategy would see the 4-lane configuration remain.

Other 'M class' requirements would see all at-grade intersections and U-turn facilities being removed and alternative routes provided for local traffic through service roads, including use of the existing pacific highway, with new overbridges provided to maintain connections in some locations.

Intersections and interchanges

The basic principles for the highway upgrade with respect to access management and the management of conflict points (such as existing intersections) includes the following principles:

- Utilise the existing highway as a service road
- Separated interchanges at major connections - Range Road only
- All other intersections on-grade. Right turn out not permitted - movement facilitated by left-turn/ U-turn in designated locations on the service road
- Property access to be via service road - left-in/left-out only. Right turn out not permitted
- Integrate the access requirements of pedestrians and cyclists with those of other road users.

The proposal to utilise the existing highway as a local service road would enable safe and efficient access to the upgraded highway. The proposal minimises the need for, and length of, backtracking for motorists' access to and from the upgraded highway. Wherever possible, intersections with the upgraded highway would be limited to left turn movements only.

Cross section and road space allocation

The highway geometry has been designed to an operating speed of 110 kilometres per hour, with a two lane, dual (divided) carriageway (ie a total of four lanes of 3.5 metres). Provisions have been made in the current design for an additional lane in each direction should the highway be upgraded to 'M class'.

There will also be a number of different lane and median configurations at various points of the concept design to allow for acceleration and deceleration lanes, highway crossovers and the like.

The upgraded highway would have:

- A median that ranges in width generally from 12 metres in areas where the footprint is restricted and wider areas where the median forms part of the fauna connectivity strategy
- A left shoulder (external shoulder) typically 2.5 metres wide on each carriageway
- A right shoulder (internal shoulder adjacent to the median) typically 1.0 metre wide on each carriageway
- Additional width would be provided for verges (minimum 0.5 metre), sufficient for batter rounding and inclusion of guide posts or safety barriers where required
- The local service road would typically consist of a single 3-3.5 metre wide traffic lane in each direction and a 1-2 metre wide shoulder on either side.

Bicycle and Pedestrian Facilities

Continuous bicycle access for experienced riders will be provided on the highway upgrade in the form of a 2.5 metre nearside shoulder, which meets Austroads guidelines. The highway does not form part of a general bicycle network so separated bicycle facilities will not be included in the design.

Bicycle access is accommodated on overbridges. Bridge parapets have been designed to satisfy bicycle requirements by providing a barrier height of 1.3 metre.

Pedestrian access is to be provided on local roads. No specific provisions have been made for pedestrians associated with incidents and emergencies. Pedestrians would be required to utilise road verges, road shoulders and road medians.

Local road and property access

For much of the upgrade, the existing highway will be utilised to provide access for the local community. The local access strategy aims to:

- Separate local traffic movements where possible resulting in increased safety
- Avoid right turn movements to and from the upgraded highway
- Cater for traffic diversions in case of incidents on the upgraded highway
- Provide opportunities for local tourism and businesses to develop
- Cater for cyclists and pedestrians.

It is proposed that access would be generally controlled along the full length of the upgraded highway. Access to the upgraded highway would be limited to formal intersections and some emergency access points.

Some local roads would be connected to the local service road, either by construction of bridges over or under the upgraded highway or by rationalising and re-routing selected sections of the local road network.

Property adjustments would be designed in consultation with the affected property owner. Temporary access arrangements may also be required during construction at some locations.

3.2 Key features of the upgrade

Bridges and other major structures

The 'A class' proposal requires a number of structures including nine bridges and other major structures such as bridge-sized culverts and retaining walls. Noise walls have been determined not to be required based on the predicted environmental conditions. Under 'M class' conditions, the number of bridges and other structures will increase.

The APBJV has undergone a design options review process in order to assess the concept bridge design, ensure suitability to the developed road alignment design and to ensure conformance with urban design objectives and Roads and Maritime guidelines. This has resulted in modification to all bridge designs.

Bridge superstructure and substructure components have been selected based on a family or hierarchy, based on visibility of the bridge to highway users and local residents. Dimensions and thicknesses are determined by the required spans and levels, which may alter the proportions of these components.

The family of bridge types is as follows:

Overbridges

Overbridges are bridges that pass over the highway to provide local road connections and are therefore highly visible to motorists using the highway. Design and materials are generally of a higher quality in comparison to other bridge types. The bridges relate closely to other bridges on the Pacific Highway in order to provide visual continuity.

The following components will generally be used for this bridge type:

- Central pier: Reinforced concrete (RC) blade form pier with square portal and tapered sides (refer **Plate 3.1**)
- Deck support: 'Super T' steel girder.

The following bridges are of this type:

- Overpass at Sherwood Creek Road
- Overpass at Kangaroo Trail Road
- Overpass at Range Road.

Underpasses

Underpasses are formed when the highway passes over local road access. Design and materials are of a lesser quality in relation to overbridges and of a higher quality in comparison to Highway bridge types. The bridges relate to other bridges on the Pacific Highway in order to provide visual continuity.

The following components will generally be used for this bridge type:

- Pier: RC pier and headstock with tapered ends
- Deck support: As this access road will connect with unformed private roads only, the deck support will be RC planks
- Note: Local roads with higher usage would warrant use of 'Super T' girder, where aesthetics would generally be considered of higher value to the project.

The following bridge is of this type:

- Twin bridges over Corindi Local Access Road.

Highway Bridges

Highway bridges are formed by the highway when passing over waterways. Design and materials are of a lesser quality in relation to other bridge types, due to lower visibility. The bridges relate to other bridges on the Pacific Highway in order to provide visual continuity.

The following components will generally be used for this bridge type:

- Pier: RC pier and headstock with square or tapered ends depending upon visibility of the structure
- Deck support: RC planks and Super-T girders.

The following bridges are of this type:

- Twin bridges over Corindi Creek
- Twin bridges over Corindi Creek Floodplain
- Twin bridges at Cassons Creek
- Twin bridges over Halfway Creek
- Twin bridges over Wells Crossing.

Earthworks

Extensive earthworks formations would be required to implement the upgrade. The design has been developed on the basis of preliminary geotechnical studies to provide a reasonable understanding of the material properties. It is proposed, depending on confirmation of its quality, to use the excavated material from significant cuttings as fill material in other areas wherever suitable and where cost effective.

The majority of cut and fill batters on the project will be designed to 2H:1V, which is steep enough to assist with minimising the construction footprint, but which also allows several revegetation methodologies to occur. Steeper slopes of 0.75H:1V and 1.5H:1V will be designed for higher-strength rock cuttings. Flatter slopes of 4H:1V will be designed for low fill batters where minimising the footprint is not a constraint.

Refer **Section 6** of this report for further discussion regarding earthworks formations.

Plate 3.1: Similar overbridge under construction on the Sapphire to Woolgoolga project (Source: SMM)

Drainage design

Road drainage generally consists of three key elements; cross drainage, longitudinal drainage and water quality treatment. Urban design and landscape design considerations in relation to these elements includes alignment/ visibility and lining materials, minimisation of disturbance to existing vegetation and opportunities and techniques for revegetation.

Cross drainage transfers existing stormwater flows across the new carriageway using bridges and culverts (refer **Plate 3.2**). The cross drainage of the upgraded highway is being designed for a 1 in 100 year storm event. The cross drainage for local roads including the local service road is being designed for a one in ten year storm event. This generally results in higher road levels in relation to the existing landscape, larger fill embankments and larger culverts. The additional fill required has been sourced by increasing the depth of cut batters elsewhere in the project.

Longitudinal drainage is used to drain stormwater from the road pavement and is designed for a one in ten year storm event. This system consists of piped and open channel systems to direct water to new water treatment facilities (generally in the form of detention basins and grassed swales). Flows in excess of the drainage capacity will pass off the roadway directly or via the cross-drainage to downstream areas following the natural topography.

Water treatment basins are provided in order to collect and treat runoff from the upgraded highway. Water treatment basins detain stormwater runoff allowing suspended sediments and nutrients to fall out prior to it being discharged downstream. Water would be further treated for suspended sediments and nutrients by the use of grassed swales and channels.

CHECKING STATIONS/ REST AREAS

Heavy Vehicle Inspection Bay

A Heavy Vehicle Inspection Bay (HVIB) will be located in Section 2 to the north of the Halfway Creek upgrade adjacent to the southbound lane.

Rest Areas

An existing rest area at the Halfway Creek upgrade (northbound) will be decommissioned as part of the upgrade as it is seen as surplus to the needs of the overall rest area strategy, does not conform with current standards and is located opposite an existing service station, which encourages pedestrian movement across the existing highway where no safe crossing exists or can be provided. The existing southbound area will be retained but not signposted in order to discourage use of the facility due to its unsuitable location.

Lighting, barriers and signage

Road lighting

General road lighting is not required on the upgrade. Where lighting has been required it has been designed in accordance with AS4282-1997.

Intersection/ Interchange lighting

Lighting at intersections and interchanges is provided where required in accordance with current Austroads and Roads and Maritime standards, guidelines and requirements.

Bridge Lighting

Bridge lighting is not required on the upgrade.

Barriers

Safety barriers are provided in accordance with current Austroads and Roads and Maritime standards, guidelines and requirements. These measures would include:

- Wire rope safety fence used generally where a barrier is required
- Safety barriers provided where fill batters are 2H:1V or steeper, and on approach or departure to bridge abutments.
- Double rail barriers used as opposed to solid barriers on bridges to maximise the highway user view to the surrounding landscape.

Signage

Signage categories include regulatory, warning, tourist, services and directional signs. All signage designed in accordance with current Austroads and Roads and Maritime standards, guidelines and requirements.

Plate 3.2: Complex drainage system at Hume Highway Woomargama Bypass (Source: Lightbox/ HHWA)

4 Landscape character and visual impact

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4.1 Existing character

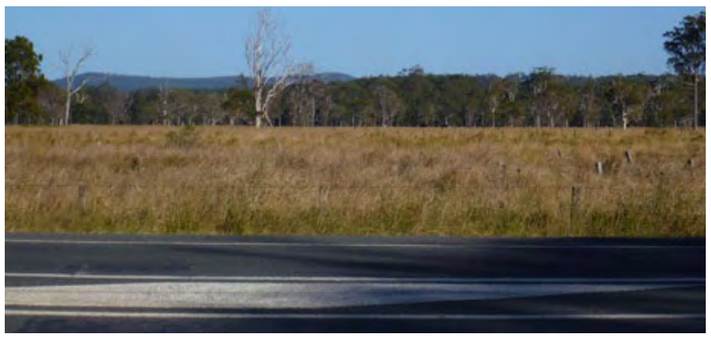


Plate 4.1: View of the Corindi floodplain in Section 1 towards the future upgrade. Landscape character precinct 3 (refer **Figure 4.1**) (Source: SMM)

Plate 4.2: Recently completed Glenugie upgrade, typical of Section 2. Landscape character precinct 8 (refer **Figure 4.1**). (Source: SMM)

The study area for the Woolgoolga to Glenugie upgrade intersects a landscape comprising coastal Melaleuca forests and tall Eucalypt forests, within which, is contained a mosaic of cleared rural lands (refer **Plate 4.1**) and small settlements. To the south and west, mountain ranges provide a noticeable backdrop, whilst undulating woodlands (refer **Plate 4.2**) dominate the upgrade route en route to Grafton.

The southern end of the upgrade forms a strong continuation of the coastal landscape stretching from Coffs Harbour in the south to Corindi Beach in the north. This landscape consists of low-lying and undulating topography, Melaleuca swamp forests, dunal vegetation, estuarine wetlands and older coastal settlements. In much of the hinterland, land use consists of banana plantations and suburban development beneath steeply rising coastal ranges.

At Corindi Beach the highway heads west, crossing a large floodplain before taking on a more enclosed route through dense vegetation, crossing several creeks and passing occasional openings into blueberry farms and rural properties.

Generally, a sequence of open and closed landscapes is encountered by the motorist, with more noticeable diversity of character in the southern/ eastern section of the upgrade (Section 1). This opening and closing of the landscape directly impacts on views to/from the highway and the way the highway and highway elements are understood by the highway motorist.

Landscape character precincts

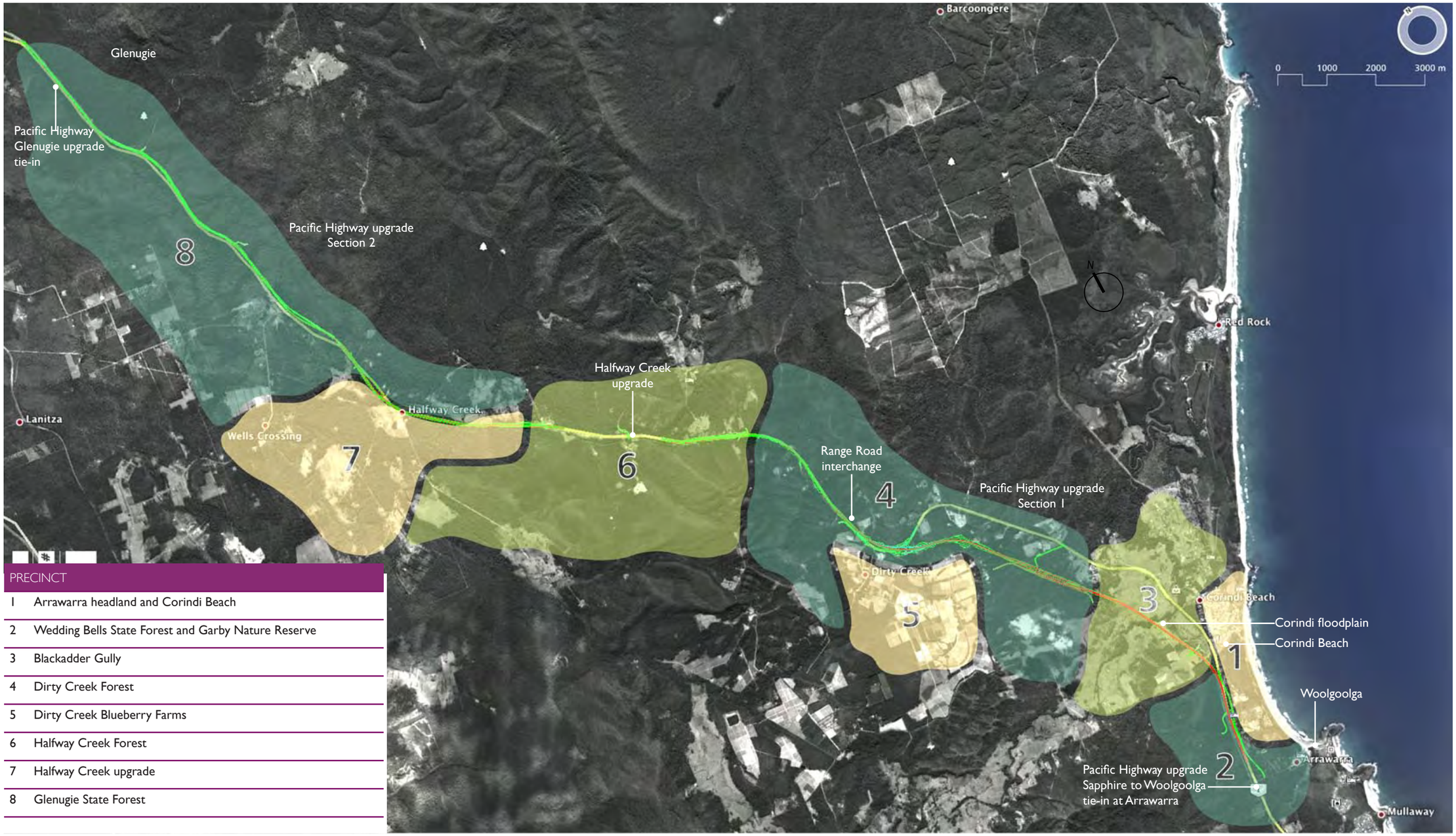
The Woolgoolga to Ballina Planning Alliance has divided the Woolgoolga to Glenugie upgrade corridor into eight landscape character precincts as illustrated in **Figure 4.1**.

These precincts broadly correspond to landscape character types in the area and allow for a more detailed discussion of the character of each precinct, construction work and associated impacts.

Each precinct has been defined through gaining an understanding of land use, topography, vegetation and other landscape characteristics and features.

The precincts have been used to assist with design options reviews and have been used during the detailed design stage to inform urban and landscape design.

For a detailed analysis of each precinct refer to the **Urban Design, Character and Visual Impact Assessment Report** (W2BPA+Hassell, 2013).



PRECINCT	
1	Arrawarra headland and Corindi Beach
2	Wedding Bells State Forest and Garby Nature Reserve
3	Blackadder Gully
4	Dirty Creek Forest
5	Dirty Creek Blueberry Farms
6	Halfway Creek Forest
7	Halfway Creek upgrade
8	Glenugie State Forest

Figure 4.1: Landscape character precinct map

(Source: Background terrain image: Copyright Google, Digital Globe, 2010)

4.2 Potential character impacts

The highway upgrade will have a substantial impact on the local landscape and visual character of the area. Such impacts include;

Highway Alignment

- Clearance of substantial areas of vegetation where highway is offline or widened. This impact will be particularly noticeable in the Dirty Creek Range cutting and Range Road Interchange.
- Visual impact of the new highway alignment in the rural-residential landscape. This will be particularly evident on the Corindi floodplain.

Cut and fill embankments

- Visual impact of high fill embankments on floodplains and in a rural-residential landscape. This will be particularly noticeable in the Corindi floodplain and in Section 2 where close to homesteads.
- Reduction of dense areas of vegetation that provide an important ecological function and contribute to landscape character. This impact will be particularly noticeable in the Dirty Creek Range cutting and Range Road Interchange.
- The steeply rising and undulating landform of the Dirty Creek Range will require extensive cut and fill.

Structures

- Nine bridge structures required to span creeks, floodplains, the main alignment itself and local access roads. Most of these bridges will only be visible from immediate areas and a handful of private properties.
- Visual impact of bridge structure 300 metres long and associated fill embankments across Corindi floodplain.

Drainage

- Requirement for permanent and temporary basins, culverts and swales, increases development footprint resulting in vegetation loss. This will be evident on the sides of major cuttings and in some widened medians where drainage lines are intersected by the highway. This will be evident throughout the upgrade.

Planting and Revegetation

- Over-clearing avoided for uses such as stockpiling of materials. This will be an important site management requirement between Corindi floodplain and Glenugie, where the upgrade passes through sections of dense forest.
- Cleared or disturbed areas, particularly where adjacent to existing pasture or the existing highway subject to a weed management program as well as re-establishment of native cover. This will be particularly important in the Corindi floodplain and in areas adjacent to the existing highway in Section 2.

Bicycle Access

- Bicycle access on the project will be limited to shoulders and overbridges, therefore impacts caused by Bicycle Access will be negligible.

Fences

- Overuse-of or doubling-up of fencing, or highly visible fencing, would result in visual clutter or impact on native vegetation and fauna corridors. Generally, boundary fencing has been avoided where fauna fencing is to be utilised.

Signage

- Signs have been designed and positioned to avoid:
  - ¬ Visual clutter due to overuse
  - ¬ Poorly positioned signs that may impede views or block visibility of other signs
  - ¬ Spacial and visual conflict between signage and other roadside furniture with revegetation and planting.
- A significant amount of signage is required on approach to the Heavy Vehicle Inspection Bay (HVIB) in accordance with regulatory requirements.

Local Road Network

- An overall strategy for local access has been developed to provide an efficient local road network.
- Duplication of road corridors will require vegetation removal and impact on fauna connectivity

Heritage

- There are no impacts as a direct result of urban design and landscape related activities or elements
- Views over floodplains are to be retained in order to maintain a sense of the agricultural history of the area

For impact mitigation strategies refer to **Section 6** of this report.

4.3 Potential visibility of the upgrade

In accordance with Roads and Maritime's requirements, an assessment has been made as to the visibility of the upgrade on surrounding viewers, both in terms of 'day one' impact and residual or long-term impacts. A visual impact assessment undertaken by the Woolgoolga to Ballina Planning Alliance during the EIS has been measured against the detailed alignment design in order to make an updated assessment of potential visual impacts. The methodology used in the original assessment was in accordance with Roads and Maritime guidelines, as described in the following sections.

VISUAL IMPACT ASSESSMENT METHODOLOGY

The magnitude of change to existing views and the sensitivity of the viewers has been assessed for each of the chosen viewpoints in accordance with the Roads and Maritime impact grading matrix (refer **Table 4-1**).

Magnitude

Magnitude of change to existing views refers to the nature and scale of the upgrade, and the extent and proximity of the view to the works. Magnitude represents the contrast in scale, form and type of work and to the location and context to which it is to be placed. A high magnitude results if the upgrade is of a major scale and are considered out of scale or uncharacteristic of the existing visual character, or if there is considerable modification to the existing landscape. A moderate magnitude would result if the upgrade is prominent but not considered to be substantially uncharacteristic with the existing visual character. A low magnitude results if there is minimal alteration to the existing view and the upgrade is of a scale and nature that is consistent with the existing visual character.

Sensitivity

Sensitivity is the measure of the visual importance of the view and is dependent on the following:

- Distance between viewer and the upgrade
- The category of viewer such as resident, visitor or worker
- The elements of the upgrade that are visible
- Importance of the view.

Visual sensitivity includes the consideration of the perceived cultural and historical values of the visual environment and the elements within it. Generally, viewers with the highest sensitivity include:

- Residents who have existing views that would be affected by the upgrade
- Users of public open space where their attention is focused on the visual landscape, for example, lookouts or other scenic natural areas
- Communities that place high cultural and historical significance on the visual landscape.

Viewers with the lowest sensitivity are most likely to be:

- Employees working within an enclosed workplace and focused on their work – however interesting views should be provided for them within a short walk from their workplace
- Motorists (apart from tourists) whose attention is focused on driving – however it is important to provide a stimulating motorist experience.

Impact

Impact is the combination of the magnitude and sensitivity rating in accordance with the Impact Assessment Grading Matrix (refer to **Table 4-1**). A combination of the physical characteristics of the site, the nature of the existing road corridor and the upgrade itself, define the visible area and the catchment from where the works are visible. This visual catchment has then been defined

In measuring the impact of change within the visual assessment precinct, the following conditions have been taken into account:

- Distance between viewer and road
- Elevation change between viewer and road
- A visual and desktop assessment made of the vertical and horizontal field of view impacted on by physical site features
- An assessment made of the type of intervention made by the upgrade into the existing landscape.

Viewpoint impact assessment

The EIS visual impact assessment identified five existing properties/ locations that would be impacted by the upgrade, as follows:

Section 1 Woolgoolga to Halfway Creek

- Kangaroo Trail Road
- 3509 Pacific Highway, Corindi Beach (driveway)
- Flinty Road, Dirty Creek Range

Section 2 Halfway Creek to Glenugie

- Georges Road (west) near Wells Crossing
- Pacific Highway near Bald Knob Tick Gate Road

Additional locations along the upgrade were requested by the Secretary Planning Assessment, as follows:

- Both sides of the highway between Arrawarra and Corindi Beach
- Residents in close proximity to the Kangaroo Trail overbridge
- Retention of views (for residents and road users) across the Corindi Creek floodplain
- Retention of filtered views of pastureland pockets north of Dirty Creek Range
- Screening of local properties north of the Dirty Creek Range
- Ensure a densely enclosed driving experience between Range Road and Kungala Road and within the Glenugie State Forest
- Maintain occasional open vistas across pastureland near Wells Crossing

Mitigation recommended during concept design

In summary, mitigation measures recommended by the landscape character and visual impact report undertaken during the EIS outlined that the minimisation of removed vegetation, the planting and seeding of vegetation on cut and fill batters and the reinstatement of forest edges and riparian vegetation should be undertaken in order to mitigate visual impacts.

Mitigation measures specified during detailed design

As the detailed urban and landscape design had to consider both the interim 'A' class and future 'M' class highway upgrades, planting and revegetation considered the ultimate form of the road including the future removal of revegetated areas alongside the 'A' class upgrade. To reinforce this thinking, multiple revegetation methods were employed that aimed to achieve 'day 1' impact as well as longer term establishment of vegetation along the corridor. In some cases, where road user views of open pastureland were the primary consideration, the reinstatement of pasture grasses on fill embankments was designed.

Modifications made to the vertical and horizontal alignment during detailed design aimed to reduce visual impacts. For example in the vicinity of Dirty Creek Road the alignment moved further away from viewpoint locations and at George Road, Wells Crossing, fill embankments were replaced with cuttings, which are less visible from nearby properties.

In all viewpoint locations, the combination of improvements to the geometric design and the planting and revegetation design that has been designed, would satisfy the intent of the visual impact assessment undertaken during the EIS.

Sensitivity \ Magnitude	High	Moderate	Low	Negligible
High	High impact	High to Moderate	Moderate impact	Negligible
Moderate	High to Moderate	Moderate impact	Moderate to Low	Negligible
Low	Moderate impact	Moderate to Low	Low impact	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

Table 4.1: Roads and Maritime impact grading matrix

5 Urban design and landscape strategy

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5.1 Urban design objectives and principles

Overview

An integrated design approach has been adopted for the upgrade in order to ensure that the best possible outcomes are achieved. This integration is achieved through multidisciplinary teams regularly collaborating to resolve design problems as opposed to working in isolation.

This approach has enabled an urban and landscape design strategy to be developed that feeds outcomes and values into the overall design for the upgrade. As a result, urban design has directly influenced key engineering aspects of the concept design, including: bridges, cuttings and embankments. The urban design strategy will continue to influence the development of the highway upgrade as it proceeds through detailed design and construction.

Landscape design responds to the existing landscape character and vegetation communities and defines a methodology for revegetation of the upgrade. This methodology involves the utilisation of several techniques in order to provide a vegetative cover to all surfaces impacted by the works.

Urban design and landscape design work in combination in order to provide a dialogue with the existing landscape, a consistency of visual outcomes along the upgrade and to provide a consistency with other upgrade projects along this section of the Pacific Highway.

Urban design objectives

The over-arching aim of the proposal is to ensure that the highway upgrade is physically and visually integrated with its surrounding environment and where possible, maximises engagement of the road user with local context in order to provide a more enjoyable and interesting driving experience. The highway design demonstrates a consistency with nearby Pacific Highway upgrade projects.

In order to meet this aim, a set of key urban design objectives and related design principles has been developed. These objectives and principles reference Roads and Maritime's *Pacific Highway Urban Design Framework*, *Beyond the Pavement* and other key guidelines. These objectives and principles are also based on an understanding of the key existing landscape and urban values of the study area and the landscape and urban design issues that affect, or are affected by, the upgrade. These objectives conform with and compliment the Director General's Requirements outlined in the project Environmental Impact Statement prepared by the Woolgoolga to Ballina Planning Alliance (September 2012).

The urban design objectives for the Pacific Highway upgrade at Woolgoolga to Glenugie are:

A. To improve the safety and operational efficiency of the highway.
B. To retain the existing character of the natural and cultural landscapes through which the highway passes.
C. To maintain the integrity of existing ecological systems.
D. To minimise the construction and operational impacts of the highway on the local community and existing environment.
E. To maintain and improve the amenity and economic viability of the local area.
F. To retain and enhance the essential qualities of the existing highway travel experience.
G. To ensure that the highway upgrade makes a positive complimentary contribution to the local and regional landscape.

Urban design principles

A series of urban design principles has been developed to ensure that the urban design objectives are achieved by the highway upgrade. The purpose of these principles is to integrate good urban design practice into all aspects of the concept design development, and also inform the detailed design and construction phases of the project.

The urban design principles relate to three broad areas of design influence:

- **General arrangement/road alignment design** - The design of the location and geometry of the highway and related local access roads.
- **Road elements design** - Input into the design of bridges, noise walls and safety barriers that are necessary to achieve the road alignment or are required for the effective operation of the highway.
- **Landscape design** - The design of new planting or bushland reconstruction areas in order to integrate the highway upgrade with the existing local landscape character and natural patterns, and to provide interest to the motoring experience.

Table 5.1 on the following page describes the interrelationship between the urban design objectives, their associated urban design principles and the areas of the highway design that they influence.

URBAN DESIGN OBJECTIVES AND RELATED PRINCIPLES	AREAS OF DESIGN INFLUENCE: General arrangement/ road alignment design	Road elements design	Softworks design
1 To improve the safety and operational efficiency of the highway.			
1A Reduce the number of local road intersections and direct property connections along the upgraded highway.	●	●	
1B Provide continuous, off-highway, local access routes wherever possible.	●		
1C Improve facilities for all road users – including motorists, pedestrians and cyclists.	●		
2 To retain the existing character of the natural and cultural landscapes through which the highway passes.			
2A Minimise the physical footprint of the highway upgrade, including during the construction stages.	●	●	●
2B Design the highway to be physically and visually integrated with the surrounding landscape.	●	●	●
2C Minimise the physical and visual intrusion of road-related elements (such as noise walls and water quality control measures) on the local landscape.	●	●	●
2D Preserve the integrity of cultural heritage sites and areas of cultural importance, regardless of whether or not they contain heritage items.	●		●
2E Minimise the impact of the highway upgrade on native vegetation and cultural planting.	●		
3 To maintain the integrity of existing ecological systems.			
3A Minimise the physical footprint of the highway upgrade, including during the construction stages.	●		
3B Minimise the impact of the highway upgrade on native vegetation.	●		
3C Avoid the introduction of environmental weeds.			●
3D Implement comprehensive water quality control measures.	●	●	●
3E Provide connectivity and safe and effective highway crossings for native fauna.	●	●	
3F Maintain the integrity of endemic plant communities and topsoils.			●
3G Maintain the ecological functionality and long-term sustainability of revegetated areas.			●

URBAN DESIGN OBJECTIVES AND RELATED PRINCIPLES	AREAS OF DESIGN INFLUENCE: General arrangement/ road alignment design	Road elements design	Softworks design
4 To minimise the construction and operational impacts of the highway on the local community.			
4A Minimise the physical footprint of the highway upgrade, including during the construction stages.	●		
4B Design the highway to be physically and visually integrated with the surrounding landscape.	●	●	●
4C Provide continuous, off-highway, local access options wherever possible.	●		
4D Provide generous and direct local vehicular and pedestrian connections across the highway of appropriate scale and character to the significance of the crossing.	●		●
4E Minimise the potential noise impacts of the highway upgrade.	●	●	
4F Consider opportunities for public transport throughout the project.	●		
4G Provide safe and effective highway crossings for livestock where necessary.	●		
5 To maintain and improve the amenity and economic viability of the local area.			
5A Provide continuous, off-highway, local access routes wherever possible.	●		
5B Provide straightforward connections between the highway and the local road network.	●		

URBAN DESIGN OBJECTIVES AND RELATED PRINCIPLES	AREAS OF DESIGN INFLUENCE: General arrangement/ road alignment design	Road elements design	Softworks design
6 To retain and enhance the essential qualities of the existing highway travel experience.			
6A Make the character of the local topography a tangible experience for the motorist by providing, as much as possible, a constantly varying horizontal (curving) and vertical (undulating) road alignment.	●		
6B Minimise the visual scale of the highway from the motorist's perspective.	●	●	●
6C Maximise the motorist's experience of, and visual connection to, the surrounding natural and cultural landscapes.	●	●	●
6D Retain, and where possible improve, regional views and views to important landmarks.	●	●	●
7 To ensure that the highway upgrade makes a positive contemporary contribution to the local and regional landscape.			
7A Avoid the use of token "gateway" statements. Instead, utilise unique features of the local area and functional elements of the highway as visual markers and experiences that provide a sense of arrival or sense of place along the highway journey.	●	●	●
7B Recognise that large-scale road elements (such as walls, cuttings, bridges and tunnels) have iconic potential and provide important visual and landscape markers. Design these elements accordingly.		●	
7C Design the visual expression of the road elements to be true to their infrastructural function, using robust materials and streamlined, uncomplicated forms.		●	

Table 5.1: Urban design objectives and principles

5.2 Road and landscape elements

Road Elements

Road elements are categorised as follows:

- **Structures** - including bridges, retaining walls that are necessary to achieve the road alignment within its surroundings
- **Earthworks formations** - including cuttings and embankments that are necessary to achieve the road alignment within its surroundings
- **Drainage and water quality structures** - including basins and open channels that are necessary in order to sensitively drain the works and ensure safe operation of the highway
- **Furniture** - such as safety barriers, signs and noise attenuation walls that are necessary for the effective operation of the highway.

Design principles

Table 5.2 summarises how the initial concept design principles have been expanded for use on the upgrade during the detailed design stage. Ongoing urban design has included assessment against these principles.

Table 5.2: **Urban design elements design principles**

	URBAN DESIGN PRINCIPLES
B2, D2	Design the highway to be physically and visually integrated with the surrounding landscape.
B3	Minimise the physical and visual intrusion of road-related elements (such as noise walls and water quality control measures) on the local landscape.
F2	Minimise the visual scale of the highway from the motorist's perspective.
F3	Maximise the motorist's experience of, and visual connection to, the surrounding natural and cultural landscapes.
G1	Utilise unique features of the local area and functional elements of the highway as visual markers and experiences that provide a sense of arrival or *sense of place* along the highway journey.
G2	Recognise that large-scale road elements (such as walls, cuttings, bridges and tunnels) have iconic potential and provide important visual and landscape markers. Design these elements accordingly.
G3	Design the visual expression of the road elements to be true to their infrastructural function, using robust materials and streamlined, uncomplicated forms.

Design approach

The general approach to the design of road elements is to satisfy the functional requirements for the safe and efficient operation of the highway while also being appropriate to their location. In all cases, the design and implementation of the road elements would need to satisfy the requirements of Austroads and Roads and Maritime design guidelines and practice notes.

It is also important that, in their detailed resolution, the visual expression of the road elements is true to their function as items of contemporary highway infrastructure. Respect for the character of the local area will not be achieved by the appropriation of stylistic cues or fashions from another era, but through sensitive consideration of the location, placement and scale of the new elements.

The following approach has been taken for the design of road elements:

- **Integration** of the highway with the surrounding landscape
- **Simplicity** in the design expression of the elements relating to the highway, in order to allow the existing natural and cultural landscapes to provide the primary interest to the motoring experience
- **Practicality** for ease of construction and reduced long-term maintenance
- **Site specific design** that acknowledges and responds to the character of the local area, while not necessarily replicating existing features
- **Consistency** with the overall Pacific Highway, by using elements that are identifiably part of the highway experience in this region
- **Integrity** to the materials and method of construction in the final finish and appearance of the road elements
- **Sustainability** in the choice of materials and resources.

Refer to **Section 6** for urban design recommendations regarding road elements.

Landscape elements

Landscape elements include:

- **Planting and revegetation** - including planting, seeding and bushland reconstruction techniques that are necessary to stabilise the works and integrate the upgrade with the surrounding environment.

Design principles

Table 5.3 summarises the principles that relate to planting design.

Table 5.3: **Landscape design principles**

	URBAN DESIGN PRINCIPLES
B2, D2	Design the highway to be physically and visually integrated with the surrounding landscape.
B3	Minimise the physical and visual intrusion of road-related elements (such as noise walls and water quality control measures) on the local landscape.
B4	Preserve the integrity of cultural heritage sites and areas of cultural importance, regardless of whether or not they contain heritage items.
C3	Avoid the introduction of environmental weeds.
C6	Maintain the integrity of endemic plant communities and topsoils.
C7	Maintain the ecological functionality and long-term sustainability of revegetated areas.
F2	Minimise the visual scale of the highway from the motorist's perspective.
F3	Maximise the motorist's experience of, and visual connection to, the surrounding natural and cultural landscapes.
F4	Retain, and where possible improve, regional views and views to important landmarks.
G4	Avoid the use of token "gateway" statements. Instead, utilise unique features of the local area and functional elements of the highway as visual markers and experiences that provide a sense of arrival or sense of place along the highway journey.

Design approach

Planting and revegetation design integrates the upgrade with the surrounding landscape, thereby mitigating the potential visual and environmental impact of the upgrade.

The following revegetation methods will be utilised:

- Seeding
- Planting
- Bushland reconstruction.

The planting and revegetation design also aims to minimise the potential ecological impacts of the highway upgrade by stabilising earthworks to prevent erosion, and reinforce existing habitats and ecological corridors through revegetation of substantial areas and species selection.

The application of these principles and techniques is broken down as follows:

- Provide a well vegetated road corridor that integrates the highway with the surrounding landscape and provide motorists with a 'sense of place' along the highway journey.
- Strike a balance between screening the highway from the sensitive views from surrounding areas and maintaining key vistas from the highway to the surrounding landscape
- Revegetation or planting of all areas affected by highway construction work
- Revegetation of residual land affected by the highway upgrade that is not viable for redevelopment. The type of revegetation would be determined by a combination of surrounding landscape character and proximity of existing ecological habitats and wildlife corridors
- Use of bushland reconstruction as a revegetation technique for off-line sections of highway that pass through dense bushland
- Provision of planting in highway medians in some locations to minimise the visual scale of the highway and contribute to road safety through the screening of headlight glare from oncoming traffic
- Revegetation of outside verges wherever possible to minimise the visual scale of the highway, and of roadside cuttings and retaining walls
- Revegetation or turfing of low side verges to allow better stabilisation and capturing of sediment and nutrient washing off the carriageway before it enters drainage structures
- Clustering of trees, particularly in floodplains to allow vistas to the broader landscape.

Refer **Section 6** for further detail on revegetation methods.

6 Urban design and landscape proposal

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6.1 Structures and earthworks formations

Structures and earthworks formations are required to reconcile the new highway levels with existing ground levels. While it is preferable in principle to build the new highway as close to the existing ground levels as possible, in practice this has not been possible in several locations. Instead, the design requires the highway to be either above or below the existing ground levels for much of the project length due to:

- The undulating shape of the existing terrain
- The minimum geometric requirements for the horizontal and vertical road alignment to meet the relevant design standards for the highway upgrade
- The requirement to achieve a minimum flood immunity
- The need to balance cut and fill volumes.

These requirements are discussed in detail in the **Pacific Highway upgrade, Woolgoolga to Glenugie 100% Detailed Design Report** (APB, 2013).

The types of earthworks formations required for this project are:

- Fill embankments - where the new highway would be situated above the existing ground, requiring the road to be elevated.
- Cuttings - where the new highway would be situated below the existing ground, requiring excavation.

The types of structures required for the project are:

- Bridges, comprising, overbridges, highway bridges with underpasses, highway bridges over flood plains or creek lines and large culvert structures.

Figure 6.1 describes the principles used to determine the types of structures and formations used on this project.

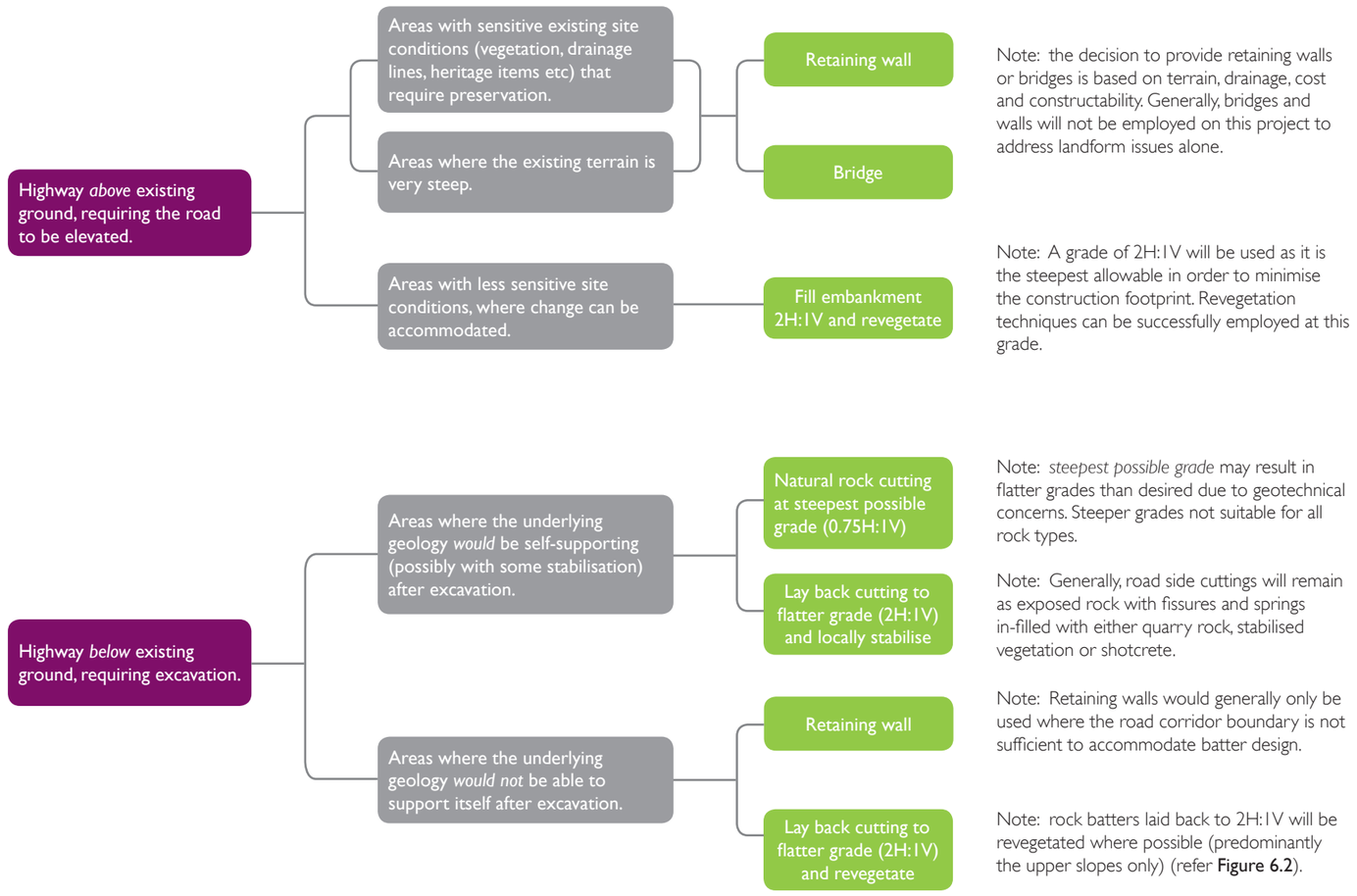


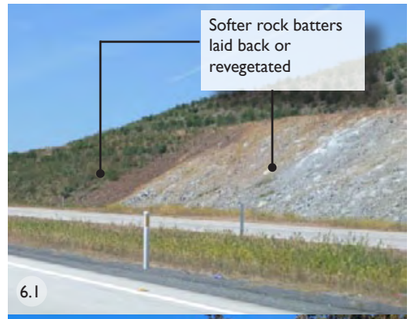
Figure 6.1: Location and types of landscape elements required in order to reconcile the new highway levels with the existing ground.

Cuttings

The following recommendations are for all cuttings along the highway upgrade.

Table 6.1: Summary of recommendations for cuttings

CUTTING ATTRIBUTE	RECOMMENDATION	RATIONALE
Cutting finish	¬ Where roadside cuttings are required, the natural rock surface is to be maintained wherever possible. Fissures and springs would be in-filled with either quarry rock (refer **Plate 6.4**), stabilised vegetation (refer **Plate 6.1**) or shotcrete ¬ Where the cutting face needs to be stabilised, rock anchors are preferred over shotcrete as they allow the natural rock to remain visible ¬ The use of shotcrete is to be avoided unless absolutely necessary. Where shotcrete is required, its application is to be designed to minimise its visibility. Techniques include matching the colour of the concrete to the surrounding rock, and recessing the shotcrete from the cutting face. Refer the Roads and Maritime's *Shotcrete Design Guidelines*.	¬ Maintaining the natural rock cutting face allows the geological character of the local landscape to be expressed in the highway corridor, providing a strong sense of place ¬ Use of quarry rock sourced from the site provides a consistency of rock colour and provides an opportunity for site materials to be reused ¬ Revegetation of cut batters is to be undertaken where rock is weak or friable and likely to require significant stabilisation. Rock surface is then ripped and a soil medium and revegetative overlay provided. Refer Landscape Implementation.
Cutting profile	¬ Cutting angles are to be as steep as possible, while taking into account the geotechnical constraints of each particular cutting location. Refer to **Figure 6.3** for cutting profile variations at the main Dirty Creek Range cutting ¬ The number of benches in each cutting face is to be minimised by adopting high cutting faces (within the requirements of the relevant design guidelines or geotechnical requirements) ¬ The top batters of cuttings are to be 'rounded' over in all cases and revegetated where residual soils are present ¬ Sides of cuttings are to be shaped back into the existing landform and progressively laid back in order to integrate with the existing contours (refer **Plate 6.3**).	¬ Steep cutting angles and fewer benches reduce the overall footprint of the cutting, which in turn minimises impacts on the surrounding landscape ¬ Batter rounding, both over and back allows for less abrupt integration with existing landform and reduces visible impact when viewed from expected road user viewing angles.
Toe of cutting	¬ Wherever possible, provide space at the base of cuttings for grassing (refer **Plate 6.2**). In such cases, over-excavation is required to provide a suitable depth planting medium.	¬ Grassing at the base of cuttings allow the cuttings to be integrated with the character of the surrounding landscape ¬ A grassing area at the base of a cutting can also function as a space to capture any loose material that is eroded from the cutting before it reaches the road surface.
Bridge cuttings	¬ At overbridge cuttings a steeper batter grade is to be employed (1.5H:1V) than the adjacent road batters (2H:1V) (refer **Figure 6.4**) ¬ Stone cladding (pitching) is to be employed beneath 'drip line' of bridge +1m of additional width. Stone is to be locally sourced if possible ¬ Transition faces, the face between the bridge cutting and the road cutting are to be minimum 10m in length, with exposed rock finish ¬ Face irregularities are to be treated in the same way as road cutting faces	¬ Steeper grade enables reduction in actual bridge length ¬ Transition face to tie-in visually with adjacent faces or be completely clad to ensure consistent finish with bridge batter.



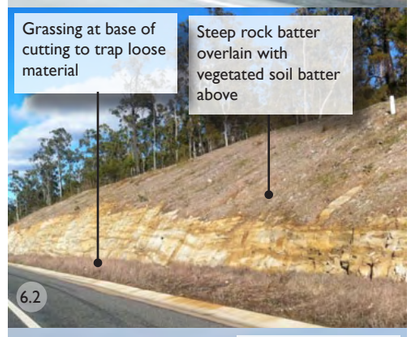


Plate 6.1: Partially revegetated cuttings along Hume highway Woomargama Bypass (Source: SMM)

Plate 6.2: Partially revegetated cuttings along Pacific Highway Glenugie upgrade (Source: SMM)

Plate 6.3: Batter tail rounding at Pacific Highway Sapphire to Woolgoolga (Source: Roads and Maritime)

Plate 6.4: Cut face treatments at Hume Highway Woomargama Bypass (Source: SMM)

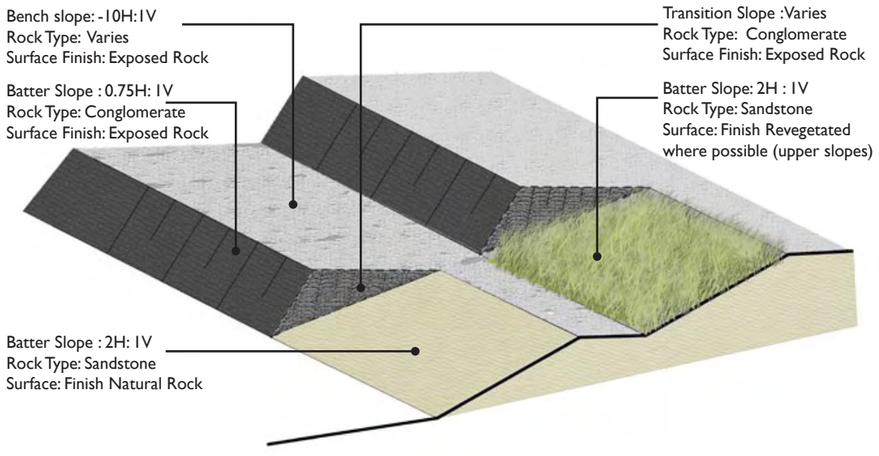


Figure 6.2: Perspective diagram showing typical rock interface with vegetated slope

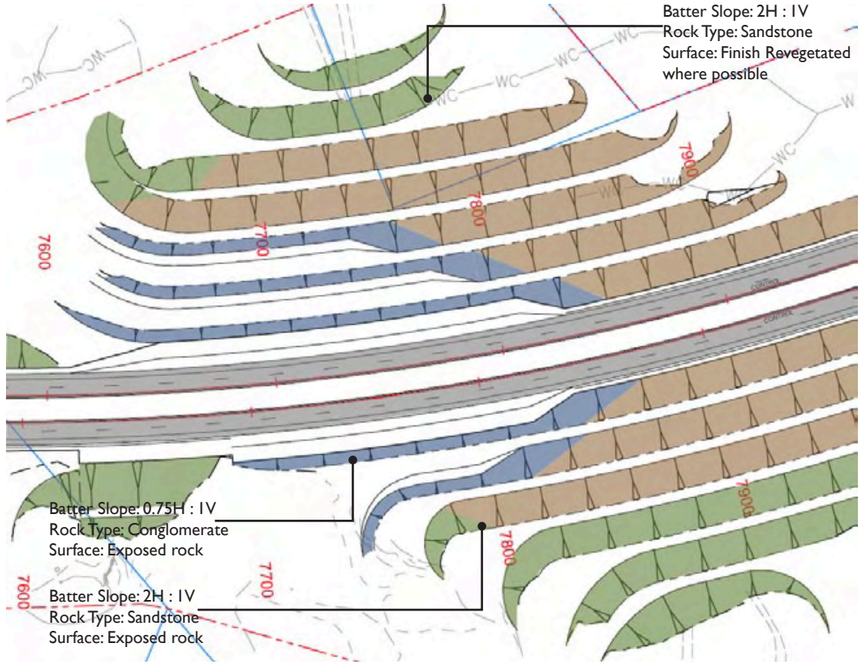


Figure 6.3: Cutting diagram showing rock interface in main cutting at Dirty Creek Range

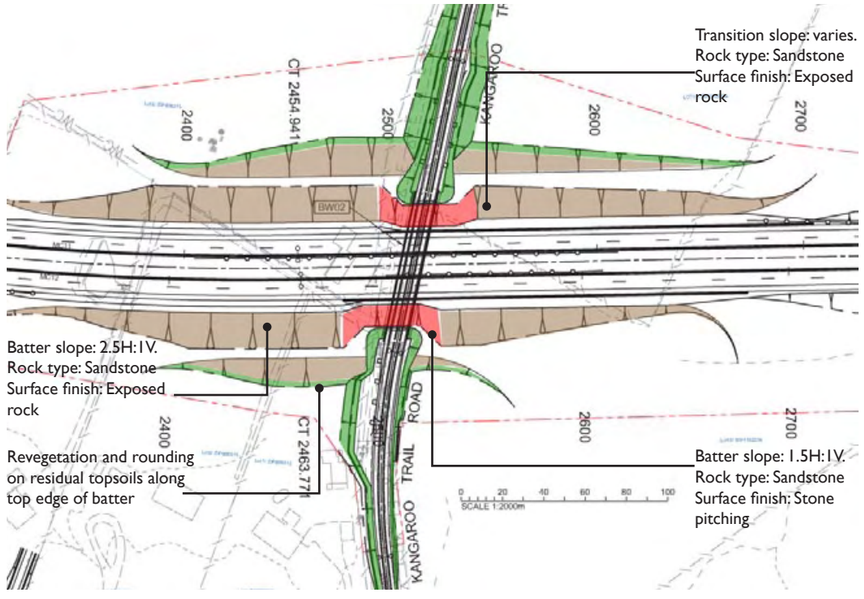


Figure 6.4: Cutting diagram showing rock interface in cutting at Kangaroo Trail Bridge

Fill Embankments

The following recommendations are for all embankments along the highway upgrade.

Table 6.2: Summary of recommendations for embankments

LOCATION	RECOMMENDATION	RATIONALE
Generally	¬ Fill embankments do not generally impact on the road user as they are located below the road level. They do however provide, through the elevation of the road, an opportunity to promote views of the broader landscape ¬ Views of the Fill embankment from the broader landscape to be considered.	¬ In open areas, limit tree planting to clusters to ensure vistas through to the broader landscape ¬ Views from the road improve the driving experience, sense of place and orientation ¬ Views of the road can be improved where the embankments are integrated with the existing landscape through shaping and revegetation.
In bushland areas	¬ Minimise the extent of fill embankments ¬ In all cases, ensure that the slope angles on embankments facilitate revegetation. In general, a slope of 2H:1V is the steepest allowable in order to maintain several revegetation options eg. Bushland Reconstruction.	¬ Minimising the physical footprint of the highway reduces the need for clearing of native vegetation in bushland areas ¬ Revegetation of embankments allows for better integration of the embankments with the character of the surrounding landscape ¬ A variety of possible revegetation techniques provides a contingency where one method may be more suitable than another.
Outside of bushland areas	¬ Embankments in agricultural areas and floodplains are to be vegetated using species that corresponds to the adjoining landscape ¬ Where the existing landform is relatively flat and space permits, provide a flatter embankment profile (4H:1V) or flatter) to better fit with the surrounding landform ¬ Where the existing landform is steep or where space is limited, provide steeper embankments to minimise extent.	¬ Flattening of batters creates a larger surface area of revegetation to occur. Do not flatten batters where additional tree loss would result as existing trees provide better initial screening than new revegetation ¬ Revegetation of embankments allows for better integration of the embankments with the character of the surrounding landscape. This is further improved where vegetation is matched to the surrounding vegetation.

Bridges

The upgrade design includes nine bridges, with additional bridges required for the future conversion to 'M class'. Detailed discussion of the technical requirements and engineering design for the bridges, including alternative options considered, can be found in the detail design reports for the individual structures. Nine new bridges are required to service the highway upgrade.

Figure 6.5 summarises the bridges required for the upgrade. The bridges have been further categorised according to similarities in either location and or type. These categories have been used to develop a consistent structural design approach for similar bridges. They also form the basis for the urban design recommendations specific to these bridges.

Plate 6.5: Retention of existing creek invert and floodplain at the Hume highway Woomargama Bypass (Source: HHWA)

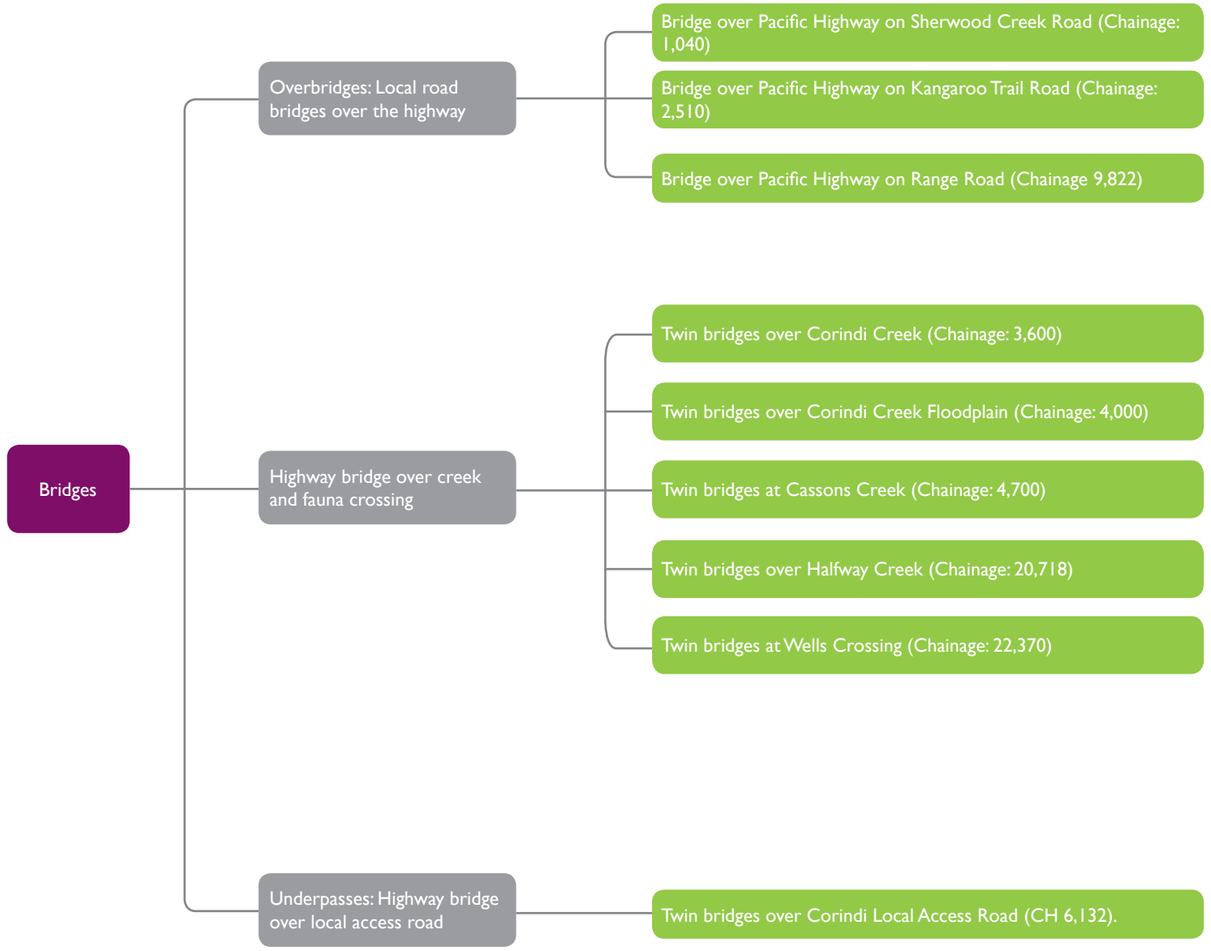


Figure 6.5: Summary of bridges on the upgrade.

Urban design recommendations for all bridges

Composition

The composition of bridge, road and landscape elements will present a form that is consistent with other bridges on the Pacific Highway in this region. These elements include bridge batters, parapets and barriers, piers and nearby revegetation as described in more detail below. Refer to **Plate 6.7** for an example of a similar well-proportioned composition of elements (note bridge under construction).

Parapets and barriers

Simple, streamlined concrete parapets will be adopted for all bridges. Vertical joints will not be provided in the parapet skirt apart from over the central piers. The parapets will incorporate the twin rail barriers and panels with subtly expressed vertical joints. Consistency in the detailing of the parapets and railings, both within the project and with other parts of the highway, provides continuity in the regional road journey.

The twin rail barriers reduce the visual 'bulk' of the bridges when viewed from their surroundings. They also allow for views out from the bridges to the surrounding landscape, which provides a sense of connection to the local area when travelling along the highway. Refer to **Plate 6.6** for an example of streamlined parapets and double rail barriers.

Safety screens

Whilst safety screens are often considered a visual obtrusion, a precedent exists for their use on this section of the Pacific Highway. Other stages including Bonville Bypass and Sapphire to Woolgoolga utilise safety screens.

It is noted that the safety screen risk assessment undertaken as part of the detail design for the two overbridges indicates that throw screens requirements are borderline. A decision has been made by the design team to include them in the upgrade for reasons of consistency and safety.

Piers

Overbridges will have central piers that taper in one direction only. The inside face of the pier will be a square portal frame to allow light to further penetrate the undercroft space through which the highway upgrade passes. This is considered an improvement from the Woolgoolga to Ballina Planning Alliance concept design, which proposed solid blade piers (refer **Figure 6.6**)

Highway bridges including underpasses will consist of a reinforced concrete pier and headstock substructure with tapering of headstock ends in visible locations. Care will be taken to retain existing creek inverts through careful construction management. Refer to **Plate 6.8** for a similar centrally positioned pier with taper.

Urban design recommendations for specific bridges

- Early in the detailed design stage, a bridge options review process was undertaken by the structural design engineers with urban design input provided. The options review considered potential modifications and improvements to the structural concept designs, as well as to ensure compliance with Roads and Maritime guidelines and ongoing environmental requirements.
- Urban design input into this process considered visual and contextual issues associated with bridges, including physical proportions of superstructural and substructural elements and position of the bridge in relation to nearby road-related landscape elements and environmental context.

Table 6.3 summarises the urban design outcomes for the bridges following the bridge options review

Figures 6.7 - 6.11 overleaf summarise the approach taken to bridge design and are representative of the bridge family types.

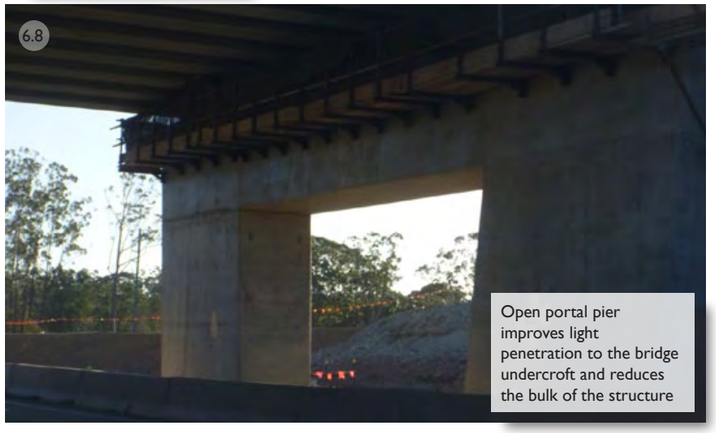


Plate 6.6: Twin Bridges on Hume Highway Woomargama Bypass at Mountain Creek
Plate 6.7: Overbridge on Sapphire to Woolgoolga project under construction
Plate 6.8: Overbridge on Sapphire to Woolgoolga project under construction (Source: SMM)

Table 6.3: Summary of recommendations for bridges

NUMBER	CHAINAGE	DESCRIPTION	LENGTH (M) APPROX	NUMBER OF SPANS	HEIGHT (M) APPROX	STRUCTURAL DESIGN COMPONENTS			FURTHER URBAN DESIGN RECOMMENDATIONS TO BE CONSIDERED FURTHER DURING DETAILED DESIGN DEVELOPMENT
						GIRDER TYPE	PIER TYPE	ABUTMENTS AND CURTILAGE	
OVERBRIDGES: LOCAL ROAD BRIDGES OVER THE HIGHWAY									
BR01	1040.000	Bridge over Pacific Highway on Sherwood Creek Road.	60.6	2	5.6	Super T, 1500mm deep	Central concrete blade, tapered in the elevation of the pier, with a constant wall thickness and square portal	Concrete sill beam, stone pitching and concrete access stairs	¬ The appearance of the central pier for these bridges is important from an urban design perspective, as the piers will be highly visible, being situated in the central median of the highway. The detailing of the piers has ensured that they are simple and streamlined, with a high quality concrete finish. ¬ The tapered blade with square portal void creates a simple, uncomplicated and elegant form for the central piers. The portal void through the pier increases light penetration to the main alignment and reduces the visual bulk of the structure. ¬ Provide stone pitching to the spill through abutments, preferably using rock excavated from the site. Stone pitching to extend minimum 1 metre out from the drip line of the bridge and include access stairs.
BR02	2510.708	Bridge over Pacific Highway on Kangaroo Trail Road;	64.0	2	8.0				
BR12	9822	Bridge over Pacific Highway on Range Road Interchange	60.0	2	6.1				
UNDERPASSES: HIGHWAY BRIDGE OVER LOCAL ACCESS ROAD									
BR06	6132.000	Twin bridges over Corindi Local Access Road.	64.0	4	4.6	Concrete planks, 600mm deep	Concrete column, headstock with tapered ends	Concrete sill beam, precast pitching and concrete access stairs on spill-through abutments	¬ The pier and headstock arrangement of this bridge type is less critical than overbridges, due to significantly less road users viewing the structure. ¬ Headstock tapering will reduce the visual bulk of the headstocks. ¬ Column piers will allow light penetration to the undercroft of the bridge and are difficult to vandalise due to reduced surface area.
HIGHWAY BRIDGES OVER CREEKS AND FAUNA CROSSINGS									
BR03	3548.000	Twin bridges over Corindi Creek;	62.5	3	7.1	Super T, 1200mm deep	Concrete column, headstock with tapered ends (only where visible - BR08 and 09)	Concrete sill beam, rock scour protection of spill-through abutments.	¬ The pier and headstock arrangement of this bridge type is the least critical due to virtually no road users viewing the structure. In some cases local property owners will view the bridge structure. ¬ Headstock tapering will reduce the visual bulk of the headstocks (only applied where visible to highway upgrade or local roads). ¬ Column piers will allow light penetration to the undercroft of the bridge and are difficult to vandalise due to reduced surface area. ¬ Reduced bulk and volume of the structural elements will allow other functions to occur such as creek and fauna passage.
BR04	4000.000	Twin bridges over Corindi Floodplain;	300.0	20	4.6	Concrete planks, 600mm deep			
BR05	4685.000	Twin bridges at Cassons Creek;	74.0	3	3.6	Super T, 1500mm deep			
BR09	22373.000	Twin bridges over Wells Crossing	77.5	3	3.7	Super T, 1200mm deep			
BR08	20718.000	Twin bridges over Halfway Creek;	57.0	2	6.6	Super T, 1200mm deep	Walled abutments		

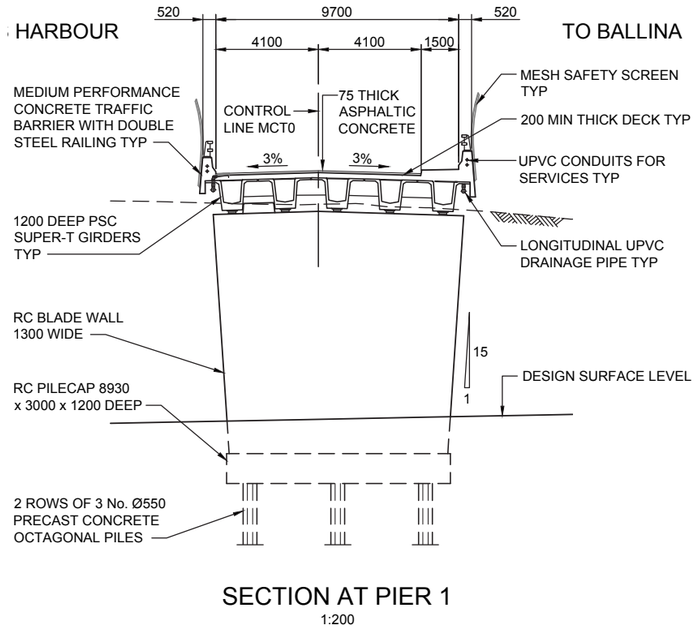
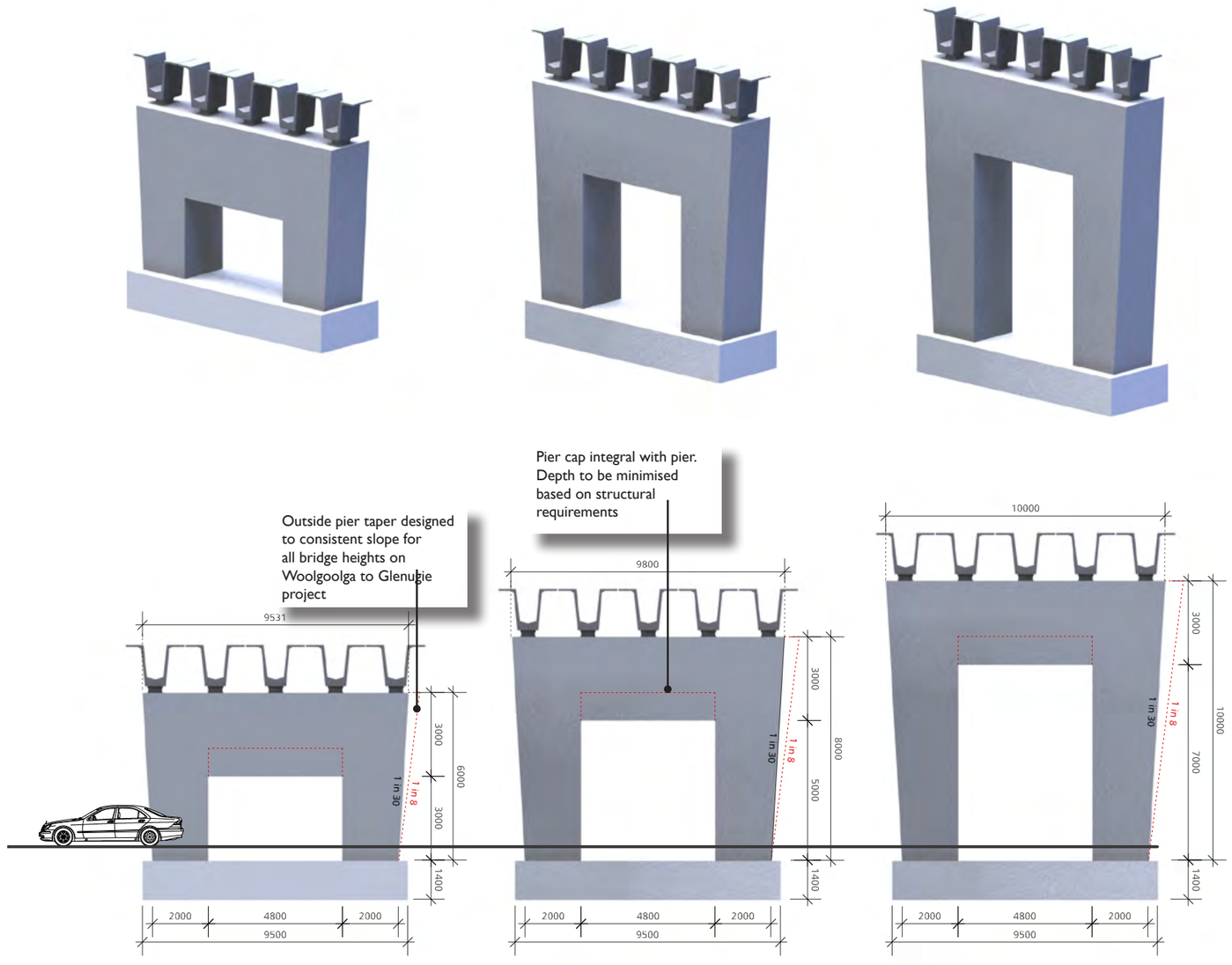


Figure 6.6: Overbridge concept design for Woolgoolga to Glenugie exhibiting solid blade pier (Source: W2BPA).



*Note: Dimensions are approximate.

Figure 6.7: Woolgoolga to Glenugie pier modelling as a result of urban design input into the bridge options review (Source: SMM)

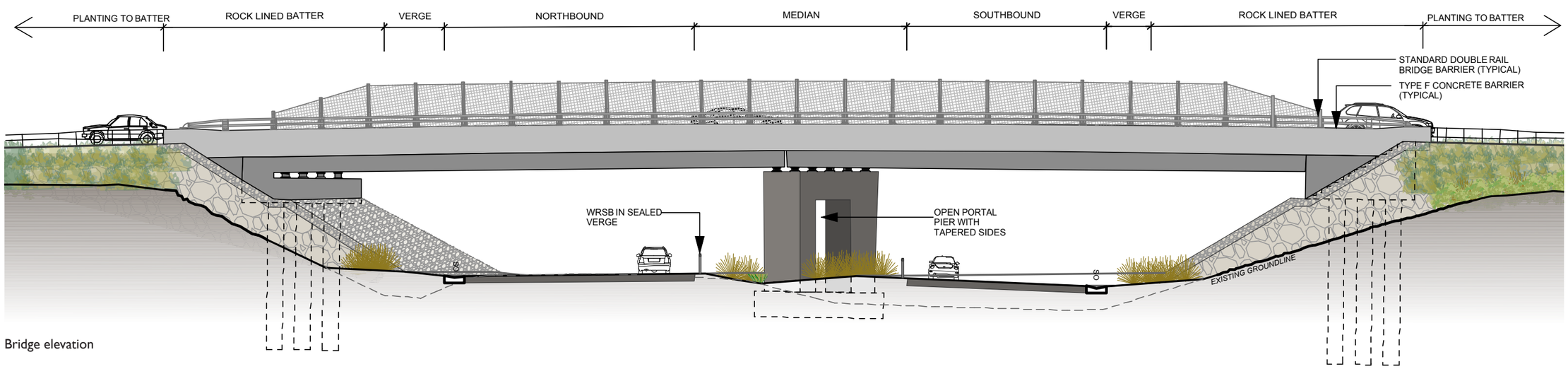
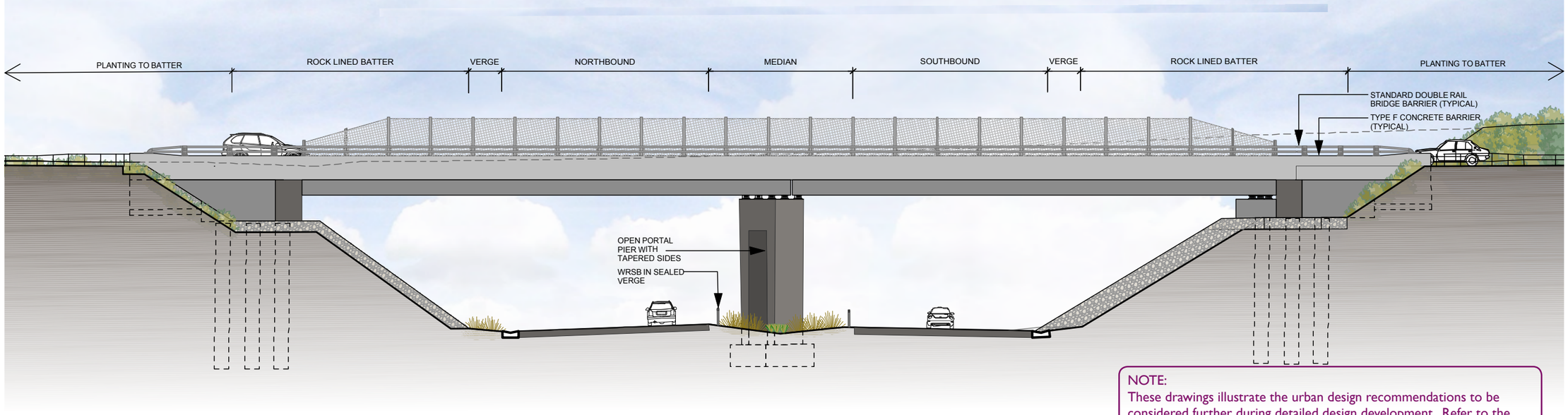
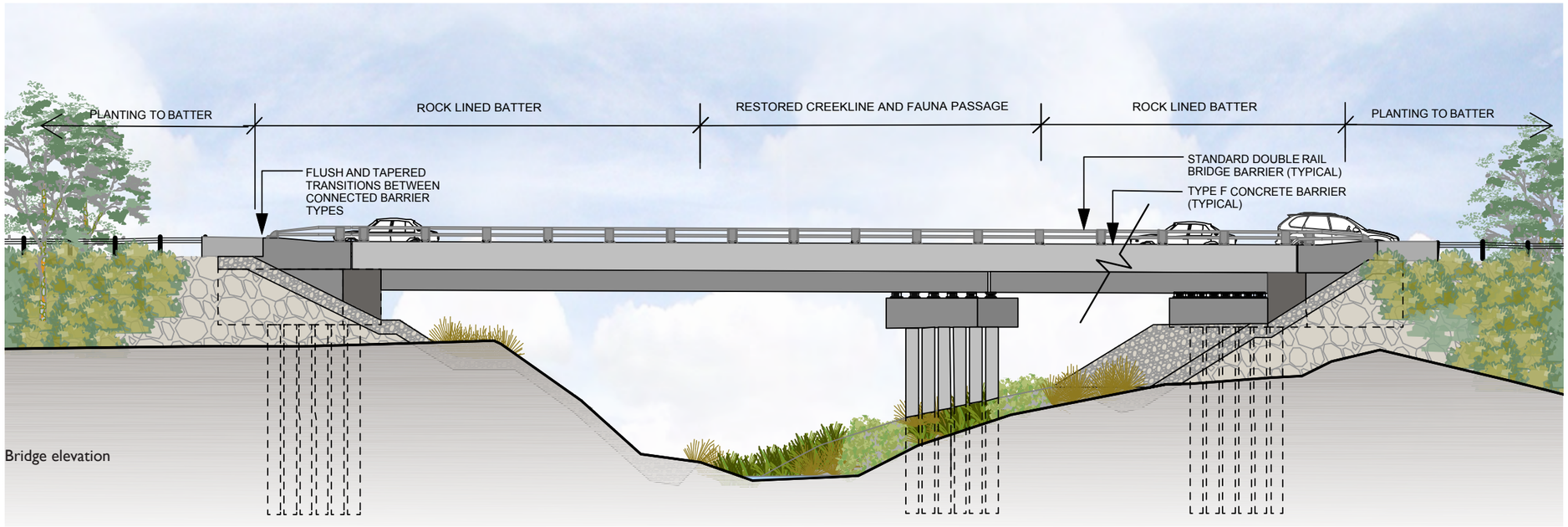


Figure 6.8: Bridge over the Pacific Highway on Sherwood Creek Road (BR01)

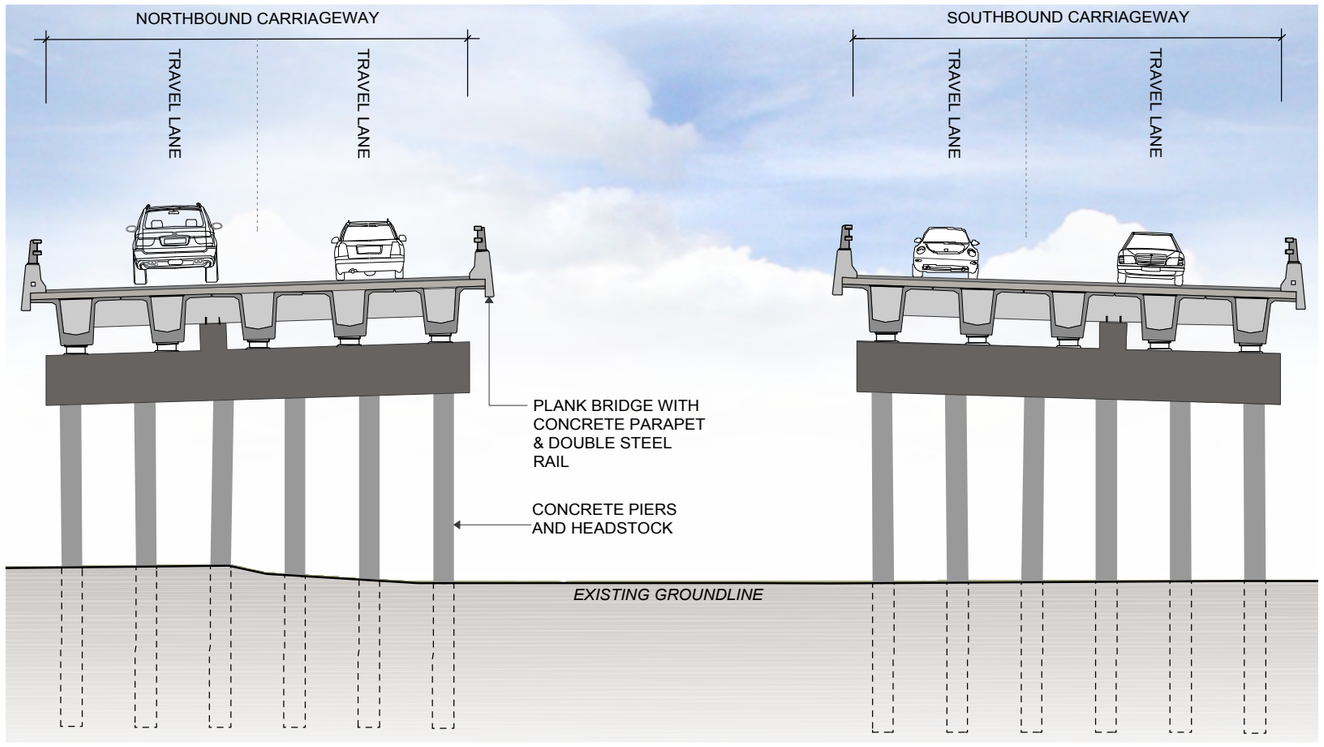


NOTE:
These drawings illustrate the urban design recommendations to be considered further during detailed design development. Refer to the structural concept design reports for the individual bridges for more detailed discussion of bridge options and drawings of the bridge designs.

Figure 6.9: Bridge over the Pacific Highway on Kangaroo Trail Road (BR02)



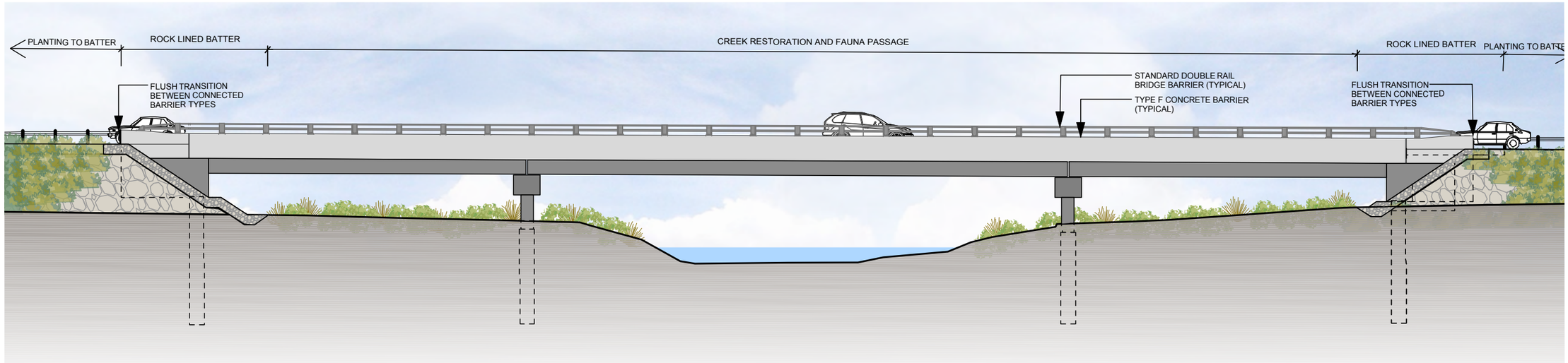
Bridge elevation



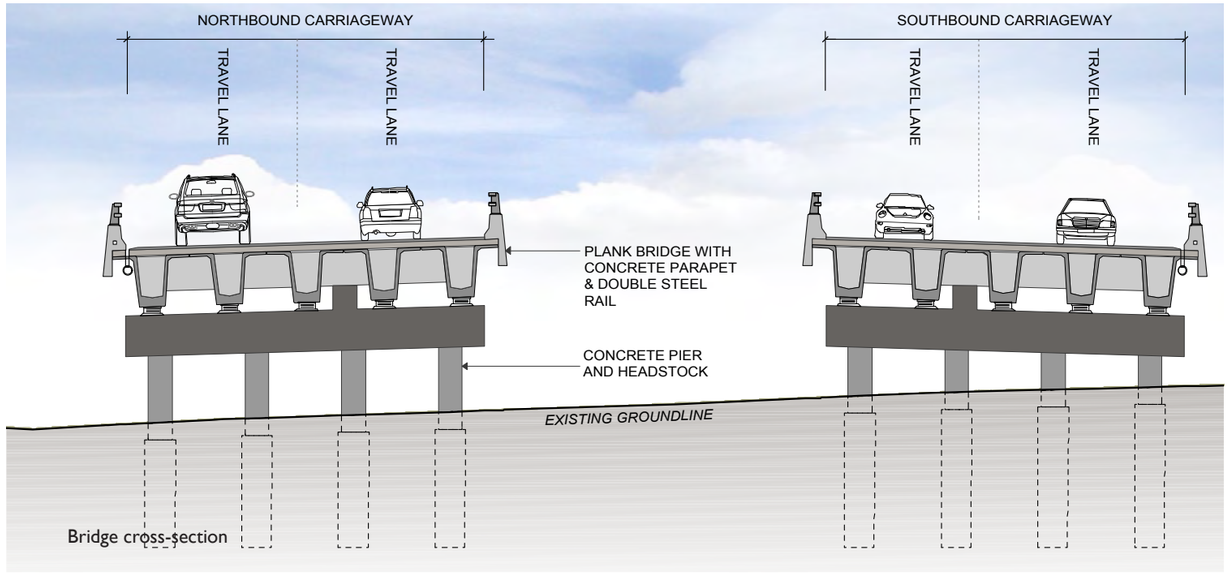
Bridge cross-section

NOTE:
These drawings illustrate the urban design recommendations to be considered further during detailed design development. Refer to the structural concept design reports for the individual bridges for more detailed discussion of bridge options and drawings of the bridge designs.

Figure 6.10: Twin bridges over Corindi Creek (BR03)



Bridge elevation



Bridge cross-section

Figure 6.11: Twin bridges over Cassons Creek (BR05)

NOTE:
These drawings illustrate the urban design recommendations to be considered further during detailed design development. Refer to the structural concept design reports for the individual bridges for more detailed discussion of bridge options and drawings of the bridge designs.

6.2 Drainage and water quality structures

The highway upgrade is situated within, and has the potential to affect, the sensitive catchments of adjacent state parks and nature reserves. Two types of water quality basins are necessary: temporary basins during construction and permanent basins for the ongoing operation of the highway.

Due to the site topography along the preferred route corridor, a large number of basins would be required to treat the construction area during all stages of the work. Additionally, a large number of drainage channels are required to manage the flow of surface water across the project area. The basins are connected by a series of open swales and pipes, which often require significant earthworks and landform remodelling - often in conjunction with other landscape formations such as fill embankments.

For detailed discussion of water quality, hydrology and drainage design, refer to the drainage reports prepared by APBJV during the detail design phase.

Landscape and urban design issues

The key landscape and urban design concerns relating to drainage and water quality structures are:

- The visual impact of the basins alongside the highway, particularly in areas where they would be highly visible to road users or local residents.
- In steep bushland areas and widened medians:
  - The large size and footprint of the basins due to the undulating terrain
  - The clearing of vegetation necessary to construct the basins and associated access tracks.
- The visual impact of the drainage channels, particularly those in highly visible or visually sensitive locations such as: along the roadside, in medians, and along the tops of cutting benches parallel to the highway (which would be visible on approach to the cuttings) (refer **Plate 6.10**).
- Erosion caused by increased water velocities along concrete channels, compounded by insufficient scour protection (refer **Plate 6.9**).

Urban design recommendations

- In the open agricultural landscape of the Corindi floodplain, the water quality basins are designed and shaped so that they integrate with the existing landscape character (refer **Plate 6.9**)
- Water quality basins and associated access tracks that are required for the construction phase only, are to be decommissioned and revegetated at the end of the construction stage
- Avoid locating water quality basins on residual land that is viable for redevelopment, in medians and in sensitive bushland areas
- Drainage channels have been designed to visually integrate with their surroundings as much as possible. For example: visible roadside channels and median channels will be vegetated. Concrete lined channels have been avoided where possible. Where they are to be used, the concrete is to be coloured and/or heavily roughened so that the resulting darker colour better integrates with the surrounding landscape (refer **Plate 6.9**).

Plate 6.9: Drainage elements at Pacific Highway Glenugie upgrade (top) and Hume Highway Woomargama Bypass (middle and below) (Source: SMM and Roads and Maritime)

6.3 Roadside furniture

Roadside furniture comprise ancillary items necessary for the effective operation of the highway. Urban design recommendations are provided for these roadside elements in order to mitigate visual impact and where possible compliment the existing landscape character.

Fauna Crossings

Fauna crossings will take the form of aerial rope-ways (refer **Plate 6.13**) as well as combined function culverts and bridge undercrofts. They provide crossing points between areas of existing vegetation that have been identified as habitat and/ or movement corridors.

Headlight Glare Attenuation Mounds

Headlight glare requires mitigation in certain circumstances to reduce light glare to oncoming traffic and local residents. Vegetated mounds will be provided in several locations, typically side roads (refer **Plate 6.10**). Frangible shrub planting has been designed for medians (refer **Plate 6.12**) in order to mitigate headlight glare on the main alignment.

Mounds have been designed to achieve a height of one metre above road level, with vegetation providing an additional 1.5 metres of screening required to achieve the minimum 2.5 metres required by Roads and Maritime standards.

Shrubs planted within the median will often be within the clear zone and therefore are required to be frangible, a specific plant mix has been developed for these locations..

Safety Barriers

Safety barriers along the road side generally consist of 'wire rope safety barriers', with steel 'W beam' or 'Thrie beam' designed for highway bridges and culverts. Other barriers include 'Monowills' steel tube barriers where pedestrian or maintenance staff safety is a potential issue eg where a fall height risk occurs.

Overbridge piers will be protected with concrete 'Type F' barriers ('Jersey Kerb'). Solid barriers of this type are generally only used where a specific safety risk occurs or where visibility from the road is not a priority.

Fencing

Fencing on the proposed upgrade consists of road corridor boundary fencing and fauna fencing. To minimise fencing requirements a combined boundary/ fauna fence will be employed in some locations, similar to that used on the Glenugie upgrade (refer **Plate 6.11**) The ultimate fence design is subject to approval by relevant authorities.

Urban design recommendations for roadside furniture are provided in **Table 6.4.**

A detailed description and locations of furniture can be found in the **Pacific Highway upgrade, Woolgoolga to Glenugie Road Furniture Detailed Design Drawings** (APBJV, 2013).

Plate 6.10: Headlight glare screening mound on Hume Highway Woomargama Bypass (Source: Roads and Maritime)

Plate 6.11: Fauna fencing at the Pacific Highway Glenugie upgrade (Source: SMM)

Plate 6.12: Wire-rope barriers and vegetated median on the Pacific Highway Bonville Bypass (Source: SMM)

Table 6.4: Summary of urban design recommendations for roadside elements

ROAD ELEMENT	LOCATION	RECOMMENDATION	RATIONALE
FAUNA CROSSINGS	All locations	¬ Fauna crossings are generally to be located under bridges and in culverts under the highway. Large fauna overpass structures will be required in some locations ¬ Fauna crossings in culverts under the highway will have vegetation at either end of the culvert to better integrate the structure into the surrounding landscape, and to provide some protection for fauna entering and exiting the culvert.	¬ Avoid the physical and visual intrusion of road-related elements on the local landscape. ¬ Provide specific planting for connectivity and integration of fauna structures. Planting to replace structures over time.
NOISE AND HEAD LIGHT GLARE ATTENUATION WALLS	All locations	¬ Vegetated landforms (mounds) are proposed in order to mitigate headlight glare. ¬ Frangible shrub planting in medians on bends.	¬ Avoid the physical and visual intrusion of road-related elements and structures on the local landscape. ¬ Landscape mounding to be planted to integrate with the surrounding landscape. ¬ Planting in medians contributes to landscape aesthetic and assists to integrate the project into the existing landscape.
SAFETY BARRIERS	All locations	¬ The preferred type of road safety barrier is Wire Rope Safety Barriers (WRSB), however this depends on a number of factors. ¬ In general, full height concrete barriers are to be avoided as they restrict views to the surrounding landscape.	¬ Allow for visual connections from the highway to the local landscape, to avoid the creation of an anonymous motoring experience.
	Adjacent to bridge abutments	¬ A combination of Type F concrete barriers, steel W beam and WRSB will be used depending on the location, type of bridge and hazard and available width.	¬ Consistency with other sections of the Pacific Highway in this region. ¬ Facilitate views from the highway to the surrounding landscape, to provide a sense of connection to the local area.
	At the top of fill embankments and other roadside situations	¬ WRSB where sufficient width available for deflection zone and as appropriate for the hazard.	¬ Facilitate views from the highway to the surrounding landscape, to provide a sense of connection to the local area.
	At medians	¬ WRSB where sufficient width available for deflection zone and as appropriate for the hazard.	¬ Minimise the visual scale of the highway from the motorist's perspective. ¬ Consistency with other sections of the Pacific Highway in this region.
FENCING	Boundary	¬ A combination or hybrid of standard Roads and Maritime boundary fencing and fauna fencing is required as many cadastral boundaries back onto the road corridor and the land is often densely vegetated so is likely to contain fauna. ¬ In cut batters, locate fences on higher tiers and setback from the edge of road.	¬ Combination fencing avoids doubling up of fence types, which are a cost and visual burden for the project. ¬ Care needs to be taken in fauna fencing design to ensure that harm to specific fauna species is minimised. ¬ Locate in upper tiers of cut batters to reduce visibility.

Plate 6.13: Fauna culvert crossing and mini wetland habitat provision on the Pacific Highway upgrade, Sapphire to Woolgoolga (Image source SMM)

6.4 Planting and revegetation methods

Landscape treatments used on the upgrade will comprise three key methodologies, these are:

- Planting (refer **Plates 6.14 - 6.17**)
- Revegetation (Seeding)
- Bushland reconstruction.

Planting

Planting will primarily be undertaken on fill batters (2H:1V or flatter) in locations where Bushland Reconstruction is not possible (refer **Plate 6.14** and **Landscape drawings**). Planting will also be undertaken on headlight attenuation mounds (refer **Plate 6.10**) and in some median areas to help control headlight glare (refer **Plate 6.15**). Other areas to be planted include areas adjacent to culverts and fauna crossing structures. Tree species throughout the project will be planted or allowed to regenerate naturally as opposed to being a seeding application.

The use of planted species will help to provide short-term impact whilst other revegetation areas are establishing. Potted stock will comprise the following sizes;

- Viro tubes (shrubs and ground covers).
- Forestry tubes (trees).

Stakes and Ties

During construction, an assessment will be made by the project design team and Roads and Maritime representatives as to the requirement for stakes and ties on this project. Staking and plant guards would be provided for initial support and removed at completion of the maintenance period.

Stakes installed as a marker for locating plants and indicating performance will be provided as part of the ongoing maintenance strategy.

Mulching

All planted areas will be mulched with hardwood mulch sourced from site. Mulch is to be stockpiled for 6 months prior to use in order to reduce the impacts of nitrogen draw-down on plant species.

Shredded mulch will be used in all topsoil mediums to assist with stabilisation. Details of this can be read in more detail in the landscape specifications.

Straw mulch will be used in hydromulching applications and also in some planting situations, for instance where mulch needs to be placed by hand due to operational requirements.

Topsoil

Topsoil will comprise site won topsoil with ameliorants added as determined through site soil testing during construction. Typical ameliorants will include shredded mulch, gypsum and urea, in order to improve the physical and chemical properties of the soil and to reduce erosion.

Turfing

Turf sods have been determined as the preferred revegetation treatment for inside verges and outside verges, where receiving surface drainage (low side) and no 'SO' concrete gutter is present. A 900 mm wide strip of turf will be provided along the interface between sealed pavement and planted or seeded batters in order to provide a more robust edge. The turf species selected is *Cynodon dactylon* (Common Couch) (refer **Plate 6.19**).

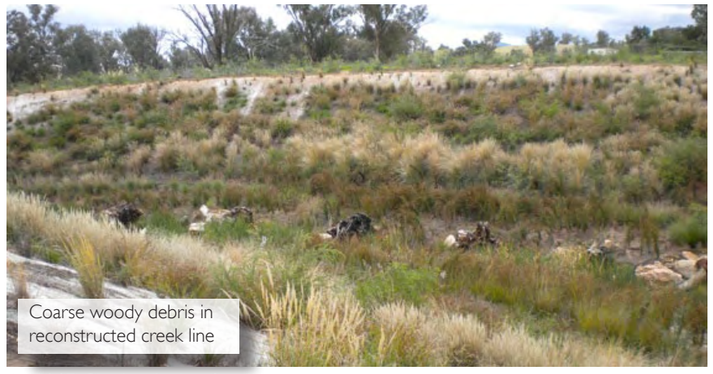


Plate 6.17: Riparian planting after two seasons

Plate 6.16: Roadside tree planting after two seasons

Plate 6.14: Roadside shrub planting after two seasons

Plate 6.15: Median shrub planting after two seasons

Revegetation

Seed Mixes

A number of different seed mixes have been developed to compliment the existing vegetation communities adjoining the upgrade and have been designed for the various different surface types and locations. Species mixes are defined in the project landscape drawings.

Where the specified type and volume of seed cannot feasibly and reasonably be sourced from the proposed clearing footprint or the immediate local area, seed is to be sourced from within the NSW North Coast bioregion (as defined by the Interim Biogeographic Regionalisation for Australia).

Seeding techniques

A combination of seeding techniques will be employed:

- Hydromulching
- Direct Drill Seeding
- Compost blanket (provisional treatment).

Hydromulching consists of a mixture of seed, straw and bonding agent and will be sprayed over areas and batters (3H:1V or steeper) including drainage channels (refer **Plate 6.18**) in accordance with Roads and Maritime **Specification R178**.

Direct drill seeding is to be used for median and roadside areas where slopes are flatter and a successful early strike rate for germination is required. Seeding rates for direct drill seeding will be in accordance with Roads and Maritime specifications as customised for the upgrade and will also depend on seed availability.

Covercrop

A cover crop is to be applied to batters, verges, basins, channels and stockpiles, generally any surface requiring stabilisation during the works regardless of the ultimate landscape method employed. Covercrop species will comprise species and application rates in accordance with Roads and Maritime specification R178 and be applied either as a single application (with final treatment to follow) or in conjunction with other seed mixes as an all-in-one application.

Compost blanket

During the detail design stage, geotechnical investigation has determined that many of the cuttings will expose underlying geological material that may not be suited to standing up at steeper grades of 0.75H:1V. These batters will be laid back to a flatter grade of 2.5H:1V in order to minimise erosion of the geological material. Low strength rock may also require that a surface treatment such as compost blanket be applied to prevent erosion.

Compost blanket comprises a bonding agent blended with site topsoil, organic fibres and local provenance seed, which is then sprayed over the batter surface as an integral layer. As with any seeding process time of year considerations are important to ensure the best growth outcome and to minimise re-spraying. Covercrop can be added to the mixture for initial growth and stabilisation whilst native seed may take longer to strike.

The likely scenarios for use of compost blanket are:

- Low strength rock encountered in lower 3 metres of cutting;

Preparation will include:

- Batter laid back to 2.5H:1V and ripped;
- Compost blanket will be applied to a depth of 50mm;
- At ends of batters tail-off the treatment in a bottom-to-top fashion
- Care needs to be taken at the junction of materials in order to reduce the risk of erosion eg using jute mesh at interface and keying in of materials with deeper profiles.

Plate 6.19: Turf strip installed along verge edges at Pacific Highway Kempsey Bypass (Source: Roads and Maritime)

Plate 6.18: Hydroseeding of median invert and direct drill seeding of median batters on the Hume Highway Woomargama Bypass at time of installation and after 2 seasons (bottom) (Source: Roads and Maritime and SMM)

Bushland Reconstruction

Bushland Reconstruction is a revegetation strategy that was employed on the Pacific Highway Glenugie upgrade (completed 2010) and has since been employed on a other Roads and Maritime projects. The methodology been identified as a suitable revegetation methodology for the Woolgoolga to Glenugie project due to its proximity to the Glenugie upgrade and similar landscape types. The enclosed nature of the forest affords an abundance of seed, which allows for native forest regeneration and establishment to occur naturally. There is also an availability of mulch material from clearing operations that can be incorporated into the topsoil medium.

By making use of natural regeneration and natural materials, the quantity of planting and seeding can be minimised and restricted to specific locations. It also means that the quantity of imported materials can also be reduced, which reduces project costs and reduces the reliance on the transportation of materials (and resulting greenhouse emissions). Some construction processes may become less efficient, however these costs are outweighed by a reduced reliance on imported materials and more expensive revegetation techniques.

Design considerations

- Environmentally sustainable design approach, minimises carbon footprint through reduced transportation of materials.
- Utilises seed already in topsoil, in forest environments, where new highway is offline (and generally weed free).
- Efficiency of delivery and cost savings;
- Better visual and environmental integration with existing landscape.

Site topsoil testing and amelioration requirements

The following is a guide to testing procedures that requires site testing and procedures in accordance with Roads and Maritime specifications:

- Soil testing and analysis of texture, chemistry and amelioration requirements;
  - Typically low pH and low nutrients can be expected
- Amelioration requirements typically comprise:
  - Urea at 50kg/Ha (to counteract Nitrogen draw-down caused by addition of woody material)
  - Phosphorous 10kg/Ha (to replace loss of nutrients)
  - Potassium 90kg/Ha (to replace loss of nutrients)
  - Calcium (gypsum) 100kg/Ha (to flocculate clay particles and reduce erosion).
- Soil mix composition has been specified as:
  - Mulch/ trash 40% by volume
  - Ameliorated topsoil 60% by volume.

Implementation and construction processes

The following is an outline of construction processes to be refined during construction and undertaken in accordance with Roads and Maritime specifications:

- Site induction/ operator education;
  - Contractor buy-in critical in order to achieve positive outcomes.
  - Led from the outset by environmental staff during clearing works.
- Vegetation clearing in incremental corridors, initially to avoid watercourses;
- Topsoil stripping and stockpiling managed in lineal 'wind-rows' adjacent to main alignment and within corridor.
  - Stockpile locations and re-use as close as possible to original location of stripping.
- Batter creation and preparation:
  - Batters surface prepared roughly to promote engagement of subsoil with topsoil mixture.
  - Rip/ tyne batter surface parallel with contour to promote infiltration.
- Large stone floaters to be assessed on-site, options as follows:
  - Leave insitu and exposed.
  - Rip to 250mm below finished levels and cover with subsoil/ topsoil.
- Soil mixture (combined topsoil and mulch) depth up to:
  - 300 mm thick.
  - Shallower depths may be required for non-alluvial soils, or should site-won materials prove insufficient.
- Soil mix implementation;
  - Site topsoil stripping to 100m depth approx.
  - Mulching of stems, branches and twigs down to 20mm in diameter.
  - Tub grinding of larger branches and trunks, however coarse woody material can also be used for habitat creation on batters and near water courses.
  - Mulch is to be composted for a minimum of 6 months to reduce Nitrogen draw-down and improve integration with topsoil. Over-composting may damage seeds. Mulch will be stockpiled in linear "wind-rows" to reduce spatial conflict with construction activities.
  - Soil mixture created on-site in rough proportions of "1 barrow of mulch to 2 buckets of topsoil" (40/60).
  - Soil mixture surface prepared roughly to promote water ponding and minimise erosion.

Operational characteristics, difficulties and potential improvements

The following is an outline of potential constraints and improvements to be refined during construction and during the maintenance period:

- Consistency of coverage is dependant on localised variations in topsoil and seed.
- Open drainage channels to be lined with double layer of jute netting with different sieve, to create three dimensional stabilised layer.
- Medians will be revegetated as planting or seeding as opposed to Bushland Reconstruction as they are typically slower to establish and more susceptible to erosion.
- Road corridor boundary/ spatial requirements may impede space available for stockpiling:
  - Operational/ spatial requirements to be carefully managed during construction.
  - Stockpile locations and spatial requirements are to be allocated during design phase.
  - Acceptance that double-handling will be required and that double-handling does not necessarily equate to additional costs or wasted time due to the revegetation methodology having other benefits to the project.
- Required inputs during construction – technical, Roads and Maritime, Soil Con etc.

- ¬ Flexible approach to site management and agency approvals once agency buy-in achieved.
- ¬ Roads and Maritime management of Day 1 expectations (community and government communication).

- Monitoring of test plots - minimum 2 square metres) during construction (field trials). Set up different scenarios/ conditions/ depths, to determine:
  - ¬ Whether additional mulch overlay required.
  - ¬ Whether covercrop overlay required.
  - ¬ Whether seeding overlay required.
  - ¬ Amount of amelioration required for each soil type;
  - ¬ Monitor plant growth.
- Maintenance outcomes/ expected requirements.
  - ¬ In clear zones maintenance will include removal of non-frangible species, however it will take several years for this to become an issue and is an issue in forest environments regardless of the revegetation methodology.
  - ¬ Ends of batters, medians and shaded areas may take longer to establish and may require several covercrop and/ or seeding overlays;
  - ¬ Overall maintenance requirements considered to be less, in terms of cost and labour, than standard revegetation techniques. Cost benefit to the overall project.

Implementation Checklist

The following is a typical checklist that would refined during construction to ensure that all recommendations made by the project's Soil Scientist and the Environmental Manager are implemented.

- Complete colour coded map of all areas detailing treatments that were applied, include:
  - ¬ Treatment type (as per above excerpt from Soil Scientist's report) and date of application/treatment for each lot/area.
  - ¬ Seed mix type (cover crop) for each area.
  - ¬ Seed mix type (native) for each area.
  - ¬ Information of any direct seeding (natives).
  - ¬ Mulch/topsoil mix % for each area.
  - ¬ Fertilizer application rates and types for each area. Ensure application is not carried out in a manner that could contaminate drainage lines.
  - ¬ Details of any herbicide application for each area in accordance with R178. Ensure application is not carried out in a manner that could contaminate drainage lines.
  - ¬ Details of any weed removal (by hand) including location. To be plotted on a map.
- Photo points – Ensure photos are taken monthly at the established monitoring locations (plotted on map with GPS coordinates). Data obtained is to be used to:
  - ¬ Monitor progress of rehabilitation works.
  - ¬ Modify treatments and identify areas requiring further attention.
- Erect signage in accordance with R178 and R179.
- Details of any seed suppliers (name, address, etc) used (native and cover crop) and details of seed certification or seed treatment by the supplier.

Refer **Figures 6.12-6.21** for vegetation mapping and key landscape treatment locations.

For detailed locations of landscape treatments refer to the Landscape drawings (**W2G-1-UL-DG-0000 - 0129** and **W2G-2-UL-DG-0000 - 0123**).

Refer to Roads and Maritime **Specification R179** for planting methodologies and maintenance requirements.

Refer to **Specification R178** for seeding and Bushland Reconstruction methodologies and maintenance requirements.

Plate 6.20: Revegetated surface at six months post-installation (above) and eighteen months post-installation (below)

Pacific Highway Glenugie upgrade (Source: Roads and Maritime and

Planting and Revegetation Summary

The methodologies are summarised in the following Table (refer **Table 6.5**).

Table 6.5: Revegetation Methodologies and location of use

TECHNIQUE	LOCATION OF USE	DOCUMENTATION	OPPORTUNITIES	CONSTRAINTS	COMMENT
Seeding: Native shrub, groundcover and grass seeding;	¬ Online sections of highway or highway passing through agricultural areas. ¬ Cut batters where bushland reconstruction not suitable and hard rock not encountered. ¬ Medians and verges generally.	¬ Standard Roads and Maritime specifications (R176 Seed procurement, R178 Vegetation). ¬ Preparation of species lists. Refer species lists for indicative species. ¬ Landscape drawings (W2G-1-UL-DG-0000 - 0129 and W2G-2-UL-DG-0000 - 0123).	¬ Cost effective broad-scale solution utilising endemic seed material sourced from the local region.	¬ Limited control over where specific species will germinate. ¬ Timing of seed application may suit project but not individual species.	
Planting: Native tree and shrub planting	¬ Fill embankments where bushland reconstruction method not suitable and hard rock not encountered. ¬ Medians where glare control required and not within sight-lines.	¬ Standard Roads and Maritime specifications (R179 Planting). ¬ Preparation of species lists. Refer species lists for indicative species. ¬ Landscape drawings (W2G-1-UL-DG-0000 - 0129 and W2G-2-UL-DG-0000 - 0123).	¬ Allows detailed locating of species to provide specific functions. ¬ Ensures non-frangible species are planted in appropriate locations. ¬ Day-1/ short term impact. ¬ Shrub planting on batters at 2m spacings provides acceptable coverage and long-term regeneration via seed.	¬ Expensive in relation to other techniques; ¬ Generally slower performance (with regards to larger pot sizes). ¬ Spacing/ density controlled by available budget.	¬ Tree and shrub species selections will be based on suitability to location as a priority to relationship to vegetation community origin.
Bushland reconstruction: involving the stockpiling and reuse of local topsoils combined with forest mulch containing seed.	¬ Offline sections of highway passing through or immediately adjacent to dense bushland and unlikely to contain weeds. ¬ Generally not to be used in medians or clear zones.	¬ Modified Roads and Maritime R178 specification. ¬ Glenugie upgrade and Hunter Expressway precedents; ¬ No species lists required as based on seed content of endemic topsoil and mulch. Refer vegetation mapping for likely species. ¬ Landscape drawings (W2G-1-UL-DG-0000 - 0129 and W2G-2-UL-DG-0000 - 0123).	¬ Extremely cost-effective broad-scale solution utilising combination of endemic topsoil, seed and mulch material sourced from the local region. ¬ Provides best erosion-resistant outcome due to media composition. ¬ Long-term benefits due to significantly reduced maintenance requirements.	¬ Operational difficulties, spatial constraints; ¬ Short-term appearance may be considered unsightly to the general public. ¬ Difficult to determine which areas are performing initially. ¬ Agency and general public expectations need to be carefully managed through consultation and education.	¬ Successful outcomes depend largely on contractor education and buy-in, this needs to be driven from the outset. ¬ Monitoring procedures crucial in order to determine performance.
Compost blanket: the application of a stabilised soil and seed mixture	¬ Cut batters, where bushland reconstruction not suitable, exposing soft rock that can not stand at 0.75H:1V and are laid back to 2H:1V.	¬ Modified Roads and Maritime R178 specification; ¬ Hume Highway upgrade precedents (Woomargama and Tarcutta).	¬ Stabilisation of loose rock surface. ¬ Visual integration with other grass seeding areas.	¬ More expensive than normal seeding techniques (use needs to be targeted to specific areas). ¬ Requirement of specialist sub-contractor.	¬ Forms part of shotcrete avoidance strategy.
Turfing	¬ Inside verges and outside verges (low side) receiving overland flow.	¬ Standard Roads and Maritime R178 specification. ¬ Landscape drawings (W2G-1-UL-DG-0000 - 0129 and W2G-2-UL-DG-0000 - 0123).	¬ Relatively cost-efficient and robust stabilisation technique suited to lineal application.	¬ Visual appearance contrasts with native grass species; ¬ Will invade sealed asphalt surfaces over time.	¬ Maintenance regime required to ensure establishment and initial management.

6.5 Planting and revegetation species

The vegetation communities along the upgrade corridor were identified in the **Woolgoolga to Ballina Biodiversity Assessment** (W2BPA 2012). Vegetation mapping was used to determine locations of communities and to define a broad list of species. A planting and revegetation palette was then developed for the upgrade. These vegetation communities are summarised in **Table 6.6**.

Species selection rationale

The following considerations determined the proposed species list:

- Seeding and planting mix species will comprise species from the appropriate vegetation communities that are considered to perform better under the modified conditions. This will allow the establishment of more suitable conditions over time for more sensitive species to regenerate naturally.
- The first pass of seed procurement is to be from cleared site areas, particularly from any trees that are being commercially sold for lumber. In Bushland Reconstruction areas seed heads can be retained for use in mulch material added to the topsoil medium.
- Bushland Reconstruction areas will by default comprise species of local provenance due to the use of topsoil embedded with seed from adjacent native vegetation.

FORMATION		COMMUNITY/ ASSOCIATION	HABITAT AND SOILS
1	**Swamp Forest**	1A Swamp Mahogany/ Forest Red Gum Swamp Forest; 1B Swamp Oak Forest; 1C Swamp Mahogany/ Paperbark Forest; ¬ Swamp Sclerophyll Forest on Coastal Floodplains (Paper bark) EEC.	Low-lying wet depressions with poor drainage, near or on floodplains of creeks with permanent water or fringes of dams. Saline influences near the coast. Soils: Poorly drained, sandy or alluvial.
2	**Moist Forest**	2A Moist floodplain Eucalypt Forest. ¬ Subtropical Coastal Floodplain Forest on Coastal Floodplains EEC.	Broad, flat to slightly undulating floodplains Soils: Deep, well-drained alluvial deposits. Typically modified by agricultural activities.
3	**Dry Forest**	3A Needlebark/ Stringybark/ Scribbly Gum Forest; 3B Spotted Gum/ Ironbark Open Forest; 3C Spotted Gum/ Square-fruited Ironbark Open Forest 3D Blackbutt Open Forest;	Sandstone ridges and upper slopes with areas of sandstone outcrops or slightly elevated flat plains above and adjoining floodplains. Soils: Well-drained, weathered sandstone or clays.
4	**Riparian**	4A Freshwater Wetland	Low elevated depressions on floodplains. Soils: Alluvial

Table 6.6: Revegetation methodology: vegetation communities

Species Lists

The vegetation communities cited in Section 02 of this report have been identified in the **Woolgoolga to Ballina Biodiversity Assessment** (Woolgoolga to Ballina Planning Alliance 2012). These communities have been used to generate revegetation species mixes for use on the project.

MIX TYPE	COMMUNITY/ ASSOCIATION	DOMINANT CANOPY SPECIES	OTHER CANOPY SPECIES	DOMINANT SHRUB SPECIES	GROUNDCOVER SPECIES	IMAGES
01	SWAMP FOREST					
	¬ Swamp Mahogany/ Forest Red Gum Swamp Forest. ¬ Swamp Oak Forest. ¬ Swamp Mahogany/ Paperbark Forest. ¬ Swamp Sclerophyll Forest on Coastal Floodplains (Paper bark) EEC.	*Casuarina glauca (SSF)* *Eucalyptus robusta (SSF)* *Eucalyptus resinifera (SSF)* *Eucalyptus tereticornis* *Melaleuca quinquenervia (SSF)*	*Corymbia gummifera* *Corymbia maculata* *Eucalyptus acmenoides* *Eucalyptus fibrosa* *Glochidion ferdinandi (SSF)*	*Acacia elongata var. elongata* *Acacia longifolia* *Acacia melanoxylon** *Acacia oshanesii** *Baccharis halimifolia* *Banksia oblongifolia (SSF)* *Banksia spinulosa var. collina* (SSF)* *Callistemon citrinus* *Callistemon pachyphyllus* *Callistemon salignus (SSF)* *Dodonaea triquetra* (SSF)* *Eustrephus latifolius* *Geitonoplesium cymosum* *Hakea dactyloides** *Leptospermum juniperinum* *Leptospermum polygalifolium ssp. cismontanum# (SSF)* *Leucopogon juniperinus** *Melaleuca linariifolia (SSF)* *Melaleuca nodosa* *Melaleuca sieberi (SSF)* *Melaleuca styphelioides (SSF)* *Oxylobium robustum** *Parsonsia straminea* *Pultenaea retusa** *Stephania japonica*	*Adiantum aethiopicum (SSF)* *Ageratina adenophora* *Baloskion tetraphyllum subsp. meiostachyum* *Baumea articulata (SSF)* *Baumea rubiginosa* *Baumea teretifolia* *Blechnum cartilagineum* *Blechnum indicum (SSF)* *Calochlaena dubia (SSF)* *Carex appressa (SSF)* *Centella asiatica (SSF)* *Chorizandra cymbaria* *Dichondra repens* *Drosera spathulata* *Eleocharis gracilis* *Fimbristylis dichotoma* *Gahnia clarkei (SSF)* *Gahnia sieberiana (SSF)* *Goodenia bellidifolia* *Hardenbergia violacea* *Imperata cylindrica (SSF)* *Isachne globosa (SSF)* *Juncus prismatocarpus* *Juncus usitatus* *Lepidosperma filiforme* *Leptocarpus tenax* *Lobelia anceps* *Lomandra longifolia subsp. longifolia (SSF)* *Melaleuca thymifolia* *Oplismenus aemulus (SSF)* *Persicaria strigosa* *Philydrum lanuginosum* *Phragmites australis (SSF)* *Pteridium esculentum* *Schoenoplectus mucronatus* *Schoenoplectus validus* *Schoenus apogon* *Schoenus brevifolius* *Selaginella uliginosa* *Villarsia exaltata* *Viola hederacea (SSF)* *Xyris juncea*	 Left to right: *Eucalyptus robusta* (Swamp Mahogany), *Casuarina glauca* (swamp she-oak), *Melaleuca quinquenervia* (Broad-leafed Paperbark). ***Key:*** ***Underlined species indicates species considered more suitable for the project.*** ***# Indicates endemic species must be used.*** **** Indicates indigenous bioregion (NNC/SEQ) species acceptable where endemic not possible to be sourced.*** ***+ Indicates endangered or threatened species.*** ***(SSF) indicates species consistent with Swamp Sclerophyll Forest on Coastal Floodplains (Paper bark) EEC.***

Table 6.7: Vegetation communities - MIX 01

MIX TYPE	COMMUNITY/ ASSOCIATION	DOMINANT CANOPY SPECIES	OTHER CANOPY SPECIES	DOMINANT SHRUB SPECIES	GROUNDCOVER SPECIES	IMAGES
02	**MOIST FOREST**					
	¬ Moist floodplain Eucalypt Forest. ¬ Subtropical Coastal Floodplain Forest on Coastal Floodplains EEC.	*Corymbia intermedia (SCF)* *Eucalyptus acmenoides* *Eucalyptus pilularis* *Eucalyptus siderophloia (SCF)* *Eucalyptus signata* *Eucalyptus microcorys* *Eucalyptus globoidea* *Eucalyptus propinqua (SCF)* *Syncarpia glomulifera*	*Angophora woodsiana (SCF)* *Lophostemon suaveolens (SCF)* *Melaleuca quinquenervia (SCF)* *Allocasuarina torulosa (SCF)* *Casuarina glauca (SCF)* *Glochidion ferdinandi (SCF)* *Cupaniopsis anacardioides (SCF)*	*Acacia brownii** *Acacia falcata** *Acacia fimbricata** *Acacia longifolia* *Acacia melanoxylon** *Acacia myrtifolia* *Acacia oshanesii** *Acacia suaveolens* *Acacia terminalis ssp. longiaxillaris* *Banksia oblongifolia* *Banksia spinulosa var. collina* *Bossiaea rhombifolia* *Cassytha pubescens* *Daviesia umbellata** *Dillwynia retorta* *Dodonaea triquetra** *Epacris pulchella* *Gompholobium latifolium** *Hakea dactyloides** *Hakea sericea* *Indigofera australis** *Lambertia formosa* *Leptospermum polygalifolium ssp. cismontanum#* *Leptospermum trinervium* *Leucopogon lanceolatus sp* *Lomatia silaifolia* *Melaleuca nodosa* (SCF)* *Melaleuca sieberi* *Monotoca scoparia* *Notelaea longifolia* *Ozmanthus diosmifolius** *Persoonia stradbrokensis (SCF)* *Petrophile pulchella* *Pultenaea euchila* *Pultenaea ferruginea* *Pultenaea retusa** *Pultenaea robusta* *Pultenaea villosa** *Xanthorrhoea glauca subsp. glauca*	*Andropogon avenaceus* *Caustis flexuosa* *Caustis pentandra* *Cymbopogon refractus* (SCF)* *Daviesia umbellata* *Dianella caerulea var caerulea (SCF)* *Dichelachne micrantha (SCF)* *Drosera spathulata* *Hardenbergia violacea (SCF)* *Hibbertia obtusifolia* *Kennedia rubicunda (SCF)* *Lindsaea microphylla* *Lomandra multiflora subsp multiflora (SCF)* *Panicum simile (SCF)* *Patersonia glabrata* *Phyllota grandiflora* *Platysace ericoides* *Pomax umbellata* *Ptilothrix deusta* *Themeda australis (SCF)*	   Left to right: , *Eucalyptus pilularis* (Blackbutt), *Eucalyptus acmenoides* (White Mahogany), *Eucalyptus siderophloia* (Northern Grey Ironbark). ***Key:*** ***Underlined species indicates species considered more suitable for the project.*** ***# Indicates endemic species must be used.*** **** Indicates indigenous bioregion (NNC/SEQ) species acceptable where endemic not possible to be sourced.*** ***+ Indicates endangered or threatened species.*** ***(SSF) indicates species consistent with Swamp Sclerophyll Forest on Coastal Floodplains (Paper bark) EEC.***

Table 6.8: Vegetation communities - MIX 02

MIX TYPE	COMMUNITY/ ASSOCIATION	DOMINANT CANOPY SPECIES	OTHER CANOPY SPECIES	DOMINANT SHRUB SPECIES	GROUNDCOVER SPECIES	IMAGES
03	**DRY FOREST**					
	¬ Needlebark/ Stringybark/ Scribbly Gum Forest. (03A). ¬ Spotted Gum/ Ironbark Open Forest. (03B). ¬ Blackbutt Open Forest (03C).	*Angophora floribunda (a)* *Corymbia gummifera (a, b)* *Corymbia maculata (b)* *Eucalyptus acmenoides (a, b)* *E. bancroftii (b)* *E. eugenioides (b)* *E. fibrosa (b)* *E. microcorys (c)* *E. pilularis (a,c)* *E. planchoniana (a)* *E. propinqua (b)* *E. tetrapleura+ (b)* *E. signata (a,c)*	*Allocasuarina littoralis* *Casuarina glauca* *Eucalyptus siderophloia*	*Acacia falcata* *Acacia fimbricata** *Acacia floribunda** *Acacia longifolia var. longifolia* *Acacia melanoxylon* *Acacia oshanesii** *Acacia terminalis ssp. longiaxillaris* *Acacia ulicifolia* *Banksia integrifolia** *Bursaria spinosa* *Cassytha glabella* *Comesperma ericinum* *Daviesia genistifolia* *Daviesia ulicifolia* *Daviesia umbellata** *Dodonaea triquetra** *Desmodium variabilis* *Glycine tabacina.* *Gompholobium latifolium** *Gompholobium pinnatum* *Hakea dactyloides* *Leptospermum polygalifolium ssp. cismontanum#* *Melaleuca nodosa* *Monotoca scoparia* *Ozothamnus diosmifolius* *Persoonia stradbrokensis* *Pimelea linifolia subsp. collina* *Pultenaea retusa* *Pultenaea robusta* *Pultenaea villosa** *Xanthorrhoea fulva*	*Aristida vagans* *Austrodanthonia fulva var. fulva* *Austrostipa pubescens* *Chrysocephalum apiculatum* *Cymbopogon refractus** *Entolasia stricta* *Eragrostis leptostachya* *Gahnia aspera* *Goodenia heterophylla* *Haemodorum planifolium* *Hardenbergia violacea* *Hibbertia riparia* *Hybanthus monopetalus* *Imperata cylindrica* *Lepidosperma laterale* *Lomandra filiformis subsp. filiformis* *Lomandra multiflora subsp. multiflora* *Patersonia sericea var. sericea* *Platysace ericoides* *Pratia purpurascens* *Pteridium esculentum* *Ptilothrix deusta* *Themeda australis* *Thysanotus microtuberosum* *Vernonia cinerea var. cinerea*	 Left to right: , *Angophora floribunda* (Rough-barked Apple), *Eucalyptus propinqua* (Grey Gum), *Eucalyptus planchoniana* (Needle-bark Stringybark).

Key:
Underlined species indicates species considered more suitable for the project.
 # Indicates endemic species must be used.
** Indicates indigenous bioregion (NNC/SEQ) species acceptable where endemic not possible to be sourced.*
+ Indicates endangered or threatened species.
(SSF) indicates species consistent with Swamp Sclerophyll Forest on Coastal Floodplains (Paper bark) EEC.

Table 6.9: Vegetation communities - MIX 03

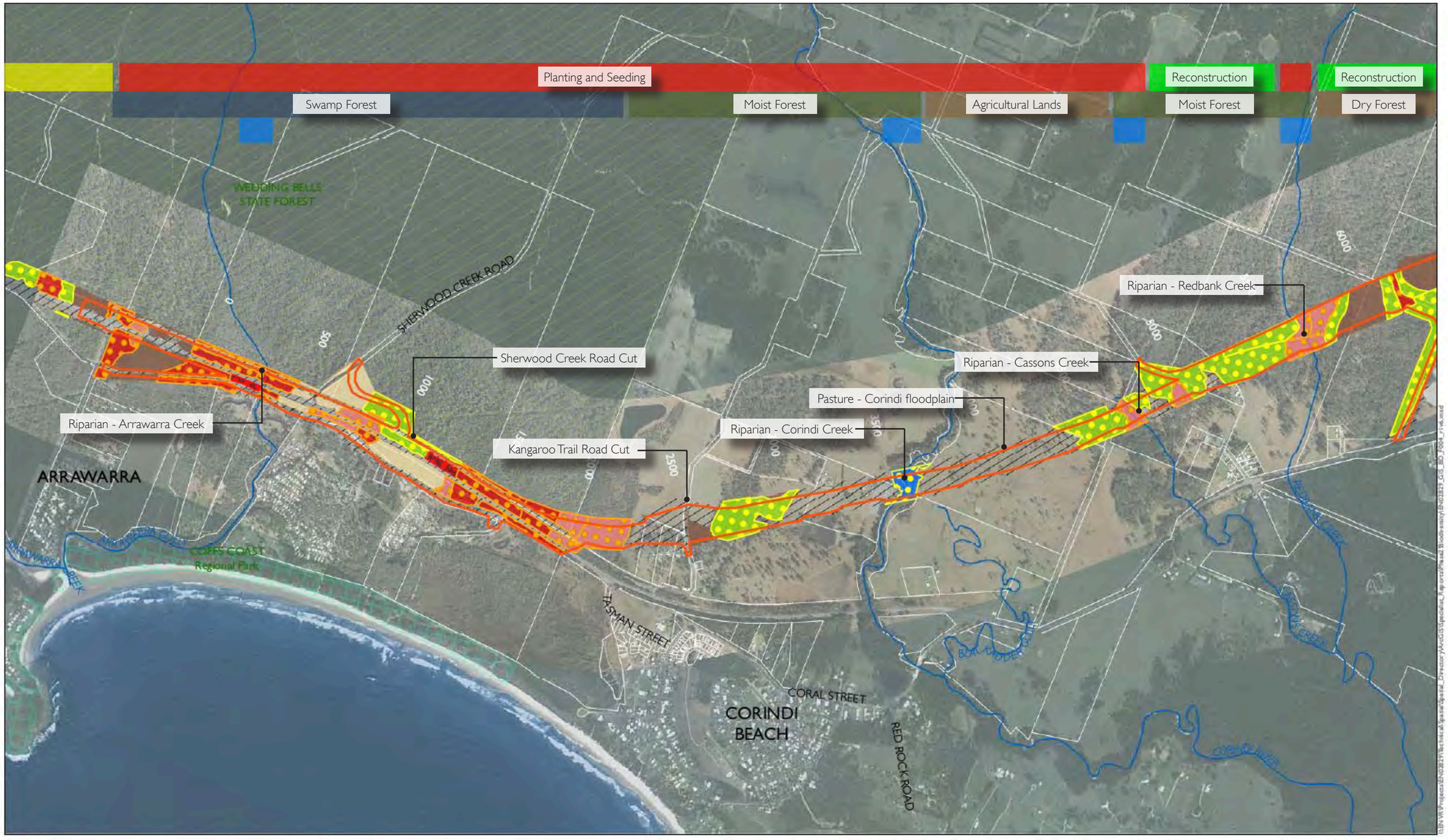
6.6 Planting and revegetation extents

As previously discussed in **Section 2.12** of this report, vegetation surveys in the study area have been undertaken on various occasions and in various formats since 2006. These surveys along with project specific surveys have been used by Woolgoolga to Ballina Planning Alliance to identify and locate these communities and in turn by APBJV to generate plant species mixes for use in the upgrade.

The following mapping provided by the Woolgoolga to Ballina Planning Alliance, outlines the locations of existing vegetation communities with an overlay provided to summarise the key landscape planting and revegetation treatments designed for the project (refer **Figure 6.12**).

For detailed information regarding planting and revegetation treatments refer to the project specifications **R178**. For designed locations refer to the Landscape drawings (**W2G-1-UL-DG-0000 - 0129** and **W2G-2-UL-DG-0000 - 0123**).

Vegetation communities of the Northern Rivers CMA (Source: Biodiversity Assessment W2B Planning Alliance).

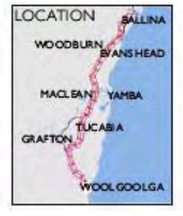


Project area at Concept Stage (subject to change)

Refer to vegetation key for existing vegetation communities likely to be found within the study area

0 500
Metres

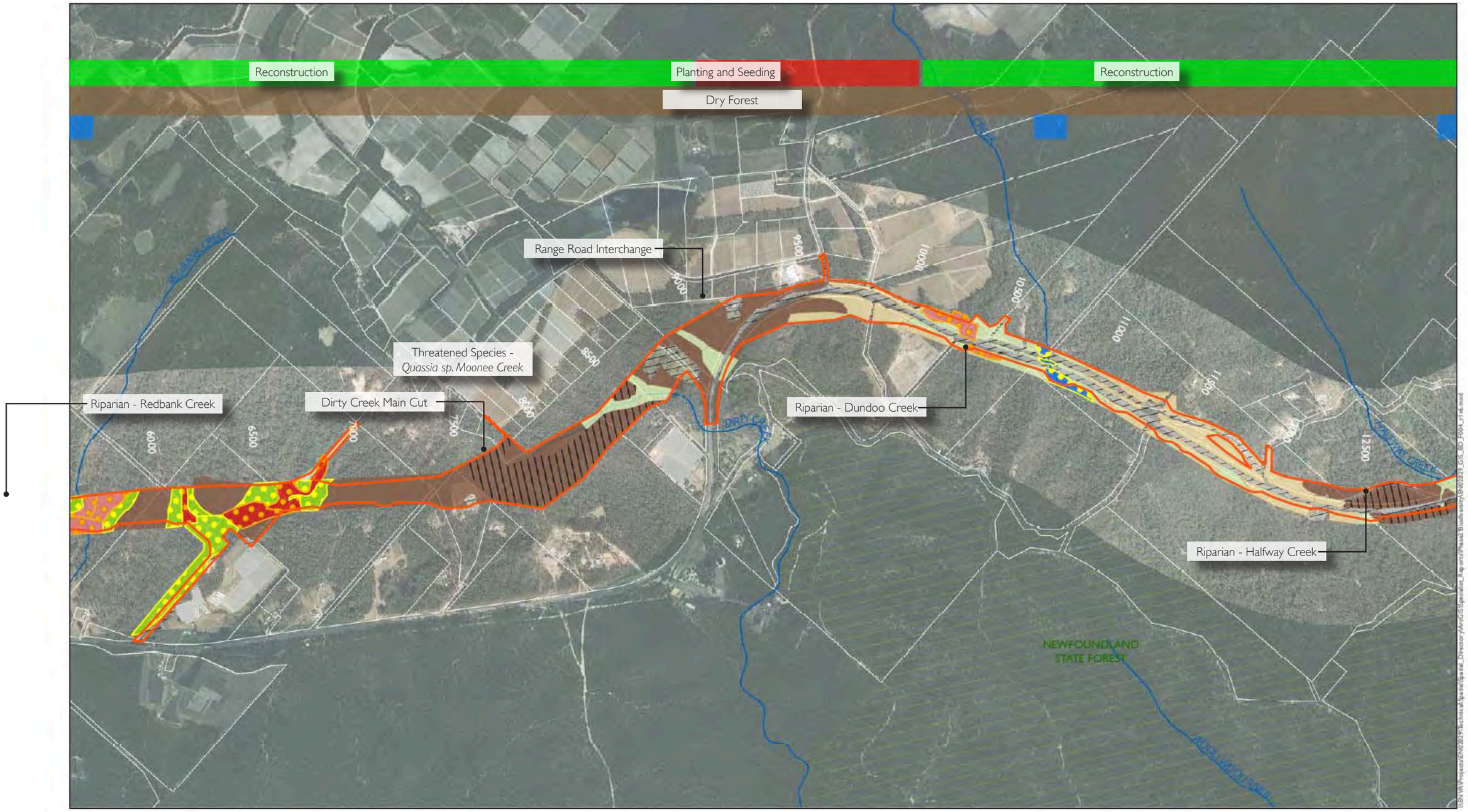
1:20,000



REVEGETATION AND PLANTING TREATMENTS

SHEET 1 OF 5

Figure 6.12: Revegetation and planting extents mapping (following pages).



Project area at Concept Stage (subject to change)

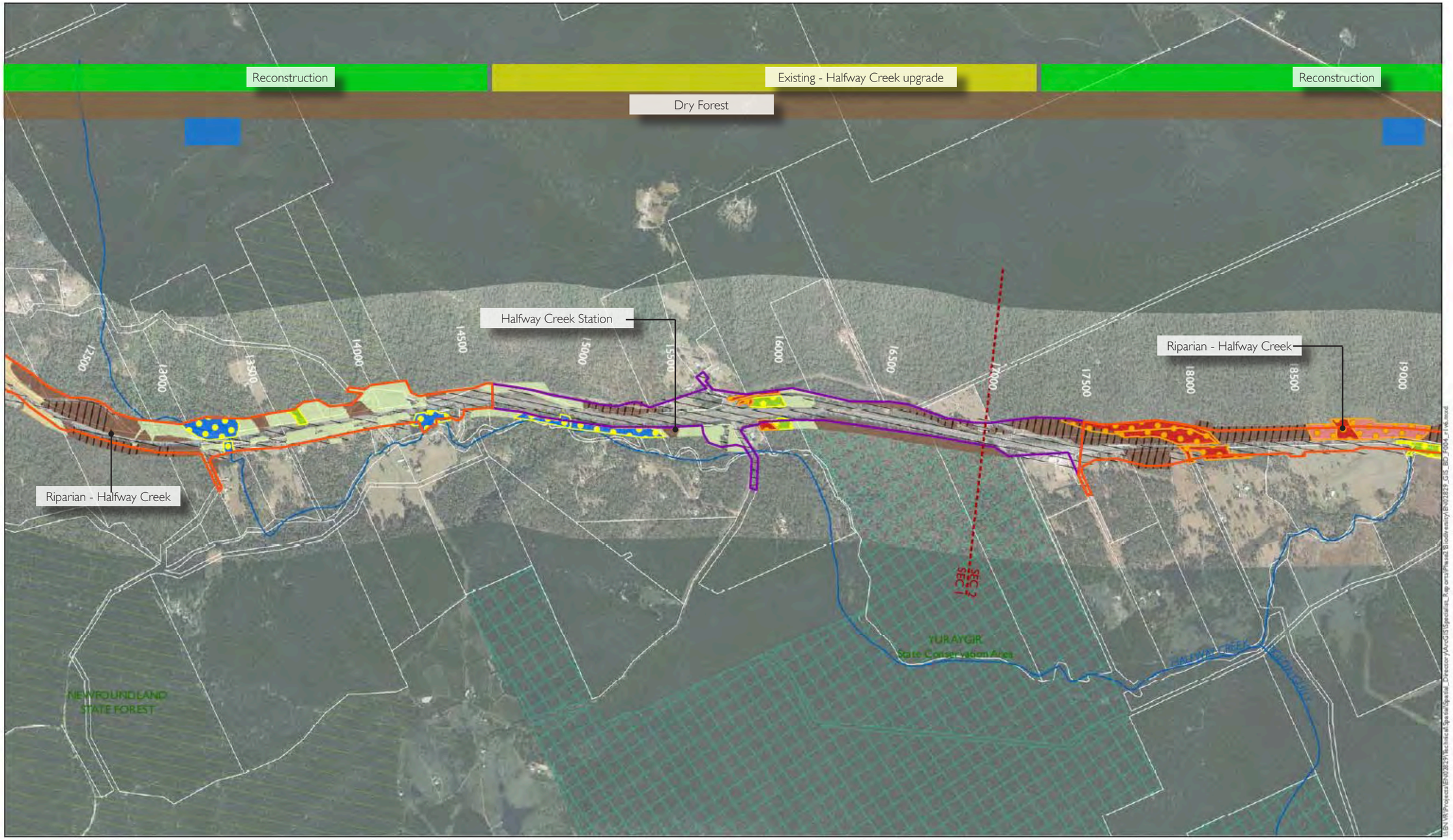
Refer to vegetation key for existing vegetation communities

0 500
Metres

1:20,000

REVEGETATION AND PLANTING TREATMENTS

SHEET 2 OF 5



Project area at Concept Stage (subject to change)

Refer to vegetation key for existing vegetation communities

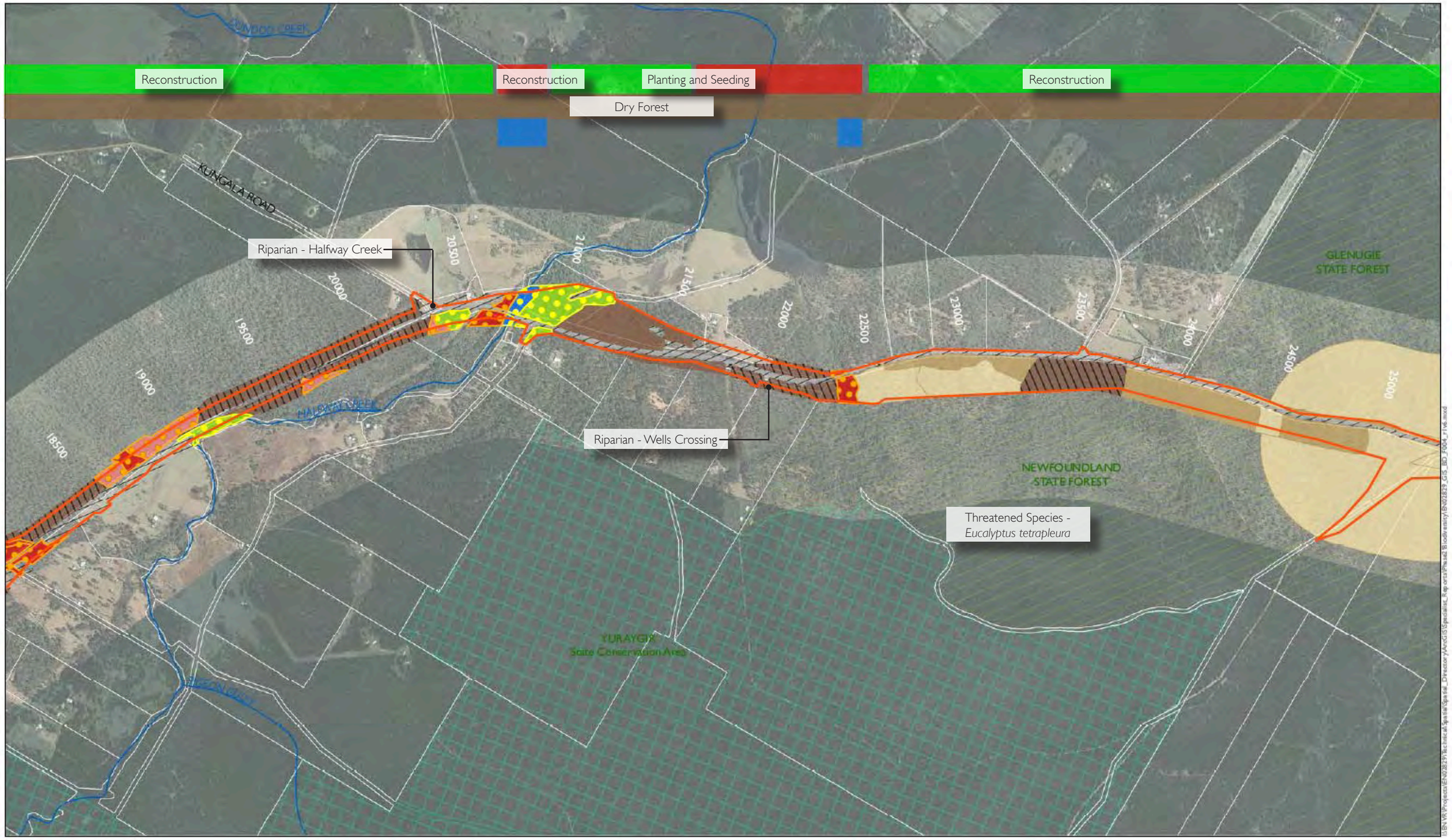
0 500
Metres

1:20,000

LOCATION
BALLINA
WOODBURN
EVANS HEAD
MACLEAN
YAMBA
GRAFTON
TUCABIA
WOOLGOOLGA

REVEGETATION AND PLANTING TREATMENTS

SHEET 3 OF 5



Project area at Concept Stage (subject to change)

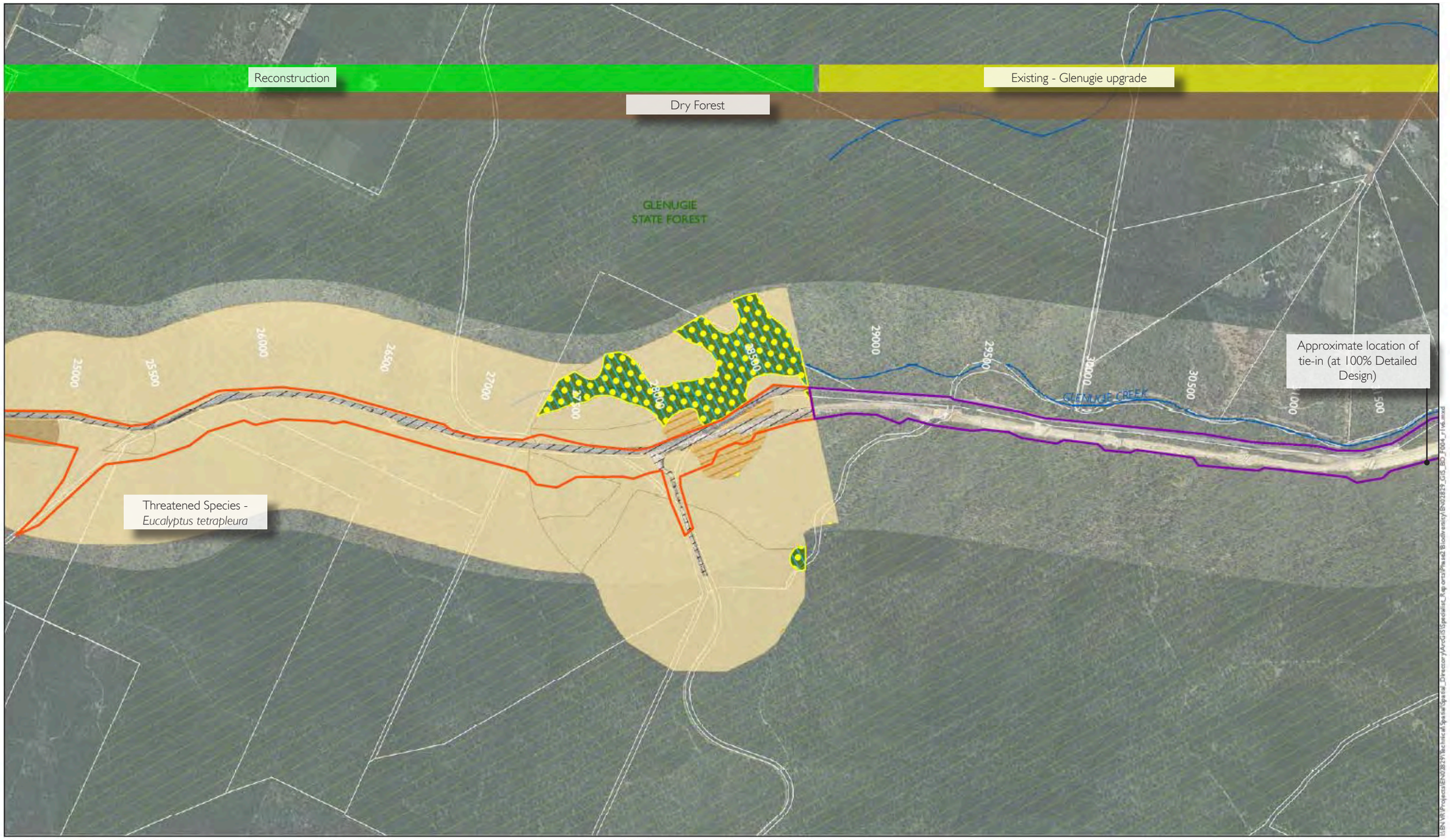
Refer to vegetation key for existing vegetation communities

0 500
Metres

1:20,000

REVEGETATION AND PLANTING TREATMENTS

SHEET 4 OF 5



Project area at Concept Stage (subject to change)

Refer to vegetation key for existing vegetation communities

0 500
Metres

1:20,000

REVEGETATION AND PLANTING TREATMENTS

SHEET 5 OF 5

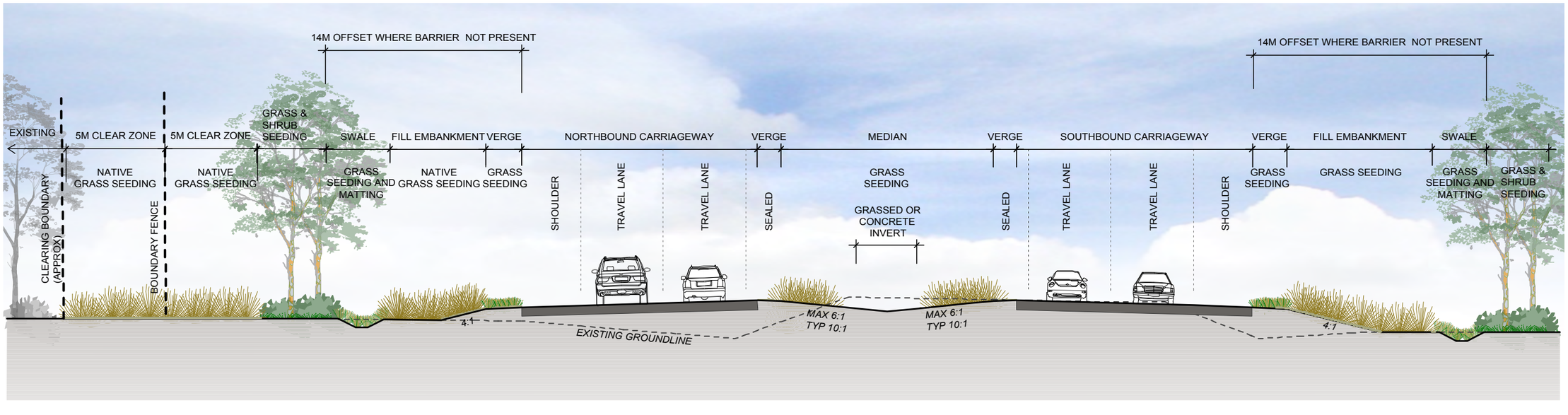


Figure 6.13: Planting and revegetation - 12m depressed median shallow fill (CH 100)

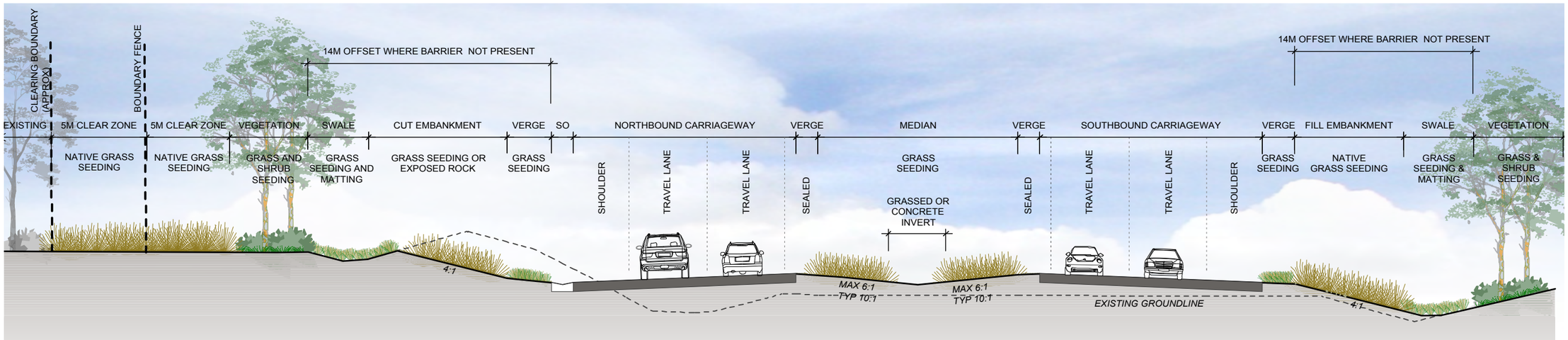


Figure 6.14: Planting and revegetation - 12m depressed median cut/fill (CH 540)

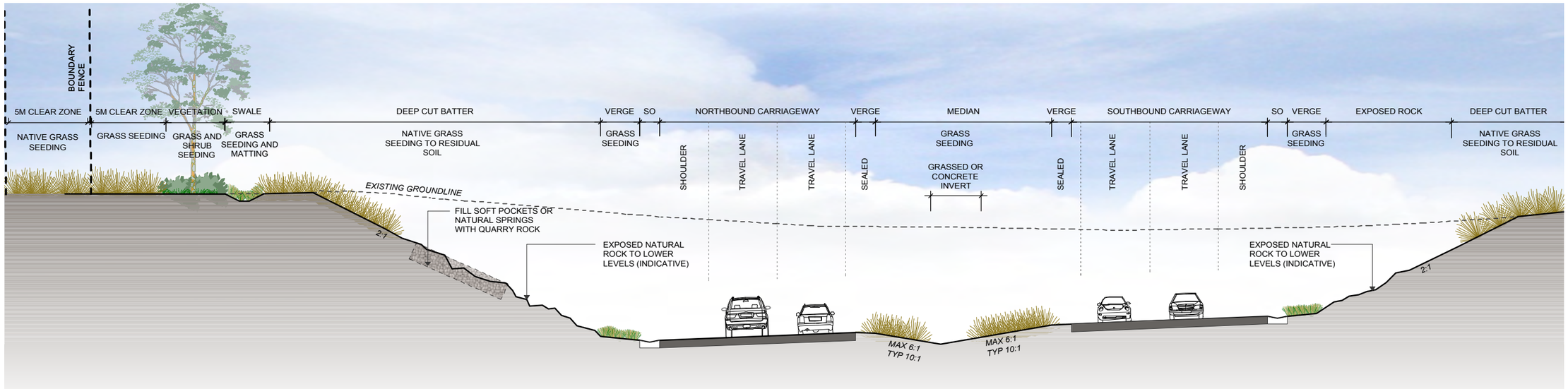


Figure 6.15: Planting and revegetation - 12m depressed median deep cut (CH 2400)

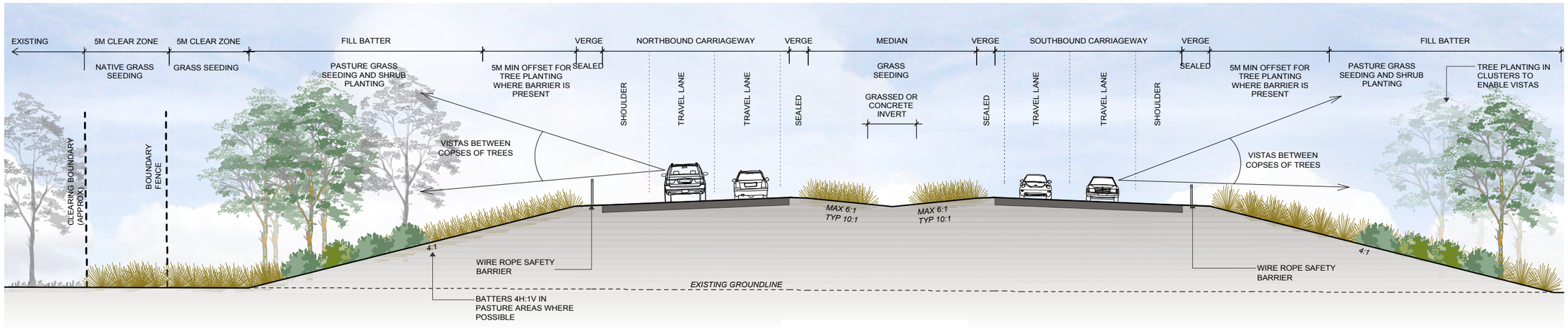


Figure 6.16: Planting and revegetation - 12m depressed median fill (CH 4400)

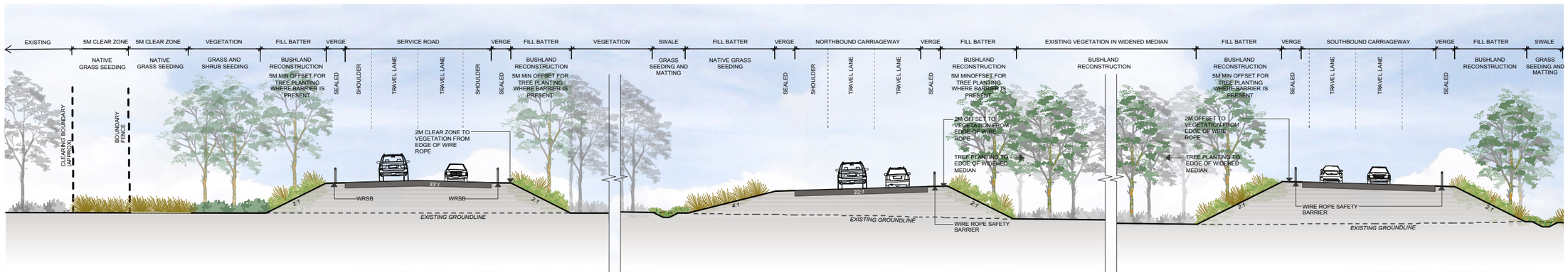


Figure 6.17: Planting and revegetation - 50m depressed median fill (CH 5700)

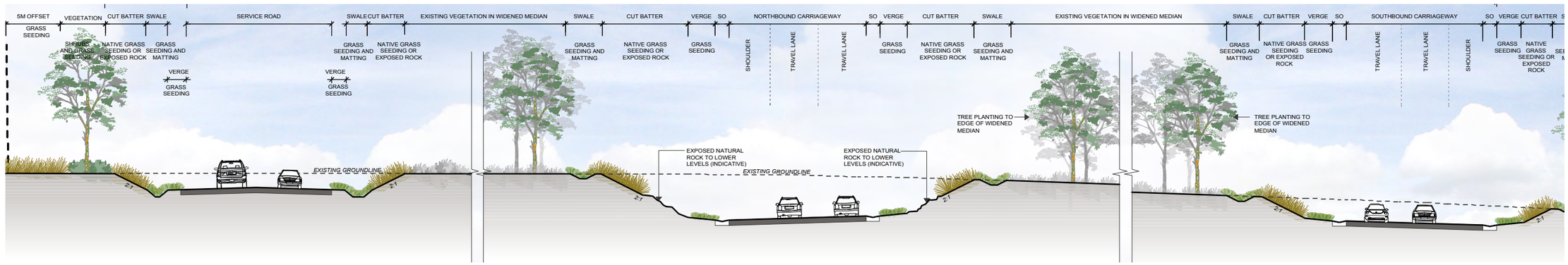
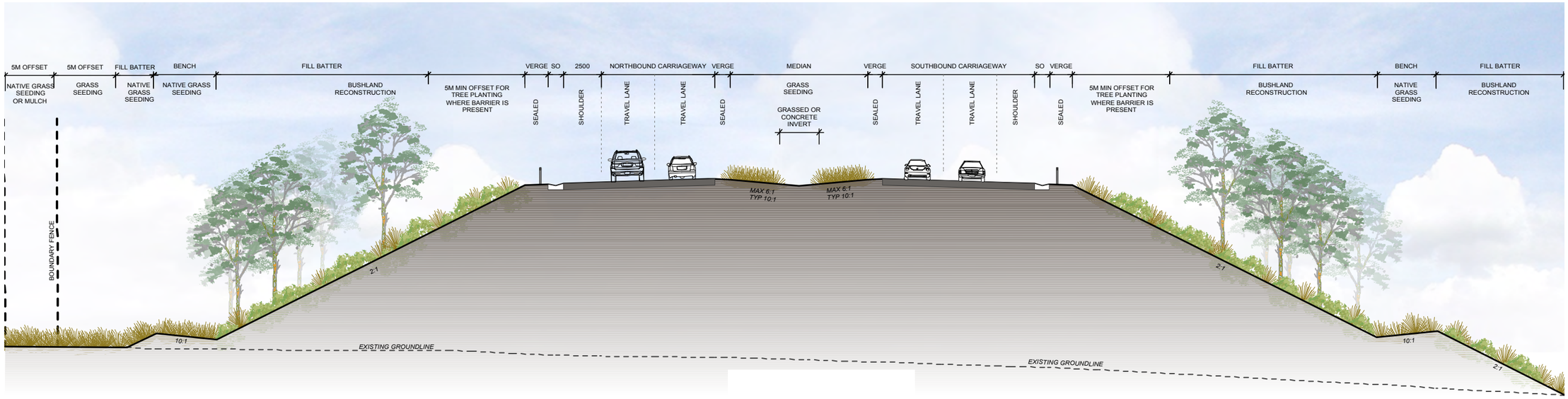


Figure 6.18: Planting and revegetation - 50m median cut (typical)

Figure 6.19: Planting and revegetation - 12m median fill (CH 7340)



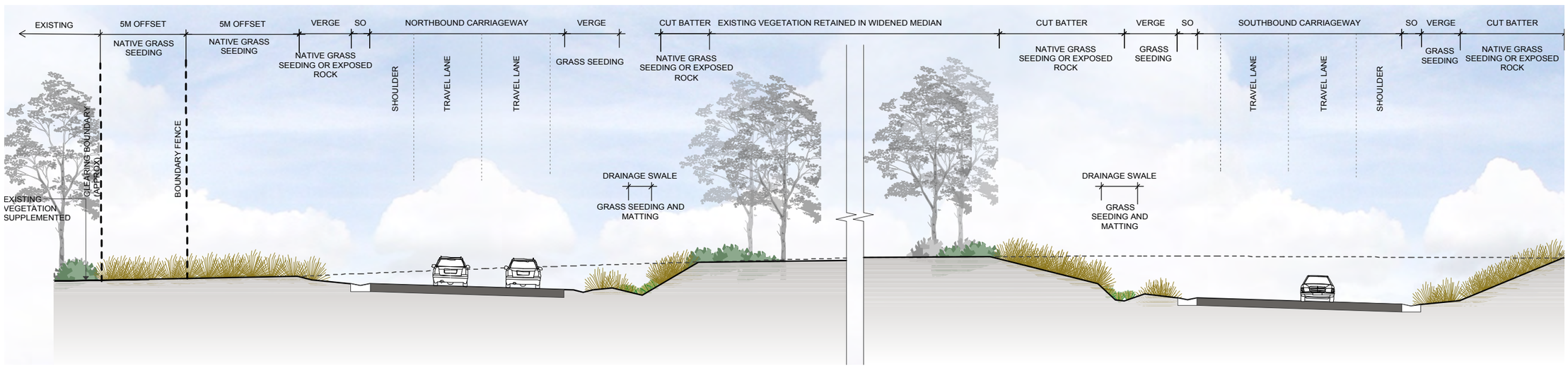


Figure 6.20: Planting and revegetation - 12m depressed wide median (CH 23400)

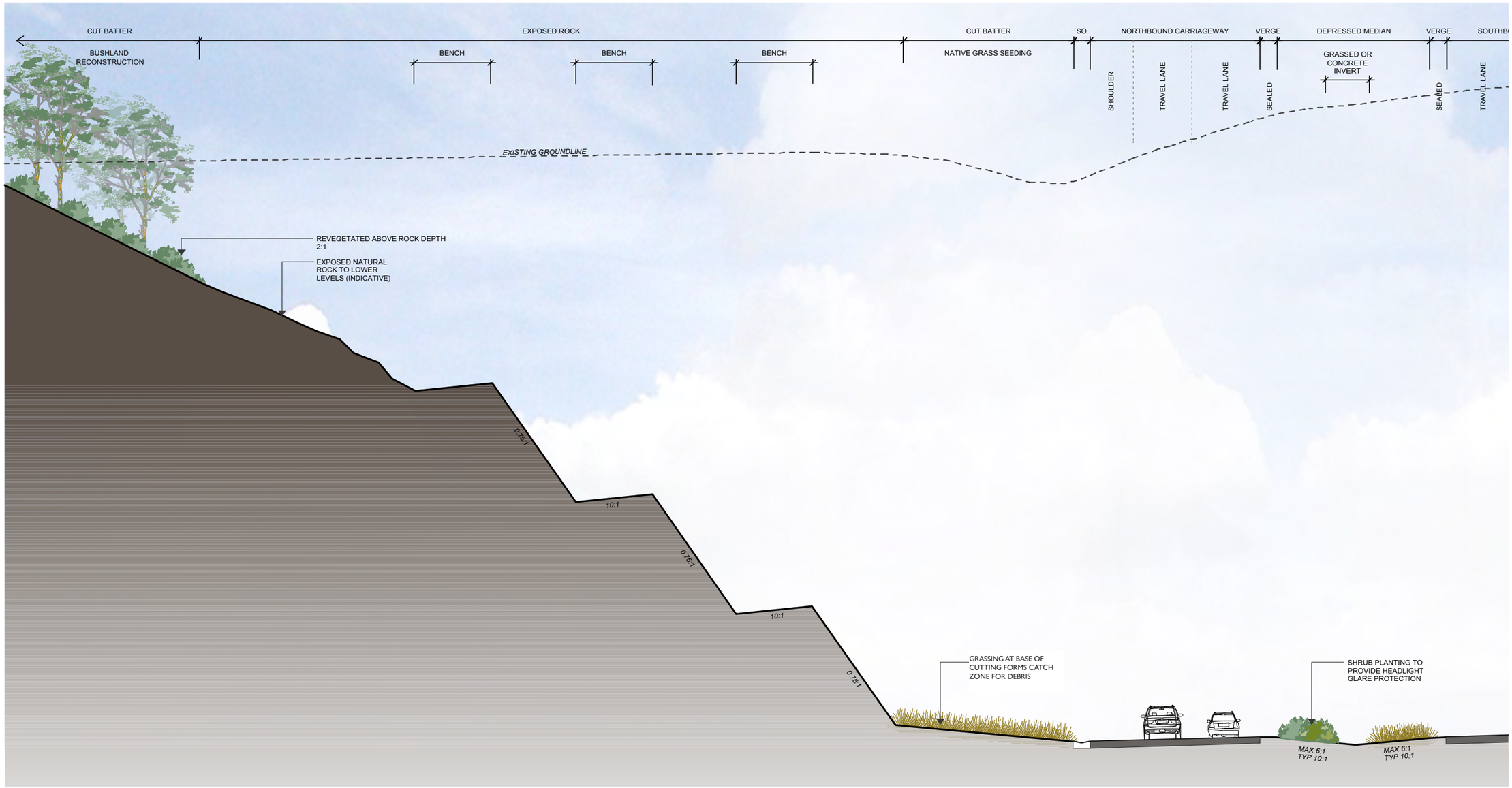


Figure 6.21: Planting and revegetation - 12m median large cut with benching (CH 7840)

6.7 Landscape management

Landscape management will be undertaken during the works and post-completion and take the form of a holistic performance review and rectification process that includes the quality control, establishment, maintenance, monitoring and ongoing assessment of:

- Topsoiling, mulching and erosion control.
- Planting and revegetation including bushland reconstruction,
- Fertilising.
- Pest control.

A landscape management program aims to maximise the performance and appearance of the upgrade, particularly at interchanges, overbridges and underpasses. Management will include replacement planting and revegetation due to failure, as well as vegetation removal if too dense or if species have germinated within offset areas.

Responsibilities

Local Council

- Existing highway and Service roads
- Rest areas and public areas.

Roads and Maritime

- Main alignment corridor.

Contractor

- All areas during construction and for post-construction maintenance period.

Maintenance areas

Different areas of the upgrade have specific maintenance requirements due to visual and/ or performance expectations, as well as having different requirements based on the landscape treatment that was applied. The areas are broken down as follows:

- Cut batters
- Fill embankments
- Basins
- Fauna crossings

Maintenance regimes

Maintenance regimes will be divided into activities, as follows:

- Pruning of vegetation for safety (sight lines, overhanging branches etc)
- Management and removal of Non-frangible vegetation (trees within safety offsets)
- Control of noxious weeds
- Rubbish removal
- Pests and diseases
- Monitoring, auditing and reporting (measures ongoing performance).

Timing of these regimes is outlined in the Landscape Management Plan, which will be further refined during construction and post-completion. Beyond the maintenance period these tasks will be managed by Roads and Maritime.

Specific details for landscape management are outlined in Roads and Maritime Specification R179-D.

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7 Appendices

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7.1 References

Roads and Maritime Services guidelines

Roads and Maritime Services, January 2014. ***Beyond the Pavement:*** RTA Urban Design Policy, Procedures and Design Principles.

RTA, November 2005. ***Pacific Highway Urban Design Framework***.

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RTA, June 2005. ***Shotcrete Design Guideline:*** Design guidelines to avoid, minimise and improve the appearance of shotcrete.

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Hassell Ltd, May 2012. ***Pacific Highway upgrade Woolgoolga to Ballina Urban Design Report Landscape Character and Visual Impact Assessment*** (First Draft).

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Sapphire to Woolgoolga upgrade Alliance, October 2009. ***Pacific Highway upgrade Sapphire to Woolgoolga Urban Design Report*** (First Draft).

Spackman Mossop Michaels, October 2009. ***Pacific Highway Glenugie upgrade Alliance Urban and Landscape Design Report*** (Rev 01).

Drawings

Woolgoolga to Ballina Planning Alliance, 2012. ***H10 – Pacific Highway, Concept for Dual Carriageway upgrade, Woolgoolga to Halfway Creek, Volumes 1 to 5***. Printed date 9th March 2012;

Woolgoolga to Ballina Planning Alliance, 2012. ***H10 – Pacific Highway, Concept for Dual Carriageway upgrade, Halfway Creek to Glenugie, Volumes 1 to 5***. Printed date 9th March 2012;

Woolgoolga to Ballina Planning Alliance, 2012. ***H10 – Pacific Highway, Concept for 'M class' Dual Carriageway, Woolgoolga to Ballina, Volume 1***. Printed date 3rd February 2012.

Arup Parsons Brinkerhoff Joint Venture, (2014). ***Pacific Highway upgrade Woolgoolga to Glenugie - 100% Detailed Design - Volumes 1-6***.

Spackman Mossop Michaels (2014). ***Pacific Highway upgrade Woolgoolga to Glenugie - 100% Landscape Detailed Design drawings (W2G-1-UL-DG-0000 - 0129 and W2G-2-UL-DG-0000 - 0123), specifications R178 - Revegetation and R179. - Planting***.

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