6 Environmental assessment

This section of the review of environmental factors provides a detailed description of the potential environmental impacts associated with the construction and operation of the proposal. All aspects of the environment potentially impacted upon by the proposal are considered. This includes consideration of the factors specified in the guideline *Is an EIS required?* (DUAP 1999) as required under clause 228(1)(b) of the *Environmental Planning and Assessment Regulation 2000*. The factors specified in clause 228(2) of the *Environmental Planning and Assessment Regulation 2000* are also considered in **Appendix A**. Site-specific safeguards are provided to ameliorate the identified potential impacts.

6.1 Traffic and transport

This section provides an assessment of the potential traffic and transport impacts associated with the proposal. It is supported by the *Technical Paper: Traffic and Transport* (AECOM, 2013) which is provided at **Appendix C**.

6.1.1 Methodology

An integrated traffic modelling and forecasting approach was used to assess the existing and future traffic conditions on the Princes Highway and the local and regional road network, including the 'Sandtrack'. Details of the methodology used are provided in the *Technical paper: Traffic and Transport* (AECOM, 2013) provided at **Appendix C**.

Table 6-1 presents the traffic modelling scenarios used to assess the potential impacts of the proposal. The 2013 'Do nothing' scenario was used to calibrate the base year spreadsheet model. The 2039 'Do nothing' scenario was developed to assess the impacts of forecast traffic volumes on the existing road network, to determine the consequence of no action in the study area. The 2039 modelled future year corresponds to the design year of the proposal, which is 20 years after the estimated completion of the proposal (2019).

The 2039 'Do something' scenario includes the Gerringong upgrade, the Foxground and Berry bypass and the proposal. It was developed to assess the traffic impacts and operational performance of the complete series of highway upgrades between Gerringong to Bomaderry and includes the expected transfer of traffic from the 'Sandtrack'.

Table 6-1 Traffic modelling scenarios

Modelling scenario	Impact measured	Network description	Modelled year		
			2013	2019	2039
'Do nothing'	Consequence of no action	Existing road network	✓	✓	✓
'Do something'	Operational impacts	Full Gerringong to Bomaderry upgrade	-	✓	✓

As the Princes Highway (in the proposal area) is in a rural area and is a major route for tourism with considerable peak period traffic during school holidays, it is not necessarily appropriate to focus the analysis of existing and future conditions on typical weekday morning and evening peak periods. Therefore, further analysis was carried out to identify the true periods of peak demand. The analysis found that these usually occurred on the first evening of a holiday period southbound and the last afternoon of a holiday period northbound during a Public Holiday weekend or other holiday period.

As a result, the following time periods were selected to report existing and future traffic flows:

- AADT.
- Average one hour during a typical morning (AM) peak between 7am and 11am.
- Average one hour during a typical evening (PM) peak between 3pm and 7pm.
- Holiday peak hour that reflects traffic patterns in the proposal area recorded during the Easter and ANZAC day public holiday weekend in 2011 (21 April 2011 – 26 April 2011).

6.1.2 Existing environment

The Princes Highway is the main north-south regional road corridor between Sydney, the Illawarra and through the NSW South Coast to Victoria. The highway serves as a:

- Commuter route between Sydney, Wollongong and Nowra.
- Local route for residents of surrounding smaller towns and rural residences.
- Major tourist route for key destinations including Gerringong, Berry, Nowra and the NSW South Coast.
- Important freight and bus route, particularly for the south coast and far south coast where there are no rail services.

Between Berry and Bomaderry the existing highway is a two-way undivided carriageway. It generally provides one lane in each direction with short sections of overtaking lanes. The remainder of the highway allows limited overtaking opportunity.

The posted speed limit is 100 kilometres per hour between Schofields Lane and around 500 metres north of Cambewarra Road. At this location, the speed limit drops to 70 kilometres per hour to reduce the speed of vehicles entering and exiting Bomaderry and the roundabout at the intersection of the highway and Cambewarra Road.

The majority of local roads and rural property accesses are at-grade junctions with uncontrolled direct access to the highway, with both left and right turn movements permitted onto the existing Princes Highway. In addition, controlled right turn provisions are currently provided at Croziers Road, Strongs Road, Boxsells Lane, Lamonds Lane, Meroo Road and Pestells Lane. **Figure 6-1** shows the existing local road network in the vicinity of the proposal.

Meroo Road offers an alternative route between the Princes Highway and Bomaderry, providing local and regional connectivity for residents and businesses. Other local roads adjacent to the highway generally provide access to rural and residential properties, with limited regional connectivity.

Beyond the immediate vicinity of the highway, the ‘Sandtrack’ provides an alternative route for light vehicles between Gerringong and Bomaderry. It comprises Fern Street, Crooked River Road, Gerroa Road and Bolong Road (refer to **Figure 6-1**). The ‘Sandtrack’ fulfils a similar role to the Princes Highway providing both local and regional connectivity and allows traffic to avoid the highway. Heavy vehicles are prevented from using the ‘Sandtrack’ by a five tonne load limit.

Figure 6-1 Transport network between Gerringong and Bomaderry

Source: LPMA, 2011

AECOM P:\60021933_G2BW4_Tech_work_area\4.7_GIS\Maps_20130621_BethAndean_BBU_Chapter 6\Fig 6-1_G108_BBU_Traffic_130621.mxd Drafted 25/10/2013

Existing traffic volumes and patterns

Annual traffic growth

As shown in **Table 6-2**, AADT on the Princes Highway increased by an average of 400 vehicles per year between 1990 and 2012. This equates to an average growth rate of 3.2 per cent per annum over a 22 year period.

Table 6-2 AADT traffic growth summary (1990–2012)

Location:	Site 7.800: Princes Highway, north of Rose Valley Road		
Year	AADT	Growth rate	
		Period	Average annual growth (%)
1990	12,944	-	-
1994	14,791	1990 – 1994	3.6
1997	15,711	1994 – 1997	2.1
2000	17,753	1997 – 2000	4.3
2002	18,960	2000 – 2002	3.4
2004	19,371	2002 – 2004	1.1
2006	18,731	2004 – 2006	-1.7
2008	19,675	2006 – 2008	2.5
2010	21,300	2008 - 2010	4.1
2012	22,125	2010 – 2012	1.9
Total	**-**	**1990 - 2012**	**3.2**

Note – The closest Roads and Maritime permanent automatic traffic count site to the proposal is site 7.800 located on the Princes Highway, north of Rose Valley Road. Although this site is located north of the proposal, it is indicative of the level of background traffic growth along the highway.

Seasonal variation in traffic volumes

A permanent automatic traffic count site 7.800 was used to provide the AADT in **Table 6-2** to determine background traffic growth on the Princes Highway. It was also used to determine the seasonal variations in traffic volume. This seasonal analysis used weekly traffic volumes in 2011 and 2012.

Traffic flows are highest during major holiday periods, including the school holidays at Christmas, Easter and Labour Day in October. Traffic volumes peak to over 28,000 vehicles per day during the Christmas and New Year period, which equates to around 25 per cent more vehicles in comparison to the AADT at this location. As stated above the holiday peak was recorded during the Easter and ANZAC Day public holiday weekend in 2011 (Thursday 21 April – Tuesday 26 April).

These variations were used to determine a seasonality factor. This factor was then applied to the daily traffic volumes recorded during traffic surveys in February 2013 to provide an AADT.

Traffic volumes

The volume of traffic on the Princes Highway north of Bomaderry is around 11,870 vehicles per day with 9800 vehicles using the alternative Bolong Road 'Sandtrack' route. The peak and daily traffic volumes for the Princes Highway, the 'Sandtrack' and on local roads are provided in Table 2.5 of the *Technical Paper: Traffic and Transport* (AECOM, 2013) at **Appendix C.** These volumes are based on traffic counts undertaken in February 2013 and have been adjusted to include the seasonality factor detailed above.

Traffic survey results indicated that:

- There is around a 55 per cent to 45 per cent split of traffic using the Princes Highway and the 'Sandtrack' respectively.
- Heavy vehicles constitute 14.9 per cent of the AADT on the Princes Highway south of Abernethys Lane.
- Heavy vehicles represent 8.7 per cent of the AADT on the 'Sandtrack' north of Meroo Road due to the five tonne vehicle load limit on that road.
- Local and regional traffic demand on Meroo Road is low in comparison to the Princes Highway and the 'Sandtrack'. Although Meroo Road provides an important link for residents and businesses within Bomaderry, the AADT is equivalent to around 15 per cent of the daily vehicles recorded on the Princes Highway south of Abernethys Lane.

The Princes Highway sees a clear increase in southbound traffic on Friday afternoons and Saturday mornings and an increase in northbound traffic on Sunday afternoons. This generally represents the recreational weekend travel from Sydney and Wollongong to the NSW South Coast. As a result, congestion and delays are more likely during these weekend peak hours as opposed to the AM and PM peaks during the week.

On an average day, traffic volumes tend to grow gradually throughout the morning and into the early afternoon. There is a noticeable peak in the morning southbound traffic particularly on Meroo Road, south of the Princes Highway and Bolong Road (the 'Sandtrack'), north of Meroo Road.

Current network performance

LoS is a qualitative measure used to describe the operational conditions and efficiency of a roadway or intersection. The definition of LoS generally outlines the operating conditions in terms of speed and travel time, freedom to manoeuvre, traffic interruptions, comfort and convenience, and road safety.

A customised highway (or midblock) LoS model has been developed to assess highway flows based on the updated Austroads *Guide to Traffic Management, Part 3: Traffic Studies and Analysis* (Austroads, 2009). The LoS criteria for intersection is provided in **Table 6-3**.

Table 6-3 Level of service criteria for intersections

LoS	Average delay/ vehicle (sec/veh)	Traffic signals and roundabouts	Give way and stop signs
A	Less than 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory; accident study required
D	43 to 56	Operating near capacity	Near capacity; accident study required
E	57 to 70	At capacity; at signals incidents would cause excessive delays	At capacity; other control mode required
F	Greater than70	Roundabouts require other control mode	At capacity; other control mode required

(Source: 'Guide to Traffic Generating Developments' (RMS 2002))

Highway level of service

As detailed in **Table 6-4**, the Princes Highway currently operates at LoS D in both the morning and evening peak at the two locations specified between Berry and Bomaderry. The 'Sandtrack' currently operates at LoS C during the morning and evening peak hours. During holiday peak periods the Princes Highway deteriorates to an unacceptable LoS E while the 'Sandtrack' operates at LoS D.

Table 6-4 2013 highway (midblock) level of service summary

Location	AM peak hour (veh/hour)		PM peak hour (veh/hour)		Holiday peak hour (veh/hour)	
	Traffic volume	LoS	Traffic volume	LoS	Traffic volume	LoS
Princes Highway, south of Mullers Lane	909	D	1013	D	1459	E
Princes Highway, south of Abernethys Lane	863	D	947	D	1379	E
The 'Sandtrack', Bolong Road, north of Meroo Road	728	C	823	C	1139	D

By 2039, the Princes Highway would operate at an unacceptable LoS E or LoS F for all peak periods in the absence of the proposal, should traffic continue to grow at the current rate (refer to **Table 6-5**). The 'Sandtrack' would be expected to operate at LoS D during the morning and evening peak hours and would also be expected to deteriorate to LoS F during the holiday peak.

The provision of additional capacity on the Princes Highway between Berry and Bomaderry is considered necessary to provide acceptable highway performance.

Table 6-5 2039 highway (midblock) level of service summary ('Do nothing' scenario)

Location	AM peak hour (veh/hour)		PM peak hour (veh/hour)		Holiday peak hour (veh/hour)	
	Traffic volume	LoS	Traffic volume	LoS	Traffic volume	LoS
Princes Highway, south of Mullers Lane	1655	E	1845	E	2655	F
Princes Highway, south of Abernethys Lane	1575	E	1725	E	2515	F
The 'Sandtrack', Bolong Road, north of Meroo Road	1295	D	1465	D	2030	F

Intersection level of service

As detailed in **Table 6-6**, LoS and average delay times were assessed at key intersections with the Princes Highway between Berry and Bomaderry. The following two intersections that provide local and regional connectivity were assessed:

- Princes Highway and Meroo Road.
- Princes Highway and Cambewarra Road.

The intersection of the Princes Highway and Meroo Road currently operates at an acceptable level of LoS A for all peak periods due to low levels of conflicting traffic demand from the local road.

The Princes Highway and Cambewarra Road roundabout accommodates high levels of travel demand on all four of the approach roads, particularly during the morning peak period when volumes on the highway and local roads are fairly balanced. Overall, the roundabout currently operates at LoS A or LoS B during the morning and evening peak periods, which represents uncongested conditions with small queues and average delays of around 14 seconds per vehicle. However, the performance of the roundabout deteriorates during the holiday peak to an unacceptable LoS E with average delays of 65 seconds on the Moss Vale Road approach road.

Table 6-6 2013 intersection level of service summary

Intersection / approach road	AM peak hour			PM peak hour			Holiday peak hour		
	Volume	Average delay (second)	LoS	Volume	Average delay (second)	LoS	Volume	Average delay (s)	LoS
Princes Highway / Meroo Road									
Princes Highway (northbound)	332	0.2	A	509	0.3	A	735	0.3	A
Meroo Road (westbound)	92	1.8	A	78	1.5	A	80	2.1	A
Princes Highway (southbound)	538	0.3	A	447	0.4	A	732	0.5	A
Princes Highway / Cambewarra Road									
Princes Highway (northbound)	635	2.3	A	980	2.8	A	1170	4.3	A
Cambewarra Road (westbound)	401	7.1	A	346	2.9	A	365	6.1	A
Princes Highway (southbound)	515	12.6	B	377	5.7	A	661	12.9	B
Moss Vale Road (eastbound)	454	14.1	B	281	14.4	B	310	64.5	E

As detailed in **Table 6-7**, in 2039 it is expected that the Princes Highway and Meroo Road intersection would continue to operate effectively with LoS A on all approach roads. While average delays may increase slightly on Meroo Road, the intersection would continue to operate effectively.

In 2039, the Cambewarra Road roundabout would operate at unacceptable performance levels based on the predicted increase in traffic; if the existing geometry and configuration of the intersection remains unchanged.

Traffic volumes for local roads which currently join the highway would remain relatively low when compared to traffic volumes on the Princes Highway. As a result, the performance of these intersections from a capacity perspective would be acceptable, although the growth in traffic turning to and from local roads would lead to an increased risk of crashes.

Table 6-7 2039 intersection level of service summary ('Do nothing' scenario)

Intersection / approach road	AM peak hour			PM peak hour			Holiday peak hour		
	Volume	Average delay (s)	LoS	Volume	Average delay (s)	LoS	Volume	Average delay (s)	LoS
Princes Highway / Meroo Road									
Princes Highway (northbound)	739	0.2	A	913	0.3	A	1037	0.2	A
Meroo Road (westbound)	110	3.1	A	125	3.2	A	126	8.6	A
Princes Highway (southbound)	814	0.7	A	819	0.7	A	1289	1.1	A
Princes Highway / Cambewarra Road									
Princes Highway (northbound)	1151	8.1	A	1538	24.1	B	1897	59.5	E
Cambewarra Road (westbound)	591	17.4	A	489	14.5	A	562	153.8	F
Princes Highway (southbound)	715	17.4	B	726	11.6	A	1127	40.0	D
Moss Vale Road (eastbound)	308	361.3	F	220	504.8	F	478	487.0	F

Travel speeds and travel times

The average travel time between Schofields Lane, south of Berry and Bolong Road, Bomaderry is around 12 to 13 minutes. The equivalent route via the 'Sandtrack' has an average travel time of around 11.5 minutes. It is similar in length but operates at a higher average speed. The longer travel time on the Princes Highway is the result of a higher proportion of slow-moving heavy vehicles than the 'Sandtrack' and varying (lower) posted speed limits.

Travel times and distances are also similar for the entire route of the Princes Highway and the 'Sandtrack' between Gerringong and Bomaderry. Between these locations, the Princes Highway is 33.2 kilometres in length and has a travel time of around 32 to 33 minutes and the 'Sandtrack' is 32.4 kilometres in length and has a travel time of around 30 minutes.

Without the proposal, travel times between Berry and Bomaderry would increase as the volume of traffic and the level of congestion on the existing road network grows. Increased travel times and delays would occur at the intersection of the Princes Highway and Cambewarra Road during peak periods. Increased volumes of through traffic would conflict with local traffic using the roundabout, resulting in delays to vehicles approaching the roundabout from local roads.

Along the rest of the Princes Highway between Berry and Bomaderry, increased traffic and midblock congestion would be expected without the proposal. This would likely result in lower operating speeds and longer travel times.

Road safety

Between 1 July 2008 and 30 June 2013 a total of 37 crashes were recorded on the Princes Highway between Schofields Lane, south of Berry and Cambewarra Road, Bomaderry. This included two fatalities and 17 injuries.

The average crash severity index on this section of the Princes Highway is 1.39, with the section between Schofields Lane and Meroo Road being the highest at 1.42. In comparison, the average crash severity index of all crashes reported on all roads open to the public across NSW in 2011 was 1.26[1]. This indicates that this section of the Princes Highway historically has a higher than average proportion of fatal and injury crashes, particularly between Schofields Lane and Meroo Road.

The average fatality rate on the Princes Highway between Schofields Lane and Cambewarra Road is 0.7 per 100 million vehicle kilometres travelled (MVKT). In comparison the average fatality rate across NSW is 0.5 per 100 MVKT[2]. This indicates that this section of the existing highway historically has over 40 per cent more fatalities per kilometre travelled than the NSW average for reported crashes on all roads open to the public.

Without the proposal, the frequency of crashes on the Princes Highway and the 'Sandtrack' would be expected to increase with the continued growth in traffic on an unchanged road network. Of particular concern on the Princes Highway would be crashes due to insufficient capacity and turning vehicles at local roads and property accesses.

Modes of travel

Private vehicles are the primary mode of transport in the Shoalhaven LGA, representing about 82 per cent of all typical weekday trips (NSW Transport Data Centre, 2012). As detailed in **Table 6-8** private vehicle trips make up a much greater proportion of all trips in the Shoalhaven LGA than in the Sydney greater metropolitan area. This is because public transport within and to the Shoalhaven LGA is limited.

Table 6-8 Average weekday travel mode share for the Shoalhaven LGA and Sydney greater metropolitan area (2010/11)

Local government area	Private vehicle			Rail passenger	Bus passenger	Walk only	Other modes
	Driver	Passenger	Total				
Shoalhaven	56 %	26 %	82 %	1 %	2 %	13 %	2 %
Sydney	49 %	22 %	71 %	5 %	5 %	17 %	2 %

(Source: NSW Transport Data Centre – 2010/11 Household Travel Survey Summary Report, 2012 Release)

Public transport

The following public transport services operate between Berry and Bomaderry:

- South Coast Railway line, with stations at Berry and Bomaderry.
- Shoal Bus, a private bus operator providing two local services per day and school bus services.
- Premier Motor Service, a private bus operator providing two regional and interstate services per day and school bus services.

The South Coast Railway line connects Sydney, Wollongong and Bomaderry and terminates in Bomaderry. There are no direct services to Berry or Bomaderry with passengers required to change trains at Wollongong, Dapto or Kiama. Bomaderry station has the largest passenger demand in the proposal area with around 680 passengers entering and exiting the station per day.

[1] Calculated using crash data from Roads and Maritime Southern Region crash data and Transport for NSW Road Traffic Crashes in NSW Statistical Statement for year ended 31 December 2011. Based on the Crash Severity Index formula presented in Figure 3.3 for the *Technical Paper: Traffic and Transport* (refer to **Appendix C**).
[2] Based on the latest available Roads and Maritime data for the 12 month period ending June 2012.

Local and regional bus services utilise the Princes Highway and local roads between Berry and Bomaderry. Services travel between Gerringong and Nowra and provide access to services utilising the 'Sandtrack' and services that continue further south. Regional services operate between Sydney and Melbourne via Kiama, Gerringong, Berry and Nowra. There are also a number of school-specific bus services that use the Princes Highway and the surrounding local road network detailed in Section 2.3.1 of the *Technical Paper: Traffic and Transport* (AECOM, 2013) at **Appendix C**. There are formal bus stops adjacent to the southbound carriageway at Mullers Lane, Croziers Road, Morschels Lane and Lamonds Lane. There are northbound bus stops adjacent to Boxsells Lane and Strongs Road servicing school and other bus services.

Walking and cycling routes

There are no footpaths provided on the Princes Highway between Berry and Bomaderry until the northern end of Bomaderry. Within Bomaderry, curbs and footpaths are provided on the highway and surrounding residential streets. On the highway, verges and shoulders can be used by pedestrians but are generally not used due to the speed of traffic and distances between towns.

There are no formal cycle routes between Berry and Bomaderry, however Shoalhaven City Council promotes various cycle routes to and from both towns. A well-defined, 37 kilometre cycle route exists between Berry and Bomaderry via Black Forest and Meroo Meadow.

A proposed 1400 kilometre coastal cycleway stretching from the Queensland border, through NSW to the Victorian border includes a section within the proposal area that follows the route of the 'Sandtrack'.

6.1.3 Potential impacts

Construction

The proposal would generate an increase in construction vehicles travelling to, from and within the proposal on the existing Princes Highway and local roads. This would include additional traffic demand generated by:

- Construction workers travelling to and from worksites.
- The delivery of heavy vehicles, machinery and other equipment required for highway construction.
- The delivery of construction materials including dry bulk such as cement, aggregates, steel and pre-fabricated structures.
- The movement of spoil generated by earthworks, including the movement of materials within worksites, transferral to stockpile sites and/or removed from the proposal area.

It is anticipated that the majority of construction-related heavy vehicles would travel to and from the proposal from the north, particularly from Kiama, Port Kembla and Wollongong. North of the proposal, both the Gerringong upgrade and Foxground and Berry bypass projects (upgrades to the Princes Highway), would likely be complete prior to construction of this proposal. This would provide a four-lane divided highway with a central median between Gerringong and Berry. The Princes Highway north of Gerringong as well as the upgraded Princes Highway between Gerringong and Berry would provide a suitable route for construction-related vehicles to safely and efficiently access the proposal.

The proposal would generally involve construction on either side of the existing Princes Highway. Where possible, construction traffic would use the cleared construction footprint for the proposal to transport materials either adjacent to the highway or via a haul route as appropriate. Controlled construction traffic entry and exit points would be minimised and the use of the existing highway would be restricted at peak hours, especially during holiday periods.

It is estimated that the proposal would generate around 50 heavy vehicles, or 100 heavy vehicle movements per day and 65 light vehicles, or 130 light vehicle movements per day.

Traffic delays and disruptions

It is Roads and Maritime's goal to maintain an 80 kilometres per hour construction speed zone (where normal posted speeds are higher than 80 kilometres per hour), which would minimise traffic delays. However, greater delays would be expected during construction in those periods when the proposal requires works on and/or would tie in with the existing highway. Some temporary disruptions and delays to local and highway traffic would be experienced during construction due to the narrowing of lanes and temporary speed reductions. There would also be delays to local traffic during periods when other local or private roads are being bridged or tied in with the proposal. There would be potential for construction of the proposal to cause delays and impacts to emergency services and existing public and school bus services. As detailed in **Section 6.1.4**, emergency services and local bus operators would be consulted prior to and during construction to minimise any potential delays and disruptions.

Local roads that would potentially experience some delays during construction include Meroo Road, Pestells Lane, Morschels Lane, Devitts Lane, Strongs Road and Jaspers Brush Road. These roads would be directly linked to, or serviced by, the new grade-separated facilities and half-interchange and would experience detours at some time during construction.

Highway performance

Based on 2019 traffic volumes, it is expected that the Princes Highway would operate at LoS E in both the morning and evening peaks during the construction of the proposal (refer to **Table 6-9**). Average travel speeds would likely drop to less than 60 kilometres per hour as a result of the expected increase in traffic, speed restrictions and the prevention of overtaking through construction zones.

During construction, the 'Sandtrack' would be expected to operate at LoS C in all three peak periods assessed. Following the construction of the Gerringong upgrade and Foxground and Berry bypass projects, it is anticipated that traffic would transfer from the 'Sandtrack' to the Princes Highway. However, there is potential that traffic may transfer back from the highway to the 'Sandtrack' from Berry via Beach Road to avoid slow moving traffic resulting from the construction of the proposal. This would mainly be expected to occur during holiday peak periods.

Table 6-9 2019 highway (midblock) level of service summary (construction scenario)

Location	AM peak hour (veh/hour)		PM peak hour (veh/hour)		Holiday peak hour (veh/hour)	
	Traffic volume	LoS	Traffic volume	LoS	Traffic volume	LoS
Princes Highway, south of Mullers Lane	1415	E	1580	E	2275	F
Princes Highway, south of Abernethys Lane	1430	E	1570	E	2285	F
The 'Sandtrack', Bolong Road, north of Meroo Road	425	C	480	C	665	C

Intersection performance

Near Bomaderry, major construction works would generally consist of widening or duplicating the existing highway. These works would be expected to cause some adverse traffic impacts during the tie-in to existing sections and local roads, however, works would be expected to only last for short periods of time.

Table 6-10 provides a summary of the expected intersection LoS at the two main connection intersections to Bomaderry during the three modelled construction periods. Results of the modelling show that the majority of the connecting local road network would be expected to accommodate forecast traffic, including light and heavy construction vehicles, with minimal delay. The intersection approach from Moss Vale Road is predicted to drop to an unacceptable LoS F during the morning and holiday peak periods, with a maximum average delay ranging from two to four minutes per vehicle.

Table 6-10 2019 intersection level of service summary (construction scenario)

Intersection / approach road	AM peak hour			PM peak hour			Holiday peak hour		
	Volume	Average delay (second)	LoS	Volume	Average delay (second)	LoS	Volume	Average delay (s)	LoS
Princes Highway / Meroo Road									
Princes Highway(northbound)	513	0.1	A	613	0.1	A	840	0.2	A
Meroo Road (westbound)	76	2.0	A	87	1.6	A	81	3.1	A
Princes Highway (southbound)	526	0.3	A	535	0.3	A	867	0.4	A
Princes Highway / Cambewarra Road									
Princes Highway (northbound)	855	3.7	A	1107	4.0	A	1329	7.9	A
Cambewarra Road (westbound)	476	8.3	A	378	3.7	A	411	9.8	A
Princes Highway (southbound)	470	14.5	B	478	7.5	A	768	14.2	B
Moss Vale Road (eastbound)	497	126.9	F	316	36.4	C	354	248.3	F

Operation

Highway performance

As detailed in **Table 6-11**, LoS has been considered for the proposal and the 'Sandtrack' for the 2039 design year, 20 years after the forecast 2019 proposal opening. This 'Do something' scenario was assessed against the current situation as well as the 'Do nothing' scenario, which considered the situation in 2039 without the proposal (refer to **Table 6-5**).

The proposal would be expected to operate at LoS B during the morning and evening peaks in both directions. During the busiest holiday period, the highway would be expected to operate at LoS C or better in both directions. Currently the highway operates at LoS D during the morning and evening peaks and LoS E during the holiday peak. In 2039, without the proposal, the highway would operate at LoS E in the morning and evening peaks and LoS F in the holiday peak (refer to **Table 6-5**). The proposal would therefore improve the operational performance of the highway in comparison the current and 'Do nothing' scenario.

The provision of two lanes in each direction would allow for an increase in the safe operating speed of the highway. As well as this, the central median and safety barrier would enable the directional flows on the highway to operate independently; as such heavy flow in one direction would no longer reduce the LoS in the other. The proposal would also provide improved flood immunity when compared to the existing alignment.

The 'Sandtrack' would be expected to operate at LoS C during the morning and evening peak periods and LoS D during the busiest holiday period. Currently the 'Sandtrack' operates at LoS C during the morning and evening peaks and LoS D during the holiday peak. In 2039, without the proposal, the 'Sandtrack' would be expected to operate at LoS D during the morning and evening peaks and at an unacceptable LoS F during the holiday peak (refer to **Table 6-5**). The proposal would therefore improve the operational performance of the 'Sandtrack' in comparison to the 'Do nothing' scenario.

As shown in **Table 6-11**, following the proposal, the performance of the 'Sandtrack' would be similar to its current performance (refer to **Table 6-4**). While traffic volumes in the region are expected to grow, there would be a shift of traffic from the 'Sandtrack' to the highway following the completion of the series of upgrades to the Princes Highway between Gerringong and Bomaderry.

Table 6-11 2039 highway (midblock) level of service summary ('Do something' scenario)

Location	Direction	AM peak hour (veh/hour)		PM peak hour (veh/hour)		Holiday peak hour (veh/hour)	
		Traffic volume	LoS	Traffic volume	LoS	Traffic volume	LoS
Princes Highway, south of Mullers Lane	Northbound	1315	B	1515	B	2045	C
	Southbound	1165	B	1220	B	1890	C
Princes Highway, south of Abernethys Lane	Northbound	1345	B	1600	B	2115	C
	Southbound	1215	B	1200	B	1950	C
The 'Sandtrack', Bolong Road, north of Meroo Road	Two-way	630	C	715	C	990	D

Intersection performance

Table 6-12 provides details of the operational performance of the two key intersections connecting to Bomaderry for the 2039 'Do something' scenario. The grade-separated half-interchange included in the proposal at Pestells Lane and Meroo Road has been assessed. However, the existing Cambewarra Road roundabout is beyond the extent of the proposal area and consequently remains unchanged in the 'Do something' scenario.

Table 6-12 indicates that for all peak period scenarios, all approach roads at the Pestells Lane and Meroo Road grade-separated half-interchange would be expected to operate at LoS A, with minimal delays incurred.

However, large volumes of traffic demand on the Princes Highway in both the southbound and northbound direction would leave fewer gaps in the traffic flow for the local roads at the Cambewarra Road roundabout and would therefore create congested conditions; particularly in the evening and holiday peak periods. Overall, the results indicate that the Cambewarra Road roundabout would operate at unacceptable 'critical' performance levels (meaning LoS F) based on the predicted increase in traffic, if the existing geometry and configuration of the intersection remains unchanged.

When compared to a 'Do nothing' scenario, the additional through traffic at the Princes Highway and Cambewarra Road roundabout induced by the proposal would increase delays. However, the analysis of the 'Do nothing' scenario in 2039 (refer to **Table 6-7**) indicates that the performance of this intersection during peak periods is expect to deteriorate considerably when compared to existing conditions, regardless of the impacts of the proposal. As a result, it appears likely that an upgrade to the existing configuration of the roundabout would be required either with or without the proposal. Upgrade to the Cambewarra Road roundabout will be progressed by RMS as a separate proposal,

Table 6-12 2039 intersection level of service summary ('Do something' scenario)

Intersection / approach road	AM peak hour			PM peak hour			Holiday peak hour		
	Volume	Average delay (second)	LoS	Volume	Average delay (second)	LoS	Volume	Average delay (s)	LoS
Princes Highway / Meroo Road									
Princes Highway(northbound)	1161	0.1	A	1490	0.1	A	1999	9.6	A
Meroo Road (westbound)	114	1.1	A	105	0.3	A	1398	0.1	A
Princes Highway (southbound)	1230	0.2	A	1260	0.2	A	146	0.6	A
Princes Highway / Cambewarra Road									
Princes Highway (northbound)	1533	22.8	B	1671	86.6	F	1790	81.4	F
Cambewarra Road (westbound)	587	134.4	F	503	150.3	F	336	352.8	F
Princes Highway (southbound)	1114	25.4	B	1134	22.9	B	1487	98.3	F
Moss Vale Road (eastbound)	180	649.0	F	196	565.5	F	142	783.4	F

As detailed in Section 7.2.3 of the *Technical Paper: Traffic and Transport* (AECOM, 2013) provided at **Appendix C**, the predicted hourly traffic volumes in 2039 would be expected to result in acceptable level of service performance (LoS C or better) during all peak periods for all of the following merge locations:

- Pestells Lane / Meroo Road on-ramp to the Princes Highway northbound carriageway.
- Pestells Lane / Meroo Road left-out connection to the Princes Highway southbound carriageway.
- Boxsells Lane left-out connection to the Princes Highway northbound carriageway.
- Lamonds Lane left-out connection to the Princes Highway southbound carriageway.
- Devitts Lane left-out connection to the Princes Highway northbound carriageway.
- Morschels Lane left-out connection to the Princes Highway southbound carriageway.

Cambewarra Road roundabout

The Cambewarra Road roundabout currently intersects with the Princes Highway, allowing for all turning movements between the highway, Cambewarra Road and Moss Vale Road. The roundabout currently operates at an acceptable service level with the exception of the Moss Vale Road eastbound approach during the holiday peak period. Under the 2039 'Do nothing' scenario, the operation of the roundabout would deteriorate to LoS D, E or F for all approach roads during the holiday peak period. Performance would further deteriorate to critical levels for the 2039 'Do something' scenario. This would be due to the predicted transfer of traffic from the 'Sandtrack' to the Princes Highway, resulting in fewer opportunities for vehicles to enter the roundabout from Cambewarra Road and Moss Vale Road, thereby increasing the congestion and delay on these 'minor' approach roads.

The Cambewarra Road roundabout is located south of and outside the proposal area. Therefore, modification to the current configuration of the roundabout does not form part of this proposal.. This separate upgrade would be considered along with other proposals that could affect the adjacent road network, including the Shoalhaven City Council proposal for a North Nowra Link Road. Roads and Maritime will undertake further investigations into the performance and upgrade of the Cambewarra Road roundabout as a separate project.

The proposal as described, is considered to achieve the proposal objectives as well as contributing to the overall Government objective of providing a four-lane divided highway between Sydney and Jervis Bay Road, Falls Creek.

Local road and property access

The introduction of a central median and safety barrier would provide substantial improvements in road safety. It would also result in the separation of opposing traffic flows, and elimination of uncontrolled right turn movements between the Princes Highway and property accesses across fast-moving two-way traffic (at locations where right turns can currently be made prior to the introduction of a central median and safety barrier). The crash data analysis shown in Section 7.2.5 of the *Technical Paper: Traffic and Transport* (AECOM, 2013) at **Appendix C** shows that around 46 per cent of crashes in the proposal area occur either at intersections or between vehicles travelling in opposing directions.

Following construction of the proposal, right-turns would be retained (via either grade-separated facilities or controlled opening of the central median) at the following locations:

- Mullers Lane.
- Croziers Road.
- Jaspers Brush Road.
- Strongs Road.
- Devitts Lane.
- Morschels Lane.
- Lamonds Lane.
- Pestells Lane.

Minor roads which join the Princes Highway currently have the ability to turn either left or right to or from the highway. Once a central median and safety barriers are installed, local roads and accesses in rural areas would generally be restricted to left-in / left-out movements only. U-turn bays would be provided at a limited number of locations, via protected right turn bays. Where the central median is in place, traffic, which would previously have turned right from, or into a minor road, would be required to travel to the nearest u-turn facility (or grade-separated facility) to make a safe right hand turn to proceed in the desired direction. This would inconvenience a small proportion of local traffic as it would require additional travel when compared to existing arrangements. However, it is considered to provide for a safer and more efficient overall road network.

Access constraints associated with the proposal have been assessed and are presented in **Figure 3-10**. The largest impact would be for southbound traffic travelling from properties near Morschels Lane wishing to access the Princes Highway and travel northbound. Vehicles would be required to travel southbound on the Princes Highway and perform a u-turn at the Pestells Lane and Meroo Road grade-separated half-interchange. The maximum additional travel time would be less than five minutes.

Relatively low volumes of additional daily traffic would be expected to use the grade-separated and u-turn facilities provided by the proposal. Any potential impacts of additional traffic on local roads in terms of performance would be mitigated by the safe and efficient design of these facilities.

Travel speed and time

The proposal would be expected to reduce travel times on the Princes Highway by around one minute in each direction in comparison to the existing conditions. The current travel time is around 12 to 13 minutes between Schofields Lane and Bolong Road. Travel times on the 'Sandtrack' would be expected to remain at around 11.5 minutes in each direction, similar to the existing conditions. Once the proposal is operational, the distance and travel times on the Princes Highway and the 'Sandtrack' would be similar, with less than one minute difference between each route.

On a larger scale, travel times on the Princes Highway between Rose Valley Road and Bolong Road would substantially decrease. This would include the entire series of upgrades of the Princes Highway between Gerringong and Bomaderry. Travel times over this distance would be expected to reduce to around 23 minutes, which would equate to a saving of 10 minutes.

Road safety

The proposal would be expected to improve road safety along and adjacent to the highway. A crash analysis has been undertaken based on data from 1 January 2008 to 30 June 2013 and using Roads and Maritime's 'Crash Reduction Guide'. The results presented in Table 7.9 of the *Technical Paper: Traffic and Transport* (AECOM, 2013) at **Appendix C** predict the following crash reductions:

- 100 per cent crash reduction between vehicles travelling in opposing directions and off path on curve due to the introduction of a central median, safety barrier and improved highway alignment.
- 50 per cent crash reduction between vehicles at intersections as current at-grade intersections would be upgraded to grade separated facilities or constrained to left-in / left-out only access.
- 65 per cent reduction in crashes involving vehicles travelling from the same direction and off path on straight road between Meroo Road and Cambewarra Road.
- 60 per cent reduction in crashes involving vehicles travelling from the same direction and off path on straight road between Schofields Lane and Meroo Road.
- 69 per cent reduction in total crashes.

Emergency access

The proposal would include the provision of three emergency cross over facilities, located between Mullers Lane and Croziers Road, between Strongs Road and Turners Lane and between Lamonds Lane and Pestells Lane. In the event that an incident blocks all lanes in one direction, the cross over facilities would allow contra-flow arrangements to be put in place by emergency services. These facilities operate in tandem, with one facility directing traffic into the contra-flow arrangement, and another directing traffic back to the normal arrangement.

Public transport, pedestrians and cyclists

The following impacts to public transport, pedestrians and cyclists would be expected as a result of the proposal:

- Bus services:
  - Bus stops would be incorporated at three u-turn facilities as well as at the Morschels Lane and Devitts Lane grade-separated facility and the Strongs Road and Jaspers Brush Road grade-separated facility. The relocation of bus stops away from the main carriageway would provide safer access and drop-off facilities for local residents.
  - Improved bus travel times as a result of higher safe travel speeds on the highway and a reduction in traffic on the 'Sandtrack'.
  - Reduction in delays to services caused by traffic incidents and congestion. The proposal would be expected to lessen the frequency of traffic crashes and thereby reduce delays. The provision of two lanes in each direction would result in an improved LoS and reduce congestion with subsequent reduction in delays to bus services.
  - Reduction in potential crashes caused by buses stopping on the Princes Highway. Following construction the practice of buses stopping at intersections with local roads and property accesses would be discouraged. This would remove the risk of crashes from buses speeding up or slowing down to a stop in high-speed traffic.
- Cyclists:
  - Improved safety and access for cyclists with access to the 2.5 metre wide shoulder. This would enable greater separation of cyclists from high-speed traffic than the existing situation.

In addition to the positive impacts generated by the proposal, there would also be some potential negative impacts to the school bus services that currently stop at numerous intersections in rural areas between the Princes Highway and local roads and accesses in the proposal area. In order to improve road safety following the construction of the proposal public and school buses would only stop at dedicated bus stop facilities (at the locations detailed above). This could potentially inconvenience some users who would be required to travel to and from formalised bus stop locations. However, this measure would improve overall safety.

6.1.4 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or mitigate the identified impacts on traffic and transport. These measures are presented in **Table 6-13** and are summarised in **Section 7.2**.

Table 6-13 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
Delays and disruptions due to construction traffic and works	Prepare and implement a traffic management plan (TMP) in accordance with Roads and Maritime's 'Specification D&C G10 Traffic Management' (Roads and Maritime 2011) and Roads and Maritime's 'Traffic Control at Worksites Manual Version 4' (Roads and Maritime 2011) as part of the CEMP. The TMP will be submitted in stages to reflect the progress of work and at a minimum will include: • Signage requirements. • Lane possession approval process during periods of online construction. • Traffic control devices such as temporary traffic signals. • A local and regional communication strategy. • Strategies to respond to any changes in road safety (including on the 'Sandtrack').	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Where feasible and reasonable, schedule construction work that will substantially reduce the performance of the road network during periods of typically lower traffic volumes.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Clearly communicate and signpost traffic controls in use, such as road closures, detours, temporary speed limits and passing constraints.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Choose suitable locations for access and egress to and from worksites and provide adequate traffic control at these locations.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Consult with local emergency services during the development of the TMP to provide procedures to maintain an unrestricted and safe environment for emergency service vehicles to pass through construction zones. Provide updates to the local emergency services on the staging and progress of construction.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Consult with local bus companies operating the school and other bus services to ensure appropriate location and access to bus stops during construction of the proposal.	Roads and Maritime project manager and construction contractor	Pre-construction and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
	Overall the TMP will aim to: • Adopt construction methods and staging that are designed to minimise road closures and disruptions to existing traffic; subject to other proposal constraints. • Implement an 80 kilometre per hour construction speed zone for highway traffic where feasible and reasonable. • Maintain continuous access to local roads and properties. • Ensure road occupancy licences are obtained for all work that impacts traffic on the existing highway. • Maintain suitable road network safety and performance during construction of the proposal.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
Operation			
Operational performance	Monitor traffic levels and operational performance on the Princes Highway between Berry and Bomaderry and at selected local roads once the proposal is operational, particularly during peak periods. Compare the actual versus modelled performance of the road network to identify differences at an early stage.	Roads and Maritime project manager	Six months and 12 months after completion of construction
Safety of cyclists	Provide cyclist access at all grade-separated facilities and half-interchanges in compliance with Roads and Maritime's 'NSW Bicycle Guidelines' (RTA, 2003).	Roads and Maritime project manager	Detailed design

6.2 Noise and vibration

This chapter provides an assessment of the noise and vibration impacts of the proposal, and is supported by the *Technical Paper: Noise and Vibration* (AECOM, 2013). The technical paper is provided at **Appendix D**.

6.2.1 Methodology

To assess the potential impacts arising from construction and operation of the proposal, the following guidelines and policies were considered:

- 'Interim Construction Noise Guideline' (ICNG) (DECC, 2009) to assess construction noise impacts.
- NSW 'Environmental Criteria for Road Traffic Noise' (ECRTN) (EPA, 1999), which has been superseded, but is used for guidance in assessing the potential for sleep disturbance.
- 'Assessing Vibration: A Technical Guideline' (DEC, 2006) to assess impacts arising from construction vibration.
- 'Road Noise Policy' (RNP) (DECCW, 2011), to assess road traffic noise impacts from the project during the operational stages of the project.
- The NSW 'Industrial Noise Policy' (INP) (EPA, 2000) in regard to background noise monitoring.
- The 'Environmental Noise Management Manual' (ENMM) (RTA, 2001), which is used by Roads and Maritime for the provision of practical guidance with regards to managing and controlling noise and vibration from vehicles, road construction and road maintenance activities, as well as the implementation of the ECRTN which has been largely replaced by the RNP since the ENMM was published.

As required by the RNP, the noise and vibration assessment has been undertaken for locations within 600 metres of the proposal. For the purposes of the noise and vibration assessment, this area is known as the study area.

Unattended (continuous) noise measurements were taken at 11 locations within the study area to determine the existing noise levels in order to establish the following:

- L_{A1}, which represents the noise level exceeded for one per cent of the sample or measurement period.
- L_{A10}, which represents the noise level exceeded for ten per cent of the measurement period.
- L_{Amax}, which represents the maximum noise level measured at a given location over the measurement period.
- L_{Aeq}, being the average sound level or energy averaged sound level over a defined measurement period. When used for traffic noise, this description is classified as $L_{Aeq15Hr}$ and L_{Aeq9Hr} for the day and night time noise levels respectively. This is commonly referred to as the ambient noise level.
- Rating Background Level (RBL), representing the average minimum background sound level, which is the tenth percentile of the L_{A90} values.

Attended noise measurements were also undertaken at each noise logging location to determine the details of the local noise environment and confirm if the road was the controlling noise source (for the calibration of the operational traffic noise model).

A detailed description of the methodology used to assess the noise and vibration impacts associated with the proposal is provided in the *Technical Paper: Noise and Vibration* (AECOM, 2013) at **Appendix D**.

6.2.2 Existing environment

Noise sensitive receivers

There are 895 noise sensitive receiver locations in proximity to the proposal, generally including residential dwellings within rural areas and low density urban areas of Bomaderry. These noise sensitive receivers have been grouped into seven Noise Catchment Areas (NCAs) for the purpose of the construction noise and vibration assessment. Details of the individual noise sensitive receivers are provided in Appendix A of the *Technical Paper: Noise and Vibration* at **Appendix D**.

Existing noise environment

There are a range of land uses within the study area including agricultural properties, rural residential properties, and urban areas in Bomaderry. Residences, businesses and community facilities within the study area are located at varying distances from the proposal.

Rural areas surrounding the proposal are located north of Bomaderry, and consist of large agricultural properties and scattered rural residences. Noise levels experienced by properties in this area are generally low, with the exception of rural properties that are located immediately adjacent to existing roads.

Traffic efficiency between Meroo Road and Schofields Lane is adversely affected by the undulating nature of this section of the existing highway. As a result, high noise levels are sometimes experienced at rural residences directly adjacent to the existing highway, as vehicles are required to brake and accelerate because of the steep grades and sharp bends.

Within the urban areas in Bomaderry the existing highway is the dominant noise source as it is the main access to the town from the north. Noise levels through Bomaderry are high at times, largely due to the use of the highway by both through traffic and local traffic comprising heavy and light vehicles. Within Bomaderry there are different noise environments related to the proximity of receivers to the highway, with high levels of traffic noise experienced at commercial properties and residential properties that front the highway.

Background noise levels

Background noise monitoring was undertaken at 11 locations throughout the study area (refer to **Figure 6-2**). The results of the background noise monitoring are provided in **Table 6-14** and **Table 6-15**. The background noise levels are typical of rural/semi-rural noise environments with little urban development alongside a major transport corridor. Road traffic noise measurements at BG5, BG6 and BG7 were affected by insect noise (confirmed by attended noise measurements) and BG10 measurements were affected by the operation of continuous noise emissions from a mechanical service, pump or other piece of equipment between 6pm and 10pm every night (not confirmed by attended noise measurements). All other road noise measurements were dominated by road traffic noise at all times (confirmed by attended noise measurements).

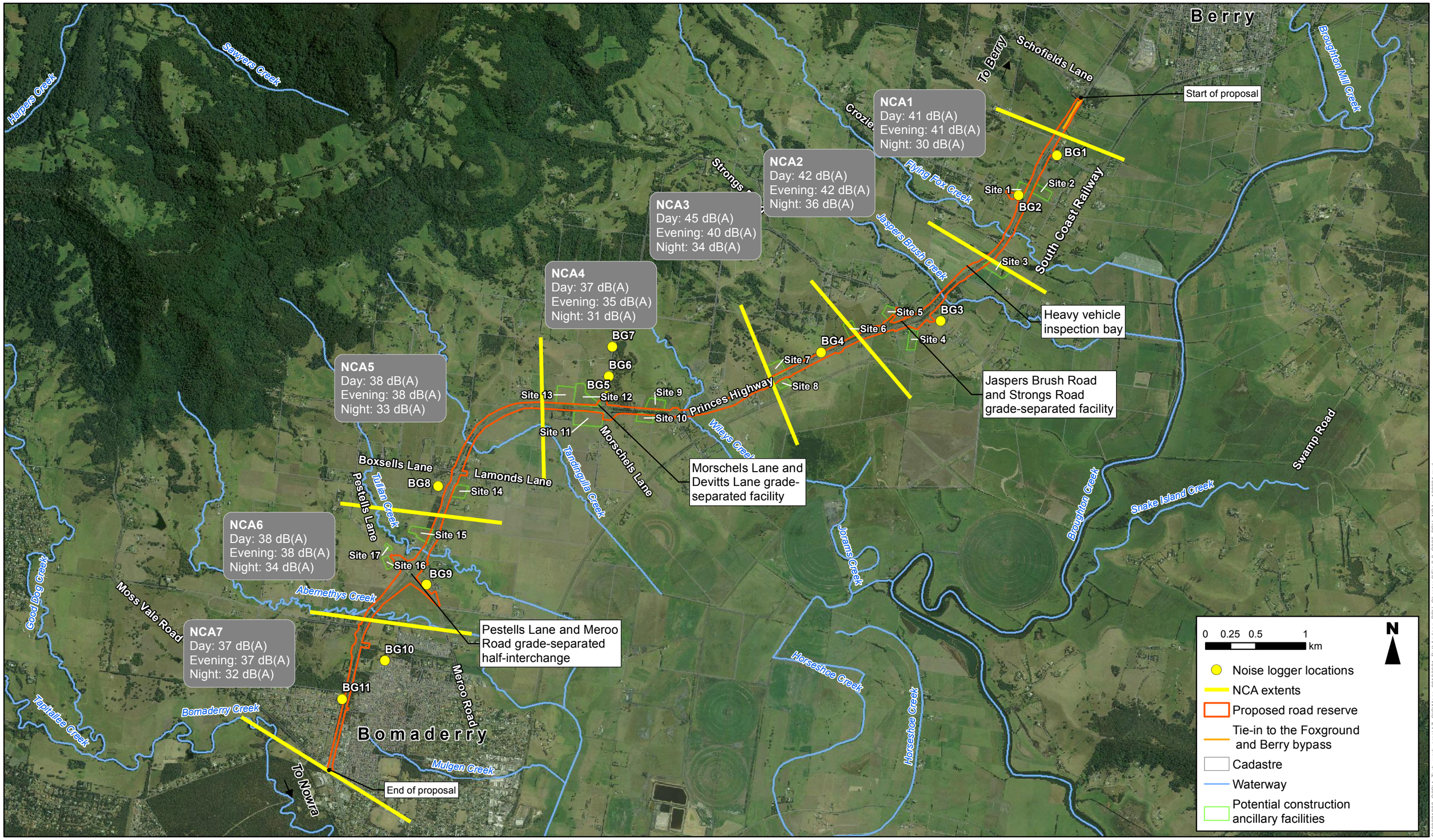

Figure 6-2 Noise catchment areas, background noise levels and noise logger locations

Source: AECOM (2013)

Table 6-14 Background noise levels

Noise logging location*	Address	Rating background level dB(A)		
		Day (7am to 6pm) L_{A90}	Evening (6pm to 10pm) L_{A90}	Night (10pm to 7am) L_{A90}
BG1	10 Mullers Lane, Jaspers Brush	41	45 (41)[1]	33
BG2	10 Croziers Road, Jaspers Brush	44	43	30
BG3	25 Jaspers Brush Road, Jaspers Brush	42	43 (42)[1]	36
BG4	510 Princes Highway, Jaspers Brush	45	40	34
BG5	Devitts Lane, Jaspers Brush	41	35	31
BG6	Devitts Lane, Jaspers Brush	39	39	32
BG7	Devitts Lane, Jaspers Brush	37	44 (37)[1]	34
BG8	19 Boxsells Lane, Meroo Meadow	38	43 (38)[1]	33
BG9	1028 Meroo Road, Meroo Meadow	38	43 (38)[1]	34
BG10	35 Gardenia Crescent, Bomaderry	37	39 (37)[1]	43 (37)[1]
BG11	38 Elvin Drive, Bomaderry	44	41	32

Noise logger locations are shown in **Figure 6-2*
[1]the RBL for the evening period has been set to no more than that for the daytime RBL. This reflects the application notes of the INP, which indicate that the community generally expects a greater control of noise during the evening and night time periods. Similarly, night-time RBLs have been set at no more than the evening RBL.

Table 6-15 Daytime and night time road traffic noise levels

Noise logging location	Address	Ambient road noise level LAeq, dB(A)	
		Day (L_{Aeq},15hour)	Night (L_{Aeq},9hour)
BG1	10 Mullers Lane, Jaspers Brush	57	53
BG2	10 Croziers Road, Jaspers Brush	58	54
BG3	25 Jaspers Brush Road, Jaspers Brush	54	49
BG4	510 Princes Highway, Jaspers Brush	64	60
BG5	Devitts Lane, Jaspers Brush	56	54
BG6	Devitts Lane, Jaspers Brush	54	46
BG7	Devitts Lane, Jaspers Brush	57	48
BG8	19 Boxsells Lane, Meroo Meadow	53	46
BG9	1028 Meroo Road, Meroo Meadow	53	51
BG10	35 Gardenia Crescent, Bomaderry	53	48
BG11	38 Elvin Drive, Bomaderry	55	50

6.2.3 Criteria

Construction noise

Construction noise assessments are undertaken in accordance with the ICNG which supersedes the ENCM. The ICNG has been used as the basis for establishing construction noise management levels (NMLs) for the proposal.

NMLs must be set for construction activities to be undertaken during the daytime (standard construction hours) and out of standard hours. The NMLs must be met where feasible and reasonable. Work that is proposed outside of standard construction hours, as defined in the ICNG, generally requires strong justification.

NMLs for airborne noise levels at residential receivers are derived using the information in **Table 6-16** (excerpt from the ICNG, refer to Section 3.1 of the *Technical Paper: Noise and Vibration* at **Appendix D**) and are outlined in **Table 6-17** for the noise catchment areas identified for the proposal.

Table 6-16 Noise management levels for residences for airborne noise

Time of day	Noise management level
	$L_{Aeq(15\ mins)}$
Standard construction hours : Monday – Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected* RBL + 10dB
	Highly noise affected** 75 dB (A)
Outside recommended standard hours for construction work	Noise affected RBL + 5 dB

Extracted from ICNG (DECCW, 2009).
**Noise affected – The point above which there may be some community reaction to noise.*
***Highly noise affected – The point above which there may be strong community reaction to noise.*

Table 6-17 Noise management levels for the proposal

NCA	Period	Rating background level[1]	Noise management levels[2]
NCA1	Day	41	51
	Evening	41	46
	Night	30	35
NCA2	Day	42	52
	Evening	42	47
	Night	36	41
NCA3	Day	45	55
	Evening	40	45
	Night	34	39
NCA4	Day	37	47
	Evening	35	40
	Night	31	36
NCA5	Day	38	48
	Evening	38	43
	Night	33	38
NCA6	Day	38	48
	Evening	38	43
	Night	34	39
NCA7	Day	37	47
	Evening	37	42
	Night	32	37

*Note: For NCA locations refer to **Figure 6-2***
Note: When there are two noise loggers in the same NCA, the lowest background noise level was used for the assessment.
*[1]RBL : refer **Table 6-14.***
[2]NML: RBL +10dBA during recommended standard hours and RBL+5dBA outside recommended standard hours.

NMLs for noise sensitive land uses other than residential receivers such as places of worship or recreational areas are based on internal noise levels. These criteria only apply when the building or area is in use. NMLs for other sensitive land uses that are applicable to the proposal are provided in **Table 6-18**. The ICNG, *Australian Standard 2107:2000 Acoustics – Recommended Design Sound Levels And Reverberation Times For Building Interiors*, or 'Australian Acoustic Consultants Guideline for Child Care Centre Acoustic Assessment' (Australian Association of Acoustical Consultants, 2010) do not provide NMLs for child care centres during construction. As a conservative approach, child care centres have therefore been designated the same NML used for residential areas for periods when the child care centre is in use.

Table 6-18 Noise management levels at sensitive land uses (other than residential) that are applicable to the proposal

Land use	Land use as defined by the ICNG	Noise Management Level (when in use)
		$L_{Aeq(15\ mins)}$
Child care centres	Not defined	Standard hours: RBL + 10dB Outside recommended standard hours: RBL + 5 dB
Commercial receivers	Offices, retail outlets	70 dB (A)
Tourist parks/hotels/motels	Residential	Standard hours: RBL + 10dB Outside recommended standard hours: RBL + 5 dB
Churches	Places of worship	Internal noise level: 45 dB (A)
Open space (active use)	Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level: 65 dB(A)
Open space (passive use)	Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level: 60 dB(A)

Where noise is predicted to be above the NMLs, all feasible and reasonable measures must be applied to reduce noise emissions. Where noise levels are predicted to be above the 'highly noise affected' NML (being 75 dB (A)), then restrictions to the hours of construction may apply.

Construction road traffic noise

The RNP does not provide a criterion to assess the noise generated by traffic during construction. Typically, the approach applied to construction traffic noise is to limit the increase in existing road noise levels to 2 dB (A). This approach has been applied to the construction noise impact assessment for the proposal.

Sleep disturbance criteria

The ICNG requires sleep disturbance to be considered where construction works are to be undertaken for more than two consecutive nights. The ICNG refers to the ECRTN for the appropriate assessment approach.

The ECRTN suggests that the $L_{A1(60\ second)}$ noise levels for night-time activities should be calculated and compared with the sleep disturbance screening criterion, being the RBL plus 15dB(A). In instances where the sleep disturbance screening criteria is exceeded, further assessment is recommended, with consideration given to how often these exceedances occur.

With regards to sleep disturbance, the ECRTN also suggests that the *'maximum internal noise levels below 50-55 dB (A) are unlikely to cause awakening reactions'.* Given that an open window provides up to 10 dB (A)[1] noise attenuation from outside to inside, it is reasonable to assume that external noise levels of 60-65 dB (A) are unlikely to result in awakening reactions. The occurrence of one or two events per night which generate noise with maximum internal levels of 65dB (A) to 70 dB (A) are unlikely to significantly affect health and wellbeing.

Construction vibration

Vibration targets vary depending on whether the particular activities of interest are continuous in nature, impulsive or intermittent, and whether they occur during the day or night. The effects of vibration can be separated into two main categories:

- Structural damage of buildings, including superficial cracking in cement render or plaster.
- Human comfort, where the occupants or users of the buildings are inconvenienced or possibly disturbed by vibration.

The relevant standards and guidelines used for assessing construction vibration are summarised in **Table 6-19**.

Table 6-19 Standards/guidelines used for assessing construction vibration

Item	Standard/guideline
Structural damage	German Standard *DIN 4150 - Part 3 - Structural Vibration in Buildings - Effects on Structures*
Human comfort (tactile vibration)*	*Assessing Vibration: A Technical Guideline* (DEC, 2006)
Human comfort (ground-borne noise)	*Interim Construction Noise Guideline* (DECC, 2009)

**This document is based upon the guidelines contained in British Standard 6472:1992, "Evaluation of human exposure to vibration in buildings (1-80 Hz)". This British Standard was superseded in 2008 with BS 6472-1:2008 "Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting" and the 1992 version of the Standard was withdrawn. Although a new version of BS 6472 has been published, the EPA still requires vibration to be assessed in accordance with the 1992 version of the Standard at this point in time.*

Structural damage

Table 6-20 provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration. The levels are designed to minimise the risk of cosmetic surface cracks and are set well below the levels that have the potential to cause damage to the main structure. Examples of threshold or cosmetic cracking include minor non-structural effects such as superficial cracking in cement render or plaster.

[1] An open window sufficiently open for ventilation purposes provides up to 10 dB(A) noise attenuation as discussed in Section 2.1.1 of the INP

Table 6-20 Structural damage vibration limits

Group	Type of structure	Vibration velocity in mm/s			
		At foundation at a frequency of		Plane of floor of uppermost storey	
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (eg buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Human comfort (ground-borne noise)

Construction activities such as compacting and drilling can generate vibration, which may enter buildings via the ground. This causes the floors, roofs, walls and ceilings to vibrate and to radiate noise, commonly referred to as ground-borne noise or regenerated noise. Ground-borne noise is typically low frequency and if audible is perceived as a 'rumble'.

Air-borne construction noise typically masks ground-borne noise levels. Consequently, ground-borne noise level values are generally only relevant when they are higher than the air-borne noise associated with construction.

Table 6-21 details the ground-borne NMLs as outlined in the ICNG. The ground-borne noise levels are applicable during the evening and night-time periods only, as the objectives are to protect the amenity and sleep of people when they are at home.

Table 6-21 Recommended ground-borne noise goals for construction activities

Time	Ground-borne noise goals
Evening (6pm to 10pm)	40 dB(A) $L_{Aeq(15\ min)}$
Night-time (10pm to 7am)	35 dB(A) $L_{Aeq(15min)}$

Operational criteria

Operational road noise criteria

Redeveloped road criteria are applied to noise sensitive receivers that are already subject to existing road traffic noise. As the works associated with the proposal would not deviate greatly from the existing alignment, the road noise levels would be assessed against the redeveloped road criteria at all sensitive receivers. Noise criteria applicable to the proposal are provided in **Table 6-22**.

Table 6-22 Road traffic noise criteria for residential receivers

Road category	Type of project/land use	Assessment criteria dB(A)	
		Day (7am – 10pm)	Night (10pm – 7am)
Freeway/ arterial/sub-arterial	Existing residences affected by noise from redevelopment of existing freeways/ arterial/ sub-arterial roads. Existing residences affected by additional traffic on existing freeways/ arterial/ sub-arterial roads generated by land use developments.	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)

In addition, the RNP also requires the 'relative increase' in noise levels to be considered for residential receivers. The relative increase is the difference in noise levels between the 'build' and 'no build' scenarios, (meaning road traffic noise without or with the proposal); with the assessment criterion set at 12 dB over the existing road traffic noise levels (refer **Table 6-23**). The 12 dB criterion has been specifically developed to capture excessive changes in amenity due to a road project, particularly in environments where there is a low level of existing traffic noise.

Table 6-23 Relative increase criteria for residential land use

Road category	Type of project/development	Total traffic noise level increase dB(A)	
		Day (7am – 10pm)	Night (10pm – 7am)
Freeway/ arterial/ sub-arterial roads and transit ways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	Existing traffic $L_{Aeq(15hour)}$ + 12 dB (external)	Existing traffic $L_{Aeq(9hour)}$ +12 dB (external)

When assessing feasible and reasonable safeguards and management measures for a redeveloped road, an increase of up to 2 dB(A) represents a minor impact where it is generally not considered feasible and reasonable to provide additional mitigation. An increase of greater than 2 dB (A) would require consideration of all feasible and reasonable safeguards and management measures.

A receiver is considered acutely affected if the predicted noise levels are equal to or greater than a daytime $L_{Aeq(15hour)}$ of 65 dB(A) or a night-time $L_{Aeq(9hour)}$ of 60 dB(A). If a noise sensitive receiver is found to be acutely affected, all feasible and reasonable mitigation options must be considered.

Noise assessment criteria for other sensitive land uses are provided in **Table 6-24.**

Table 6-24 Noise assessment criteria for other sensitive land uses

Existing sensitive land use	Assessment criteria		Additional considerations
	Day (7am to 10pm)	Night (10pm to 7am)	
Child care centre	Sleeping rooms $L_{Aeq(1hour)}$ 35 Indoor play areas $L_{Aeq(1hour)}$ 40 (internal) Outdoor play areas $L_{Aeq(1hour)}$ 55 (external)	-	Multi-purpose spaces, such as shared indoor play/sleeping rooms should meet the lower of the respective criteria. Measurements for sleeping rooms should be taken during designated sleeping times for the facility, or if these are not known, during the highest hourly traffic noise level during the opening hours of the facility.
Commercial receivers	-	-	The RNP refers to desirable noise levels in Australian Standard AS 2107:2000 – recommended design sound levels and reverberation times for building interiors. Table 1 of AS 2107:200 details maximum recommended design sound levels for different areas of occupancy in industrial buildings and shop buildings. These levels vary from 45 dB (A) for specialty shops, to 70 dB (A) for areas where light machinery is in use. The RNP states that “for commercial and industrial premises, information on desirable internal noise levels is contained in Australian Standard 2107:2000”.
Tourist parks/hotels/motels	-	-	Assessed against the residential road criteria (**Table 6-22**).
Open space (active use)	$L_{Aeq(15hour)}$ 60	-	In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise intrusion should be established. For areas where there may be a mix of passive and active recreation, such as school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.
Open space (passive use)	$L_{Aeq(15hour)}$ 55	-	

Existing sensitive land use	Assessment criteria		Additional considerations
	Day (7am to 10pm)	Night (10pm to 7am)	
Church (place of worship)	$L_{Aeq(1hour)}$ 40 (internal)	$L_{Aeq(1hour)}$ 40 (internal)	The criteria are internal, ie the inside of a church. Areas outside the place of worship, such as a churchyard or cemetery, may also be a place of worship. Therefore, in determining appropriate criteria for such external areas, it should be established what in these areas may be affected by road traffic noise. For example, if there is a church car park between a church and the road, compliance with the internal criteria inside the church may be sufficient. If, however, there are areas between the church and the road where outdoor services may take place such as weddings and funerals, external criteria for these areas are appropriate. As issues such as speech intelligibility may be a consideration in these cases, the open space (passive) use criteria may be applied. The open space (passive) land use has a noise assessment criterion of LAeq (15 hour) 55 (external) when in use. This criteria is applicable between 7am and 10pm.

Industrial noise criteria

The INP provides guidelines for the assessment and control of industrial noise, which would be applied to the heavy vehicle inspection bay, which would be staffed as needed and locked when not in use. Industrial noise assessments comprise two components, controlling intrusive noise impacts in the short term for residences and the maintenance of noise level amenity for particular land uses including residences.

Industrial noise sources are generally considered acceptable if the equivalent continuous (energy-averaged) level of noise from the industrial noise source (LAeq), measured over a 15 minute period, does not exceed the RBL in the absence of the source by more than 5dB(A). This is termed the intrusiveness criterion.

Amenity

The amenity criterion (otherwise known as background creep) is relevant to locations where an industrial noise source is present. The amenity criterion stipulates that the background noise level should not exceed the level appropriate for the particular locality and land use. To limit increasing noise levels, the maximum ambient noise level within an area from an industrial noise source should not normally exceed the acceptable noise levels specified in the INP.

The noise logger closest to the heavy vehicle inspection bay is BG3 (25 Jaspers Brush Road, Jaspers Brush) located in NCA2 (refer **Figure 6-2**). At this location, logging indicated that traffic noise is the dominant noise source, and industrial noise is not an existing feature in either of the areas.

Environmental noise criteria

Intrusiveness and amenity criteria must be applied at the most noise affected boundary or 30 metres from the nearest residential receiver, whichever is closer. A summary of the intrusiveness and amenity criterion for NCA2, where the heavy vehicle inspection bay would be located is provided in **Table 6-25**.

Table 6-25 Environmental noise criteria for the proposal

NCA	Period	RBL (L_{A90})	Intrusiveness criterion	Amenity criterion, dB(A)	Final environmental criterion, dB(A)
NCA 2	Day	42	47	50	47
	Evening	42	47	45	45
	Night	36	41	40	40

Sleep disturbance criteria

The RNP includes a review of international sleep arousal research and concludes that at our current level of understanding, it is not possible to establish absolute noise level criteria that would correlate to an acceptable level of sleep disturbance.

Application notes for the RNP recommend that sleep disturbance is assessed based on the emergence of the $L_{A1(1\ minute)}$ noise level over the corresponding $L_{A90(15\ minute)}$ noise level (ie the noise level exceeded for one per cent of the measurement period, or the 'typical maximum' noise level, against the background noise). The emergence is the proportion that the maximum noise levels rise above the typical noise levels. If the maximum noise levels (typically from engine braking) are significantly higher than the typical noise levels, the noise has a high level of emergence. As the emergence increases, the likelihood for sleep disturbance also increases. The emergence level is used as the basis for the sleep disturbance assessment.

The following screening criterion for sleep disturbance has been used in the assessment of sleep disturbance: $L_{A1(1\ minute)} < L_{A90(15\ minute)}$ + 15 dB(A).

6.2.4 Assessment of potential impacts

Construction

The proposed construction activities have the potential to generate a range of impacts on noise sensitive receivers within the study area of the proposal. These impacts have been considered separately and are as follows:

- Impacts from construction noise sources and activities.
- Impacts from construction noise during standard construction hours.
- Impacts from out of hours works, including sleep disturbance.
- Impacts from temporary construction and ancillary facilities such as compounds and stockpiles.
- Impacts from increased traffic noise due to construction traffic movements.
- Cumulative construction noise impacts.

Impacts from construction noise sources and activities

For the purposes of this assessment, five main construction activities have been identified. The equipment expected to be used during standard construction hours for each construction activity are provided below in **Table 6-26**. Sources of construction noise and vibration would comprise a range of heavy vehicles, plant and equipment and hand tools, with the noisiest activities expected to be related to rock crushing and asphalt paving activities. Based on the typical sound power levels for these sources, noise level predictions have been undertaken (refer to **Appendix D** for further details).

Table 6-26 Construction equipment required for general construction works

Activity	Typical equipment used	SWL dB(A)
Site establishment/ landscaping	**Typical activity SWL**	**105**
	Chainsaws	110
	Mulching plant and chipper	113
	Cranes	104
	Generators	101
	Bobcat	104
	Powered hand tools	108
	Air compressor	109
	Spoil trucks	95
	Material trucks	95
	Excavators	99
Earthworks	**Typical activity SWL**	**112**
	Compactors	104
	Grader	103
	Multi-tyred and vibratory rollers	97
	Concrete trucks	105

Activity	Typical equipment used	SWL dB(A)
	Concrete vibrator	97
	Asphalt paving plant	112
	Backhoe	103
	Sweeper	104
	Compressor	109
	Generators	101
	Rock crushing	112
	Road trucks	95
Paving	**Typical activity SWL**	**113**
	Compactor	104
	Jackhammers	108
	Multi-tyred vibratory roller	97
	Concrete truck	105
	Concrete vibrator	97
	Asphalt paving plant	112
	Backhoe	108
	Concrete saw	111
	Profiler	108
	Sweeper	104
	Compressor	109
	Generator	101
	Road trucks	95
Bridge works	**Typical activity SWL**	**111**
	Cranes	104
	Piling rigs	103
Local road and new road tie-in works	**Typical activity SWL**	**112**
	Vibratory compactor	104
	Excavator	98
	Concrete truck	105
	Concrete vibrator	97
	Backhoe	108
	Crane	104
	Asphalt paving plant	112
	Dump truck	95
	Delivery truck	98
	Light vehicle	90
	Trenching machine	99
	Milling machine	110

Activity	Typical equipment used	SWL dB(A)
	Line marking truck	102
	Hand tools and power tools	108

SWL – Sound Power Level. The Typical SWL represents noise levels from a range of the equipment listed at various distances around a 'typical' site with varying duty cycles. The levels have been refined from predictions and measurements undertaken at similar sites over many different projects. The typical levels are not a summation of all the equipment listed in this table.

A noise source may exhibit a range of particular characteristics that increase annoyance, such as tones, impulses, low frequency noise and/or intermittent noise. Where this is the case, an adjustment is applied to the noise level received at the assessment point to account for the additional annoyance caused by the particular characteristics of this noise source. The adjustments have been applied to the activities detailed above.

Impacts from construction noise during standard working hours

The majority of construction activities would occur between 7am and 6pm, Monday to Friday, and 8am to 1pm Saturdays. No construction works would be undertaken on Sundays or public holidays.

The predicted noise levels for the four construction activities that would be undertaken during standard construction hours and the number of sensitive receivers that would be impacted are provided in **Table 6-27**. The predicted noise levels indicate that 266 receivers would be impacted during site establishment (with no receivers highly affected), 498 receivers would be impacted during earthworks (with 27 receivers highly affected), 54 receivers would be impacted during bridge works (with no receivers highly affected) and 453 receivers would be impacted during paving works (with 31 highly affected). These results do not factor in reductions in noise levels that can be achieved through feasible and reasonable safeguards and management measures. The table also provides a total number of highly noise affected sensitive receivers (being those above 75 dB(A)).

NCA7, which represents Bomaderry, contains the majority of the impacted sensitive receivers owing to the higher density of sensitive receivers within this noise catchment, and the proximity of construction works to sensitive receivers.

Whilst this assessment represents the worst potential 15 minute period of construction activity, it does not necessarily represent the noise impact at noise sensitive receivers for an extended period of time. High noise activities, such as rock breaking and the use of concrete saws are only likely to occur for a small fraction of the total construction period. Construction noise impacts would be reduced by the implementation of feasible and reasonable safeguards and management measures, as outlined in **Section 6.2.5**.

Table 6-27 Predicted levels of construction noise during standard construction hours (daytime)

NCA	NML dB(A)[1]	Predicted noise levels dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers[2]
Establishment/landscaping works				
NCA1	51	**69**	7	0
NCA2	52	**67**	11	0
NCA3	55	**68**	3	0
NCA4	47	**61**	9	0
NCA5	48	**65**	13	0
NCA6	48	**64**	6	0

NCA	NML dB(A)[1]	Predicted noise levels dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers[2]
NCA7	47	**71**	217	0
Total			266	0
Earthworks				
NCA1	51	**76**	11	1
NCA2	52	**74**	12	0
NCA3	55	**75**	3	1
NCA4	47	**68**	16	0
NCA5	48	**72**	18	0
NCA6	48	**71**	8	0
NCA7	47	**78**	430	25
Total			498	27
Bridge works (daytime activities only)				
NCA1	51	**66**	8	0
NCA2	52	**73**	10	0
NCA3	55	42	0	0
NCA4	47	**61**	14	0
NCA5	48	**64**	6	0
NCA6	48	**67**	8	0
NCA7	47	**56**	8	0
Total			54	0
Paving				
NCA1	51	**77**	12	1
NCA2	52	**75**	13	1
NCA3	55	**76**	3	1
NCA4	47	**69**	18	0
NCA5	48	**73**	18	0
NCA6	48	**72**	8	0
NCA7	47	**79**	471	28
Total			543	31

*Note 1: Noise management levels are explained in **Table 6-16***
Note 2: Highly noise affected is considered to be ≥75 dB(A)
NCA – Noise Catchment Area
NML – Noise Management Limit
*Refer to **Table 6-17** for NMLs specific to NCAs*
Bold numbers indicate levels that exceed the relevant criteria

Impacts from construction noise during out of hours works, including sleep disturbance

Out of hours works

Out of hours work would be required for construction of the proposal. This work would not typically be noise intensive and/or would be impractical to be undertaken during standard construction hours owing to safety considerations and the need to maintain the operation of the highway. Works that are anticipated to be undertaken out of hours would potentially include:

- Bridge works, namely lifting and setting of support beams or girders over existing roads. These works would potentially be undertaken out of hours to restrict impacts to traffic movements along the proposal, which would need to be closed to allow the works to be undertaken safely. The evening and night time noise modelling results for bridgeworks are provided in **Table 6-28** and **Table 6-29**.
- Existing local road and new road tie in works at the beginning and end of the proposal and at local road junctions. This would potentially be undertaken at night time to limit the impacts of construction works on traffic movements along the highway and to allow the works to be undertaken safely. The evening and night time noise modelling results for existing local road and new road tie-in works are provided in **Table 6-28** and **Table 6-29**.
- Utility adjustments. Adjustments would potentially be required to be completed outside of standard working hours to minimise the impact on utility operations, road traffic and to provide a safe work environment.
- Refuelling and maintenance operations. Undertaking these activities outside of standard working hours would maximise the efficiency of plant and machinery operations during the standard working hours, which would potentially reduce the overall duration of construction of the proposal.
- Other works including: delivery of large pre-cast concrete components such as bridge girders; concrete cutting; and concrete pouring/curing.

Should any out of hours works exceed the relevant construction noise criteria in accordance with the ICNG, approval would be sought from the EPA on a case by case basis. Such works would also be undertaken in consultation with potentially noise affected sensitive receivers.

Table 6-28 Predicted levels of construction noise during the evening

NCA	NML dB(A)[1]	Predicted noise levels dB(A)	Exceedance of NML dB(A)	Number of receivers where NMLS are exceeded	Number of highly noise affected receivers[2]
Bridge works					
NCA1	46	**66**	20	18	0
NCA2	47	**73**	26	16	0
NCA3	45	42	no exceedance	6	0
NCA4	40	**61**	21	21	0
NCA5	43	**64**	21	22	0
NCA6	43	**67**	24	8	0
NCA7	42	**56**	14	654	0
Total				745	0
Existing local road and new road tie-in works					
NCA1	46	**67**	21	18	0
NCA2	47	**68**	21	19	0
NCA3	45	**83**	38	6	1
NCA4	40	**62**	22	21	0
NCA5	43	**69**	26	22	0
NCA6	43	**59**	16	8	0
NCA7	42	**80**	38	691	3
Total				785	4

*Note 1 Noise management levels are explained in **Table 6-16***
Note 2 Highly noise affected is considered to be ≥75 dB(A)
NCA – Noise Catchment Area
NML – Noise Management Level.
*Refer to **Table 6-17** for NMLs specific to NCAs*
Bold numbers indicate levels that exceed the relevant criteria

Table 6-29 Predicted levels of construction noise during the night time period

NCA	NML dB(A)[1]	Predicted noise levels dB(A)	Exceedance of NML dB(A)	Number of receivers at which NMLs exceeded	Number of highly noise affected[2]
Bridgeworks					
NCA1	35	**66**	31	30	0
NCA2	41	**73**	32	28	0
NCA3	39	**42**	3	6	0
NCA4	36	**61**	25	21	0
NCA5	38	**64**	26	22	0
NCA6	39	**67**	28	8	0
NCA7	37	**56**	19	764	0
Total				879	0
Existing local road and new road tie-in works					
NCA1	35	**67**	32	30	0
NCA2	41	**68**	27	30	0
NCA3	39	**83**	44	6	1
NCA4	36	**62**	26	21	0
NCA5	38	**69**	31	22	0
NCA6	39	**59**	20	9	0
NCA7	37	**80**	43	771	3
Total				889	4

*Note 1 Noise management levels are explained in **Table 6-16***
Note 2 Highly noise affected is considered to be ≥75 dB(A)
NCA – Noise Catchment Area
NML – Noise Management Level
*Refer to **Table 6-17** for NMLs specific to NCAs*
Bold numbers indicate levels that exceed the relevant criteria

The assessment presented above assumes that all bridge works and existing local road and new road tie-in works would occur at the same time. However, all bridgeworks and existing local road and new road tie-in works would not be undertaken simultaneously. The number of affected receivers at any given time would be less than those detailed above with construction taking place at only one or two bridges or existing and new road tie-in locations simultaneously.

The predicted noise levels indicate that during the evening (6pm to 10pm), a maximum of 745 receivers would be potentially impacted if all bridgeworks were undertaken simultaneously. No receiver would be highly noise affected during bridgeworks. Similarly, a maximum of 785 receivers would be potentially impacted if all existing local road and new road tie-in works were undertaken simultaneously. Under this scenario, the tie-in works would also result in four receivers being highly noise affected during the evening. During the night time period (10pm to 7am), bridgeworks would potentially impact a maximum of 879 receivers if all works were undertaken simultaneously. Existing local road and new road tie-in works would potentially affect 889 receivers if all works were undertaken simultaneously. Under this scenario, four receivers would be highly noise affected as a result of existing local road and new road tie-in works.

Additional out of hours works would be undertaken outside of the standard working hours in the following circumstances:

- When the works would not exceed the outlined NMLs.
- For the delivery of materials that require an escort by the police or other relevant authorities for safety reasons.
- For emergency reasons to avoid the loss of life, property and/or to prevent environmental harm.

The extent of construction works, and the indicative construction plant and equipment that would be required outside of standard construction hours is not currently known and would be determined during the detailed design phase of the proposal. All feasible and reasonable safeguards and management measures would be implemented to ensure that the potential for adverse impacts on sensitive receivers are minimised.

Sleep disturbance

Construction works would generally not be undertaken during the night time, and the likelihood of sleep disturbance occurring as a result of the proposal is considered to be low. However, sleep disturbance may occur should construction activities, particularly bridgeworks and existing local road and new road tie in works be undertaken during the night time period. **Table 6-30** and **Table 6-31** detail the modelling results of the sleep disturbance assessment which adopted a worst-case approach with all bridgeworks being undertaken simultaneously, or all existing local road and new road tie in works being undertaken at the same time.

The predicted noise levels indicate that sleep disturbance screening criteria would be exceeded at 653 receivers and awakening reaction criteria would be exceeded at 37 receivers should all bridgeworks be undertaken simultaneously during night time periods. Similarly, should all existing local road and new road tie-in works be carried out simultaneously during the night time period, sleep disturbance criteria would be exceeded at 60 receivers with the awakening reaction criteria exceeded at six receivers.

The assessment was carried out with the construction information available at the time of writing. Sleep disturbance would be reassessed by the construction contractor following the detailed design phase of the proposal when more accurate construction information is available.

Table 6-30 Sleep disturbance assessment – bridgeworks

NCA[1]	Predicted $L_{A1(1min)}$) noise levels, dB(A)	Sleep disturbance screening criteria dB(A)			Sleep disturbance awakening reaction criteria dB(A)		
		Criteria dB(A)	Exceedance of criteria dB(A)	Number of receivers where criterion are exceeded	Criteria dB(A)	Exceedance of criteria dB(A)	Number of receivers where criterion are exceeded
NCA1	75	45	30	30	65	10	3
NCA2	76	51	25	22	65	11	3
NCA3	92	49	43	6	65	27	1
NCA4	70	46	24	19	65	5	1
NCA5	77	48	29	17	65	12	4
NCA6	67	49	18	8	65	2	2
NCA7	88	47	41	551	65	23	23
		Total		653	**Total**		37

[1]*NCA – Noise Catchment Area*

Table 6-31 Sleep disturbance assessment – existing local road and new road tie-in works

NCA[1]	Predicted $L_{A1(1min)}$) noise levels, dB(A)	Sleep disturbance screening criteria dB(A)			Sleep disturbance awakening reaction criteria dB(A)		
		Criteria dB(A)	Exceedance of criteria dB(A)	Number of receivers where criterion are exceeded	Criteria dB(A)	Exceedance of criteria dB(A)	Number of receivers where criterion are exceeded
NCA1	66	45	21	14	65	1	1
NCA2	73	51	22	12	65	8	4
NCA3	42	49	no exceedance	0	65	no exceedance	0
NCA4	60	46	14	15	65	no exceedance	0
NCA5	64	48	16	6	65	no exceedance	0
NCA6	66	49	17	7	65	1	1
NCA7	55	47	8	6	65	no exceedance	0
		Total		60	**Total**		6

[1]*NCA – Noise Catchment Area*

Noise impacts from temporary construction ancillary facilities

Some construction ancillary facilities may need to be used out of standard construction hours to support out-of-hours activities such as paving, bridge works, refuelling activities, utility adjustments and road tie-in works. These would be required to minimise road safety impacts, minimise disruption to traffic flows and/or for technical and timetabling reasons. Construction ancillary facility sites that may need to be used out of standard construction hours include sites 4, 5, 6, 11, 12, 13, 15, 16 and 17 as shown in **Figure 1-1**.

The equipment used at the construction compounds would be similar to those in the scenarios listed in **Table 6-26**, specifically for site establishment and landscaping and earthworks. As a consequence, the typical sound power level from construction ancillary facilities would be 112 dB(A).

Table 6-32 presents the results of the modelling for temporary construction ancillary facilities. The predicted noise levels indicate that 56 receivers would be impacted during the day period, 91 receivers would be impacted during the evening period and 94 receivers would be impacted during the night time period. Four receivers would be highly noise affected. It should be noted that this situation would only occur if all seventeen potential sites for construction ancillary facilities were operational during the same period. The number of affected receivers is likely to be far less with activities likely to occur in fewer than 17 locations. The ancillary facilities should be assessed in further detail when locations are finalised by the construction contractor.

Table 6-32 Predicted noise levels from ancillary facilities

NCA[1]	NML day / evening / night dB(A)	Predicted noise level dB(A)	Number of receivers where NMLs day / evening / night are exceeded	Highly noise affected receivers[2]
NCA1	51 / 46 / 35	99	12 / 21 / 21	2
NCA2	52 / 47 / 41	93	11 / 17 / 17	2
NCA3	55 / 45 / 39	67	2 / 4 / 6	0
NCA4	47 / 40 / 36	64	12 / 19 / 20	0
NCA5	48 / 43 / 38	69	14 / 19 / 19	0
NCA6	48 / 43 / 39	65	5 / 8 / 8	0
NCA7	47 / 42 / 37	45	0 / 3 / 3	0

[1]NCA – Noise Catchment Area
[2]Highly noise affected is considered to be ≥75 dB(A)

Noise impacts of construction traffic

Spoil would be transported by truck using the cleared construction footprint for the proposal either adjacent to the highway or via an unsealed haul route as much as reasonably practicable for the duration of construction. Construction of the proposal would however increase both light and heavy vehicle movements on the Princes Highway during standard construction hours. An overall increase in traffic during the night-time period is not predicted.

Noise from additional traffic associated with the construction of the proposal is likely to be less than 0.5 dB (A). As this increase is well below 2 dB (A), the impact from additional traffic associated with the construction works would not be significant in accordance with the ENMM.

Operations such as trucks idling for long periods close to noise sensitive receivers may potentially adversely impact sensitive receivers. Safeguards and management measures outlined in **Section 6.2.5** would be implemented to minimise this potential impact.

Impacts from construction vibration

Vibration intensive works may occur throughout each phase of the proposal. This has the potential to result in structural/cosmetic damage or cause human discomfort by continuous, intermittent and impulsive vibration generated by general construction activities. Ground-borne noise impacts may also be generated by vibration-generating activities, such as compacting and drilling. Safe working distances that relate to cosmetic/structural damage and human discomfort for the proposal are presented in **Table 6-33**.

Table 6-33 Recommended safe working distances for vibration intensive plant

Plant	Rating/description	Safe working distance	
		Cosmetic damage (metres)	Human response (metres)
Vibratory roller	< 50 kN (Typically 1-2t)	5	15-20
	< 100 kN (Typically 2-4t)	6	20
	< 200 kN (Typically 4-6t)	12	40
	< 300 kN (Typically 7-13t)	15	100
	> 300 kN (Typically 13-18t)	20	100
	> 300 kN (> 18 t)	25	100
Small hydraulic hammer	300 kg – 5-12t excavator	2	7
Medium hydraulic hammer	900 kg – 12-18t excavator	7	23
Large hydraulic hammer	1600 kg – 18-34t excavator	22	73
Vibratory pile driver	Sheet piles	2–20	20
Pile boring	≤ 800 mm	2	N/A
Jackhammer	Handheld	1 nominal	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other structures. Any heritage property would need to be considered on a case by case basis.

Construction activities within the safe working distances may be unavoidable in some circumstances as a result of the works required and the prevalent geological site conditions. As a result, the safe working distances provided above may be exceeded. In these instances, the safeguards and management measures provided in **Table 6-35** would need to be implemented.

Operational noise

To assess the operational impacts of the proposal, both daytime and night-time noise levels were predicted for 2019, being the forecast year that the proposal would open, and 2029, ten years following. Two scenarios were then developed for both years in accordance with the RNP, being:

- The 'no build' scenario, being noise levels without the proposal. This would determine the road traffic noise levels that would occur due to natural traffic growth in the absence of the proposal.
- The 'build' scenario, being noise levels with the proposal. This scenario was used to assess noise levels at noise sensitive receivers to which the redeveloped road noise criterion applies; being those sensitive receivers that are already exposed to road traffic noise. This criterion is discussed further in **Section 6.2.3**.

Operational road noise

Residential receivers

The proposal has the potential to generate impacts on residential noise sensitive receivers within the study area during operation. The number of residential sensitive receivers at which the relevant road traffic noise criteria would be exceeded during daytime and night-time as a result of the proposal are provided in **Table 6-34**. A small increase in noise of typically one dB (A) and two dB (A) is predicted between 2019, the forecast year of opening, and 10 years after opening (2029). Locations at which the operational noise criteria would be exceeded are illustrated in **Figure 6-3** to **Figure 6-6**.

Table 6-34 Exceedances of operational noise criteria at residential sensitive receiver locations with the proposal

Time	Number of residential properties where relevant criteria are exceeded	Number of residential properties that are considered to be 'acute'*
Daytime period	73	30
Night-time period	83	38

**Acute - $L_{Aeq(15\ hour)}$ of 65 dB(A) or greater*

With low noise pavement, which is included in the concept design for the proposal, road traffic noise criteria as a result of the proposal would be exceeded at 73 residential receivers during the daytime period and of those, 30 residential receivers would experience noise levels which are considered to be acute ($L_{Aeq,\ (15\ hour)}$ is 65 dB(A) or greater). During the night-time period, road traffic noise levels would exceed the relevant noise criteria at 83 receivers and of those, 38 receivers would experience noise levels which are considered to be acute.

Not all receivers at which the noise criteria are predicted to be exceeded would be considered for noise mitigation. Section 6.2 of the *Technical Paper: Noise and Vibration* at **Appendix D** provides an explanation of eligibility for consideration of noise mitigation.

Receivers 123, 124, 125, 126 and 127 (refer **Figure 5-3** of the *Technical Paper: Noise and Vibration* at **Appendix D**) have been found to experience noise levels which exceed the relevant criteria. However, they are affected by road traffic noise from Meroo Road, not from the proposal. These receivers would therefore not be considered for any mitigation. A summary of the noise contributions for these receivers from the existing highway, the proposed grade-separated half-interchange at Meroo Road and Pestells Lane, Meroo Road and the proposal is provided in **Table 5-2** of the *Technical Paper: Noise and Vibration* at **Appendix D**.

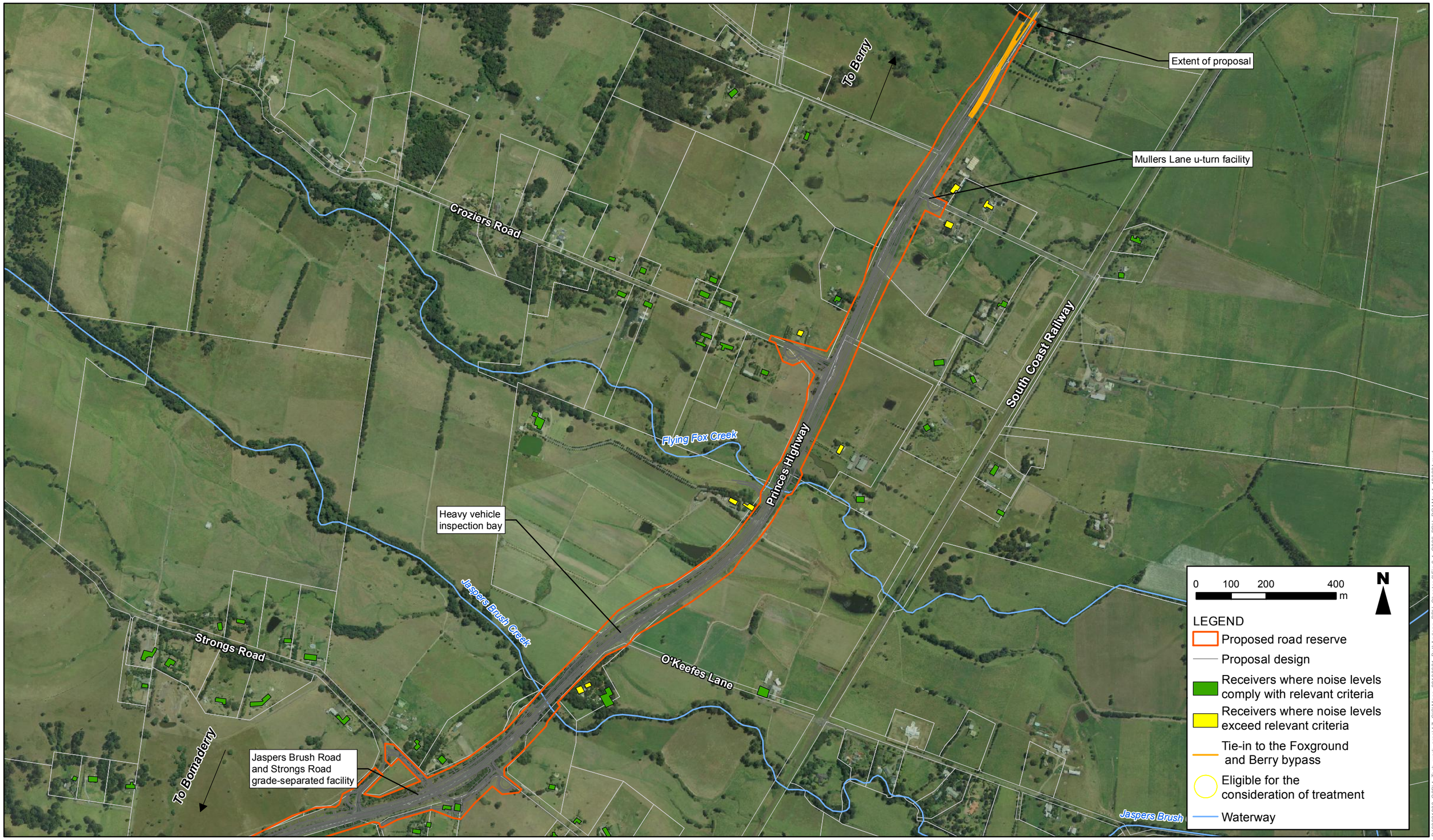

Figure 6-3 Receivers at which it is predicted noise criteria would be exceeded - Map 1

Source: AECOM (2013)

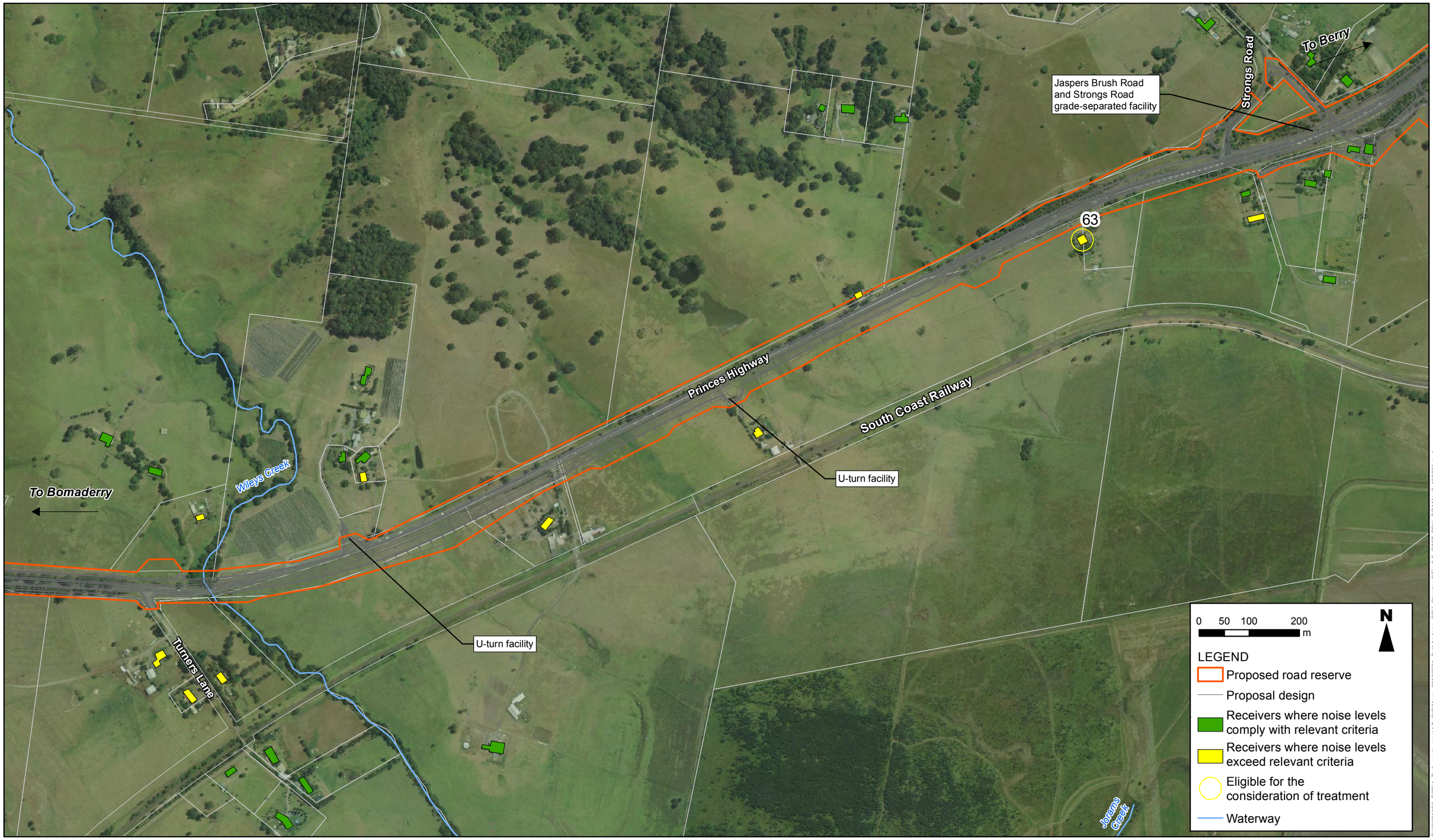

Figure 6-4 Receivers at which it is predicted noise criteria would be exceeded - Map 2

Source: AECOM (2013)

P:\60021933_G2B\4_Tech_work_area\4.7_GIS\Maps_20130621_BethAndean_BBU_Chapter 6\Fig 6-5_G097_BBU_DGAMap2_130624.mxd

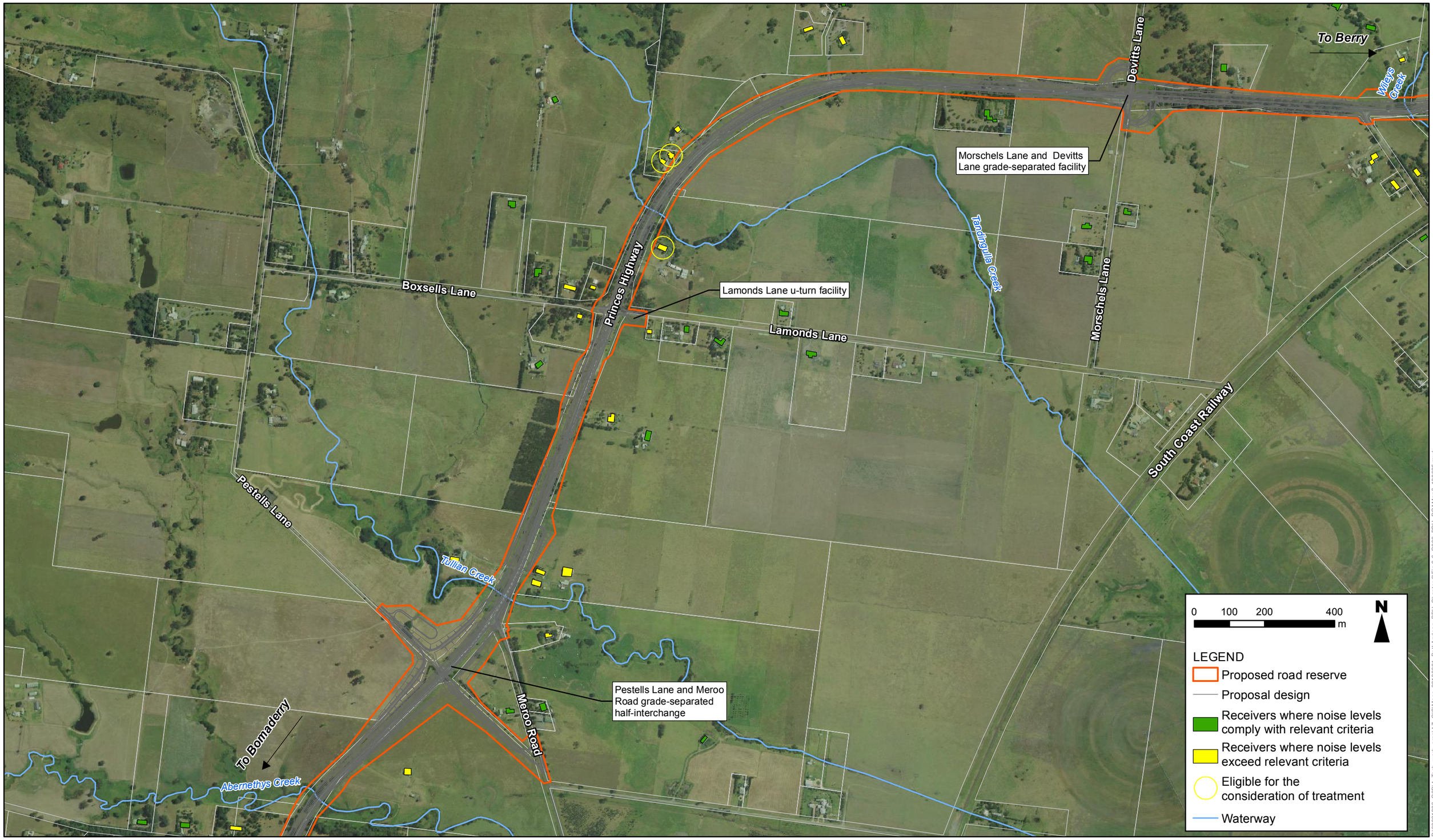

Figure 6-5 Receivers at which it is predicted noise criteria would be exceeded - Map 3

Source: AECOM (2013)

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Figure 6-6 Receivers at which it is predicted noise criteria would be exceeded - Map 4

Source: AECOM (2013)

Other sensitive land uses

Other sensitive land uses assessed as part of the proposal included Meroo Union Church, a childcare centre, three commercial receivers, tourist parks and motels and recreational facilities. Tourist parks and motels are assessed as residential receivers in accordance with the ICNG (**Table 6-18**). The predicted L_{Aeq} noise levels at sensitive land uses with the proposal are provided in **Section 6.2.1** of the *Technical Paper: Noise and Vibration* at **Appendix D** and summarised below.

Meroo Union Church (receiver 103) is located on the corner of the Princes Highway and Boxsells Lane, Meroo Meadow and has been assessed using low road noise pavement. Predicted noise levels for this receiver in 2019 using low road noise pavement are 59 dB(A) during the daytime and 55 dB(A) during the night time. In 2029, predicted noise levels at Meroo Union Church would be 60 dB(A) during the daytime and 56 dB(A) during the night time. When the church is in use, it is assumed that the windows and doors would be closed, which would provide up to 20 dB noise attenuation. An internal noise criterion of $L_{Aeq(1hour)}$ 40 dB(A) can therefore reach compliance with an external noise level of $L_{Aeq(1hour)}$ 60dB (A). Noise levels at this receiver would therefore comply with the relevant criteria and no further consideration of mitigation is required.

The child care centre at 281 Princes Highway, Bomaderry (receiver 778), assessed with low noise pavement, is predicted to have a daytime $L_{Aeq(15hour)}$ of 67 dB(A) in the year 2019 and 68 dB(A) in the year 2029. The noise assessment criteria for child care centres is detailed in **Table 6-24**. Noise levels at the receiver are predicted to be 69 dB(A) in the year 2019 and 71 dB(A) at year 2029. Therefore, the proposal would result in an exceedance of the applicable criteria for sleeping rooms, indoor play areas and outdoor play areas at the child care centre during the day (when in use). Additional safeguards and management measures provided in **Table 6-35** specific to the child care centre have therefore been considered.

Predicted noise levels at commercial receivers would comply with the applicable criteria of 70dB(A) under the build scenario in 2019 and 2029. No further consideration of impacts or application of safeguards and management measures has been undertaken at these locations.

Tourist parks and hotel/motels are located at 262 Princes Highway, Bomaderry (Treehaven Village); 278 - 280 Princes Highway, Bomaderry (Treehaven Tourist Park), 271 Princes Highway Bomaderry (The Bounty Hotel) and 173 Cambewarra Road, Bomaderry (Balan Village Motel). Tourist parks such as the ones being assessed often have permanent residents. As a precaution, these receivers have therefore been considered as part of the operational road noise assessment with regards to sensitive residential receivers (refer to **Table 6-34**). The results of this assessment are provided in Appendix I and Appendix J of the *Technical Paper: Noise and Vibration* at **Appendix D**).

Maximum noise levels and sleep disturbance

The ECRTN states that the relationship between maximum noise levels and sleep disturbance is not currently well defined. A review of relevant research in the ECRTN concluded that the maximum noise level, the extent that noise exceeds the ambient noise level and the number of noise events all contribute to sleep disturbance. Furthermore, international sleep arousal research included in the RNP (which largely supersedes the ECRTN) concludes that at the current level of understanding, it is not possible to establish absolute noise level criteria that would correlate to an acceptable level of sleep disturbance.

The RNP and the ENMM do not outline any requirements to provide noise mitigation options on the basis of the maximum noise levels criteria. Rather, maximum noise levels assessment can be used to prioritise the application of noise safeguards and management measures to limit the impact on noise sensitive receivers.

A maximum noise level event has been defined by the ENMM as any pass-by (vehicle movement along the proposal) which is more than 15 dB(A) greater than the difference between the maximum noise level recorded during noise monitoring (L_{max}), and the average measured noise level over a defined period (L_{Aeq}). The ENMM requires maximum noise levels to be calculated by determining the existing number of maximum noise level events and increasing it proportionally with the predicted traffic growth. Future maximum noise level events are highly dependent on the gradient of the road alignment, the curvature of the alignment and the speed changes along the alignment, which all impact a vehicle's ability to accelerate and decelerate, and for trucks to engage their brakes. There is currently no tool or methodology available to undertake an assessment which would accurately determine the likely impact of the proposal on maximum noise levels.

Maximum noise level events along the existing highway were measured on 20 June 2013 at 43 Morschels Lane, Meroo Meadow. The existing alignment at this location requires vehicles to brake more frequently than at other locations along the proposal. A total of 136 maximum noise level events were recorded on 20 June. It can therefore be assumed that the sleep disturbance noise goal of 65 dB(A) would be exceeded more than two or three times in one night at some locations, and could consequently be considered regular events. However, it is not possible to state that any given location is generally representative of the proposal with regards to maximum noise levels, and this location provides a conservative assessment. Noise logging undertaken as part of the proposal determined that maximum noise level events are currently typical occurrences at some locations along the alignment.

The proposal would be largely contained within the existing road corridor, and would reduce the grade of the existing highway through the construction of cuttings and bridges, which would assist to flatten the existing undulating alignment. Reducing the grade of the existing highway, and flattening the alignment would reduce the requirement for braking and accelerating in some places, resulting in a more consistent speed profile. As a result, some residences that are in close proximity to the proposal could potentially experience a reduction in the maximum noise levels, which could also reduce in frequency.

As traffic volumes increase, the average noise levels along the proposal would also increase. Should the maximum noise level events remain similar to those currently experienced from the existing highway, the difference between the average noise level and the maximum noise level (which defines a maximum noise level event) would be less and the potential for sleep disturbance to occur as a result of maximum noise level events could also decrease. On this basis, noise sensitive receivers located further away from the proposal are likely to experience a lower frequency of maximum noise levels than those receivers located closer to the proposal.

Maximum noise levels are generally thought to reduce from the source at twice the rate of average noise levels. Therefore, sensitive receivers exposed to road traffic noise from a relatively large distance from the proposal would be likely to experience maximum noise levels comparable to current conditions.

Impacts from the operation of the heavy vehicle inspection bay

Modelling of the heavy vehicle inspection bay was undertaken in accordance with the INP. The results of the industrial noise modelling are presented in Table 5-3 of the *Technical Paper: Noise and Vibration* at **Appendix D**.

Modelling of the heavy vehicle inspection bay considered noise levels at sensitive receiver 28 and receivers 30 to 34 (refer to Appendix A of **Appendix D**). The results showed that the operation of the heavy vehicle inspection bay would not lead to exceedances of the relevant criteria at any of the receivers assessed.

Noise management at sensitive receivers

The hierarchy of noise mitigation is firstly to consider at-source noise mitigation measures such as road design and traffic management, then the use of quieter pavements. If these measures cannot be designed to meet the noise criteria the use of 'in corridor' mitigation measures should be considered, which are generally noise barriers and mounds. Finally, if the applicable noise criteria cannot be met by using a combination of all these methods, at-receiver mitigation measures can be considered such as architectural treatments and property boundary walls.

In accordance with the ENMM, a total of 45 residential receivers during the daytime period and 54 residential receivers during the night time period would be considered for noise mitigation. Some of these receivers would be considered for mitigation under both daytime and night-time criteria. Receiver 103 (Church) and receiver 778 (Child Care Centre) would also be considered for noise mitigation. These receivers are summarised in Appendix I of the *Technical Paper: Noise and vibration* at **Appendix D**. A range of available road design and traffic management options for the proposal have been considered including the provision of low noise pavement for the entire alignment.

The results indicate that with a low-noise pavement, which has been included in the concept design for the proposal, a total of 43 receivers, including 42 residential receivers and one child care centre, would be considered for further feasible and reasonable mitigation. A total of 26 of these receivers would be isolated, meaning they are located in groups of three or less. Architectural treatment should be offered, where reasonable and feasible, to isolated receivers at which the noise criteria are exceeded and are located in groups of three or less. A noise barrier may be considered for receivers that are located in larger groups.

A noise barrier was considered for receivers located along the eastern side of the Princes Highway in Bomaderry township to reduce noise levels to the applicable noise criteria. However, the receivers in this area currently have road access directly onto the Princes Highway. The proposal would also allow property access in a left-in /left-out arrangement directly onto the Princes Highway. A noise barrier in this area would require either large gaps for property access or an alternative property access route. Given that the performance of a noise barrier would be considerably reduced with large gaps and that alternative access to these properties would require the construction of additional roads and property acquisition, a barrier is not deemed feasible or reasonable. As a result, a total of 42 residential receivers and one child care centre would be considered for architectural treatment.

6.2.5 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or manage noise and vibration impacts. These measures are provided in **Table 6-35** and summarised in **Section 7.2**.

Low noise pavement has been included in the concept design of the proposal and is therefore not part of the safeguards and management measures for the proposal.

Table 6-35 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
Construction noise impacts on sensitive receivers	Revise the noise and vibration assessment based on the final detailed design.	Roads and Maritime project manager and Qualified noise specialist	Detailed design
	Prepare and implement a Construction Noise and Vibration Management Plan (CNVMP) in accordance with Practice Note VI of the ENMM (RTA, 2001) prior to the commencement of construction that: • Identifies feasible and reasonable approaches to reduce noise and vibration impacts during construction of the proposal, including ancillary facilities. • Identifies the extent that noise sensitive receivers are affected. • Provides an assessment of the construction noise impact of the proposal on the community. • Considers potential cumulative impacts associated with the concurrent construction of the proposal with other major construction projects following the receipt of detailed construction schedule when available. • Includes a sleep disturbance assessment. • Considers appropriate height and location of temporary noise barriers and mounds for noise attenuation within ancillary facilities. • Identifies details of the out of hours works. • Complies with the requirements of the project EPL (once obtained).	Construction contractor	Pre-construction and construction
	Provide detail regarding proposed consultation with the community on noise and vibration in the community involvement plan for the proposal.	Construction contractor	Pre-construction and construction
	Inform the community about any out of hours works in accordance with Practice Note VII of the ENMM.	Construction contractor	Pre-construction and construction
	Implement a 24-hour hotline and complaints management procedure for noise and other construction related complaints.	Construction contractor	Pre-construction and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
	Include specific noise management measures within the CNVMP such as: • Carry out noise intensive construction works during standard construction hours where feasible and reasonable. • Schedule noisy activities that cannot be undertaken during standard construction hours as early as possible during the evening and/or night-time periods. • Select appropriate plant for each task, to minimise the noise impact. • Plan the delivery of material to, and removal of spoil and waste from the proposal so there is a consistent and minimal number of trucks arriving at the site at any one time. Carry out these activities during standard construction hours where reasonably practicable and safe to do so. • Minimise reversing. • Fit non-tonal reversing alarms on all construction equipment where possible, reasonable and where acceptable from a work health safety perspective. • Maximise the distance between noisy plant items and nearby residential receivers. • Orientate noisy equipment away from residential receivers where feasible and reasonable. • Locate site access points and roads as far as reasonably practicable away from residential receivers. • Use structures or enclosures to shield residential receivers from noise sources where reasonably practicable. • Require trucks to travel via internal haul routes and major roads and routes where reasonably practicable. • Minimise truck queuing or idling near residential dwellings. • Provide respite periods during times of noise intensive works where sensitive receivers will be adversely impacted for extended periods. These could include late start and/or early finishes.	Construction contractor	Pre-construction and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
	• Plan noise intensive works in the following order of priority to minimise the potential impacts on sensitive receivers: – Standard working hours. – Evening working hours. – Night-time working hours. • Use bored piling in place of impact piling wherever possible. Additionally, only undertake impact piling during standard construction hours and only where ground conditions require it. • Stage traffic movements to restrict movement which pass by noise sensitive receivers. • Minimise noise from plant and equipment using treatments which could include mufflers, enclosed working areas and screening.		
Construction noise impacts from ancillary facilities	Where necessary to minimise noise impacts, and where feasible and reasonable, use noise barriers and mounds at the temporary construction ancillary facility sites.	Construction contractor	Pre-construction and construction
	Include any additional mitigation measures in the CNVMP in relation to the operation of the ancillary facilities.	Construction contractor	Pre-construction and construction
Construction vibration impacts on sensitive receivers	Minimise the size of vibration intensive equipment, taking into account the safe working distances and the distance between the area of construction and the nearest sensitive receiver. If vibration intensive works are required outside of the safe working distances, use alternative equipment to ensure distances are not exceeded.	Construction contractor	Construction
	Undertake construction works in accordance with the following procedure when the use of vibration intensive equipment within safe working distances for cosmetic damage cannot be avoided: • Notify the affected residents and community of the proposed works. • Undertake attended vibration measurements prior to the commencement of vibration intensive works. • Install a permanent vibration monitoring system if ongoing vibration intensive works are required. The system will warn operators when vibration levels are approaching cosmetic damage levels. • Carry out dilapidation surveys on potentially affected properties.	Construction contractor	Construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
Operation			
Noise levels from road traffic exceed criteria at sensitive receivers	Develop and implement all feasible and reasonable safeguards and management measures to meet the applicable noise criteria in consultation with sensitive receivers.	Roads and Maritime project manager	Detailed design and construction
	Specific noise mitigation for this proposal includes building architectural treatments. Consideration of architectural treatment has been recommended for 42 residential properties and one child care centre to achieve the applicable noise criteria where feasible and reasonable. Treatments for properties with exceedences of up to 8 dB (A) could include modifications to buildings such as the provision of fresh air ventilation, sealing of wall vents and upgrading window and door seals. The type of architectural mitigation to be implemented at receivers specified for consideration of architectural treatment will be confirmed during detailed design.	Roads and Maritime project manager	Detailed design and construction
	Undertake post construction noise monitoring in accordance with the ENMM to determine whether the noise mitigation measures are adequate. Take appropriate action if further mitigation is required and is feasible and reasonable.	Roads and Maritime project manager	Detailed design and construction
Operational noise impacts on sensitive land uses	Undertake a site inspection of the child care centre at 281 Princes Highway (receiver 778) during the detailed design phase. Consult with the owner of the centre on feasible and reasonable noise safeguards and management measures available and implement the agreed measures. Examples may include: • Upgraded fencing. • Upgraded seals, doors, glazing. • Upgrade to mechanical ventilation system.	Roads and Maritime project manager and construction contractor	Pre-construction

6.3 Biodiversity

This chapter provides an assessment of terrestrial and aquatic biodiversity, and is supported by the *Technical Paper: Terrestrial Flora and Fauna* (Biosis, 2013), and the *Technical Paper: Aquatic Ecology and Water Quality Management* (Cardno Ecology Lab, 2013). The technical papers are provided at **Appendix E** and **Appendix F** respectively.

6.3.1 Methodology

For the purposes of the terrestrial and aquatic biodiversity assessments, the study area is defined as the footprint of the proposal (the proposal area) plus a 200 metre buffer. The assessment of aquatic ecology was also undertaken within an expanded study area, due to the potential for aquatic ecosystem impacts to occur in areas beyond the study area. The expanded study area includes areas upstream and downstream of each of the eight identified creeks that transect the proposal within the study area, as well as the lower estuaries of Broughton Creek and the Shoalhaven River.

The detailed scope and methodology of the terrestrial biodiversity assessment is provided in Section 2 of the *Technical Paper: Terrestrial Flora and Fauna* (Biosis, 2013) at **Appendix E**. The general methodology included desktop review of flora and fauna likely to occur in the study area, targeted flora and fauna surveys and ground-truthing and the assessment of impacts to flora, fauna and their habitats.

The detailed scope and methodology of the aquatic ecology and water quality assessment is provided in Section 2 of the *Technical Paper: Aquatic Ecology and Water Quality Management Assessment* at **Appendix F**. The general methodology included desktop assessment of aquatic habitats and their associated biota and field sampling, including assessments of water quality and aquatic ecology.

6.3.2 Existing environment

Terrestrial flora

Vegetation communities

Native vegetation communities

Seven native vegetation communities have been mapped during field surveys as occurring within the study area, Currambene-Batemans Lowlands Forest, Shoalhaven Sandstone Forest, Illawarra Gully Wet Forest, Riverbank Forest, South Coast Grassy Woodland, Reedland and Acacia Scrub. Two additional vegetation communities, grassland and planted vegetation which were also present are not considered to be native or derived vegetation communities.

Threatened ecological communities

One critically endangered community listed under the EPBC Act is likely to occur within the expanded study area, being the Littoral Rainforest and Coastal Vine Thicket. However, the study area for the proposal is not under direct marine influence, and this EEC was not observed during field surveys for the proposal. No further assessment of this EEC was deemed necessary.

A search of the BioNet Atlas of NSW Wildlife within the expanded study area identified 14 Threatened Ecological Communities (TECs) listed as endangered under the TSC Act (refer to Section 3.2.2 of the *Technical Paper: Aquatic Ecology and Water Quality Management* at **Appendix F**), Four of these TECs are considered relevant to the terrestrial and aquatic environment within the study area, including:

- Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions (Coastal Saltmarsh). Coastal Saltmarsh is not present within the study area but is located downstream of the proposal area in areas of saline influence and periodic tidal inundation.
- Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (FWCF). FWCF are associated with periodic or semi-permanent inundation by freshwater, typically occurring on silts, muds or humic loams in depressions, flats, drainage lines, backswamps, lagoons and lakes associated with coastal floodplains. The composition of FWCF is primarily determined by the frequency, duration and depth of waterlogging. The vegetation characteristics of all creeks within the study area visited during the field survey are consistent with this community, although they were generally heavily degraded by weed infestation. FWCF in such a degraded state is still considered to be part of this ecological community.
- River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Coast Bioregions (RFEFCF). The mapped Riverbank Forest vegetation community within the study area is consistent with RFEFCF. Within the study area, RFEFCF has been severely fragmented by current and historical activities including vegetation clearance, flood mitigation and drainage works, urban and industrial development, urban and agricultural runoff, weed invasion, grazing and other soil disturbance (NSW Scientific Committee, 2004).
- Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion (ILGW). ILGW occurs on relatively gently sloping to undulating lands less than 200 metres elevation. Most remnants of this community are small and fragmented, and their long term viability is threatened. Within the study area, ILGW occurs as several scattered patches on the northern side of the Princes Highway to the west of Strongs Road. All stands of ILGW within the study area are considered to be in a poor condition, based on the species present and the ongoing impacts from weed invasion and livestock grazing.

Refer to the following figures for the locations of these TECs:

- FWCF Figures 3.3 to 3.8 of the *Technical Paper: Aquatic Ecology and Water Quality Management* (Cardno 2013).
- RFEFCF Figures 3.1 to 3.22 of the *Technical Paper: Terrestrial Flora and Fauna* (Biosis 2013).
- ILGW Figures 3.1 to 3.22 of the *Technical Paper: Terrestrial Flora and Fauna* (Biosis 2013).

Coastal Saltmarsh is not shown in the technical paper figures as it is located about 10 to 15 kilometres outside the study area for the proposal.

Threatened flora

Database searches of the NSW BioNet Atlas of Wildlife and EPBC Protected Matters Search Tool identified previous records of 26 listed threatened flora species or their habitat as occurring within 10 kilometres of the study area. All threatened flora species listed as occurring within 10 kilometres of the proposal are considered to have a low to medium likelihood of occurrence within the study area (refer to Table A2-1 of the *Technical Paper: Terrestrial Flora and Fauna* at **Appendix E**).

No TSC Act or EPBC Act listed flora species were recorded in the study area during field surveys undertaken for the proposal.

Based on the proximity of previous records and/or the presence of identified habitat preferences, potential habitat may exist within the study area for four threatened flora species:

- Illawarra Greenhood (*Pterostylis gibbosa*), listed as an endangered species under the TSC Act and the EPBC Act.
- Leafless Tongue Orchid (*Cryptostylis hunteriana*), listed as a vulnerable species under the TSC Act and the EPBC Act.
- Austral Toadflax (*Thesium australe*), listed as a vulnerable species under the TSC Act and the EPBC Act.
- Bauer's Midge Orchid (*Genoplesium bauera*), listed as an endangered species under the TSC Act.

These four threatened flora species have a medium likelihood of occurrence in the study area. No threatened flora species are considered to have a high likelihood of occurrence in the study area.

Eucalyptus langleyi is listed as a vulnerable species under the TSC Act and EPBC Act and an endangered population under the TSC Act. Searches of the Atlas of NSW Wildlife (OEH,2013) identified the potential for individual *Eucalyptus langleyi* as well as an endangered *Eucalyptus langleyi* population to occur north of the Shoalhaven River and inside the study area. As the species, and therefore the endangered population, was not recorded in the study area, and due to the limited availability of suitable habitat present, the *Eucalyptus langleyi* species and endangered population are considered to have a low likelihood of occurrence in the study area.

Weeds

Field surveys within the study area identified eight exotic species listed as noxious weeds within the Shoalhaven LGA. **Table 6-36** provides a list of these species and the weed classes to which they belong. The regulatory requirements for the management of these noxious weed classes include:

- Class 4 – The growth and spread of the flora must be controlled according to the measures specified in a management plan published by the local control authority.
- Class 5 – The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with.

Given that the survey effort for noxious weeds was focussed within areas of native vegetation, it is considered likely that further noxious weed species would occur within cleared and disturbed portions of the study area.

Table 6-36 Noxious weeds recorded in the study area

Scientific name	Common name	Noxious weeds class
Ageratina riparia	Mistflower	4
Ligustrum lucidum	Large-leaved Privet	4
Ligustrum sinense	Small-leaved Privet	4
Salix fragilis	Crack Willow	5
Ageratina adenophora	Crofton Weed	4
Ageratina riparia	Creeping Crofton Weed	4
Lantana camara	Lantana	4
Rubus fruiticosus sp. agg	Blackberry	4

Two weeds of national significance; Lantana (*Lantana camara*) and Blackberry complex (*Rubus fruiticosus*), were recorded in the study area during field surveys. Other than the requirements of the *Noxious Weeds Act 1993*, there are no additional regulatory obligations to control weeds of national significance. The invasion of lantana is also listed as a key threatening process under the TSC Act.

Environmental weeds were present in all areas of native vegetation that were surveyed as part of the field surveys for the proposal, and also dominated cleared and disturbed areas throughout the study area. Environmental weeds recorded throughout the study area largely comprised annual and perennial grasses and herbs.

Terrestrial fauna

Threatened fauna

Seventy threatened fauna species listed under the EPBC Act and/or TSC Act or their potential habitat have been previously recorded within 10 kilometres of the study area. During the field survey, no threatened or migratory species were recorded. Of the 70 species listed, 43 were considered to have a low likelihood of being present within the study area, 15 species had a medium likelihood and 12 species were identified as having a high likelihood, including eight species which have been previously recorded within the study area. Species with a medium or high likelihood of occurrence are listed in **Table 6-37**.

Six fauna habitat types were identified within the study area, ranging from predominantly cleared areas of low to moderate habitat value to fragmented small patches of native vegetation. The majority of the vegetation that would be cleared to accommodate the construction footprint of the proposal is in poor condition or has been considerably altered and is considered to have low conservation significance. Regardless, both cleared areas and patches of remnant and native vegetation regrowth within the study area support habitat features for native fauna, including tree hollows, riparian vegetation, falling logs and feeding resources.

Fauna species with a medium to high likelihood of occurrence within the study area are considered to have potential habitats present within the study area which are in poor to moderate condition. Additionally, these species are either known to occur or are likely to occur within the study area, and would utilise habitats opportunistically within the study area during seasonal migration, or would regularly use the habitats present within the study area.

Table 6-37 Threatened fauna species with a medium to high likelihood of occurrence in the study area

Species		TSC Act Listing		EPBC Act listing		Likelihood of occurrence	Recorded during field surveys (recent or historic)
Scientific name	**Common name**						
Botaurus poiciloptilus	Australasian Bittern	Yes	Endangered	Yes	Endangered	Medium	No
Burhinus grallarius	Bush Stone-curlew	Yes	Endangered	No	N/A	Medium	No
Callocephalon fimbriatum	Gang-gang Cockatoo	Yes	Vulnerable	No	N/A	High	No
Calyptorhynchus lathami	Glossy Black-Cockatoo	Yes	Vulnerable	No	N/A	High	Yes
Dasyurus maculatus	Spotted-tailed Quoll	Yes	Vulnerable	Yes	Endangered	Medium	No
Daphoenositta chrysoptera	Varied Sittella	Yes	Vulnerable	No	N/A	Medium	No
Glossopsitta pusilla	Little Lorikeet	Yes	Vulnerable	No	N/A	Medium	No
Hieraaetus morphnoides	Little Eagle	Yes	Vulnerable	No	N/A	Medium	No
Ixobrychus flavicollis	Black Bittern	Yes	Vulnerable	No	N/A	Medium	No
Lathamus discolor	Swift Parrot	Yes	Endangered	Yes	Endangered	Medium	No
Lophoictinia isura	Square-tailed Kite	Yes	Vulnerable	No	N/A	High	No
Neophema pulchella	Turquoise Parrot	Yes	Vulnerable	No	N/A	Medium	No
Ninox connivens	Barking Owl	Yes	Vulnerable	No	N/A	Medium	No
Ninox strenua	Powerful Owl	Yes	Vulnerable	No	N/A	High	No
Petroica boodang	Scarlet Robin	Yes	Vulnerable	No	N/A	Medium	No
Tyto novaehollandiae	Masked Owl	Yes	Vulnerable	No	N/A	Medium	No

Species		TSC Act Listing		EPBC Act listing		Likelihood of occurrence	Recorded during field surveys (recent or historic)
Scientific name	**Common name**						
Tyto tenebricosa	Sooty Owl	Yes	Vulnerable	No	N/A	Medium	No
Litoria aurea	Green and Golden Bell Frog	Yes	Endangered	Yes	Vulnerable	Medium	No
Chalinolobus dwyeri	Large-eared Pied Bat	Yes	Vulnerable	Yes	Vulnerable	Medium	Yes
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Yes	Vulnerable	No	N/A	High	No
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Yes	Vulnerable	No	N/A	High	Yes
Mormopterus norfolkensis	Eastern Freetail-bat	Yes	Vulnerable	No	N/A	High	Yes
Myotis macropus	Southern Myotis	Yes	Vulnerable	No	N/A	High	Yes
Petaurus australis	Yellow-bellied Glider	Yes	Vulnerable	No	N/A	High	No
Pteropus poliocephalus	Grey-headed Flying-fox	Yes	Vulnerable	Yes	Vulnerable	High	Yes
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Yes	Vulnerable	No	N/A	High	Yes
Scoteanax rueppellii	Greater Broad-nosed Bat	Yes	Vulnerable	No	N/A	High	Yes

Wildlife corridors

The majority of the study area is covered by cleared areas and grazed paddocks, containing little native vegetation and have not been mapped or described as a native plant community.
Within the study area, the landscape is highly modified and provides a low level of connectivity between areas of remnant vegetation and flora and fauna habitats situated outside of the study area. This includes Seven Mile Beach National Park and the Cambewarra Range onwards to Morton National Park, east and west of the study area respectively. This low level connectivity and the additional barrier of the existing highway limit wildlife corridors in the study area.

Vegetation complexity in the study area is considered to be low, with vegetation other than grassland limited to discontinuous and narrow strips of tree cover with understorey in some places, as well as minor patches and isolated trees over the lower Shoalhaven floodplain. As a result, the study area is likely to support a narrow range of fauna species and does not provide favourable conditions for the dispersal of native flora.

Riparian vegetation associated with Wileys Creek and Jaspers Brush Creek that traverse the proposal are identified as environmental corridors under the *South Coast Regional Conservation Plan* (DECCW, 2010). Creeks and some road reserves within the study area provide some limited value as local wildlife corridors for some species. These smaller local corridors are important in linking the larger corridors, and provide additional value of protecting riverbanks, improving water quality and flows, controlling soil erosion and increasing land productivity through shelterbelts, windbreaks and screens (Shoalhaven City Council 2005). Wildlife corridors within the study area are presented in **Figure 6-7**.

Migratory species

In an expanded search, which included the distant downstream Shoalhaven / Crookhaven estuary, 40 migratory fauna species were listed as potentially occurring within 10 kilometres of the study area. No migratory species were observed during the field surveys undertaken for the proposal (Biosis, 2013), however; previous surveys within the study area included recordings of four migratory species; White-bellied Sea-eagle (*Haliaeetus leucogaster*), Cattle Egret (*Ardea ibis*), Black-faced Monarch (*Monarcha melanopsis*) and Rufous Fantail (*Rhipidura rufifrons*).

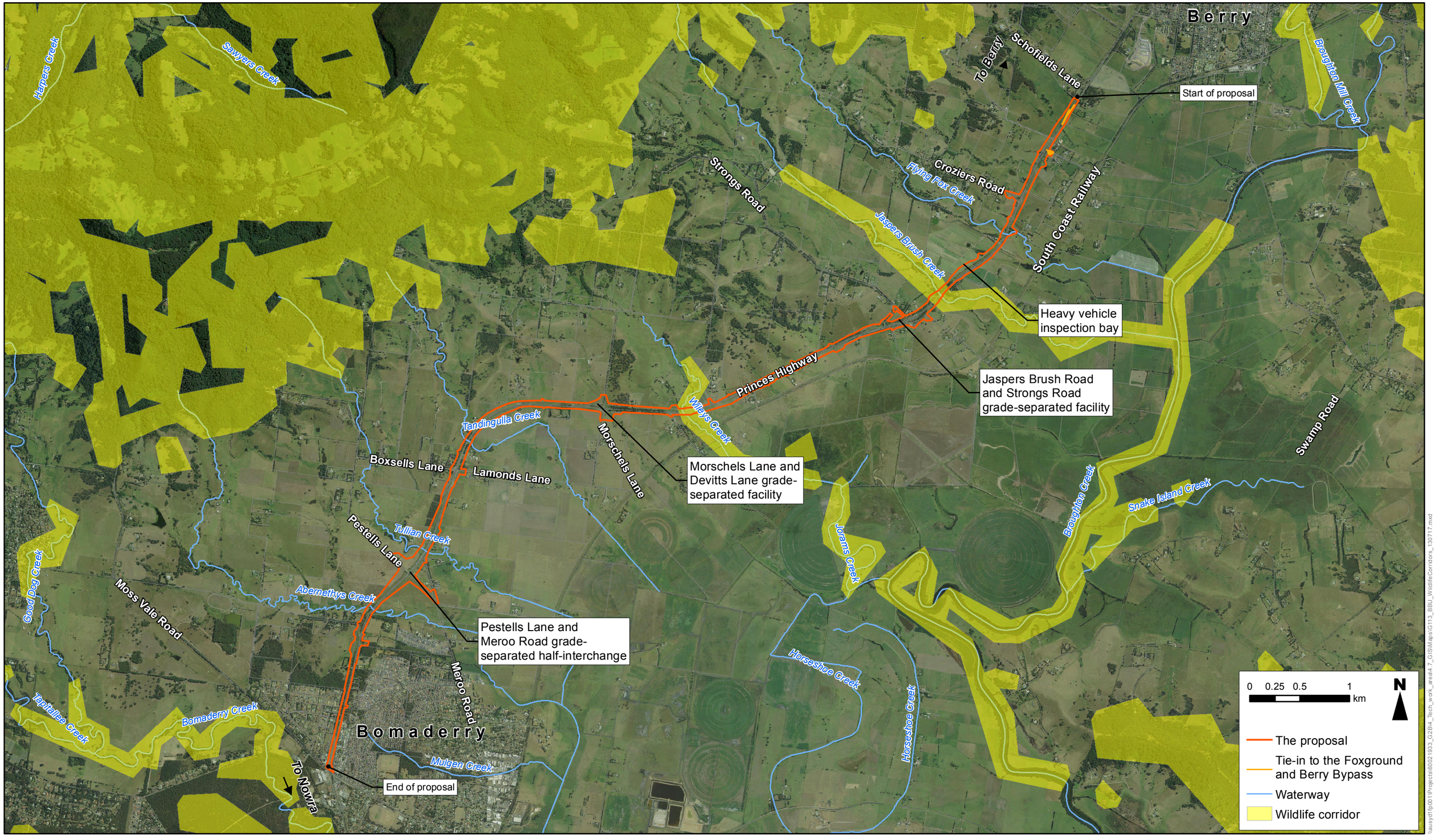


Figure 6-7 Wildlife corridors

Source: AECOM (2013), Biosis (2013)

Terrestrial habitats

Open forest

Open forest is found within areas identified on **Figure 6-8** to **Figure 6-10** as Currambene Batemans Lowland Forest, Shoalhaven Sandstone Forest and Illawarra Gully Wet Forest. Open forest within the study area is largely disturbed and highly fragmented as a result of historic and ongoing grazing on farmland and from residential development. The understorey, shrub layer and groundcover consists of scattered patches of weed species, and native and exotic grasses, providing limited foraging and sheltering habitat for small birds and ground dwelling fauna.

Areas of remnant open forest largely consist of mature trees with hollows and stands of *Allocasuarina littoralis*, a key feed tree for the threatened Glossy Black Cockatoo *Calyptorhyncus lathami*. Several other bird species listed as vulnerable, threatened or endangered under the TSC Act and / or the EPBC Act have been previously recorded within open forests in the study area, or this habitat type provides potential fauna habitat for these species. Despite the high level of disturbance of the understorey, open forest provides a moderate level of habitat features important in the maintenance of native fauna diversity and the lifecycle of local populations of birds and arboreal and ground dwelling mammals. These features largely comprise potential breeding and nesting/roosting habitat, and foraging resources.

Riparian corridors

Riparian corridors are located within areas defined as Riverbank Forest on **Figure 6-8** to **Figure 6-10** and have been affected by ongoing grazing, erosion and weed infestation. Within the study area, this habitat type contains mature *Casuarina cunninghamiana* species with hollows, providing potential roost sites and landscape connectivity for fauna, including arboreal mammals and microchiropteran bats. Areas of weed infestation provide foraging, nesting and sheltering habitat for small birds. There is little capacity for regeneration of natural riparian vegetation without considerable resource allocation.

Woodland

Poor condition woodland habitat comprising scattered remnant trees is present as South Coast Grassy Woodland and low quality Currambene Batemans Lowland Forest vegetation communities (**Figure 6-8** to **Figure 6-10**). Woodland habitat present in the study area provides some foraging and nesting habitat for small birds, and roosting resources for microchiropteran bats. Hollow-bearing trees exist within cleared grazing lands, providing potential roosting sites for fauna, particularly microchiropteran bats. Fauna species present would be limited to common species tolerant of highly disturbed vegetation such as the Rainbow Lorikeet (*Trichoglossus haematodus*) and the Eastern Rosella (*Platycercus eximius*).

Scrubland / planted vegetation

Areas of scrubland and planted vegetation within the study area are considered to be of moderate condition and of moderate habitat value. This habitat type has a patchy distribution within the study area (**Figure 6-8** to **Figure 6-10**), providing nesting and foraging habitat for some species of birds.

Scrubland is dominated by native Acacia spp. with the understorey present in patches, comprising a mixture of other native shrubs and introduced species. The ground cover consists of annual and perennial weeds, with no leaf litter deposits due to recent disturbance, limiting the ability of this habitat type to provide reptilian habitat.

In areas where planted stands are present, they largely consist of a native vegetation structure, with some stands containing Black Oak (*Allocasuarina littoralis*), a known feed tree for the listed Glossy Black Cockatoo (*Calyptorhyncus lathami*). Some of the more mature planted stands contain high levels of debris, providing potential foraging and sheltering habitat for reptiles and small ground dwelling mammals. There is potential for threatened species to use this habitat for foraging and habitat dispersal. Several bird species were observed utilising this habitat during field surveys of the study area.

Exotic closed grassland

Exotic closed grassland is widely dispersed within the study area and is in poor condition. Grassland was observed to provide foraging habitat for raptor species, with open areas providing prey such as exotic rodent species, rabbits, hares and native reptiles. Grassland is also considered to provide potential roosting and foraging habitat for microchiropteran bats in isolated hollow-bearing trees and stags. Grassland may also provide potential foraging habitat for reptiles, ground-dwelling mammals and nocturnal forest owls.

Koala habitat

Three preferred feed tree species were recorded within the study area, including Tallowwood (*Eucalyptus microcorys*), Scribbly Gum (*Eucalyptus robusta*) and Forest Red Gum (*Eucalyptus tereticornis*).

Tallowwood was recorded within the study area as plantings. This species comprised less than 15 per cent of the canopy and therefore does not constitute Potential Koala Habitat. Scribbly Gum occurs within a small roadside, forest patch, on the eastern side of the Princes Highway between Cambewarra Road and Abernethys Lane in Bomaderry. Mapped as Shoalhaven Sandstone Forest (refer to **Figure 6-10**), the patch covers approximately five hectares, and is completely surrounded by urban development. As Scribbly Gum within the patch comprises more than 15 per cent of the total number of upper strata species, this area is classified as 'Potential Koala Habitat' under SEPP 44.

Forest Red Gum occurs within the study area as scattered roadside trees on the western side of the Princes Highway, between Strongs Road and Wileys Creek. Mapped as five small patches of ILGW (refer to **Figure 6-8**), this vegetation is not classified as 'Potential Koala Habitat' under SEPP 44 as the small stands of trees do not equal or exceed one hectare in area. Due to the isolation of these patches within the landscape, it is unlikely that they would provide habitat for the koala.

There are five documented records for Koalas within 10 kilometres of the proposal, situated outside of the study area to the north-east, east, south and west. The only recent record of a Koala within 10 kilometres of the proposal is within the Seven Mile Beach Reserve, north-east of the study area.

It is considered unlikely that the study area currently supports or could potentially support a population of Koala, with the species determined as having a low likelihood of occurrence within the area of ‘potential’ Koala habitat and the remainder of the study area.

Habitat trees

Seventy-five habitat trees (both dead stags and alive) containing hollows or exfoliating bark were recorded during the field surveys within the study area. Of these, 37 are confirmed hollow-bearing trees, eight contain fissures in the bark suitable for threatened microbat roosts and the remaining trees were located in clusters containing both hollows and fissures. These habitat trees may provide habitat for tree-roosting threatened and/or non-threatened microbats, parrots and arboreal mammals.

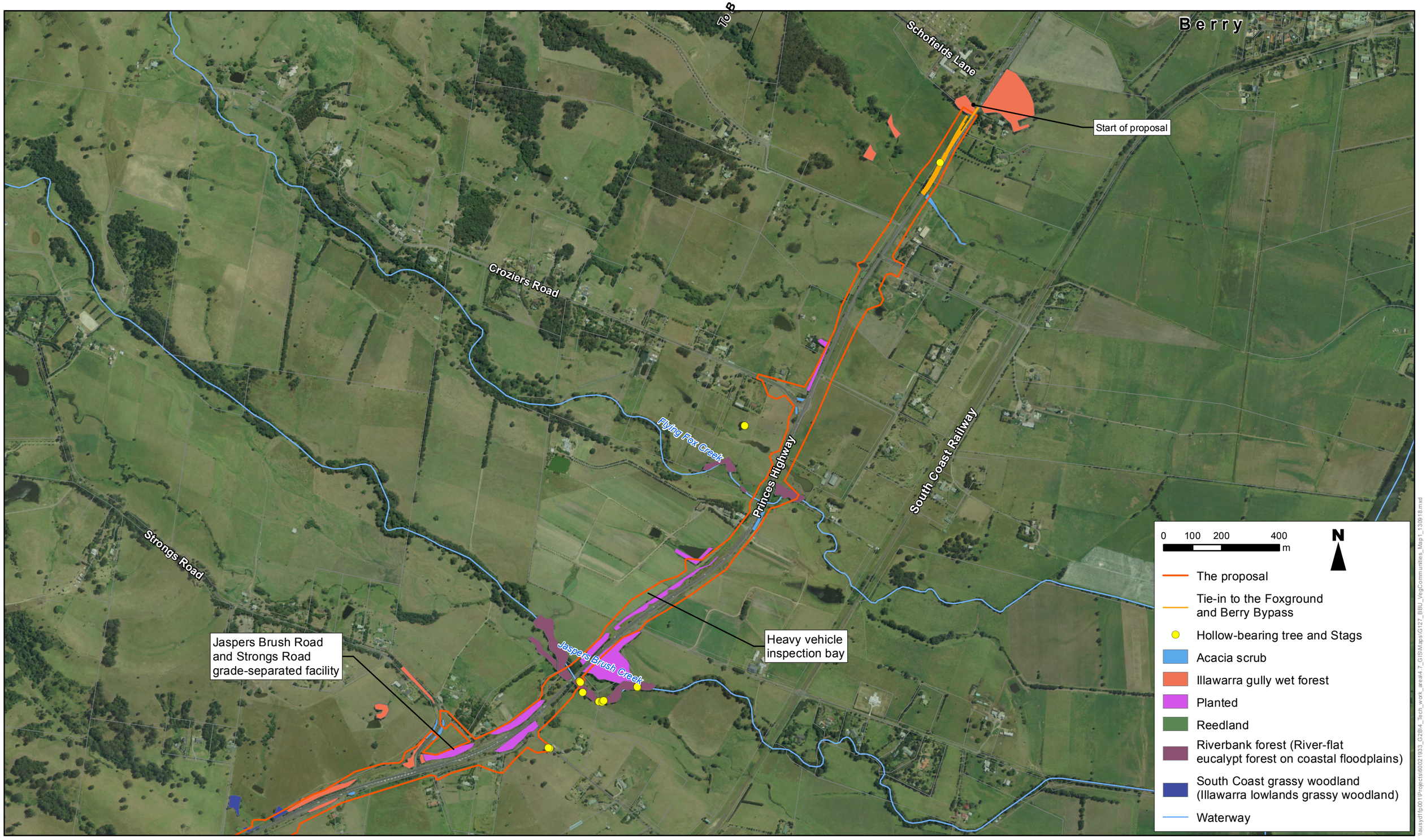


Figure 6-8 Vegetation communities - Map 1

Source: AECOM (2013), Biosis (2013)

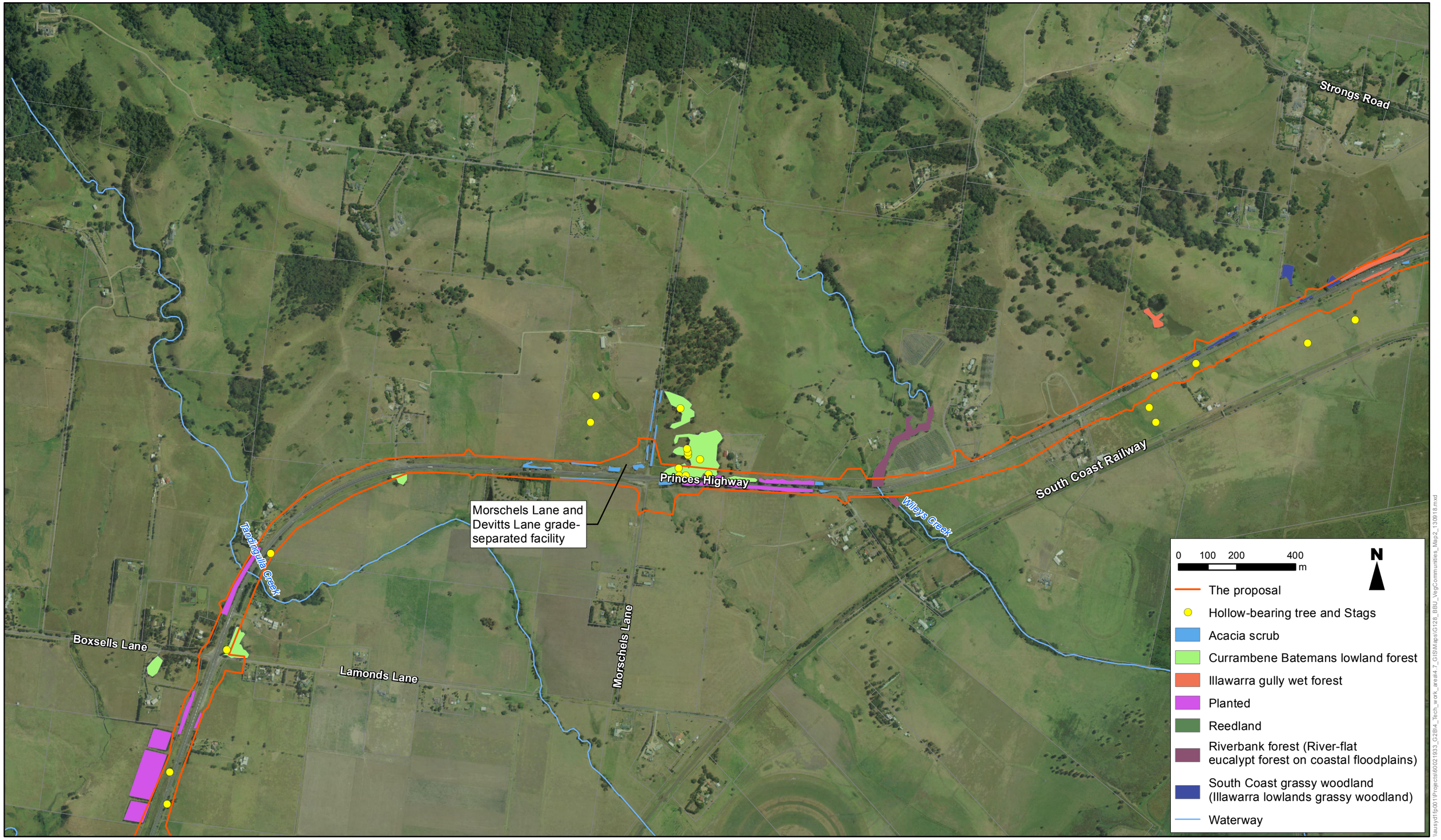


Figure 6-9 Vegetation communities - Map 2

Source: AECOM (2013), Biosis (2013)

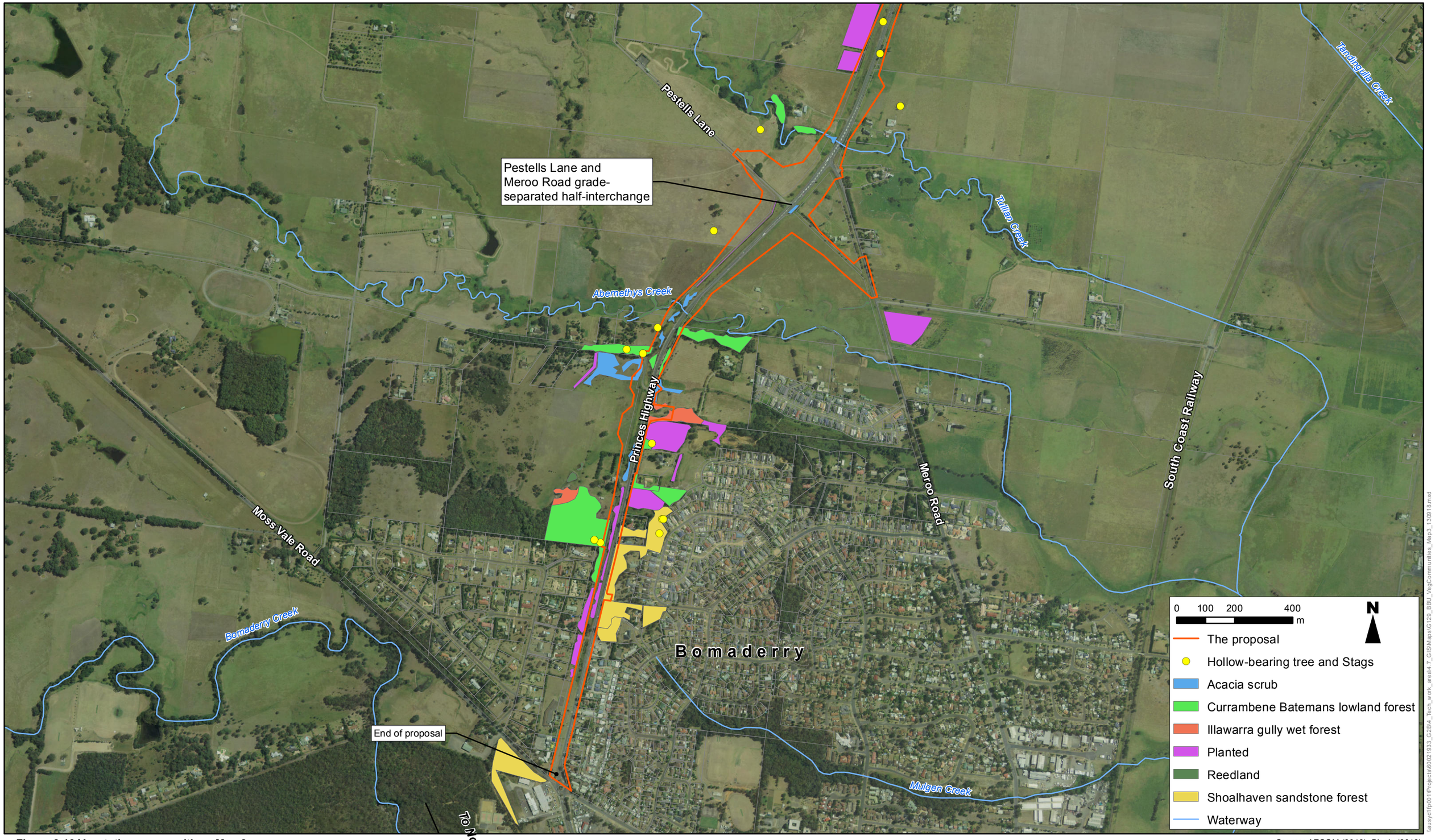


Figure 6-10 Vegetation communities - Map 3

Source: AECOM (2013), Biosis (2013)

Aquatic flora and fauna

Macrophytes

Previous surveys undertaken by The Ecology Lab (2007) identified 15 macrophyte species within the study area. These included Cumbungi (*Typha sp*.), Spikerush (*Isolepis prolifera*), Starwort (*Aster sp*.), Duckweed (*Lemna sp*.), Water Ribbons (*Triglochin procerum*), Arum Lilies (*Zantedeschia aethopica*), Tall Spikerush (*Eleocharis sphacelata*), River Clubrush (*Schoenoplectus validus*), Unidentified Rush (*Cyperus sp*.), Common Reed (*Phragmites australis*), Knotweed (*Persicaria sp*.), Water Plantain (*Alisma plantago-aquatica*), Watermilfoil (*Myriophyllum sp*.), Watercress (*Nasturtium officinale*) and Blunt Pondweed (*Potamogeton ochreatus*).

Three of the listed threatened flora species identified as part of the terrestrial flora and fauna assessment are also associated with the Coastal Saltmarsh EEC, including the Narrow-leafed Wilsonia (*Wilsonia backhousei*), Round-leafed Wilsonia (*Wilsonia rotundifolia*) and Australian Saltgrass (*Distichlis distichophylla*).The Coastal Saltmarsh EEC is not located within the study area for the proposal; however, 2.06 square kilometres of saltmarsh is present about 10 to 15 kilometres downstream of the study area in the Shoalhaven/Crookhaven estuary.

Macroinvertebrates

Details of all macroinvertebrate taxa collected from edge habitat sites within the study area during the field surveys are provided in Appendix F of the *Aquatic Ecology and Water Quality Management Technical Paper* at **Appendix F**. The greatest number of macro invertebrate taxa were collected upstream of Tullian Creek, and the least were collected downstream of unnamed creek crossing number two, which is located north of Andersons Lane at chainage 19800 (refer to Figure 2.1 of the *Technical Paper: Aquatic Ecology and Water Quality Management* at **Appendix F**).

Fish

Thirty-six fish species were identified through a literature and database search as potentially existing or being present historically within the study area. Of these, 33 are native species and three are exotic species (Table 3.1 of **Appendix F**). It is likely that some species, particularly the larger and more sensitive, may not be present within the study area.

Previous field surveys within the study area identified nine freshwater and estuarine fish species within the waterways that intersect the proposal (The Ecology Lab, 2007). Four of these species; the Long-finned Eel (*Anguilla reinhardtii*), Flathead Gudgeon (*Philypnodon grandiceps*), Striped Gudgeon (*Gobiomorphus australis*) and Empire Gudgeon (*Hypseleotris compressa*) were recorded within freshwater habitat associated with the Broughton Creek catchment. An additional five species, including the Australian Smelt (*Retropinna semoni*), Pacific Blue-eye (*Psuedomugil signifer*), Estuary Perchlet (*Ambassis marianus*), Sea Mullet (*Mugil cephalus*) and the introduced Eastern Gambusia (*Gambusia holbrooki*), were recorded at the upper tidal limit in the Broughton Channel, as well as the Flathead Gudgeon (The Ecology Lab, 2007).

Nine fish species, a mixture of freshwater and estuarine, were caught during the field surveys undertaken for this assessment: Longfinned Eel (*Anguilla reinhardtii*), Flathead Gudgeon (*Philypnodon grandiceps*), Striped Gudgeon (*Gobiomorphus australis*), Empire Gudgeon (*Hypseleotris compressa*), Shortfinned Eel (*Anguilla australis*), Eel (*Anguilla* spp.), Australian Smelt (*Retropinna semoni*), Eastern Gambusia (*Gambusia holbrooki*), and Gudgeon spp. Exact locations of where these species were caught, are detailed in Table 3.4 of **Appendix F**.

Migratory species

An expanded search, which included the distant downstream Shoalhaven / Crookhaven estuary identified 35 aquatic fauna species that are provided protection and listed under the Section 248 of the EPBC Act, as either migratory marine species, listed marine species or whales and other cetaceans (refer to Table 3.1 of **Appendix F**). Ten of these species are listed as migratory marine species, comprising six mammals and four reptiles. There are 26 listed marine species, including two mammals, four reptiles and 20 ray finned fishes from the order Syngnathiformes (including pipefish, pipehorses, seahorses, seadragons and ghostpipefish).

Threatened aquatic fauna

Three of the native fish species identified in literature and database searches as occurring or having the potential to occur within 10 kilometres of the proposal are listed as threatened. The FM Act and EPBC Act list the Macquarie Perch (*Macquaria australasica*) as an endangered species. The Black Cod (*Epinephelus daemelii*) is listed as a vulnerable species under the EPBC Act and FM Act, and the Australian Grayling (*Prototroctes maraena*) is listed as a protected species under the EPBC Act and as a vulnerable species under the FM Act.

A search of the BioNet Atlas of NSW Wildlife identified five amphibian species listed as threatened or vulnerable under the TSC Act as occurring or likely to occur within the expanded study area of the proposal. No other aquatic fauna were identified as occurring.

Noxious aquatic fauna

One noxious fish species listed as a Class 1 noxious fish under the FM Act in the Shoalhaven LGA, the Eastern Gambusia (*Gambusia holbrooki*) was identified during the field survey. Other Class 1 noxious species may potentially occur within or surrounding the study area, including the Common Carp (*Carprinus carpio*), Redfin Perch (*Perca fluviatilis*) and Oriental Weatherloach (*Misgurnus anguillicaudatus*).

Aquatic habitats

Broughton Creek catchment

Broughton Creek originates just below the Illawarra Plateau upstream of the proposal in the north, and ends downstream of the proposal at the Shoalhaven River. The upper freshwater section of Broughton Creek provides major fish habitat (Class 1 waterway) and has a relatively high Riparian, Channel and Environmental (RCE) score (refer to Appendix A of the *Technical Paper: Aquatic Ecology and Water Quality Management* at **Appendix F**). Upper tributaries are ephemeral, only flowing during large rainfall events, and have poorly defined channels with few standing pools. These tributaries are often colonised by pasture grasses and are considered unlikely to provide fish habitat (Class 4 waterway).

Creeks that traverse the study area flow south-east off the Cambewarra Range south of Berry, and enter Broughton Creek in its lower estuarine reach. The creek channels are less clearly defined within the floodplain and have been modified and straightened into irrigation channels in some areas. Fringing wetlands and billabongs appear to be present within the floodplain along previous creek channel alignments.

Downstream of the proposal, the channel of Broughton Creek is estuarine and up to 50 metres wide, discharging into the lower Shoalhaven River estuary. The estuarine reach of Broughton Creek has been previously classed as major fish habitat (Class 1 waterway) (The Ecology Lab, 2007). Broughton Creek has been cleared for agriculture within the floodplain, and riparian vegetation is thin and sparse.

Abernethys Creek catchment

Abernethys Creek and Broughton Creek sub-catchments have similar landform, land use and aquatic characteristics and are also likely to have similar flora, fauna and aquatic habitat characteristics. For the purpose of this assessment, Abernethys Creek has been considered in conjunction with the Broughton Creek catchment.

Aquatic and semi-aquatic fauna habitat

Reedland vegetation communities within the study area are classified as aquatic and semi aquatic fauna habitat (**Figure 6-8** to **Figure 6-10**). Within the study area, aquatic and semi aquatic habitats are considered to be in moderate condition, providing moderate fauna habitat value. Semi aquatic vegetation such as creeklines, drainage lines and water bodies such as farm dams contain a number of microhabitats suitable for foraging, sheltering and breeding resources for fauna, as well as supporting fringing vegetation, consisting of mostly exotic species. A number of creeklines and drainage lines contain *Typha domingensis*, which provides potential breeding, foraging and sheltering habitat for frogs.

All water bodies contain fringing and emergent vegetation, with areas of mapped Reedland, provide feeding, nesting and sheltering habitats for aquatic birds, frogs and reptiles, as well as resources for microchiropteran bats. A number of birds were observed using this habitat type, as well as some frog species and the Red-bellied Black Snake (*Paeudechis porphriacus*). Ground dwelling mammals may also use this habitat as dispersal and foraging corridors.

SEPP 14 Coastal Wetlands

The SEPP 14 listed Coomonderry Swamp is located about seven kilometres east of the study area, inland of Seven Mile Beach National Park. Coomonderry Swamp lies on the eastern side of a ridge that separates the Broughton Creek valley and floodplain from the coast. The 670 hectare semi-permanent freshwater swamp is fed by surface and groundwater from the eastern slopes of Harley Hill, Moeyan Hill and Coolangatta Mountain (NSW NPWS 1998). The drainage catchments of Coomonderry Swamp, situated five kilometres southeast of Berry are not within the study area, and would be unaffected by the proposal.

The Shoalhaven/Crookhaven estuary is located downstream of the confluence of Broughton Creek and the Shoalhaven River. It supports a number of significant estuarine wetlands, many of which are SEPP 14 listed, including the Comerong Island Nature Reserve.

Groundwater dependent ecosystems

Shallow alluvial groundwater systems have been identified upstream of the proposal in the Broughton Creek floodplain and in the area immediately north of Berry, where Broughton Mill Creek, Bundewallah Creek and Connollys Creek converge (RTA, 2010). Groundwater levels in these areas are typically between 0.37 metres and 2.5 metres below ground level. Shallow alluvial groundwater systems are often in direct connection with surface water bodies, such as coastal waterways. These systems can be quickly recharged and their water levels restored when droughts break (DLWC, 2002). The groundwater system in the study area is likely to support surface flows, hyporheic ecosystems and terrestrial vegetation such as riparian forests. The hyporheic zone is a fluctuating region where water exchanges between the surface and groundwater and is an important habitat for many aquatic invertebrates and a refuge during droughts and floods.

Shallow groundwater can support riparian vegetation either permanently or seasonally. The groundwater needs to be sufficiently high to sustain the vegetation. The sections of riparian habitat most dependent on groundwater within the study area are most likely to occur in areas where the water table is closest to the surface. However, the relationship between groundwater and survival of riparian vegetation in the study area is not known.

Groundwater can also be important for the persistence of aquatic macrophytes during periods when waterways are not flowing. An example would be Cumbungi, whose roots penetrate beneath creek beds.

Groundwater flow can be an important part of maintaining instream flow to support shallow aquatic habitat, such as riffles. Groundwater contribution to surface water flows can also be important to the long term survival of unconnected pools. This is especially the case during droughts as pools function as a refuge for aquatic flora and fauna. The importance of groundwater to base flow of waterways within the study area is not known. There are no known significant springs in the study area.

Coomonderry Swamp is a well-known groundwater dependent ecosystem (GDE) within the region. Its groundwater inflows come from a catchment outside the study area (to the east of Harley hill, Moeyan hill and Coolangatta Mountain) and therefore would be unaffected by the proposal.

6.3.3 Potential impacts

Construction – Terrestrial

Vegetation clearance and terrestrial habitat loss, including loss of Threatened Ecological Communities

Construction of the proposal would directly and indirectly impact on native vegetation as a result of vegetation clearance. Direct impacts would be via the clearance of 5.11 hectares of terrestrial native vegetation to accommodate the footprint of the proposal (refer to **Table 6-38**), and would include the loss of fauna habitat features including nesting habitat and roosting hollows, as well as feeding, shelter and dispersal resources. The following habitat trees would require removal for construction of the proposal:

- Nine individual hollow-bearing trees.
- Three clusters of hollow-bearing trees and stags, with each cluster containing up to five Spotted Gums and/or stags.
- Six dead stags.

The majority of the vegetation that would be cleared for the proposal is in poor condition or has been completely altered and is considered to have low conservation significance. While the native vegetation to be cleared provides a range of food, shelter and dispersal resources, the proposal is unlikely to considerably impact on important terrestrial habitat within the study area.

Table 6-38 Impacts of the proposal to terrestrial native vegetation within the study area

Native vegetation community	Habitat type	Direct impacts (hectares)	Indirect impacts (hectares)	Total impact
Currambene Batemans Lowland Forest	Open Forest	1.44	2.36	3.80
Illawarra Gully Wet Forest	Open Forest	0.24	1.56	1.80
Shoalhaven Sandstone Forest	Woodland	0.98	0.74	1.72
South Coast Grassy Woodland (ILGW)*	Woodland	0.53	0.74	1.27
Riverbank Forest (RFEFCF)*	Riparian corridor	0.30	0.01	0.31
Reedland#	Riparian	0.12	0.19	0.31
Acacia scrub	Scrubland	1.50	0.49	1.99
Total (hectares)		5.11	6.09	11.2

**Threatened Ecological Community*

*#0.02 hectares of directly impacted Reedland and 0.16 hectares of indirectly impacted Reedland have been identified and mapped as FWCF by Cardno Ecology Lab for the purposes of the Aquatic Ecology and Water Quality Management Assessment (refer to Section 4.4 of **Appendix F**). Impacts to FWCF as a result of the proposal are detailed below in construction – aquatic impacts subsection of **Section 6.3.3**.*

Threatened ecological communities

The 5.11 hectares of terrestrial native vegetation to be removed during construction of the proposal includes 0.53 hectares of RFEFCF and 0.30 hectares of ILGW. The RFEFCF to be removed to accommodate the proposal is located along Jaspers Brush Creek, Wileys Creek and Flying Fox Creek (refer to **Figure 6-8** to **Figure 6-9**). The ILGW to be removed comprises several scattered patches of vegetation on the northern side of the Princes Highway, to the west of Strongs Road (refer to **Figure 6-9**).

An assessment of significance for both TECs under Section 5A of the EP&A Act concluded that there is unlikely to be a significant impact on either vegetation community as:

- The areas likely to be impacted are considered to be of low conservation significance.
- The proposal would not result in significant further fragmentation or isolation of any patches of these communities.
- The two communities are likely to persist as poor condition vegetation or better within 10 kilometres of the proposal, including areas in good condition in conservation reserves.

However, there would remain an unavoidable loss of RFEFCF and ILGW as a result of the proposal.

Fragmentation and loss of connectivity

Habitat fragmentation is the division of a single area of habitat into two or more smaller areas, with a new habitat type (often dominated by weed species) occurring in the area between the fragments. The process of fragmentation can impact on the species within the existing and newly created habitats, through barrier effects, genetic isolation and edge effects.

Barrier effects occur where particular species are either unable to or are unwilling to move between suitable areas of fragmented habitat. Roads through areas of native vegetation can act as barriers, with barrier effects greater for some species than others (Goosem, 2002).

The study area has been highly disturbed and contains only small isolated patches of native vegetation which are currently subject to edge effects from the existing highway. The proposal generally follows the path of the existing Princes Highway, thereby minimising further fragmentation of habitats and barrier effects in new locations. The construction of the proposal is unlikely to increase the impact of fragmentation or exacerbate edge effects.

Riparian zones often act as wildlife corridors facilitating the movement of wildlife (Harris and Bamford 2011). Eight out of 17 bridge or culvert waterway crossings on the existing highway are currently suitable for ground-dwelling fauna such as reptiles, frogs and mammals, as well as avifauna including microbats and birds. During construction, there would be temporary connectivity impacts at these locations where fauna passage would be limited by vegetation clearance, increased traffic and noise and indirect impacts to waterways.

The South Coast Regional Conservation Plan (DECCW, 2010) identifies Wileys Creek and Jaspers Brush Creek as riparian corridors. Vegetation clearance at these locations would directly impact on 0.27 hectares of riparian vegetation. As the riparian vegetation in the vicinity of the proposal provides a low level of connectivity at a landscape scale, and is currently subject to edge effects, the proposal is unlikely to impact considerably on corridors assessed and mapped by DECCW (2010) throughout construction.

Loss of threatened species and their habitats

Threatened flora species and their habitat

Four threatened flora species are assessed as having a medium likelihood of occurrence in the study area. Three of these species *Pterostylis gibbosa*, *Cryptostylis hunteriana* and *Thesium australe* have dual listing under the TSC and EPBC Acts with one species *Genoplesium baueri* listed under the TSC Act.

Currambene Batemans Lowland Forest, South Coast Grassy Woodland, Shoalhaven Sandstone Forest, Illawarra Gully Wet Forest and South Coast Grassy Woodland have varying potential to provide potential habitat for these four species. As a result, direct impacts (such as vegetation removal) and indirect impacts (such as edge effects) could result in the loss of these four threatened species at localised areas of impact and/or the degradation of the existing populations, should they be identified as present within the study area.

Assessments of significance were undertaken under the TSC Act and the EPBC Act for the Illawarra Greenhood Orchid (*Pterostylis gibbosa*), Leafless Tongue Orchid (*Cryptostylis hunteriana*), and the Austral Toadflax (*Thesium australe*), and under the TSC Act for Bauer's Midge Orchid (*Genoplesium bauera*). Assessments of significance for all four species under the TSC Act and/or EPBC Act concluded that the proposal would have a minimal impact on threatened plant species or their potential habitat within 10 kilometres of the proposal on the basis that:

- No individuals were recorded in the study area despite targeted surveys, including for those that are considered relatively inconspicuous.
- The majority of impacts of the proposal would mostly be limited to areas that are cleared and disturbed.
- The proposal would not result in further isolation or fragmentation of potential habitat for any of the subject flora species.
- The proposal is unlikely to interfere with important lifecycle functions of the subject species.

Based on the outcomes of the significance assessments undertaken, referral to the Federal Minister for the Environment is not considered to be necessary for the proposal with regards to potential impacts on listed flora species.

Field surveys identified the presence of suitable habitat and the cryptic habits of the flora species subject to assessments of significance. It is therefore recommended that targeted surveys be undertaken for these four species.

Threatened fauna species and threatened fauna habitat

Eight threatened fauna species listed under the TSC Act were recorded during field surveys. Table A2-2 of the *Technical Paper: Terrestrial Flora and Fauna* at **Appendix E** outlines the likelihood of occurrence for all species recorded or predicted to occur within 10 kilometres of the proposal, and summarises the potential impacts of the proposal on all TSC Act listed threatened fauna species. Assessments of significance were carried out in accordance with the requirements of the TSC Act for the 27 threatened fauna species with a medium to high likelihood of occurrence in the study area (refer to **Table 6-37** for a list of these species). The assessments concluded that the proposal would be unlikely to significantly impact on any of the species assessed, and an SIS is not considered necessary (refer to Appendix D of the *Technical Paper: Terrestrial Flora and Fauna* at **Appendix E**).

There are six EPBC Act-listed threatened fauna species with known and/or potential habitat within the study area. EPBC Act significant impact criteria assessments were prepared for these six species.

The assessments concluded that it would be unlikely that the proposal would significantly impact any of these species, and a referral to the Federal Minister for the Environment is therefore not considered necessary for any EPBC Act-listed threatened fauna species (refer to Appendix E of the *Technical Paper: Terrestrial Flora And Fauna* at **Appendix E**).

The assessment identified the presence of suitable habitat (particularly important habitat) and the potential for greater impacts to occur for the Green and Golden Bell Frog, Microchiropteran Bats including the Eastern Bentwing-bat *Miniopterus schreibersii oceanensis,* Eastern Freetail-bat *Mormopterus norfolkensis,* Southern Myotis *Myotis macropus*, Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris* and Greater Broad-nosed Bat *Scoteanax rueppellii* and Forest Owls*,* including the Barking Owl *Ninox connivens,* Powerful Owl *Ninox strenua*, Sooty Owl *Tyto tenebricosa* and Masked Owl *Tyto novaehollandiae.* The *Technical Paper: Terrestrial Flora and Fauna* (**Appendix E**) recommended that targeted surveys be undertaken for these species during the detailed design phase of the proposal. This would allow for adequate lead time to undertake full and complete surveys at appropriate times of the year for each of the targeted species, and for the surveys to be undertaken in accordance with any species-specific guidelines in place at the time of targeted surveys. Following the completion of targeted surveys, the initial assessments of significance would be updated to reflect the outcomes of the targeted surveys.

Vegetation clearance to accommodate the footprint of the proposal would result in the direct removal of about 5.11 hectares of threatened terrestrial fauna habitat, as well as the loss or modification of fauna habitat features that occur in the study area. This would include nesting habitat and roosting hollows, dead stags, as well as feeding and shelter resources provided by native and derived vegetation, constructed dams and drainage lines.

Injury and mortality of individuals

Construction works, particularly during periods of bulk vegetation removal and earthworks could potentially result in the injury or death of resident or visiting fauna. Some species such as birds are more readily able to avoid injury. Many species are however unlikely to move quickly enough to avoid being caught such as nocturnal species that shelter during the day, and smaller, ground-dwelling species such as lizards and snakes.

Loss of habitat for migratory species

Known and/or potential migratory species habitat within the study area is not considered important for migratory species listed in Table A2-3 of the *Technical Paper: Terrestrial Flora and Fauna* at **Appendix E**. Additionally, the proposal is unlikely to increase the level of habitat fragmentation, and only previously disturbed areas of vegetation would be directly impacted by the proposal, with indirect effects not expected to extend further than 50 metres from the footprint of the proposal.

The study area would not be classified as ‘important habitat’ for migratory species as defined under the *Matters of National Significance Impact Guidelines 1.1* (DEWHA 2009) and is not considered to support an ecologically significant proportion of the population of any migratory species identified as occurring or likely to occur in the study area. Further, the proposal is unlikely to result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for migratory species. As a result, no assessments of significance were completed for migratory species previously recorded or likely to occur within the study area. A referral to the Federal Minister for the Environment is therefore not considered necessary for any EPBC Act-listed migratory species.

Construction –Aquatic

Loss of threatened species and their habitats, including loss of threatened ecological communities and impacts to fish passage

<u>Threatened aquatic flora and fauna</u>

No threatened aquatic flora or fauna listed under the FM Act and EPBC Act were observed within the study area during the field surveys. Based on the desktop assessment and field survey data, it was determined that the Macquarie Perch (*Macquaria australasica*), Australian Grayling (*Prototroctes maraena*), and Black Cod (*Epinephelus daemelii*), all listed under both the FM Act and EPBC Act could potentially occur within the study area. Assessments of significance for the Macquarie Perch and Australian Grayling were completed in accordance with the EPBC significant impact guidelines. The assessments concluded that the proposal would be unlikely to significantly impact the Macquarie

Perch, Australian Grayling and as such no referral to the Federal Minister for the Environment is required.

An assessment of significance was also undertaken for the Macquarie Perch in accordance with the FM Act. Similar to the assessment undertaken under the EPBC Act, the assessment concluded that as this species is unlikely to be present in the study area due to the presence of generally unsuitable habitat within the study area, the fact that the Macquarie Perch's life cycle would not be disrupted as a result of the proposal, and no obstruction to fish passage is expected, a SIS is not considered necessary for the Macquarie Perch.

The Black Cod is not a freshwater fish species and would therefore not be found in the study area. It is considered possible, although highly unlikely, that Black Cod could occur in the region of the expanded study area that may be influenced by freshwater from the Broughton Creek or Abernethys Creek catchments. As it is considered highly unlikely for Black Cod to occur in the study area, an assessment of significance was not undertaken for this species.

Threatened ecological communities

The permanent removal of FWCF would occur in areas where permanent construction precludes the recovery of vegetation, such as on creek banks where concrete is established for bridge foundations. Disturbance of vegetation consistent with FWCF would occur where vegetation is damaged or removed but then recovers through natural or assisted processes. Both disturbance and removal are direct impacts to the FWCL EEC. Construction of the proposal is predicted to disturb around 0.63 hectares of FWCF along the length of waterways within the study area. The extent of FWCF that would be permanently removed as a result of the proposal and would have no possibility of recovery is likely to be small ie limited to the concreted area of bridge foundations.

An assessment of significance was undertaken for FWCF in accordance with the EP&A Act. The assessment concluded that the proposal would not have a significant impact on the FWCF EEC within the study area and a Species Impact Statement (SIS) is not required.

Fish passage

It is not expected that fish passage would be affected throughout construction of the proposal as:

- Temporary construction pads would potentially only partially obstruct waterways, and would not block the entire waterway.
- Bridge piers would be located outside of waterways.
- Existing waterways would continue to follow their natural course throughout bridge construction.
- Sediment controls would not be placed across waterways.
- Continuous water flow would be maintained throughout the diversion of waterways during culvert construction.

Loss of aquatic habitats

Temporary construction pads are likely to be required during the construction phase of the proposal to assist with bridge construction. Construction pads may involve the temporary placement of rocks or other construction materials within waterways. Proposed safeguards and management measures presented in **Section 6.3.4** would avoid and minimise impacts to aquatic habitats as much as practically possible.

In-stream woody debris provides habitat for macroinvertebrates and fish including refuge from predation, habitat for prey and as damming structures that create pools. Large woody debris was only present within larger waterways in the study area, namely Flying Fox Creek and Jaspers Brush Creek. It is unlikely that the proposal would degrade such habitat to an extent that it would impact considerably on aquatic ecology.

Reduction of water quality

Potential water quality impacts to aquatic ecology throughout construction of the proposal would include sedimentation, pollution and disturbance of ASS.

Sedimentation

The mobilisation of sediments into local aquatic habitats could potentially occur during earthworks in the construction phase of the proposal. Mobilised sediment can become suspended in aquatic environments for long periods and is deposited downstream, often to the detriment of receiving aquatic ecosystems.

The concept design for the proposal includes a number of strategies designed to mitigate sediment mobilisation into waterways. The proposal includes sediment detention basins and permanent water quality basins which would minimise the impact of the proposal on aquatic ecology within the study area.

Pollution

Potential water pollution during construction of the proposal could mobilise contaminants such as petroleum hydrocarbons, heavy metals, leachate, construction materials and organic pollutants into aquatic habitats. Potential construction impacts would be largely due to acute toxicity impacts resulting from spills of material during construction which reach waterways and/or drainage channels.

Construction related impacts have the potential to be magnified following rainfall events, where pollutants are more readily mobilised by stormwater runoff. Pollution is considered a threat to TSC Act and EPBC Act-listed aquatic species and TECs in close proximity to aquatic habitats.

Disturbance of acid sulfate soils

High and low risk ASS are present within the study area on floodplain areas associated with Broughton Creek. There is no actual ASS within the construction footprint of the proposal; however, PASS exists within several sections of the study area, including the construction footprint (refer to **Figure 6-41**).

If ASS are encountered during construction of the proposal and without proper management, potential impacts to aquatic ecology could include habitat degradation, fish kills, reduced aquatic food resources, lower migration potential of fish, lower fish recruitment, altered macrophyte communities, weed invasion by acid-tolerant flora and secondary water quality changes. The presence of ASS can also increase the susceptibility of fish to fungal infections and subsequent diseases.

Considering the groundwater table is not expected to be lowered considerably and ASS would be avoided during construction, impacts related to ASS are not expected to occur.

Alterations of natural flow regimes.

During construction of the proposal, the establishment of sediment and water quality control basins, and the dewatering of excavation sites and basins could potentially alter hydrological pathways within the study area.

The temporary construction sediment basin and operational water quality basins to be established during construction would initially retain water that would have otherwise flowed into waterways within the study area. The volume of water to be retained for these basins would be small in comparison to the volume of water that flows through the study area from catchments upstream of the proposal. Basins are considered necessary for the treatment of surface water runoff throughout construction of the proposal.

During construction of the proposal, localised temporary dewatering may be required to artificially lower the watertable to maintain dry working conditions within excavations and at bridge footings. Discharge of extracted groundwater would be the same as for surface water discharge and the impacts associated with these changes are expected to be minor considering the relatively small volumes of water that this would involve.

Flood mitigation and drainage works are listed as threats to both the FWCF EEC and RFEF EEC. The proposal is not expected to result in any major hydrological change throughout construction of the proposal. Construction works would potentially include the retention of water in sediment basins throughout construction, however changes to hydrology as a result would be of small volumes only and temporary in nature.

Construction of the proposal would disturb about 3.5 kilometres of waterways within the study area, including 0.63 hectares of waterway classed as FWCF EEC. Disturbance to FWCF in these locations has historically been subject to major disturbance from existing highway infrastructure.

Impacts to Groundwater Dependent Ecosystems.

The proposal has the potential to impact upon GDEs within the study area through ground conditioning in areas where settlement has been assessed as a geotechnical issue, such as alluvial soils of floodplain areas and at locations of cuttings. It is anticipated that the proposal would have minor and localised impacts on groundwater flows (**Section 6.4**).

Groundwater seepage into road cuttings would be collected by a longitudinal drainage system and transferred to vegetated swales or sediment basins within the Broughton Creek catchment. As discussed in **Section 6.4**, the treatment of soft-soils may cause some reduction in the permeability of underlying soils but groundwater would still flow, particularly through the sandy soil horizon.

Operation - Terrestrial

Fragmentation and loss of connectivity

The proposal includes the construction of permanent, man-made barriers, including cuttings and wire rope central median barriers, which can create and increase permanent barriers during the operational phase of the proposal. Given that the proposal is an upgrade of the existing highway, operation of the proposal is considered unlikely to exacerbate barrier effects within the study area.

It is estimated that operation of the proposal would indirectly impact about 0.49 hectares of environmental corridor mapped by DECCW (2010) within riparian zones. In view of the low level of connectivity in riparian vegetation at a landscape scale in the study area and the existing impacts of edge effects to riparian zones, the proposal is unlikely to considerably impact on the corridors assessed and mapped by DECCW (2010).

Loss of threatened species and their habitats

<u>Threatened flora species and threatened flora habitat</u>

Potential impacts during operation of the proposal would mainly be indirect impacts. The majority of vegetation that would be subject to ongoing impacts during operation of the proposal would be the Grassland vegetation type. This vegetation supports the lowest quality native flora habitat and the area that would be subject to indirect impacts is estimated at 129 hectares.

Approximately 4.57 hectares of the derived vegetation communities and planted vegetation type flora habitat would be indirectly impacted. Additionally up to 5.41 hectares of native vegetation supporting better quality flora habitats would be affected during operation of the proposal as a result of potential indirect impacts such as alteration of microclimate, soil conditions, weed invasion and over spraying of herbicide during maintenance.

Threatened fauna species and threatened fauna habitat

Throughout the operation of the proposal, up to about 10.15 hectares of threatened fauna habitat would be indirectly impacted, including nine fauna habitat trees. Indirect impacts to threatened fauna habitat and habitat trees would be a result of edge effects associated with vegetation clearances to accommodate the construction footprint of the proposal. Indirect effects to fauna habitat trees could potentially include removal at a later date as a result of the impact of edge effects and a decrease in preferential breeding and foraging resources due to increased noise and vibration.

Injury and mortality of individuals

Terrestrial fauna injury or death can occur during operation of the proposal. During operation, injury and mortality of fauna is largely due to road kills, which have the potential to affect local fauna species at the sub-population level.

Invasion of exotic species, pests and pathogens

Along the edges of native vegetation communities and habitat, weed invasion can be a considerable issue. As a result of changed environmental conditions, weeds may be able to outcompete native flora species, resulting in the loss of native vegetation communities.

The study area is generally highly disturbed and modified by large areas of agricultural land and rural-residential development. Dispersal and establishment of weed species already established in the study area and dispersal and establishment of new weed species as a result of the proposal would be most likely to occur along the new edges of native plant communities in the study area. This would result from vegetation clearance required to accommodate the construction footprint of the proposal. In this instance the impacts are likely to be greatest where the native plant communities maintain a high resilience and corresponding higher flora and fauna habitat values. Overall the proposal is not likely to considerably increase the impact of weed invasion in the study area during operation.

Pest vertebrate fauna species have been recorded in the current and previous fauna surveys in the study area and include European fox *Vulpes vulpes*, Rusa deer *Cervus timorensis* and European rabbit *Oryctolagus cuniculus*. The proposal would add to some processes and features that promote and provide for the dispersal and establishment of pest fauna species such as edge effects and increased or improved passage (eg larger culverts). There may be a minor increase in the existing pest species populations or introductions of new pest vertebrate fauna as a result of the operation of the proposal.

Operation – Aquatic

Alterations of natural flow regimes

Operation of the proposal could potentially change hydrological pathways through the following:

- Re-routing stormwater arising from new road surfaces through new drainage structures, including pipes, swales and basins.
- Increase in impermeable surfaces associated with new road areas and altered peak discharge.
- Re-routing floodwaters through new culverts, particularly the flood mitigations structure at the Pestells Lane grade-separated half-interchange.

The re-routing of stormwater captured from road surfaces through new drainage structures such as stormwater pipelines, sedimentation basins and swales would give rise to small changes to water flow dynamics in the study area. New stormwater infrastructure would result in the retention of some water within basins that would otherwise have been directly discharged into local waterways. Alterations to water flow as a result of this infrastructure is expected to be minimal as the new road surfaces which form part of the proposal represent a small surface area in comparison to the total catchment area of each waterway, and the amount of road surface near waterways would not increase significantly compared to the existing road surface.

The main potential hydrological impacts associated with the operation of the proposal would be as a result of changes in flood flow dynamics along creeks and drainage channels because of modification of structures and new culverts to be installed for flood mitigation. Changes to flood flow dynamics may result in some localised changes to aquatic ecosystem connectivity and water quality during flood events. The main areas of change would be along larger creeks within the study area, including Flying Fox Creek, Jaspers Brush Creek, Tullian Creek and Abernethys Creek. Hydrological changes such as this may impact on creek and fringing wetland habitat through changes to wetland extent and species composition over the long term, including FWCF EEC.

The drainage and flood mitigation structures associated with the Pestells Lane grade separated half-interchange and the grade-separated facility at Jaspers Brush Creek and Strongs Road may change the flood flow behaviour of local waterways and could potentially result in channel realignment.

Flood mitigation and drainage works is listed as a key threatening process to the FWCF and RFEFCF EECs. Potential impacts to FWCF EEC include isolation and/or drying in areas predicted to experience a reduction in flood water levels (refer to **Section 6.5**), and areas upstream of the proposal around creek channels and fringing wetlands of major watercourses. Fringing wetlands such as those that occur within the Abernethys Creek catchment are more isolated and less frequently inundated than the main channel, and are therefore more likely to experience impacts from reduced flood water levels. increases in the concentration of flow, such as around the Pestells Lane grade-separated half-interchange (refer to **Section 6.5)** could increase flood water levels and/or flow velocities within the FWCF EEC, which could alter habitat and species composition. The RFEFCF EEC has been identified along Jaspers Brush Creek and Flying Fox Creek in the study area. These two waterways are anticipated to experience changes in flood flow dynamics as a result of the proposal.

6.3.4 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or manage the identified impacts to biodiversity and to improve and/or maintain biodiversity. These measures are identified in **Table 6-39** and summarised in **Section 7.2**.

Table 6-39 Safeguards and management measures

Potential impact	Safeguards and management measures	Responsibility	Timing
General construction impacts	Prepare a construction Vegetation Management Plan (VMP) to be integrated with the urban and landscape character plan for the proposal and included in the CEMP. The VMP will: • Identify measures to manage vegetation within the road reserve, • Detail restoration, regeneration and rehabilitation of areas of native vegetation that will be removed to accommodate the proposal. This will be in accordance with Guide 3: Re-establishment of Native Vegetation of Roads and Maritime's Biodiversity Guidelines (RTA,2011). • Detail appropriate management for the potential habitat of threatened flora and fauna species that will be indirectly impacted by the proposal. This may include fencing and signage. • Identify weed management strategies.	Construction contractor	Pre-construction

Potential impact	Safeguards and management measures	Responsibility	Timing
	As part of the site induction process, provide all site personnel with information on the biodiversity values of the study area, including threatened species, no-go areas and responsibilities under relevant environmental legislation, including but not limited to the EP&A Act, TSC Act and EPBC Act and associated management plans for individual species.	Construction contractor	Pre-construction and construction
	Should unexpected threatened fauna be located at any time during construction, cease work immediately in the area to prevent further harm to the individual. Contact the Senior Environment Officer Southern Region and a suitably qualified ecologist to determine if further assessment or management plans are required.	Construction contractor	Construction
Vegetation clearance	Restrict vegetation clearing to those areas where it is necessary.	Construction contractor	Construction
	Undertake vegetation clearance in accordance with Guide 1 Pre-clearing Process of Roads and Maritime's Biodiversity Guidelines (RTA 2011). Pre-clearing surveys should include: • Targeted surveys for the Green and Golden Bell Frog, microchiropteran bats and forest owls. • Hollow-bearing tree/stag watching survey of habitat trees to be removed. • Installation of nest boxes.	Construction contractor	Construction
	Where clearing is required, establish exclusion zones in accordance with Guide 2 Exclusion zones of Roads and Maritime Biodiversity Guidelines (RTA 2011) to ensure clearing does not extend beyond the area necessary.	Construction contractor	Construction
Habitat fragmentation and loss of connectivity and Injury and mortality of individuals	Where reasonably practicable, minimise disturbance to stream banks through avoidance of the use of in-stream structures.	Construction contractor	Construction
	Where feasible and reasonable incorporate fauna-friendly features into bridge design at Wileys Creek, Jaspers Brush Creek and Flying Fox Creek to maintain or improve fauna passage under the Princes Highway, fauna movement corridors and vegetation connectivity.	Roads and Maritime project manager	Pre-construction
	Where fauna friendly' features are incorporated into bridge design, consider the use of appropriate fencing to funnel wildlife through under the 'fauna friendly' bridge and prevent wildlife from accessing the highway.	Roads and Maritime project manager	Pre-construction

Potential impact	Safeguards and management measures	Responsibility	Timing
Loss of threatened species and their habitats	Minimise removal of native vegetation and fauna habitat.	Construction contractor	Construction
	Implement exclusion zones to protect threatened ecological communities and threatened species habitat.	Construction contractor	Construction
	Undertake targeted surveys for microchiropteran bats at any bridges and culverts scheduled for removal in accordance with detailed survey guidelines (refer to Section 3.5 of the *Technical Paper: Terrestrial Flora and Fauna* at **Appendix E**). If microchiropteran bats are recorded roosting within bridges or culverts prior to or during construction, develop and implement a Microbat Management Plan. As a minimum, the plan will: • Determine the types of roost habitat and locations to install replacement roost habitat. • Provide information regarding staged habitat removal including removal of secondary or less preferential roosting habitat prior to removal of primary habitat. • Methodology for a pre-demolition inspection of roost habitat, and the implementation of exclusion measures to prevent the continuing use of existing roosts. • Outline monitoring requirements for the replacement habitat, such as outlining the predetermined number of occasions for which monitoring is required, and for the appropriate length of time that considers seasonal movements and habits of the subject species.	Qualified ecologist	Pre-construction

Potential impact	Safeguards and management measures	Responsibility	Timing
	Undertake targeted surveys for the Green and Golden Bell Frog in areas identified as providing potential breeding habitat in accordance with detailed survey guidelines (refer to Section 3.5 of the *Technical Paper: Terrestrial Flora and Fauna* at **Appendix E**). If the Green and Golden Bell Frog is recorded within the study area, develop and implement a Green and Golden Bell Frog Management Plan. At a minimum, the plan will address: • The type of and locations for temporary and permanent replacement habitat including consideration of staged habitat removal. • The most optimal alignments for frog exclusion fencing. • Diurnal and nocturnal pre-clearing surveys. • Environmental induction training for construction contractors. • Site hygiene management including prevention of chytrid fungus. • GGBF relocation procedures. • Construction works procedures (including timing of works). • Reporting procedures.	Qualified ecologist	Pre-construction
	Undertake targeted surveys for forest owls within suitable breeding, roosting and foraging habitat of the study area in accordance with detailed survey guidelines (refer to Section 3.5 of the *Technical Paper: Terrestrial Flora and Fauna* at **Appendix E**). The type and extent of habitat to be removed will inform the installation of nest boxes (ie for prey and/or owls) and subsequent pre-clearance survey methodology.	Qualified ecologist	Pre-construction
	Provide nest boxes to mitigate impacts of removing hollow-bearing trees.	Construction contractor	Construction
	Where reasonable and feasible, retain mature and hollow bearing habitat trees, including the dead stag (habitat tree 29) located within the temporary construction ancillary facility area shown in Figure 3.12 of the *Technical Paper: Terrestrial Flora and Fauna* at **Appendix E**.	Construction contractor	Construction
	Remove trees in accordance with Guide 4: Clearing of Vegetation and Removal Of Bushrock of Roads and Maritimes Biodiversity Guidelines (RTA, 2011) and in the presence of a qualified ecologist or wildlife expert experienced in the rescue of fauna.	Construction contractor and qualified ecologist / experienced wildlife expert	Construction

Potential impact	Safeguards and management measures	Responsibility	Timing
	Carry out a hollow bearing tree survey and stag-watching exercise, (targeting threatened parrots, cockatoos, forest owls, arboreal mammals and microbats) in order to identify the number and type of nest boxes required and the appropriate locations to install them.	Roads and Maritime project manager and qualified ecologist	Pre-construction
	Install roost and nest boxes in accordance with Table 8.1 of Guide 8 Nest Boxes of Roads and Maritime's Biodiversity Guidelines (RTA 2011) at least one month prior to the commencement of construction.	Construction contractor	Pre-construction and construction
	Include locally indigenous species in post-construction revegetation works. These species will promote fauna habitat, for example, the planting of Allocasuarina species for the Glossy Black Cockatoo.	Construction contractor and qualified ecologist	Construction
	Salvage and relocate tree hollows and woody debris to appropriate locations for reuse in accordance with Guide 5: Re-use of Woody Debris and Bushrock Of Roads and Maritime's Biodiversity Guidelines (RTA, 2011).	Construction contractor and qualified ecologist	Pre-construction and construction
	Include native in-stream vegetation (macrophytes) and snags where appropriate where establishment or rehabilitation of a riparian zone is required.	Construction contractor	Construction
	Manage riparian areas in accordance with Roads and Maritime's 'Biodiversity Guidelines Guidance Note 10: Aquatic Habitats And Riparian Zones' (RTA, 2011).	Construction contractor	Construction and operation
Impacts to water quality	Measures to mitigate potential water quality impacts for example from spills during construction are outlined in **Section 6.4.5**, **Section 6.11.4** and **Section 6.13.2**.		
	Fence off areas within ancillary sites seven and nine that are located less than 50 metres from a waterway as environmentally sensitive areas.	Construction contractor	Construction
Invasion of exotic species	Manage vegetation within the road reserve and adjacent to areas of vegetation clearing in accordance with Guide 6 Weed Management and Guide 10 Aquatic Habitats and Riparian Zones of Roads and Maritime's Biodiversity Guidelines (RTA 2011) to reduce invasion of noxious weed species.	Construction contractor and Roads and Maritime's project manager	Construction and operation
	Use weed-free topsoil in landscaping and revegetate disturbed sites with locally indigenous species in accordance with the Urban and Landscape Character Plan outlined in **Section 6.6.3**.	Construction contractor	Construction

Potential impact	Safeguards and management measures	Responsibility	Timing
	Undertake pre-construction weed management around all creek crossings to remove noxious vegetation from the work areas.	Construction contractor	Pre-construction and Construction
	Ensure that relevant construction staff are trained in the identification and appropriate disposal of noxious species. This should include Eastern Gambusia.	Construction contractor and qualified ecologist	Pre-construction and Construction
Fish passage	Should alteration of fish passage occur during construction consult with NSW Department of Primary Industries to determine if a permit under Section 219 of the FM Act is required.	Roads and Maritime project Manager	Construction

6.4 Surface water and groundwater

This chapter provides an assessment of surface water and groundwater. It is supported by the *Technical Paper: Surface Water, Groundwater and Flooding* (AECOM, 2013), which is provided at **Appendix G**.

6.4.1 Methodology

The study area for the surface water and groundwater assessments comprised the construction footprint of the proposal, plus a 200 metre buffer. Potential construction and operational impacts of the proposal on surface water and water quality have the potential to extend into areas upstream and downstream of the proposal which are outside of the study area. The assessment of surface water has therefore been undertaken within an expanded study area. The expanded study area includes the upstream catchment area of each waterway that transects the study area, as well as the downstream lower estuaries of Broughton Creek. Where considered relevant, impacts of the proposal on the expanded study area have been included in this assessment.

Surface water

The general approach and methodology for the assessment of the proposal on surface water includes:

- Desktop review of existing information, including existing mapping and reports, as well as construction and operational water quality guidelines and Roads and Maritime and industry standards.
- Review of the water quality analyses conducted by Cardno Ecology Lab in 2007, 2009 and 2011 (as reported in the *Technical Paper: Aquatic Ecology and Water Quality Management* at Appendix F) against trigger values set in Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment Conservation Council (ANZECC), 2000).
- Review of geotechnical investigations undertaken for the wider Princes Highway upgrade program to identify potential geotechnical, soil and fill issues for the proposal and to assist in identifying safeguards and management measures.
- Assessment of existing water quality within the study area and expanded study area (where relevant) with reference to *The Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000).
- Assessment of potential soil and erosion risks during construction as well as the identification of appropriate safeguards and management measures, with consideration of relevant Roads and Maritime and industry standards and guidelines.
- Development of performance targets for operational water quality basins based on Managing Urban Stormwater: Council Handbook (EPA, 1998).
- Use of the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) (Version 4), a water quality modelling package to develop an operational water quality strategy. Three scenarios were modelled to predict pollutant loadings (kilograms per year) within a one hectare catchment for Total Suspended Solids, Total Phosphorus and Total Nitrogen:
  - Pre-existing (representing rural land uses only).
  - Existing (being the current highway).
  - The proposal.

The detailed methodology that was adopted for the surface water assessment is provided in the *Technical Paper: Surface Water, Groundwater and Flooding* at **Appendix G**.

Groundwater

The general scope and methodology for the assessment of the impacts of the proposal on groundwater includes:

- Consideration of guidelines and policies relevant to the protection of groundwater and GDEs in NSW.
- Desktop review of existing information, including searches of registered groundwater bores in the vicinity of the proposal, as well as a review of groundwater quality data obtained from databases that are maintained by the NSW Office of Water (NOW).
- Consideration of the relevant findings of the *Technical Paper: Aquatic Ecology and Water Quality Management* (Cardno Ecology Lab, 2013) with respect to GDEs.
- Consideration of the relevant findings of the assessment of surface water impacts associated with the proposal.
- Review of previous geotechnical investigations undertaken as part of the wider Princes Highway upgrade program between 2007 and 2011 to identify potential groundwater issues for the proposal.

The detailed methodology that was adopted for the groundwater assessment is provided in the *Technical Paper: Surface Water, Groundwater and Flooding* at **Appendix G**.

6.4.2 Existing environment

Surface water

Waterways in the study area

The study area is located in the Shoalhaven sub-region of the Southern Rivers Catchment Management Authority (SRCMA). The sub-region covers an area of 4660 square kilometres along 1000 kilometres of the NSW South Coast from Foxground in the north to Durras in the South (SRCMA, 2013).The study area is situated on the western margin of the Shoalhaven floodplain on low undulating rises that have been substantially cleared for agriculture.

There are 28 locations within the study area where the existing highway crosses a waterway. These waterway crossings are located within 22 catchments that drain the Cambewarra Range and discharge into Broughton Creek downstream of the study area (refer to **Figure 6-11**). During large flow events the Broughton Creek floodplain becomes inundated and the creeks discharge to the Broughton Creek floodplain. A number of waterways flow in a south-easterly direction from the Cambewarra Range, intersecting the proposal at about 10 metres above sea level along the boundary of the Cambewarra Range with the Shoalhaven River floodplain. All waterway crossings within the study area are freshwater, becoming estuarine at varying distances downstream of the proposal as they approach Broughton Creek and the Shoalhaven River.

The assessment of existing water quality identified that seven waterway crossings within the study area and the downstream receiving waterways are sensitive receiving waterways. Outside the study area are the lower Broughton Creek and the lower Shoalhaven River, which are estuarine environments and are classified as Class 1 major fish habitats (The Ecology Lab, 2007). Parts of the lower Shoalhaven River are listed as SEPP 14 wetlands.

Water quality in waterways

Previous investigations in the study area (The Ecology Lab, 2007) found that water quality in the study area is typical of aquatic ecosystems that have been disturbed by agricultural practices. The investigations also found that long term agricultural land use has given rise to surface water pollution which exceeds the levels considered to be suitable for the sustainability of ecosystem integrity.

Broad-scale agricultural and rural settlement within the study area has resulted in widespread vegetation clearance. Relatively intact riparian vegetation is present in the upper reaches of some smaller waterways, however; as these waterways flow into lower lying land, such as that within the study area; they have been cleared almost entirely of native vegetation for the purposes of agriculture. Remaining areas of vegetation within the study area have mostly been recolonised by pasture grasses and weeds. Downstream of the proposal in low-lying floodplains, waterways and associated vegetation have been highly modified for the drainage of arable land (land that is suitable for the growth of crops).

Previous studies of water quality within the Broughton Creek catchment found that levels of pH and conductivity were generally within the limits of the ANZECC Fresh and Marine Water Quality Guidelines, however turbidity was not. Sampling of dissolved oxygen levels during periods of low rainfall in 2007 were frequently below the ANZECC lower limits for dissolved oxygen levels (The Ecology Lab, 2007). The low dissolved oxygen levels can be attributed to low flow conditions and / or high in-stream organic loads in waterways that traverse the study area. Phosphorous levels within Broughton Creek frequently exceeded ANZECC threshold values for the protection of aquatic ecosystems, which is likely to be from fertilizer applied to surrounding pastures, and from livestock manure.

The existing highway in the proposal area does not have water quality treatment measures in place as part of the drainage infrastructure. As such, stormwater runoff and any spills from the existing highway are not treated prior to discharge into the receiving environment.

Groundwater

Site-specific groundwater information has been derived from the *Geotechnical Interpretive Report of Concept Design – AECOM Preferred Route of the Princes Highway, Gerringong to Bomaderry* (Coffey, 2010). As part of Coffey's investigations, 20 groundwater monitoring wells were constructed. Groundwater was encountered at all monitoring wells along the proposal; however, no groundwater quality data was obtained.

Groundwater along the proposal is associated with tributaries of Broughton Creek and also the underlying bedrock within the siltstone, sandstone and volcanoclastic rocks of the Shoalhaven Group. Groundwater is typically shallow, ranging between 0.5 metres and four metres below ground level along the proposal, reflecting the low topographical setting.

Aquifer systems

Along the proposal there are two main aquifer systems present; unconsolidated and unconfined alluvial / colluvial aquifers and Shoalhaven Group sediments.

Unconsolidated and unconfined alluvial aquifers occur as sand, silt-clay and gravel adjoining creek systems and as more widespread floodplain deposits. Groundwater flow is via intergranular flow (between grains of sediment); where sand and gravel lenses are interconnected, providing favoured pathways of higher permeability. Within the Broughton Creek floodplain sediments, localised perched groundwater is expected above interbedded clay horizons.

Groundwater within the Shoalhaven Group sediments is present in volcanoclastic sediments of the Broughton formation, as well as within sandstone, siltstone and shale. Groundwater occurs within perched horizons inside weathered sandstone, siltstone and latite, and within the deeper regional aquifer. The groundwater yield is believed to be influenced by the degree of fracturing of the intersected bedrock.

Groundwater within the perched horizon is limited to and dominated by flows in-between individual grains of materials in weathered sedimentary rocks. Within deeper aquifers, groundwater flow is along areas where the bond between grains of materials is weak allowing water to flow through, or via features such as joints between two different materials, shear zones, faults and bedding planes. Within areas of volcanic material, groundwater flows mostly through fractures.

Groundwater bores

There are 15 bores registered with the NOW within 500 metres of the existing highway. The groundwater within the study area is extracted from a variety of aquifers, including latite, gravels, sandstone, shale and fractured rock of a variable yield. Groundwater is extracted for a range of purposes including for stock, domestic and irrigation purposes to supplement surface water supplies collected in dams and pumped from local waterways. Of the 15 registered bores, three are test bores and two are monitoring bores. Only one bore is located within the alluvial aquifers, indicating groundwater within the alluvium is of limited use for groundwater extraction.

Groundwater dependent ecosystems

Groundwater from the alluvial aquifer systems associated with the Broughton Creek floodplain discharges into Broughton Creek. Riparian vegetation associated with Broughton Creek is likely to be dependent upon groundwater to some extent. Local shallow groundwater flow systems also exist within elevated parts of the catchment within the Berry Sandstone and latite.

The proposal falls within the mapped extent of the Sydney Basin South Groundwater Source as identified within the 'Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011'. No groundwater dependent ecosystems are listed in Schedule 4 of this Water Sharing Plan, however higher in the catchment above the proposal; groundwater may discharge from springs at the base of colluvial sequences, particularly after extended rainfall events. Springs that discharge groundwater for extended periods are often the source for farm dams. There are no major wetlands or swamps within the proposal area, although groundwater is likely to flow into Broughton Creek which is known to be pumped by landowners for stock and domestic purposes.

Groundwater dependent ecosystems

GDEs are ecosystems whose species composition and natural ecological processes are determined by groundwater. GDEs may either be entirely dependent on groundwater for survival, may use groundwater opportunistically or as a supplementary source of water. GDEs are most likely to occur in low-lying areas with shallow groundwater close to the surface.

Shallow alluvial groundwater systems associated with the Broughton Creek floodplain discharge into Broughton Creek. Groundwater that is discharged via springs, seeps or spring-fed dams may also sustain small local groundwater dependent communities. Riparian vegetation associated with Broughton Creek is likely to be dependent on groundwater in some capacity.

Coomonderry Swamp, located six kilometres east of the existing highway and outside of the study area is a well-known GDE within the Shoalhaven region, and is listed under SEPP 14. It is also identified as a high priority GDE in the 'Sydney Basin Southern management zone of the Greater Metropolitan Regional Water Sharing Plan'. There are no GDEs within the study area that are registered within the Sydney Basin Southern Management Zone of the Greater Metropolitan Regional Water Sharing Plan. Additional information regarding GDEs is provided in **Section 6.3**.

6.4.3 Criteria

The ANZECC water quality guidelines form part of the National Water Quality Management Strategy and list a range of environmental values for water bodies. These guidelines are typically used to assess surface water and groundwater quality.

The ANZECC guidelines for the protection of aquatic ecosystems are used for the purpose of this assessment, with trigger values for lowland rivers in south-east Australia at a 95 per cent level of protection for fresh water.

Groundwater quality data sourced from the NOW groundwater database for the aquifers underlying the proposal area indicates that the majority of groundwater intersected was of 'good or fair' salinity confirming the adoption of the freshwater guidelines is appropriate.

6.4.4 Assessment of potential impacts

Surface water

Construction

Construction of the proposal could result in an increase in sediment entering waterways within the study area. This could potentially occur through the following activities:

- Sediment release from stockpiles within temporary construction ancillary facilities and earthmoving activities into local waterways.
- Settlement of dust generated from construction activities in local waterways.
- Runoff from stockpiles following a flood event.
- Removal of riparian vegetation to accommodate the construction footprint of the proposal.

Increased sedimentation and erosion of local waterways due to runoff from the construction footprint of the proposal poses the greatest potential impact to water quality within the study area. An increase in the area of cleared and impervious surfaces would increase the volume of surface water discharged to local waterways. This has the potential to increase scour and erosion within receiving waterways and could alter their hydrology by increasing the amount of water within waterways.

The potential scouring of waterway areas and the need for scour protection and creek stability works as a result of the proposal would be assessed further during detailed design.

An increase in the volume of sediment discharged to local waterways within the study area has the potential to increase turbidity and erosion. The subsequent settlement of sediment in these waterways could smother aquatic habitats and organisms present. The potential for these impacts to occur would be greatest following vegetation clearance and cut and fill activities, as bare soil would be exposed to erosion. The clearance of vegetation also has the potential to increase the temperature of water within local waterways, which can lower the concentration of dissolved oxygen and may limit the growth and reproduction of some species.

The potential for construction activities to impact on surface water quality within the study area is exacerbated further during high rainfall and wind events. Such events enable sediments and / or pollutants released during construction works to more easily flow, or be blown, from construction areas into sensitive receiving environments. Without proper consideration and management, transportation of sediments and pollutants from construction activities could potentially degrade water quality.

Construction of the proposal could mobilise contaminants and gross pollutants into local waterways, affecting water quality. Potential mechanisms for the mobilisation and discharge of pollutants into local waterways could include:

- Acidic runoff from the exposure of PASS within the construction footprint of the proposal.
- Spills and leaks of hydrocarbons from construction equipment into local waterways.
- Contaminated runoff or spills into waterways from chemical storage areas within temporary construction ancillary facilities due to stockpile damage, including from high rainfall events.
- General construction waste material entering local waterways.
- Discharge or runoff of tannins and other organic leachate materials from vegetation stockpiles within temporary construction ancillary facilities.

The introduction of a greater quantity and / or concentration of contaminants and gross pollutants can have environmental impacts on the water quality of waterways within the study area. This can include alterations to pH levels and increases in pollutant loads and potentially toxic metal levels of the waterway which could also be detrimental to birdlife and the quality of aquatic habitats within the study area. Ingestion of gross pollutants discharged to waterways could directly impact fauna, and an increase in organic materials in local waterways could alter dissolved oxygen levels. This action could result in the potential suffocation of in-stream fauna, alterations of the local pH of waterways and promotion of algal growth.

During construction, water would be required largely for the purposes of dust suppression. It is anticipated that about 12 litres of water per square metre would be required for each full day of construction works. However, this would be variable along the length of the proposal and would be dependent upon weather conditions (rainfall, wind type, wind direction and intensity) and the size and type of exposed soils. The priority with which construction water would be sourced for dust suppression would be as follows:

- Recycled effluent from the Nowra Sewage Treatment Plant and the Berry Sewage Treatment Plant (in accordance with Roads and Maritime policy and guidance for the use of reclaimed water).
- Surface water, sourced from on-site detention basins.

If required, potable water supplied by Shoalhaven City Council could also be used. The recycled effluent, which is fit for discharge for irrigation purposes and eventual discharge into waterways, would be dispersed within the proposal area for a short duration at low loadings. It is not anticipated that the discharge of construction water into local waterways would have major impacts to water quality, as long as the appropriate safeguards and management measures outlined in **Section 6.4.5** are implemented.

To supplement recycled effluent water, water may be extracted from construction and operational sediment basins that would collect runoff along the proposal during construction. The use of potable water would be the least preferred option for construction water.

Operation

The water quality treatment system selected for the proposal (a combination of water quality basins and swales) aims to improve the quality of surface water runoff compared to the existing highway where runoff is not treated (refer to **Figure 3-1**, **Figure 3-2** and **Figure 3-3** for indicative locations of operational water quality basins). The locations of operational water quality basins have been based on avoiding and protecting sensitive receiving environments such as local waterways. Preliminary sediment basin sizing indicates that the seven operational water quality basins would be of sufficient size to be meet the 85th percentile, five day rainfall event design criteria for their indicative locations. The operational water quality treatment system includes pavement drainage and the construction of swales.

A range of swales of varying length are proposed within the median and outer road edges to convey and treat runoff. As a minimum, swales would be 100 metres in length and at least two metres wide per hectare of upstream catchment area.

Runoff from bridges would be collected in a pavement drainage system. Where this runoff would be discharged into swales, the design would discharge runoff as far upstream as possible. Check dams or spill basins would be incorporated into the swale design where feasible and reasonable to capture spills.

Additionally, the water quality treatment system would be provided to meet the suggested water quality targets downstream of the proposal, being:

- An 80 per cent reduction in the amount of total suspended sediment.
- A 60 per cent reduction in the amount of total phosphorous.

It is expected that the operational water quality treatment system would produce a future net benefit to water quality.

The proposal would increase the amount of surface water runoff entering local waterways due to an increase in impervious surface area. This would also increase the frequency, volume and velocity of flows within receiving waterways. Without a water quality treatment system, the proposal would place additional stress on waterways. This could include new occurrences of erosion, exacerbation of existing erosion and could increase the potential for pollutants to enter local waterways via road runoff. The water quality treatment system which forms part of the concept design for the proposal, includes operational water quality treatments designed to largely avoid impacts to water quality (refer to **Figure 3-1**, **Figure 3-2** and **Figure 3-3** for indicative locations of operational water quality basins).

Heavy metals, hydrocarbon products and nutrients are primarily transported to the receiving environment as particle bound contaminants in road runoff. The protection of local aquatic ecosystems and the treatment of road runoff as part of the proposal are therefore focused towards the removal of suspended solids and associated contaminants.

Groundwater

Construction

Construction of the proposal has the potential to impact on groundwater flow conditions and quality, and could potentially impact GDEs. Potential impacts throughout construction may occur via localised dewatering activities required for excavations and cuttings, compaction of soil for construction works, exposure and migration of ASS, as well as accidental fuel and chemical spills and leaks.

<u>Impacts to groundwater flow conditions</u>

Depending on the depth of groundwater, dewatering to artificially lower the water table may be required for excavations and cuttings during construction. This may be required to maintain dry working conditions, particularly within excavations and at bridge footings. Dewatering has the potential to temporarily lower groundwater levels in boreholes, and could result in the groundwater levels being below existing pump inlet settings.

Excavations and road cuttings that extend beneath the watertable and / or intersect perched groundwater aquifers could cause groundwater to drain into culverts, creeks or rivers. This could result in local increases to groundwater discharge which may lower the watertable. This could impact on the yield of nearby water bores and / or limit the volume of groundwater available for shallow-rooted plants.

The majority of road cuts required for the proposal are less than two metres deep and would not intersect the water table. The typical risk of the proposal lowering the water table by more than 1.5 metres (the natural seasonal variation) as a result of the construction of cuttings is considered low.

The larger cutting required for the proposal at Strongs Road and Jaspers Brush Road (300 metres long and up to a maximum of ten metres deep) would cut through the Berry Siltstone and intersect the watertable. Berry Siltstone has a low permeability and the risk of groundwater levels being lowered at this location is considered to be low. One licensed stock and domestic bore is located 300 metres from the large cutting at Strongs Road and Jaspers Brush Road. It is believed to be located a sufficient distance away from the cutting so as to not be affected by construction of the proposal.

A review of the proposed construction works indicates that no major dewatering is likely to be undertaken in close proximity to registered groundwater bores along the proposal route. Should dewatering of the alluvial aquifer be required during construction, the extent of groundwater drawdown would be limited to the base of footings, and the zone of influence/induced cone of depression. Groundwater drawdown would be limited due to the highly transmissive nature of alluvial aquifers.

It is considered unlikely that bedrock aquifers would require dewatering for construction of the *proposal. If this becomes necessary, the extent of drawdown would be dependent on the local* hydraulic conductivity of the aquifer, and the extent of secondary structural water bearing features within the aquifer.

Dewatering of groundwater for construction of the proposal would be minor, temporary and localised, and would be undertaken during the construction phase of the proposal only.

The construction of the proposal could cause soil compaction in areas of unconsolidated alluvial sediments, potentially reducing the volume of groundwater recharge. It is considered unlikely that compaction within the construction footprint of the proposal would impact on the aquifer storage or water transmitting properties within the study area. Impacts to groundwater recharge conditions and the hydrological regime within the study area during the construction of the proposal due to compaction of the aquifer is therefore considered to be negligible.

Impacts to groundwater quality

Construction of the proposal could result in fuel and chemical spills occurring by virtue of construction vehicle accidents, refuelling incidents or from stockpile and storage areas. Fuel and chemical leaks could potentially introduce petrol, diesel, hydraulic fluids and lubricants into the local environment, which could contaminate groundwater and GDEs, particularly if a leak occurs on highly permeable sandy soils. With the implementation of safeguards and management measures described in **Section 6.4.5** the risk of these impacts is considered to be low.

In the unlikely event that the proposal lowers the water table where PASS are present (refer to **Figure 6-41**), the action could result in the oxidation of sulphide materials. This could potentially generate sulphuric acid and increase metal concentrations in solution, which can lead to groundwater degradation. Additionally, rainfall runoff could potentially cause acidic water to migrate within the shallow groundwater system and discharge into surface water systems and groundwater receptors.

Impacts to groundwater dependent ecosystems

Although there are no GDEs listed in Schedule 4 of the 'Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011' in the study area, localised groundwater discharge from springs may sustain local ecosystems or recharge farm dams after rainfall events. If present, these small ecosystems are likely to be higher in the catchment above the study area and are unlikely to be impacted by the proposal.

Groundwater flow volumes within Broughton Creek would remain virtually unchanged and surface water discharged into the creek would be treated prior to discharge. Downstream impacts to GDEs in Broughton Creek are therefore considered to be unlikely.

Operation

Impacts to groundwater flow conditions

The excavations and road cuttings that would be constructed as part of the proposal would be a permanent feature and would be present throughout operation of the highway. It is not expected that the operation of the proposal would impact the level of the watertable in areas of excavations or cuttings any further than what is experienced during construction.

Increasing the extent of hard road surface area including drainage infrastructure would increase the volume of surface water runoff and reduce the level of groundwater discharge. The reduction in groundwater discharge as a consequence of the increased surface area of the proposal is considered to be negligible, given the limited extent of the proposal area compared to the surrounding rural environment.

Impacts to groundwater quality

The existing highway runoff may contain pollutants associated with vehicular movements and normal use due to leaks, spills and crashes. The contaminants can include hydrocarbons (petrol, diesel and oils), metals, nutrients from exhausts, suspended solids and other compounds. The concentration of contaminants is likely to increase as a result of operation of the proposal as there would be a higher traffic load and the road pavement would be wider than the existing highway. As part of the proposal, operational water quality basins would be established to remove suspended solids and to meet ANZECC surface water quality criteria (refer to Section 3.5.1 and Figure 3-1 of the *Technical Paper: Surface Water, Groundwater and Flooding* at **Appendix G**). The design of the water quality basins include gross pollutant traps and oil separators to improve the quality of the runoff that is discharged into the receiving environment. Impacts to groundwater quality as a result of the proposal due to increased concentrations of contaminants are therefore considered unlikely.

Impacts to farm dams

Construction and operation of the proposal would potentially modify the surface water and groundwater flow patterns within the study area, upstream and downstream of the proposal and could potentially change the yield of existing farm dams. Surface water runoff within the proposal area during construction and operation that would flow to farm dams under existing highway conditions may be diverted around road cuttings or embankments as part of the proposal via catch drains or other drainage structures. This would discharge runoff from the proposal into a natural waterway or into a different dam catchment, and as a result could change the catchment area that contributes to a particular farm dam, which could also impact on water users.

Surface water within the study area generally flows in an easterly direction from the Cambewarra Range through to the Broughton Creek floodplain. Farm dams to the east of the proposal would therefore have a greater potential to be affected by the proposal. The proposal would impact four existing farm dams to the east of the proposal. Of these four dams, three would have a reduction in their catchment area of between 7.6 per cent and 15.7 per cent. The catchment area of one farm dam would be increased by 5.7 per cent. Further details of impacts to farm dam catchments is provided in Section 5.1 and Figure 5-1 of the *Technical Paper: Surface Water, Groundwater and Flooding at* **Appendix G**.

6.4.5 Safeguards and management measures

Safeguards and management measures would be implemented to minimise and manage impacts of the proposal on surface water and groundwater throughout construction and operation. These measures are presented in **Table 6-40** and are summarised in **Section 7.2**.

Table 6-40 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
General construction impacts	Prepare and implement a Soil and Water Management Plan (SWMP) and site specific erosion and sediment control plans (ESCPs) as part of the CEMP. Based on the high risk rating of this proposal and in accordance with Roads and Maritime's erosion and sedimentation management procedure, the SWMP and ESCP would be prepared in consultation with a soil conservation consultant to be engaged from Roads and Maritime's panel of registered soil conservation consultants. The soil conservation consultant would assist the construction contractor in identifying the most appropriate approach to erosion and sediment control.	Construction contractor	Pre-construction and construction
	Prepare and implement SWMP and ESCPs in accordance with Managing Urban Stormwater-Soils and Construction, Volume 2D (Landcom 2004), and the conditions of the EPL for the proposal	Construction contractor	Pre-construction and construction
Sedimentation and erosion	Construct temporary drainage structures in accordance with the 'Technical Guideline – Temporary Stormwater Drainage for Road Construction' (Roads and Maritime, 2011).	Construction Contractor	Construction
	Manage and use treated effluent in accordance with Roads and Maritime's Environmental Direction No. 19 – Use of Reclaimed Water (RTA, 2006) and Roads and Maritime's Tip Sheet – Use of reclaimed water (RTA, 2006).	Construction Contractor	Construction
	Minimise scour and creek instability through installation of structures such as rock revetments, where necessary. These would be designed to minimise impacts to aquatic ecology, surrounding land uses and the visual amenity of the area.	Roads and Maritime project manager and construction contractor	Detailed design and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
Impacts to water pollution (surface water and groundwater)	Store fuels, chemical and hazardous materials in secure, bunded areas within temporary construction ancillary facilities.	Construction contractor	Construction
	Capture and dispose of spill and contaminated materials from temporary construction ancillary facilities at a licensed facility.	Construction contractor	Construction
	Undertake refuelling, washdown and the preparation of construction materials within bunded areas to mitigate risks in relation to spills or leaks of fuels/oils or other hazardous onsite construction material.	Construction contractor	Construction
	Apply good practice measures with regards to the storage and handling of dangerous and hazardous goods to minimise the risk of a spill occurring.	Construction contractor	Construction
	Provide spill kits around temporary construction ancillary facilities.	Construction contractor	Construction
	Manage and minimise the generation and discharge of tannins from vegetation mulch within temporary construction ancillary facility areas in accordance with Roads and Maritime's *Environmental Direction Number 25 – Management of Tannins from Vegetation Mulch* (Roads and Maritime, 2012).	Construction contractor	Construction
Impacts to groundwater flow conditions	Minimise the depth of excavations in areas of alluvium.	Construction contractor	Construction
	Manage dewatering using a work method statement prepared in accordance with Roads and Maritime's Environmental Management of Construction Site Dewatering (RTA, 2011).	Construction contractor	Construction
	Should dewatering of the alluvial aquifer be required during the construction of the bridge footings, limit groundwater drawdown to the base of the footing.	Construction contractor	Construction
Potential impacts of ASS	Refer to safeguards and management measures in **Section 6.11**	Construction contractor	Construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
Operation			
Impacts to surface water quality	Prepare and implement an operational water quality strategy that includes a combination of water quality basins and swales. Where feasible and reasonable, the strategy should aim to achieve the suggested water quality treatment targets for the proposal of an 80 per cent reduction in total suspended sediment load and a 60 per cent reduction in total phosphorous load.	Construction contractor	Construction
	Six indicative operational water quality basins have been planned for the proposal as part of the concept design. The number and location of basins would be refined and finalised during detailed design.	Roads and Maritime project manager	Detailed design
	Direct runoff from bridges over watercourses and floodplains to water quality basins and swales.	Construction contractor	Construction
Monitoring and maintenance of surface water quality, swales and water quality basins	Inspect swales and basins every three months or following storm events until the system has become established. Inspections of swales would include: • Checking vegetation is at a suitable height to allow design flow capacity. • Clearing of any obstructions or debris. • Checking for erosion, weeds, plant conditions, oil spill and the build-up of litter and sediment. • Mowing, as required. Inspections of sediment basins would include: • Checking pits, pipes, weirs and other structures are clear of obstructions and debris. • Checking for erosion, weeds, plant condition, oil spills and the build-up of litter and sediment.	Roads and Maritime project manager	Operation
	To minimise maintenance requirements: • Use native species for the water treatment features of the landscape (as part of the design of swales and basins). • Plant using high and diverse planting densities to make aquatic features resistant to weed establishment.	Roads and Maritime project manager and construction contractor	Detailed design and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
Impacts to groundwater quality	If the Strongs Road cutting intercepts groundwater, direct the groundwater to the road drainage network via a drainage system.	Roads and Maritime project manager	Construction and operation
Impacts to farm dams	Undertake consultation with affected landowners where there would be permanent losses or gains in dam catchments. Determine and implement appropriate mitigation measures in consultation with landowners.	Roads and Maritime project manager	Detailed design

6.5 Flooding

This chapter provides an assessment of the flood impacts of the proposal, and is supported by the *Technical Paper: Surface Water, Groundwater and Flooding* (AECOM, 2013). The technical paper is provided at **Appendix G**.

6.5.1 Methodology

A quantitative flood assessment was undertaken within the vicinity of the proposal to understand what impacts a 100 year ARI flood event has on the existing highway under current conditions, and the impacts the proposal may have on flooding. The flooding assessment included all waterways that intersected the proposal area. Flood impacts upstream and downstream of the proposal within each waterway were also taken into account as part of this assessment.

To undertake the flood assessment, the study area was divided into three sections; northern, central and southern. These sections were determined using catchment boundaries to ensure hydraulic independence between sections. The three sections, and the extent of the flood models used as part of the assessment, are shown in **Figure 6-11**. A description of the three flooding assessment sections is provided in **Table 6-41**.

Table 6-41 Flooding assessment sections

Assessment section	Description	Catchment numbers
Northern section	Between Berry and Jaspers Brush. The northern assessment section includes the proposal's interface with the Foxground and Berry Bypass project interchange (chainage 19200), and extends south to include the Strongs Road and Jaspers Brush Road interchange (chainage 21700).	One to eight.
Central section	Strongs Road south, up to and including the Morschels Lane grade separated interchange (chainage 25300).	Nine to 15.
Southern section	The remainder of the proposal to chainage 30300, including the Meroo Meadow and Bomaderry areas.	16 to 22

Flood conditions during a 100 year ARI flood event were modelled at 28 locations where the proposal crosses an existing waterway. A combination of one-dimensional, two dimensional and culvert hydraulic modelling methods were used to undertake the assessment. The modelling assessed the flooding conditions of the waterway crossing locations and flooding impacts within the study area during a 100 year ARI flood event under:

- Existing flood conditions (refer **Section 6.5.2**).
- Proposed flood conditions with and without Shoalhaven River flooding conditions where relevant.
- Proposed flood conditions with an appropriate allowance for climate change impacts.

The above mentioned flood conditions were modelled and assessed for two hydraulic modelling scenarios; low tailwater and high tailwater.

The low tailwater scenario addresses flood behaviour when there is heavy rainfall on the Cambewarra Range with little flooding on the Broughton Creek floodplain. This scenario assumes that the water levels in Broughton Creek are two metres Australian Height Datum (AHD), which is representative of when flows are contained within the banks of Broughton Creek. The low tailwater scenario provides information about the greatest relative change in water levels between the existing and proposed flooding conditions.

The high tailwater scenario addresses flood behaviour when there is heavy rainfall on the Cambewarra Range which coincides with a water level in Broughton Creek of five metres AHD, representative of a 100 year ARI flood event in the lower Shoalhaven River. The high tailwater scenario typically provides information about the highest absolute water levels.

The concept design for the proposal has been developed with the aim of providing a flood immune highway during a 100 year ARI flood event. To achieve this, the proposal would be built at a level higher than the existing highway.

In order of importance the flood impact objectives for the proposal are:

- Provide a 100 year ARI flood immune highway.
- Minimise impacts on important infrastructure (eg the South Coast Railway).
- Minimise impacts on houses.
- Minimise impacts on structures (eg farm infrastructure).
- Minimise impact on agricultural and pasture land.

The methodology of the flooding impact assessment undertaken for the proposal is provided in Section 2.1 of the *Technical Paper: Surface Water, Groundwater and Flooding* (AECOM, 2013) at **Appendix G**.

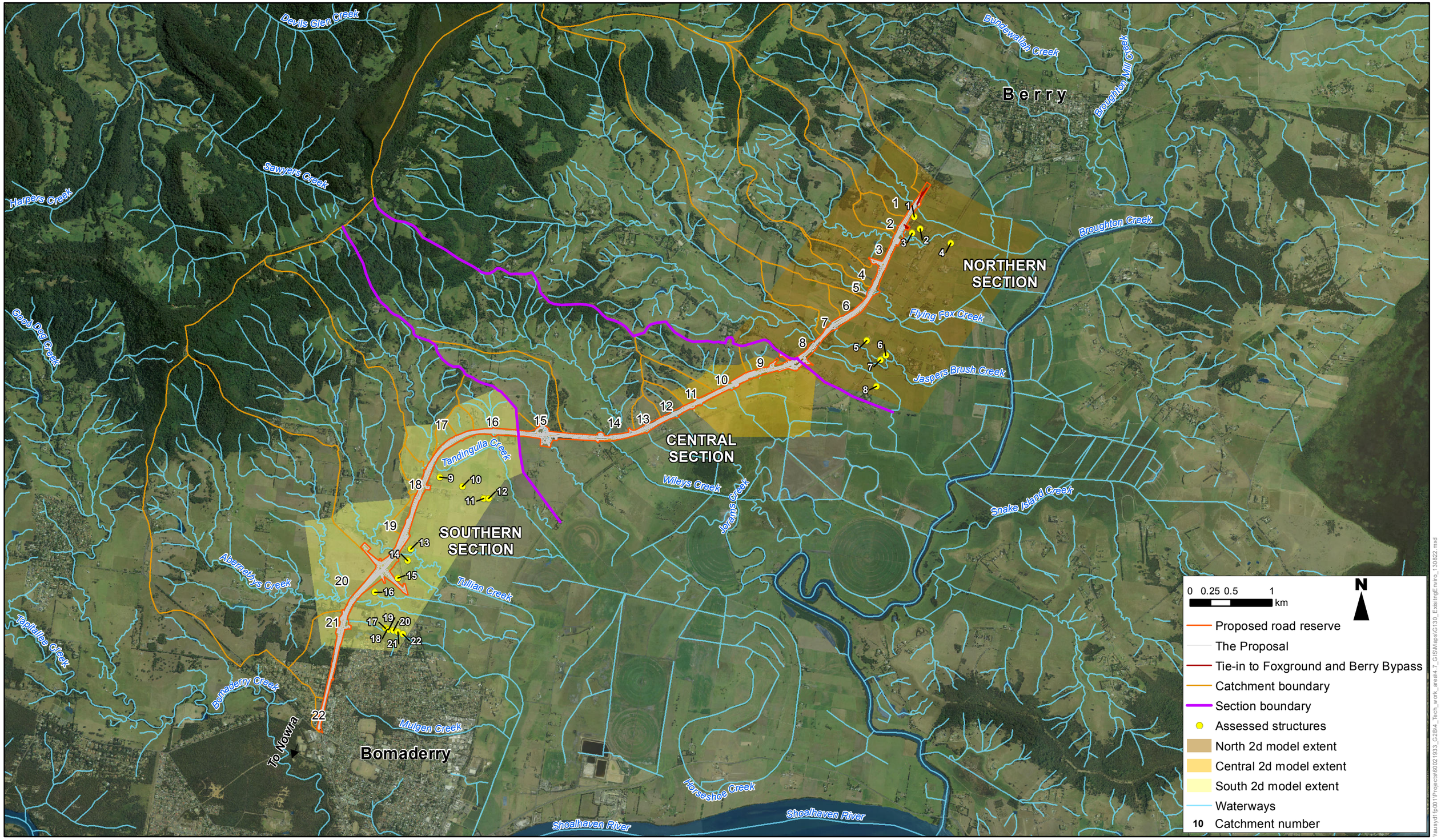


Figure 6-11 Existing environment

Source: LPMA (2011)

6.5.2 Existing environment

Catchments and waterway crossings within the study area

There are 28 locations where the proposal crosses an existing waterway. These waterway crossings are located across 22 catchments (**Figure 6-11**). During a 100 year ARI flood event, the existing highway is overtopped by floodwaters at 21 of the 28 waterway crossing locations. The depth of water which overtops the existing highway at these locations ranges from between 0.01 metres to 0.59 metres. Additional catchment details are provided in **Table 2-3** of the *Technical Paper: Surface Water, Groundwater and Flooding* (AECOM, 2013) at **Appendix G**.

Flooding mechanisms within the study area

The flooding behaviour of waterways within the study area are the result of two flooding mechanisms; mainstream regional flooding of the Shoalhaven River, and flooding originating from the local catchments of the Cambewarra Range.

Long duration, widespread rainfall (typically more than 24 hours) within the Shoalhaven River catchment produces flood flows that can fill Broughton Creek and its floodplain. Mainstream flooding of the Shoalhaven River is typically low velocity with long warning times. This creates a high tailwater at the bottom of the Cambewarra Range that can increase water levels upstream, and cause the discharge of water to be slower.

Flooding of the Shoalhaven River is subject to tidal influence from the ocean entrance at Shoalhaven Heads and from potential sea level rise under a climate change scenario. Within the study area, this flooding mechanism would particularly affect low lying areas of the central section (**Figure 6-12**), which is located within or in close proximity to the Broughton Creek floodplain.

The steeper local catchments of the Cambewarra Range have a response time to rainfall events of less than six hours. Flood waters drain through the study area, and cross the highway with considerable velocity before draining to the Broughton Creek floodplain. Flooding originating from the Cambewarra Range affects all waterways and waterway crossings within the study area.

Current flooding situation

Northern section

There are ten waterway crossings within the northern assessment section, located across eight catchments. Within the study area, these catchments have been largely cleared for agricultural land use, and many have been straightened into more formal drainage channels. The four larger waterways within the northern section of the study area (unnamed catchments one and three, Flying Fox Creek and Jaspers Brush Creek) are typically low gradient and meandering within the study area, and all overtop their banks during a 100 year ARI flood event.

The existing culverts and bridges at waterway crossings within catchments one to five are not capable of passing flood waters underneath the existing highway during a 100 year ARI flood event. This causes flood waters to pond upstream of the embankment and eventually overtop the existing highway. In this circumstance, floodwaters are also transferred between catchments and affect six existing houses and structures, which are mostly located around Mullers Lane, O'Keefes Lane and Jaspers Brush Road.

Catchments six, seven and eight currently overflow into each other upstream of the proposal during a 100 year ARI flood event, forming a large flood extent. Jaspers Brush Creek (catchment 8), the largest waterway within the study area, is the main contributing catchment. Flood flows that overtop the banks of Jaspers Brush Creek combine with the smaller flows from catchments six and seven. The existing culverts within catchments six and seven are not large enough to convey flood waters from the upstream section of these catchments, as well as the overflow from Jaspers Brush Creek during a 100 year ARI flood event. The highway is overtopped at this location during this event.

Central section

There are seven catchments and seven corresponding waterway crossings within the central assessment section of the study area. With the exception of Wileys Creek, catchments within the central section of the study area are generally small and have been largely cleared for agricultural land use. A small amount of vegetation is present along some creek banks. During a 100 year ARI flood event, culvert structures at all waterway crossings within the central assessment section are unable to cope with the volume of water traversing underneath the existing highway, causing water to pond upstream and eventually overtop the existing highway. No standing structures are affected by flood waters during a 100 year ARI flood event under existing conditions.

Wileys Creek (catchment 14) is situated about 200 metres east of the lowest point of the existing highway (around Turners Lane at chainage 24500). In the vicinity of the Wileys Creek waterway crossing, the existing highway is overtopped by floodwaters during a 100 year ARI flood event by up to 0.59 metres.

Waterway crossing nine, within catchment nine, overtops the existing highway during a 100 year ARI flood event under current conditions. This water flows south along the existing highway via the existing road cutting and into catchment 10. This reduces the volume of water that travels through the existing culverts under the South Coast Railway line immediately downstream of catchment nine. However, it increases the flow of water through the South Coast Railway line culvert immediately downstream of catchment 10. The South Coast Railway line culvert downstream of catchment 10 currently overtops the rail line during a 100 year ARI flood event.

Southern section

There are seven catchments and 11 waterway crossings within the southern assessment section of the study area. The southern section has three major creeks; Tandingulla Creek (catchment 17), Tullian Creek (catchment 19) and Abernethys Creek (catchment 20). Catchments 16, 18 and 21 are minor tributaries of these creeks. Agricultural land use practices on the Broughton Creek floodplain, as well as construction of the existing highway and South Coast Railway line, has altered the natural geomorphology of these creeks and their tributaries through relocation and realignment.

The banks of Tandingulla Creek (catchment 17) downstream of the existing highway are relatively low and as a result, are overtopped during high water flow. Some of the flow that overtops the creek banks follows an overland flow path to the south-east towards Lamonds Lane. The area between Lamonds Lane and the Princes Highway, including a number of buildings are impacted by flood waters during a 100 year ARI flood event. The remainder of flood waters from Tandingulla Creek cross the highway north of Boxsells Lane towards the north, and contributes to conditions which cause flows from catchment 16 to overtop the existing highway.

The creek bed at Pestells Lane, north of the existing highway and the gently sloped channel immediately south of the existing highway is currently dry. The dry creek bed may have been the historical route for Tullian Creek (catchment 19), however it is currently undulating pasture land used for agricultural purposes.

Hydraulic modelling undertaken for the existing highway indicated that during high flows, water from Tullian Creek flows into Abernethys Creek (catchment 20), overtopping the existing highway at this location. The banks of Tullian Creek overtop during a 100 year ARI flood event at a number of locations upstream and downstream of the existing highway. This water flows over the existing highway over a length of about 600 metres at Pestells Lane to join Abernethys Creek (catchment 20).

Flows from catchment 21, a tributary of Abernethys Creek overtop the existing highway south of Abernethys Lane during a 100 year ARI flood event. Some of this flow is conveyed along the existing highway cutting to Abernethys Lane, with the remainder of the flow continuing down a tributary of Abernethys Creek, passing south of a residential area located along Emerald Drive.

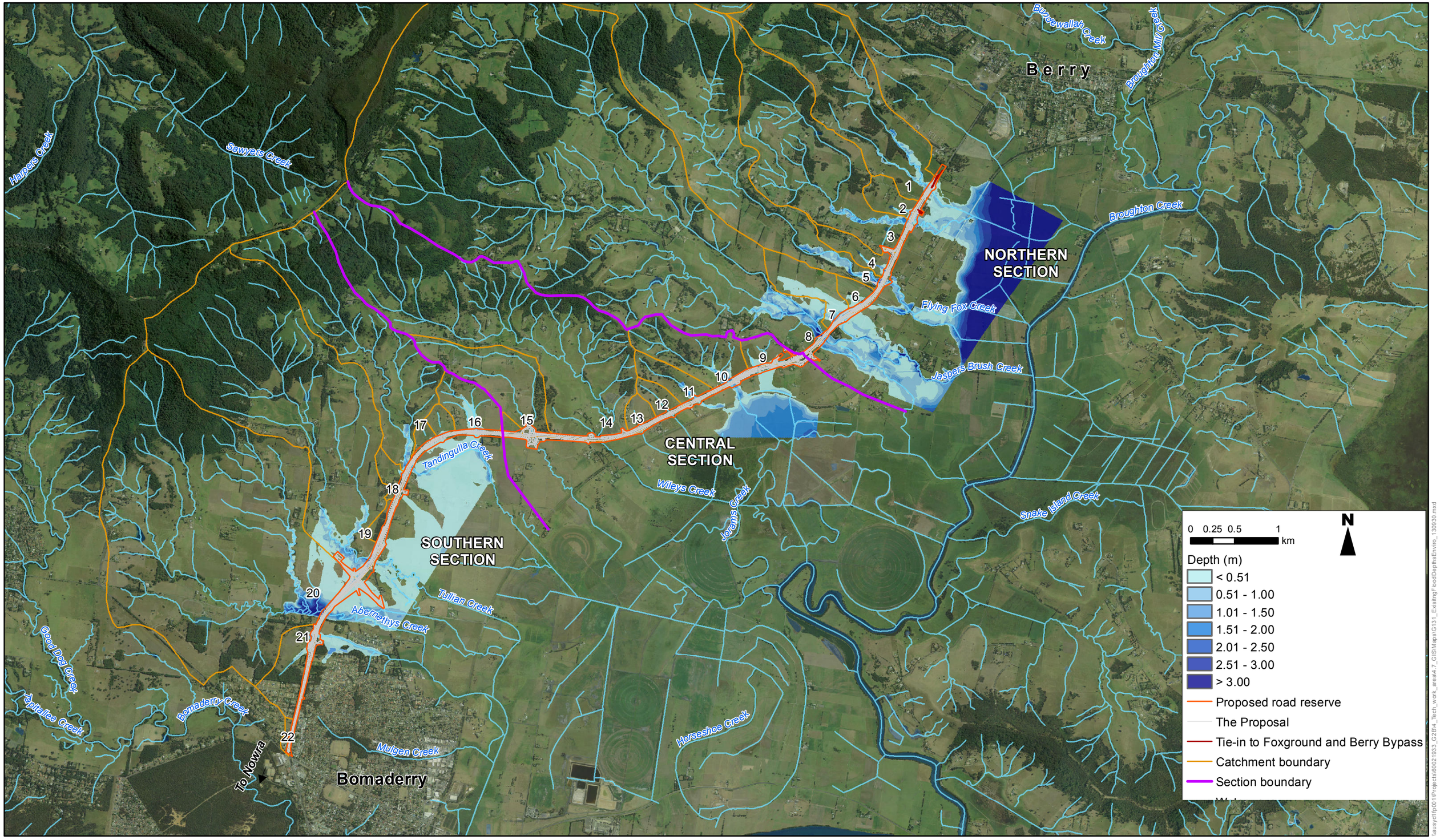


Figure 6-12 Existing flooding conditions (100 year ARI flood event)

Source: LPMA (2011)

6.5.3 Potential impacts

Construction

Ancillary facilities

Figure 1-1 presents 17 potential temporary construction ancillary facility locations for the proposal. Preliminary site selection criteria were determined to support the appropriate location of ancillary facilities. All 17 potential ancillary facilities are located outside of the 100 year ARI flood extent, and at least 50 metres away from waterways. Additional details regarding ancillary facility site selection is provided in **Chapter 3**.

There is the potential for a large flood event to occur during construction of the proposal. The impact of a large flood would be dependent on the stage of construction at the time of the event. Flooding during construction of the proposal could potentially impact the whole or part of the construction footprint and/or cause damage to construction plant and equipment. Safeguards and management measures to avoid and mitigate impacts of flooding on the proposal during construction of the proposal are provided in **Section 6.5.4**.

Operation

The design criteria for the proposal includes flood immunity during a 100 year ARI flood event (refer to **Section 3.2.1**). New structures built as part of the proposal would be designed so that they are capable of containing flood flows during a one in 100 year ARI flood event. The high tailwater scenario has been used to set design levels for the proposal, and a six per cent increase in rainfall intensity in accordance with the NSW Climate Impact Profile (CSIRO, 2006) has been incorporated into the design.

To achieve this, the proposal would modify the existing flood characteristics that relate to flows from the Cambewarra Range by altering the waterway area beneath the proposal. There would be no modification of the flood characteristics of Broughton Creek or the Shoalhaven River.

A number of options have been considered to provide a flood immune highway including setting the proposal embankment at an elevation higher than the existing highway and increasing the waterway area underneath the highway. Without appropriate compensation for the removed overtopping waterway area, there would be a considerable increase in flood levels upstream of the proposal. By increasing the waterway area underneath the proposal, there may be an increase in flood flows and greater maximum flood levels downstream of drainage structures. A number of culverts would be replaced with bridges, and some existing culverts would be upgraded, which could alter flood behaviour with concentrated flows both at and downstream of the proposal. This is reflected by a reduction in flooding at some locations, while increasing flood levels in the creek waterway and overbank area immediately downstream of the proposal as a consequence. Flood impact objectives have been adopted throughout the development of the proposal. In order of importance, these objectives are to provide a 100 year ARI flood immune highway, minimise impacts on important infrastructure, minimise impacts on houses, minimise impacts on structures, and minimise impacts on agricultural and pastureland.

The proposal would result in no flood waters overtopping the highway during a 100 year ARI flood event and would enable a larger flood flow to be contained within creek lines and drainage channels within the study area. This would modify the volume of water conveyed through these waterways during a 100 year ARI flood event, and would alter the velocities and concentrations of flows.

The proposal has both adverse and beneficial impacts to standing structures and pastureland within the study area. Impacts of the proposal as a consequence of its design are described below.

Northern section

Within the northern assessment section of the study area the waterway area underneath the proposal would be increased. This would be achieved by modifying the vertical and horizontal alignment of the Princes Highway within the study area, constructing five bridges over waterway crossings, upgrading five existing culverts and constructing a 45 metre long flood mitigation bridge south of O'Keefes Lane at about chainage 21200. The proposal would not change the extent or duration of flooding during a 100 year ARI flood event, however there would be impacts on existing structures, the South Coast Railway and pastureland within the study area. The relative change in 100 year ARI flood levels is shown on **Figure 6-13**.

Impacts to buildings and structures

Under current conditions, there are eight existing structures which are potentially flood affected during a 100 year flood event (**Figure 6-13**). As a result of the proposal, two of these structures would no longer be flood affected during a 100 year ARI flood event (structures one and five), four would not be impacted by the proposal (structures two, six, seven and eight), and two would have negligible impacts (structures three and four). Refer to **Figure 6-14** of this chapter and Table 2-4 of the *Technical Paper: Surface Water, Groundwater and Flooding* at **Appendix G** for further information.

The proposal would increase the waterway area underneath the highway with the construction of a new bridge and upgraded culvert within catchment one. No flood water would overtop the proposal during a 100 year ARI flood event within catchment one, and structure one would no longer be flood affected during a 100 year ARI flood event (**Figure 6-14**).

Water from catchments two and three would be conveyed through a replacement bridge and upgraded culvert. The increased waterway area underneath the proposal from these structures means that during a 100 year ARI flood event, flood flows would no longer overtop the highway at this location (**Figure 6-14**).

Upstream of catchments six, seven and eight, water flow is complex and forms a large flood extent. To replicate the existing flow distribution and flooding characteristics of these catchments, the proposal includes the construction of a flood mitigation bridge about 45 metres long within catchment seven, accompanied by a series of low, wide box culverts underneath the heavy vehicle inspection bay. In addition, the existing culvert in catchment six would be upgraded and the bridges over Wileys Creek (catchment seven) and Jaspers Brush Creek (catchment eight) would be replaced. The flood mitigation bridge would increase the concentration of water flow during a 100 year ARI flood event by up to 0.35 metres and flow velocity would also increase. The increased flow and velocity at this location would restrict driveway access to a property on O'Keefes Lane (Woodbyne). The existing driveway has been constructed with a considerable embankment across the waterway at this location, with two pipe culverts underneath the embankment. Safeguards and management measures to mitigate impacts to this property are provided in **Section 6.5.4**. Structure number five on O'Keefes Lane would no longer be flood affected during a 100 year ARI flood event.

The proposal would not impact upon the South Coast Railway in the northern assessment section during a 100 year ARI flood event.

Impacts to pastureland

The proposal would be constructed at a higher elevation than the existing highway to prevent water from overtopping the proposal. The upgraded culvert within catchment two and the replacement bridge in catchment three would result in upstream flood levels increasing by up to 0.15 metres in a 100 year ARI flood event within existing pastureland. This would not impact upon the extent and duration of flooding at this location.

The culvert upgrade within catchment four would result in a minor increase in flood levels and velocity at the farm dam immediately downstream of this culvert during a 100 year ARI flood event. This would result in additional shallow ponding of water to the east of the farm dam towards the South Coast Railway line. This additional shallow ponding would be minor, and no greater than 0.01 metres in depth.

The new bridge at Flying Fox Creek (catchment five) would increase the waterway underneath the proposal, resulting in a minor increase in 100 year ARI flood levels downstream of the proposal within the road reserve boundary. Upstream of the proposal within catchment five, flood levels during this event would be reduced by up to 0.6 metres within some areas of pastureland.

During a 100 year ARI flood event, flood levels in pastureland upstream of catchment six and catchment seven would be increased by up to 0.35 metres. Within catchment seven, the flood mitigation bridge and new bridge over the waterway crossing would result in a large reduction in flood extent downstream of the proposal in this location. Further, the replacement of the Jaspers Brush Creek Bridge (catchment eight) would increase the waterway area under this area and would cause flood levels to increase by up to 0.15 metres within pastureland downstream of the proposal at this location.

Regional flooding impacts

The Probable Maximum Flood (PMF) is the largest flood that could conceivably occur at a particular location and is a theoretical maximum event. During the PMF, the heavy vehicle inspection bay would be inundated. The majority of impacts during the PMF event would be concentrated to the upstream side of the proposal due to the increase in elevation of the highway compared to the existing highway. No structures upstream of the proposal would be impacted during the PMF. The increased area under the Jaspers Brush Creek Bridge (catchment eight) would give rise to increased flood levels downstream of the proposal at this location.

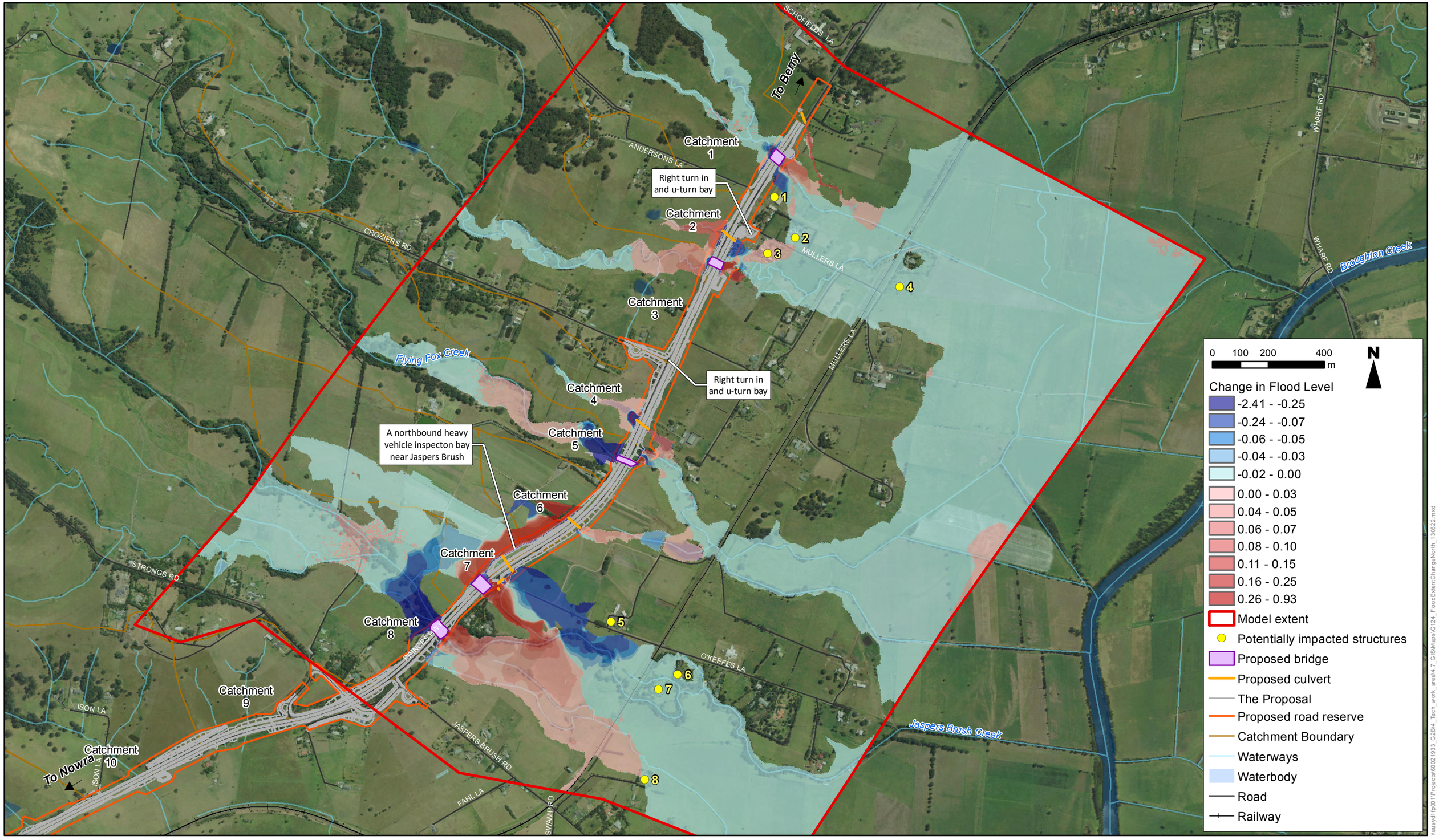


Figure 6-13 Northern section – changes in flood level with the proposal (100 year ARI flood event)

Source: LPMA (2011)

Figure 6-14 Northern section – changes in flood extent with the proposal (100 year ARI flood event)

Source: LPMA (2011)

Central catchment section

Impacts to the South Coast Railway line

A 300 metre long overflow channel would be constructed parallel to the proposal through the road cutting from catchment nine to catchment 10. This would prevent an increase in the downstream flows in catchment nine at the South Coast Railway line during a 100 year ARI flood event as a result of the removal of the existing overland flow path. The overflow channel would only operate during large rainfall events and would pass excess water from catchment nine to catchment 10 once the culvert at catchment nine is operating at capacity. This would limit the increase in flood level to 0.05 metres at the South Coast Railway line culverts (**Figure 6-15**). It is unlikely that the proposed flood mitigation works within catchment nine would impact on rail operations at this location.

At the rail embankment in catchment 11, a minor increase in flood levels would not impact on the operation of the South Coast Railway line.

Impacts to buildings and structures

There would be no flooding impacts to any buildings or structures within the central section as a result of the proposal.

Impacts to agricultural and pasture land

The proposal would cause a minor increase in the extent and velocity of flooding in pastureland downstream of catchment nine. Upgrades to culverts within catchments 10, 11, 12 and 13 would reduce the depth of upstream flooding levels by between 0.1 metres and 0.6 metres. Upgrades to culverts within catchments 12 and 13 would result in minor impacts to pastureland immediately downstream of the proposal at these locations due to changes in the concentrations of flow through these catchments (**Figure 6-16**).

The new bridge at Wileys Creek (catchment 14) would give rise to a slight increase in the depth of flooding upstream of the proposal by in the order of 0.1 metres. The extent of flooding in this area would remain unchanged and would be contained to vineyards and pastureland (**Figure 6-15**).

Drainage infrastructure within catchment 15 at the Morschels Lane and Devitts Lane grade-separated facility would result in a minor increase in flood depths by up to 0.1 metres within pastureland on one property directly adjacent to the proposal (**Figure 6-15**).

Regional flooding impacts

The majority of the central section of the proposal is situated on low-lying land and is susceptible to inundation during the PMF. The depth of flood impacts would be contained to upstream of the proposal, would not impact any existing structures and would have a negligible impact on the South Coast Railway line downstream of the proposal. During the PMF, the underpass at the Morschels Lane and Devitts Lane grade-separated facility would potentially be flooded.

Figure 6-15 Central section - changes in flood level with the proposal (100 year ARI flood event)

Source: LPMA (2011)

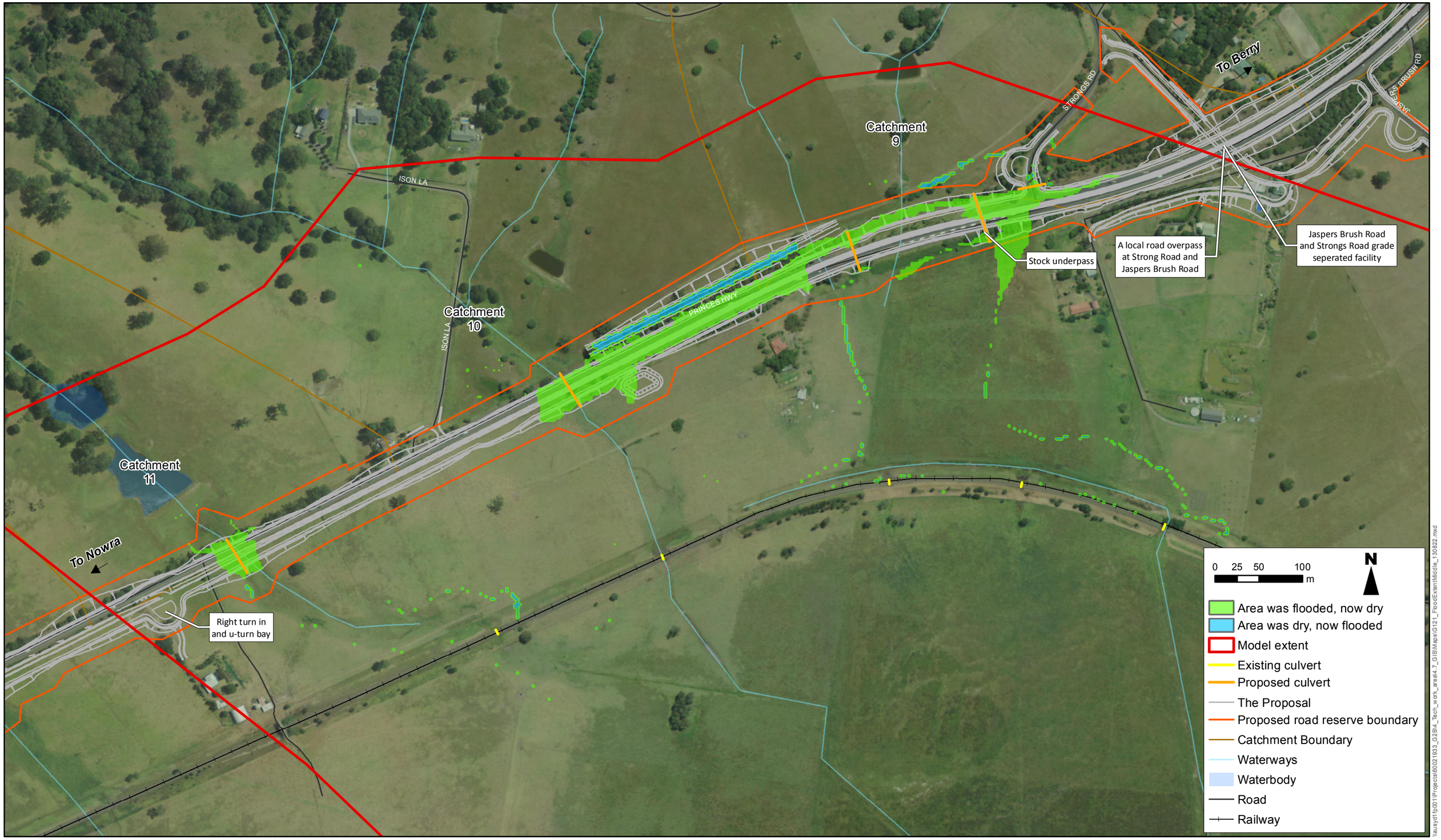


Figure 6-16 Central section - changes in flood level with the proposal (100 year ARI flood event)

Source: LPMA (2011)

Southern section

Within the southern assessment section of the study area ten culverts would be upgraded and three new bridges would be constructed. The proposal would impact both pastureland and existing structures within this section of the study area.

Impacts to structures

The new bridge at Tandingulla Creek (catchment 17) would increase the waterway area underneath the proposal. The proposal would increase the depth and velocity of floodwaters within the waterway which would be mostly contained within the banks of the creek. The flood depth at structure number nine would increase by 0.04 metres (**Figure 6-17**). Safeguards and management measures to minimise impacts of the proposal to this structure are provided in **Section 6.5.4**.

The proposal would move the overland flow path from Tullian Creek (catchment 19) to Abernethys Creek (catchment 20), increasing the depth of flood levels at structures 13 and 14 by 0.04 metres during a 100 year ARI flood event. Flood extents at Meroo Road would be reduced and flood evacuation routes improved for properties located between the roundabout on Meroo Road and the Pestells Lane and Meroo Road grade-separated half-interchange.

Impacts to pastureland

The new bridge at Tandingulla Creek (catchment 17) would increase the waterway area underneath the proposal and would prevent overtopping of the highway during a 100 year ARI flood event. The increased waterway area would reduce the area of downstream flood affected pastureland and would provide more high ground for stock evacuation within the catchment.

The proposal involves the construction of embankments at the grade-separated half-interchange at Pestells Lane and Meroo Road, and a north-south orientated overflow culvert underneath the half-interchange, which would consist of eight box culverts, each 130 metres long. The drainage infrastructure at this location would convey high flows to the existing drainage depression, downstream of the proposal. This would result in an increase in the concentration of flows within adjacent pastureland of between 0.1 metres and 0.5 metres deep in areas that are not flood affected under existing highway conditions during a 100 year ARI flood event. These flows would be restricted to pastureland between the discharge location from drainage infrastructure and Abernethys Creek (catchment 20). In this area, flows would be up to one metre deep and 30 metres wide during a 100 year ARI flood event. Upstream of the proposal within this catchment, about three hectares of pastureland that is currently flood affected would no longer be impacted during a 100 year ARI flood event. On balance, impacts of the proposal at this location are considered to be beneficial.

Removing the overland flow path between Tullian Creek (catchment 19) and Abernethys Creek (catchment 20) would increase the waterway level within the creek waterway by up to 0.1 metres with flood level rises in the overbank and floodplain area of up to 0.06 metres. This would include low-lying pastureland that is already flood affected under the existing highway conditions during a 100 year ARI flood event.

The new bridge at Abernethys Creek (catchment 20) would reduce the upstream flood depths by up to 0.55 metres and would also reduce the 100 year flood extent at this location (**Figure 6-18**). Removal of the overland flow path from catchment 21 to catchment 20 would increase the concentration of flow to the Abernethys Creek tributary (catchment 21), south of Emerald Drive. To minimise the potential for flood levels to increase as a result of the proposal behind the Emerald Drive residential area, a slightly undersized culvert would be constructed at catchment 21. As a result, during a 100 year ARI flood event, water would pond upstream by up to an additional 0.6 metres. The flood extent upstream of the proposal in this catchment area would increase by up to 0.55 hectares during a 100 year ARI flood event. The increased flood extent would be of short duration on low-lying pastureland.

Regional flooding impacts

During the PMF, multiple locations within the proposal would be inundated by flood waters. The flood level impacts would be largely contained to upstream of the proposal. Downstream of the proposal, there would be an increased flood level at Tandingulla Creek (catchment 17) and Tullian Creek (catchment 19) as a result of the increased waterway area underneath the proposal. Flood levels at existing structures located downstream of catchments 19 and 20 in the overbank areas would also be greater downstream of the creek crossings in these catchments during the PMF.

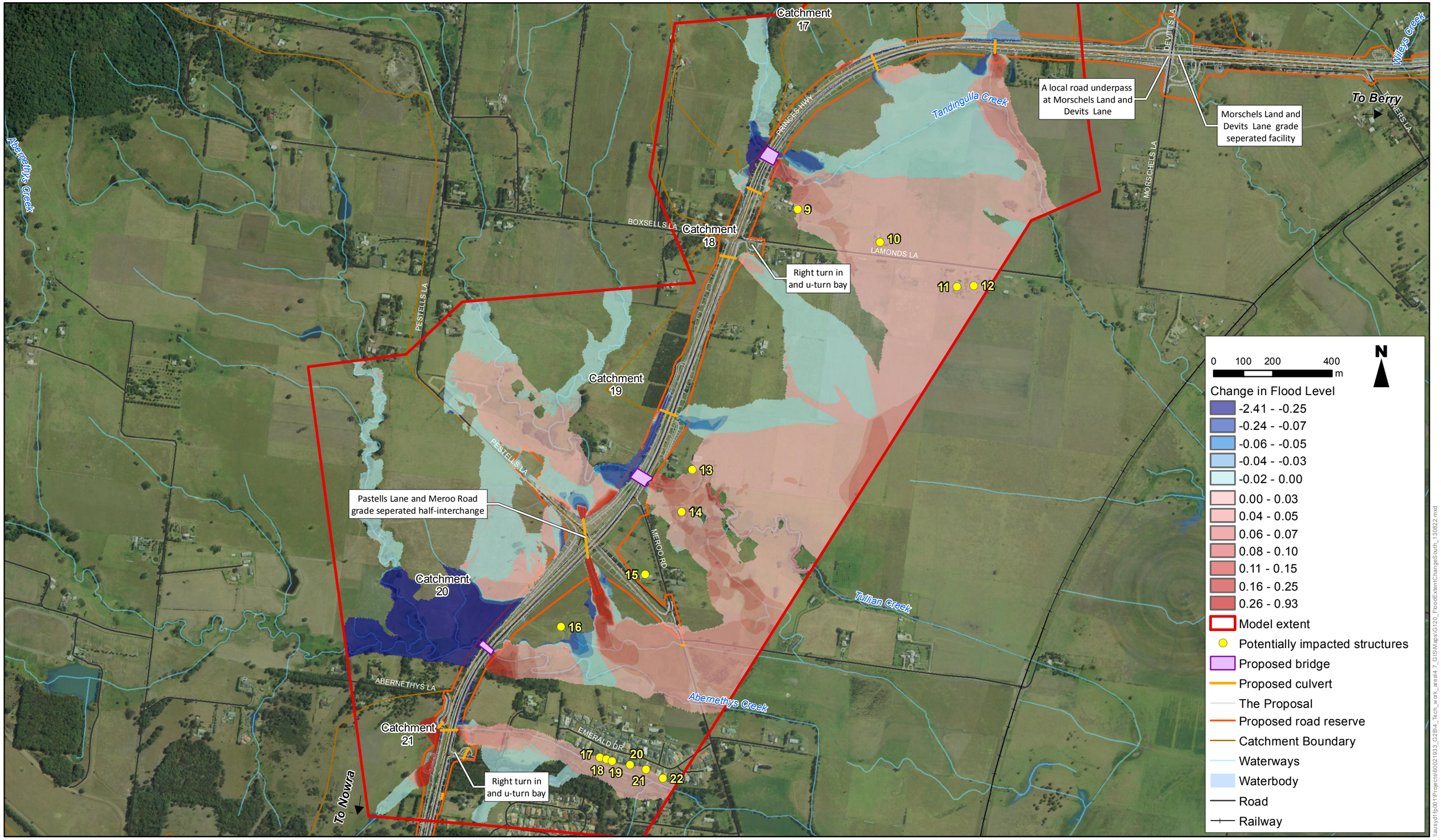


Figure 6-17 Southern section – changes in flood level with the proposal (100 year ARI flood event)

Source: LPMA (2011)

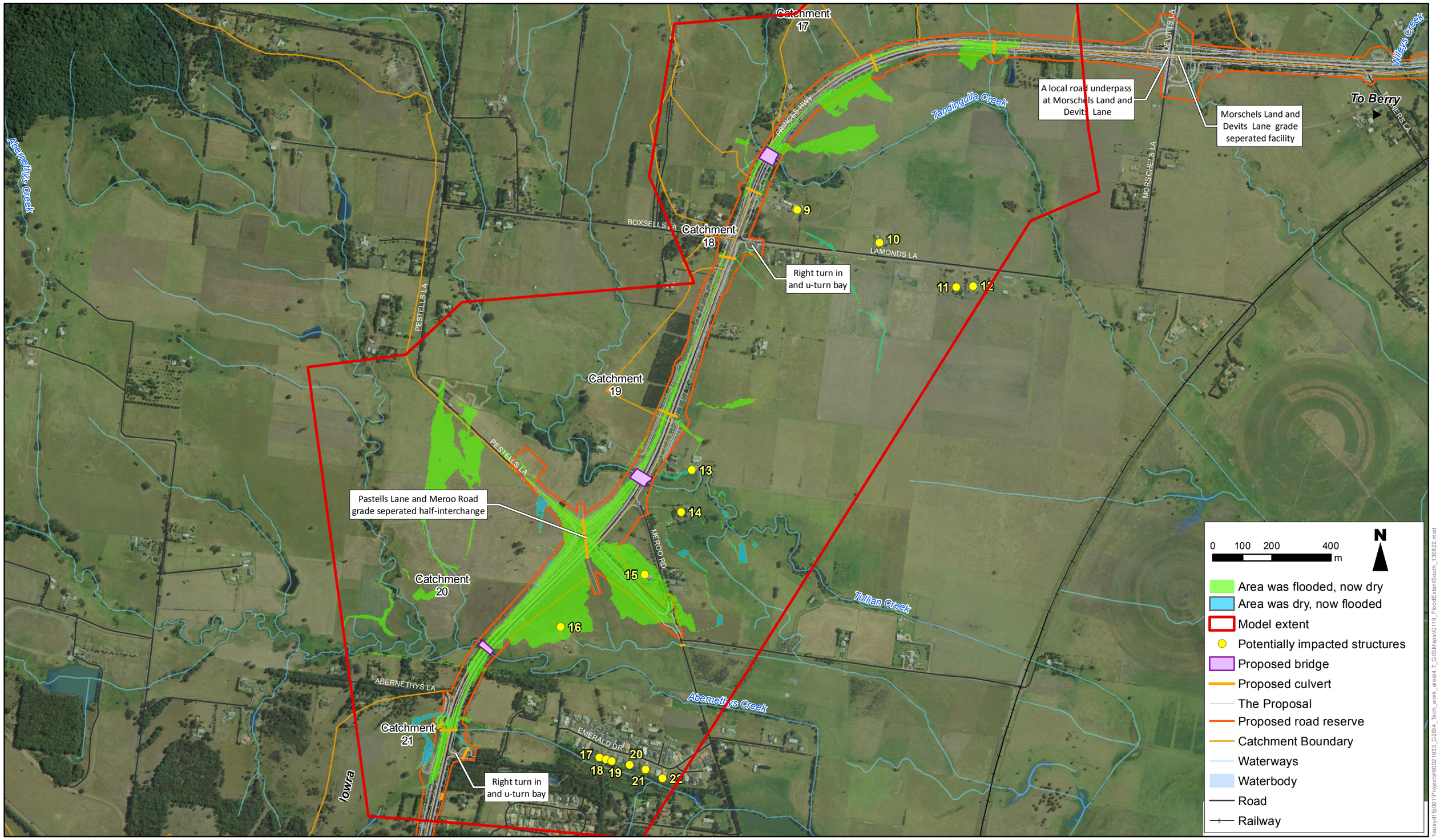


Figure 6-18 Southern section – changes in flood extent with the proposal (100 year ARI flood event)

Source: LPMA (2011)

Residual impacts

One of the design objectives of the proposal is to contain unavoidable flood impacts to pastureland as much as reasonably practicable. However, following the implementation of the safeguards and management measures outlined in **Section 6.4.5**, some residual impacts would persist on existing building structures following the design and construction of the proposal. Four structures (one, five, 15 and 16) would no longer be flood affected during a 100 year ARI flood event and six (two, six, seven, eight, 11 and 12) would not be affected by the proposal. Seven structures (three, four, 10, 18, 19, 20 and 21) would experience a negligible increase in flood depth during a 100 year flood event of between 0.01 metres and 0.02 metres (refer to **Table 2-4** of the *Technical Paper: Surface Water, Groundwater and Flooding* at **Appendix G**. The remaining four structures, as well as the South Coast Railway line, would experience a minor increase in flood depth of between 0.03 metres and 0.05 metres.

6.5.4 Safeguards and management measures

The safeguard and management measures would be implemented to minimise or mitigate identified impacts to flooding. These measures are presented in **Table 6-42** and are summarised in **Section 7.2**.

Table 6-42 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
Flooding and construction	The construction methodology will minimise flooding impacts to and from the proposal. Refine the assessment of construction phase flooding impacts when the construction methodology is progressed.	Roads and Maritime project manager	Pre-construction
	Construct the proposal in stages where practicable to: • Allow flood waters to flow naturally and not be retarded or altered by construction activities. • Reduce the risk of flood levels increasing upstream by a substantial amount. • Limit the potential for the construction site to be flooded.	Construction contractor	Construction
	Prepare a construction flood risk response plan for the proposal as part of the CEMP. This would formalise the planned flood risk management response and incorporate the safeguards and management measures.	Construction contractor	Pre-construction
	Use an automatic weather station (AWS) to gather accurate and timely weather data such as rainfall volumes and communicate weather warnings to Roads and Maritime staff and construction contractors.	Construction contractor	Pre-Construction
	Store chemicals and fuels above the one in 100 year ARI flood level where possible.	Construction contractor	Pre-Construction and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
Operation			
Impacts to residential buildings and structures	In consultation with the landowner, design and construct a driveway and waterway opening at 4 O'Keefes Lane which is flood immune during a 100 year flood event.	Roads and Maritime project manager	Detailed design
	Undertake floor level surveys at potentially flood affected properties to quantify flooding impacts of the proposal at each building/structure. If the surveys determine the change in flood level would impact habitable areas consult with the affected landowners to agree on and implement appropriate local mitigation works.	Roads and Maritime project manager	Detailed design
	Carry out modifications to the farm dam downstream of catchment four in consultation with the landowner.	Roads and Maritime project manager	Detailed design and construction
Impacts to pastureland	Following modification of the farm dam downstream of catchment four and in consultation with the landowner, design and implement measures to mitigate shallow ponding of water on pastureland between the dam and the South Coast Railway line. This may include constructing a higher embankment and spillway downstream of the dam.	Construction contractor	Construction
Impacts of climate change	Undertake sensitivity testing for: • Blockage impacts of culverts and bridges. • A 10 per cent, 20 per cent and 30 per cent increase in rainfall due to climate change. • Tailwater levels for the northern and central catchments.	Roads and Maritime project manager	Detailed design

6.6 Landscape character and visual amenity

This section provides an assessment of landscape character and visual amenity impacts of the proposal. It is supported by the *Technical Paper: Urban Design, Landscape Character and Visual Amenity* (AECOM, 2013), which is provided at **Appendix H**.

6.6.1 Methodology

Overview

Early planning is a key to achieving an integrated urban design strategy for major infrastructure projects such as the proposal. The establishment of a collaborative multidisciplinary design team prior to route selection has provided consistent, high level awareness of the landscape and urban design objectives and has enabled an integrated 'whole-of-corridor' outcome for the proposal within the context of the Princes Highway and the urban design objectives developed for the Princes Highway upgrades between Gerringong and Bomaderry. Development of the concept urban design for the proposal has been a process of informing, and being informed, by each of the design disciplines to provide a holistic and integrated solution.

Concept design development approach and process

Consistent with the overall philosophy and goals for urban design, as described within 'Beyond the Pavement' (RTA, 2009), the urban and landscape design team has been continually engaged throughout the development of the concept design for the proposal and maintenance of the integrity of the urban design objectives has been met through a range of initiatives including:

- Participation in value management and value engineering workshops.
- The preparation of artist's impressions and diagrams to measure the potential impacts of the proposed design options.
- Collaboration with the environmental, heritage, geotechnical and earthworks and road and drainage design disciplines to maximise opportunities for integrated concept design solutions.
- Urban design studies of Bomaderry that illustrate the broader contextual impacts of the proposal and what opportunities and constraints these present.
- The preparation of the urban design and landscape concept plan that is outlined in Section 3.0 of the Technical Paper: Urban Design, Landscape Character and Visual Amenity (AECOM, 2013) which is provided at Appendix H, which was informed by ongoing visual assessment and contextual analysis during design development. The visual assessment and contextual analysis identified impacts associated with the proposal and the urban design and landscape concept plan proposes relevant design treatments that have been integrated into the concept design to minimise potential impacts.

Landscape character and visual impact assessment

For the purposes of assessing the landscape character and visual impact of the proposal, the study area was broken down into three landscape character units including Jaspers Brush, Meroo Meadow and the Bomaderry gateway. These landscape character units are illustrated in **Figure 6-19**

The methodology for the landscape character and visual amenity assessment was based on Roads and Maritime's 'Environmental Impact Practice Note: Guideline for Landscape Character and Visual Impact Assessment' (Roads and Maritime, 2013) and was divided into two parts. The first part was an overall assessment of the proposal in the study area and the second was an individual assessment of the three landscape character units within the study area.

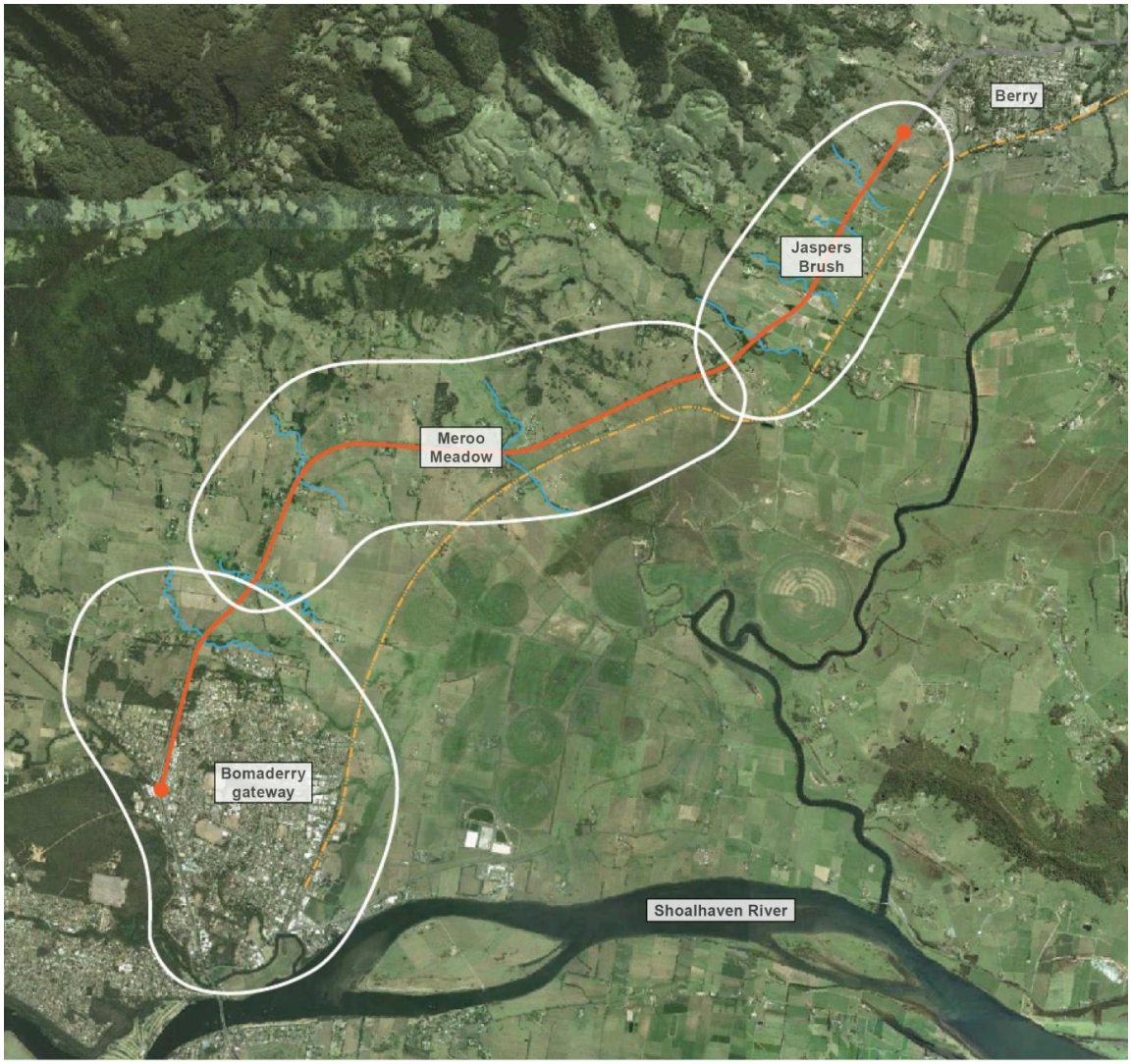


Figure 6-19 Landscape character units within the study area

The assessment of the landscape character and visual impact within each of the three landscape units was based on an evaluation of the sensitivity of the area and the magnitude of the proposal within each landscape character unit and included the following:

- A description of the proposal components within each of the three landscape units.
- Analysis of the existing landscape character.
- Description of the impacts and the visibility of the proposal.
- Assessment of sensitivity to the proposed change.
- Assessment of the magnitude of the proposed change.
- The overall assessment of the impact.
- The recommendation of mitigation strategies.

Sensitivity refers to the quality of the view and how sensitive that view or character is to the change associated with the proposal. Magnitude refers to the nature and scale of the proposal and its proximity to assumed viewer groups, which primarily consist of adjacent rural residents and users of the road corridor within the three landscape character units.

An overall rating of the impact of the proposal on landscape character and visual amenity was achieved by combining the ratings of sensitivity and magnitude. This was undertaken using the impact grading matrix presented in **Table 6-43**.

Table 6-43 Landscape character and visual impact grading matrix

Potential visual impact		Magnitude of change				
		High	**High to moderate**	**Moderate**	**Moderate to low**	**Low**
Sensitivity	**High**	High impact	High impact	High to moderate impact	High to moderate impact	Moderate impact
	High to moderate	High impact	High to moderate impact	High to moderate impact	Moderate impact	Moderate impact
	Moderate	High to moderate impact	High to moderate impact	Moderate impact	Moderate impact	Moderate to low impact
	Moderate to low	High to moderate impact	Moderate impact	Moderate impact	Moderate to low impact	Moderate to low impact
	Low	Moderate impact	Moderate impact	Moderate to low impact	Moderate to low impact	Low

For the purpose of the assessment, viewers include road users and local residents and viewpoints were selected for each landscape character unit, upon which the assessment of potential impacts was based. The viewpoints were selected on the basis that they are vantage points or represent concentrations of people who may be affected by the proposal.

A visibility analysis was also undertaken using a Geographic Information System (GIS) based view shed analysis to help inform the selection of the viewpoints. The analysis considered topography (slope), water courses, vegetation cover, land use and the level of visibility of the proposal elements within the surrounding landscape.

Visual envelope maps were produced to illustrate the area of likely visual impact associated with the proposal, to represent the range of views to the study area, including points both within and outside of the study area. View sheds for each of the selected viewpoints were mapped using GIS to illustrate the overall visual catchment. The selected viewpoints and their associated view sheds within each of the landscape character units are shown in **Figure 6-24**, **Figure 6-27** and **Figure 6-29** and a detailed description is included in the *Technical Paper: Urban Design Report, Landscape Character and Visual Assessment* (AECOM 2013) provided at **Appendix H**.

6.6.2 Existing environment

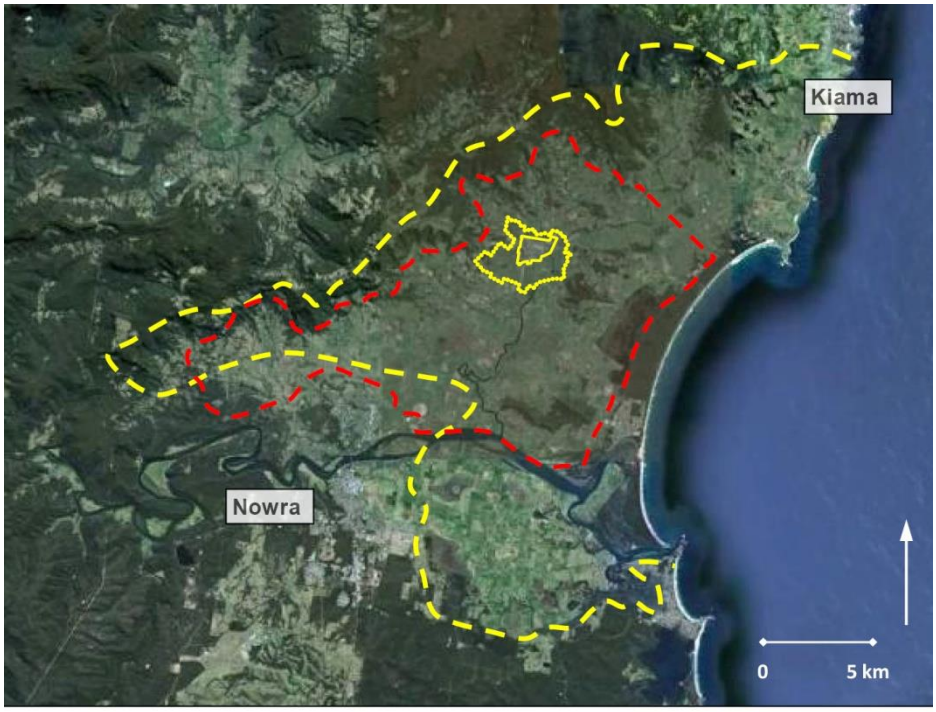
Cultural landscape context

The *Technical Paper: Non-Aboriginal (historic) Heritage* (NOHC, 2013) provided at **Appendix J** defines the broader region, including the study area, as the Southern Illawarra Coastal Plain and Hinterland Cultural Landscape (SICPHCL). The Cultural landscape framework of the SICPHCL can be separated into three identifiable areas; the Berry Bolong Pastoral Landscape, the Berry District Landscape Conservation Area, and the Berry Township Urban Conservation Area (BTUCA) and buffer zone. These areas are presented in **Figure 6-20**.

The proposal lies almost entirely within the Berry Bolong Pastoral Landscape, with the exception of the southernmost extent, just north of Bomaderry. Within the Berry Bolong Pastoral Landscape, the major source of differences in the landscape is a consequence of the variable topography. The rural backdrop is markedly different to the undulating higher elevations associated with the forested foothills of the Illawarra Escarpment to the west, and the open areas of the Broughton Creek floodplain to the east. The interaction between these topographic features has influenced the landscape character and visual qualities of the area and is a defining feature of the landscape for those who live and work within the study area and broader surrounds.

The study area has retained a unique, aesthetically balanced and fundamentally nineteenth century pastoral structure and is located at the interface of the foothills and floodplain. The character of the landscape is strongly identified with by local residents and it is also more widely recognised as a key regional asset.

The area immediately surrounding the proposal has been strongly influenced both culturally and physically by the dairy industry. The study area was gradually cleared for agricultural purposes following the establishment of agricultural estates on land grants during early European settlement. Dairy farming was the predominant form of agriculture in the second half of the nineteenth century, resulting in a characteristic landscape of cleared rolling to flat pasture with prominent cultural plantings, which identify farmhouses and / or property boundaries.



Legend

- Visual boundary of the BTUCA*
- Buffer zone of the BTUCA
- Sub-division boundary of the BTUCA
- Boundary of the Berry Bolong Pastoral Landscape

*** Defines the boundary of the Berry District Landscape Conservation Area**

Figure 6-20 Cultural landscape conservation areas (image provided courtesy of NOHC Pty Ltd 2011).

For road users, the natural and cultural landscape within the study area is uniquely rich and engaging. The coast and fertile coastal plains are often present in distant views across the rural landscape, with many well established stately trees creating a sense of prosperity. On a broad scale, these trees create a 'portal', whereby road users experience travelling from open landscapes with broad views to enclosed tunnels where canopies almost enclose the road corridor before opening up again. Views from the existing highway also contain tree covered ridge lines, escarpments, as well as meandering creeks and rivers that flow into the coastal plains, lakes and wetlands.

Landscape character units

The Jaspers Brush and Meroo Meadow landscape character units are located within the Berry Bolong Pastoral Landscape. The Bomaderry gateway landscape character unit is associated with the forest landscapes of the Shoalhaven and the urban landscape of the Bomaderry Township. These landscapes have all been modified for agricultural purposes and the patterns of tree planting reflect this intervention.

Jaspers Brush

The Jaspers Brush landscape character unit is mostly rural, occupying the landscape from just south of Berry to the low ridgeline at Jaspers Brush Road. Within this unit, there are four small creeks which travel from west to east underneath the existing highway, and there are a number of small dams on agricultural properties. Local roads, driveways and internal property access roads run perpendicular to the existing highway, providing access to rural residences and generally run along the top of the higher ground that separates the creeks. An aerial view of the Jaspers Brush landscape character unit is shown in **Figure 6-21**

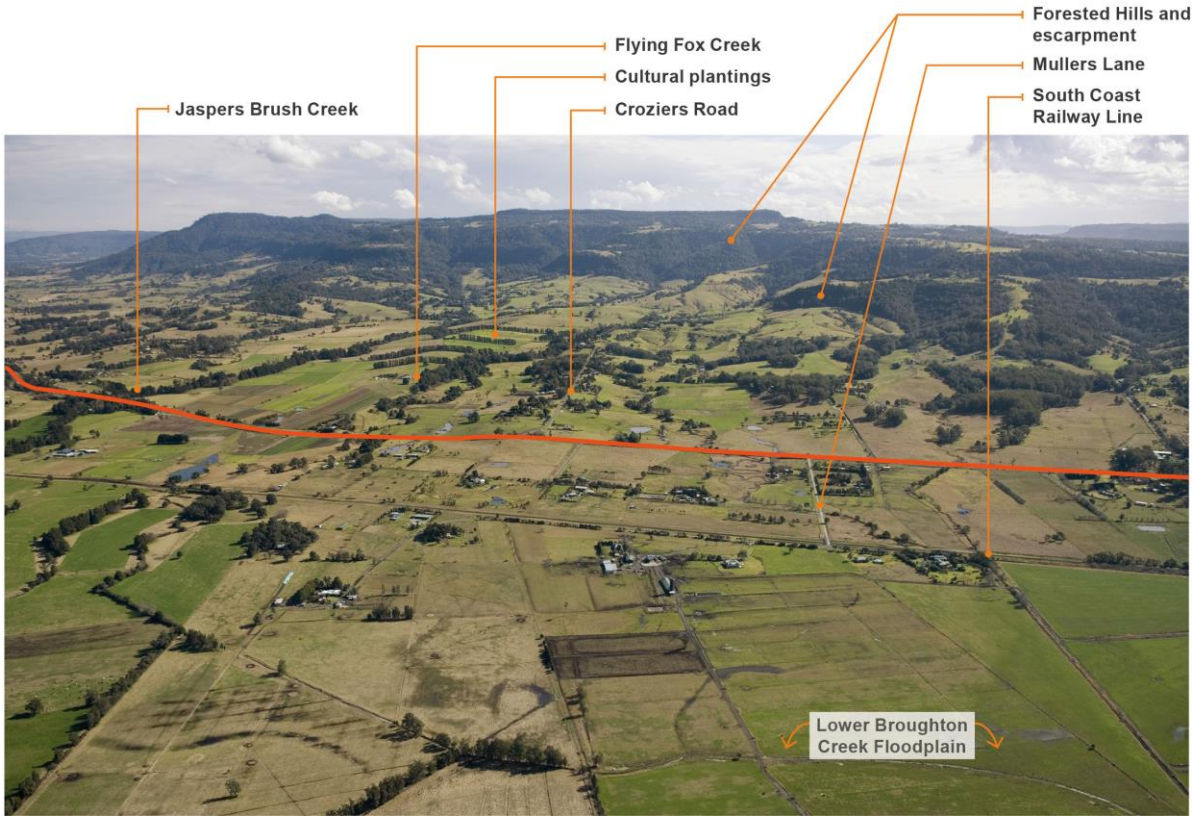


Figure 6-21 Jaspers Brush landscape character unit looking west

Meroo Meadow

Meroo Meadow is located to the south of Jaspers Brush, and is flatter with a generally more open landscape. Residences to the east of the existing highway through this area are limited as the majority of this landscape character is low lying, flood prone land. South of Turners Lane the existing highway is enclosed by a thin line of vegetation, including old pine trees (*Pinus radiata*), Hoop Pines (*Araucaria cunninghamiana*), Moreton Bay Figs (*Ficus macrophylla*) and Eucalyptus species. The residences and farmhouses located on the areas of higher ground to the north and west of the existing highway also comprise distinctive cultural plantings which define entrances, property boundaries and / or fence lines. An aerial view of the Meroo Meadow landscape character unit is shown in **Figure 6-22**.

Figure 6-22 Meroo Meadow landscape character unit looking northeast

Bomaderry gateway

The open pastoral and agricultural landscapes south of Meroo Road begin to rise up towards the Shoalhaven and between the low point at Abernethys Creek and the intersection of the existing highway and Cambewarra Road, the vertical height of the road level increases by about 40 metres. As road users travelling in a southerly direction approach Bomaderry, a broad stand of remnant Eucalyptus high forest forms a screen between the Bomaderry urban area and the open pastoral landscape. Entering into Bomaderry from the north along the existing highway, there is an abrupt transition from bushland fringed road to a more suburban character.

The Bomaderry Township is largely residential, with most of the residential area located to the east of the Princes Highway. A number of local residents utilise Meroo Road for access to the existing highway. Commercial areas are generally located along the Princes Highway corridor south of the proposal, and south of the intersection of Cambewarra Road and Moss Vale Road. The roadway in this area reflects its urban setting and includes a planted median, grassed verges and footpaths on both sides. An aerial view of the Bomaderry gateway landscape character unit is shown in **Figure 6-23**.

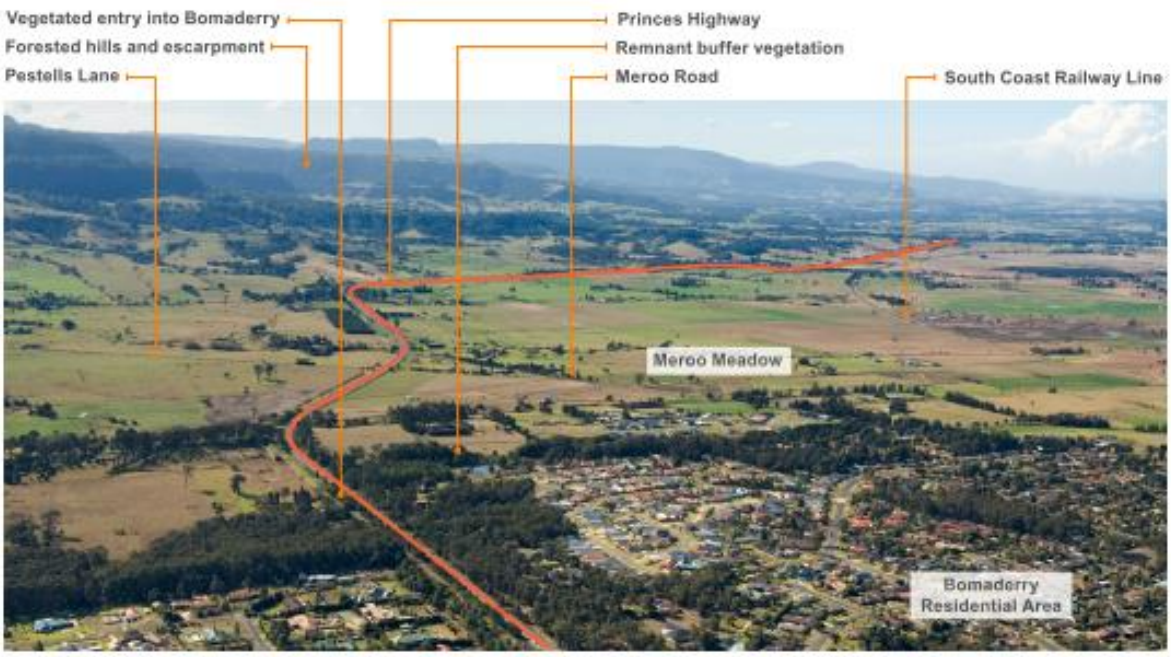


Figure 6-23 Bomaderry gateway landscape character unit looking north towards Meroo Meadow

6.6.3 Assessment of potential impacts

Overall, the construction and operation of the proposal would change the well-established cultural landscape relationship that has evolved between the existing highway and the adjacent land use practices.

Construction

Landscape character and visual amenity impacts during the construction phase of the proposal would occur across all three landscape character units. The visual amenity for road users and the amenity of rural residences in close proximity to the proposal would be impacted by the construction works, which would be highly visible and may result in a loss of views for the duration of construction. These impacts would be the most obvious immediately following vegetation clearance and prior to the establishment of landscaping works, when the construction works and associated plant and equipment as well as new road infrastructure would be clearly visible.

The construction of new bridges and structures including the grade separated facilities at Jaspers Brush and Strongs Road and Morschels Lane and Devitts Lane and the grade separated half-interchange at Pestells Lane and Meroo Road would be highly visible in an otherwise relatively flat landscape. The extent of these impacts would be similar to those that would be experienced during operation of the proposal, but could be slightly increased during construction due to the site being cleared and the presence of plant and equipment.

The requirement for temporary construction ancillary facilities, including site offices, stockpiles and compounds would also have associated landscape character and visual amenity impacts. Construction ancillary facilities would temporarily increase the extent of the footprint of the proposal, would require some vegetation clearance and would in some cases be visible from adjacent residences.

Operation

Generally, the proposal responds to the natural grain of the landscape by following the existing contours through the landscape and utilising the existing alignment where possible.

Headlight glare from vehicles would occur as a result of both the existing highway and the proposal. As the proposal would primarily follow the existing highway corridor it is not expected that headlight glare from vehicles using the highway would be much greater than currently experienced. There is a potential change to headlight glare experienced at properties next to the proposed grade-separated facilities and the half-interchange.

It is proposed to provide some lighting at the grade-separated facilities and the half-interchange, at the merges and diverges associated with on and off ramps and at right turn bays. The provision of lighting would be developed further during detailed design and in order to minimise the potential for light spill impacts on the surrounding environment, the amount of additional lighting would be limited to that required to meet road safety guidelines. It is not expected that the provision of limited lighting at interchanges would cause a substantial impact to the surrounding environment.

Potential landscape character and visual impacts and the overall impact rating within each of the three landscape character units are described below and a summary of the potential impact rating associated with the overall proposal is also provided. The potential impact rating for the overall proposal was based on the average of assessments completed for each of the three landscape character units.

Potential impacts within the Jaspers Brush landscape character unit

The selected viewpoints and their associated view sheds within the Jasper Brush landscape character unit are shown in **Figure 6-24.**

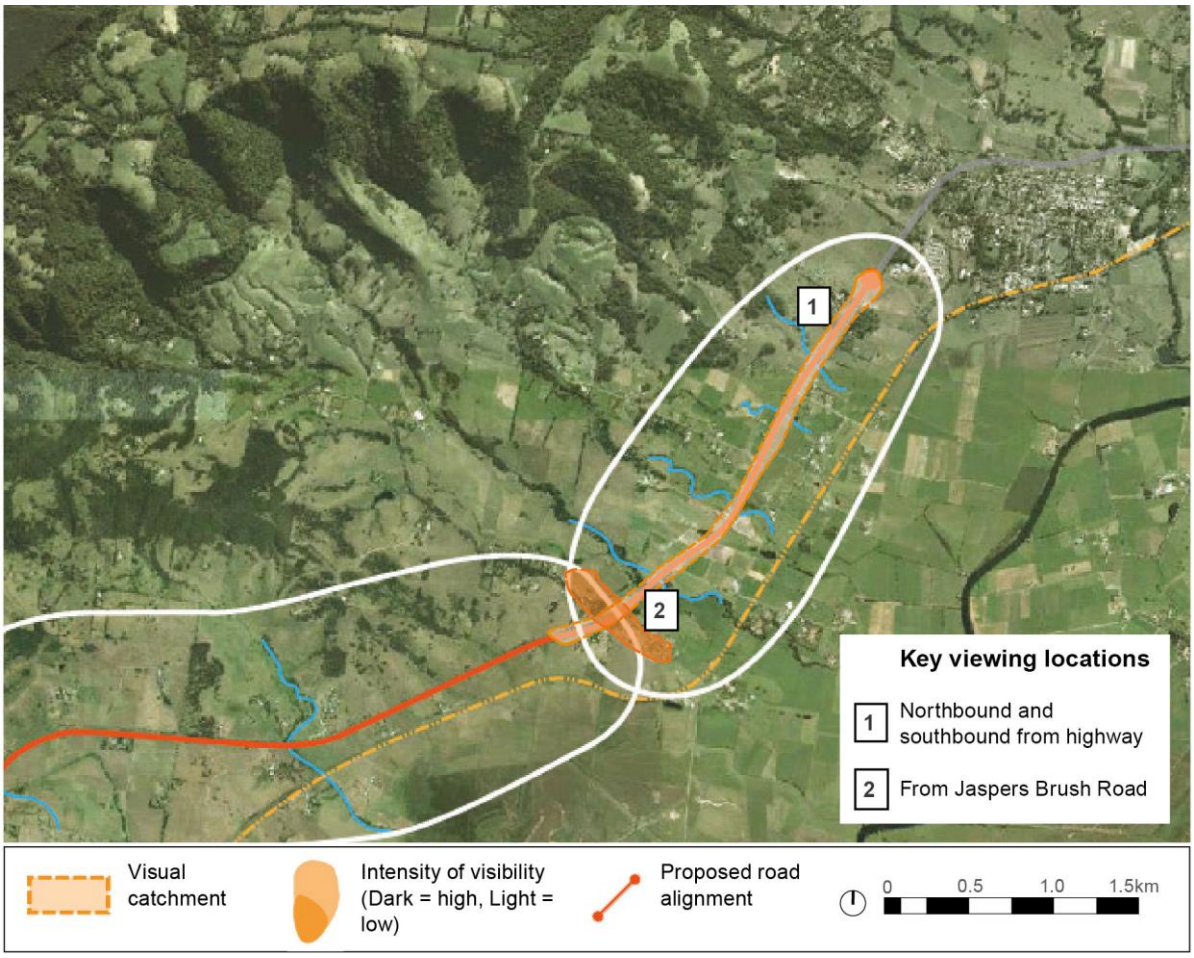


Figure 6-24 Visual catchment and key viewpoints of the Jaspers Brush landscape character unit

Aspects of the proposal that would impact on the landscape character and visual amenity of the Jaspers Brush landscape character unit would include:

- Increased width of the road reserve.
- Increased visibility of new highway infrastructure.
- Increased cut batters along the east and west facing slopes.
- Loss of roadside vegetation associated with the widening of the road reserve and bridgeworks.

The visual catchment of Jaspers Brush is relatively contained with a low number of viewers. Most of the adverse impacts within this landscape character unit would be incurred by rural homesteads located adjacent to the existing highway. The cutting at the Jaspers Brush Road and Strongs Road grade separated facility would be reasonably well screened for these viewers, and would allow for the over bridge (part of the grade separated facility) to be set into the landscape. An artist's impression of the grade separated facility at Strongs Road and Jaspers Brush Road is illustrated in **Figure 6-25**.

For road users, the main impacts of the proposal within the Jaspers Brush landscape character unit would be the increased scale and size of the cutting through the ridge line and the widened highway. The cutting at Strongs Road would be about 300 metres long and up to ten metres deep.

At about Chainage 21000, near O'Keefes Lane, the road reserve would be considerably widened to allow for the heavy vehicle inspection bay. The inspection bay has been designed with the intention of minimising additional land take. As a result the distance between the main highway and the inspection bay is minimal and does not allow for screen planting. A cross section of the proposal, including the heavy vehicle inspection bay is shown in **Figure 6-26**.

Four existing bridges would be replaced over creek crossings. The replacement bridges would be set down into the landscape within the creek line and floodplain as much as practically possible and would have a relatively low visual impact. A major drainage and flood mitigation bridge would be constructed just south of O'Keefes Lane at Chainage 21200. This bridge would be about 45 metres long and up to 3.5 metres high. As it would be elevated above the level of the existing highway, it would be highly visible within the landscape.

Overall assessment of impacts within the Jaspers Brush landscape character unit
The sensitivity of the Jaspers Brush landscape character unit to changes associated with the proposal, and the magnitude of the proposed changes have been rated as moderate. Based on the overall scale of the proposal within this area and the relative distance from which the majority of users would experience these changes, the overall rating of impact to the Jaspers Brush landscape character unit has been assessed as **moderate**.

Figure 6-25 Artist's impression of the grade separated facility at Jaspers Brush and Strongs Road facing south (not representative of time of opening-vegetation will need time to establish).

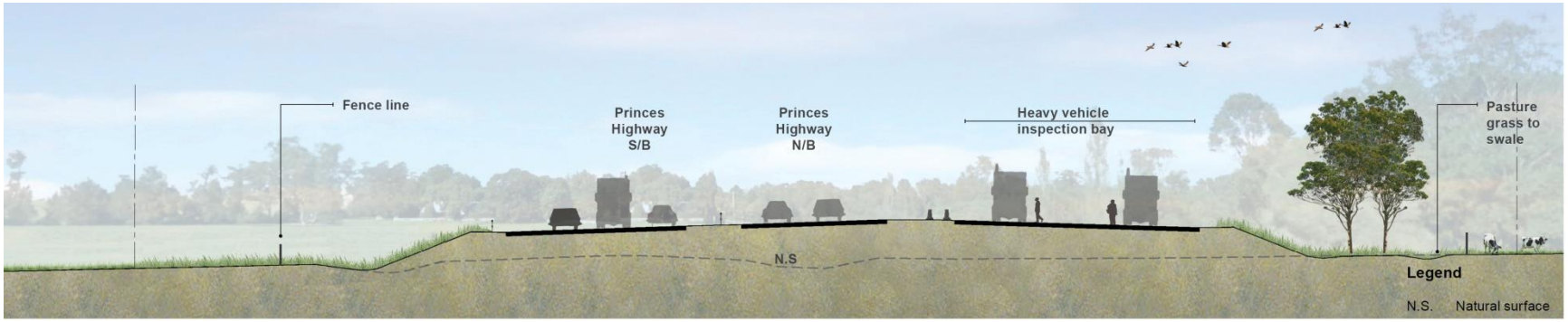


Figure 6-26 Cross section of the heavy vehicle inspection bay facing south (not representative of time of opening-vegetation will need time to establish).

Potential impacts within the Meroo Meadow landscape character unit

The selected viewpoints and their associated view sheds within the Meroo Meadow landscape character unit are shown in **Figure 6-27**.

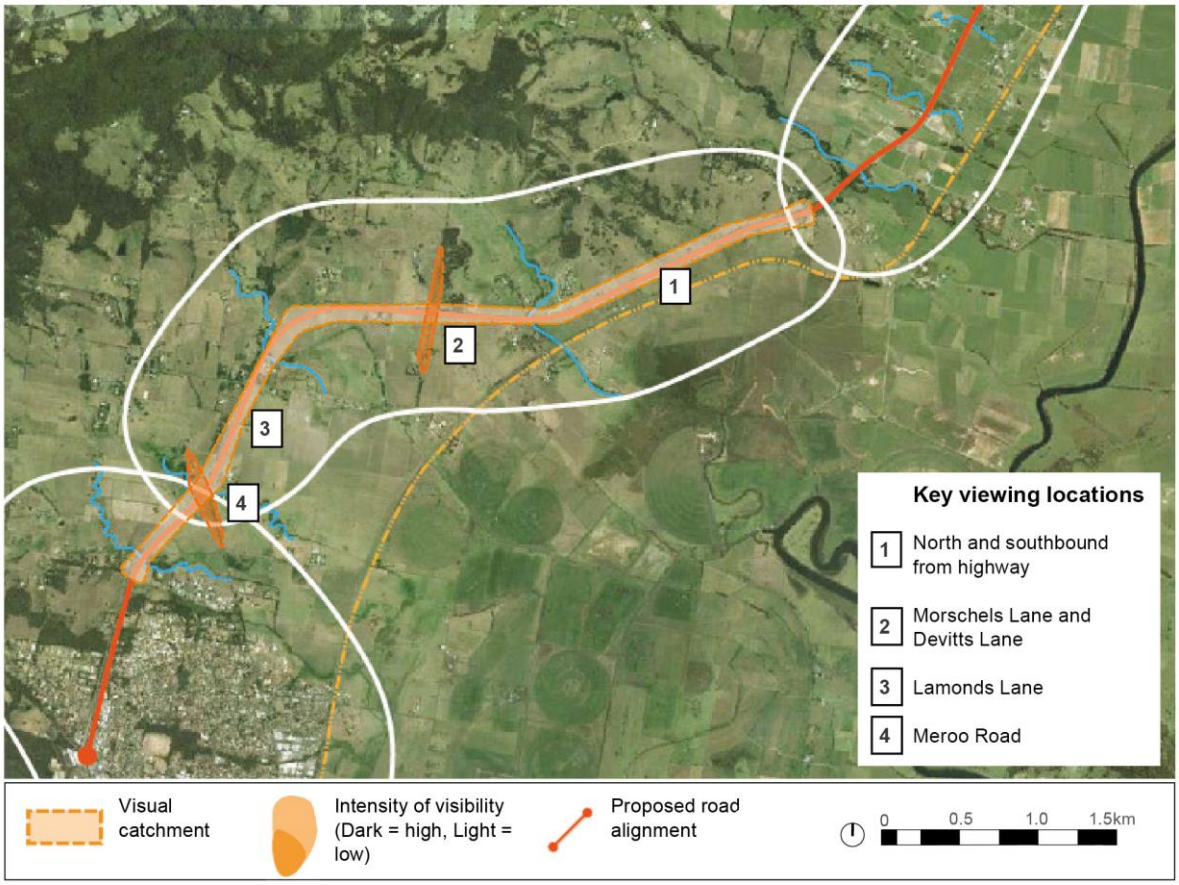


Figure 6-27 Visual catchment and key viewpoints of the Meroo Meadow landscape character unit

Aspects of the proposal that would impact on the character and visual amenity of the Meroo Meadow landscape character unit include:

- An increased width of the road reserve.
- Increased visibility of elevated highway infrastructure.
- Loss of roadside vegetation associated with the widening of the road corridor and bridgeworks.

The main features associated with the proposal in the Meroo Meadow landscape character unit would be the introduction of the grade separated facility at Morschels Lane and Devitts Lane and the increased earthworks and embankments required to elevate the road corridor to provide flood immunity. A cross section of the Morschels Lane and Devitts Lane grade separated facility is illustrated in **Figure 6-28**

The visual catchment of the proposal within the Meroo Meadow landscape character unit is relatively contained and the number of viewers of the proposal (not including road users) is considered to be low. Views to the Meroo Meadow landscape are mostly experienced by road users and an isolated number of rural residents.

Overall assessment of impacts within the Meroo Meadow landscape character unit

The sensitivity of the Meroo Meadow landscape character unit to the proposal is considered high to moderate and the magnitude of the proposed changes within this landscape character unit have been rated as moderate. Considering the overall scale of the proposal within this area, and the relative distance that the majority of users would be exposed to the proposed changes, the overall impact of the proposal on the Meroo Meadow landscape character unit has been rated as **high to moderate**.

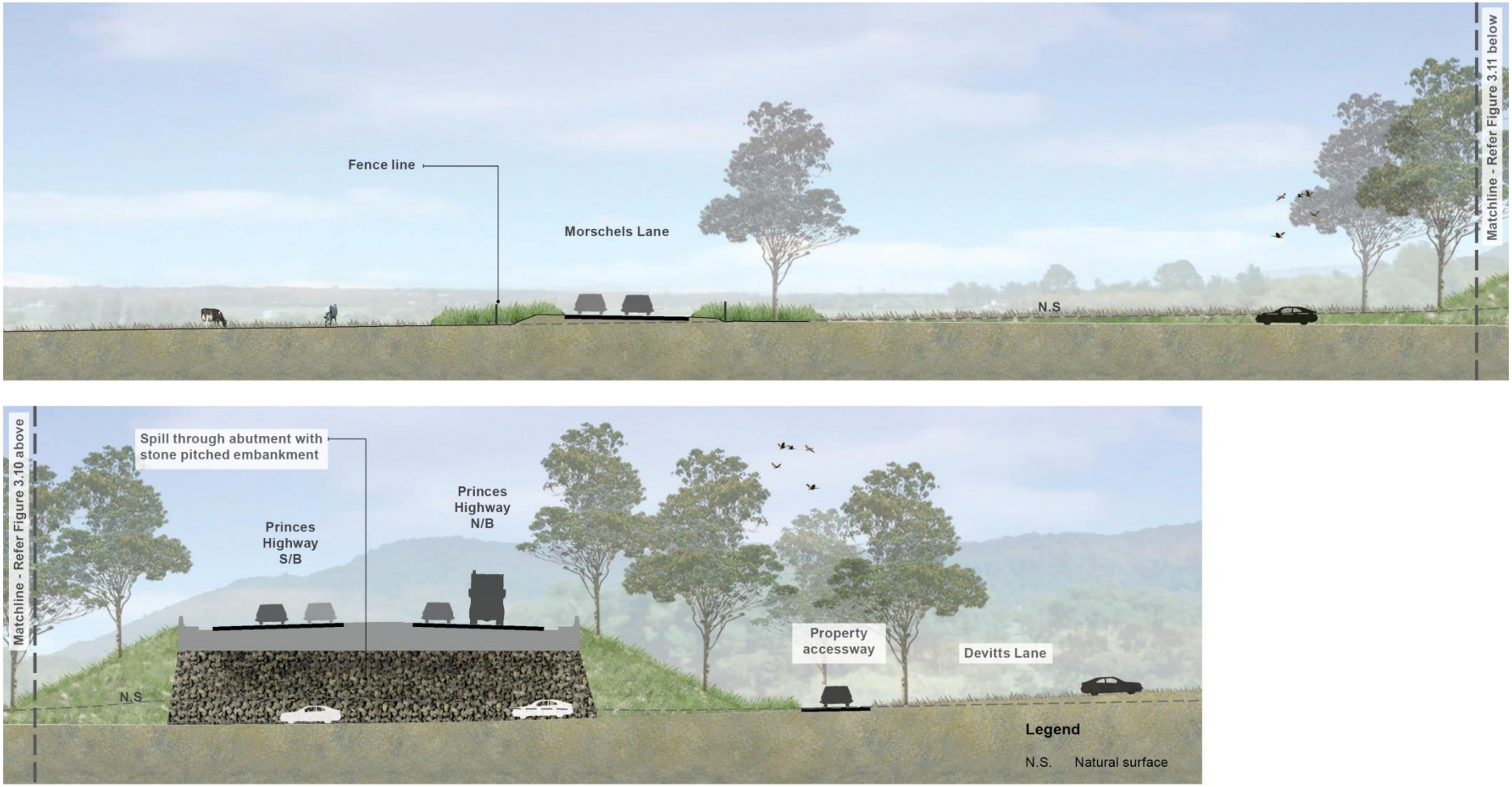


Figure 6-28 Morschels Lane grade separated facility facing south (not representative of time of opening-vegetation will need time to establish).

Potential impacts within the Bomaderry gateway landscape character unit

The selected viewpoints and their associated view sheds within the Bomaderry gateway landscape character unit are shown in **Figure 6-29**

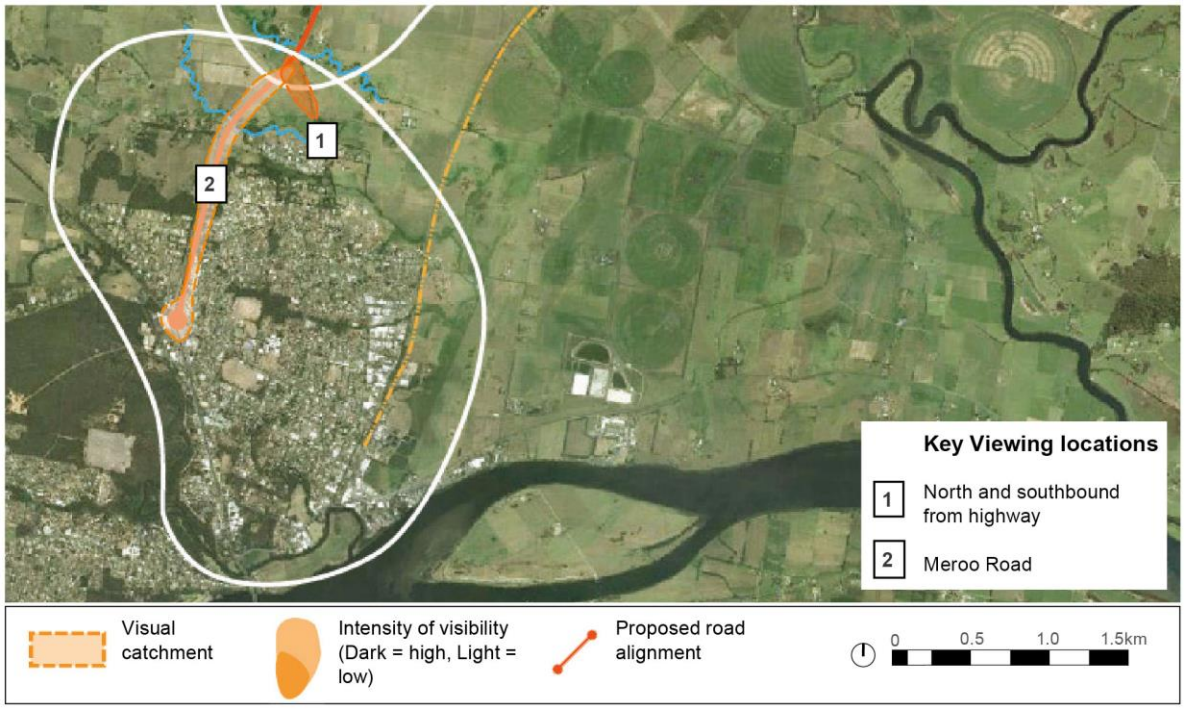


Figure 6-29 Visual catchment and key viewpoints of the Bomaderry gateway landscape character unit

Aspects of the proposal that would impact on the landscape character and visual amenity of the Bomaderry gateway landscape character unit would include:

- An increased width of the road reserve.
- Loss of vegetation.
- The introduction of new large scale infrastructure into a relatively flat and open landscape.

The increased footprint of the highway, the physical size of the proposed grade-separated half-interchange at Pestells Lane and Meroo Road and the flood mitigation structure would be the most substantial changes within the Bomaderry landscape character unit as a result of the proposal.

The design of the grade separated interchange includes a 130 metre long flood mitigation structure for the control of water flow under the proposal during flood events. The footprint of the interchange and associated infrastructure would require further vegetation clearance in this area, which would subsequently increase the visibility of this section of the proposal. An artist's impression of the grade separated half-interchange and a cross section are provided in **Figure 6-30** and **Figure 6-31** respectively.

Views within the Bomaderry gateway landscape character unit are typically experienced by road users and a small number of rural residences alongside the existing highway. There are also views from a cluster of residents at the southern end of the proposal close to the Bomaderry Township.

The visual catchment of the Bomaderry gateway landscape character unit is relatively contained and the number of viewers is low because the majority of residents within Bomaderry are screened from the proposal by the remnant vegetation located along the northern edge of the Bomaderry Township.

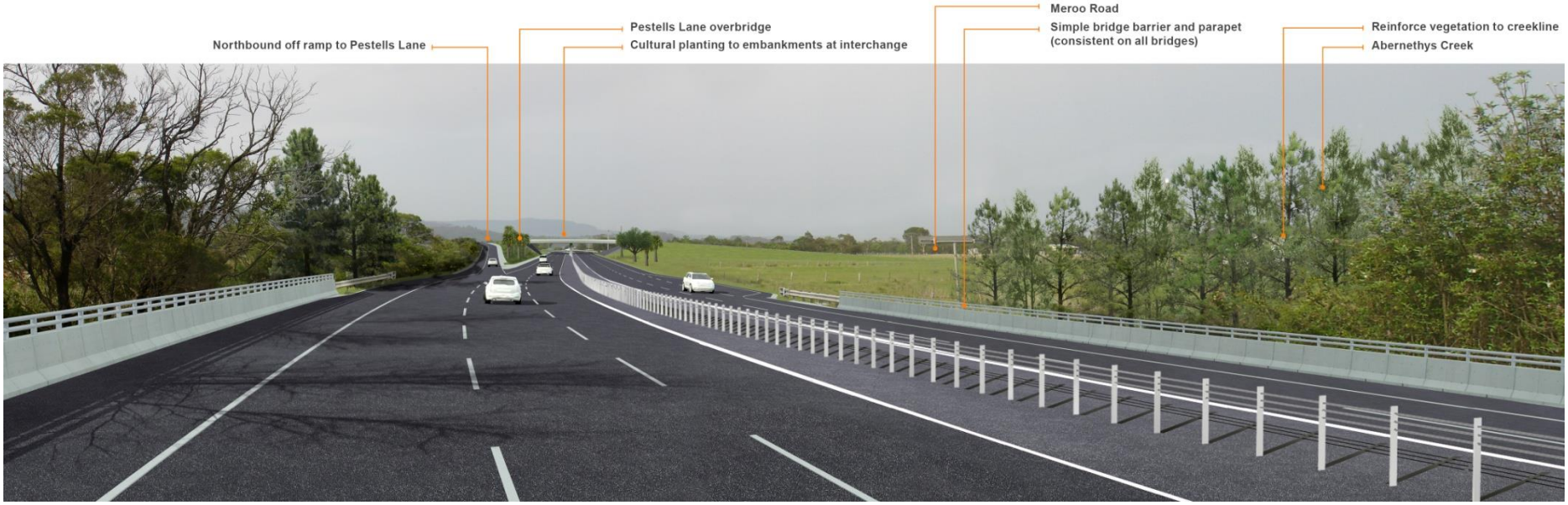


Figure 6-30 Artists impression of the Pestells Lane and Meroo Road grade separated half-interchange (not representative of time of opening-vegetation will need time to establish).

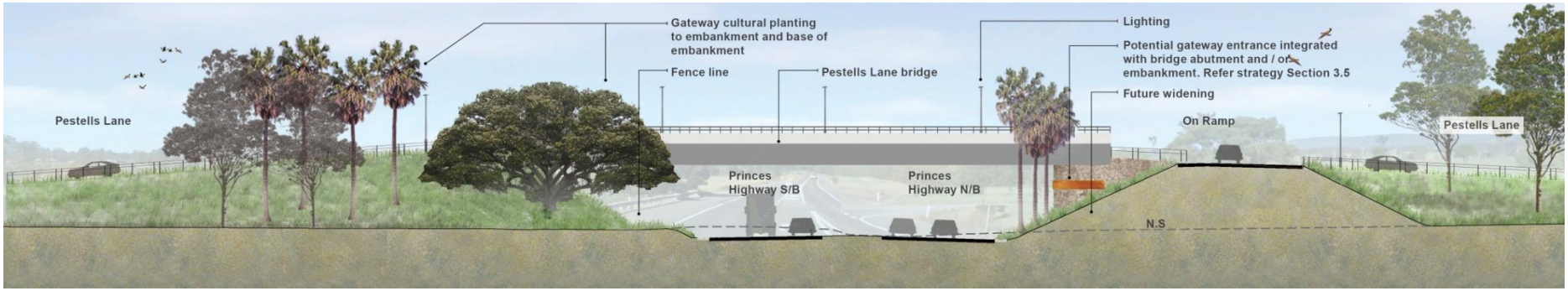


Figure 6-31 Cross section of the Pestells Lane and Meroo Road grade separated half-interchange (not representative of time of opening-vegetation will need time to establish).

Consideration of a Bomaderry arrival and departure strategy
The southern extent of the proposal at the junction of the existing highway at Cambewarra Road presents challenges associated with speed management and road safety. The southern extent of the proposal at this location marks the end of about 45 kilometres of upgraded highway along which road users would travel continuously at speeds of up to 100 kilometres per hour. Potential speed management and road safety issues at this location as a result of the proposal would be exacerbated further, should the design of the proposal create a disconnect as the Berry-Bolong Pastoral Landscape transitions into the urban landscape context of the Bomaderry Township.

Development of the concept design recognised the constraints of the proposal at this location as being:

The requirement for a safe transition from the highway environment into an urban environment.

- The need for safe access provisions for existing properties on the approach to Bomaderry.
- Potential noise impacts associated with increased traffic.

Following the identification of these constraints, design opportunities for the southern tie in were identified. These included:

- Reinforcement of the vegetation buffer between the rural highway environment and urban landscape interface at the northern boundary of the Bomaderry Township.
- Potential use of urban design initiatives to assist in the transition from a highway environment to the local road network.
- Enhancement of the arrival and departure experience to the Shoalhaven Region at Bomaderry.

The concept design for the proposal has incorporated these design opportunities as much as feasible and reasonable through the formation of an arrivals and departure strategy, which is described in Chapter 4 of the *Technical Paper: Urban Design Report, Landscape Character and Visual Assessment* (AECOM 2013) provided at **Appendix H**. The strategy would allow for the integration of speed management, which would be reinforced by locally relevant urban design and landscape treatments from the grade separated half-interchange at Pestells Lane and Meroo Road to the southern extent of the proposal at Cambewarra Road.

Aspects of the proposed Bomaderry arrivals and departure strategy which have been incorporated into the concept design include:

- The provision of a widened roadside shoulder and raised central median from the service station at Chainage 29800 to the Cambewarra Road/ Princess Highway roundabout.
- A change in the speed limit from 100 kilometres per hour to 70 kilometres per hour on the approach to Bomaderry from just south of Abernethys Lane at about Chainage 29100. Similarly, travelling in the opposite direction, the speed limit exiting Bomaderry would remain at 70 kilometres per hour until Chainage 29100, where it would change to 100 kilometres per hour.
- A slow transition from the low point in the road at Abernethys Creek associated with the concept design and the proposed change of grade by six metres over one kilometre of the proposal (between Chainage 28500 and 29100). This would then be followed by a visibly noticeable change in the road grade of 22 metres over one kilometre (between Chainage 29100 and 30100) coming into and out of Bomaderry.

The design features of the proposal would be supported by landscape and urban design elements to reinforce the transition from highway conditions into a local road context through roadside plantings, highway furnishings and fixings, as well as the implementation of appropriate signage. Roadside plantings would include:

- The use of culturally relevant and / or feature species over a distance of around 700 metres in the vicinity of the Pestells Lane and Meroo Road grade separated half-interchange. These plantings would be used to reinforce the unique cultural planting of the Berry Bolong Pastoral Landscape.
- Provision of a vegetated buffer between the Berry Bolong Pastoral Landscape and urban landscape of Bomaderry across about 1500 metres from just before Abernethys Creek to around the proposed u-turn facility at chainage 29900. This would include roadside plantings of Eucalyptus species which would also reinforce the remnant bushland that screens the residential areas of Bomaderry from the existing highway.
- Formal or structured tree planting with culturally relevant species for a distance of around 400 metres between the service station at Chainage 29800 and the Cambewarra Road roundabout. These plantings would reinforce the form and structure of the road edge, and would further reinforce the transition from highway conditions to local road conditions and speeds.

Road signage along the proposal as part of the arrival and departure strategy would include the provision of:

- One hundred kilometres per hour speed limit signs at the Pestells Lane and Meroo Road grade separated half-interchange for road users travelling in both directions. A 100 kilometre per hour speed limit sign would also be provided between the existing service station at Chainage 29800 and the Cambewarra Road roundabout for road users travelling north after departing the Bomaderry Township.
- Warning signage ('70 ahead') to coincide with the grade change of 22 metres from just south of Abernethys Lane and the Cambewarra Road roundabout for southbound traffic on the approach to Bomaderry.
- Seventy kilometres per hour speed limit signage between just south of Abernethys Lane and the Cambewarra Road roundabout for southbound traffic.

The potential urban and landscape treatments for the arrival to and departure from Bomaderry are presented in **Figure 6-32** and a cross section of the proposal as it approaches Bomaderry taken just north of the service station is provided in **Figure 6-33**

Overall assessment of impacts within the Bomaderry gateway landscape character unit
Elements of the proposed Bomaderry arrivals and departure strategy have been incorporated into the concept design. With consideration of these elements, the sensitivity of the Bomaderry gateway landscape character unit to the proposal is considered moderate to high, and the magnitude of the proposed changes within this landscape character unit are both considered to be moderate. Based on the overall scale of the proposal in this landscape character unit and the relative viewer distance, the overall impact is rated as **moderate**.

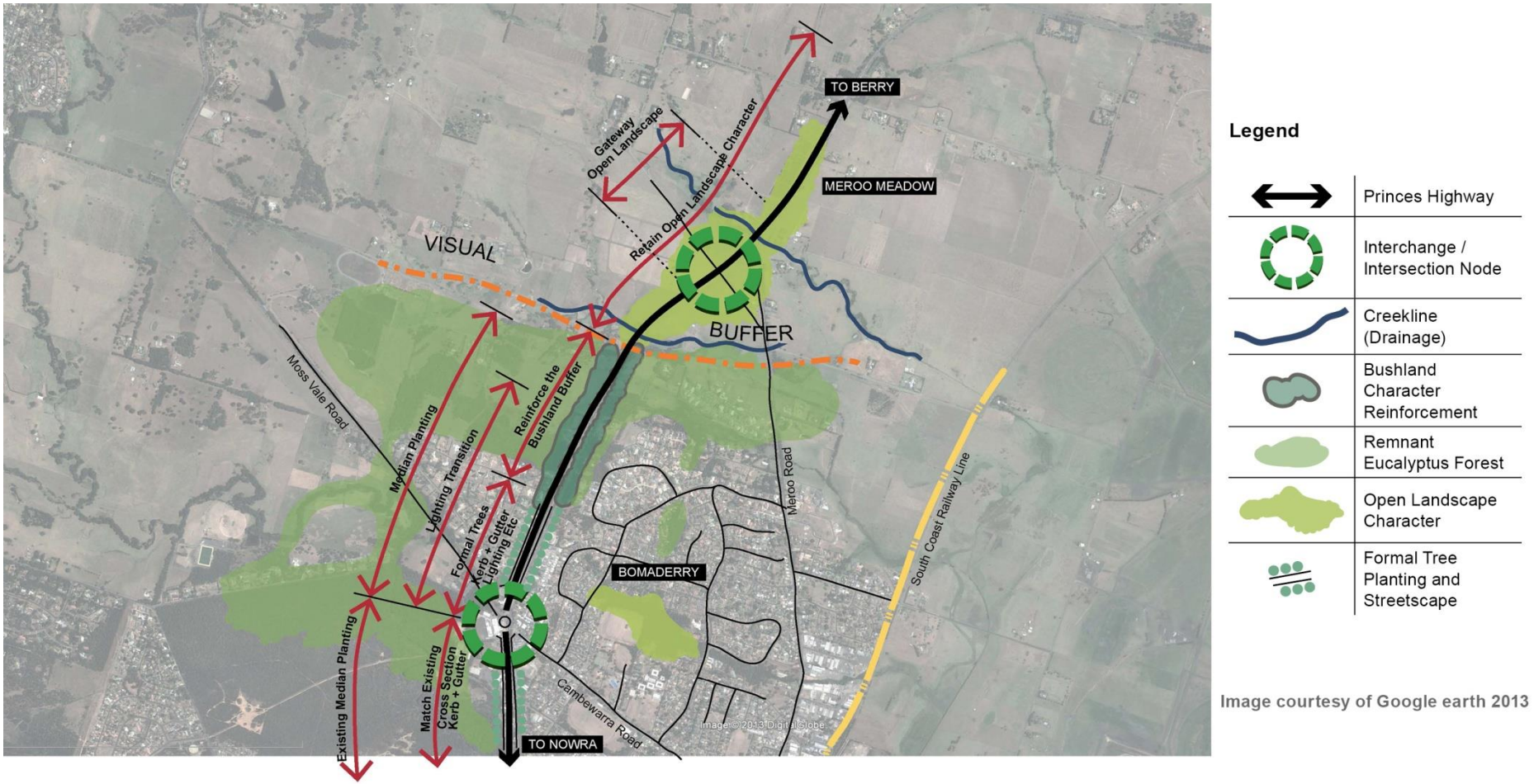


Figure 6-32 Potential urban and landscape treatments for the arrival to and departure from Bomaderry

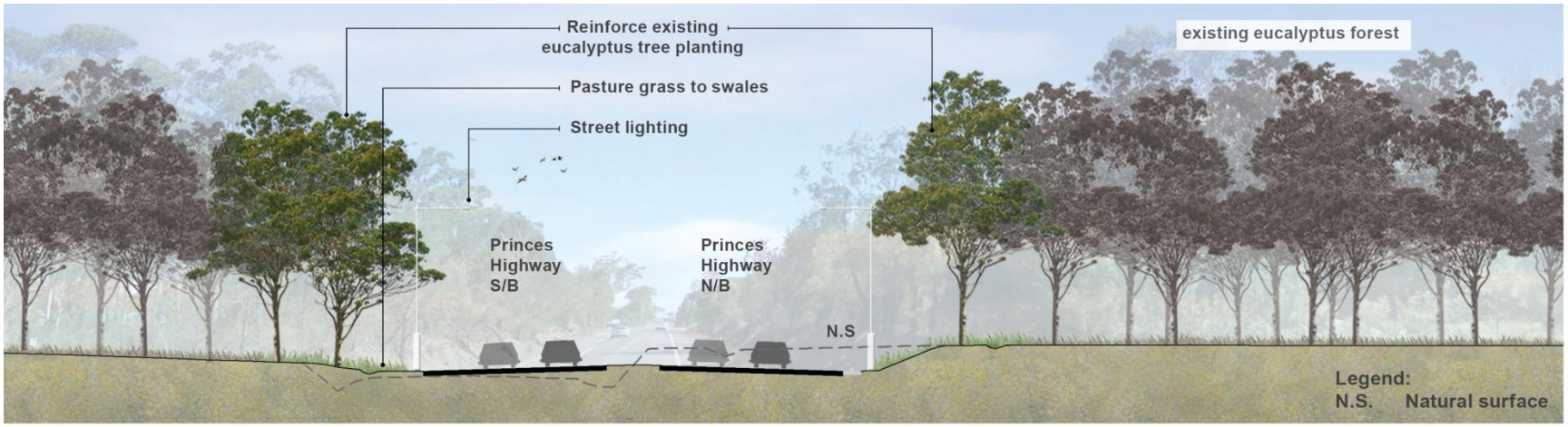


Figure 6-33 Cross section of the arrival into Bomaderry at chainage 29500 (not representative of time of opening-vegetation will need time to establish).

Summary of potential impacts associated with the overall proposal

The overall impact assessment was based on the average assessments completed for each of the three landscape character units as outlined above and the impact ratings are summarised in **Figure 6-34**.

Potential landscape and visual impact summary table			
Category	Landscape Character Unit		
	Jaspers Brush	Meroo Meadow	Bomaderry Gateway
Sensitivity	Moderate impact	High to Moderate impact	Moderate impact
Magnitude	Moderate impact	Moderate impact	Moderate impact
Overall	Moderate impact	High to Moderate impact	Moderate impact
Overall (All units)	Moderate impact		

Figure 6-34 Landscape and visual impact summary

Based on the overall scale of the proposed intervention and the relative distance that the majority of users would experience these interventions from, the potential impact associated with the overall proposal is rated as **moderate**.

6.6.4 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or manage landscape character and visual amenity impacts of the proposal. These measures are presented in **Table 6-44** and are summarised in **Section 7.2**.

Table 6-44 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
Loss of visual amenity	Avoid excessive vegetation clearance by demarcating areas requiring removal.	Construction contractor	Pre-construction
	Progressively stabilise cut batters and exposed areas with appropriate seed mixes for cover crop and install landscape plantings as soon as reasonably practicable.	Construction contractor	Construction
	Engage with adjacent land owners to assess whether early works mitigation (eg landscape planting) can be implemented to help reduce or soften the visual impacts of the proposal. Implement these measures where appropriate.	Roads and Maritime project manager and construction contractor	Construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
Operation			
General loss of landscape character and visual amenity along the length of the proposal	In addition to the area-specific measures outlined below, implement the urban design and landscape concept plan outlined in Section 3.0 of the *Technical Paper: Urban Design, Landscape Character and Visual Amenity* (AECOM, 2013), which is provided at **Appendix H**.	Roads and Maritime project manager and construction contractor	Construction
	Minimise lighting impacts of the proposal by designing lighting in accordance with 'Australian Standard 1158 Road Lighting'. Where lighting is proposed it will be designed for a non-intrusive angle to minimise light spill impacts on adjoining residential properties.	Roads and Maritime project manager and construction contractor	Detailed design
Visual impacts at specific locations and precincts – Jaspers Brush and Meroo Meadow	Roll back the top of the cutting at Strongs Road to minimise the overall appearance of the cutting.	Roads and Maritime project manager	Detailed design
	Reinstate the vegetation as close to the top of cuttings as possible (whilst allowing for the provision of required drainage structures and maintenance access) in the spaces between the access ramps for Strongs Road and Jaspers Brush Road and along the tops of the embankments on the ridge line south of Jaspers Brush Creek.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Use cultural plantings to highlight property boundaries and waterways and along the top of embankments where appropriate.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Construct embankment slopes at a gradient less than 2:1 where feasible and reasonable. Vary the embankment slopes and blend the slopes to the edge of new proposal infrastructure where practicable.	Roads and Maritime project manager and construction contractor	Detailed design and construction
Visual impacts at specific locations and precincts – Bomaderry gateway	Reinforce existing vegetation with additional plantings where appropriate at Abernethys Creek.	Roads and Maritime and construction contractor	Construction
	Soften the grade of fill embankments so that the new slopes can be reinstated with turf grass.	Roads and Maritime project manager and construction contractor*	Pre-construction and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
Inappropriate design of the southern tie in of the proposal.	Further develop the Bomaderry arrival and departure strategy in consultation with Shoalhaven City Council during detailed design. Implement the agreed urban and landscape design treatments proposed in the Bomaderry arrival and departure strategy.	Roads and Maritime project manager and Construction Contractor.	Detailed design and construction.

6.7 Aboriginal heritage

This section provides an assessment of Aboriginal cultural heritage and is supported by the *Aboriginal Cultural Heritage Assessment Report* (Navin Officer Heritage Consultants (NOHC), 2013). The *Cultural Heritage Assessment Report* is provided at **Appendix I**.

6.7.1 Methodology

The Aboriginal cultural heritage assessment that was undertaken for the proposal included Aboriginal community consultation, a literature and database review, field survey and archaeological test excavation. The study area for the Aboriginal cultural heritage assessment comprised the construction footprint of the proposal plus an additional 200 metre buffer.

Consultation with the Aboriginal community has been ongoing throughout the wider Princes Highway upgrade program since the commencement of the investigations phase. Aboriginal community consultation and investigations for the purposes of the proposal were undertaken consistent with the *Aboriginal cultural heritage consultation requirements for proponents* (DECCW 2010) and Roads and Maritime's *Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (PACHCI, June 2011[1]). At the time of writing, stage three of the procedure had been completed for the proposal, being formal consultation and preparation of an *Aboriginal Cultural Heritage Assessment Report* (NOHC, 2013). Further details regarding the consultation with and participation of Aboriginal stakeholders is detailed in **Chapter 5** and **Appendix B** of this review of environmental factors, as well as in **Appendix E** of the *Aboriginal Cultural Heritage Assessment Report* (NOHC, 2013) at **Appendix I**.

A literature review of previous archaeological investigations within the Southern Illawarra region and comparable landforms elsewhere on the NSW South Coast and a search of OEH's Aboriginal Heritage Information Management System (AHIMS) database were undertaken to determine if known Aboriginal sites were located within the study area. Based on the results of the literature review and database search, a set of predictive statements were made about the nature and incidence of Aboriginal archaeological sites within the study area and surrounding region (refer to *Literature and database searches* in Section 7.2, and Section 4.4 of the *Aboriginal Cultural Heritage Assessment Report* at **Appendix I**) These statements were used to identify archaeologically sensitive areas and landforms within the study area and to place them within an archaeological and heritage management context. Aboriginal literature sources included the AHIMS database and associated files and catalogues of archaeological reports. The review also included searches of local histories, maps, archaeological reports and searches of the relevant heritage registers and schedules.

Field surveys were conducted over two months (February to April 2009) in multiple survey events across the study area. The field surveys involved the detection of surface archaeological materials through inspections both on foot and by vehicle, depending on the property access and ground visibility. The field survey provided an assessment of the potential for archaeological material to be located below the ground surface within the study area. The field surveys were dependent upon property access availability and local weather conditions. The results, where relevant, have been considered in this assessment.

Archaeologically sensitive landforms identified within the study area have been termed potentially archaeologically sensitive areas (PASAs). The identification of PASAs to inform the archaeological test excavation program was based on the predictive statements made for the study area and surrounds, ethno-historical information, a review of landscape characteristics relative to known archaeological site patterning and landscape disturbance, locations suggested by Aboriginal community representatives and the outcomes of the literature and desktop reviews and field surveys.

[1] When investigations began, NOHC used PACHCI (2008) and changed to the updated version when released - PACHCI (2011)

Sixteen PASAs were identified as occurring within the study area (PASA 1-11, 45-47 and 51-52), three of which are associated with previously recorded surface artefacts (PASA 9, PASA 45 and PASA 52) (refer to **Section 6-35**). A description of the location and landforms of each of these PASAs, and the property details where they are located are provided in Section 2.1 and Section 2.2 of the *Aboriginal Cultural Heritage Assessment Report* (NOHC, 2013) at **Appendix I**. It should be noted that the identification of the PASAs has not been attempted outside of the likely area of direct construction impact. In most cases, PASAs are likely to extend beyond the identified boundaries.

Test excavations were undertaken at all 16 PASAs over a ten week period between 2 October 2012 and 7 December 2012 in accordance with the *Code of Practice for Archaeological Investigation of Aboriginal Objects* (DECCW, 2010). The test excavations were undertaken to determine if Aboriginal sites or Aboriginal objects were present within the identified PASAs. The methodology used for the excavation of test pits is provided in **Section 7.4** of the *Aboriginal Cultural Heritage Technical Paper* at **Appendix I**. Two hundred and seventy eight archaeological test pits were excavated in the 16 PASAs.

The PASAs which were confirmed to contain Aboriginal artefacts during the test excavations changed from being potential sites to confirmed sites. As a result, the naming of these sites was changed to 'G2B A#' format to reflect this updated status. The G2B A# format is sequential and follows on from the numbering convention adopted for the Gerringong upgrade and Foxground and Berry bypass projects. Further information with regards to these sites is provided in **Section 6.7.2**.

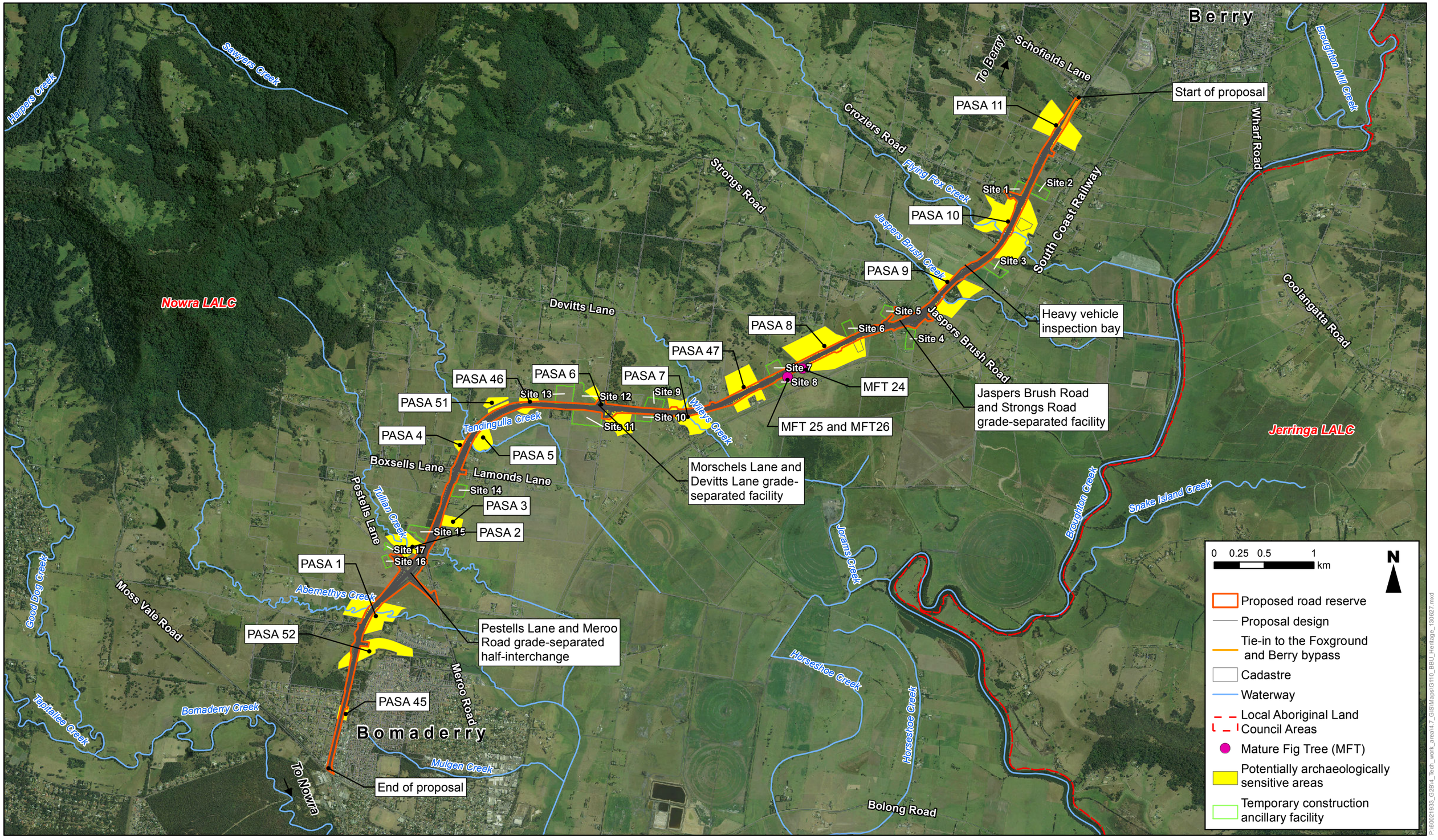


Figure 6-35 Potentially archaeologically sensitive areas in the study area

Source: AECOM (2013)

6.7.2 Existing environment

Aboriginal uses of the landscape

Past Aboriginal occupation within the study area and surrounds was likely based around former wetland basins. These areas would have been used for camping activities and the handling and sharing of other resources and the wetlands themselves would have been used as resource hubs for hunting and gathering activities. Prominent high points within the local landscape were used as cross country travel routes. They may have also served as travel routes from the coastal plain to the tops of the ridges and the lowlands beyond.

Aboriginal tribal boundaries

Within the lower Shoalhaven area, Aboriginal groups have tended to be described as having a single cultural character. This has meant that Shoalhaven tribes are generally treated collectively and thought to speak one dialect. The term Dharawal of Tharawal has been used by many modern researchers to refer to the tribal group within the Illawarra, however; contemporary local Aboriginal people prefer the term Wodi Wodi. Aboriginal people of the Nowra region refer to themselves as the Wandiwandian people (pers. comm. Sonny Simms 2007).

The term 'tribe' is generally used to describe a large group of people who, for the most part, speak a common language and occupy a broad tract of land. Within tribes, there are 'clans' which consist of loosely-related families who own the land. Within these clans there are also smaller groups referred to as bands that perform the daily tasks of group maintenance. The boundaries between clans and bands were flexible and permeable, which allowed groups to move about (Pioneer 1976). Aboriginal people of the Shoalhaven banded together for specific activities, were together for a time and then split apart. They later formed new groups which most likely had closely-related families at their core.

It is likely that throughout early European settlement, Aboriginal tribes were able to maintain their structure. In response to continued European settlement, these Aboriginal tribes may have sought refuge, established camps at a distance or close to European properties, been partially integrated into maritime or pastoral activities, or remained on the fringes of European communities.

Intensification of land-use would have placed further demands on natural resources, which in turn would have radically diminished the food sources of Aboriginal people. The introduction of dairy farming in the 1840s and 1850s (Bell, 1960) would have reduced the availability of game in the Shoalhaven region. The then government issued rations, which encouraged clustering of Aboriginal people into camps, compromising the previous social structures of bands, clans and tribes.

Aboriginal social structure appears to have been weakened or broken down by the 1880s, as Aboriginal people were pressed into reserves or missions. Although missions provided a place for the distribution of rations, they may have additionally been inappropriately positioned and/or presented constraints and other forms of control.

Local Aboriginal Land Councils

Within the study area and surrounds, there are three Local Aboriginal Land Councils (LALCs), being the Illawarra LALC, Jerringa LALC, and the Nowra LALC. The study area lies wholly within the Nowra LALC. The boundaries of these LALCs in the vicinity of the proposal are shown on **Figure 6-35**.

Historical overview

References to initial interactions between Aboriginal tribes and Europeans in the Shoalhaven relate to survivors of the 'Sydney Cove' shipwreck. It is believed that exhausted survivors, who walked from Gippsland to the north of the Illawarra, were met with 'unfriendly natives, at whose hands it is thought some of the exhausted ones lost their lives' when they came towards the Shoalhaven' (Cambage, 1916).

An exploratory trip to the Shoalhaven River by James Meehan in 1805 noted the existence of red cedar along the lower reaches (Antill, 1982). This trip was followed by the arrival of legal and illegal cedar getters. The first official shipment of cedar from the Shoalhaven was in 1811, and a year later, there were seven ships engaged in the trade. An undocumented and probably violent story of cultural contact and exploitation followed the cedar cutters.

In 1822, Alexander Berry facilitated the establishment of permanent European settlement in the Shoalhaven. He received a government grant of 10,000 acres on the Shoalhaven River and a labour force of 19 convicts. Berry selected an area of land at the foot of a hill variously referred to as Coolungatta, Cullengatty, Coloomgatty and Cooloomgatta. The name was recorded by Surveyor James McBrien in 1824 as Aboriginal, meaning 'high hill' and is now known as Coolangatta (Antill, 1982:10). It is believed that Berry's selection of this location was treated with apprehension by the local Wodi Wodi people. Coolangatta Mountain is a place of ancestral significance to local Aboriginal people.

Berry noted that in June of 1822, "during the construction of a hut and a canal near the Shoalhaven Heads, an Aboriginal person called Wagin (a local chief), confronted the workers and claimed the ground where they had been working" (Jervis 1942:235). The action by Wagin falls into context when it is acknowledged that the Coolangatta Mountain was a place of ancestral significance to local Aboriginal people.

Berry's settlement along the Shoalhaven River grew steadily with the introduction of herds of cattle and the establishment of plant crops at Numbaa. Berry initially considered the local Aboriginal people to be ferocious, and his timber people attempted to drive them away. Berry noted that several weeks after his arrival, a party of about 20 Aboriginal people camped near his settlement, suggesting that most of the Aboriginal population was centred on the more fertile coastal plains.

There are numerous historical accounts of hostilities between tribal groupings of the northern and southern Dharawal speaking tribes in the Illawarra in the early to mid-nineteenth century. These hostilities included clashes between local tribes and northward offensives (including the Bong Bong, Broughton Creek, Kiama and Shoalhaven tribes), which has been interpreted as a consequence of changes in social order, resource distribution and political alliances due to European settlement and occupation of tribal lands (DEC 2005:16).

By the late 1830s the majority of the lower coastal plain between Gerringong and the mouth of the Shoalhaven River had been taken up as government issued land grants. Alexander Berry's Coolangatta Estate then had a population of about 270 people.

Through the 1840s and 1850s, Aboriginal communities were increasingly impacted by the spread and consolidation of European settlement. Aboriginal people responded by either settling on pastoral stations in 'fringe camps' adjacent to European settlement, or were forced into adjacent rough and mountainous country. Egloff (1981) concluded that by the 1840s, Aboriginal people of the Shoalhaven had been reduced to remnant groups which subsisted at the edge of the now permanent European settlement, or wandered large tracts of the coast.

Reports from the 1850s onwards suggest a trend in Aboriginal occupation and subsistence such that camps and most food gathering and hunting became concentrated along the coast. This pattern was shaped by European settlement, which pushed Aboriginal people onto land deemed unsuitable for agriculture, including the coast and adjacent wetlands (DEC 2005:25). Permanent Aboriginal camps became established on Broughton Creek (Berry), Crooked River (also referred to as Black Head or Gerongong), around Jervis Bay and in a gully on the northern side of the Coolangatta Mountain on the Berry Estate (Egloff, 1981). The Coolangatta camp had grown within the Berry Estate, and a number of the residents there were employed as labourers and to grow vegetables (Egloff, 1981). Other encampments known from the latter half of the 19th century include the banks of Broughton Creek at Broughton Village (Donlon 1991:12) and the banks of Broughton Mill Creek (Barbara Timberry in DEC 2005:39-41).

By the 1860s potential refuge offered by the remaining mountainous and forested slopes was being eroded by closer European settlement. This resulted in a reduction in the availability of bush foods and game due to forest clearance and pasturage of cattle and sheep herds.

From 1873, major reclamation of the Shoalhaven wetlands commenced, with more than 600 kilometres of drains constructed by 1909. The draining of the wetlands in the Shoalhaven region effectively alienated the last terrestrial wild food areas open to the remaining local Aboriginal people. The response of Aboriginal groups to the dispossession of land in the region was varied, and included fostering camps close to pastoral properties, as well as places of refuge away from European settlement. Some people moved into areas of settlement, and communities grew on the edges of rural towns, to which the New South Wales Government responded by establishing a series of Aboriginal reserves in the 1880s.

A “Protector of Aborigines”, George Thornton, was appointed in 1881. The Protector was replaced by the Aborigines Protection Board in 1883, which established 133 reserves within NSW by 1900. In 1899 a government Aboriginal reserve of 43 acres was established near the northern end of Seven Mile Beach, and was revoked in 1953 (AR 29911, McGuigan nd:39). Toward the latter part of the nineteenth century, government authorities placed pressure on Aboriginal people to re-settle within government reserves. This effectively removed local Aboriginal groups from freehold and crown lands, and concentrated the remaining populations onto reserve lands. Reserves were often situated on marginal land, away from traditional lands and forced peoples of differing tribal affiliation into close contact. Despite this, the occupation of coastal and fringe camps continued in the region, especially as people continued to move around looking for seasonal work.

In a census conducted by the Commonwealth in 1901, the Aboriginal population of the Illawarra was distributed across seven camps with 33 people at Port Kembla, 13 people at Minnamurra River, eight people at Dapto, 18 people at Bombo, 20 people at Gerringong, three people at Jamberoo and three people at Kiama, giving a total of 98 people (DEC 2005:24).

From 1940 to 1969 the Aborigines Protection Board vigorously pursued a policy of assimilation. Reserves were reduced in size or were revoked (Long 1970). Houses and facilities were allowed to deteriorate in an attempt to force Aboriginal people to move off the reserves.

Today, Aboriginal people live throughout the Illawarra and the NSW South Coast as residents of the larger towns and cities including Bega, Nowra and Wollongong, as well as maintaining communities on former reserves. Family groups are found throughout the region.

Literature review and database searches

Previous cultural heritage studies undertaken for the upgrades to the Princes Highway between Gerringong and Bomaderry identified 74 Aboriginal sites in an area 26 kilometres by 19 kilometres in size. Of these 74 sites, there were 32 artefact scatters, 19 shell middens, seven isolated finds, seven rock shelters with art, deposits and/or rock engravings, one natural mythological site, one bora/ceremonial site, one midden/artefact scatter, one potential archaeological deposit, four axe grinding groove sites and one Aboriginal place at Foxground.

An AHIMS search identified nine aboriginal recordings within one kilometre of the proposal. The nine recordings included eight subsurface artefact occurrences and one surface isolated find.

Aboriginal archaeological site prediction

Based on the literature review and database searches, the following landforms, if present within the study area are identified as being archaeologically sensitive areas:

- Locally elevated landforms within valley floor contexts, on alluvium and which are in proximity of major streams and rivers.
- The lower elevation or terminal section of major spurs and ridgelines where they adjoin or traverse the valley floor.
- Level or low gradient ground on the crests and spurs of ridgelines.
- The downslope margin of alluvial terraces.
- The banks of rivers and creeks where they are locally elevated and well drained.
- Locally elevated, well drained and low gradient micro-topographies within 200 metres of known or predicted former wetland. These criteria may be of particular relevance to the margins of former 'Meadow' areas (now-drained swamp basins).
- Locally elevated sand bodies outside of coastal barrier or dune systems, such as fossil beach ridges on the margins and flats of infilled estuaries, and source-bordering dunes.

Identified sites and assessment of significance

Based on the findings of the literature and database searches, field surveys, text excavations and consultation with Aboriginal stakeholders, 32 Aboriginal heritage recordings were identified within the study area including:

- Archaeological recordings:
  - Three surface artefact scatters associated with subsurface artefacts, including one AHIMS listed site (AHIMS# 52-05-0287).
  - Twenty subsurface artefact occurrences.
  - One isolated surface find.
- Places or landscapes of reported historical and cultural Aboriginal significance:
  - Five ethno-historical recordings, being the Coolangatta Estate, the Southern Illawarra Range, Coolangatta Mountain, the Moeyan Hill Bunan Ground and Bomaderry Children's Home.
  - Three large and old growth fig trees.

The Aboriginal heritage recordings are described in **Table 6-45** and Appendix D of the *Aboriginal Cultural Heritage Assessment Report* (NOHC, 2013) at **Appendix I**.

Table 6-45 New and existing site names and designations for PASAs following test excavations

Site ID	PASA ID	Recording type
G2B A1	45	Isolated surface artefact
G2B A2	9	Surface scatter and archaeological deposit
G2B A41	11	Archaeological deposit
G2B A42	10	Archaeological deposit
G2B A43	10	Archaeological deposit
G2B A44	9	Surface scatter and archaeological deposit
G2B A45	8	Archaeological deposit
G2B A46	47	Archaeological deposit
G2B A47	47	Archaeological deposit
G2B A48	47	Archaeological deposit
G2B A49	47	Archaeological deposit
G2B A50	7	Archaeological deposit
G2B A51	6	Archaeological deposit
G2B A52	6	Archaeological deposit
G2B A53	46	Archaeological deposit
G2B A54	5	Archaeological deposit
G2B A55	4	Archaeological deposit
G2B A56	4	Archaeological deposit
G2B A57	3	Archaeological deposit
G2B A58	2	Archaeological deposit
G2B A59	1	Archaeological deposit
G2B A60	1	Archaeological deposit
G2B A61	52	Archaeological deposit
Abernethys Creek 1	52	Surface scatter and archaeological deposit
MFT24	-	Mature Fig Tree
MFT25	-	Mature Fig Tree
MFT26	-	Mature Fig Tree
The Coolangatta Estate	-	Place of Aboriginal historical and/or cultural significance
The Southern Illawarra Range	-	Landscape of Aboriginal historical and/or cultural significance
Coolangatta Mountain	-	Place of Aboriginal historical and/or cultural significance
The Moeyan Hill Bunan Ground	-	Place of Aboriginal historical and/or cultural significance
Bomaderry Children's Home	-	Place of Aboriginal historical and/or cultural significance

Archaeological recordings

On close analysis the 24 sites in **Table 6-45** and shown in **Figure 6-36,** that have been designated a PASA ID tend to occur in locations with specific characteristics as follows:

- A greater number and/or richness of artefacts tend to coincide with major and low gradient basal slopes above, and set back from the valley floor.
- The valley floor, particularly alluvial flats are generally characterised by intermittent and low incidences of artefacts.
- Micro-topographic features such as locally elevated terraces and creek banks, within the broader valley floor context, tend to contain a higher occurrence of artefacts.
- Ridgeline crests and saddles (shallow depressions) tend to be characterised by intermittent and low incidences of artefacts, with higher incidences occurring in association with features such as the crests of low gradient hills and breaks of slope (refer to Appendix D of the *Aboriginal Cultural Heritage Assessment Report* (NOHC, 2013) at **Appendix I**).

Of the 24 Aboriginal archaeological sites, 11 were assessed as having low archaeological significance within a local context (G2B A41, G2B A46, G2B 48, G2B A50, G2B A52, G2B A56, G2B A57, G2B A58, G2B A59, G2B A60 and G2B A61). This was based on the low technological diversity and the relatively low or absent, and discontinuous artefact incidence encountered at these sites.

Eight sites; G2B A2, G2B A43, G2B A44, G2B A45, G2B A47, G2B A49, G2B A53 and Abernethys Creek 1 were considered to have a moderate level of archaeological significance in a local context. These eight sites were identified as having a greater research potential due to higher artefact incidence and/or higher average assemblage richness.

Four sites; G2B A42, G2B A51, G2B A54 and G2B A55 were assessed as having a moderate to high level of significance in a local archaeological context. This was based on the higher artefact incidence and/or higher than average assemblage richness.

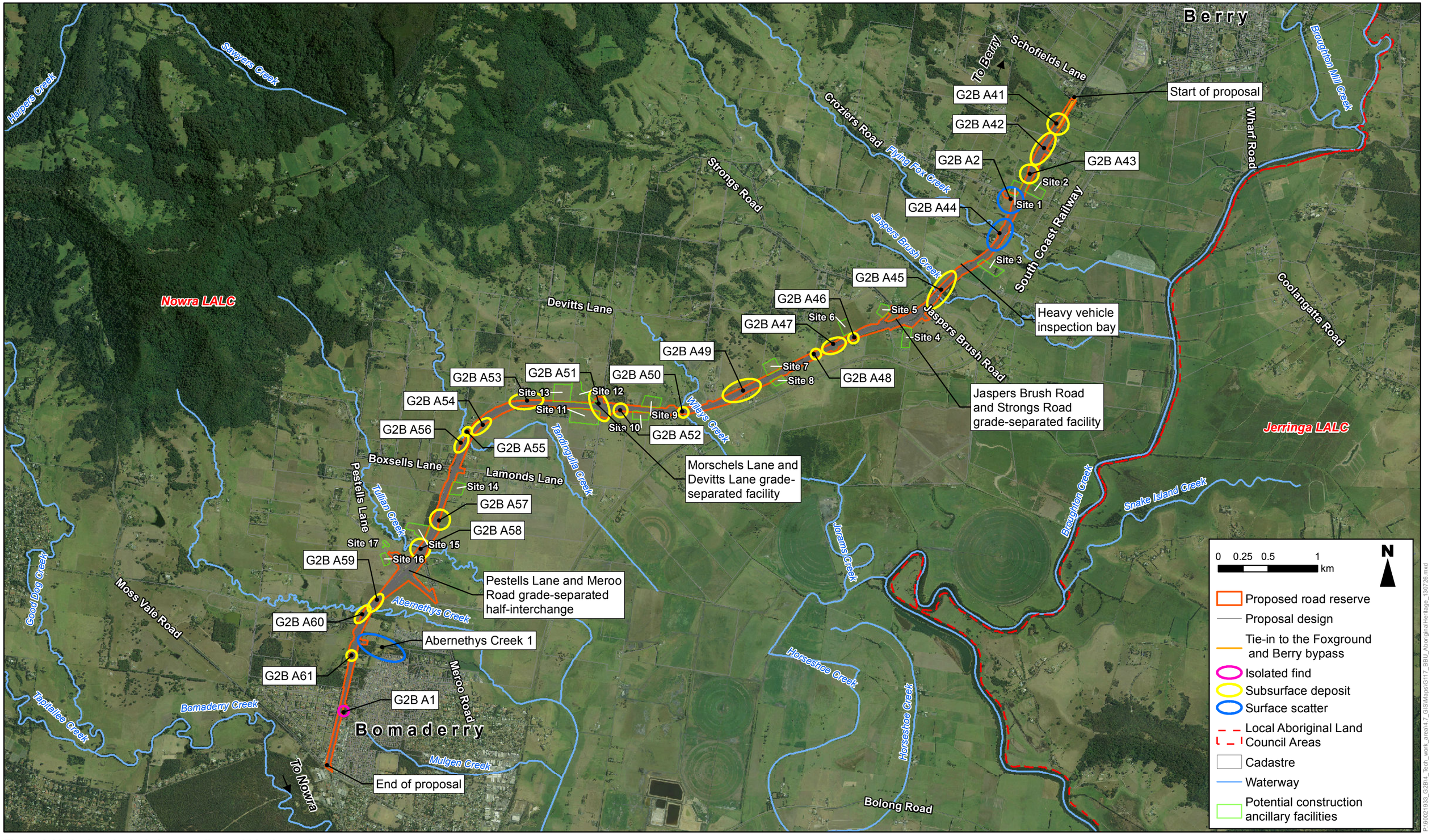


Figure 6-36 Archaeological site recordings within the study area

Source: AECOM (2013)

Places or landscapes of reported historical and cultural Aboriginal significance

Places and landscapes which have, or may potentially have historical or cultural significance to the local Aboriginal community within the proposal area and surrounds include:

- The Coolangatta Estate.
- The Southern Illawarra Range.
- Coolangatta Mountain.
- The Moeyan Hill Bunan Ground.
- Bomaderry Children's Home.
- Three large and old growth fig trees.

Other generalised landscape features within the study area and surrounds that are considered by Aboriginal stakeholders to have cultural significance and value include:

- Large and old growth fig trees.
- Remnant and regenerating native vegetation.
- Plants and animals with significance in past and contemporary Aboriginal cultural practice.
- Landforms which remain unchanged by European land use or strongly resemble the pre-European landscape (examples include prominent ridgelines, escarpments, hills, former swamp basins and river and creek corridors).
- Natural ecological systems associated with features such as creeks and rivers, forests and swamps.

Places or landscapes of Aboriginal cultural heritage significance could also potentially contain archaeological remains. However, the importance of these places is not dependent on the presence of such remains. The cultural significance of the Aboriginal landscapes and places within and surrounding the study area are described below.

The Coolangatta Estate

The Wodi Wodi people of the lower Shoalhaven responded in part to the establishment of the Berry Estate at Coolangatta with the development of an Aboriginal settlement adjacent to the European one. The settlement may have had an independent 'fringe' character, as well as a more formal and estate sanctioned function. It is known that Aboriginal people were variously employed on the Coolangatta Estate, and the encampment probably served as a residence for these workers. Egloff (1981) states that the camp grew with the Berry Estate and a number of the residents were employed to grow vegetables.

There were cholera and typhoid epidemics in the Coolangatta camp in the late 1890s, which were followed by the breakup of the Berry Estate lands and the end of the practice of managers looking after the camp. The Board for Protection of Aborigines moved residents to a newly proclaimed Reserve at Roseby Park (Orient Point) in 1900 (Antill 1982, Bayley 1975, Egloff, Navin and Officer 1995).

The Southern Illawarra Range

There are only fragments of remaining ethnographic information for the Southern Illawarra Range. From these, it can be demonstrated that Aboriginal people utilised specific routes and passes across the range. Additionally, certain places had cosmological and/or high cultural significance.

Prior to the 1860s all European access into Kangaroo Valley was via established bridle trails which followed existing Aboriginal trails or were based on routes originally revealed by Aboriginal guides. The Wattamolla and Woodhill Mountain Roads generally follow these routes.

Coolangatta Mountain

Coolangatta Mountain has been variously referred to as Coolungutta, Cullengatty, Coloomgatty and Coolomgatta. Coolangatta Mountain was originally recorded by Surveyor James McBrien in 1824 as Aboriginal and meaning ‘high hill’ (Antill. 1982; op cit). Coolangatta Mountain has been recorded as a site which features strongly in local spiritual beliefs (Matthews, 1896, Matthews, 1898). Part of Coolangatta Mountain has recently been listed as an Aboriginal Place, the listed place is known as the Cullunghutti Aboriginal Area.

It is believed that the mountain was where the dead went after burial in midden sands. The spirits of the recently buried had to ascend from a rock on the mountain’s eastern side to a world of spirits. In doing so, they were required to avoid various dangers which were relative to their life’s deeds.

Moeyan Hill Bunan Ground

The remains of a ceremonial male burial ground on the south-west slopes of Moeyan Hill were first recorded by Mathews in 1896. The ground was shown to Matthews by a group of Aboriginal people and he observed an Aboriginal ceremony. Matthews identified the ceremony as a bunan, being an initiation ceremony lasting several days for boys approaching puberty. It included aspects of tribal lore, through the use of dance, drama and instructional pictures and the removal of a top front tooth from the initiates.

Matthews describes the existence of 29 carved trees with geometric linear designs, together with nondescript patterns and devices cut into the soil and numerous raised earth figurative sculptures. The area of the Moeyan Hill ceremonial ground is subdivided into rural residential lots and includes a number of residential buildings together with cleared slopes supporting pasture grasses. The tributary creek line is still evident, and there is remnant and regenerating forest on the steeper and upper gradients of Moeyan Hill.

The area of the bunan ground, together with the Moeyan Hill region in general is valued by the local Aboriginal community as a landscape of cultural significance. Both form an integral component of a larger cultural landscape within the lower Shoalhaven which includes the Illawarra Range and Coolangatta Mountain.

Bomaderry Children’s Home

The Bomaderry Aboriginal Children’s Home was established by the Bomaderry United Aboriginal Mission in 1908 when it received seven 'native' children, six orphans and one baby ‘rescued’ by Miss Thompson, ‘a missionary to the Aborigines’ (Bayley 1975:176). It was situated at 59 Belinda Street Bomaderry and consisted of a range of cottages, dorms and grounds (Alice Adams in DEC 2005:1 5).

The Home continued to operate under a number of authorities until 1988 when it was closed. Many Aboriginal people of the Shoalhaven can relate childhood experiences at the home, most following removal from their families – members of what are now known as the stolen generation. The Nowra Local Aboriginal Land Council bought the property in 1993.

Large and old growth fig trees

Within the Illawarra region, large and old growth fig trees are considered to be of high Aboriginal cultural value. Trees which are large and mature, or can be classified as old-growth are of stated cultural significance to at least some Aboriginal stakeholders in the Illawarra. The reasoning and justification behind the cultural significance value is variable, with some of the stated reasons for the cultural values of the trees including:

- The well-developed buttresses of the mature fig trees were used by Aboriginal people as shelter and weather breaks and were often used as camp sites.
- Fig trees were a good source of food, including figs in season and the animals that lived on them, such as possums and fruit bats.
- The trees are associated with the spirit of Yaroma. The Yaroma is a creature resembling a man but of greater size and strength, with longer teeth and hair all over its body. The Yaroma is described as a strong and dangerous creature that may be concealed within a fig tree and which may ambush unsuspecting passers-by.
- Mature fig trees are associated with birthing and women's lore. In some examples, notches were made along limbs of trees to signify births into a tribe or family group.

These are values which may be irrespective of a European planted, or pre-European and/or natural origin for the tree. Three large or old growth fig trees (MFT24 – MFT26) have been noted as occurring within the study area. All of these are interpreted as trees which have grown and matured within an open grassland environment, after the clearance of the original high canopy forest.

6.7.3 Assessment of potential impacts

The potential impacts of the proposal on Aboriginal cultural heritage recordings include:

- A direct impact to items of Aboriginal cultural heritage significance within the construction footprint of the proposal.
- A direct impact to items of Aboriginal cultural heritage significance within construction ancillary facility areas.
- Indirect impacts to Aboriginal cultural heritage values.

Impacts to items of Aboriginal cultural heritage significance within the construction footprint of the proposal

The impacts of the proposal on the following 27 Aboriginal heritage recordings were assessed:

- Three sites containing surface artefact scatters associated with archaeological deposits, including one previously AHIMS listed site at Abernethy's Creek (AHIMS #52-5-0287).
- The 20 sites determined to contain subsurface artefacts based on the test excavation of PASAs.
- One isolated find.
- Three large and old growth fig trees within the study area.

Of the 27 recordings, 10 would be fully impacted, 14 would be partially impacted and three would not be impacted by the proposal. With the exception of one isolated find, all fully impacted recordings consist of archaeological deposits. Partially impacted items include 11 archaeological deposits and three surface artefact scatters associated with archaeological deposits. Partially and fully impacted sites are listed in **Table 6-46**. The three large and old growth fig trees within the study area would not be impacted by the proposal.

The potential avoidance of these sites by realigning the proposal would be counterproductive, given that in most cases, with the exception of G2B A1 (isolated find), the known distribution of the identified artefacts are indicative of archaeologically sensitive landform zones which extend beyond the construction footprint of the proposal. A shifted alignment would impact many of the archaeological deposits within adjacent areas, and would move the proposal into subsurface areas which are currently undisturbed by the existing highway. To minimise impacts, the proposal is located within the existing road reserve boundary as much as possible. This reduces the need to establish new corridors which would likely impact a more intact and less degraded archaeological resource.

Where further archaeological investigation is required at specific sites prior to the commencement of construction, this is detailed in the safeguards and mitigation measures in **Section 6.7.4.**

No further archaeological investigation is required at G2B A2, G2B A41, G2B A43, G2B A46, G2B A48, G2B A50, G2B A52, G2B A56, G2B A57, G2B A58, G2B A59, G2B A60, G2B A61 and Abernethys Creek 1.

Table 6-46 Summary of anticipated construction related impacts to Aboriginal heritage recordings

Site ID	Recording type	Level of significance	Direct impact	Degree of impact	Comments
G2B A1	Isolated surface artefact	Low	Yes	Full	Surface artefact is present on the edge of the concept design footprint.
G2B A2	Surface scatter and archaeological deposit	Moderate	Yes	Partial	Known surface exposure is wholly within the concept design footprint. Known subsurface deposit likely to extend to either side of the footprint.
G2B A41	Archaeological deposit	Low	Yes	Full	Deposit exists within the concept design footprint.
G2B A42	Archaeological deposit	Moderate to high	Yes	Partial	Deposit likely to extend to either side of concept design footprint.
G2B A43	Archaeological deposit	Moderate	Yes	Partial	Deposit likely to extend to either side of concept design footprint.
G2B A44	Surface scatter and archaeological deposit	Moderate	Yes	Partial	Known surface exposure extends outside of concept design footprint to the south-east.
G2B A45	Archaeological deposit	Moderate	Yes	Partial	Deposit likely to extend to the north west of the concept design footprint.
G2B A46	Archaeological deposit	Low	Yes	Full	Deposit exists within concept design footprint.
G2B A47	Archaeological deposit	Moderate	Yes	Partial	Deposit likely to extend to the southeast of the concept design footprint.
G2B A48	Archaeological deposit	Low	Yes	Full	Deposit exists within concept design footprint.
G2B A49	Archaeological deposit	Moderate	Yes	Partial	Deposit may extend to the south of the concept design footprint. Degree of impact will be better assessed after the completion of subsurface testing at this site.
G2B A50	Archaeological deposit	Low	Yes	Full	Deposit exists within concept design footprint.
G2B A51	Archaeological deposit	Moderate to high	Yes	Full	Deposit exists within concept design footprint.
G2B A52	Archaeological deposit	Low	Yes	Full	Deposit exists within concept design footprint.
G2B A53	Archaeological deposit	Moderate	Yes	Partial	Deposit likely to extend to the south of the concept design footprint.
G2B A54	Archaeological deposit	Moderate to high	Yes	Partial	Deposit exists on the southern boundary of the current concept design.

Site ID	Recording type	Level of significance	Direct impact	Degree of impact	Comments
G2B A55	Archaeological deposit	Moderate to high	Yes	Partial	Deposit likely to extend to the northwest of the concept design footprint.
G2B A56	Archaeological deposit	Low	Yes	Full	Deposit exists within concept design footprint.
G2B A57	Archaeological deposit	Low	Yes	Partial	Deposit likely to extend to the east of the concept design footprint.
G2B A58	Archaeological deposit	Low	Yes	Full	Deposit exists within concept design footprint.
G2B A59	Archaeological deposit	Low	Yes	Partial	Deposit likely to extend either side of the concept design footprint.
G2B A60	Archaeological deposit	Low	Yes	Partial	Deposit likely to extend to the west of the concept design footprint.
G2B A61	Archaeological deposit	Low	Yes	Full	Deposit exists within concept design footprint.
Abernethy's Creek 1	Surface scatter and archaeological deposit	Moderate	Yes	Partial	Known subsurface deposit exists within the concept design footprint.
MFT24	Mature Fig Tree	-	No	-	Outside construction footprint of current concept design of the proposal.
MFT25	Mature Fig Tree	-	No	-	Outside construction footprint of current concept design of the proposal.
MFT26	Mature Fig Tree	-	No	-	Outside construction footprint of current concept design of the proposal.

Impacts to items of Aboriginal archaeological cultural significance within ancillary facility sites

Seventeen potential temporary construction ancillary facilities have been identified within the study area (refer to **Figure 6-35**). Activities associated with ancillary facilities could directly impact items of Aboriginal cultural significance either wholly or partially. These include:

- Establishment of bunded fuel and chemical storage areas.
- Construction of offices and sheds.
- Sediment and erosion control works.
- Clearing and levelling.
- Construction of hardstand areas for construction plant and equipment.
- Temporary storage of construction materials generated from within the construction site.
- Installation of fencing.

Where reasonable and feasible, the 17 potential temporary construction ancillary areas have been positioned in locations with a low likelihood of having Aboriginal heritage significance and/or potential in order to avoid further direct impacts to items of Aboriginal archaeological significance. The temporary construction ancillary facility areas have been evaluated relative to the assessed Aboriginal archaeological sensitivity of the surrounding landscape (refer to Section 10 and Appendix B of the *Aboriginal Cultural Heritage Assessment Report* (NOHC, 2013) at **Appendix I**). It was determined that the use of the proposed temporary construction ancillary facility Area 1 and Area 12 would impact areas of Aboriginal archaeological sensitivity.

Area 1 would impact an area that is considered to be an area of moderate sensitivity within a local context that is also located within and impacted by the construction footprint of the proposal. It is not recommended that archaeological salvage be undertaken at this location, as a site of similar landscape context (G2B A44) has been assessed to be of higher amenity for further research, due to a more continuous incidence of artefacts. Intact archaeological deposits relating to this area exist outside of the footprint of the concept design, and would be undisturbed by the proposal.

Area 12 would impact an area of moderate to high archaeological sensitivity that is also located within and impacted by the construction footprint of the proposal. As a result of the archaeological sensitivity of the land within Area 12, its use as a temporary construction ancillary facility would be subject to subsurface salvage prior to ancillary facility or construction-related impacts.

Temporary construction ancillary facility Area 8 would be located in the vicinity of mature/old growth fig trees 25 and 26 (refer to **Figure 6-35**) which are at potential risk of inadvertent impact as a result of proximity to Area 8.

Impacts on objects of Aboriginal cultural value

The proposal would have varying levels of impact on cultural landscape values. Proposed activities which would impact cultural landscape values include:

- Construction of grade separated facilities and a half interchange.
- One large cutting at Strongs Road, Jaspers Brush of around 300 metres long and up to a maximum of ten metres deep, in addition to various smaller cuttings along the proposal.
- The loss of some areas of vegetation which may also include plants known to have traditional uses.
- Modifications to natural landforms within the construction footprint of the proposal, through the construction of road platforms and cuttings.

The physical and visual changes within the construction footprint of the proposal would impact on the landscape character within the study area and surrounds (refer to **Section 6.6**), which include features that are considered to have Aboriginal cultural significance. The impacts would mostly relate to the removal of remnant and regenerating vegetation, particularly along creek lines. The majority of vegetation to be removed as part of the proposal is in a poor condition, or has been completely altered and is considered to be of low conservation significance (refer to **Section 6.3.3**).

The removal of vegetation, the large cutting at Strongs Road, and modification to the natural landforms within the construction footprint of the proposal would indirectly impact Aboriginal cultural values within the study area by increasing the visibility of the proposal from places and landscapes of Aboriginal cultural significance. The two grade separated facilities, the grade separated half-interchange and the cutting at Strongs Road, Jaspers Brush represent the most visible features of the proposal in the cultural landscape. To minimise the visual impact on surrounding places and landscapes of Aboriginal cultural significance, the proposal has been designed so it would be located within the footprint of the existing highway as much as feasible and reasonable.

6.7.4 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or mitigate the identified impacts on Aboriginal Heritage. These measures are presented in **Table 6-47** and are summarised in **Section 7.2**.

Table 6-47 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
Stakeholder consultation	Undertake ongoing consultation with Aboriginal stakeholders in accordance with the PACHCI protocol.	Roads and Maritime project manager	Ongoing
	Advise the AFG of the final locations of ancillary facilities and any proposed mitigation measures applicable to these areas.	Roads and Maritime project manager	Pre-construction
	Provide three copies of this report to the NSW Office of Environment and Heritage.	Roads and Maritime project manager	Pre-construction
Impacts to items of Aboriginal archaeological significance within the study area	Undertake all subsurface testing and salvage in accordance with the methodology outlined in **Appendix C** of the *Aboriginal Cultural Heritage Assessment Report* (NOHC, 2013) at **Appendix I**.	Roads and Maritime project manager	Pre-construction
	Apply for and obtain an AHIP which would cover the entire construction footprint of the proposal, including impacted areas of site G2B A49 and G2B A53 (if construction impacts are expected to extend to the south of the current road reserve at this location) and temporary construction ancillary facilities, for both impact and salvage.	Roads and Maritime project manager	Pre-construction
	Carry out archaeological salvage excavation within impacted areas of sites G2B A42, G2B A44, G2B A45, G2B A46, G2B A47, G2B A51, G2B A53, G2B A54 and G2B A55.	Roads and Maritime project manager	Pre-construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
	Carry out surface artefact collection within impacted areas of G2B A1 and G2B A44.	Roads and Maritime project manager	Pre-construction
	Follow Roads and Maritime's 'Standard Management Procedure: Unexpected Archaeological Finds' (RMS, 2011) in the event that construction related disturbance results in the discovery of Aboriginal objects or suspected human remains.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
Impacts to items of Aboriginal archaeological cultural significance within ancillary facility areas	If ancillary area 8 is to be used, fence sites MTF25 and MTF26 to avoid any inadvertent impact to these sites.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	If ancillary area 12 is to be used, include the area of impact from the ancillary area in the recommended salvage excavation at site G2B A51.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Where an Aboriginal site, or portion thereof, is situated adjacent to, but outside of the construction footprint, erect temporary fencing or other means where temporary fencing is not reasonably practicable between the zone of construction activity and the adjacent site area and/or archaeological deposit, with the aim of defining a 'no–go' area for vehicles, material storage or other actions likely to result in ground disturbance. Signpost such sites as Environmentally Sensitive areas.	Roads and Maritime project manager and Construction contractor	Pre-construction

6.8 Non-Aboriginal (historic) heritage

This section provides an assessment of non-Aboriginal (historic) heritage and is supported by the *Non-Aboriginal (Historic) Heritage Technical Paper* (NOHC, 2013) which is provided at **Appendix J**.

6.8.1 Methodology

The study area for the non-Aboriginal heritage assessment includes the footprint of the proposal and a 200 metre buffer which includes the area required for the temporary construction ancillary facilities.

Archaeological and historical data relevant to the proposal was reviewed to:

- Determine if known historical sites were located within the study area.
- Facilitate site prediction on the basis of known regional and local site patterns.
- Place the proposal within an archaeological and heritage management context.

Historical information reviewed included regional and local histories, heritage studies and theses, parish maps, newspaper articles, oral history reports, local museum displays and websites. Searches of relevant statutory and non-statutory heritage registers and schedules were undertaken in March 2013. The registers and schedules that were searched for the assessments are listed in Section 2.1 of the *Non-Aboriginal (Historic) Heritage Technical Paper* (NOHC, 2013).

Consultation was undertaken with Shoalhaven City Council as all potentially impacted heritage items have a local level of heritage significance. Consultation with Shoalhaven City Council included:

- Discussions regarding the status of unlisted items.
- Updates regarding fieldwork progress and findings.
- Submission of a draft report in accordance with Clause 14 of ISEPP.

An archaeological field survey and inspection was undertaken over a period of three months (February to April 2009). Isolated and supplementary inspections were undertaken intermittently in 2010, 2011, 2012 and 2013.

The field assessment involved the inspection of standing structures, surface archaeological remains within the study area, and an assessment of the potential for subsurface archaeological material. A detailed methodology for archaeological survey and test excavations is provided in Chapter 2 of the *Non-Aboriginal (Historic) Heritage Technical Paper* (NOHC, 2013).

6.8.2 Existing environment

Historical context

A summary of the historical context of the region is provided below. A detailed description is provided in Section 4 of the *Technical Paper: Non-Aboriginal (Historic) Heritage* (NOHC, 2013).

Early exploration

The Shoalhaven region was first crossed overland by survivors of the Sydney Cove and Cumberland shipwrecks in 1797. An expedition in 1805 by Lieutenant Kent of HMS Buffalo which involved overland exploration north of Jervis Bay confirmed the area was originally covered with rainforest, brush cedar, soft and hardwood and a variety of bushes, palms, vines and ferns. Independent cedar getters were in the Shoalhaven from at least 1811, with the first recorded cargo arriving in Sydney in December 1812.

Landward exploration began in early 1818, when Dr Charles Throsby and James Meehan set out from Sydney to find an overland route to Jervis Bay. The party reached Kangaroo Valley, crossed the Shoalhaven and reached Jervis Bay, but deemed the route impractical. An improved route was made in 1821, pioneered by Hamilton Hume and Charles Throsby through Tallaganda Shire, which was developed further in the 1840s.

Development of the Berry Estate

Alexander Berry and Edward Wollstonecraft started a business together as international merchants, and travelled to Sydney in 1819. Berry and Wollstonecraft were given land grants in the study area from 1822 onwards, which were used to pasture the stock that they had been given in lieu of debts. The land was located on the southern side of the Shoalhaven River between the Shoalhaven and Crookhaven Rivers, and the headquarters were located on the northern side at the foot of Mount Coolangatta. By 1843, historical maps indicate that Wollstonecraft, Berry and his brother David owned the majority of the study area, with more than 40,000 acres owned by the partners in 1863.

The partners bought a ship to provide transport between Sydney and the Shoalhaven, and they also built a sloop and began draining the extensive swamps within their grants. On Wollstonecraft's death in 1832, the property was passed to Alexander Berry who soon began to let farms on clearing leases within his estate, which facilitated the development of the Shoalhaven district.

David Berry took charge of the estate in 1836 and inherited the estate when Alexander Berry died in 1873. David further leased part of the estate lands to tenants. Following his death in 1889, the management of the estate passed onto (Sir) John Hay. David Berry allocated large amounts of his estate to the University of St. Andrews (Scotland) and to the endowment of a hospital at Berry, making it necessary for the sale of the estate. John Hay, the Trustees and others set about comprehensive improvements to the estate prior to its sale, including the reclamation of swamp areas.

Development of settlements and townships

Alexander Berry established a location for a township at "Bumaderry" in December 1859. The town's location was based on the areas strategic position relative to the north-western position of the Berry Estate lands and the presence of higher ground on the north shore of the Shoalhaven River. Growth was slow within the township relative to downstream estate settlements and the northern settlement of Broughton Creek (Berry). The first sale of town lots was held on March 30 1892, and was officially named in 1893.

Evolution of settlements within the study area appears to have been more organic, and focused initially around areas of prominent higher ground (such as spurs) with maritime access (Jaspers Brush) and natural clearings (Meroo Meadow). The development of Jaspers Brush and Meroo Meadow reflected the need of freehold and tenant farmers adjacent to the Berry Estate to form a focus for community life and services, including religious observance, education, a postal service and dairy infrastructure.

Development of the dairy industry

Alexander Berry was the first to establish a dairy on the South Coast. Within two years of his arrival, farm produce from the estate, including butter and cheeses were shipped to Sydney. Within 10 years, the dairying herd at Berry's estate had increased in quantity and quality.

Dairying was established as the chief industry in the Shoalhaven with the leasing of the Berry Estate to tenant farmers. Within the study area, several dairy factories were established in the late 1880s, when there was a general movement for the establishment of local butter factories or creameries. These included dairies at Jaspers Brush and Meroo Meadow.

In the late nineteenth century, the approach to dairying became increasingly scientific in the Shoalhaven, including the establishment of an experimental farm in 1899. The first milking machines in the Meroo district were installed in 1917 at the 'Pomona' dairy farm, and tractors were introduced in the 1930s and 1940s. Concrete silos were developed to store silage for the feeding of dairy herds. Silos are now redundant and mostly abandoned, however; they remain a persistent regional landscape feature.

Development of the main road between Kiama and Bomaderry

The first European established roads were most probably sawyer's tracks, which allowed for the hauling of felled red cedar logs from hinterland forests to points of maritime access such as coastal ports and navigable streams. This would have likely commenced in conjunction with the first cedar harvesting in the Shoalhaven in 1812. Trails are likely to have followed terrain and gradients of least resistance, such as ridge and spur crests, and level ground of the valley floors and associated meadows. Centres of settlement became linked by informal trails as the cedar getting occupation extended beyond maritime access point. These informal trails developed into tracks with their continued use.

An alternative to these tracks was a coastal track which informally developed to link the coastal settlements from Bulli to Kiama. The 'track' consisted of a series of headlands traverses. Creek, river and estuary mouths were a hazard that could be crossed depending on local conditions and the depth of sand barriers. In 1856, Alexander Berry privately constructed the Berry Estate Road across his lands from Gerringong to Broughton Creek (Berry) in 1856 and later to Bomaderry by 1858 (JME 1951:81; Cousins 1948:105). The alignment of the Berry Estate Road established a transport corridor with many sections of the existing highway following this alignment. The general route of the current Princes Highway was declared the Main South Coast Road in 1906, and renamed the Princes Highway during a visit by the Prince of Wales in 1920.

The late 1920s to 1930 saw the upgrading of the deviation of the highway which generally followed the current Meroo Road, resulting in the highway bypassing Bomaderry to the west. The present reinforced concrete highway bridge over Abernethys Creek (G2B H2) was constructed as part of these works in 1929.

Tree plantings were established along the existing highway in the first half of the twentieth century within or adjacent to settlements. These often consisted of avenues with plantings on both sides of the road. Some of these have been actively maintained, with some present at Meroo Meadow (G2B H78), where the western side of an original avenue of pines remains, and between Meroo Meadow and Wileys Creek (G2B H5), where north and south-side plantings remain, including individual pines, silky oak, bunya pine, camphor laurel and Eucalyptus. There is evidence to suggest that the Pine trees close to the Meroo Union Church were planted in 1905 (Northern Star 29 July 1905).

Literature and database review

The review of archaeological and historical data and literature identified 10 heritage items within the study area. Of these items, five are listed on statutory registers and five are non-statutory listings. The five statutory listings include:

- The Princes Highway Abernethys Creek bridge, listed on Roads and Maritime's Section 170 Heritage and Conservation Register (heritage item G2B H2).
- Four items listed on the Heritage Conservation Schedule (Schedule 7) of the *Shoalhaven Local Environmental Plan 1985*, being:
  - The Meroo Meadow Union Church (heritage item G2B H3).
  - The former Meroo Meadow public school and schoolmasters residence, now the 'Hotel Woodbyne' (heritage item G2B H4).
  - The former Jaspers Brush public school and schoolmasters residence (heritage item G2B H44).
  - 'Pomona' a late nineteenth century dairy farm complex (heritage item G2B H46).

The *Draft Shoalhaven Local Environmental Plan 2013* does not include any additional proposed listings relevant to the proposal.

Three of the five non-statutory listings relate to landscape heritage values. These listings include the Berry District Landscape Conservation Area, Berry-Bolong Pastoral Landscape and the Berry Township Urban Conservation Area. The two remaining non-statutory listings are 'Northcote', an early twentieth century cottage which was the former site of the Jaspers Brush post office, and 'Exeter', a Victorian farmhouse and its silo, just north of Bomaderry.

Additional details of these heritage recordings and their locations are provided in **Table 6-48**.

Archaeological field survey

Thirty-nine non-Aboriginal (historic) heritage field recordings were made within the study area (G2B H1 – H9, H44, H46, H66 – H92 and the SICPH CL). The locations of the recorded items are shown in **Figure 6-37** and in Appendix A of the *Technical Paper: Non-Aboriginal (Historic) Heritage* at **Appendix J**.

Eight of these recordings were not found to have heritage significance against the NSW Heritage Branch's heritage assessment criteria (refer **Section 6.8.3**). The remaining 31 items were assessed as having non-Aboriginal heritage significance against the NSW Heritage Branch's heritage assessment criteria and are classed as heritage items. These consist of:

- Two remnants of the 1858/69 Berry Estate road between Bomaderry and Broughton Creek (Berry) (G2B H7 and 9).
- One highway bridge (G2B H2).
- Two public school buildings and associated residences (G2B H4 and 44).
- One former 1880s public (tent) school site with potential to include archaeological deposits (G2B H91).
- The site of the former Meroo Meadow Hall (G2B H67).
- The Meroo Meadow Union Church (G2B H3).
- A former agricultural water reservoir and pipeline easement constructed as part of the Berry Estate swamp reclamation scheme (G2B H81).
- Ten former Berry Estate farms or unidentified buildings, five of which consist of only potential archaeological deposits from the Berry Estate era (G2B H73, 80, 88, 90 and 92). Five include standing farm buildings and structures which post-date the Estate and may include earlier potential archaeological deposits (G2B H76, 82, 83, 85 and 89). One substantially modified Berry Estate tenant farm building remains (G2B H83).
- Six post Berry Estate farm houses, cottages or building complexes (G2B H1, 46, 66, 71, 77 and 89).
- The site of two former local Dairy Co. factories (G2B H68 and 75).
- Three road side tree plantings (G2B H5, 78 and 86).
- One cultural landscape, the SICPH CL.

Of these heritage items, five are included on existing statutory heritage listings (G2B H2, H3, H4, H44, and H46).

Archaeological test excavations were not carried out as part of this assessment as none of the sites with predicted archaeological potential within the study area were considered to have a potential level of significance which would necessitate *in situ* conservation or avoidance of impact.

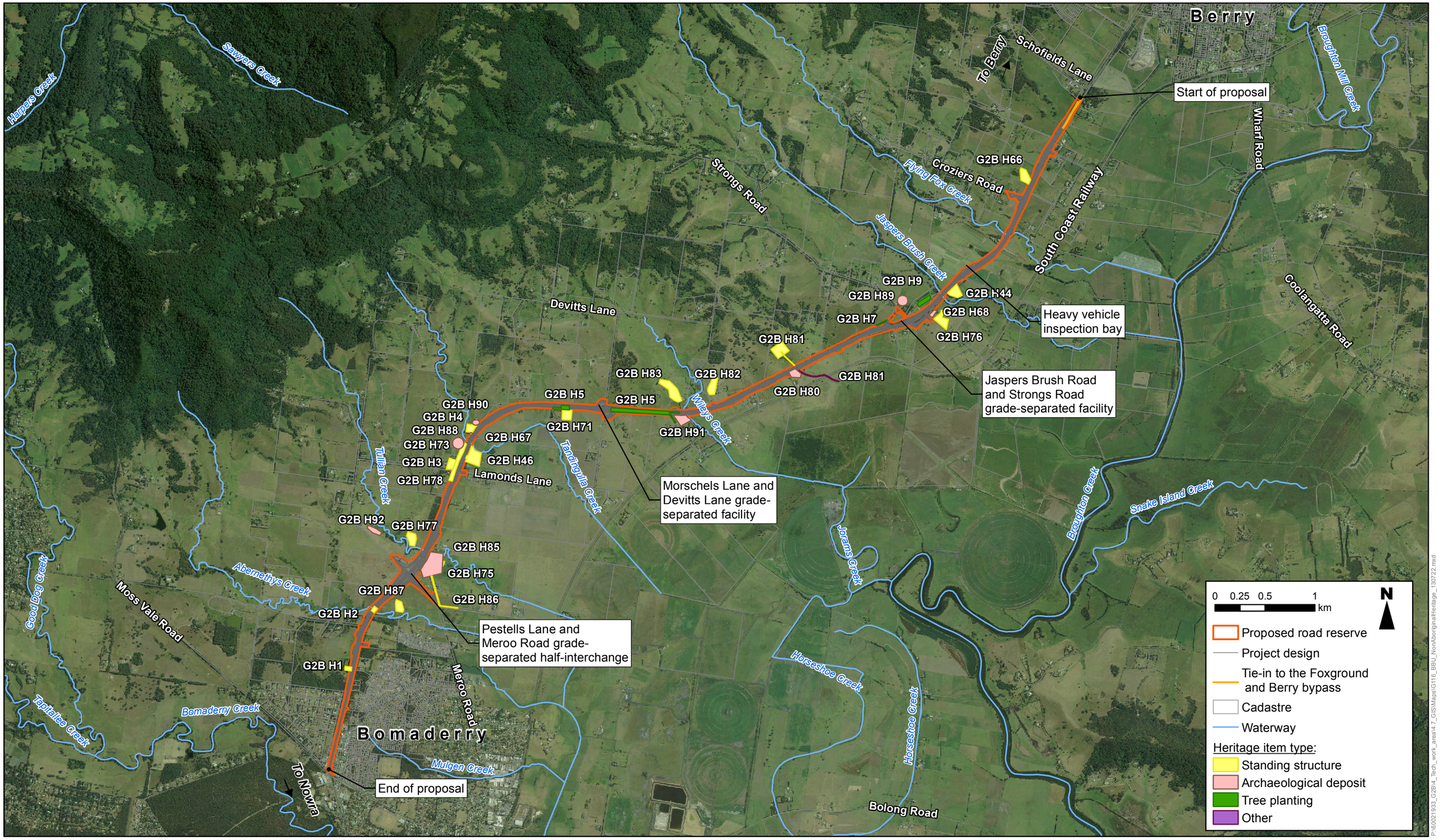


Figure 6-37 General location of non-Aboriginal heritage recordings

Source: AECOM (2013)

Cultural landscape value

Southern Illawarra Coastal Plain and Hinterland Cultural Landscape

The proposal is located in the SICPH CL, which is a predominantly pastoral landscape of the coastal plain and basal slopes. The SICPH CL generally encompasses the Berry District Landscape Conservation Area listed by the National Trust, and is bounded by the Southern Illawarra Range in the north, Mount Pleasant in the east, Browns Mountain in the west and south to Greenwell Point. The National Trust has recognised the cultural, aesthetic and natural values of the landscape of the Southern Illawarra by defining the Berry District Landscape Conservation Area (BDLCA), which includes the coastline south of Kiama to Greenwell Point, the lower Shoalhaven River plain and the slopes leading up to the Illawarra Escarpment.

The identification of the SICPH CL seeks to recognise the cultural heritage values of this area as a consequence of the interplay between cultural practice and the physical environment. The western portion of this precinct has been identified by Shoalhaven City Council as the Berry-Bolong Pastoral Landscape (Peter Freeman Pty Ltd 1988:44). The continuation of dairy farming across the region has contributed to the survival of the underlying nineteenth century and early twentieth century pastoral landscape.

Despite the decline of many smaller villages and communities, changes in population density, the diminishing viability of small farms and the growth of rural subdivision, the region contains a fundamentally nineteenth century pastoral structure. These elements are aesthetically held together by the backdrop of the Southern Illawarra Range. The settlement, land use patterns and archaeology of the agricultural development of the Southern Illawarra are evident across this cultural landscape through the farmscapes, churches, public schools, nineteenth century plantings, a range of buildings, silos and drainage schemes.

The northern end of the study area extends 400 metres into the buffer zone of the BTUCA, listed by the National Trust (NSW) in 2011. The listing recognises the historic development of the town, and its distinctive urban character set within a rolling agricultural landscape. The BTUCA listing incorporates three listing levels; a broad scale visual boundary, subdivision boundary and buffer zone.

6.8.3 Assessment of potential impacts

Significance assessment

An item is considered to be of State (or local) heritage significance if, in the opinion of the Heritage Council of NSW, it meets one or more of the assessment criteria presented in Section 6.1 of the *Non-Aboriginal (Historic) Heritage Technical Paper* at **Appendix J**.

Of the 39 field recordings:

- Eight have been found to fall below the significance thresholds defined within the assessment criteria. These are G2B H6, G2B H8, G2B H69, G2B H70, G2B H72, G2B H74, G2B H79 and G2B H84. These field recordings were not considered further with regards to potential impacts and safeguards and management measures associated with the proposal.
- Eight cannot be given definitive assessments until the nature of the predicted archaeological deposits are confirmed through test excavation. These items have therefore been given indicative assessments of local context significance, subject to confirmation (G2B H73, G2B H75, G2B H80, G2B H88, G2B H89, H2B H90, G2B H91 and G2B H92).
- The remaining 23 items are assessed as having heritage significance within a local context, according to one or more of the specified significance criteria.

A detailed assessment of each site or item against the assessment criteria is presented in Appendix D of the *Non-Aboriginal (Historic) Heritage Technical Paper* at **Appendix J**.

Impacts on items of non-Aboriginal heritage significance

Impacts to items of non-Aboriginal heritage significance can be broadly characterised as direct or indirect. A direct impact would occur when a development/activity results in the physical loss or change to a physical item. This could affect a place or item in part or as a whole. Indirect impacts would avoid direct impacts to a place or item of non-Aboriginal heritage significance, but would change its context or surroundings. This mostly occurs when a development/activity is located in relative proximity to the place or item, resulting in a change in the setting of that place or item. Indirect impacts may reduce the historical integrity of a place or item, and could compromise the interpretation or visual appreciation of the place or item.

The potential impacts of the proposal on non-Aboriginal heritage items have been categorised in **Table 6-48** in accordance with the following criteria:

Impact category A	A whole or complete degree of direct impact to a heritage item resulting in the physical loss of the item. This can be expected to occur in up to 100 per cent of the planned highway corridor, although there may be some limited potential for site remnants to survive in undeveloped areas or in some ancillary areas.
Impact category B	Partial or minor direct impact to heritage item(s). The resulting loss or reduction in heritage significance will depend on the nature of the item and the extent and scope of the physical impact. Included in this category are: instances where a proportion of the item will remain, impact to the defined curtilage of an item, and impact to a minor or small proportion of an item, such as the root stock of a heritage tree.
Impact category C	Indirect impacts, such as to the contextual and landscape values associated with an item. Typically this occurs when a development is now adjacent to, or closer to the item.
Impact category D	Indirect impact to items of movable heritage which could be moved to avoid direct impact and as a consequence lose contextual integrity.
Impact category E	No substantial impact. This category involves instances where the development would either: not pose an impact to a heritage item (direct or indirect), or any measurable impact was insignificant and did not reduce the heritage value or significance of the item. An example would be where a development occurs within the viewshed from an item, but does not obscure, remove or reduce the role of contextual or landscape components that contribute to the significance of the item. A further example would be where a development, close to an item, does not increase the level of impact that has already occurred from existing elements or actions.

Of the 31 heritage items:

- 18 would not be directly impacted (impact categories c and e).
- Eight would be, or would potentially be, partially impacted (impact category b).
- Two would be, or would potentially be, wholly impacted (impact category a).
- The extent of direct impact is not known for three items (impact category f).

Of those 18 items not directly impacted, seven would be subject to indirect impacts relating to their landscape and/or visual contexts. All heritage items subject to direct and indirect impact have been assessed as being of a local scale of significance. A summary of the impact categories is provided in **Table 6-48**.

A Statement of Heritage Impact (SOHI) has been prepared for each of the impacted items (refer to Appendix E of the *Non-Aboriginal (Historic) Heritage Technical Paper* at **Appendix J**). Overall, impacts to items of non-Aboriginal heritage significance were found to be acceptable, subject to the implementation of safeguards and management measures described in **Section 6.8.4**.

Table 6-48 Summary of identified heritage items and potential impacts

Site ID	Heritage item	Description	Significance	Extent of impact	Impact category	Comments
G2B H1	'Mount View', Abernethys Lane Meroo Meadow	Representative twentieth century farmhouse.	Local	Indirect	c	Upgraded highway corridor boundary would encroach to within four metres of front veranda, and would remove most of the enclosure front garden, thus imposing a high degree of impact to the context of this house.
G2B H2	Abernethys Creek Bridge Princes Highway Meroo Meadow	Reinforced concrete bridge constructed in 1929.	Local	Direct (whole)	a	Bridge cannot be retained as a functional upgrade component because it would not comply with flood level specifications or the new upgrade elevation. The bridge would be demolished.
G2B H3	Meroo Union Church 8 Boxsells Lane Meroo Meadow	One of few remaining community buildings. Representative of a late nineteenth century Union church constructed in the Victorian Free Gothic Style.	Local	No impact	e	Loss of mature pine trees along highway corridor in nearby areas would increase visual and aesthetic value of remaining pine plantings bordering church property.
G2B H4	Former Meroo Meadow public schoolhouse and schoolmasters residence C385 and C395 Princes Highway Meroo Meadow	Late 1890s buildings are representative of turn of the (nineteenth) century, Victorian Georgian school architecture. The schoolhouse has a high degree of intactness and is largely unchanged since its closure in 1971. Archaeological deposits may survive on the property.	Local	Indirect	c	Carriageway would be seven metres closer and existing vehicle entrance to property would be replaced by new driveway on an existing ramp. No direct impact to structures. No change to existing property boundaries required, however existing front garden (which acts as an open space curtilage around the buildings) occurs within current highway easement. The existing corridor boundary passes approximately one metre from the front wall of the schoolhouse, which introduces the possibility of construction activities occurring up to this distance from the building.

Site ID	Heritage item	Description	Significance	Extent of impact	Impact category	Comments
G2B H5	Avenue of planted road-side trees Princes Highway (and Turners Lane) Meroo Meadow	Representative plantings dating from the early to mid-twentieth century along the highway of the south. Includes numerous old growth trees with high aesthetic appeal.	Local	Direct (partial)	b	All trees along the northern side of the highway would need to be felled. However, the trees on Turners Lane and a majority of the trees on the southern side of the highway occur outside of the construction footprint for the proposal. This provides the potential for the retention of these trees within the highway road reserve, subject to safety requirements. Potential ancillary areas 9, 10 and 13 adjoin this site.
G2B H7	Remnant portion of mid nineteenth century Berry Estate Road 29 Strongs Road Jaspers Brush	Rare example of a transport corridor that was locally historically important as a private road and the first main inland route that bypassed Seven Mile Beach. It has a strong association with the Berry Estate and has potential to contribute to an understanding of nineteenth century road construction and use.	Local	Direct (partial)	b	Impact would occur at eastern end of remnant. The remnant is small and this degree of impact would reduce heritage value substantially.
G2B H9	Remnant portion of mid nineteenth century Berry Estate road 20B Strongs Road Jaspers Brush	Rare example of a transport corridor that was locally historically important as a private road and the first main inland route that bypassed Seven Mile Beach. It has a strong association with the Berry Estate and has potential to contribute to an understanding of nineteenth century road construction and use.	Local	No impact	e	Proposal impact elsewhere would mean that this recording would be the only remaining remnant of this road, south and west of Berry.

Site ID	Heritage item	Description	Significance	Extent of impact	Impact category	Comments
G2B H44	'Hotel Woodbyne' former Jaspers Brush public schoolhouse and residence 4 O'Keefes Lane Jaspers Brush	The former school has high social value as a previous focus for community activities, local history and its association with local identities. Potential archaeological deposits may remain within the grounds and along the adjacent creek bank.	Local	Indirect	c	No significant change in distance to carriageway, minor change required to property boundary, potential visual impact through loss of bordering vegetation within the existing highway corridor.
G2B H46	'Pomona' C360 Princes Highway Meroo Meadow	Dairy farm complex (including farmhouse and outbuildings), dating back to the sale of the Berry Estate. Strongly associated with the Muller family who continue to operate the dairy farm to this day.	Local	Direct (partial)	b	Existing entrance gateway would be directly impacted. Carriageway would be 13 metres closer and upgraded highway corridor boundary would encroach to within 10 metres of farmhouse and approximately two metres within existing front garden enclosure.
G2B H66	'Westbury' B210 Princes Highway Berry	Early twentieth century Victorian farmhouse and associated outbuildings have a substantial degree of intactness and are locally representative of a relatively large post Berry Estate farm.	Local	Indirect	c	Carriageway would be four metres further away, however upgraded highway corridor boundary will include boundary plantings of mature camphor laurel trees, which would require removal. Potential ancillary area one adjoins the southern boundary of this site.
G2B H67	Site of former Meroo Meadow public hall Princes Highway Meroo Meadow	Served as a focus for social and political life of the Meroo Meadow community and district for forty years. High degree of social value for community members.	Local	Direct (partial)	b	Carriageway would be seven metres closer, however upgraded highway corridor boundary would encroach 20 metres into site, leaving a six metre section of the remaining lot.

Site ID	Heritage item	Description	Significance	Extent of impact	Impact category	Comments
G2B H68	Site of former Jaspers Dairy Co. and Jaspers Brush Dairy Co. factory 25 Jaspers Brush Road Jaspers Brush	Dairy factory which commenced operations in 1888, and was operational for 50 years. Its development and evolution was representative of the south coast industry as a whole.	Local	Direct (partial)	b	Minor direct impact would occur along the southern boundary of the lot within which the site is located. This would be the result of earthworks adjacent to Jaspers Brush Road. It is not known if any components of this site were/are situated along this boundary as the exact location is not known.
G2B H71	'Fairview' C480 Princes Highway Meroo Meadow	Early twentieth century farmhouse, with heritage values associated with remaining outbuildings.	Local	Indirect	c	Carriageway would be slightly further away, No change to property boundaries. Potential visual impact from loss of bordering vegetation in the highway corridor. Potential ancillary area 11 adjoins the eastern boundary of this site.
G2B H73	Site of former Berry Estate building complex 26A Boxsells Lane Meroo Meadow	This locality does not include a functioning farm and has therefore not been disturbed by latter occupation (apart from ploughing).	Local Subject to confirmation through archaeological excavation	No impact	e	No change to property boundary.

Site ID	Heritage item	Description	Significance	Extent of impact	Impact category	Comments
G2B H75	Approximate site of former Meroo Meadow Dairy Co. factory May occur within Meroo Meadow at: • 43 Fletchers Lane and • 1003 and 1028 Meroo Road	The archaeological record has potential to provide information on the local emergence of the co-operative dairy industry and the evolution from local to centralised factories.		Direct*	f	The exact location of the factory is not known. The area within which the factory was probably situated includes the eastern side of the existing highway corridor, either side of Meroo Road. Despite minimal extension of the highway platform in this direction, this area would probably be impacted by construction works for the Tullian Creek bridge and nearby interchange works. The extension of the highway easement to include provision for a future upgrade of a south bound off ramp would encroach between 20 and 50 metres into the potential factory area. The presence of archaeological deposits is subject to confirmation.
G2B H76	'Northcote' 25 Jaspers Brush Road Jaspers Brush	Twentieth century farmhouse cottage with heritage values demonstrated in the remaining outbuildings.	Local	No impact	e	No change to property boundaries, distance to roads and upgrade works remains similar to present.
G2B H77	'Exeter' C265 Princes Highway Meroo Meadow	Federation/Edwardian style farmhouse which retains its distinctive and original architectural character and design.	Local	Indirect	c	Upgraded highway corridor boundary would encroach 35 metres into property adjacent to farmhouse. However this would be 100 metres from the farmhouse. Farmhouse is locally elevated and the Meroo Road interchange, overpass and ramps would be visible 130 and 200 metres away. Potential ancillary area 15 adjoins the northern boundary of this site.

Site ID	Heritage item	Description	Significance	Extent of impact	Impact category	Comments
G2B H78	Avenue of planted road-side trees Princes Highway Meroo Meadow	Alignment of pine trees is the remnant of an avenue, originally also present on the opposite side of the highway.	Local	Direct (partial)	b	Pine trees adjacent to the Meroo Meadow Union Church property and one tree on south side of Boxsells Lane would not be impacted. All other trees within this avenue would need to be felled.
G2B H80	Site of former Berry Estate tenant farm 'house' B353 Princes Highway Jaspers Brush	Remaining archaeological deposits may have potential to contribute to an understanding of the settlement and development of the Berry Estate and the Meroo Meadow/Jaspers Brush area.	Local	Direct (whole)*	a**	Construction footprint would extend 26 metres into area which potentially contains archaeological remains. Upgraded highway corridor boundary extends 40 metres into same area, representing approximately three quarters of area of potential. Site location is approximate and the presence of archaeological deposits is subject to confirmation.
G2B H81	Agricultural earth dam and former associated pipeline easement B510 Princess Highway Jaspers Brush	Formed part of the swamp reclamation program conducted across the Berry Estate lowlands in the 1890s.	Local	Direct (partial)	b**	No substantive impact to reservoir dam which would be 170 metres upslope of the upgraded highway corridor boundary. If a remnant section of the pipeline remains within/under, and/or to either side of the existing carriageway, then this would be impacted within the construction footprint which would extend 8 and 31 metres to the north and south (respectively) of the existing platform.
G2B H82	'Silos Estate' B640 and B640A Princes Highway Meroo Meadow	Property which includes several items of heritage value, such as a remnant sandstone flagstone floor and undeveloped tenant farm buildings.	Local	No impact	e	No significant change to boundaries or visual impact relative to heritage items.

Site ID	Heritage item	Description	Significance	Extent of impact	Impact category	Comments
G2B H83	'County Fair' B680 Princes Highway Meroo Meadow	Farm complex comprising a butchery, dairy and combined silo and covered feed stall of heritage significance.	Local	No impact	e	No significant change to property boundaries or visual impact relative to heritage items.
G2B H85	'Maylands' 1003 Meroo Road Meroo Meadow	Archaeological remains of former nineteenth century tenant farm buildings. Also present is a former blacksmith shed which retains a considerable amount of its original fabric.	Local	No impact	e	No change to property boundaries. Farmhouse is not elevated and is already screened from the highway by vegetation. Meroo Road interchange would be 215 metres away and visible from property.
G2B H86	Road-side planted trees Meroo Road and Fletchers Lane Meroo Meadow	This alignment of trees includes two large Bunya pines which contribute to the aesthetic values of the local and regional landscape.	Local	No impact	e	These plantings would remain close to Meroo Road. The construction of an adjacent round-about would not necessitate tree removal.
G2B H87	[unnamed] farmhouse and dairy C190 Princes Highway Meroo Meadow	1920s farm complex associated with the locally prominent Abernethy family. Contains characteristics representative of 1920s structures.	Local	Indirect	c	No significant change in distance to carriageway.
G2B H88	Site of former 'hut' building, part of former Berry Estate 'Meroo Station' 26A Boxsells Lane Meroo Meadow	Archaeological deposits, if present, may have potential to contribute to an understanding of the settlement and development of the Berry Estate and the Meroo Meadow area in particular.	Local	Direct**	f	No change to property boundaries. Area of recording occurs partially within existing highway corridor and within adjacent property. Potential for direct impact to the portion within the existing corridor. Site location is approximate and the presence of archaeological deposits is subject to confirmation.

Site ID	Heritage item	Description	Significance	Extent of impact	Impact category	Comments
G2B H89	'Jaspers Grove' 20A Strongs Road Jaspers Brush	Archaeological deposits, if present, may have potential to contribute to an understanding of the settlement and development of the Berry Estate and the Jaspers Brush area in particular.	Local	No impact	e	No significant change to position of Strongs Road carriageway. Property already substantially screened by vegetation. Site location is approximate and the presence of archaeological deposits is subject to confirmation.
G2B H90	Site of former Berry Estate 'Meroo Station' homestead C395 Princes Highway Meroo Meadow	Archaeological deposits, if present, may have potential to contribute to an understanding of the settlement and development of the Berry Estate and the Meroo Meadow area in particular.	Local	No impact	e	No change to property boundaries.
G2B H91	Site of former 'Little Meadow' Public (tent) School, 15 Turners Lane Meroo Meadow	Presence of archaeological remains unknown. Regardless of their presence, this locality has historical significance in demonstrating the development of public school sites in the late nineteenth century and the interrelation between the Berry Estate and Government authorities.	Local	Direct**	f	Exact location of tent school is not known, however it is likely to have been close and parallel to the (1882) road formation. The proposed upgraded highway corridor boundary extends around 20 metres from the existing highway platform and there is potential for archaeological deposits to be situated within this area. The presence of archaeological deposits is subject to confirmation.
G2B H92	Site of former Berry Estate tenant farm buildings, (Pestells Lane) C265 Princes Highway Meroo Meadow	Archaeological deposits, if present, may have potential to contribute to an understanding of the settlement and development of the Berry Estate and the Meroo Meadow area in particular.	Local	No impact	e	Nearest upgrade works would be situated approximately 150 metres to the south east.

Site ID	Heritage item	Description	Significance	Extent of impact	Impact category	Comments
SICPH CL	Southern Illawarra Coastal Plain and Hinterland Cultural Landscape	Historically, it is locally significant in terms of its strong association with the local Aboriginal community. It is the only remaining such portion of the broader Illawarra cultural landscape that has not been substantially impacted by urban infill. As such it is also representative of its type and displays considerable research potential in terms of historical themes at local and State levels.	Local	Direct (partial)	b and c	Impacts would include the visual and structural impact of the carriageway formation, cuttings, and visually obtrusive embankments, overpasses and ramps.

**Extent of impact currently unknown*
***Potentially*

Impacts to cultural landscape values

The proposal would result in a modern structural component located within the existing landscape. The degree and severity of these components relative to the existing environment would vary according to the difference between the forms of the current highway and the proposal. The major components would be the introduction of dual carriageways, substantially increasing the width of the corridor, the introduction of elevated components at grade separated facilities and the half-interchange, such as overpasses, on-ramps and off-ramps, and changes to noise and artificial light levels. The principal flood impact objective for the proposal is to provide a 100 year ARI flood immune highway. Abernethys Creek Bridge (G2B H2), which is listed on Roads and Maritime's Section 170 Heritage Register would not comply with the flood level specifications or the new upgrade elevation of the proposal, and as such, cannot be retained as a functional upgrade component of the proposal.

The physical elements of the proposal would contrast with those of the existing landscape. This would occur in the following ways:

- The vertical alignment of the proposal would be more gradual and incremental, with more widespread use of ramps, embankments and cuttings to maintain standard rates of climb and/or descent.
- The inclusion of overpasses and approach ramps which would introduce elevated landscape features which may intrude or obstruct the quality of viewsheds to and from heritage items.
- The supply of artificial lighting at selected areas along the proposal, including grade separated facilities and the half-interchange, which may interfere with the quality of viewsheds to and from a heritage item.
- The width of the proposal corridor (including carriageways, ramps and associated road reserve) would vary between 50 metres and 250 metres with an average of 70 metres. This is in contrast to the existing highway corridor which can be less than 20 metres where not extended in anticipation of the proposal.
- The proposal would create or accentuate its own topography of cuttings and embankments as required by the necessary horizontal and vertical alignment. As a consequence, the proposal would accentuate the character of the existing highway which runs contrary to the natural flow of ridges, valley orientation and slope contours.

Aspects of the proposal which respect or enhance the cultural landscape values

The proposal generally follows the alignment of the existing highway, which was constructed in the study area based on the original Berry Estate Road constructed for vehicles between Berry and Bomaderry. The main exception to this is the 1930 Bomaderry bypass (south of Meroo Road) and the traverse across the Jaspers Brush spurline. Constructing the proposal along the existing highway provides a degree of historical and functional integrity to the proposal – a modern manifestation of an original nineteenth century access and transport corridor.

The design of the proposal was undertaken with the aim of minimising and ameliorating visual impacts. This included consideration of embankments, cuttings and elevation of the carriageway, minimising these where feasible and reasonable, in conjunction with the establishment of vegetation.

Potential impacts of temporary construction ancillary facilities

An analysis of the potential non-Aboriginal heritage impact of each potential temporary construction ancillary facility area is presented in **Table 6-49**. None of the potential ancillary areas include heritage recordings. In seven instances the potential ancillary areas are situated adjacent to a heritage recording (six of which are heritage items), and there are consequential risks of direct impact to tree root zones (areas 1, 10 and 11). In one case of an adjacent heritage recording (area 4), the recording is not a heritage item (G2B H69, 'Amaroo Park') and would be demolished because it is situated within the construction footprint of the proposal.

There are three other instances where a potential temporary construction ancillary area is proposed adjacent, or close to, heritage recordings which would be directly impacted by the construction footprint. These are: area 5 (approximately 20 metres from G2B H7), and areas 9 and 13 (each are adjacent to the northern alignment of trees in G2B H5).

There are four instances where the potential temporary construction ancillary areas are situated close to a heritage recording (all of which are heritage items). Close is defined as within 100 metres, but excluding recordings situated on the opposite side of the highway. These are areas 5, 8 and 17. Area 5 has been discussed above, and in the remaining areas 8 and 17, the potential temporary construction ancillary facilities pose no risk of direct or indirect impact as the items are 50 metres or more away and constitute below-ground potential archaeological deposits.

Table 6-49 Analysis of potential non-Aboriginal heritage impact of each potential temporary construction ancillary facility

Area number	Size (m^2)	Heritage recordings included within proposed ancillary area	Heritage recordings adjacent or close to proposed ancillary area	Potential for impact
1	13657	None	G2B H66 adjoins northern boundary of proposed ancillary area.	Potential for direct impact to root zone of trees located within G2B H66 boundary.
2	18313	None	None	None
3	44344	None	None	None
4	17364	None	G2B H69 adjoins the northern boundary of proposed ancillary area.	None, G2B H69 falls below the threshold for local heritage significance. This site would be directly impacted by the construction footprint of the proposal independent of any ancillary facilities or actions.
5	11,047	None	The eastern end of G2B H7 is situated approximately 20 metres south of the south-eastern corner of the proposed ancillary area.	None, the eastern end of G2B H7 would be directly impacted by the construction footprint of the proposal independent of any ancillary facilities or actions.
6	14,231	None	None	None
7	17,801	None	G2B H81 is situated approximately 50 metres upslope and to the north of the north-eastern corner of the proposed ancillary area.	None
8	8471	None	G2B H80 is situated approximately 50 metres to the east of the eastern boundary of the proposed ancillary area.	None

Area number	Size (m^2)	Heritage recordings included within proposed ancillary area	Heritage recordings adjacent or close to proposed ancillary area	Potential for impact
9	18,526	None	G2B H5 adjoins the southern boundary of the proposed ancillary area.	None, the portion of G2B H5 situated north of the current highway would be directly impacted by the construction footprint of the proposal independent of any ancillary facilities or actions.
10	12,666	None	G2B H5 adjoins the northern boundary of the proposed ancillary area.	Potential for direct impact to root zone of trees located near to northern boundary of proposed ancillary area.
11	41,972	None	G2B H71 adjoins the western boundary of the proposed ancillary area.	Potential for direct impact to root zone of trees located within G2B H71 boundary.
12	36,134	None	None	None
13	31,139	None	G2B H5 adjoins the southern boundary of the proposed ancillary area.	The portion of G2B H5 situated north of the current highway would be directly impacted by the construction footprint independent of any ancillary facilities or actions.
14	15,609	None	None	None
15	22,507	None	G2B H77 adjoins the south-western boundary of proposed ancillary area.	No potential for direct impact because the adjoining portion of G2B H77 consists of potential archaeological deposits and the standing remains of a concrete silo. The heritage item boundary includes a sufficient buffer to protect these features.
16	7482	None	None	None
17	2648	None	G2B H92 is situated approximately100 metres to the north-west of the proposed ancillary area.	None

Residual impacts

Following the implementation of safeguards and management measures, the proposal would have residual impacts on the SICPH CL. These would include:

- Disturbance to, loss and truncation of, landscape elements due to the physical placement of the proposal.
- The addition of major engineered landscape components in the form of a consistently graded and angled road platform associated with bridges, cuttings and embankments.
- Increased visual intrusion of the proposal into views of, and across, the landscape.
- Disturbance to and truncation of the built environment and landscape elements due to the physical placement of the proposal. These include the front yards and gardens of farmhouses, fencelines and field systems, riparian vegetation and road alignments.

Impacts on the SICPH CL and landscape setting of Berry currently occur in settings which are already impacted by the existing highway corridor, and thus represent further or incremental impacts of types already present.

With the effective implementation of these safeguards and management measures, it can be concluded that the residual impacts of the proposal on the SICPH CL would be acceptable when weighed against the benefits and objectives of the proposal.

6.8.4 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or manage impacts to non-Aboriginal heritage as a result of the proposal. These measures are identified in **Table 6-50** and summarised in **Section 7.2**.

Table 6-50 Safeguards and management measures

Potential impact	Safeguards and management measures	Responsibility	Timing
Construction			
General construction impacts	Follow the Standard Management Procedure – Unexpected Archaeological Finds (RMS, 2012), or a Roads and Maritime approved revised version, in the event that unexpected heritage/archaeological finds are encountered during construction of the proposal.	Roads and Maritime project manager and construction contractor	Construction
	Include heritage awareness, including requirements specific to the proposal, in the site induction training for proposal staff.	Construction contractor	Construction
	Subject to stakeholder agreement, lodge any non-Aboriginal artefact materials recovered during archaeological or construction related excavations with either the Berry Museum (Berry and District Historical Society) or Nowra Museum (Shoalhaven Historical Society), depending on the location and the nature of the finds. The material will be appropriately inventoried and accompanied by supporting documentation.	Roads and Maritime project manager	Pre-construction and construction

Potential impact	Safeguards and management measures	Responsibility	Timing
	Prepare and implement a Heritage Interpretation Plan (HIP). The HIP would contain: • An archival recording strategy for items where direct impacts are unavoidable. The strategy would include creating a documentary and photographic record of items, which would act as a form of information recovery and can be used as a reference in the future. • A site interpretation strategy for the management of sites where archaeological excavation may be required. Where appropriate the strategy may include options such as physical memorials, interpretive signage, printed, internet and/or electronic media, and supportive local museum displays.	Roads and Maritime project manager	Pre-construction and construction
	Establish no-go zones between construction zones and sites G2B H1, G2B H3, G2B H4, G2B H5, G2B H7, G2B H44, G2B H46, G2B H66, G2B H68, G2B H75, G2B H78, G2B H80, G2B H86, G2B H88 and G2B H91. The no-go zones would prevent impacts to areas or items with heritage value which are situated close and adjacent to the proposal, or constitute remnants of partially impacted sites. If temporary fencing is not practical at some heritage sites, adopt an alternate strategy to demarcate the boundaries of the no-go areas.	Construction contractor	Construction
Impacts to heritage items within potential temporary construction ancillary facility sites	Where the root zone of trees located on heritage sites (G2B H5, G2B H66 and G2B H71) extend into adjacent ancillary areas (ancillary areas 1, 10 and 11), demarcate the likely root zone of those trees as 'no-go' areas.	Construction contractor	Pre-construction and construction
Direct impacts to road infrastructure	Prior to construction, carry out archival recordings for heritage items G2B H2 and G2B H7.	Roads and Maritime project manager	Pre-construction
	Notify the Heritage Council of NSW at least 14 days prior to the removal of item G2B H2 (Abernethys Creek Bridge) from Roads and Maritime's Section 170 Heritage Register	Roads and Maritime project manager	Construction

Potential impact	Safeguards and management measures	Responsibility	Timing
Direct impacts to buildings and structure	In accordance with the HIP for the proposal, carry out test excavations to determine the presence and nature of archaeological deposits, and any further management strategies for the following heritage items: • 'Pomona' Homestead, Meroo Meadow (G2B H46). • Site of former Jaspers Dairy Co. and Jaspers Brush Dairy Co. Factory, Jaspers Brush (G2B H68). • Approximate site of former Meroo Meadow Dairy Co. factory, Meroo Meadow (G2B H75). • Site of former Berry Estate tenant 'house', Jaspers Brush (G2B H80). • Site of former Meroo Station hut building, Meroo Meadow (G2B H88). • Site of former Berry Estate tenant farm buildings, Meroo Meadow (G2B H92).	Roads and Maritime project manager and specialist heritage consultant	Pre-construction
	Further management strategies, if required, could include salvage excavation and/or the provision of site interpretation in accordance with the HIP.	Roads and Maritime project manager and specialist heritage consultant	Pre-construction
	'Pomona' Homestead (G2B H46). • Conduct an archival recording of the entrance gateway prior to construction impact. • Disassemble and reconstruct the entrance gateway at a new location, to be determined in consultation with the owner. • The reconstructed gateway should be as close to the original as is feasible and reasonable. • If feasible and reasonable avoid impacts to the front garden and yard.	Roads and Maritime project manager	Pre-construction
	Former Meroo Meadow public hall (G2B H67) Commemorate and interpret this site in an appropriate form and method in accordance with the HIP for the proposal.	Roads and Maritime project manager	Pre-construction
	Depending on the results of further research and archaeological investigations, where reasonable and warranted, interpret the sites G2B H68, G2B H75, G2B H80, G2B H81, G2B H88 and G2B H91 in an appropriate form and method in accordance with the HIP for the proposal.	Roads and Maritime project manager	Pre-construction

Potential impact	Safeguards and management measures	Responsibility	Timing
Impacts to potential archaeological deposits	All subsurface archaeological investigations will be undertaken in accordance with a Section140 excavation permit (under the *Heritage Act 1977*), which will be required for the proposal.	Roads and Maritime project manager	Pre-construction
	Site of former Jaspers Dairy Co. and Jaspers Brush Dairy Co. Factory, Jaspers Brush (G2B H68) and Site of former Meroo Station hut building, Meroo Meadow (G2B H88). • Where feasible and reasonable avoid direct impact to the area of G2B H88 and to the land to the north of the current Jaspers Brush Reserve easement (Part of G2B H68). • If impact is not avoidable conduct an archaeological test excavation in the areas of anticipated impact within sites G2B H88 and G2B H68, prior to construction impact. • Based on the findings of the test excavation, any further necessary management actions such as salvage excavation should be conducted prior to construction impact.	Roads and Maritime project manager	Pre-construction
	Approximate site of former Meroo Meadow Dairy Co. factory, Meroo Meadow (G2B H75). • Conduct a program of archaeological test excavation to determine the presence and nature of any archaeological deposits within the portion of the proposal area which occurs within site G2B H75. Test excavation is not required if any additional historical analysis undertaken prior to construction determines that the factory is located outside of the proposal area. • Based on the findings of the test excavation program, any further management actions such as salvage excavation and/or the provision of site interpretation would be conducted prior to the commencement of construction.	Roads and Maritime project manager	Pre-construction
	Site of former Berry Estate tenant 'house', Jaspers Brush (G2B H80), agricultural earth dam and former associated pipeline, Jaspers Brush (H81) and site of former 'Little Meadow' Public (tent) School (G2B H91). • Conduct a program of archaeological test excavation within the potentially impacted portions of sites G2B H80, G2B H81 and G2B H91 to determine the presence and nature of any archaeological deposits, and any required management strategies. • Based on the findings of the test excavation, any further management actions such as salvage excavation and/or site interpretation are to be conducted prior to construction impact.	Roads and Maritime project manager	Pre-construction

Potential impact	Safeguards and management measures	Responsibility	Timing
Indirect impacts to buildings and structures	Implement urban design initiatives to minimise the visual and contextual impacts of the proposal in relation to viewsheds, noise and artificial light to and from heritage items, including G2B H1, G2B H4, G2B H44, G2B H46, G2B H66, G2B H71, G2B H77 and G2B H87.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Meroo Meadow Public Schoolhouse and residence (G2B H4). Define and fence off a no-go area in front of the buildings. The downslope extent of the no-go area should be as large as reasonably practicable. Retain a portion of the road reserve adjacent to G2B H4 as an open space curtilage in front of the heritage buildings.	Roads and Maritime project manager and construction contractor	Pre-construction
	'Hotel Woodbyne (G2B H44) and 'Fairview' (G2B H71). Maintain or replace visual barrier between the proposal and the heritage items G2B H44 ('Hotel Woodbyne', Jaspers Brush) and G2B H71 ('Fairview', Meroo Meadow) with appropriate planting of vegetation along the proposal.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	'Mount View' Meroo Meadow (G2B H1). Undertake all feasible and reasonable measures to minimise the loss of open space on the eastern side of the buildings. Maintain this space as an effective curtilage between the building and the construction footprint of the proposal.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
Impacts to tree plantings	Tree plantings, Meroo Meadow (G2B H5). • Minimise direct impacts to old growth tree plantings on the southern side of the proposal. • Undertake archival recordings of the whole tree planting group prior to direct construction impact. • Replace felled trees with new plantings using the same or similar tree species in an appropriate and safe location and configuration. This would maintain or restore and support the landscape character and heritage values of the plantings. • Avoid direct impacts to the trees on Turners Lane. This area, including the root zones of the trees, is to be fenced off and designated as a no-go zone. • Conduct dendro-chronological analysis of trunk-section samples from select felled trees in each group of tree plantings impacted by the proposal.	Roads and Maritime project manager and construction contractor	Pre-construction and construction

Potential impact	Safeguards and management measures	Responsibility	Timing
	Tree plantings, Meroo Meadow (G2B H78). • Avoid direct impacts to the trees adjacent to the Meroo Union Church (part of G2B H78), and the single pine on the south side of Boxsells Lane (part of G2B H78). These areas, including the root zones of the trees, are to be fenced off and designated as no-go zones. • Undertake archival recordings of tree plantings prior to construction. • Define no-go areas around trees to be retained, particularly around Meroo Union Church and on the opposite side of Boxsells Lane, where possible. • Conduct dendro-chronological analysis of trunk-section samples from select felled trees in each group of tree plantings impacted by the proposal.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Tree plantings (G2B H86). • Define and fence off no-go areas around tree plantings within G2B H86 to avoid direct impacts throughout construction.	Construction contractor	Pre-construction and construction
	'Westbury' (G2B H66). • Where feasible and reasonable retain the Camphor Laurel trees on either side of the driveway.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Where feasible and reasonable, the construction and finishing of the proposal corridor, including embankments and cutting faces would be undertaken in such a way to minimise and ameliorate adverse visual impacts, and facilitate the re-establishment of vegetation. This would be undertaken in a manner consistent with the Urban Design and Landscape Concept Plan, which is detailed in the *Technical Paper: Urban Design,, Landscape Character and Visual Impact Assessment* at **Appendix H**.	Roads and Maritime project manager	Pre-construction and construction
	Establish new plantings in areas where existing heritage tree plantings would be directly impacted by the proposal. The new plantings would aim to maintain, restore and/or support the landscape character and heritage values of the existing tree plantings along the proposal and would be consistent with the Urban Design And Landscape Concept Plan, which is detailed in the *Technical Paper: Urban Design Landscape Character and Visual Impact Assessment* at **Appendix H**. The type and variety of plantings used should seek to replicate those felled and/or be locally prominent.	Roads and Maritime project manager	Pre-construction and construction

Potential impact	Safeguards and management measures	Responsibility	Timing
	Establish appropriate forms of vegetation along the proposal corridor and adjacent areas to assist in mitigating broad-scale landscape and visual impacts of the proposal corridor.	Roads and Maritime project manager	Pre-construction and construction
	Carry out vegetation plantings with an awareness of maintaining important vistas from the road corridor, and the use of vegetation boundaries and alignments which conform to the rectangular patchwork of the surrounding landscape. This would serve to break up or scatter the dominant curvilinear character of the proposal.	Roads and Maritime project manager	Pre-construction and construction
Impacts to cultural landscape values, including the SICPH CL	Where appropriate incorporate artistic elements in structures adjacent to the carriageway. This could include the use of designs derived from local cultural heritage themes, particularly at locations in close association to places/items of significance.	Roads and Maritime project manager	Pre-construction and construction
Operation			
General construction impacts	Consider entering all heritage items which would remain in whole, or in part, within the easement of the proposal following the completion of construction, on Roads and Maritime's Section 170 Heritage and Conservation Register(s). This would likely include heritage items G2B H5, G2B H7, G2B H67, G2B H78, G2B H80, G2B H86 and G2B H88.	Roads and Maritime – Environment Branch	Operation

6.9 Property and land use

This section assesses the potential property and land use impacts associated with the proposal and identifies environmental safeguards to manage these impacts.

6.9.1 Policy setting

An overview of the legislative and policy framework relevant to property and land use within the Shoalhaven LGA is provided. This includes State and local government land use policies and strategies.

South Coast Regional Strategy

As detailed in **Section 2.1.2**, the 'South Coast Regional Strategy 2006-2031' (DoP, 2007) provides projections for population growth within the Shoalhaven LGA. The strategy states that the Shoalhaven LGA is projected to grow by an additional 34,000 people by 2031. The majority of this growth will be concentrated in Nowra-Bomaderry. This strategy also predicts that an additional 26,300 dwellings will be required in the Shoalhaven by 2031, the majority of which would be in Nowra-Bomaderry.

Nowra and Bomaderry Structure Plan

The 'Nowra-Bomaderry Structure Plan' (Shoalhaven City Council, 2006) provides a framework for the integrated development of the Nowra and Bomaderry area. It establishes areas of ongoing urban growth in Nowra and Bomaderry, these areas would not be impacted by the proposal.

The structure plan identifies the area between Pestells Lane and Cambewarra Road as being a long term area for living (residential). Parts of this area are currently undeveloped. Meroo Meadow and an area north of Moss Vale Road have been identified as areas of potential growth for residential development. Access from these areas to the proposal would likely be via the Pestells Lane and Meroo Road grade-separated half interchange.

The Nowra-Bomaderry Structure Plan also includes provision for the North Nowra Link Road. The North Nowra Link Road would provide an alternative route from North Nowra to the Princes Highway. The structure plan states that the link is required in the short term regardless of new development, however it is also considered to be an essential link to facilitate any new development north of the Shoalhaven River. Shoalhaven City Council currently has a concept plan approval for the North Nowra Link Road with the preferred option being the connection of Illaroo Road at Pitt Street with Narang Road.

Shoalhaven Local Environmental Plan 1985

Land use and development in the vicinity of the proposal is subject to the provisions of the Shoalhaven LEP and the draft Shoalhaven LEP.

Section 4.2 details the zones within which the proposal would be located, the objectives of these zones and the consistency of the proposal with these objectives.

Under the Shoalhaven LEP, the majority of the proposal is zoned 1(b) Rural (Arterial and Main Road Protection). Small areas of the proposal are also zoned 1(g) Rural (Flood Liable), 5(d) Special Uses (Proposed Arterial Roads Reservation and Widening of Existing Arterial Roads Reservation) and 7(d2) Environmental Protection (Special Scenic). The land use zones along the length of the proposal are shown in **Figure 4-1**. **Figure 4-2** shows the land use zones within Bomaderry.

For land zoned as rural under the Shoalhaven LEP (which encompasses the majority of land adjacent to the proposal), dwellings cannot be constructed on properties that are below 40 hectares in size. However, Shoalhaven LEP provides exemptions to the minimum lot size subject to meeting the listed objectives and criteria of the LEP.

Under the draft Shoalhaven LEP, the majority of the proposal would be zoned SP2 Infrastructure and RU1 Primary Production. A small portion of the proposal near Bomaderry would also be zoned E2 Environmental Conservation.

The draft Shoalhaven LEP recognises the growth areas established in the 'Nowra-Bomaderry Structure Plan' as well as potential future infrastructure developments. Under the draft Shoalhaven LEP a number of lots between Moss Vale Road and Pestells Lane would be rezoned from 1(a) Rural (Agricultural Production) Zone under the Shoalhaven LEP to zone R1 General Residential.

6.9.2 Existing environment

The Princes Highway is the main north-south regional road between Sydney and the NSW South Coast. It is a commuter route between employment centres such as Wollongong, Nowra and Bomaderry as well as providing a local route for residents of surrounding smaller towns and rural residences.

Nowra and Bomaderry are located immediately south of the proposal. The Nowra-Bomaderry area is a major regional centre and the largest centre within the Shoalhaven LGA (DoP, 2007). As detailed in **Section 6.10**, the majority of growth in the Shoalhaven LGA is expected to be concentrated in the Nowra-Bomaderry area, strengthening its role as the major residential, employment and administrative centre in the region (DoP, 2007).

The township of Berry, located immediately north of the proposal, is not identified in the 'South Coast Regional Strategy' (DoP, 2007) as an emerging centre and does not contain any major future growth areas.

Figure 6-38 and **Figure 6-39** show the land uses of properties adjacent to the proposal between Schofields Lane and Cambewarra Road. Land uses near the proposal are largely consistent with the land use zones in which they are located. Between Schofields Lane and Abernethys Lane, land uses are generally rural and consist of agricultural and rural residential properties with a small number of properties used for commercial and tourist purposes. Between Abernethys Lane and Cambewarra Road, urban land uses dominate, with a mix of residential and commercial land uses at the northern end of Bomaderry.

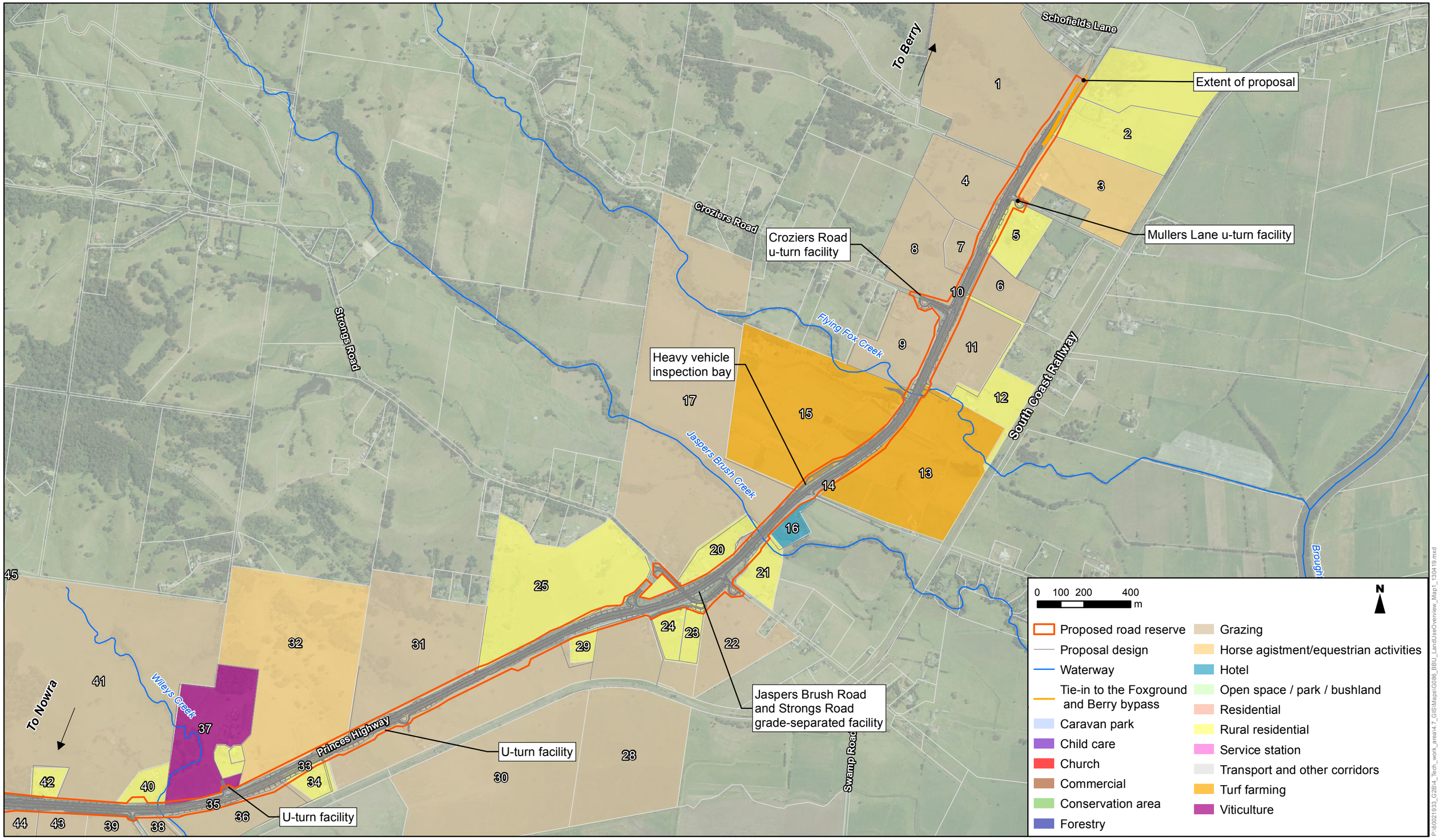


Figure 6-38 Overview of land uses - Map 1

Source: Dept. of Lands (2011), DECCW NSW (2007)

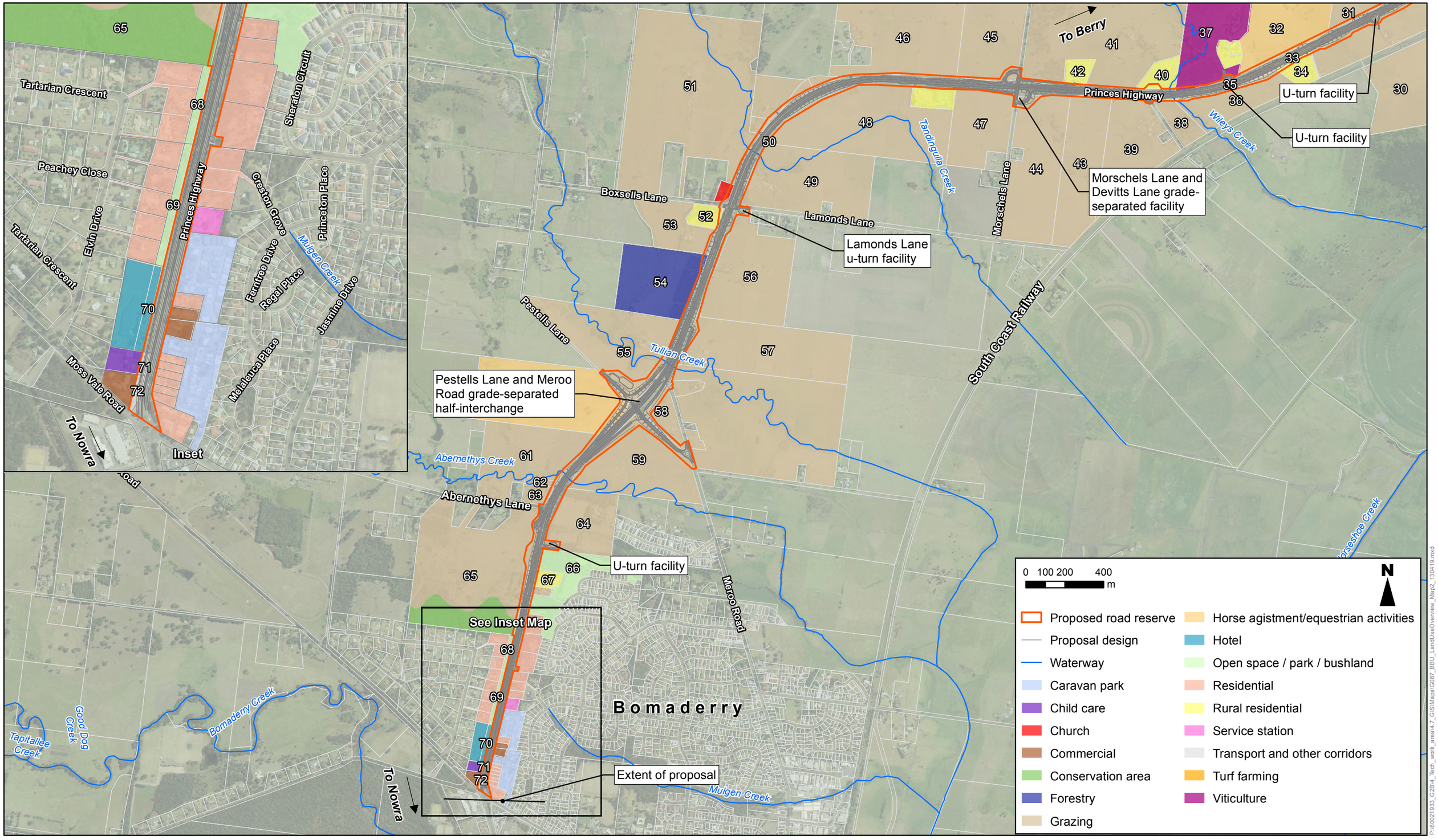


Figure 6-39 Overview of land uses - Map 2

Source: Dept. of Lands (2011), DECCW NSW (2007)

Rural land use

Between Schofields Lane and Abernethys Lane the predominant land use is rural, including uses such as rural residential, grazing, horse agistment, forestry, turf farming, viticulture and a horse stud. Agricultural properties used for grazing for dairy and beef production are the primary land use through this area. As detailed in **Section 6.10**, dairy farms are one of the largest economic contributors to the region and supply the Berry Rural Cooperative (which trades as the South Coast Dairy Cooperative) and the Shoalhaven Dairy Cooperative.

Rural agricultural properties located adjacent to the existing highway are generally between three and 100 hectares in size. There are also a number of smaller lots, less than three hectares in size, that form part of larger agricultural properties.

Agricultural land can be assessed using NSW Agriculture's land classification system (NSW Agriculture, 2002). This system presents five classes to classify land in terms of its suitability for agricultural use, with Class 1 land being the most productive and Class 5 land being generally unsuited to agriculture.

The proposal is predominantly surrounded by Class 3 land, and there is also a small pocket of Class 2 land near Jaspers Brush Creek. These land classifications exhibit the following characteristics:

- Class 2 – arable land that is suitable for regular cultivation for crops but not suited to continuous cultivation. It has moderate to high sustainability for agriculture, but soft soil factors or environmental constraints reduce the overall level of production and may limit the cropping phase to a rotation with sown pastures.
- Class 3 – grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture. The overall production level is moderate. Erosion, hazards, soil structure and other factors (such as climate) may limit capacity for cultivation. Soil conservation and drainage works may be required.

There are two vineyards located near the proposal. Silos Winery is located adjacent to the highway in Jaspers Brush. Silos Winery also operates as a tourist business offering accommodation and a restaurant. Jasper Valley Wines is located off Croziers Road, it is not directly adjacent to the highway.

Smaller lots along the proposal typically have rural residential land uses and generally are not used for agricultural purposes. Rural residential properties adjacent to the existing highway are generally smaller lots between one hectare and 12 hectares in size. There are also a number of accommodation providers occupying smaller lots, such as a hotel and a caravan park as well as the two wineries and the Meroo Union Church.

Urban land use

Bomaderry and Nowra form a major regional and employment centre within the Shoalhaven, which supports industrial and commercial activities as well as substantial areas of residential development. North of the Shoalhaven River, industrial land uses are generally located along the South Coast railway and there is also a small pocket of industrial land use on the Princes Highway just south of Cambewarra Road. Commercial or business land uses are generally located near the Bomaderry (Nowra) railway station and there is a large section of commercial and business development south of the Shoalhaven River.

Nowra and Bomaderry are dominated by residential land uses and there are also a number of areas designated for future residential expansion. As discussed above, the 'Nowra-Bomaderry Structure Plan' identifies Meroo Meadow and an area north of Moss Vale Road as future long term living areas. The plan also includes provision for the North Nowra Link Road which would facilitate new development north of the Shoalhaven River.

Along the Princes Highway, the northern extent of Bomaderry commences south of Abernethys Lane. As a result, urban land uses are located at the southern extent of the proposal, near the Cambewarra Road roundabout. There is a mix of predominantly commercial and residential properties adjacent to the existing highway in this area.

The low-scale commercial land uses adjacent to the existing highway just north of the Cambewarra Road roundabout include tourism businesses such as a hotel and a caravan park as well as businesses that service both passing motorists and residents, such as a service station and mechanics. There are also commercial or office land uses and a child care centre.

The remaining properties adjacent to the highway north of the Cambewarra Road roundabout are generally residential. The majority of properties in this area that do not directly adjoin the highway are also residential but are accessed from Moss Vale Road via Elvin Drive and from Cambewarra Road via Jasmine Drive.

There is a small bushland area located on the western side of the Princes Highway. This area connects the highway to residential streets in Bomaderry such as Marigold Close and is used by local residents as a walking track and recreational area. There is also a vegetated conservation area on the eastern side of the highway in the same location.

6.9.3 Potential impacts

Construction

Long-term impacts on property and land use would occur from the commencement of construction. These impacts would generally be related to property acquisition, changes to local road connections to the highway and changes to property access. These immediate but long term impacts have been discussed below as operational impacts of the proposal. Short term property impacts and land use changes would occur during construction. These impacts would occur as a result of:

- Construction ancillary facilities.
- Construction sediment basins.
- Disruptions or temporary changes to local roads and property accesses.

Temporary construction ancillary facilities would include site compounds for administration and construction support as well as stockpile sites. One construction ancillary facility, located near Pestells Lane, would be located on land to be acquired by Roads and Maritime. The remaining construction ancillary facilities would be located on sites not owned by Roads and Maritime. Discussions would be held with owners of land on which temporary construction ancillary facilities are proposed in relation to leasing these sites during construction. Property and land use impacts on leased sites would be temporary.

Construction sediment basins would be located within the road reserve and would be situated at sites where operational sediment basins would be required. As a result, the construction impacts would not be over and above the operational impacts of the proposal.

As detailed in **Section 6.1**, temporary disruptions to local roads and property accesses would be expected during construction of the proposal. Local roads that would potentially experience some delays during construction include Meroo Road, Pestells Lane, Morschels Lane, Devitts Lane, Strongs Road and Jaspers Brush Road. These roads would be directly linked to, or serviced by, the new grade-separated facilities and interchanges and would experience detours at some time during construction. These impacts would be minimised through the implementation of a Traffic Management Plan as discussed in **Section 6.1.4**. Impacts to internal access on rural properties would not be expected as a result of the proposal.

Operation

Operational impacts on property and land use as a result of the proposal would commence during construction. These impacts would be permanent impacts and include:

- Property acquisition impacts, including impacts on dwelling entitlements.
- Land use severance.
- Changes in external property access.
- Impacts to land use viability, including to agricultural, rural residential and urban land use.

Property acquisition

The proposal would directly impact around 46 hectares of predominantly rural land used for agriculture. This land is outside the existing road boundary and would be permanently included in the road reserve for the proposal. There would be 66 lots affected by strip acquisition directly adjacent to the existing road reserve. Impacts to lots would generally consist of partial acquisitions, where part of the lot would fall within the road reserve for the proposal and that part only would be acquired.

Details of direct property acquisition are provided in **Table 6-51**, property reference numbers correspond with **Figure 6-38** and **Figure 6-39**. Directly impacted sections of larger lots would be permanently required for the proposal. Of the 66 lots affected, 50 lots would have less than one hectare of land directly impacted. Direct impacts to the remaining 16 lots would be between one and four hectares, however, only three of these lots would have direct impacts to over three hectares of land.

It is unlikely that residual portions of partially impacted lots would be impacted by the proposal and acquisition of this residual land would also be unlikely. The proposal would allow for the continuation of existing land uses on these residual portions of land during both construction and operation of the proposal.

Of the 66 lots, five small lots would be directly impacted in their entirety meaning they would require full acquisition. Three of these lots are privately owned and two are owned by Shoalhaven City Council. The three privately owned lots are between 0.2 hectares and 1.7 hectares in size and form part of larger rural residential and agricultural properties and the land use impacts to these properties are discussed below in the land use viability section.

Table 6-51 also shows six lots that are currently owned by Roads and Maritime and form part of the existing road reserve. These lots have been identified but have not been included in the property acquisition calculations required for the proposal.

As of October 2013, there were also two properties that have been acquired in full by Roads and Maritime. One property (property reference number 5), has been acquired by Roads and Maritime as part of the Foxground and Berry bypass project. The Mullers Lane u-turn facility would be constructed on this property as part of that project. Another property (property reference number 55), has been acquired under the hardship provisions of Roads and Maritime's 'Land Acquisition Information Guide' (RTA, 2011). This property would be directly impacted by the Pestells Lane and Meroo Road grade separated half-interchange. Following construction, any land that is in excess of the proposal needs, meaning outside the road reserve, would be re-sold.

A dwelling on one rural residential property would be impacted as a result of the proposed overbridge between Jaspers Brush Road and Strongs Road. The residual land on this lot, being land not directly impacted by the proposal, would be less than 40 hectares in size, which is less than the minimum lot size required under the Shoalhaven LEP. However the Shoalhaven LEP would allow the dwelling to be relocated within the residual land on the property, subject to approval by Shoalhaven City Council. In consultation with the property owner, this property may be acquired in full by Roads and Maritime.

The areas of direct impact to property have been calculated using the proposed road reserve boundary, ground survey and cadastral overlay. This would be subject to further refinement during the detailed design phase of the proposal, which may alter the final acquisition requirements and estimates. All acquisitions would be undertaken in consultation with land owners and in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* and Roads and Maritime's 'Land Acquisition Information Guide' (RTA, 2011).

Table 6-51 Direct property impacts as at October 2013

Property reference	Lot and DP	Predominant land use	Total lot size (hectares)	Area of direct impact (hectares)	Percentage of lot directly impacted	Ownership
1	Lot 87 DP 48603	Grazing	37.51	1.88	5	Shoalhaven City Council
2	Lot 5 DP 615284	Rural residential	11.69	0.12	1	Private
3	Lot 6 DP 615284	Horse agistment	14.64	0.65	4	Private
4	Lot 10 DP 249692	Grazing	10.84	0.82	8	Private
5	Lot 1 DP 625307	Rural residential	5.32	1.60	30	Roads and Maritime
6	Lot 1 DP 870847	Grazing	4.48	0.17	4	Private
7	Lot 1 DP 249692	Grazing	2.54	0.22	8	Private
8	Lot 3 DP 249692	Grazing	11.35	0.35	3	Private
9	Lot 2 DP 711868	Grazing	9.45	0.89	9	Private
10	Lot 12 DP 249692	Road reserve	0.004	0.004	100	Shoalhaven City Council
11	Lot 1 DP 1082572	Grazing	9.88	2.07	21	Private
12	Lot 2 DP 630838	Rural residential	6.17	0.06	1	Private
13	Lot 43 DP 250662	Turf farm	26.51	1.14	4	Private
14	Lot 44 DP 250662	Turf farm	0.20	0.20	100	Private
15	Lot 42 DP 250662	Turf farm	33.48	1.43	4	Private
16	Lot 1 DP 872572	Hotel	1.72	0.04	2	Private
17	Lot 103 DP794485	Grazing	64.34	0.21	0.3	Private
18*	Lot 40 DP 250664	Road reserve	0.01	0.01	100	Roads and Maritime
19*	Lot 40 DP 250664	Road reserve	0.16	0.16	100	Roads and Maritime
20	Lot 26 DP 250664	Rural residential	3.63	0.02	1	Private
21	Lot 5 DP 740764	Rural residential	3.53	0.31	9	Private
22	Lot 4 DP 577929	Grazing	10.56	0.62	6	Private

Property reference	Lot and DP	Predominant land use	Total lot size (hectares)	Area of direct impact (hectares)	Percentage of lot directly impacted	Ownership
23	Lot 1 DP 601531	Rural residential	2.21	0.44	20	Private
24	Lot 1 DP 628177	Rural residential	2.30	0.30	13	Private
25	Lot 2 DP 1121436	Grazing	27.58	1.23	4	Private
26*	Lot 27 DP 250664	Road reserve	0.09	0.09	100	Roads and Maritime
27*	Lot 18 DP 250663	Road reserve	0.06	0.06	100	Roads and Maritime
28	Lot 4 DP 813335	Grazing	30.73	0.20	1	Private
29	Lot 31 DP 877098	Rural residential	1.39	0.17	13	Private
30	Lot 32 DP 877098	Grazing	57.76	4.04	7	Private
31	Lot 4 DP 1002214	Grazing	25.37	0.97	4	Private
32	Lot 2 DP 582832	Equestrian activities	40.52	0.72	2	Private
33	Lot 4 DP 253591	Rural residential	0.67	0.67	100	Private
34	Lot 1 DP 253591	Rural residential	2.07	0.17	8	Private
35	Lot 5 DP 253591	Grazing	1.70	1.70	100	Private
36	Lot 21 DP 856928	Grazing	7.98	0.58	7	Private
37	Lot 4 DP 776151	Viticulture	15.28	0.60	4	Private
38	Lot 1 DP 1088466	Grazing	2.99	0.10	3	Private
39	Lot 21 DP 626705	Grazing	13.77	0.35	3	Private
40	Lot 3 DP 251300	Rural residential	2.51	0.42	17	Private
41	Lot 3 DP 840940	Grazing	105.72	1.07	1	Private
42	Lot 1 DP 211643	Rural residential	1.67	0.12	7	Private
43	Lot 5 DP 251300	Grazing	15.45	0.19	1	Private
44	Lot 41 DP 829070	Grazing	19.92	1.41	7	Private
45	Lot 1 DP 840940	Grazing	30.39	1.08	4	Private

Property reference	Lot and DP	Predominant land use	Total lot size (hectares)	Area of direct impact (hectares)	Percentage of lot directly impacted	Ownership
46	Lot 104 DP 777264	Grazing	37.73	0.55	2	Private
47	Lot 8 DP 774904	Grazing	11.25	0.28	3	Private
48	Lot 4 DP 739850	Grazing	26.09	1.04	4	Private
49	Lot 2 DP 620160	Grazing	20.20	0.68	3	Private
50	Lot 8 DP 249776	Grazing	0.06	0.04	64	Private
51	Lot 4 DP 589387	Grazing	52.24	0.05	0.1	Private
52	Lot 10 DP 875853	Rural residential	1.86	0.03	2	Private
53	Lot 11 DP 875853	Grazing	7.60	0.15	2	Private
54	Lot 1 DP 249776	Forestry	14.03	0.42	3	Private
55	Lot 4 DP 249085	Grazing	20.62	3.17	15	Roads and Maritime
56	Lot 2 DP 829213	Grazing	19.31	0.66	3	Private
57	Lot 3 DP 249085	Grazing	21.72	0.57	3	Private
58	Lot 1 DP 249085	Grazing	2.91	0.83	28	Private
59	Lot 27 DP 131007	Grazing	18.32	3.16	17	Private
60	Lot 93 DP 130760	Equestrian activities	23.76	1.30	5	Private
61	Lot 5 DP 582148	Grazing	15.79	0.70	4	Private
62	Lot 12 DP 130822	Grazing	0.55	0.05	10	Private
63	Lot 11 DP 130822	Grazing	1.36	0.10	7	Private
64	Lot 1 DP 130825	Grazing	10.40	0.67	6	Private
65	Lot 2 DP 882059	Grazing / conservation area	34.91	1.36	4	Private
66	Lot 630 DP 882833	Open space / park / bushland	6.62	0.13	2	Shoalhaven City Council

Property reference	Lot and DP	Predominant land use	Total lot size (hectares)	Area of direct impact (hectares)	Percentage of lot directly impacted	Ownership
67	Lot 1 DP 838336	Rural residential	1.08	0.05	5	Private
68	Lot 2 DP 806783	Open space / park / bushland	0.34	0.09	27	Roads and Maritime
69	Lot 11 DP 776413	Open space / park / bushland	0.53	0.14	27	Roads and Maritime
70	Lot 5 DP 619493	Hotel	0.37	0.10	27	Private
71*	Lot 163 DP 827651	Road reserve	0.11	0.11	100	Roads and Maritime
72*	Lot 162 DP 827651	Road reserve	0.15	0.15	100	Roads and Maritime

Lots that are currently owned by Roads and Maritime and form part of the existing road reserve. These lots have been identified but have not been included in the property acquisition calculations required for the proposal.

Land use severance and sterilisation

Land use severance is defined as the creation of a physical barrier between a property and an existing road access to that property from an external road network or between one part of a property and another part of the same property. A number of properties would be subject to varying degrees of land use severance as a result of the proposal given that strip acquisition would be required along the length of the proposal. These impacts would relate to changes to external property access and are detailed below. Given the strip acquisition, no parts of the same property would be severed by the proposal.

Land use sterilisation occurs when properties and their land use are severed into a size or shape that makes on-going use of that land for that purpose unfeasible. As stated above, only strip acquisition would be required for the proposal and no properties would be severed by the proposal. As a result land use sterilisation impacts are not expected as a result of the proposal.

Changes in external property access

External property access refers to the connection of a property to the external road network. This may be a direct driveway connection at the property boundary, via a private road, or by a right of way access through a neighbouring property.

All property accesses that connect directly to the existing highway in the proposal area would be impacted by the proposal. The central median barrier would restrict all property accesses directly connected to the proposal to left-in left-out movements. Further details on these restrictions, impacts to travel times and u-turn facilities are provided in **Section 6.1**.

A total of 16 properties that currently have direct access to the existing highway would have physical changes to their external access. This could involve connection to a different location on the highway, connection to a local road or connection to an interchange or u-turn facility. Details of these physical changes to property accesses are provided in **Table 6-52**.

Table 6-52 Physical changes to external property access

Property reference / Lot and DP	External access changes
15	The property is currently provided with access to the existing highway. The existing access would be realigned to a new location around 70 metres to the north to accommodate the acceleration lane from the heavy vehicle inspection bay. Direct access to the highway would be maintained.
23, 24, 28 and Lot 3 DP 715639	Four properties are currently provided with access to Jaspers Brush Road via a private access road. The private access road would be realigned to accommodate the Jaspers Brush Road and Strongs Road grade separated facility. The new access road would connect to the overbridge between Jaspers Brush Road and Strongs Road. The connections between the four driveways and the private access road may also require realignment.
20	The property is currently provided with access to Strongs Road. The proposal would provide access to this property via the driveway that would connect to the link road/overbridge between Jaspers Brush Road and Strongs Road. This driveway would therefore provide access to the highway via either Strongs Road or Jaspers Brush Road.
31	The existing driveway provides direct access to the existing highway. The proposal would provide property access to an unnamed laneway, which would be realigned slightly east of its existing location.

Property reference / Lot and DP	External access changes
30	The property is currently provided with direct access to the highway. The proposal would provide property access to the u-turn facility at about chainage 23200. The driveway would be realigned slightly to the east of existing driveway.
Lot 1 DP 233455, 37	The two properties are currently provided with individual access to the existing highway via separate driveways. The proposal would provide property access to both properties via individual driveways connected to the u-turn facility at around chainage 24000.
42	The property is currently provided with direct access to the highway. The proposal would provide a private access road of around 250 metres in length that would connect to Devitts Lane.
Lot 3 DP 739850	The property is currently provided with direct access to the highway. The proposal would provide a private access road that would connect to Morschels Lane.
49	The property is currently provided with access to both the existing highway and Lamonds Lane. Following the proposal access would only be provided via Lamonds Lane. Direct access to the highway would be closed to accommodate the deceleration lane for Lamonds Lane.
55	The property is currently provided with direct access to the existing highway. The proposal would maintain direct access to the highway via the driveway that would be realigned around 300 metres north to accommodate the northbound on-ramp for the Pestells Lane and Meroo Road grade separated half-interchange.
57	The property is currently provided with direct access to the existing highway. The proposal would maintain direct access to the highway via the driveway that would be realigned about 150 metres to the north to accommodate the Meroo Road southbound deceleration lane.
64	The property is currently provided with direct access to the existing highway. The proposal would provide access to this property via the u-turn facility at around chainage 28950. The continuation of the driveway connected to the u-turn facility would be in the same location as the existing driveway.

Land use viability

Agricultural land

As shown in **Table 6-51**, the majority of land that would be required for acquisition as part of the proposal is agricultural land used for grazing. This land is generally Class 2 agricultural land and is used for grazing for dairy and beef production.

Around 40 hectares of agricultural land would be acquired as a result of the proposal. This would include partial acquisition of land used for grazing, viticulture, forestry, turf farming and equestrian activities. The majority of acquisition would occur directly adjacent to the existing highway and would only require a small percentage of each lot to be acquired and incorporated into the road reserve for the proposal.

Impacts to the viability of the majority of agricultural properties would not be expected as a result of the proposal as:

- The amount of land to be acquired would generally be only a small percentage of the overall lot size.
- Land use sterilisation impacts would not be expected, given that the required acquisition would be adjacent to the existing highway and would not inhibit the use of residual land for agricultural purposes.

Potential impacts as a result of property acquisition may occur at one property (property reference number 3) used for horse agistment. The majority of the property is low lying with high ground being located near the existing highway. Stock is moved to this land during a flood event. The high ground would be partially impacted by the strip acquisition required for the proposal, however the level of this impact is not known at this stage.

As well as this, as shown in **Table 6-51**, there are three small privately owned agricultural lots that would be impacted in their entirety. These lots range in size from 0.2 hectares to 1.7 hectares and form part of larger agricultural properties. As a result the overall land use of the property as a whole would be maintained. For example, one lot near O'Keefes Lane (property reference number 14) would be acquired in full. This is a small lot with a total lot size of 0.2 hectares that forms part of a larger agricultural property which operates as a turf farm. Impacts to the viability of the turf farm operation would not be expected as a result of this acquisition.

Rural residential land

Rural residential properties along the proposal are generally smaller properties that are not used for agricultural purposes. As detailed in **Table 6-51**, small areas of partial acquisition would be required at a number of rural residential properties. Of these lots, one dwelling (property reference number 23) would require demolition as a result of the proposal. Impacts to dwellings on other residential properties would not be expected and as such land use impacts to rural residential properties would be unlikely.

Partial acquisition would be required at the hotel located adjacent to the highway near Jaspers Brush Creek (property reference number 16). However, only 0.04 hectares of the property would be required for the proposal which equates to two per cent of the total lot size. As a result, impacts to the viability of the hotel would not be expected.

Urban areas

The area of Bomaderry just north of Cambewarra Road is the most urbanised and densely populated section of the proposal area. However, the majority of land required for the construction of the proposal is already included in the road reserve, limiting the need for acquisition. Therefore, land use and property impacts in this area would be minimal.

Direct impacts would occur at three properties in the urban area just north of the roundabout at Cambewarra Road. Property numbers 68 and 69 are currently used as open space and are already owned by Roads and Maritime. Partial acquisition would be required at property number 70 which forms part of the hotel that is situated on the adjoining lot. The hotel's buildings and facilities would not be impacted by the acquisition required for the proposal therefore impacts to the viability of the hotel would not be expected.

6.9.4 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or mitigate the identified impacts of the proposal on property and land use. These measures are presented in **Table 6-53** and are summarised in **Section 7.2**.

Table 6-53 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
Loss of agricultural land for use as ancillary sites.	Strip and stockpile topsoil during the preparation of any ancillary sites.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Reinstate topsoil as part of the rehabilitation of these areas for ongoing agricultural use.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
Traffic disruptions and changes to property access.	Undertake consultation and regularly communicate with affected landowners and residents where temporary property access changes would be required.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Provide property owners and residents with advanced notification of construction schedules and any changes to local roads and property access.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Provide community updates on changes to the local road network during construction, in accordance with the Traffic Management Plan detailed in **Section 6.1**.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
Operation			
Permanent acquisition of land.	Acquire land for the proposal in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* and Roads and Maritime's 'Land Acquisition Information Guide' (RTA, 2011).	Roads and Maritime project manager	Pre-construction
	Continue consultation with all affected property owners regarding property acquisition during the detailed design of the proposal.	Roads and Maritime project manager	Detailed design and Pre-construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
	Complete property adjustments for fencing, access tracks and other farm infrastructure in consultation with property owners.	Roads and Maritime project manager	Pre-construction
Changes to external property access.	Relocate property accesses that are lost as a result of the proposal in consultation with affected land owners.	Roads and Maritime project manager and construction contractor	Detailed design and pre-construction
Land use impacts	Continue consultation with the property owner (property reference number 3) whose high ground would be partially impacted by strip acquisition. This consultation would determine the likely level of impact from the proposal and potential mitigation measures or acquisition would be negotiated with the property owner.	Roads and Maritime project manager	Detailed design and pre-construction

6.10 Socio-economic issues

This chapter provides an assessment of the socio-economic impacts of the proposal, and is supported by the *Technical Paper: Socio-economic issues* (AECOM, 2013). The technical paper is provided at **Appendix K**.

6.10.1 Existing environment

The study area for this assessment includes the road corridor itself, as well as those lands immediately adjacent to it. The wider catchment is also considered as it relates to current usage of the Princes Highway, for example for trips between Sydney and the NSW South Coast. The study area is situated entirely within the Shoalhaven LGA.

Nowra is a regional centre for government, administrative, retail and commercial activity in the Shoalhaven region. Bomaderry contains a mix of heavy industrial, commercial and residential uses.

The existing social and economic environment of the study area includes the consideration of:

- Socio-demographic indicators.
- Community character, including community values.
- The economic environment, including:
  - Agricultural businesses.
  - Non-agricultural businesses.
  - Tourism and tourist related businesses.
- Travel patterns.
- Community facilities.

Socio-demographic profile

The study area has been profiled by examining Australian Bureau of Statistics (ABS) data for the State Suburbs of Meroo Meadow, Jaspers Brush and Bomaderry.

Key socio-economic characteristics of the study area include:

- The population of the study area declined between 2006 and 2011, however there was a five per cent increase in the population of the Shoalhaven LGA over the same period. Modest growth is expected in the Shoalhaven LGA between 2011 and 2036, with the majority expected to be concentrated in Nowra and Bomaderry.
- The median age of the population in the study area ranges between 43 and 49 years. The median age in both the study area and the Shoalhaven LGA was higher than the median age in NSW. The study area also has a higher proportion of the population aged over 65 compared with NSW, which may indicate that the area is favoured by retirees.
- The proportion of Indigenous population has increased in the study area between 2006 and 2011. In the study area, 6.8 per cent of the population is Indigenous, which is higher than both the Shoalhaven LGA and NSW.
- The study area and Shoalhaven LGA are relatively homogenous with over 95 per cent of the population speaking English at home.
- The majority of people (around 90 per cent) in the study area and the Shoalhaven LGA travel to work by car.

- In 2011, Bomaderry had a total workforce of 2555 people; Jaspers Brush had 181 and Meroo Meadow 187. The largest employment category in Bomaderry and Jaspers Brush was health care and social assistance. The largest industry of employment in Meroo Meadow was agriculture, forestry and fishing. The unemployment rate in the study area was 8.3 per cent which is higher than NSW at 5.9 per cent.
- In 2011, the study area had an average of 2.5 people per household. The Shoalhaven average is 2.3 people per household and the NSW average is 2.6 people per household. The majority of occupied dwellings in the study area and the Shoalhaven LGA are separate houses. Almost a third (30 per cent) of houses in the study area are rented, 38.8 per cent are owned outright and 28.3 per cent are owned with a mortgage.

In summary, the study area has a homogenous and ageing population. A higher median age and a higher proportion of the population aged 65 and older suggests a link to the retiree market. Given that health care and social assistance is the largest employer, it is assumed that the labour force is employed in service industries that support the ageing population. Although the population fell between 2006 and 2011, it is expected to grow over the next 20 years, particularly in Nowra-Bomaderry.

Community character

The study area is predominantly rural in character, consisting mainly of large lot agricultural holdings. Traditionally, agriculture has been dominated by the dairy industry, but more recently, wineries and equestrian activities have become increasingly prominent in the sector.

Bomaderry contains a mix of heavy industry, commercial and residential land uses. It has the highest population and dwelling density (8.3 persons and 3.55 dwellings per hectare) within the Nowra-Bomaderry centre. Retail, commercial and industrial businesses are predominately located near the Bomaderry (Nowra) railway station, Meroo Street. Community infrastructure in Bomaderry consists of several educational facilities, places of worship, open space, a community centre, sporting and recreational facilities, and clubs.

The historically active localities of Jaspers Brush and Meroo Meadow are today an agglomeration of rural residential allotments. The Meroo Union Church at Meroo Meadow is active and used for weddings, functions and ceremonies of worship.

Community values

Community consultation has been undertaken over the past six years during the route selection and planning stages of the proposal (refer to **Chapter 5** for further details). Consultation has shown that the local community places high value on the visual amenity of the region and considers the pastoral surroundings to be an economic asset for both its agricultural productivity and because it draws tourists to the area. The community also value the existing community spirit, support and cohesion as well as the area's recreational facilities and open space. These elements make up the lifestyle qualities that have attracted people to the region.

Economic environment

The economic environment of the study area is dominated by agricultural businesses. The tourism industry and businesses within Bomaderry also form an important part of the economy of the study area. There is no evidence that there are any trucking or similar transport related business within the study area, however; the trucking industry would generally use this road as a thoroughfare. Impacts of the proposal on traffic and transport are detailed in **Section 6.1**.

Agricultural businesses

Agricultural land within the study area is used for dairy and beef production, viticulture, turf farming, horse agistment and other equestrian activities, forestry and organic farming. The dairy industry is the largest economic contributor in the region. The dairy farms located in the northern section of the study area, near Berry, generally supply the Berry Rural Cooperative, which trades as the South Coast Dairy Cooperative. The dairy farms located in the mid and southern parts of the study area generally supply the Shoalhaven Dairy Cooperative.

The different types of agricultural land uses and the classifications of agricultural land within the study area are detailed in **Section 6.9**. The majority of agricultural land within the study area is Class 3 land, which is suitable for grazing and has a moderate overall production level, for activities such as horticulture and viticulture.

The two commercial vineyards between Berry and Bomaderry, Jasper Valley Wines and Silos Winery are also tourist attractions offering function centres, accommodation and restaurants in addition to wine tastings and wine for purchase.

Non-agricultural businesses

Between Berry and Bomaderry, most businesses are primarily agricultural in nature. Silos Estate, whilst primarily agricultural, operates a restaurant, an art gallery and a function facility. The Woodbyne Private Hotel, which is located in Jaspers Brush on the Princes Highway operates as a bed and breakfast catering for both tourists and highway through traffic.

Businesses in Bomaderry are generally clustered near the roundabout at the intersection of the Princes Highway and Cambewarra Road. These businesses cater mainly for local residents but also serve visitors and highway through traffic. These businesses include a restaurant, child care centre, motel, caravan park, homes showroom, a charitable organisation and a service station.

In a broader context, Nowra and Bomaderry are considered to form the major regional employment centre within the Shoalhaven LGA. Businesses within Bomaderry, not located immediately adjacent to the Princes Highway, include a steel works, an ethanol refinery, a packaging plant and a paper mill. These as well as other commercial and industrial businesses are generally located near the Bomaderry (Nowra) railway station.

Tourism

Tourism is an important part of the economy of the NSW South Coast region. Nearly a quarter of all businesses serve this sector as opposed the national average which was around 20 per cent in June 2009. Employing businesses, which employ staff as opposed to sole traders, comprise 54.8 per cent of all tourism businesses in the region, compared to the national benchmark of 39.7 per cent.

The number of visits to the NSW South Coast continues to increase. In the year ending 30 September 2011, international visitation to the area increased by 13 per cent over the previous year, with an expenditure in excess of $190 million. In this year, the Shoalhaven LGA also received 1.2 million domestic visitors, an increase of 11 per cent over the previous year. Domestic overnight and day visitors to the area injected $617 million into the local economy, supporting 6000 jobs. Nationally, the Shoalhaven area ranks as the third most visited LGA behind the Gold Coast and Sunshine Coast.

A desktop review and site visit identified 15 accommodation providers in the study area, including the two vineyards, Jasper Valley Wines and Silos Winery. Four accommodation providers currently have direct access to the Princes Highway. There are 11 accommodation providers along ‘The Sandtrack’ as well as three vineyards, Two Figs Winery, Mountain Ridge Wines and Coolangatta Estate.

The tourism sector is therefore important to the study area both in terms of economic activity and job creation.

Travel patterns

The Princes Highway is the main route for traffic between Sydney and the NSW South Coast. It is a major freight and tourist route and also serves commuters travelling to Sydney, Wollongong and Nowra as well as locals travelling between smaller towns. The importance of the highway as a tourist route is confirmed by the highest traffic flows recorded on weekends and during holiday periods (refer to **Section 6.1**).

Outside the study area, the 'Sandtrack' between Gerringong and Bomaderry is used by light vehicle traffic to avoid delays behind slow moving heavy vehicles (which are prevented from using the 'Sandtrack' by a five tonne load limit). There is currently a 55 per cent / 45 per cent split of traffic using the Princes Highway / 'Sandtrack'.

Travel in the study area is dominated by private car use. There are eight bus services in the area per weekday, including four school services. Rail mode share is low because Bomaderry is the last stop on the South Coast Railway line to Wollongong and Sydney and services are infrequent.

There are no formal cycle specific facilities along the existing highway or in Bomaderry. An alternative route between Berry and Bomaderry via Back Forest and Meroo is promoted by Shoalhaven City Council. There are limited opportunities for pedestrian trips around the study area due to the high speed environment of the existing highway, the lack of a footpath and the distance between settlements.

Community facilities

Nowra provides primary facilities and services such as hospitals, emergency services and utilities. Bomaderry has a number of smaller and secondary facilities and services that complement the facilities and services available in Nowra.

Along the proposal, community facilities are mainly concentrated at the corner of the Princes Highway and Cambewarra Road in the southern part of the study area. The William Campbell Foundation, a charitable organisation that is licensed to accommodate and support children and young people in out-of-home care, is located next to the child care centre on the Princes Highway in Bomaderry.

On the corner of the Princes Highway and Boxsells Lane in Meroo Meadow is the Meroo Union Church, a non-denominational place of worship. It is one of two churches given to the community by David Berry in 1889.

6.10.2 Potential impacts

Construction

The following socio-economic impacts would potentially occur during the construction of the proposal:

- Amenity impacts.
- Impacts to community cohesion and severance.
- Impacts on traffic conditions and access arrangements.
- Economic impacts.

Amenity impacts

Amenity impacts include any factors that affect the ability of a resident, visitor or business owner to enjoy their home and daily activities, for example, noise, vibration, detrimental changes to views or changes to air quality. Amenity impacts during construction of the proposal are discussed in detail in **Section 6.2**, **Section 6.6** and **Section 6.12**.

The bulk of construction activities would take place between 7am and 6pm, Monday to Friday and between 8am and 1pm Saturday, with no work on Sunday or public holidays. However, certain activities would be required to take place during the evening and night-time periods due to technical, safety and traffic management considerations (refer to **Section 3.4.2** for further details). This has potential to disturb the sleep of local residents.

During construction, around 27 receivers would be highly affected by noise from earthworks and around 31 receivers would be highly affected by noise from paving works. Elevated noise levels from construction could disturb residents in their day-to-day activities. However, as detailed in **Section 6.2**, these activities would not be carried out continuously. Noise impacts from construction traffic are expected to be negligible. Refer to **Section 6.2** for further details.

Dust would be generated during the construction of the proposal from excavation and stockpiles at temporary construction ancillary facilities. As discussed in **Section 6.12**, it is predicted that average dust levels would exceed the minimum criteria at eight receivers. However, the actual impact is expected to be lower given the conservative assumptions used in this assessment, such as simultaneous stockpiling on all ancillary sites over a 12 month period, which is unlikely to occur, and with the implementation of appropriate mitigation measures detailed in **Section 6.12.4**.

The construction phase would also create visual impacts to road users and to residents of rural properties in the vicinity, not only from road works but also from associated materials stockpiles adjacent to the corridor. Construction ancillary facilities would be temporary and the majority would not be used simultaneously across the construction period. Where required, these sites may be subject to remediation and would be able to be returned to their original use following construction.

Residents of the study area would experience the construction phases of the Gerringong upgrade and Foxground and Berry bypass projects prior to experiencing the impacts associated with this proposal. As a result, there is the potential for residents and motorists to experience construction fatigue, especially residents in the Jaspers Brush area, near the southern end of the Foxground and Berry bypass project.

Community cohesion and severance

Construction of the proposal has the potential to impact on community cohesion, if it results in physically alienating sections of the community, even on a temporary basis. Potential severance impacts that could arise during construction of the proposal are limited to Meroo Meadow and the approach to Bomaderry.

Community severance of properties along Lamonds Lane and the northern section of the highway at Meroo Meadow from the Meroo Union Church may occur during the construction phase of the proposal. Community groups and worshipers who meet at this church at the corner of Boxsells Lane and Princes Highway may have their travel to and from this destination temporarily disrupted during this time.

There would be negligible impact on community cohesion at the southern end of the route near Bomaderry as there is currently limited cross-highway community interaction due to restricted property access onto the highway for residences and businesses to the east.

Access to public transport may be temporarily disrupted during the construction phase of the proposal. The current bus stop at the corner of Princes Highway and Croziers Road, Jaspers Brush and the bus stop north of Mullers Lane along the Princes Highway would be relocated and incorporated into one bus stop at Mullers Lane. In addition, these bus stops currently facilitate school buses as well as informal collection of school children from property accesses. During the construction period, access to these bus stops, and therefore to public transport, may be limited and could potentially result in increased journey time for commuters.

Consultation with those people who may be affected by changes during construction has aimed to reduce uncertainty by providing relevant information and an opportunity to become aware of, suggest improvements to and adjust to the changes. Elderly residents are particularly affected by uncertainty. The study area includes a higher than average proportion of elderly residents compared with the rest of NSW, so it is particularly important to mitigate this impact by providing early and ongoing information, as described in the mitigation measures in **Section 6.10.3**.

Traffic conditions and access arrangements

During construction, temporary access changes would be required at some properties. These changes would generally be consistent with the changes required for the operation phase of the proposal and are discussed below in further detail.

Roads and Maritime would aim to maintain an 80 kilometre per hour speed limit through the construction zones for the proposal. However, traffic efficiencies would be reduced during construction for both local and regional commuters and there would be potential for delays due to local road closures and detours. As described in **Section 6.1.4**, construction traffic impacts would be managed through consultation and the implementation of a traffic management plan.

Economic impacts

Potential negative business impacts include changes to the volume of traffic on the existing route and therefore passing trade, but these are balanced by the economic impacts of investment in the construction of the road, at a local, state and national level.

The proposal would be constructed in a way that would maintain access to residences and businesses throughout the construction phase of the proposal. Access arrangements may change during construction but access to properties would be maintained. Access to businesses and therefore trade would not be directly affected during construction.

Construction of the proposal is estimated to cost approximately $281 million. However, during the construction phase of the proposal, it is estimated that the proposal would generate income of $45.8 million for those directly involved with the construction of the proposal and in those businesses that directly supply labour and materials for construction. The total number of full-time equivalent positions generated during the construction phase could be up to 330 and the direct contribution of the proposal to the economy would be of $75 million. The total output impact of the proposal at the national level is estimated to be $624 million, of which $621 million occurs within NSW.

At a local level, the flow on economic impact of the proposal would include construction worker expenditure over the construction period, which would benefit local services in the vicinity of the highway, such as cafes and takeaways in Nowra and Berry, service stations, trades and services suppliers and potentially some accommodation providers. The expenditure of construction workers would potentially have further flow on effects to other businesses in the area.

Potential delays during construction may encourage a small proportion of drivers to divert to the 'Sandtrack', but this is not expected to have a considerable impact on turnover as businesses in the area are not dependent on passing trade, with the possible exception of the service station located on the Princes Highway at Bomaderry. The service station may be impacted by altered access conditions for a short period during construction. The Gerringong upgrade and Foxground and Berry bypass projects are expected to attract greater volumes of diverted traffic and these would be in place prior to construction of the proposal. Potential visitors to the area may perceive that construction works would create an impact on amenity and their enjoyment of their stay, which may discourage them from visiting the area. This may impact local businesses in the tourism sector.

Agricultural businesses

During the construction phase, agricultural business could potentially be impacted by the need to store materials or locate site offices adjacent to the highway corridor on land used for agricultural purposes.

Some temporary losses of productive agricultural land for these ancillary uses are anticipated as a result of the proposal. A number of the proposed temporary construction ancillary sites are currently owned by Roads and Maritime, others are not and would need to be leased or acquired for the proposal.

Land acquired that lies outside of the operational highway corridor may be repackaged and sold on completion of the proposal. Therefore, once rehabilitated and if practical, there would be potential for the temporary construction ancillary sites to be returned to their previous use once construction of the proposal is complete.

Operation

The following socio-economic impacts would potentially occur during the operation of the proposal:

- Amenity impacts.
- Impacts to community cohesion and severance.
- Impacts on traffic conditions and access arrangements.
- Economic impacts.

Amenity impacts

Amenity changes associated with the proposal would potentially be associated with changes to the visual amenity, air quality and noise levels in the study area.

The proposal would follow the alignment of the existing highway, but the increased scale of the proposal, which includes an increased footprint, increased elevation and large new structures at grade-separated facilities and a half-interchange would increase amenity impacts for residents in proximity to the route. As detailed in **Section 6.6**, the design of the proposal minimises the visual impacts by the use of cuttings and setting bridges as low in the landscape as practicable, whilst still providing a highway free from flooding in events up to the 1 in 100 year flood event.

Visual impacts to residents would not only result from the increased scale of the highway as a result of the proposal but also the removal of vegetation and the introduction of a heavy vehicle inspection bay at Jaspers Brush. **Section 6.6** assesses the proposal as having a moderate visual impact. Residents living close to the alignment may perceive impacts to their privacy if vegetative screening is removed and the road is physically closer than before. The mitigation measures provided in **Section 6.6.4** would assist in minimising these impacts.

Air quality impacts in the study area as a result of the proposal are expected to be negligible (refer to **Section 6.12** for further detail).

There are around 59 residences or businesses that would be eligible for the consideration of noise mitigation where feasible and reasonable. The affected residences are located both in the rural areas along the proposal and in Bomaderry. A childcare centre at Bomaderry would also experience increased noise levels. Mitigation measures for noise impacts are described in **Section 6.2**.

Community cohesion and severance

The proposal has the potential to impact community cohesion in both positive and negative ways. In a positive way, it has the ability to bring communities closer together through the provision of safer access routes, but in other locations it may interrupt access to facilities and the ability of individuals or groups to interact.

The proposal, which follows the existing highway alignment, has been designed to minimise impacts on the community identity of Jaspers Brush, Meroo Meadow and Bomaderry. Land acquisition is not expected to impact the sense of belonging in those communities.

None of the heritage buildings in the study area that contribute to the identity of localities would be directly affected as a result of the proposal (refer to **Section 6.8**). The Meroo Union Church is the last remaining public building in the Meroo locality and the maintenance of the church is funded by revenue from weddings and other events. The Friends of Meroo Union Church are concerned that the impact on views from the church would impact the number of bookings, the revenue and therefore the ability to maintain this heritage item. The highway would be widened in this location but the distance to the carriageway from the Church would not alter greatly. The roadside pine trees would be retained, which would minimise the impact.

The cultural landscape in the study area would be impacted by the proposal due to the size and scale of the proposal and its associated structures. However, the design follows the existing highway alignment which has historical roots as the original access route through the area used since the nineteenth century. As a result, the historical route is reinforced as a result of the proposal (refer to **Section 6.8**).

The proposal has the potential to cause severance of local communities once operational, if communities are permanently prevented from interacting across a physical or perceived barrier. The proposal would follow the existing highway alignment but as the footprint is wider due to the increased number of lanes and the median separation, there is potential to increase severance in communities that are located on both sides of the highway. However, localities such as Jaspers Brush and Bomaderry presently have limited community interaction across the existing highway and are not expected to be adversely affected by the proposal. The negative impact of severance would be balanced by the positive impact of improved safety for residents and visitors to these locations.

The proposed relocation and incorporation of the bus stop at the corner of Princes Highway and Croziers Road, Jaspers Brush and the bus stop north of Mullers Lane along the Princes Highway, have the potential to impact members of the community wishing to travel south towards Bomaderry. The new incorporated bus stop is proposed to be located at Mullers Lane as part of the proposed bus stop / u-turn bay. The additional round trip for someone to walk from the original Croziers Road bus stop as a result of the proposal would be around one kilometre. The proposed relocation of these bus stops has the potential to impact community cohesion by physically alienating sections of the community, particularly the elderly and less mobile members who are adversely affected by the increased walk time. The bus stop on Mullers Lane in a bus stop / u-turn bay has the potential to increase safety of bus commuters, including school bus commuters, by relocating the bus stop off the highway and on to a quieter side road. Pedestrian safety would also be improved through the separation from general traffic via the outside shoulder.

As detailed in **Section 6.9**, potentially directly impacted properties would be considered for partial or full acquisition by Roads and Maritime, and discussions have commenced with affected landowners. Where only a part of a property is required for the proposal, Roads and Maritime would generally seek to acquire only that part needed for the proposal. The majority of land that would be acquired is currently used for rural purposes.

Wherever reasonably practicable, the proposal has been sited to avoid direct impact on dwellings. The road boundaries for the concept design would require demolition of one rural residential dwelling located on a hobby farm.

Traffic conditions and access arrangements

Changes to the local and regional road network would generally relate to the changed functionality of local roads and property accesses. Changes to local roads are provided in **Section 3.3** and the descriptions of the physical changes to property accesses are provided in **Section 6.9**. Detailed assessment of changes to traffic movements is provided in **Section 6.1**.

Access arrangements such as right-in / right-out restrictions, access routes and driveway alterations would impact about 32 properties along the route. Access would be maintained to residences and businesses although the arrangement of the access may change. There are around 16 properties in the study area that would experience physical modifications to property access as a result of the proposal (refer to **Section 6.9**). Consultation with business and property owners would continue to ensure that revised accesses would accommodate vehicles required to visit the properties, such as milk trucks. Junctions, grade-separated facilities and the grade-separated half-interchange along the proposal would be designed to accommodate heavy vehicles likely to service businesses in the area.

The introduction of a median and a central wire rope median barrier would provide substantial improvements in road safety, including the elimination of traffic turning to and from minor roads across fast-moving two-way traffic. However, it would also limit property access and local road access to the highway to left-in / left-out movements only, adding travel time to trips to and from affected properties of up to about four minutes. The proposal would reduce travel times by approximately one minute for trips between Berry and Bomaderry which would offset some of the additional travel time incurred as a result of changes to access. The cumulative travel time saving for users of the entire Gerringong to Bomaderry route following the Gerringong upgrade and Foxground and Berry bypass projects and this proposal is approximately 10 minutes. Further details regarding access arrangements, travel times and general traffic impacts are provided in **Section 6.1**.

Drivers affected by right turn restrictions would be required to utilise one of five u-turn facilities, the grade separated facilities at Morschels and Devitts lanes or Jaspers Brush Road and Strongs Road or the grade separated half-interchange at Pestells Lane. At Croziers Road, a right turn facility and u-turn bay would be available for southbound traffic, but traffic leaving Croziers Lane and wishing to travel south would first need to travel north to Mullers Lane and use the u-turn facility. Emergency vehicles would be able to use both the u-turn facility, grade separated facilities and the grade separated half-interchange in addition to dedicated emergency cross over facilities across the highway at three locations.

An upgraded intersection including a u-turn bay at Silos Winery at Jaspers Brush would permit left-in / left-out movements and provide a right turn lane for southbound traffic. This would greatly improve safety for employees, visitors and delivery vehicles that access the site as well as other users of the highway. In addition, the proposed opposing right turn bays at Boxsells Lane would permit southbound traffic to enter Boxsells Lane and access the Meroo Meadow Union Church. The intersection would improve safety for residents and those who access the church facilities on Boxsells Lane.

Reduced travel times on the route would benefit bus users (not including the additional travel time to bus stops) and those travelling to railway stations. School bus safety would improve by limiting stops to certain locations away from the highway, although this could cause some inconvenience to existing users. Cycle safety would also be improved as the wider shoulder would provide a greater distance between cyclists and vehicles. Pedestrian and cycle safety on the ‘Sandtrack’ would also improve as a result of reduced traffic volumes once traffic diverts to the proposal.

Economic impacts

Improved connectivity to the NSW South Coast would enhance business opportunities in the area and support the existing agricultural and tourism industries. Industries in the Nowra area would also benefit from improved accessibility to markets and raw materials in Sydney and Wollongong.

Reducing travel time and improving safety on the Princes Highway may lead people to enter the labour market in the study area or move to more productive jobs as a result. When people make decisions about whether or not to work, where to work and how much to work, they take into account not only the wages on offer, but also lifestyle costs associated with each option such as time forsaken, commuting costs and stress. High commuting costs can lead workers to work less or work in less productive and lower paid jobs than they otherwise would.

Non-agricultural local businesses, such as the motels and caravan parks, and the service station located on the Princes Highway at Bomaderry are to some extent reliant on passing trade. Changes in access to these businesses to enable left-in / left-out movements only, are not expected to impact levels of passing trade, turnover and employment, as customers can use u-turn bays provided at frequent intervals along the route and grade-separated facilities to reach the businesses. The wineries and accommodation providers located along the 'Sandtrack' are also not reliant on passing traffic for visitors. A reduction in trade would not be expected at 'Sandtrack' businesses. The service stations along the 'Sandtrack' are situated within the town of Bomaderry and are not perceived as directly reliant on passing trade.

Agricultural businesses

The majority of property acquisition required for the proposal would affect agricultural land. This acquisition has the potential to impact on the economic productivity and viability of agricultural businesses. Specifically, the productivity of agricultural businesses could be affected by:

- Loss of productive land.
- Changes to the size and shape of paddocks.
- Changes to farming conditions as a result of the road development affecting flooding behaviour and water supply.
- Changes to external access and access between different parts of the property.

There are 50 agricultural properties which would be affected by land acquisition. The majority would be affected by strip acquisition, which is unlikely to affect the productivity or viability of the land. Agricultural properties subject to acquisition would not be affected by fragmentation, or severance of high quality land. No changes to stock underpasses or to access between different parts of properties are expected.

There are three agricultural properties that would experience relatively substantial land acquisition at the Pestells Lane grade-separated half-interchange. However, the acquisition would be unlikely to result in the severance or fragmentation of these properties. One property is used for horse breeding, another for dairy farming and the third may be used for horticulture in the future but currently has no commercial use. Land acquisition at the latter two properties is not expected to affect the viability or profitability of current or future operations or the dairy cooperatives or dairy industry as a whole. The owners of the horse stud have raised concerns that land acquisition, proximity of the highway and changes to drainage patterns may affect the viability of the business and the safety of the employees and horses when riding on the property. These issues would be further investigated during the detailed design phase of the proposal. Proposed mitigation measures are presented in **Table 6-54**.

The proposal would directly impact a residence located on a hobby farm property at Jaspers Brush. The impact on the current dwelling is to such an extent that the dwelling would need to be demolished. Roads and Maritime has had initial discussions with the affected property owners, and subject to determination of the proposal, it is expected that the whole of this property would be acquired.

Property owners have highlighted concerns relating to changes to drainage and flooding patterns which could affect the ability to use certain paddocks. Flooding impacts to rural properties as well as proposed mitigation measures are discussed in **Section 6.5**.

Four businesses may be impacted by a change to the catchment of farm dams and therefore the water levels that can be stored for irrigation and to water livestock. Surface water runoff that would have previously flowed to the farm dams may be diverted around road cuttings or embankments thus leaving water levels in these dams lower than if the proposal did not proceed. This impact would be minimised through the implementation of mitigation measures presented in **Section 6.4.5**.

An objective for managing flood impacts is to confine flooding to land used for pasture, and as a result some agricultural businesses may be affected during a 1 in 100 year flood event. Certain agricultural properties would be less affected by major floods as a result of the proposal. Other properties would be affected by minor changes to the extent of the flooded area during a 1 in 100 year flood event or an increase in the depth of the water and therefore the time taken for the floodwater to dissipate would be greater for some properties used for silage and grazing. Further details and mitigation measures are provided in **Section 6.5**.

6.10.3 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or mitigate the identified socio-economic impacts. These measures are presented in **Table 6-54** and are summarised in **Section 7.2**.

Table 6-54 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
Community impacts	Implement a Community Involvement Plan to provide timely, regular and transparent information about changes to access and traffic conditions, details of future work programs and general construction progress throughout the construction phase of the proposal. Provide information in a variety of ways including letter box drops, media releases, an internet site and variable message signs. Set up a 24 hour hotline and complaints management process.	Roads and Maritime and construction contractor	Pre-construction and construction
Construction fatigue and noise impacts from construction works	Safeguards and management measures to address construction fatigue and noise impacts are described in **Section 6.2**.		
Dust impacts from construction works	Safeguards and management measures to address air quality impacts during construction are described in **Section 6.12**.		
Visual impacts of construction works	Safeguards and management measures to address visual impacts during construction are described in **Section 6.6**.		
Potential community cohesion and severance impacts	Continue consultation with the Friends of Meroo Union Church throughout the detailed design and construction phases of the proposal to develop and implement measures to minimise and mitigate amenity impacts on the church arising during construction.	Roads and Maritime project manager	Detailed design and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
	Continue consultation with bus commuters at Croziers Road and Mullers Lane bus stops, including parents/carers of school children, throughout the detailed design and construction phases of the proposal, to develop and implement measures to minimise impacts on access to public transport facilities during construction.	Roads and Maritime project manager	Detailed design and construction
Potential impacts from traffic delays and changed access arrangements	Advise residents, businesses and road users in a timely manner of any changes to road and property access arrangements.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	In consultation with affected property owners, residents and businesses, provide temporary or alternative access arrangements to affected properties, where required to maintain uninterrupted access.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Prepare and implement Traffic Control Plans to manage peak tourist/holiday traffic on Friday and Sunday afternoons and days immediately prior and following public holidays.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
Impacts on the viability of agricultural land	Carry out property acquisition in accordance with Roads and Maritime's 'Land Acquisition Information Guide' (RMS, 2012) and the *Land Acquisition (Just Terms Compensation) Act 1991*.	Roads and Maritime project manager and construction contractor	Pre-construction and post-construction
	Continue consultation with all affected property owners and agricultural business operators during detailed design and construction phases of the proposal to develop and implement measures to minimise and mitigate impacts on land use viability, farm operations and infrastructure.	Roads and Maritime project manager and construction contractor	Pre-construction and post-construction
	Continue consultation with the owner of the residence to be demolished (property reference number 23) during the acquisition phase in accordance with Roads and Maritime's 'Land Acquisition Information Guide' (RMS, 2012).	Roads and Maritime project manager and construction contractor	Pre-construction and post-construction
	Safeguards and management measures to address farm dam impacts are described in **Section 6.4**.		

Potential impacts	Safeguards and management measures	Responsibility	Timing
	Maintain both internal and external property access for agricultural businesses for the duration of construction. Should temporary or alternative access be required this would be agreed and provided in consultation with the affected property owner(s).	Roads and Maritime project manager and construction contractor	Pre-construction and post-construction
	Rehabilitate land as appropriate that has been acquired or leased for use as a temporary ancillary facility site for the construction, if it is not required during operations. Rehabilitate land for return to its previous use or for sale.	Roads and Maritime project manager and construction contractor	Pre-construction and post-construction
Operation			
Amenity impacts	Provide architectural treatments and other noise management measures as detailed in **Section 6.2**.		
	Implement the urban and landscape design strategy as detailed in **Section 6.6**.		
	Safeguards and measures to address visual amenity impacts during operation are provided in **Section 6.6**.		
Changed traffic and access arrangements	Safeguards and management measures to address changes to traffic and access arrangements are described in **Section 6.1**.		
Economic impacts to businesses and agriculture	Provide signposting to encourage highway traffic to visit tourist destinations and to indicate routes via u-turns to businesses on the other side of the carriageway. Signposting would be consistent with Roads and Maritime signposting guidelines.	Roads and Maritime project manager	Pre-construction and operation

6.11 Geology and soils

This section provides a description of the soil landscapes and geological features present within and surrounding the proposal and also includes a summary of the Phase 1 Environmental Site Assessment (Phase 1 ESA) undertaken for the proposal. This section also provides an assessment of potential impacts associated with the proposal as a result of the local soils and geology, as well as historical and existing areas of potential contamination concern. Measures to avoid, mitigate or manage these impacts have also been identified.

6.11.1 Methodology

Soils and geology

Geotechnical investigations have been undertaken to identify potential geotechnical, soil and fill issues for the proposal and to assist in identifying appropriate mitigation and management measures for the proposal's construction and operational phases.

Investigations into the surface, geological and soil characteristics of the construction footprint for the proposal were undertaken in 2007 as part of the route options development for the broader upgrade of the Princes Highway between Gerringong and Bomaderry, and in 2013 during the development of the concept design for the proposal. Geotechnical investigations included (but were not limited to) core drilling, piezometers, electric cone (piezocone), test pits and laboratory testing of soil and rock samples. The outcomes of these investigations were used to provide information about the local geological context of the proposal, and about the local soil landscapes present. In addition, the following information was used to inform this review of environmental factors:

- Soil Landscapes of the Kiama 1:100,000 Sheet Map and Report prepared by the former DCLM (Hazelton, 1992).
- Erosion and Sedimentation Management Procedure (RTA, 2008).
- OEH acid sulfate soil risk maps prepared by the former DLWC (DLWC, 1997).

Phase 1 environmental site assessment

A Phase 1 ESA was undertaken for the proposal by AECOM in 2013. The study area for the assessment comprises the construction footprint of the proposal, and the 71 separate lots which border the existing highway between Schofields Lane, Berry and Cambewarra Road, Bomaderry. There are also several properties outside the footprint of the proposal which have been included in the study area of the Phase 1 ESA due to the potential for contaminants to migrate from these properties into the road reserve. These properties include current and former petrol stations, mechanical workshops and auto repair buildings.

The Phase 1 ESA was undertaken to identify potential areas of contamination within the study area which may pose a potential risk to workers or the environment during construction of the proposal. The Phase 1 ESA included a site inspection, a review of geotechnical investigations, a review of historical aerial photographs, interviews and a review of land zoning maps. Additional sources were used to provide information about potential historical and existing sources of contamination in the study area, as well as context with regards to land use practices in the study area. These sources included:

- The OEH Contaminated Sites Register and POEO Licence Register for land within the study area.
- The NOW, Water Access Licence Register, for water bores registered within 500 metres of the proposal.
- Certificates of Title and for the 71 separate lots within the study area.
- Section 149 Planning Certificates for 10 properties within the study area.

Properties considered to have potential current or historical contaminating land uses or activities were identified through the review of aerial photographs and a site inspection. Where the landowner gave written consent, a search of the Stored Chemical Information Database (SCID) maintained by WorkCover was conducted to identify any existing or historical licenses or records for the storage of dangerous goods.

6.11.2 Existing environment

Soils

The OEH Soil Landscapes of the Kiama 1:100,000 Sheet (Hazelton, 1992) identified the presence of three soil landscape units within the proposal area (refer to **Figure 6-40**):

- Shoalhaven landscape unit, which corresponds to the creeks and floodplain areas associated with Broughton Creek.
- Nowra landscape unit, which includes the land on which the Bomaderry township is located.
- Coolangatta landscape unit, which largely corresponds to the undulating hills originating to the west of the proposal.

The Shoalhaven landscape unit is the dominant landscape unit across the Broughton Creek floodplain, and is characterised by fluvial soils comprising gravel, sand, silt and clay, derived mostly from sandstone and shale overlying buried estuarine sediments. The erosion hazard is rated as slight to low. Other limitations of the landscape unit include its low wet-bearing strength and potential for localised surface and mass movement.

The Nowra landscape unit is a shallow depositional unit comprised of low permeability silty and sandy clays on coastal plains which develop on moderate to gently undulating slopes. This erosion hazard of the topsoil of this landscape unit is low, however the lower part of the unit has a high erosion hazard. Other limitations of this landscape unit include its low wet-bearing strength, shallow soil depth and hard-setting nature.

The Coolangatta landscape unit is an erosional unit consisting of sands and stiff to hard clays. The erosion hazard for this landscape unit is extreme, and the topsoils are highly to moderately erodible. Other limitations of the unit include its low wet-bearing strength, as well as its potential for localised surface and mass movement.

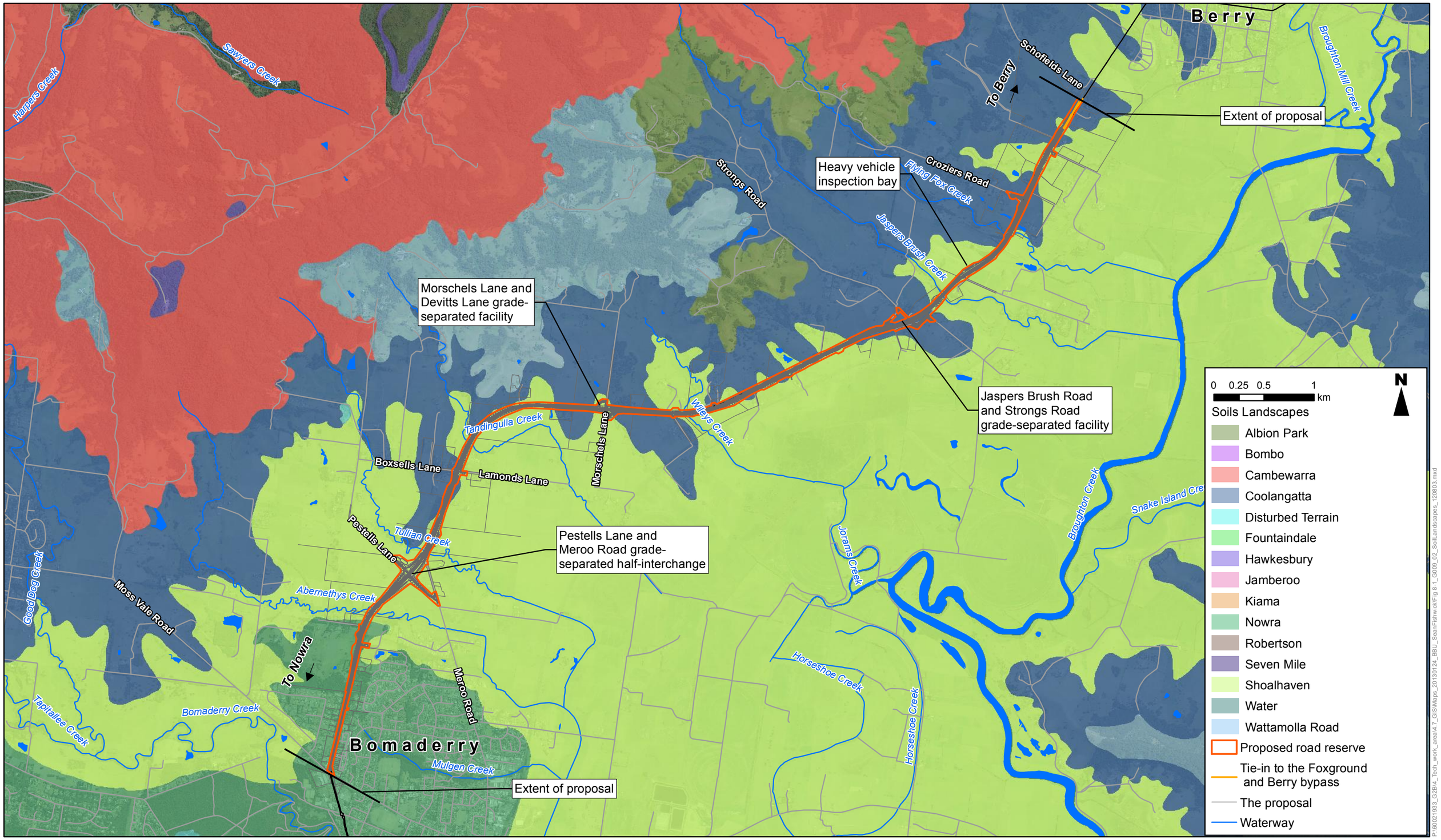


Figure 6-40 Soil landscape units according to *Soil Landscapes of Kiama 1:100,000 Sheet* (Hazelton, 1992)

Source: OEH (2011)

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Topography

The regional topography near the proposal consists of two main topographic groups, being:

- The undulating hills and foothills which extend north-west from the South Coast Railway line.
- The Shoalhaven lowland plain, extending south-east of the foothills towards the Shoalhaven Bight.

The local topography near the proposal is principally influenced by the Broughton Creek floodplain and tributary valley floor, which forms part of the Shoalhaven lowland plain and is mostly located south-east of Berry and east of the proposal. In the vicinity of the proposal, these flatter areas, associated with the Shoalhaven landscape unit are traversed by undulating hills which originate to the west of the Princes Highway and are associated with the Coolangatta landscape unit. The numerous transitions between these two topographic groups contribute to the characteristic rises and falls of the Princes Highway in this region.

Geology

The proposal is located in the southern part of the Sydney Basin, a major structural feature containing a Palaeozoic-Permian-Triassic (290 to 200 million years old) sedimentary sequence which overlies older basement rocks of the Lachlan Fold Belt. There are no major structural features, such as synclines, anticlines, thrusts and faults, in the vicinity of the proposal, however minor faulting may be present within the overall rock mass. The regional dip of the rock strata grades gently to the north and north-west, with the oldest rocks generally present along the coast, south-east of the proposal (Coffey, 2010).

The proposal is underlain by interbedded rocks that are of mid to late Permian age and known as the Shoalhaven Group. The Shoalhaven Group, is defined as comprising three sub-groups; the Volcanic Sandstones (including the Budgong Sandstone, Nowra Sandstone and Broughton Formation); Volcanic Facies; and Berry Siltstone formation.

The Shoalhaven Group consists of volcanoclastic rocks comprised of latites and tuffs in the upper part of the sequence, which is underlain by sedimentary sequences, including Jamberoo Sandstone and Kiama Sandstone, members of the Broughton Formation, which are interbedded with volcanics. This sedimentary sequence is then underlain by Berry Siltstone, which outcrops at the edges of the Broughton Creek floodplain. The Shoalhaven Group is overlain by Quaternary alluvium, colluvium and floodplain sediments flanking the major creeks and Broughton Creek floodplain.

The alignment of the proposal is predominantly underlain by residual soils and weathered rock of the above mentioned formations. In the vicinity of the proposal the alluvial deposits overlie the low lying Broughton Creek and Shoalhaven River floodplains.

Cuttings along the existing highway and the proposal are typically underlain by residual soils and weathered rock. The major fill sections of the existing highway are underlain predominantly by alluvial soils in the floodplain areas and residual soils in the undulating, elevated areas.

A summary of the main geological units along the proposal is provided in **Table 6-55**.

Table 6-55 Summary of the main geological units along the proposal

Unit	Description
Topsoil	Topsoil layers (up to 0.5 metres thick) – dark brown to brown, clayey silt, with many roots and organic materials.
Fill	Encountered in existing highway embankments and hardstand areas. Imported asphalt, road base or local soil fill for highway embankments and pavement fill materials.
Residual soils	Very stiff to hard clays and extremely weathered rock developed in units associated with the underlying rock materials. Some residual soils also present between transported soils and highly weathered (or less weathered) rock.
Alluvial deposits	Soft to very stiff clays, silty clays and sands associated with Quaternary Alluvium, with some hard zones, brown-grey, often mottled. Clayey and sandy gravel are also present in some low lying areas.
Berry Siltstone	Mid to dark grey siltstone and fine sandstone with interbedded shale.
Nowra Sandstone	Quartz Sandstone.

Acid sulfate soils

ASS are naturally occurring soils and sediments that contain iron sulphides. The majority of acid sulfate sediments were formed by natural conditions in the Holocene geological period (the last 10,000 years). ASS are formed when the sulphidic mineral pyrite is exposed and reacts to the air (Troedson et al, 2004). The reaction of the exposed pyrite with oxygen produces sulphuric acid, which can lead to a wide range of environmental issues. ASS can be classified into two types, being actual ASS and PASS. Actual ASS can also have underlying PASS. PASS are waterlogged soils rich in iron sulphides that have not been oxidised. PASS are harmless to the environment if they are kept in this state or under water. Any exposure of PASS to air or the lowering of the water table would lead to the development of ASS and sulphuric acid would be formed.

The construction footprint for the proposal is located within areas of land that have been mapped by OEH (the then DLWC) in 1997 as having no known occurrence of actual ASS. Actual ASS are present at varying depths to the east of the proposal, outside of the construction footprint (see **Figure 6-41**).

Several sections in the area of the proposal have been identified as having PASS being present (refer **Figure 6-42**). Areas have been identified as potentially containing PASS based on the presence of Holocene aged sediments that have pyrite present as part of their composition. PASS are located mostly along existing and historical creek lines within the study area, including the Broughton Creek floodplain. These areas of PASS are located within the construction footprint of the proposal at several locations.

Soft soils

Soft soils generally occur in low lying areas or floodplains, and correspond to areas where deep alluvial soils are present. Soft soils have limited resistance to loads, and as such, roads constructed on soft soils, without ground improvement works, risk ongoing maintenance as a result of ground settlement. This would result in poor road conditions and pavement damage.

The presence and depth of alluvial soils varies across the proposal. Alluvial soils are the most prominent in the vicinity of the Broughton Creek and Shoalhaven River floodplains, and within the Nowra landscape unit at Bomaderry.

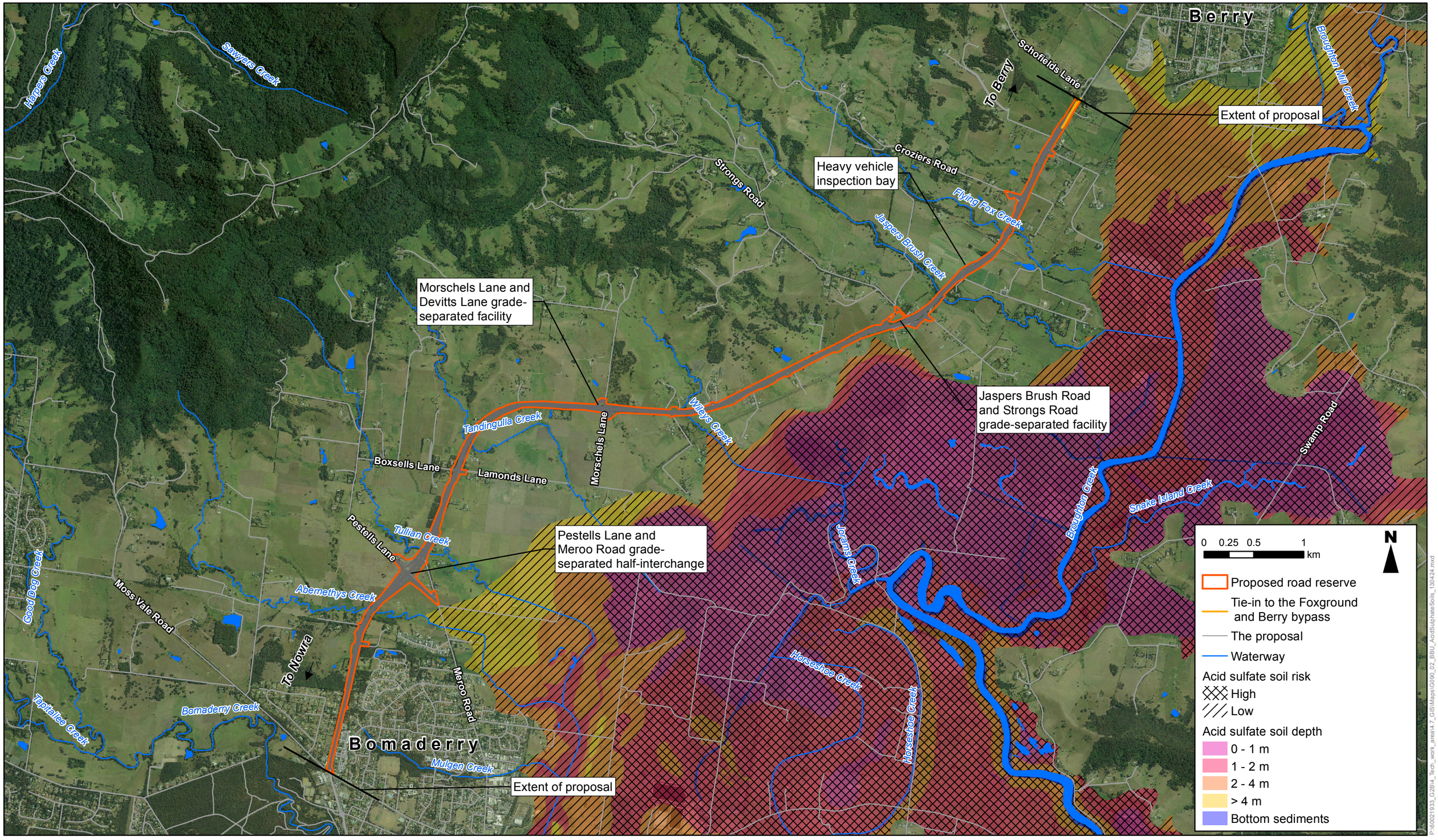

Figure 6-41 Acid sulfate soils near the proposal

Source: Dept. of Lands (2011), DECCW (2002)

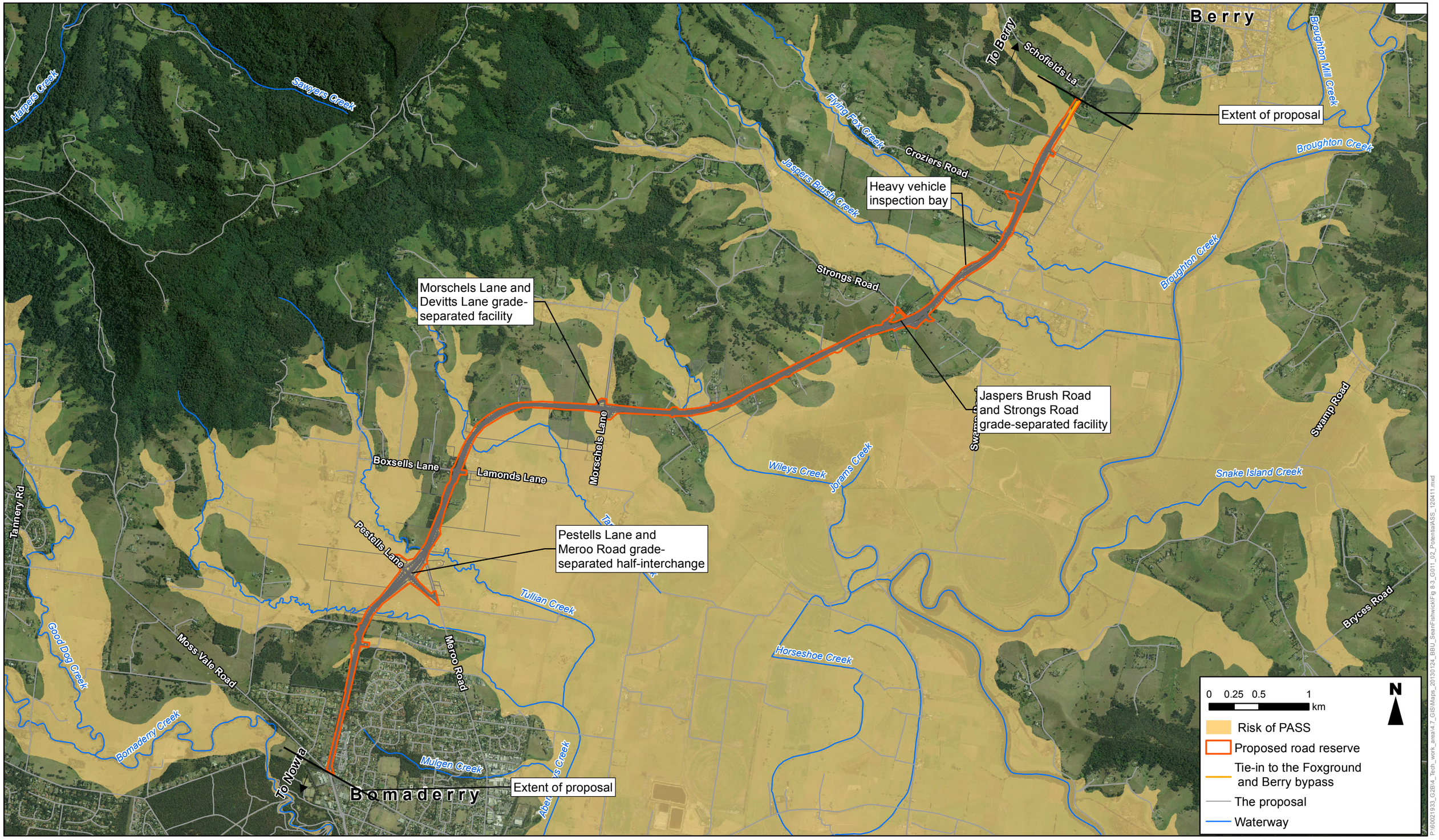

Figure 6-42 Additional areas of potential acid sulfate soil risk

Source: AECOM (2012)

Contamination

The Phase 1 ESA study area comprises mostly rural land, with residential housing within and surrounding the township of Bomaderry. Commercial and industrial properties which are located within the proposal area to the north of Bomaderry include a winery, current and former petrol stations, mechanical workshops and auto repair buildings, as well as a Department of Primary Industries Research Centre. Based on the site history information and observations made during the site inspection for the Phase 1 ESA, potentially contaminating (historical and continuing) activities that may have been, or are being, undertaken on land within the Phase 1 ESA study area have been identified. These are described in **Table 6-56**. Sites of potential broad scale contamination such as large waste dumps, landfills, chemical manufacturing plants and fuel depots were not identified as having been present or operational within the Phase 1 ESA study area.

Discussions with Roads and Maritime staff within the Southern Region Office identified one spill incident along the existing highway that occurred in December 2012. The incident involved a collision between a utility and a tanker carrying ethanol at the intersection of Jaspers Brush Road with the Princes Highway. One of the fuel tanks ruptured during the collision, spilling ethanol onto the road. The Roads and Maritime report about the incident states that ethanol being transported in the tanker spilled from the vehicle onto the road. The ethanol was covered in fire suppression liquid immediately following the incident. Anecdotal information also suggests that the EPA attended the scene following the accident and remediation work was subsequently conducted. The volume of ethanol spilled, and the details regarding remediation works are currently unknown.

Interviews with Roads and Maritime staff did not identify any further potential contamination issues associated with the Phase 1 ESA study area or the construction footprint of the proposal.

Table 6-56 Potentially contaminating activities within the Phase 1 ESA study area and associated contaminants of concern

Potentially contaminating activity	Potential contaminants of concern
Use in buildings and weathering of hazardous materials, such as fibre-cement building materials that contain asbestos, and lead based paints.	Asbestos, lead
Storage and use of pesticides, fuels and /or other agricultural chemicals on rural land.	Metals and metalloids (arsenic, cadmium, chromium, copper, nickel, lead, zinc and mercury), Organo-chlorine and Organo-phosphorus Pesticides (OCPs and OPPs), Herbicides, Fungicides, Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethylbenzene, Xylene (BTEX), Polycyclic Aromatic Hydrocarbons (PAHs), Volatile Organic Compounds (VOCs), Volatile Halogenated Compounds (VHCs)
Treatment of livestock with pesticides at sheep/cattle dips.	OCPs, OPPs, Arsenic
Use of fill of unknown origin along the roadway and on adjacent land.	TPH, BTEX, PAHs, OCPs, OPPs, Polychlorinated Biphenyl (PCBs), Metals and metalloids (arsenic, cadmium, chromium, copper, nickel, lead, zinc and mercury), Herbicides, Fungicides, Asbestos
Localised dumping or burial of waste materials on private properties and along public roadways.	TPH, BTEX, PAHs, PCBs, OCPs, OPPs, Metals and metalloids (arsenic, cadmium, chromium, copper, nickel, lead, zinc and mercury), Herbicides, Fungicides, Asbestos

Potentially contaminating activity	Potential contaminants of concern
Spillage of fuel, oil, and potentially hazardous loads from traffic accidents along the Princes Highway and on intersecting roads.	TPH, BTEX, PAHs, Metals and metalloids (arsenic, cadmium, chromium, copper, nickel, lead, zinc and mercury),
Use of fire fighting foam to extinguish fires resulting from traffic accidents along the Princes Highway and on intersecting roads.	Perflorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA)
Potential leaks or seepage from septic tanks located on rural properties. It is noted that no septic tanks were identified during inspection of the study area.	Nutrients, pathogens

Based on the outcomes of the review of historical aerial photographs and the site inspection, a copy of the Section 149 Planning Certificate was obtained for 10 properties that were considered to have potential or current historical contaminating land uses or activities.

Written permission was granted by three of the 10 landowners of these properties to undertake a search of the SCID, maintained by WorkCover. The SCID searches of these three properties did not identify any existing or historical licences or records for the storage of dangerous goods. Landowner consent was not received from the remaining seven properties, and as such, a search of the WorkCover NSW database was not undertaken for these properties.

Water bores registered with NOW within a 500 metre buffer of the proposal were reviewed in March 2013. The review identified 15 registered bores, used for various purposes including domestic and/or livestock water supply, monitoring wells, test bores and irrigation. Based on the depths of the groundwater bores and the insignificant use of local groundwater as a resource, it is considered unlikely that registered bores are interacting with surface soils that could be contaminated.

The OEH Contaminated Sites Register lists both former and currently contaminated sites which have had regulatory involvement. The register identifies the location of the listed sites and provides notices relating to those sites. These notices also indicate the contaminants of concern and their nature of harm to the environment and human health. A search of the register (undertaken on 25 March 2013) did not identify any sites within the Phase 1 ESA study area. However, searches of the register identified five sites within two kilometres of the proposal, but outside of the study area.

Areas of potential concern with respect to contamination as identified in this Phase 1 ESA are summarised in **Table 6-57**.

Table 6-57 Areas of potential contamination concern

Area of concern	Potential source of contamination	Potential contaminants
Seven identified rural residential properties that abut the proposal.	Presence of fill material of unknown origin, mounded adjacent to the proposal.	Metals, TPH, PAHs, OCPs, OPPs, Asbestos.
One identified rural residential property that abuts the proposal.	Sheep/cattle dip site.	OCPs, OPPs, Arsenic
One identified rural residential property that abuts the proposal.	Rusted drums present in paddock adjacent to the proposal.	Unknown
Five identified rural residential properties that abut the proposal.	Presence of fibro building with the potential for asbestos to be present.	Asbestos, Lead
Entire alignment (existing).	The use of fill of unknown origin.	TPH, BTEX, PAH, OCPs, OPPs, PCBs, Metals, Herbicides, Fungicides, Asbestos
Entire alignment (existing).	Illegal dumping or burial of waste material.	TPH, BTEX, PAH, PCB, OCPs, OPPs, Metals, Herbicides, Fungicides, Asbestos
Entire alignment (existing) and known accident site at the Jaspers Brush Road intersection.	Spillage of fuel and loads from historical road accidents.	TPH, BTEX, PAH, PFOS, PFOA, Metals
Areas of excavation cut and fill.	Cut and fill of unknown origin sourced from the existing highway.	Unknown
Commercial and light industrial properties that have the potential for contaminants to migrate into the proposal area.	Current or former petrol stations, mechanical workshops or auto repair buildings.	TPH, BTEX, PAH, Metals, VHCs

6.11.3 Assessment of potential impacts

Construction

Erosion and sedimentation

Construction of the proposal would require the disturbance of the soil surface and subsurface, with a greater level of disturbance to soils and the underlying geology where cuttings and embankments are proposed. The greatest extent of disturbance would take place in relation to the cutting of around 300 metres long and up to about 10 metres deep at Strongs Road, Jaspers Brush. There are several smaller cuttings along the length of the proposal which would also require disturbance of the underlying geology.

Siltstone beds within the Berry Siltstone rock are particularly prone to erosion and deterioration when exposed to water, which could create a potential erosion risk for the proposal both in the short and long term.

Soils within the southern section of the proposal and associated with the Nowra soil landscape are prone to moderate to extreme levels of erosion. Earthworks for cuttings within this section of the proposal, if required, would facilitate the erosion of exposed soils and weathered rock that would potentially lead to embankment and cut slope instability and fretting.

The stockpiling of spoil and topsoil would pose a risk for erosion and sedimentation during construction of the proposal. Soil loss could occur due to the effects of wind or water.

Acid sulfate soils

The areas of low risk of PASS in the vicinity of the proposal are limited to the areas of the catchment located within the Broughton Creek floodplain and the Shoalhaven River floodplain. However, possible exposure of ASS or PASS could occur during the construction of embankments and operational water quality basins, replacement and construction of bridges, culvert upgrades, and other land forming works. Piling would be required for the construction of bridges and grade separated facilities. This may potentially require excavation through PASS to reach the necessary piling depths. In addition, construction and/or excavation works that result in lowering the water table in locations where PASS are present could potentially lead to the development of ASS.

The sulphuric acid and iron rich leachate resulting from the development of actual ASS could have major environmental, agricultural and structural impacts in affected areas if not adequately managed. Potential impacts may include the following:

- Negative impacts to aquatic ecosystems (refer to **Section 6.3**).
- Impacts on vegetation growth and agricultural productivity due to low soil pH levels causing stunted vegetation growth, mobilisation of heavy metals (such as aluminium, iron and manganese), nutrient deficiencies and decreased soil microbes.
- Structural damage and corrosion of steel and concrete structures due to acidity, resulting in considerable ongoing maintenance costs.

The risk of exposing PASS or ASS during construction of the proposal is considered to be low, due to the generally shallow depths of excavations required, and the general nature of other construction activities associated with the proposal.

Soft soils

Alluvial soils are of low strength and are highly compressible. The bearing capacity (or strength) of alluvial soils improves as settlement occurs. Embankments and bridge works would be constructed in areas comprised of quaternary alluvium. The settlement of such soils as a result of the loads being placed on these areas poses a risk to the proposal in the short term (in terms of time and cost) and long term (if not sufficiently mitigated). This is particularly relevant to the construction of the Morschels Lane and Devitts Lane grade-separated facility and the Pestells Lane and Meroo Road grade-separated interchange.

Where widening works would be undertaken as part of the proposal in areas where soft or alluvial soils are known to be present, there is the potential for the proposal to settle or ‘sink’ to a depth that is different to that of the existing highway, both during and post-construction.

Based on the extent, depth and type of alluvial soils (or soft soils) elsewhere along the proposal alignment, the extent of settlement is unlikely to be excessive.

Contamination

Based on the results of the ESA, there is a low likelihood of land being affected by contamination as a result of current and historic land use practices within the footprint of the proposal. The potential for contamination to be encountered during construction of the proposal on agricultural, residential and/or commercial lands is considered to be low. This could include the presence of the following within the construction footprint of the proposal:

- Asbestos and lead from hazardous building materials potentially contained in the one residential building which would require demolition and removal as a result of the proposal.
- Herbicides, fungicides and pesticides (including organochlorins and organophosphates) from the application, disposal, leaks and spills within properties where agricultural land use practices have been or are carried out. Organochlorins, organophosphates and arsenic could also be present within rural residential lands in areas associated with the treatment of livestock with pesticides at cattle dips.
- TPH, PAH, BTEX, PCB and heavy metals where property fuel stores have leaked, where spills within properties or on roads have occurred, or where fill of unknown origin is present.
- PFOS and PFOA, from the use of fire fighting equipment to extinguish fires resulting from traffic accidents along the Princes Highway and intersecting roads within the study area.
- Unknown contaminants within fill mounds of unknown origin adjacent to the existing highway.

In the event that contamination is encountered during construction of the proposal, it is likely to be localised to areas identified as being of potential concern (**Table 6-57**).

Construction activities have the potential to cause soil contamination from accidental spills of fuels, oils and other hazardous materials such as bitumen. Spillages may result in adverse impacts on soils and on the surrounding environment.

Operation

Erosion and sedimentation

Mobilisation and loss of soil by wind and water throughout the operation of the proposal could potentially impact on the agricultural productivity of the study area and surrounds. Soil mobilisation and subsequent movement of sediment laden water into surrounding waterbodies and drainage channels could reduce water quality and block stormwater drainage structures. This could potentially impact the aquatic ecology in the study area, as well as result in localised flooding.

Contamination

During operation of the proposal, there is potential for traffic accidents to result in contamination as a result of:

- Spillage of fuel from a ruptured fuel tank.
- Spillage of a hazardous load being carried by a vehicle (ie fuel, chemicals).
- Use of fire fighting foam or fire retardants following an accident.

Impacts of spills are discussed in **Section 6.13.**

6.11.4 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or manage identified impacts on geology and soil. These measures are presented in **Table 6-58** and are summarised in **Section 7.2**.

Table 6-58 Safeguards and management measures

Potential impacts	Safeguards and management measures	Timing	Responsibility
Construction			
Short and long term stability of embankments and cuttings.	Create cut and fill batters at a maximum of 2:1 slope unless otherwise agreed during detailed design. In areas of particular risk of erosion, investigate measures which may include: • Retaining structures or soil nailing at steep or vertical cuts in areas where soft soils and highly weathered rock, such as the Berry Siltstone and Nowra Sandstone are present. • Retaining structures at bridge abutments. • Erosion protection measures, such as drainage structures, hydroseeding, hydro mulching and the use of geotextile fabric. Mitigation strategies designed to minimise the visual impact of these measures are discussed in **Section 6.6**.	Roads and Maritime project manager and Construction contractor	Detailed design and Construction
Instability of soft soils	Where required, undertake ground improvements within areas of soft soils to provide sufficiently stable areas for construction to commence, and to provide long-term durability of the proposal.	Roads and Maritime project manager and Construction contractor	Pre-construction and construction
Erosion and sedimentation	Refer to mitigation measures in **Section 6.4**		
Disturbance of acid sulfate soils	Develop an Acid Sulfate Soils Management Plan (ASSMP) in accordance with the 'Guidelines for the Management of Acid Sulfate materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulphidic Black Ooze' (RTA, 2005).	Roads and Maritime project manager and Construction contractor	Pre-construction
	Seek opportunities to avoid PASS and to avoid lowering of the water table in the vicinity of PASS. If it is not feasible and reasonable to avoid disturbance of PASS, limit areas of disturbance as much as possible and implement management measures documented in the ASSMP.	Roads and Maritime project manager	Detailed design, pre-construction and construction

Potential impacts	Safeguards and management measures	Timing	Responsibility
Contamination	Further assessment of areas of potential contamination concern will be required in areas that will be disturbed. Assessments could include: • Sampling of the fill mounds identified adjacent to the existing highway within the study area prior to the disturbance of these areas, if these fill mounds will be disturbed or utilised during construction of the proposal. • Conduct a hazardous materials audit on buildings requiring demolition, disturbance or alteration as part of the proposal. • Consult with the 10 landowners identified as having current or historical land use activities that store or may have previously stored petroleum hydrocarbons in order to evaluate whether potential contamination may have migrated into the construction footprint of the proposal.	Roads and Maritime project manager	Pre-construction
	Undertake further investigation in the area identified as the truck spill site that occurred on 15 December 2012 at Jaspers Brush to evaluate the presence of residual contamination prior to the commencement of construction. This will include a review of EPA records, inspection and sampling, as required. Subject to the findings of the additional investigation, recommendations will be made regarding the requirement for the management or remediation of contamination (if identified).	Roads and Maritime project manager	Pre-construction
	Prepare and implement a procedure for handling the unexpected discovery of contamination prior to the commencement of construction. The procedure will be incorporated into the CEMP for the proposal and will outline the process for the identification and assessment of potentially contaminated material in the event that previously unidentified contamination is discovered during construction of the proposal.	Roads and Maritime project manager	Pre-construction

6.12 Air quality

This section provides an assessment of potential air quality impacts associated with the construction and operation of the proposal. This section also identifies measures to avoid, mitigate or manage these potential impacts.

The assessment of the potential construction and operational impacts of the proposal has considered impacts related to the emission of the following pollutants:

- Carbon monoxide.
- Oxides of nitrogen, including nitric oxide and nitrogen dioxide.
- Particulate matter, including PM_{10}, total suspended particulate (TSP) and deposited dust.
- Sulphur dioxide.

These substances are known to be harmful to human health if the concentration is too high over a particular exposure period. The emissions of sulphur dioxide associated with the proposal would be minor, therefore, this pollutant is not considered further in this assessment.

6.12.1 Existing environment

The existing air quality in the proposal area is generally considered to be good. It is mainly influenced by local road traffic. Agricultural and manufacturing activities, such as dairy and beef production also contribute to air quality in the region, particularly dust emissions. The effects of agriculture and manufacturing on air quality are considered to be relatively small and localised.

Sensitive receivers were identified along the alignment within 300 metres of the proposal. **Figure 6-43** shows the locations of the 434 sensitive receivers identified and modelled as part of the assessment.

Climatic conditions

Temperature, humidity and rainfall data was collected from the Nowra Royal Australian Navy (RAN) automatic weather station located at HMAS Albatross, around eight kilometres south-west of the central business district of Nowra. This data was recorded between 2000 and 2013 (Bureau of Meteorology, 2013).

The annual average maximum and minimum temperatures experienced at Nowra RAN are 22.2 degrees Celsius and 11.4 degrees Celsius respectively. On average, January is the hottest month with an average maximum temperature of 27.5 degrees Celsius. July is the coldest month, with average minimum temperature of 6.5 degrees Celsius.

The annual average humidity reading collected at 9 am is 66 per cent, and at 3 pm the annual average is 55 per cent. The months with the highest humidity on average are February and March with a 9 am average of 75 per cent, and the lowest humidity is in August with a 3 pm average of 46 per cent.

Rainfall data collected shows that February is the wettest month, with an average rainfall of 144.7 millimetres. The average annual rainfall is 847.9 millimetres.

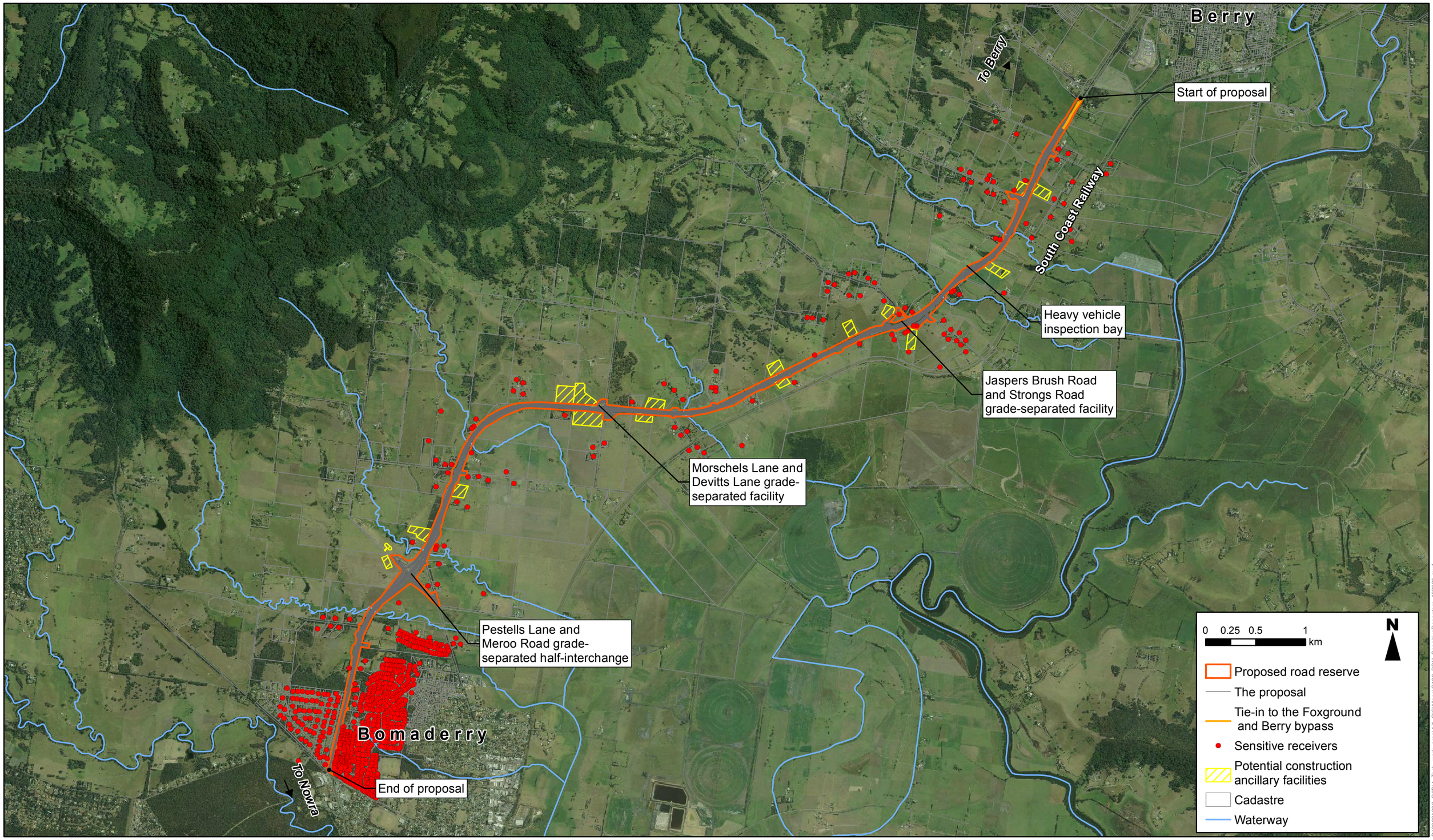

Figure 6-43 Location of sensitive receivers near the proposal

Source: AECOM (2013)

On an annual basis, the most common winds were from the north-west and south. In summer winds were predominantly from the east-northeast and south, while in winter winds were predominantly from the west-northwest. The annual average wind speed at the Nowra RAN was 3.4 metres per second.

A stability class was assigned to each hour of the meteorological data using concurrent cloud cover information and the methodology of Turner as documented in the *Workbook of Atmospheric Dispersion Estimates* (Turner, 1970). Stability is dependent on a number of factors, such as wind speed, terrain and the temperature profile of the atmosphere and is classified as A through to F. Class A is defined as very unstable while Class F is defined as very stable conditions.

The most common stability occurrences were calculated to be class F, which indicates that there was regularly poor dispersion in the area. This class occurred around 31 per cent of the time; with the second highest being class D which occurred around 30 per cent of the time. Emissions would be likely to disperse more quickly under class D conditions compared to class F conditions.

Air quality monitoring data

The closest NSW EPA monitoring stations were used to assess existing air quality and provide an understanding of existing background pollutant concentrations. Between 1997 and 2005 monitoring data was sourced from Croom Road monitoring station in Albion Park, approximately 15 kilometres north of Gerringong. This site was decommissioned early in 2005 and a new station was commissioned at Terry Reserve, Albion Park South in December 2005. Data for carbon monoxide was sourced from a monitoring site in Wollongong.

Air quality monitoring data between 1997 and 2007 is displayed in **Table 6-59**. Maximum 1-hour average and annual average nitrogen dioxide concentrations were well below the EPA air quality criteria. The maximum 1-hour average and maximum 8-hour average carbon monoxide concentrations were also well below the EPA air quality criteria.

As detailed in **Table 6-59**, the maximum PM_{10} concentrations were on occasions above the 24-hour goal of 50 micrograms per cubic metre over the 10 year period. In 2003 the maximum recorded 24-hour average concentration recorded was 281 micrograms per cubic metre. The NSW EPA annual compliance report (NSW DEC, 2004) notes that dust storms occurred on the day this value was recorded. The maximum recorded 24-hour average concentration recorded in 2004 was also high (195 micrograms per cubic metre) which was likely related to a similar event. Considering that particle pollution is affected by environmental factors such as bushfires and dust storms, other high levels may also be attributed to these factors. The annual average concentrations of PM_{10} were below the NSW EPA air quality goal of 30 micrograms per cubic metre except in 2003, which was likely to be the result of dust storms.

Nitrogen dioxide and carbon monoxide levels in the area are below all relevant criteria, meaning that pollutant levels are low and the air quality is generally good. The maximum 24-hour average concentrations for particulate matter are above the relevant criteria most years, which is likely to be influenced by local land uses and weather conditions. The annual average concentrations of particulate matter still generally fall below the relevant criteria again meaning that the air quality is generally clear.

Table 6-59 Air quality monitoring data between 1997 and 2007

Year	Nitrogen dioxide		PM_{10}		Carbon monoxide	
	Maximum 1-hour average	Annual average	Maximum 24-hour average	Annual average	Maximum 1-hour average	Maximum 8-hour average
Goal	**246 (µg/m^3)**	**62 (µg/m^3)**	**50 (µg/m^3)**	**30 (µg/m^3)**	**30 (mg/m^3)**	**10 (mg/m^3)**
1997[(a)]	90	8	**62**	18*	ND	ND
1998[(a)]	166	8	**64**	15	5.5	2.8
1999[(a)]	100	8	49	13	5.1	3.0
2000[(a)]	113	10	**63**	15	5.6	3.0
2001[(a)]	105	8	**59**	16	10.6	5.3
2002[(b)]	98	10	**88**	20	4.8	2.9
2003[(b)]	113	31	**281**	**40**	4.1	2.6
2004[(b)]	90	8	**195**	18	4.0	2.6
2005	ND	ND	ND	ND	3.5	2.3
2006[(c)]	104	9	**60**	18	3.4	1.9
2007[(c)]	92	9	**54**	16	3.2	1.6
Median	102	9	**63**	17	4.5	2.7
Maximum	166	31	**281**	40	10.6	5.3

mg/m^3 – milligrams per cubic metre
µg/m3 – micrograms per cubic metre
ND – No data available
**One or more quarters of the year had data availability less than 75 per cent*
(a)DEH (2004)
(b)NSW EPA (2002-2012)
Bold numbers indicate levels that exceed the relevant goals

Modelled existing highway

In 2007, a modelling study was conducted which investigated air quality impacts of the existing highway between Berry and Bomaderry (Holmes Air Sciences, 2007). The Caline series of dispersion models was used to estimate the concentration of oxides of nitrogen, carbon monoxide and PM_{10} that are likely to occur in the vicinity of the existing Princes Highway. The results indicate that all predicted concentrations were well below their respective air quality criteria. The nearest residences in Bomaderry are approximately 10 metres from the kerb. Pollutant levels experienced at this distance due to existing traffic volumes are very low and well below air quality criteria.

6.12.2 Criteria

The EPA specifies ground-level concentration criteria for airborne pollutants within 'Approved Methods for Modelling and Assessment of Air Pollutants in NSW' (DEC, 2005) (refer to **Table 6-60**). As noted in **Table 6-60**, the EPA has historically noted air quality goals determined by the World Health Organisation (WHO), the United States Environmental Protection Agency (US EPA) and the National Health and Medical Research Council of Australia (NHMRC).

Table 6-60 NSW EPA air quality assessment criteria

Pollutant	Goal	Averaging period	Source
Carbon monoxide	30 mg/m^3 10 mg/m^3	1-hour 8-hour	WHO (2000) NEPC (1998)
Nitrogen dioxide	246 µg/m^3 62 µg/m^3	1-hour Annual	NEPC (1998) NEPC (1998)
Particulate matter < 10 µm (PM_{10})	50 µg/m^3 30 µg/m^3	24-hour Annual	NEPC (1998) EPA (1998)
Total suspended particles	90 µg/m^3	Annual	NHMRC (1996)
Deposited dust	2 g/m^2/month 4 g/m^2/month	Incremental Total	NERDCC (1988)

mg/m^3 – milligrams per cubic metre
µg/m^3 – micrograms per cubic metre
g/m2/month – grams per square metre per month
< - Less than

6.12.3 Assessment of potential impacts

Construction

Dust would be generated from earthworks associated with the construction of the proposal and the total amount of dust would depend on the silt and moisture content in the soil and the types of activities being carried out.

The main activities that would generate dust during construction would be the use of excavators, front-end loaders and dump trucks as well as wind erosion from exposed areas. Potential dust emissions from these activities have been estimated and are presented in **Table 6-61**. These emissions are calculated prior to mitigation measures being implemented and as a result emissions of this magnitude would not be expected as a result of the proposal.

There would be other sources of dust such as vehicle movements on unsealed (haul) roads. These are not easily quantifiable as the distances travelled by vehicles would be highly variable.

Table 6-61 Estimated dust emissions from earthworks (pre-mitigation)

Source/activity	Intensity	Emission factor	Total emission
Site setup and excavation (Time period – 24 months)			
Excavators on material	736,000 t	0.0022 kg/t	3580 kg
Front-end loaders moving material	1,627,595 t	0.0022 kg/t	3580 kg
Haulage	1,627,595 t	0.0139 kg/t	22,624 kg
Wind erosion	8 ha	0.4 kg/ha/h	91,100 kg
Total (over a 24 month period)			120,884 kg
Average annual emission			60,442 kg/y

t – tonne
ha – hectare
kg - kilogram
kg/t – kilogram per tonne
kg/ha/h – kilogram per hectare per hour
kg/y – kilogram per year

Dust emissions of this scale are unlikely to cause any adverse impacts at the nearest sensitive receivers. There are major dust producing industries such as quarries and other extractive industries which emit dust at rates considerably greater than that expected during the construction of the proposal and still comply with both health and nuisance long-term criteria. There may be short-term nuisance impacts at locations adjacent to construction activities and these would generally occur on dry days where wind speeds are elevated. These short-term effects can generally be well managed through the measures provided in **Section 6.12.4**.

Temporary construction ancillary facilities

The main potential source of dust at temporary construction ancillary facilities would be exposed stockpiles which may be affected by wind erosion. A conservative assessment was undertaken which assumed that all potential construction ancillary facilities would contain stockpiles and that all stockpiles would be 50 per cent exposed at all times over a 12 month period and subject to wind erosion 24 hours per day. It should be noted that these conditions would be unlikely to occur over the course of the construction period as construction would be staged and not all construction ancillary facilities and stockpile sites would be in use at the same time. The emissions were also calculated with only watering of exposed areas included as a dust suppression measure. The mitigation measures presented in **Table 6-65** were not included in the modelling.

Figure 6-43 provides the potential construction ancillary facilities (assumed to be stockpile sites for the purpose of this assessment) and shows the sensitive receivers considered in the assessment.

The results of the modelling found that none of the annual concentration criteria for dust levels are expected to be exceeded due to wind erosion from stockpile sites along the proposal. The highest predicted annual average PM_{10} level at any of the sensitive receivers was estimated to be approximately six micrograms per cubic metre, while the maximum predicted annual average TSP concentration at these receptors was 12 micrograms per cubic metre. These predictions are both well below their respective goals of 30 micrograms per cubic metre and 90 micrograms per cubic metre.

Dust deposition levels were predicted to have an annual average level of more than two g/m^2/month at eight sensitive receivers. This exceeds the incremental criterion. However, it is considered highly unlikely that this exceedance would occur in reality given the conservative modelling assumptions detailed above and following the implementation of management measures presented in **Table 6-65**.

Predictions of 24 hour PM_{10} concentrations at almost all of the sensitive receivers were below 20 micrograms per cubic metre. However, one residence was predicted to experience a maximum 24 hour PM_{10} concentration of 43 micrograms per cubic metre when potential impacts from the proposal were added to existing background levels. Further review of results at that particular receiver showed that there were only six days in the year where predictions were above 20 micrograms per cubic metre. The review also indicated that these higher values would be very infrequent and likely to be the result of winds blowing directly from the stockpile towards that particular receiver for a number of hours within the 24 hour period. The implementation of mitigation measures provided in **Table 6-65** would manage both the long-term deposition and short-term PM_{10} impacts.

Operation

Predicted concentrations of pollutants have been provided to assess the likely air quality impact resulting from the operation of the proposal (refer to **Table 6-62**, **Table 6-63** and **Table 6-64**). Predictions have been provided for the proposal alone as well as with consideration of potential cumulative impacts, which include background air quality.

The CALRoads package was used to assess the likely air quality impacts associated with the proposal. The information required to be input into this model included meteorological conditions, traffic volumes, emissions information and sensitive receiver locations.

Carbon monoxide

As detailed in **Table 6-62**, the predicted carbon monoxide concentrations at the most affected sensitive receivers are well below the EPA criteria for the 1-hour and 8-hour averages in both 2019 and 2029. The predicted concentrations also remain below the EPA criteria for each scenario when background air quality levels and cumulative effects are factored in.

The background air quality data is the highest level recorded and includes emissions from the existing highway. As a result, the cumulative impact provided is a conservative estimate. It would therefore be unlikely that the EPA air quality criteria for carbon monoxide would be exceeded as a result of the proposal. Also, the modelling does not account for the likelihood that the percentage of older vehicles would be lower in 2029, further reducing carbon monoxide emissions.

Table 6-62 Predicted maximum carbon monoxide concentrations at the most affected sensitive receiver in 2019 and 2029

	Maximum 1-hour average carbon monoxide concentration (mg/m^3)		Maximum 8-hour average carbon monoxide concentration (mg/m^3)	
EPA Criteria	**30 mg/m^3**		**10 mg/m^3**	
Maximum background	**10.6 mg/m^3**		**5.3 mg/m^3**	
Year	**2019**	**2029**	**2019**	**2029**
Proposal alone	0.49	0.6	0.11	0.14
Cumulative impact (including background)	11.09	11.2	5.41	5.44

mg/m^3 – milligrams per cubic metre

Oxides of nitrogen

Estimating nitrogen dioxide concentrations is more complicated than estimating carbon monoxide concentrations. It is dependent on the rate of conversion of nitric oxide and other oxides of nitrogen into nitrogen dioxide. The conversion rate increases as the distance of the receiver from the roadside increases. Studies conducted by the then RTA in 1997 suggest that a conversion rate of 15 per cent at ten metres from the roadway would be a conservative estimate (RTA, 1997). At a distance of 20 to 60 metres from the roadway a conversion rate of 20 per cent was considered a conservative estimate. For the purpose of this assessment a 50 per cent conversion rate has been used. This is a highly conservative estimate considering that the nearest sensitive receiver would be located around 30 metres form the proposal.

As shown in **Table 6-63**, the predicted nitrogen dioxide concentrations resulting from the proposal are well within the EPA criteria for both the 1-hour and annual averages for the two years modelled. Nitrogen dioxide concentrations are also predicted to remain below the EPA criteria when added to the background levels even using the conservative approach described above.

Table 6-63 Predicted maximum nitrogen dioxide concentrations at the most affected sensitive receiver in 2019 and 2029

	Maximum 1-hour average nitrogen dioxide concentration (µg/m^3)		Maximum annual average nitrogen dioxide concentration (µg/m^3)	
EPA Criteria	**246 µg/m^3**		**62 µg/m^3**	
Maximum background	**166 µg/m^3**		**31 µg/m^3**	
Year	**2019**	**2029**	**2019**	**2029**
Proposal alone	76	79	3	3
Cumulative impact (including background)	242	245	34	34

µg/m^3 – micrograms per cubic metre

Particulate matter

As shown in **Table 6-64**, the highest predicted 24-hour average and annual average PM_{10} concentrations associated with the proposal are well below the EPA criteria and would not be expected to result in adverse impacts on air quality at nearby sensitive receivers.

It is expected that PM_{10} concentration would occasionally exceed the 24-hour assessment criteria because on occasions recorded background levels are already close to or exceed these criteria.

In order to assess the cumulative PM_{10} impacts associated with the proposal, the median background levels have been used instead of the maximum background levels. Median background levels are considered to be more appropriate in this instance because PM_{10} levels on any given day can be affected by regional events such as dust storms and bush fires and can be greatly affected by short-lived, localised dust generating activities. Also, the maximum background level may have occurred on a single day, while the remainder of readings are well below this.

The median 24-hour average background level exceeds the EPA air quality criteria for PM_{10}. The maximum predicted 24-hour concentration is expected to represent less than two per cent of the EPA assessment criteria in both 2019 and 2029. It is therefore unlikely that PM_{10} criteria would be exceeded as a result of the proposal. It is not expected that the maximum annual average PM_{10} concentration would exceed the EPA criteria at the most affected sensitive receiver.

Table 6-64 Predicted maximum particulate concentrations at the most affected sensitive receiver in 2019 and 2029

	Maximum 24-hour average PM_{10} concentration (µg/m^3)		Maximum annual average PM_{10} concentration (µg/m^3)	
EPA Criteria	**50 µg/m^3**		**30 µg/m^3**	
Median background	**63 µg/m^3**		**17 µg/m^3**	
Year	**2019**	**2029**	**2019**	**2029**
Proposal alone	0.93	0.83	0.29	0.27
Cumulative impact (including background)	63.93	63.83	17.29	17.27

µg/m^3 – micrograms per cubic metre

Overall air quality impacts associated with the proposal are expected to be short term and with the implementation of the safeguards and management measures outlined in **Section 6.12.4** are expected to be negligible.

6.12.4 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or mitigate the identified impacts on air quality. These measures are presented in **Table 6-65** and are summarised in **Section 7.2**.

Table 6-65 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
Air quality – dust generation	Develop an Air Quality Management Plan (AQMP), which will form part of the CEMP. The AQMP will aim to minimise dust generation.	Construction contractor	Pre-construction and construction
	Undertake dust deposition monitoring at the nearest sensitive receivers to construction ancillary facilities that are in use to determine compliance with relevant EPA criteria.	Construction contractor	Pre-construction and construction
Operation			
	Air quality impacts during operation of the proposal would be minimal and therefore no mitigation measures have been proposed.		

6.13 Hazard and risk

Environmental hazards resulting from the construction and operation of the proposal, and the identification of measures to avoid, mitigate or manage these risks, are addressed throughout **Chapter 6** of this review of environmental factors.

Hazards arising from incidents during project construction and operation could also pose a risk to human health, as well as that of the environment. Such potential risks and appropriate management measures are discussed below.

6.13.1 Potential impacts

Construction

The following hazards and risks would be associated with construction of the proposal:

- Potential impacts on the environment and human health resulting from accidental releases or improper transport, handling and storage of hazardous substances related to the proposal.
- Occupational Health and Safety hazards, such as dangers to the construction workforce, road users and the general public.
- Potential rupture or interference with underground services, particularly the Eastern Gas Pipeline.

Hazardous materials that may be transported and used on site would include, but would not be limited to:

- Diesel fuels.
- Oil, grease and lubricants.
- Gases (oxy-Acetylene) (Class2.1).
- Bitumen (Class 3 PGIII).
- Paints and epoxies (Class 3 PGII and Class 3 PGIII).
- Herbicides (Class 6.1 PGII).
- Hydrated lime (non-dangerous good).
- Curing compounds (non-dangerous good).

The above classifications have been determined using the 'Australian Code for the Transport of Dangerous Goods by Road and Rail' (7th edition) (National Transport Commission, 2007).

The majority of these substances would be stored within the major construction compound sites. The storage, handling and use of the materials would be undertaken in accordance with the *Occupational Health and Safety Act 2000* and the 'Storage and Handling of Dangerous Goods Code of Practice' (WorkCover NSW, 2005).

Potential inadvertent toxic impacts, fire and explosions resulting from the handling, storage and transportation of hazardous materials may adversely affect the quality of the local environment and impact human safety. However, the potential for such incidents to occur is considered to be low in view of the following factors:

- The quantities of hazardous goods required are expected to be low and below the thresholds requiring preparation of a preliminary hazard analysis as detailed in 'Applying State Environmental Planning Policy 33 (SEPP 33): Hazardous and Offensive Development Application Guidelines' (DP&I, 2011). As such, a preliminary hazard analysis is not required.
- Hazardous substances would be transported in accordance with relevant legislation and codes.
- The likelihood of a crash occurring during the transportation of hazardous substances to and from work sites and spillage to the receiving environment is considered low.
- The project is located mostly in a sparsely populated area (with the exception of Bomaderry, where it interacts with properties fronting the existing Princes Highway between Abernethys Lane and Cambewarra Road) and it is unlikely that a potential incident would impact on local properties. Risks to road users would be limited to those directly involved in the incident.
- Implementation of environmental management measures such as those identified in Section 6.13.2 would reduce the risk to the environment, construction personnel and the public.

Rock falls and steep slopes at cuttings would present a potential hazard during construction. Rock falls could occur if instability exists at proposed cuttings, particularly the larger cuttings such as the cutting near Strongs Road and Jaspers Brush Road. Rock falls could pose a hazard to construction personnel, others in the vicinity of construction and construction machinery. Steep slopes pose a potential slip or fall hazard for construction personnel.

During excavation works there is the potential for works to rupture underground services, which could give rise to additional hazards such as electrocution or fire if a local gas pipeline is impacted. Underground services located near the proposal are discussed in **Section 3.6**.

Overall, the hazards and risks associated with the project during construction are considered low and would be managed with the implementation of standard management and mitigation measures such as those identified in **Section 6.13.2**.

Operation

It is not anticipated that large volumes of hazardous substances would be used by Roads and Maritime during operation of the proposal.

Potential operational hazards and risks are likely to be associated with the transportation of goods. Dangerous goods are permitted to be transported in large quantities on the Princes Highway in accordance with relevant regulations and codes and may include:

- Flammable and combustible petrol, diesel and liquefied petroleum gas.
- Toxic gases, such as ammonia and chlorine.
- Corrosive acids and alkalis.
- Other toxic materials, such as pesticides.
- Nitrogen-based fertilisers.
- Bulk explosives.

The nature of the project means that there is an inherent risk of vehicle collision associated with its operation, which could result in the accidental spill of dangerous goods. This would have the potential to adversely affect the quality of the local environment and impact human safety, with potential hazards including toxic effects, fire and explosions. Contaminants, either directly associated with a potential spill or hazardous material clean up, may enter the receiving environment from both paved and unpaved surfaces.

The potential for such a spill and consequential impacts is considered to be low in view of the following factors:

- Dangerous goods vehicle movements along the highway are expected to comprise only a small proportion of total daily traffic movements and the probability of a crash involving a vehicle containing dangerous goods is low.
- The improved road safety environment provided by the road design standard of the proposal would reduce the potential for road crashes relative to the existing situation.
- The existing stringent legislative controls on the transport of dangerous goods reduce the risk of impacts.
- The proposal is largely located within a sparsely populated area, except in the vicinity of Bomaderry) so most incidents would have limited potential to affect those not directly involved in the crash or incident.
- In the unlikely event of a traffic crash involving a vehicle carrying hazardous substances, any spills would typically be contained to the roadway area by the appropriate incident and emergency response teams. Runoff from bridges over watercourses and floodplains would be directed to and captured in the permanent water quality basins or swales. These water quality treatment measures provide capacity to treat first flush from the pavement surface and reduce the risk of spills discharging onto adjacent land or watercourses.

Hazards and risks associated with the project during operation are considered low and would be managed with the implementation of standard management and mitigation measures identified in **Section 6.13.2**.

6.13.2 Safeguards and management measures

The safeguards and management measures would be implemented to avoid, minimise or manage hazards and risks associated with the proposal. These measures are presented in **Table 6-66** and are summarised in **Section 7.2**.

Table 6-66 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
General	Prepare site specific Hazard and Risk Management Plans as part of the CEMP, which may include items such as: • Details of the hazards and risks associated with construction activities. • Risk management measures, including those identified in **Chapter 6**. • Procedures to comply with all legislative and industry standard requirements. • Contingency plans, as required. • Site-specific Occupational Health and Safety plans and safe work method statements. • Training for all personnel (including subcontractors) in site inductions, including the recognition and awareness of site hazards and the location of relevant equipment to protect themselves and manage any spills.	Construction contractor	Pre-construction and construction
Contamination from accidental releases or improper transport, handling and storage of hazardous substances.	Transport all hazardous substances in accordance with relevant legislation and codes, including the *Road and Rail Transport (Dangerous Goods) (Road) Regulation 1998* and the 'Australian Code for the Transport of Dangerous Goods by Road and Rail' (National Transport Commission, 2008).	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Manage specific risks associated with the transport of hazardous substances to and from work sites, including the risks associated with temporary changes in local traffic conditions during the construction period, through the implementation of measures detailed in the CEMP.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Undertake a preliminary hazard analysis if the quantities of hazardous substances during construction are found to exceed threshold levels provided in 'Applying SEPP 33: Hazardous and Offensive Development Application Guidelines' (DP&I, 2011).	Roads and Maritime project manager and construction contractor	Pre-construction and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
	Store, handle and use hazardous construction materials in accordance with the *Occupational Health and Safety Act 2000* and the 'Storage and Handling of Dangerous Goods Code of Practice' (Workcover NSW, 2005).	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Provide secure, bunded areas around storage areas for oils, fuels and other hazardous liquids.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Locate chemical storage areas outside areas subject to the 1 in 100 year flood event. Where this is not feasible, provide sufficient freeboard to avoid inundation during events of this size.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	In the event of an incident leading to a spill of a hazardous substance during construction, use appropriate incident control measures in accordance with contingency plans for the worksite.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Construct temporary drainage structures as detailed in **Section 6.4** and in accordance with the 'Technical Guideline – Temporary Stormwater Drainage for Road Construction' (Roads and Maritime, 2011).	Roads and Maritime project manager and construction contractor	Pre-construction and construction
	Carry out regular maintenance and inspection of all environmental and safety protection controls.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
Rupture or damage to underground utilities	Undertake utility checks (such as dial before you dig), consult with relevant service infrastructure providers and if required, relocate and/or protect utilities within the proposal area prior to the commencement of construction.	Roads and Maritime project manager and construction contractor	Pre-construction and construction
Operation			
Contamination from transportation of hazardous substances	Design water quality treatment measures to provide capacity to treat first flush from the pavement surface and reduce the risk of spills discharging onto adjacent land or into watercourses. Confirm locations and design capacity during the detailed design phase of the proposal.	Roads and Maritime project manager	Detailed design

6.14 Waste and resource management

This section identifies the types of wastes that will be generated by the proposal, describes the potential impacts of the wastes generated, and provides an outline of the management approach for minimising, recycling and disposing of these wastes.

6.14.1 Policy setting

Roads and Maritime policies

The policies 'Towards a more sustainable RMS' (RTA, 2010a) and the 'Waste Reduction and Purchasing Plan' (RTA, 2010b) commit Roads and Maritime to reduce the impact of its activities through the adoption of the waste hierarchy principles of waste avoidance, resource recovery, recycling and disposal.

Waste classification

In NSW all wastes are classified in accordance with the 'Waste Classification Guidelines: Part 1 Classifying Waste' (EPA 2008). This guideline groups wastes that pose similar risks to the environment and human health into the following six classes of waste:

- Special waste.
- Liquid waste.
- Hazardous waste.
- Restricted solid waste.
- General solid waste (putrescible).
- General solid waste (non putrescible).

Resource recovery exemptions

Resource recovery exemptions are granted by the EPA where the land application or use of a waste material is a bona-fide, fit for purpose, reuse opportunity that causes no harm to the environment or human health, rather than a means of waste disposal. An exemption facilitates the use of these waste materials outside of certain requirements of the waste regulatory framework.

The following general resource recovery exemptions have been issued by the EPA and are of most relevance to road construction activities:

- Excavated natural material.
- Excavated public road material.
- Raw mulch.
- Reclaimed asphalt pavement.
- Recovered aggregate.

Utilisation of these exemptions would facilitate the re-use of project wastes particularly excavated soils.

6.14.2 Assessment of potential impacts

Construction

Construction of the proposal would generate waste through the following activities:

- Plant and vehicle maintenance.
- Excavation / earthworks.
- Demolition.
- Vegetation removal.
- General site office activities.
- Surplus construction material.
- Packaging material from general construction and site office deliveries.

Potential waste materials likely to be generated during construction of the proposal and their classification in accordance with the 'Waste Classification Guideline' (EPA, 2008) are detailed in **Table 6-67**. The expected quantity of excavated waste (such as spoil and rocks) that would be unable to be reused within the proposal is provided in **Section 3.4.3**. Around 10.52 hectares of native and exotic vegetation removal would be required for the proposal resulting in the generation of green waste. The likely quantities of other waste materials are unknown at this stage and would be determined during the detailed design of the proposal.

Table 6-67 Potential type and sources of waste generated during construction of the proposal

Waste type (as per Waste Classification Guidelines)	Waste material	Source of waste material
Liquid Waste	Fuel	Plant and vehicle maintenance
	Oil	
Hazardous Waste	ASS[1]	Excavation
	Paints	Demolition and general construction activities
	Solvents	
	Chemicals and chemical containers	
Restricted Solid Waste	Contaminated soils[2]	Excavation
General Solid Waste (putrescible)	Food waste	General office activities
General Solid Waste (non-putrescible)	Pipes (plastic and metal)	Demolition
	Bricks	
	Corrugated iron	
	Fibrous cement	
	Pavement	
	Spoil	Excavation
	Rock	
	Fencing material	Surplus construction material
	Sediment	
	Concrete	
	Reclaimed asphalt	

Waste type (as per Waste Classification Guidelines)	Waste material	Source of waste material
	Sand bags	
	Scrap metal	
	Pallets	Packaging material
	Crates	
	Cartons	
	Plastics	
	Wrapping materials	
	Vegetation	Green waste
	Noxious weeds	
	Chemical containers	Plant and vehicle maintenance
	Paper	General office activities
	Cardboard	
	Beverage containers	

[1] *The feasibility of treating ASS in situ would be investigated prior to disposal at an appropriately licensed off-site facility and would be undertaken in accordance with the ASSMP for the proposal.*
[2] *Depending on the specific contaminant concentration (SCC) in the soil (DECC, 2008).*

The generation of waste from construction of the proposal has the potential to impact the surrounding terrestrial and aquatic environment in the short and long term if not managed appropriately and in compliance with NSW waste regulations. Potential impacts of inappropriately managed waste include:

- Reduction in the quality of the local waterways as a result of:
  - Contamination from spills and leakages of fuel and oil during plant and vehicle maintenance.
  - The movement of stockpiled or excavated ASS into the surrounding waterways.
  - Movement of construction and demolition waste (such as packaging material, asphalt, concrete and green waste) into the local waterways.
  - Sedimentation and erosion due to the inappropriate implementation or maintenance of sediment control measures.
- Impacts to the terrestrial environment resulting from:
  - Untreated excavated contaminated soils leaching into the surrounding ground.
  - Spills and leakages of fuel and oil, which could potentially leach into the soil causing local contamination impacts.
  - The movement of stockpiled, excavated ASS, potentially affecting vegetation growth and causing structural damage and corrosion of steel and concrete structures.
  - Litter generated through construction and demolition activities polluting the surrounding environment and impacting the visual amenity of the surrounding landscape.

However, with the implementation of the standard safeguards and management measures provided in **Table 6-68**, the potential impacts associated with the inappropriate management of waste during construction of the proposal are expected to be minimal.

Operation

During the operational phase of the proposal, wastes would originate from routine maintenance and repair activities that are required over time. The nature and extent of maintenance and repair activities would dictate the type and volumes of waste generated through these works. Waste would also be generated by road users throughout the operation of the proposal. Types of waste generated throughout the operational phase of the proposal (as defined by the EPA's Waste Classification Guidelines) would include:

- General solid waste (non-putrescible), including:
  - Green wastes from mowing and vegetation trimming of landscaped areas along the road side.
  - Road waste including asphalt, aggregates and concrete from routine maintenance and repair activities.
  - Silt and soil from the clearing of culverts and drainage structures.
  - Roadside litter collected along the length of the proposal from road users.
- Liquid waste, namely fuel and oils from routine maintenance activities.

Standard work practices detailed in **Table 6-68** would be implemented during routine maintenance and repair activities. Consequently, the overall impact of operational waste streams would be minimal.

6.14.3 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or manage waste streams generated as a result of the proposal. These measures have been identified in **Table 6-68** and summarised in **Section 7.2**.

Table 6-68 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
Construction			
Inappropriate management of waste	Manage and dispose of all waste in accordance with applicable State legislation and government policies, including: • *Waste Avoidance and Resource Recovery Act 2001* (WARR Act). • *Waste Avoidance and Resource Recovery Strategy 2007* (DECC, 2007). • 'Waste Reduction and Purchasing Policy' (WRAPP) (RTA, 2009). • Compliance with relevant EPA resource recovery exemptions.	Construction contractor	Pre-construction and construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
	Prepare a Waste Management Plan as part of the CEMP, detailing appropriate procedures for waste management according to the waste management hierarchy: • Avoidance of unnecessary resource consumption to reduce the quantity of waste being generated. • Recovery of resources for reuse onsite or offsite for the same or similar use without reprocessing. • Recovery of resources through recycling and reprocessing so that waste can be processed into a similar non-waste product and reused. • Disposal of residual waste material.	Construction contractor	Pre-construction and construction
	In the instance that there are no other feasible and reasonable options for waste avoidance, reuse or recycling, all residual waste material will be disposed to a suitably licensed landfill or waste management facility. Waste materials requiring removal from site would be classified, handled and stored onsite in accordance with the 'Waste Classification Guidelines: Part 1: Classifying Waste' (DECCW, 2009) until collection by a contractor for disposal.	Construction contractor	Pre-construction and construction
Unnecessary resource consumption	Avoid unnecessary resource consumption by making realistic and accurate predictions on the required quantities of resources, such as construction materials.	Construction contractor	Construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
	Apply resource recovery principles, including reuse, recycling and reprocessing, to the management of waste generated during construction, including: • Recovery of resources for reuse. Reuse waste materials generated by the proposal onsite or off-site where possible, including the reuse of topsoil within the construction footprint of the proposal. Onsite reuse would include landscaping works and re-contouring activities. Where such material cannot be reused for the proposal, it may be stockpiled for use on other road projects, or removed from the proposal site for other uses (subject to the third party obtaining any relevant approvals). • Recovery of resources for recycling. Segregate resources such as paper, plastic, glass, aluminium cans and other recyclable materials for recycling during construction. These materials would subsequently be removed from the proposal site and disposed of at a local recycling facility for processing. • Recovery of resources for reprocessing. Mulch or chip green wastes onsite and use for landscaping in the absence of a more beneficial use being identified (such as harvestable timber or fence posts). Larger green waste such as logs can be used for sediment and erosion control and habitat replacement as part of the landscaping and revegetation.	Construction contractor	Construction
	Use recycled products in construction to reduce the demand on resources, in instances where the use of such material is cost and performance competitive (for example, where quality control specifications allow). This may include the use of fly ash and slag within concrete mixes.	Construction contractor	Construction

Potential impacts	Safeguards and management measures	Responsibility	Timing
Excess spoil	Prepare a spoil management strategy to address excess spoil (refer to **Section 3.4.4**). The strategy would consider the following options: • Reduction of spoil volume through detailed design refinement or during construction (should increased quantities of spoil be encountered) through reuse within the proposal. This could include flattening batters or incorporating fill into landscaping (including landscaped mounds, if appropriate). The reuse of excess spoil during construction will be undertaken in accordance with Roads and Maritime's resource recovery exemptions detailed in **Section 6.14.1**. • Further geotechnical investigation during detailed design which may lead to design refinements that reduce the predicted volume of excess spoil. • Utilisation of excess spoil to flatten fill batters to blend the proposal into the existing landscape. • Utilisation of excess spoil in the formation of noise or landscape mounds, where feasible. • Utilisation of excess spoil in the construction of other road projects. • Provision of excess spoil to adjoining landowners, Shoalhaven City Council or other parties requiring spoil[1]. This may include the provision of excess spoil to Shoalhaven City Council to provide stock mounds in flood prone areas as part of its flood mitigation works in the region which are still under investigation by Council.	Roads and Maritime project manager and construction contractor	Detailed design, pre-construction and construction
Operation			
Roadside litter	Manage roadside litter in accordance with the existing Roads and Maritime road maintenance and litter collection program for the Princes Highway.	Roads and Maritime Asset Maintenance	Operation

[1] *Any provision of excess soil or similar materials to a third party would be dependent on the demonstration by the third party that it has obtained the necessary approvals for the use of the material (such as development consent from the relevant local council or a license under section 143 of the Protection of the Environment Operations Act 1997). Appropriate environmental controls would be installed at sites where excess materials are delivered.*

6.15 Greenhouse gas and climate change

This section provides an assessment of the potential impacts of climate change upon the proposal and provides an assessment of the impacts of the proposal on climate change, due to the release of greenhouse gas (GHG) emissions during the construction, operation and maintenance stages. This section also describes measures to avoid or reduce impacts.

6.15.1 Methodology

Greenhouse gas emissions assessment

This GHG assessment was conducted in accordance with the general guiding principles outlined in:

- *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard, Revised Edition* (World Council for Sustainable Business Development and World Resources Institute, 2004).
- *National Greenhouse Accounts (NGA) Factors* (DCCEE, 2012).
- *Greenhouse Gas Assessment Workbook for Road Projects* (Transport Authorities Greenhouse Group (TAGG), 2011), herein referred to as the *TAGG Workbook*.

GHG emissions have been assessed in accordance with the TAGG Workbook.

Climate change risk/impact assessment methodology

The climate change risk assessment is based on the latest available climate science and risk assessment research and publications. The climate change risk assessment undertaken for the proposal applied an approach to risk assessment as recommended by:

- Australian and New Zealand Standard AS/NZS 4360 Risk Management.
- Draft Australian and New Zealand Standard AS/NZS DR AS 5334 Climate change adaptation for settlements and infrastructure.
- Climate Change Impacts and Risk Management: A Guide for Business and Government (Department of the Environment and Heritage Australian Greenhouse Office, 2006).

6.15.2 Assessment of potential impacts

GHG emissions

Construction GHG emissions

The construction of the proposal would generate about 55,427 tonnes of carbon dioxide equivalent (tCO_2-e) emissions. The majority (around three quarters) of total GHG emissions would be Scope 3 emissions being those indirect upstream or downstream emissions (eg associated with the off-site mining, production and transport of materials used in the construction or maintenance of the proposal). The remaining emissions would be Scope 1 emissions being those generated directly by the proposal such as fuel use onsite.

The use of materials for construction of the pavement, bridges, drainage infrastructure and road furniture would be the major source of GHG emissions, accounting for around 59 per cent of total construction GHG emissions. The use of diesel fuel to operate construction equipment on-site would also account for around 27 per cent of total construction emissions.

Operation and maintenance GHG emissions

Activities that would generate GHG emissions during operation and maintenance of the proposal include:

- Road infrastructure operation: The use of electricity for powering street lighting and variable message signage.
- Road infrastructure maintenance: Diesel fuel use for the operation of maintenance equipment and the delivery of maintenance materials.
- Road infrastructure maintenance: Use of materials for maintaining the road pavement.

Annual use of electricity to power street lighting and variable message signage for the proposal would produce around 74 t CO_2-e. The total quantity of GHG emissions associated with road maintenance activities of the proposal would be about 11,786 t CO_2-e, over the life (100 years) of the proposal. The proposal would generate around 192 t CO_2-e GHG emissions annually.

As the proposal is a highway duplication, there would not be a substantial change in the highway length, alignment or grade. Consequently it is not expected that there would be a change in fuel use (total vehicle kilometres travelled) associated with vehicles using the road.

Climate change

Climate change impacts to the proposal

Potential climate change risks and impacts for the proposal are identified in **Table 6-69.**

Table 6-69 Climate change risks and potential impacts

Climate change risk	Possible impacts/consequences of climate change risk	Evaluation of risk level after mitigation
Increased temperatures and evaporation	Bridge structural material degradation: through thermal expansion of bridge joints and paved surfaces, damage can occur to bridge structure material.	Negligible risk – the forecast increase in mean maximum and minimum temperature arising from climate change is within the range of temperatures presently experienced by bridge infrastructure across the state. Australian design standards allow for hotter (hot inland desert) and cooler (Snowy Mountains) environments than predicted under climate change in the Shoalhaven region.
	Asphalt degradation: due to heat events. Deterioration can lead to melting, cracking or rutting.	Negligible risk – there is sufficient knowledge and experience to demonstrate that bituminous and concrete surfaces currently perform satisfactorily in Australia's extremely hot climates such as the tropical north and the dry inland where extreme weather conditions are similar to or more severe than predicted as a result of climate change on the NSW State road network.

Climate change risk	Possible impacts/consequences of climate change risk	Evaluation of risk level after mitigation
Increased intensity and frequency of fire-risk days resulting from increased temperatures and evaporation.	Public safety risk arising from bushfire events	Negligible risks – there is currently a range of site-specific plans that are used on a day to day basis by traffic controllers, working with the Police, Ambulance, Fire and other emergency services to respond to unplanned incidents on the road network. Should climate change result in more frequent floods or fires, these plans are available for implementation, or may be updated over time should that be necessary.
Increased severity and frequency of heavy rainfall.	Asphalt degradation: heavy rainfall can lead to cracking, potholes or rutting.	Negligible risk – existing road pavements already cope with a wide range of rainfall events across the State within the range of climate change related changes. Standards and specifications are constantly being reviewed to ensure pavements perform to a high standard.
	Road foundation degradation: the road foundation can deteriorate due to increased moisture resulting in cracking.	Negligible risk – existing road foundations already cope with a wide range of rainfall events across the State and standards and specifications are constantly being reviewed to ensure foundations perform to a high standard.
Increased severity and frequency of flood events resulting from heavy rainfall.	Flood damage to roads: overtopping and inundation of roads and other road infrastructure as a result of flood events can damage road materials through erosion or other failure modes.	Medium risk - roads are designed to cope with a certain degree of overtopping. However with climate change, there may be changes in floodwater velocity and height which can increase the risk of damage. The road level has been designed not to be overtopped (to the edge of the shoulder) by the one in 100 year event including a six per cent climate change allowance.
	Flood damage to bridges: overtopping and inundation of bridges as a result of flood events can damage bridge structure.	High risk – bridges are difficult to modify once constructed. Flooding loads are well understood and the bridge structural design: • Allows for the passage of a 100 year average recurrence interval design flood with a six per cent climate change allowance in the design event. • Effectively accounts for potentially larger increases in rainfall intensity by considering loads on the structure and lateral loads from overtopping floodwater by undertaking a sensitivity analysis modelling of a 1 in 2000 year flood event.

Climate change risk	Possible impacts/consequences of climate change risk	Evaluation of risk level after mitigation
	Underpass flooding: flooding of culverts or underpasses can result in structural damage and deterioration of material.	High risk – underpasses are very difficult to modify once constructed. Climate change related rainfall increases have been included through a six per cent climate change allowance in the design event. As new information about the impact of climate change on performance of materials becomes available, should there be concern that existing design practices or policies are insufficient, the policies, specifications or practices would be reviewed.
	Overloading of drainage systems and inaccessible drainage elements: as a result of flood events, roads with poor or inadequate drainage systems can become overloaded or blocked. This can lead to a loss of strength and bearing capacity in the road foundation.	Medium risk – inaccessible drainage elements (e.g. drainage culverts and pits) are very difficult to modify once constructed and typically have a structural design life of around 100 years. Climate change related rainfall increases have been accounted for by including a six per cent climate change allowance in the design event.
Increased severity and frequency of flood events resulting from heavy rainfall. Increased intensity and frequency of fire-risk days resulting from increased temperatures and evaporation.	Damage to landscaping and road-side vegetation: due to flood or heat events which can result in a variety of impacts including direct impacts on flora and fauna, biodiversity or habitat and blocked roads or damaged vehicles due to fallen trees.	Medium risk – it is recognised that changes to the climate would have an impact on vegetation and fauna.

The proposal has been planned with an awareness of the potential for climate change impacts. Drainage structures would adequately withstand future climatic changes, such as increased rainfall intensity and more frequent flood events. Specifically:

- The proposal has been designed and would be constructed to provide flood immunity on the carriageway for a 100 year flood event (without accounting for climate change).
- An additional six per cent increase in rainfall intensity has been factored into design of the drainage infrastructure for the proposal to ensure adequate drainage to take into account the effect of climate change.

6.15.3 Safeguards and management measures

Safeguards and management measures would be implemented to avoid, minimise or manage GHG and climate change impacts. These measures are presented in **Table 6-70** and are summarised in **Section 7.2**.

Table 6-70 Safeguards and management measures

Potential impacts	Safeguards and management measures	Responsibility	Timing
GHG emissions	Where feasible and reasonable select the most fuel efficient plant, equipment and vehicles available through consultation with subcontractors and suppliers.	Construction contractor	Construction
	Maintain all plant and vehicles regularly to maintain fuel efficiency.	Construction contractor	Construction
	Procure locally produced goods and services where feasible, reasonable and cost effective to reduce transport fuel emissions.	Construction contractor	Construction
	Specify construction materials with lower emissions intensity in the detailed design (eg recycled steel in place of virgin steel and asphalt in place of concrete) where engineering and other technical specifications can be met and the alternative is feasible and reasonable.	Roads and Maritime project manager	Detailed design
	Seek opportunities to reduce the quantity of construction materials used through innovative design and construction methodologies.	Construction contractor	Pre-construction and Construction
	Where feasible and reasonable, procure recycled content road construction and maintenance materials such as recycled aggregates in road pavement and surfacing (including crushed concrete, granulated blast furnace slag, glass, slate waste and fly ash). This measure forms part of Roads and Maritime's implementation of the NSW Government's WRAPP.	Construction contractor	Pre-construction and Construction
	Plan earthworks to minimise long haulage distances and reduce excess spoil.	Construction contractor	Pre-construction and Construction

6.16 Cumulative impacts

Clause 228 of the EP&A Regulation 2000 requires that for the purposes of Part 5 of the EP&A Act, any cumulative environmental effect of the proposal with other existing or likely future activities must be taken into account when consideration is being given to the likely impact of an activity on the environment.

The assessment of cumulative impacts associated with the proposal was separated into cumulative impacts that would arise from the Princes Highway upgrade program between Gerringong and Bomaderry, and cumulative impacts with other projects in the vicinity of the proposal.

Smaller scale developments such as residential construction projects were excluded from the assessment of cumulative impacts.

6.16.1 Princes Highway upgrade program

Roads and Maritime plans to upgrade about 30.6 kilometres of the Princes Highway between Gerringong and Bomaderry to provide at least a four-lane divided highway (two lanes in each direction) with median separation. This upgrade has been divided into three separate projects:

- The Gerringong upgrade.
- The Foxground to Berry Bypass.
- The proposal.

The overall upgrade of the Princes Highway between Gerringong and Bomaderry will be staged over a number of years, and at the time of writing, is anticipated to be completed by about 2019.

The Gerringong upgrade project

The Gerringong upgrade project involves duplicating 7.5 kilometres of the Princes Highway to a four-lane divided highway between Mount Pleasant and Toolijooa Road. Key features of the proposal include two grade-separated interchanges, northbound and southbound climbing lanes, a new bridge over the Crooked River and extensive drainage structures in the low lying area at Omega Flat. At the time of writing, the Gerringong upgrade project is in the construction phase, and is anticipated to be operational by mid-2015 (see http://www.rmsa.nsw.gov.au/roadprojects/projects/princes_hway/gerringong/ for project updates).

The Foxground and Berry bypass project

The Foxground and Berry bypass project will upgrade 11.6 kilometres of the Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry. The project will provide a four-lane divided highway with median separation, and bypasses of Foxground and Berry. Key features of the project include the construction of about 6.6 kilometres of new highway where the project deviates from the existing highway, five grade separated interchanges, four new highway bridges, a major cutting at Toolijooa Ridge, three highway overbridges, eight underpasses, modifications to local roads and property accesses, the diversion of Town Creek, provision of bus stops, u-turn facilities, roundabouts and cul-de-sacs and the construction of permanent operational ancillary facilities (see http://www.rms.nsw.gov.au/roadprojects/projects/princes_hway/foxground_berry_bypass/ for project updates). At the time of writing, the Foxground and Berry bypass project is in the detailed design phase. Construction is expected to occur between late 2014 and 2018. It is expected to be operational by late 2018.

Cumulative construction impacts

Cumulative construction impacts of the proposal, the Gerringong upgrade and the Foxground and Berry bypass have been considered for two scenarios: simultaneous construction; and consecutive construction. Simultaneous construction of the Foxground and Berry bypass project and the proposal is considered unlikely. The potential impacts associated with this construction scenario have nonetheless been considered as part of this assessment, should this construction scenario occur.

Traffic and transport

Impacts to traffic as a result of the construction of the proposal have been considered in **Section 6.1** of this review of environmental factors. The *Technical Paper: Traffic and Transport* (AECOM, 2013) is provided in **Appendix C**. Simultaneous construction of the proposal and the Foxground and Berry bypass project would increase the number of construction vehicle movements along the Princes Motorway (previously the F6 Southern Freeway) and Princes Highway between Wollongong, Port Kembla, Kiama and the Princes Highway upgrade construction sites. This construction scenario would also result in an increased number of construction vehicles travelling within construction sites and along the roads in close proximity to the Princes Highway at this location, which could affect road performance and increase traffic delays and disruptions along the local and regional road network.

In the unlikely circumstance that simultaneous construction does occur, construction vehicles would be travelling along a mostly upgraded four lane-divided highway, including the completed Gerringong upgrade section of the highway (up until the active construction zones of the Foxground and Berry bypass project and the proposal). The upgraded highway would minimise the potential traffic disruptions and delays that may arise from simultaneous construction of the Foxground and Berry bypass and the proposal.

Consecutive construction of the proposal could potentially have the following impacts:

- Prolonged construction vehicle movements between Wollongong, Port Kembla, Kiama and the proposal.
- Prolonged traffic delays and disruptions along the Princes Highway between Gerringong and Bomaderry as a result of construction activities.

Consecutive construction along the Princes Highway between Gerringong and Bomaderry could also potentially result in construction fatigue at sensitive residential receivers located in close proximity to the proposal's northern highway tie-in, and for road users travelling between Gerringong and Bomaderry.

Throughout construction of the Gerringong upgrade project and the Foxground and Berry bypass project, it is anticipated that some light vehicle traffic would transfer from the existing highway to the 'Sandtrack' to avoid traffic delays from construction works. As the construction works are progressively completed for these two projects, it is expected that some of this traffic would gradually transfer back to the Princes Highway and the impacts to the 'Sandtrack' would be temporary.

During holiday periods, some light vehicle traffic may transfer back to the 'Sandtrack' from the Princes Highway via Beach Road at Berry to avoid slow moving traffic through the proposal. This would be temporary and would not impact the LoS or travel times along the 'Sandtrack'.

Safeguards and management measures to avoid and/or minimise impacts of the proposal on traffic and transport are provided in **Section 6.1.4**. Safeguards and management measures to minimise cumulative traffic and transport impacts would be included in the TMP for the proposal which would be incorporated into the CEMP. Relevant safeguards and management measures would include:

- Appropriate scheduling of construction work.
- The use of traffic controls,
- Selection of appropriate worksite access and egress locations.
- Monitoring of traffic levels and operational performance along the proposal.

Noise and vibration

Construction noise and vibration impacts as a result of construction of the proposal have been considered in **Section 6.2** of this review of environmental factors. The *Technical Paper: Noise and Vibration* (AECOM, 2013) is provided in **Appendix D**. Cumulative construction noise and vibration impacts (simultaneous or consecutive) would be localised to noise sensitive receivers in close proximity to the proposal's northern tie-in point with the Foxground and Berry bypass project.

Simultaneous construction of the proposal and the Foxground and Berry bypass project could potentially generate noise at levels higher than that assessed for these projects separately. This could occur as a result of additional noise sources being present at these locations at the same time.

The consecutive construction of the Foxground and Berry bypass project and the proposal would result in noise sensitive receivers being exposed to construction noise sources for a prolonged period of time, particularly at the northern tie-in point of the proposal. This could give rise to construction fatigue at noise sensitive receivers that are exposed to construction noise from both the proposal and the Foxground and Berry bypass project.

Safeguards and management measures to avoid and/or minimise impacts of the proposal on noise and vibration are provided in **Section 6.2.5**. Safeguards and management measures to minimise cumulative noise and vibration impacts would be included in the NVMP for the proposal which would be incorporated into the CEMP. Relevant safeguards and management measures would include:

- Selecting appropriate plant and equipment for construction activities.
- Plan the delivery of material to, and removal of spoil and waste from the proposal so there is a consistent and minimal number of trucks arriving at construction areas at any one time.
- Carrying out construction works during standard construction hours where feasible and reasonable.

Biodiversity

Impacts from construction of the proposal on biodiversity are considered in **Section 6.3** of this review of environmental factors. The *Technical Paper: Terrestrial Flora and Fauna* (Biosis, 2013) prepared for the proposal and provided at **Appendix E** included an assessment of cumulative impacts of the Princes Highway upgrade program between Gerringong and Bomaderry. Cumulative vegetation clearances required for the Princes Highway upgrade have been quantified and summarised in **Table 6-71**. The proposal accounts for about 16.53 per cent of the total vegetation clearance required for the Princes Highway upgrade.

Table 6-71 Impacts to native vegetation as a result of the Princes Highway upgrade program between Gerringong and Bomaderry

Project	Type of impact	Total (hectares)	Percentage cumulative total (direct and indirect)
Gerringong upgrade	Direct	0.1	0.14
	Indirect	1.58	2.24
Foxground and Berry bypass	Direct	30.40	43.14
	Indirect	26.74	37.95
Berry to Bomaderry upgrade	Direct	5.72	8.12
	Indirect	5.93	8.41
Total		70.47	100

Safeguards and management measures to avoid and/or minimise impacts of the proposal on biodiversity are provided in **Section 6.3.4**. Safeguards and management measures to minimise cumulative biodiversity impacts would be included into the VMP for the proposal which would be incorporated into the CEMP. Other relevant safeguards and management measures would include:

- Restricting vegetation clearance where reasonable and feasible.
- Undertaking vegetation clearance in accordance with Roads and Maritime's Biodiversity Guidelines (RTA, 2011).

Landscape character and visual amenity

Impacts of the proposal on the surrounding landscape character and visual amenity have been outlined in **Section 6.6** of this review of environmental factors. The *Urban Design Report, Landscape Character and Visual Impact Assessment* (AECOM, 2013) is provided at **Appendix H**. Simultaneous construction of the proposal and the Foxground and Berry bypass project would result in an increased active construction footprint across the two upgrade projects in the vicinity of the proposal's northern tie-in point, and could potentially also include the use of both project's temporary construction ancillary facilities at the same time. An increase in the active construction footprint would increase the visual presence of construction within the local landscape for both sensitive residential receivers and road users.

Consecutive construction of the Foxground and Berry bypass project and the proposal would result in the presence of construction equipment and construction zones between Foxground and Bomaderry over an extended period of time, particularly in the vicinity of the northern tie-in point of the proposal. The prolonged presence of construction equipment and zones would disrupt the viewsheds within this area, which would impact on the landscape character and visual amenity of the Berry Bolong Pastoral landscape for both road users and local residents.

Consecutive construction of the Princes Highway upgrade between Gerringong and Bomaderry would mean that construction zones and construction plant and equipment would be used progressively along the highway, moving south towards Bomaderry as the Gerringong upgrade project and Foxground and Berry bypass project's construction phases are completed. The consecutive construction of the Princes Highway upgrade program would mean that construction equipment would be visible along the proposed road reserve between Gerringong and Bomaderry for an extended period of time, which could potentially give rise to construction fatigue for road users along the Princes Highway. Landowners whose properties are located with views to the northern highway tie-in of the proposal may also be exposed to construction fatigue, as construction equipment would be present at this location for both the proposal and the Foxground and Berry bypass project. The duration of construction at the northern tie-in of the proposal, and for the Foxground and Berry bypass project is currently unknown. This would be determined during the respective detailed design phases for both projects.

Safeguards and management measures to avoid and/or minimise impacts of the proposal on the landscape character and visual amenity are provided in **Section 6.6.4**. Safeguards and management measures to minimise cumulative landscape character and visual amenity impacts would include:

- Progressive stabilisation of disturbed areas.
- Implementation of the Urban Design Plan (refer to Section 3 of the *Technical Paper: Urban Design, Landscape Character and Visual Amenity* (AECOM, 2013) at **Appendix H**).
- Reinstating vegetation as close to the top of cuttings as possible.

Air quality

Section 6.12.3 of this review of environmental factors describes the construction impacts of the proposal on air quality.

Simultaneous construction of the proposal and the Foxground and Berry bypass has the potential to increase dust emissions above what has been assessed by either project separately. Consecutive construction of the Gerringong upgrade project, Foxground and Berry bypass project and the proposal would result in prolonged dust emissions between Gerringong and Bomaderry. This could result in construction fatigue for road users, and for residents in close proximity to the highway.

Safeguards and management measures to avoid and/or minimise impacts of the proposal on air quality are provided in **Section 6.12.4**. Safeguards and management measures to minimise cumulative air quality impacts would be included in the AQMP for the proposal which would be incorporated into the CEMP. Relevant safeguards and management measures would include:

- Stabilisation of disturbed areas as soon as practicable.
- Maintenance of stockpiles, compounds and equipment to minimise dust generation and exhaust emissions.

Cumulative operational impacts

Traffic and transport

The traffic and transport impact assessment undertaken for the proposal included a cumulative traffic assessment which took into account the impacts of the proposal in conjunction with the Gerringong upgrade project and the Foxground and Berry bypass project. The proposal would improve the operational performance of the section of the Princes Highway covered by the proposal.

Following completion of the proposal, the performance of the 'Sandtrack' would be slightly improved when compared to its current performance and its performance throughout construction of the Foxground and Berry bypass project and the proposal. While traffic volumes in the region are expected to grow, there would be a shift of traffic from the 'Sandtrack' to the highway following the series of upgrades to the Princes Highway between Gerringong and Bomaderry.

The proposal, as part of the wider Princes Highway upgrade between Gerringong and Bomaderry is expected to improve the roadway LoS within the proposal area. However, the increase in traffic travelling along the Princes Highway could put pressure on unimproved sections and/or intersections of the highway to the south of the proposal. This would include the intersection of the Princes Highway and Cambewarra Road roundabout. While an upgrade to the Cambewarra Road roundabout is outside the scope of this proposal, Roads and Maritime acknowledge that congestion at this roundabout warrants further investigation of forecast traffic impacts as part of a separate study.

The proposal is considered to have overall beneficial operational traffic impacts. The proposal, in conjunction with the Gerringong upgrade project and the Foxground and Berry bypass project would increase both the safety and efficiency of vehicle movements along the Princes Highway between Gerringong and Bomaderry.

Land use and property

The Princes Highway upgrade between Gerringong and Bomaderry would require the permanent acquisition of about 258 hectares of land to accommodate the footprint of the Gerringong upgrade project, the Foxground and Berry bypass project and the proposal. The land to be acquired comprises mostly rural land used predominantly for the purposes of agriculture.

Of the 258 hectares of land to be acquired, about 46 hectares, or 18 per cent would be for the purposes of the proposal. The land to be acquired to accommodate the proposal would include strip or partial acquisition across 66 individual lots. Of the 66 lots, five small lots would be directly impacted in their entirety. Three of these lots are privately owned and two are owned by Shoalhaven City Council. The three privately owned lots are between 0.2 hectares and 1.7 hectares in size and form part of larger rural residential and agricultural properties. A summary of land acquisition for the Princes Highway upgrade between Gerringong and Bomaderry is provided in **Table 6-72**.

The land acquisition required to accommodate the footprint of the proposal, in conjunction with the land to be acquired for the Gerringong upgrade project and the Foxground and Berry bypass project would be unlikely to impact on the residual portions of land, and would allow for the continuation of existing land use on the residual portions.

Although land acquisition is required along the entire alignment for the purposes of the Princes Highway upgrade between Gerringong and Bomaderry, this acquisition would be largely strip acquisition and would not affect the viability of agricultural industries within the Shoalhaven region. Property acquisition that has been undertaken for the proposal, and future property acquisition, has and would continue to be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*.

Table 6-72 Land acquisition required for the Princes Highway upgrade between Gerringong and Bomaderry

Upgrade section	Land acquisition required (hectares)	Proportion of total land required for acquisition (%)	Lots requiring strip or partial acquisition	Lots requiring full acquisition
Gerringong upgrade project	112	43	31	3
Foxground and Berry bypass project	100	39	51	39
Berry to Bomaderry upgrade project	46	18	61	5
Total	258	100	143	47

6.16.2 Other proposals and activities

Searches of the DP&I Major Projects website and the Southern Region Joint Regional Planning Panel projects register identified two projects that, if carried out concurrently with the proposal, could result in the generation of cumulative impacts. These two projects include the North Nowra Link Road and the Shoalhaven Starches factory site proposed gas pipeline.

North Nowra Link Road concept plan

The concept plan for the North Nowra Link Road was approved by the Planning Assessment Commission on the 20 December 2012. The North Nowra Link Road is located north of the Shoalhaven River between Illaroo Road, West Cambewarra Road and the Princes Highway. Concept approval was granted for the northern option, which is south of, and runs parallel to, West Cambewarra Road.

Shoalhaven Starches factory site proposed gas pipeline

The Shoalhaven Starches factory site proposed gas pipeline project would include the installation of a 5.5 kilometre underground gas pipeline. The pipeline would connect the Shoalhaven Starches factory site at Bolong Road, Bomaderry (about 3.7 kilometres south of the proposal) to the eastern gas pipeline at Pestells Lane, Meroo Meadow. The proposed gas pipeline project was approved by the DP&I on 30 October 2012.

Cumulative construction impacts

North Nowra Link Road

The timing and the proposed staging of construction for the North Nowra Link Road is not currently known. There is the potential for cumulative impacts to occur should the North Nowra Link Road be constructed simultaneously or consecutively with the proposal, due to the proximity of the southern tie-in point of the proposal to the North Nowra Link Road.

Should the North Nowra Link Road be constructed simultaneously with the proposal, there is the potential for the following cumulative impacts to occur:

- Increased construction vehicle movements along the proposal route and the regional road network from the north.
- Impacts to local road and intersection performance, in addition to impacts associated with the proposal.
- Further construction noise, from additional and/or louder construction plant and equipment.
- Increased visible presence of construction zones and equipment, temporarily affecting the landscape character and visual amenity of the region covered by the proposal and the proposed North Nowra Link Road.

Due to the proximity of the North Nowra Link Road to the proposal, there is the potential for impacts to arise should consecutive construction occur. These would be related to construction fatigue at any receiver determined to be impacted by construction of both projects, which would be mostly located near the southern tie-in of the proposal. Construction fatigue impacts could occur in this area and would be the result of prolonged exposure from continued:

- Construction vehicle movements.
- Construction speed limits and traffic delays, affecting road performance.
- Construction noise.
- Presence of construction zones and associated plant and equipment.

Shoalhaven Starches factory site proposed gas pipeline

The timing and staging of construction of the approved Shoalhaven Starches gas pipeline is currently unknown, however it is anticipated that construction would not commence until at least 2015. Construction of the proposed gas pipeline would require the excavation of a 660 millimetre wide trench along, and boring under the Princes Highway in the southern section of the proposal in the vicinity of the Pestells Lane and Meroo Road grade separated half-interchange, where it would then follow the transmission line easement to Meroo Road.

Should construction of the section of the proposed gas pipeline in the vicinity of the Princes Highway be undertaken simultaneously with the proposal, there is the potential for construction timing to be impacted. This could include construction delays for the proposal, and the potential for short-term out of hours works to be undertaken. The duration of works in the vicinity of the proposal is unknown and as such, timing implications of concurrent construction would not be determined until detailed design.

Cumulative operation impacts

North Nowra Link Road

The North Nowra Link Road would increase the volume of traffic travelling along Cambewarra Road and may impact on the performance of the roundabout along this road which intersects the Princes Highway, just south of the proposal. In conjunction with the additional traffic travelling along the upgraded Princes Highway, the North Nowra Link Road would place further pressure on this roundabout. While an upgrade to the Cambewarra Road roundabout is outside the scope of the North Nowra Link Road and the proposal, Roads and Maritime acknowledge that congestion at this roundabout warrants further investigation of forecast traffic impacts as part of a separate study.

The North Nowra Link Road would improve access between North Nowra and the Princes Highway, and would also alleviate traffic congestion and improve safety on Illaroo Road. In conjunction with the proposal and the Princes Highway upgrade, the North Nowra Link Road would have a beneficial impact to traffic conditions along the local road network.

Shoalhaven Starches factory site proposed gas pipeline

The operation of the proposed Shoalhaven Starches gas pipeline would be almost entirely below the ground surface. As a result, typical operation of the proposed pipeline in the vicinity of the proposal is not expected to affect operation of the proposal.

6.16.3 Safeguards and management measures

The majority of cumulative impacts would be mitigated and managed by the safeguards and management measures outlined throughout **Chapter 6** of this review of environmental factors. **Table 6-73** below outlines specific safeguards and management measures which would be implemented to minimise and mitigate cumulative impacts associated with simultaneous and/or consecutive construction and operation of the proposal with other projects and proposals in the area.

Table 6-73 Safeguards and management measures

Potential impact	Safeguards and management measures	Responsibility	Timing
Construction			
Cumulative impacts – other projects	Consult with proponents of the North Nowra Link Road project and Shoalhaven Starches factory site proposed gas pipeline project to obtain information about project timeframes and impacts. Identify and implement appropriate safeguards and management measures to minimise cumulative impacts of construction if either of these projects are constructed at the same time as the Berry to Bomaderry upgrade.	Roads and Maritime project manager and construction contractor	Pre-construction and construction.

6.17 Summary of beneficial effects

Beneficial outcomes resulting from the proposal would include:

- Improved road safety. This includes:
  - The provision of a divided road with a central median barrier and safety barrier along the length of the proposal which would help to control traffic turning into and out from local roads and property accesses across fast-moving two-way traffic.
  - A predicted 69 per cent reduction in total crashes along the proposal.
  - Safer access to and from drop-off facilities at bus stops for local residents.
  - Improved safety for cyclists on the highway through the provision of a 2.5 metre wide shoulder. This would enable greater separation of cyclists from high-speed traffic than the existing situation.
- Improved traffic efficiency, including:
  - Higher safe operating speeds.
  - A reduction in travel times by about one minute along the proposal route.
  - Improved operational performance of the Princes Highway along the proposal route and the 'Sandtrack'.
- Improved access to the existing tourism industry on the NSW South Coast.
- Improved access to markets and raw materials in Sydney and the Wollongong-Kiama area for industries in the Nowra area due to reduced travel times and increased road safety.
- Improved quality of surface water runoff into local waterways compared to the existing highway, as a result of the installation of an operational water quality treatment system.
- Improved flood immunity of the highway along the proposal route when compared with the existing highway.

The details of these beneficial effects are described throughout **Chapter 6**.

6.18 Summary of adverse effects

The proposal would generate some short term adverse environmental and social impacts. This would include temporary increases in noise levels at some sensitive receiver locations and a reduction in traffic efficiency caused by speed limit restrictions and increased heavy and light vehicle movements along the road network during construction. In the longer-term, the proposal would result in some adverse environmental and social impacts that would require management including:

- Changed access arrangements and modifications to local roads and properties. Local roads and accesses would be restricted to left-in / left-out movements due to the introduction of a central median and safety barrier fencing along the length of the proposal.
- Highly noise affected receivers. During standard construction hours, 27 noise sensitive receivers would be highly noise affected (more than 75 dB (A)) during earthworks activities and 31 noise sensitive receivers would be highly noise affected during paving works.
- Increased operational noise levels at some properties. A number of sensitive receivers would be exposed to noise levels above the relevant operational noise criteria. To address noise impacts low noise pavement has been included in the concept design for the entire length of the proposal. With low noise pavement, 42 residential receivers and one child care centre would be considered for architectural treatment. Noise barriers are not considered to be feasible or reasonable in these locations.
- Impacts to native vegetation. Potential direct and indirect impacts to 11.65 hectares of native vegetation (terrestrial and aquatic), including the following impacts to EECs:
  - Disturbance of 0.63 hectares of Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (FWCF) EEC.
  - Removal of 0.53 hectares of the River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Coast Bioregions EEC (RFEFCF).
  - Removal of 0.30 hectares of the Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion EEC (ILGW).
- Impacts to Aboriginal heritage. Complete loss of 10 and a partial impact to 14 sites, items or objects of Aboriginal heritage significance.
- Impacts to non-Aboriginal heritage. Complete loss of two, and partial impact to eight sites, items or objects of non-Aboriginal (historic) heritage significance.
- Impacts to the existing landscape character of the proposal area. This is associated with the construction of two additional lanes along the length of the proposal, two grade-separated facilities, a grade separated interchange, eight new bridges over local waterways and a large cutting at Strongs Road, Jaspers Brush.
- Land acquisition. The permanent acquisition of 46 hectares of land currently outside of the existing road reserve, some of which has already been acquired by Roads and Maritime.
- A reduction in the LoS of the roundabout at the intersection of the Princes Highway and Cambewarra Road, Bomaderry. Without the proposal, the roundabout would perform at an unacceptable level by 2039 and with the proposal, it would perform at an unacceptable ‘critical’ performance level by 2039. Roads and Maritime acknowledges that with or without the proposal, further investigation into the performance and upgrade of this roundabout is warranted as part of a separate study.
- Inconvenience to bus users. School bus services currently stop at numerous intersections in rural areas between the Princes Highway and local roads and accesses in the proposal area. In order to improve road safety following the construction of the proposal public and school buses would only stop at dedicated bus stop facilities. This could potentially inconvenience some users who would be required to travel to and from formalised bus stop locations.
- Impacts to business. Potential impacts to four agricultural businesses as a result of changes to farm dam catchments, as well as potential impacts to the viability of one horse stud business as a result of land acquisition.

A number of safeguards and management measures have been identified to adequately address, manage and minimise potential adverse environmental impacts associated with the proposal. These management measures (see **Chapter 6** and **Section 7.2**) would be incorporated into the detailed design and applied during the pre-construction, construction and operation of the proposal.