New England Highway bypass of Muswellbrook

Review of Environmental Factors

Transport for NSW | October 2021

New England Highway bypass of Muswellbrook

Review of Environmental Factors

Transport for NSW | October 2021

Prepared by AECOM Australia Pty Ltd and Transport for NSW
Publication Number: 21.299. ISBN 978-1-922549-41-9

Document controls

Approval and authorisation

Title	New England Highway bypass of Muswellbrook review of environmental factors
Accepted on behalf of Transport for NSW by:	Hannah Gilbert Project Development Manager
Signed:	
Dated:	

Document status

Document status	Date	Prepared by	Reviewed by
0	11/10/2021	AECOM Australia Pty LtD	Transport for NSW

Executive summary

The proposal

Transport for NSW (Transport) proposes to build a New England Highway bypass of Muswellbrook (the proposal). The proposal is located to the east of Muswellbrook and connects the New England Highway to the north and south of Muswellbrook. Key features of the proposal include:

- About nine kilometres of new highway (the bypass) with a single lane in each direction and a wide centreline treatment
- Connection with the New England Highway at the southern end of the proposal, which provides all traffic movements (southern connection)
- A 38 metre bridge over the bypass at the southern connection
- A 76 metre long bridge over Muscle Creek Road and the Main North railway line
- A 114 metre long bridge over Muscle Creek
- Connection with Coal Road, which provides all traffic movements (Coal Road connection)
- A 43 metre long bridge over Coal Road
- A 367 metre long bridge over Sandy Creek Road, Sandy Creek, the Main North railway line and southbound exit ramp
- Connection with the New England Highway at the northern end of the proposal, which provides all traffic movements (northern connection).

Timing for construction of the proposal is subject to project approval. However, construction is expected to start in late 2022 with enabling works. The main work is expected to start in 2023 and would take about three and a half years to complete. The NSW Government has committed full funding for the proposal.

Need for the proposal

The New England Highway is a major freight and commuter route forming part of the Sydney to Brisbane corridor of the National Land Transport Network and the primary route connecting the Upper Hunter with Newcastle. The highway currently passes through Muswellbrook, forming the main road access through the town. Highway traffic passes through multiple sets of traffic lights, a roundabout, a school zone and under a narrow railway overpass, which all impact on travel time. The current route causes a restriction to the efficiency of freight/heavy vehicle movements, which also leads to safety and local amenity concerns.

A bypass of the town centre would remove conflicts between local and through vehicles, significantly improving the efficiency of through freight movements along the New England Highway, while also improving safety and local amenity.

The proposal is also considered consistent with the objectives of many Australian and State government strategic documents including the Future Transport Strategy 2056 (Transport for NSW, 2018).

Proposal objectives

The objectives of the proposal are:

- Improve network efficiency on the New England Highway, particularly travel times for long haul freight movements
- Improve safety for all road users in the town centre, particularly relating to heavy and light vehicle interactions
- Improve amenity of Muswellbrook township by removing freight traffic.

Options considered

Transport has carried out multiple investigations to identify a preferred route for a New England Highway bypass of Muswellbrook. In 2005, the Australian Government announced a preferred option for a bypass of Muswellbrook which was subsequently included in the Muswellbrook Local Environment Plan 2009. In 2018, several corridors were investigated, with a refined version of the 2005 preferred option recommended as the preferred route corridor.

In 2020 Transport completed a detailed review and refinement of the 2018 preferred route corridor to select a preferred bypass option. Selection of the preferred option considered technical, social, environmental and economic factors.

Statutory and planning framework

As the proposal is a road and is to be carried out by Transport it can therefore be assessed under Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Development consent from council is not required. This review of environmental factors (REF) has examined and considered all matters affecting or likely to affect the environment by reason of the proposed activity.

A strategic assessment under Transport's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) – Strategic Assessment also applies to the proposal. This REF has been prepared to meet the requirements of the EPBC Act strategic assessment approval with respect to the impacts of Transport's road activities on nationally listed threatened species, ecological communities and migratory species. A referral to the Australian Department of Agriculture, Water and the Environment is not required.

Community and stakeholder consultation

Consultation with community and stakeholders on proposed routes for a potential bypass has been carried out since the Australian Government first announced a preferred option for a Muswellbrook bypass in 2005. Feedback has been considered as route options have been further developed and refined. A preferred route options report was published in 2018. The 2018 report identified a preferred route corridor and included potential bypass connections.

A preferred option for the bypass was displayed for community and stakeholder feedback between 23 November and 18 December 2020. Feedback received on the preferred option was considered to further refine and prepare the concept design and environmental assessment for the bypass.

During the development of this REF, Transport has consulted with potentially affected property owners, community members, local business owners and relevant government agencies, including Muswellbrook Shire Council and other stakeholders. Comments received during consultation have been considered and addressed in the REF.

Consultation with Aboriginal stakeholders has been carried out in accordance with the *Procedure for Aboriginal Cultural Heritage Consultation and Investigation* (PACHCI) (Roads and Maritime Services, 2011), the *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW, 2010) and the requirements of Clause 60 of the *National Parks and Wildlife Regulation 2009*.

Transport will continue to consult with the community and stakeholders as planning progresses. Information about the proposal is also available on the Transport website.

Environmental impacts

The main environmental impacts of the proposal are:

Biodiversity

A Biodiversity Assessment has been prepared to assess the potential biodiversity impacts associated with the proposal. The assessment indicates the proposal is unlikely to lead to a significant impact on any threatened species, populations, ecological communities or their habitats.

Four threatened ecological communities (TECs) listed under the *Biodiversity Conservation Act 2016* (BC Act) and two threatened ecological communities listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) would be impacted by the proposal. Removal of up to 94.28 hectares of TECs under the BC Act may result from the proposal with 9.46 hectares of this also listed as critically endangered under the EPBC Act. Low condition derived native grasslands accounts for 75.66 hectares native vegetation clearing.

There were 11 threatened fauna species recorded and 31 threatened fauna species having a moderate or high likelihood of occurrence within the study area. Impacts to fauna have been minimised or avoided throughout the concept design particularly around habitat of the Striped Legless Lizard. Fauna infrastructure would be installed including an aerial crossing, nest boxes and utilising Muscle Creek bridge as an underpass, with fauna fencing further considered during detailed design.

An assessment of significance has been carried out for threatened species and ecological communities that are likely to occur in the proposal area. The assessment found the proposal is not likely to significantly impact threatened species or ecological communities or their habitats, within the meaning of the *BC Act* or the *Fisheries Management Act 1994.* The proposal is not likely to significantly impact threatened species, ecological communities or migratory species, within the meaning of the EPBC Act.

A Biodiversity Offset Strategy would be prepared in accordance with Transport's '*Guidelines for Biodiversity Offsets'* (November 2016), to identify biodiversity credits and/or supplementary measures for those entities impacted.

Surface water, hydrology and flooding

The proposal crosses the Hunter River floodplain and the Sandy Creek and Muscle Creek tributaries.

The proposal would have limited potential to affect flood levels for Sandy Creek. Flood modelling for all events up to and including one per cent Annual Exceedance Probability (AEP) event showed 28 out of 33 properties in the adjacent study area had either no increase in peak flood level, or a very minor increase (less than 0.03 metres). Of the remaining five properties, only two showed an increase above 0.1 metre (one of which is an agricultural lot containing a groundwater bore well). In the probable maximum flood (PMF) event, ten properties would have a flood level increase above 0.1 metres. In this extreme event, surrounding local roads and properties would already be inundated to significant depths.

For Muscle Creek, the potential flood impacts resulting from the proposal would be minimal as the flow would remain largely in the banks of the creek for events up to and including the 0.05 per cent AEP event. All modelled events except for the PMF event showed no notable impacts to properties near the Muscle Creek impact zone. In the PMF event, two properties would be impacted. In this extreme event, surrounding local roads and properties would already be inundated to significant depths.

Traffic and transport

The proposal would significantly reduce heavy vehicles volumes on the New England Highway through the Muswellbrook Town Centre.

On year of opening, the proposal is expected to remove up to 4800 vehicles per day (including about 1900 heavy vehicles) from the New England Highway through Muswellbrook. This represents an expected reduction in heavy vehicles of between 57 and 77 per cent, along sections of the New England Highway through Muswellbrook.

The proposal would improve travel times by providing a shorter travel distance with a posted speed limit of 100 kilometres per hour. It is expected the proposal will result in travel time savings of between 5.3 and 6.7 minutes during peak travel times on year of opening.

Noise and vibration

An assessment of the potential noise and vibration impacts for the proposal was carried out for construction and the following operational scenarios, ‘Do Minimum’ (without the proposal) and ‘Design (with the proposal) in the years 2027 and 2037.

The assessment identified that construction noise levels from the proposal would exceed the noise management levels at nearby receivers during a number of scenarios. Earthworks and pavement work are likely to cause the largest number of exceedances. Safeguards and management measures have been developed to reduce the potential noise impacts from the work.

The operational road traffic noise assessment concluded that 24 noise sensitive receivers are eligible for consideration of at-receiver noise treatment. These mitigation recommendations would be re-evaluated at the detailed design phase and are subject to change. This may result in more or less sensitive receivers qualifying for consideration of at-receiver noise mitigation. This will take into account any changes to the design and would involve consultation with affected residents.

It is expected that the maximum noise events would decrease in number and duration with the proposal due to reduced traffic volumes, particularly heavy vehicles, on the existing route and reduced congestion for receivers within Muswellbrook.

Aboriginal heritage

The proposal is anticipated to impact 11 Aboriginal archaeological sites during construction, with a total loss of value for four sites and partial loss of value for the remaining seven sites. Two sites of cultural significance would also be impacted by the proposal. An Aboriginal heritage impact permit would be sought for the proposal.

Aboriginal archaeological survey and test excavations were completed in consultation with Aboriginal stakeholders in accordance with Transport’s procedures. Refinement of the project corridor following the test excavation has resulted in avoidance of one archaeological site and reduced the extent of the proposed impact at five other moderately significant sites.

Air quality

The proposal would notably reduce the number of sensitive receptors subjected to elevated concentrations of particulates. Once the bypass is operational, predicted $PM_{2.5}$ exceedances adjacent to the New England Highway would be limited to within about 20 metres of the kerb. This is less than predicted exceedances under the ‘no build scenario’ which are predicted to extend up 40 to 50 metres from the kerb.

Socio-economic

During construction, the proposal would result in temporary amenity impacts associated with construction activities including noise and vibration, air quality and visual impacts. Impacts on traffic on the New England Highway during construction would be minor and temporary in nature. During construction, businesses are unlikely to be impacted, with expenditure from workers benefiting local businesses and suppliers.

While businesses relying on passing trade may experience a decrease in turnover and reduced employment in the short term, businesses away from the bypass may be more attractive to residents and visitors alike as the amenity of the town improves with the reduction in heavy traffic. Employment and business within the Muswellbrook local government area (LGA) would continue to grow as a result of the region's diverse range of industry sectors.

The proposal is forecast to improve travel times, reduce future congestion and reduce travel costs. Improvements in the efficiency and reliability of these transport networks would likely result in increased productivity, reduced costs and broader economic benefits.

Justification and conclusion

The proposal is recommended as it would best address the objectives for the New England Highway bypass of Muswellbrook. The proposal is consistent with Government strategic planning at Commonwealth, State and regional levels. While there would be some adverse impacts to the local environment and community, they have been avoided or minimised wherever possible through design and site-specific safeguards.

The NSW Government is committed to delivering an efficient and effective transport system which reduces the time it takes to travel across NSW. The proposal would improve transport connections and lower vehicle operating costs between employment and tourist destinations. It would enable increased average speeds for freight and passenger movements on the New England Highway.

The proposal is justified because it would help reduce travel times along the New England Highway particularly for long haul freight movements, improve road safety and improve amenity in Muswellbrook and meet future traffic needs.

Display of the review of environmental factors

This REF is on display for comment between Monday 8 November 2021 to Friday 17 December 2021. You can access the documents in the following ways:

Internet

The documents are available as pdf files on the Transport for NSW website at nswroads.work/muswellbrook

A virtual engagement room, virtual information and the opportunity to register for updates is available at the online portal nswroads.work/muswellbrook

Printed copies

Due to COVID-19 restrictions, hard copies will not be available. You can view the Muswellbrook Bypass REF and Concept Design at our virtual consultation room at nswroads.work/muswellbrook

How can I make a submission?

To make a submission about this proposal, please send your written comments to:

- our online submission form at nswroads.work/muswellbrook
- submit via email at Muswellbrook.Bypass@aecom.com
- mail a submission to Muswellbrook bypass project team Locked Bag 2030 Newcastle NSW 2300

Submissions must be received by 5pm Friday 17 December 2021. Submissions will be managed in accordance with the Transport for NSW Privacy Statement which can be found at https://www.transport.nsw.gov.au/privacy-statement or by contacting 1800 953 777 for a copy.

What happens next?

Transport will collate and consider the submissions received during public display of the REF.

After this consideration, Transport for NSW will determine whether or not the proposal should proceed as proposed and will inform the community and stakeholders of this decision.

If the proposal is determined to proceed, Transport for NSW will continue to consult with the community and stakeholders prior to and during construction.

Contents

Tables

Figures

Appendices

Appendix A	Biodiversity Assessment Report
Appendix B	Socio-Economic Impact Assessment Report
Appendix C	Aboriginal Cultural Heritage Assessment Report (Stage 3 PACHCI)
Appendix D	ISEPP Consultation
Appendix E	Flood Assessment Report
Appendix F	Mining Assessment Report
Appendix G	Government Agencies and Stakeholder Consultation
Appendix H	Consideration of clause 228(2) factors and Matters of National Environmental Significance and Commonwealth Land
Appendix I	Surface Water and Groundwater Assessment Report
Appendix J	Phase 1 Contamination Assessment Report
Appendix K	Traffic and Options Modelling Report and Additional Traffic Modelling
Appendix L	Noise and Vibration Impact Assessment Report
Appendix M	Old Coal Rail Spur Bridge Heritage Assessment and Statement of Heritage Impact
Appendix N	Air Quality Impact Assessment Methodology and Data
Appendix O	Landscape Character and Visual Impact Assessment Report

1. Introduction

This chapter introduces the proposal and provides the context of the environmental assessment. In introducing the proposal, the objectives and proposal development history are detailed and the purpose of the report provided.

1.1 Proposal identification

Transport for NSW (Transport) proposes to build a New England Highway bypass of Muswellbrook.

The location of the proposal is shown in Figure 1-1. Chapter 3 provides a detailed description of the proposal.

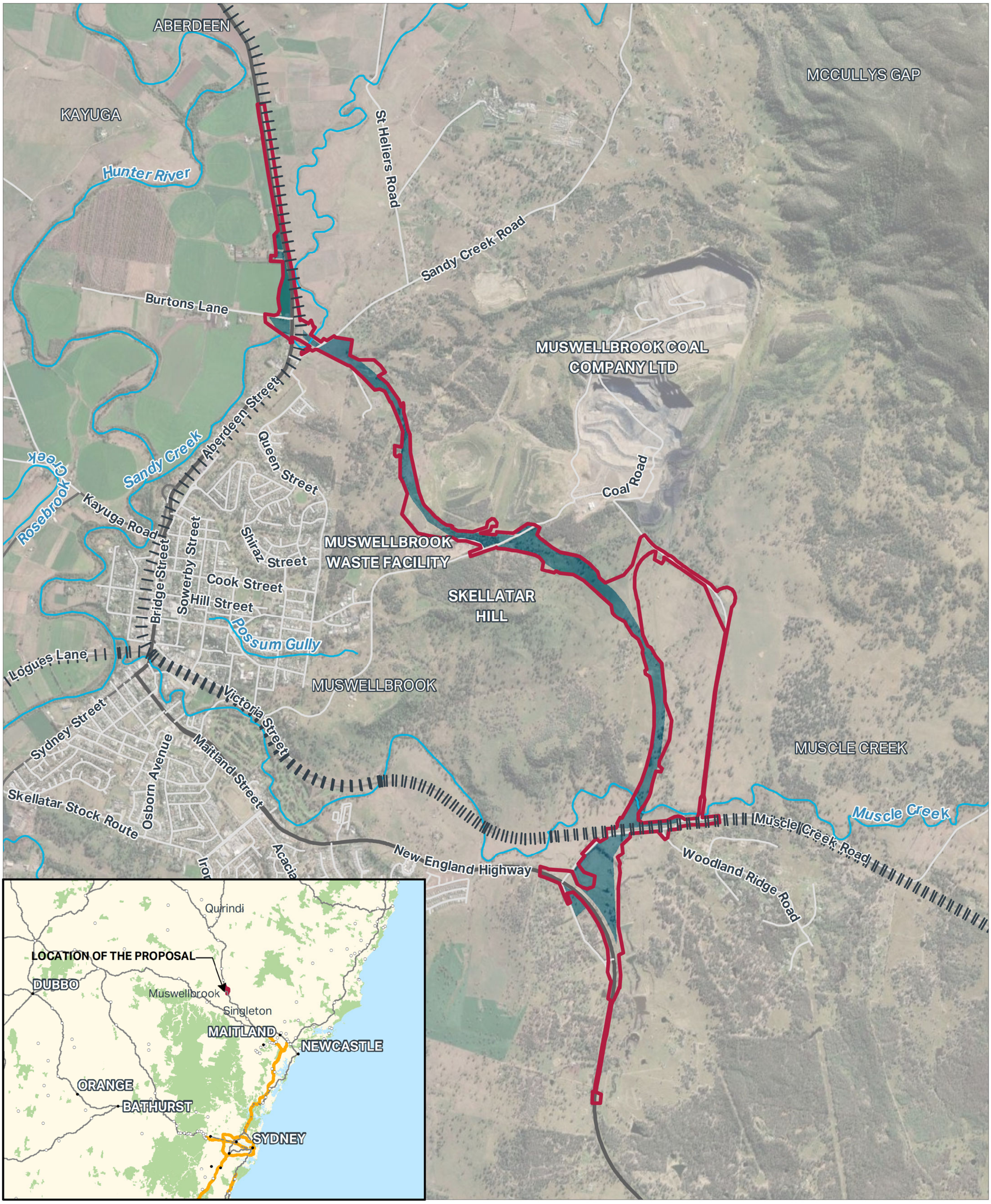


FIGURE 1-1: LOCATION OF THE PROPOSAL

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse

N

0 0.5 1 km

AECOM

1.2 Purpose of the report

This review of environmental factors (REF) has been prepared by AECOM Pty Ltd on behalf of Transport. For the purposes of this work, Transport is the proponent and the determining authority under Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The purpose of the REF is to describe the proposal, to document the likely impacts of the proposal on the environment, and to detail mitigation and management measures to be implemented.

The description of the proposed work and assessment of associated environmental impacts has been carried out in the context of clause 228 of the Environmental Planning and Assessment Regulation 2000, the factors in *Is an EIS Required? Best Practice Guidelines for Part 5 of the Environmental Planning and Assessment Act 1979* (Is an EIS required? guidelines) (DUAP, 1995/1996), *Roads and Related Facilities EIS Guideline (DUAP 1996)*, the *Biodiversity Conservation Act 2016 (BC Act), the Fisheries Management Act 1994* (FM Act), *and the Australian Government's Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

In doing so, the REF helps to fulfil the requirements of:

- Section 5.5 of the EP&A Act including that Transport examines and takes into account to the fullest extent possible, all matters affecting or likely to affect the environment by reason of the activity
- The strategic assessment approval granted by the Federal Government under the EPBC Act in September 2015, with respect to the impacts of Transport's road activities on nationally listed threatened species, ecological communities and migratory species.

The findings of the REF would be considered when assessing:

- Whether the proposal is likely to have a significant impact on the environment and therefore the necessity for an environmental impact statement to be prepared and approval to be sought from the Minister for Planning and Public Spaces under Division 5.2 of the EP&A Act
- The significance of any impact on threatened species as defined by the BC Act and/or FM Act, in section 1.7 of the EP&A Act and therefore the requirement for a Species Impact Statement or a Biodiversity Development Assessment Report
- The significance of any impact on nationally listed biodiversity matters under the EPBC Act, including whether there is a real possibility that the activity may threaten long-term survival of these matters, and whether offsets are required and able to be secured. The potential for the proposal to significantly impact any other matters of national environmental significance or Commonwealth land and the need, subject to the EPBC Act strategic assessment approval, to make a referral to the Australian Government Department of Agriculture, Water and the Environment for a decision by the Commonwealth Minister for the Environment on whether assessment and approval is required under the EPBC Act.

2. Need and options considered

This chapter describes the need for the proposal in terms of its strategic setting and operational need. It identifies the various options considered and the selection of the preferred option for the proposal.

2.1 Strategic need for the proposal

The New England Highway is a major freight and commuter route forming part of the Sydney to Brisbane corridor of the National Land Transport Network and the primary route connecting the Upper Hunter with Newcastle. The route allows for the transport of goods to domestic and international markets via Newcastle and Sydney. The Hunter is Australia's fifth largest economic region and the Port of Newcastle handles about 40 per cent of sea cargo for NSW. Consequently, the New England Highway is very important to many communities in the region. Due to mining activities in the region, the route also accommodates the transport of mining equipment and vehicles, which are often over-size over-mass (OSOM).

The proposal would enable road users to continue their journey on a bypass which would reduce the volume of heavy freight vehicles and road users travelling through Muswellbrook. A bypass of the town centre would remove conflicts between local and through vehicles, significantly improving the efficiency of through heavy vehicle movements along the New England Highway, while also improving local amenity.

The proposal is expected to improve traffic flow, travel times and safety through Muswellbrook, which would meet the proposal objectives as outlined in Section 2.3.1.

2.1.1 Strategic planning framework

The proposal is considered to be consistent with the objectives of the Australian and State government strategic documents outlined in Table 2-1.

Table 2-1: Consistency with relevant strategic documents

Relevant strategic documents	Consistency with the proposal
New England Highway Draft Corridor Strategy (Transport for NSW, 2016)	The New England Highway Draft Corridor Strategy aims to create an efficient road transport corridor that has the capacity for future growth. Short-term investment priorities under this Strategy include: • Develop options to progressively increase capacity between the Golden Highway and Muswellbrook • Investigate options for a bypass of Muswellbrook
Future Transport Strategy 2056 (Transport for NSW, 2018)	The Future Transport Strategy 2056 is a vision for how transport can support growth and the economy of New South Wales over the next 40 years. The 'New England Highway, Muswellbrook Bypass' is listed as a regional NSW committed initiative
Regional NSW Services and Infrastructure Plan (Transport for NSW, 2018)	The Regional NSW Services and Infrastructure Plan is the NSW Government's blueprint for transport in regional NSW from now until 2056. The plan has committed to the planning of the 'New England Highway, Muswellbrook Bypass' initiative

Relevant strategic documents	Consistency with the proposal
Hunter Regional Plan 2036 (Department of Planning and Environment, 2016)	The Hunter Regional Plan 2036 identifies the New England Highway as one of several national freight networks linking the Hunter Region to global gateways like the Port of Newcastle. The plan outlines actions to enhance the efficiency of these networks (including at Muswellbrook) to support economic growth and diversification of regional NSW
Hunter Regional Transport Plan (Transport for NSW, 2016)	The Hunter Regional Transport Plan identifies the need to progressively provide upgrades along the New England Highway to address safety and congestion issues. This includes reducing the impact of freight movements on the urban centre of Muswellbrook
Hunter Economic Infrastructure Plan (Regional Development Australia, 2013)	The Hunter Economic Infrastructure Plan was prepared to ensure the region has an integrated plan to assist mining communities, improve export capacity and support the Hunter's future economic growth. The plan identifies a 'bypass of the New England Highway around Muswellbrook' as one of 13 key road infrastructure projects in the region
Upper Hunter Strategic Regional Land Use Plan (Department of Planning and Infrastructure, 2012)	A key objective of the Upper Hunter Strategic Regional Land Use Plan is to supply required infrastructure to cater for sustainable economic and population growth in the region. This Plan notes that consideration needs to be given to potential town bypasses
Muswellbrook Land Use Development Strategy (Muswellbrook Shire Council, 2015)	The Muswellbrook Land Use Development Strategy notes that the 'proposed bypass' would create significant benefits to the existing town centre including removing conflicts between local traffic and through traffic in the Muswellbrook town centre, removing heavy vehicle through traffic away from the town centre and adjacent residential areas, providing an opportunity to develop a more pedestrian friendly environment in Muswellbrook's main street and improving residential amenity by reducing traffic noise levels in the town

2.2 Limitations of existing infrastructure

The route of the New England Highway, which currently passes through Muswellbrook, causes a restriction to the efficiency of freight/heavy vehicle movements on the New England Highway, which also leads to safety and local amenity concerns. Within the town centre, there are conflicting demands on the New England Highway (Bridge Street), between light vehicles undertaking local trips (shopping, employment and school), and heavy vehicles, particularly longer articulated vehicles which predominantly undertake long haul freight trips.

The New England Highway passes through the town centre of Muswellbrook, forming the main road access through the town. Currently highway traffic passes through multiple sets of traffic signals, a roundabout, a school zone and under a narrow railway overpass, which all impact on travel time. The narrow railway underpass also poses limitations for OSOM vehicles which are required to use alternate routes around the town.

The New England Highway is four lanes for most of the route through Muswellbrook, with a two-lane section between Denman Road (Sydney Street) and the Market Street roundabout at the rail underpass.

As such, the existing travel times along the New England Highway through Muswellbrook are constrained by its road environment and a 50 kilometre per hour posted speed. The proposal would improve travel times by providing a free flow 100 kilometre per hour alternative route which would be compatible with the existing New England Highway road environment either side of Muswellbrook.

2.3 Proposal objectives and development criteria

2.3.1 Proposal objectives

Objectives of the proposal include:

- Improve network efficiency on the New England Highway, particularly travel times for long haul freight movements
- Improve safety for all road users in the town centre, particularly relating to heavy and light vehicle interactions
- Improve amenity of Muswellbrook township by removing freight traffic.

2.3.2 Development criteria

Development criteria for the proposal include:

- Provide new highway bypass of the town of Muswellbrook, with one lane in each direction undivided with wide centreline treatment
- Provide connections to existing New England Highway at both the northern and southern ends of Muswellbrook.

The design criteria are provided in further detail in Section 3.2.1.

2.3.3 Urban design objectives

Urban design objectives for the proposal include:

- Respond to the landform
- Contribute to the urban structure
- Maximise the travel experience
- Respond to landscape patterns
- Design for minimal lifestyle costs
- Coordinate a simple and consistent design language along the road corridor.

The urban design objectives are provided in further detail in Section 3.2.4.

2.4 Alternatives and options considered

The following sections describe the options that have been considered and assessed over the development of the proposal.

2.4.1 Methodology for selection of preferred option

Transport has carried out multiple investigations to identify a preferred option for a New England Highway bypass of Muswellbrook.

In 2005, the Australian Government announced a preferred option for a bypass of Muswellbrook which was subsequently included in the Muswellbrook Local Environment Plan 2009 (Muswellbrook LEP).

In 2015, the NSW Government announced funding to progress planning for the bypass. Transport undertook a review of route options with the aim to identify an economically viable option. In 2018, a preferred route options report was published (Roads and Maritime, 2018). The blue option (a refined version of the 2005 preferred option) was recommended as the preferred route corridor. This option also included potential bypass connections.

In 2019, the NSW Government announced full funding to complete planning and construction of the bypass. Transport completed a detailed review and refinement of the 2018 preferred option (blue option). The alternate option (2020) (a refined version of the 2018 preferred option) was recommended as the preferred option. The preferred option (2020) included full southern and northern connections with the existing New England Highway, which provide for all traffic movements. Selection of the preferred option took into account technical, social, environmental and economic factors.

The preferred option (2020) was displayed for community comment from 23 November to 18 December 2020. Feedback received on the preferred option was considered to further refine and prepare the concept design and environmental assessment for the bypass.

The shortlisted route options from 2018 and 2020 are discussed in Section 2.4.2, and the options analysis is provided in Section 2.4.3. The preferred option (2020) selection is described in Section 2.5. Design refinements made to the preferred option (2020) were displayed as discussed in Section 2.6.

2.4.2 Identified options

Route options 2018

Transport undertook a review of multiple route options including consideration of in-town routes, as well as full and staged outer bypass options. Transport reviewed strategic designs, cost estimates, traffic modelling and economic analysis for potential route options as well as constraints analyses identified from preliminary environmental investigations, desktop studies and site inspections.

The main features of the five shortlisted route options considered for a New England Highway bypass of Muswellbrook are described below and the alignments shown in Figure 2-1. The do nothing option was also considered.

Do nothing option

This option would result in the New England Highway through Muswellbrook continuing to function in its current state. There would be no New England Highway bypass of Muswellbrook or improvement in traffic flow, travel times and safety though Muswellbrook.

Option A (blue option) – preferred option (2018)

Option A would be about 9.1 kilometres long. This option would depart from the existing New England Highway near Milpera Drive. The bypass would head north on new bridges crossing Muscle Creek Road and the Main North railway line and another bridge further north crossing Muscle Creek.

The bypass would continue north on the eastern side of Skellatar Hill before curving north-west and crossing Coal Road between the Muswellbrook Waste Management Facility and the Muswellbrook Coal Mine. This option would potentially include a connection to Coal Road.

The bypass would then continue north on four new bridges crossing Sandy Creek Road, Sandy Creek, the Main North railway line, then an overpass, before connecting with the existing New England Highway about 1.2 kilometres north of Sandy Creek Road.

Option B (purple option)

Option B would be about 7.9 kilometres long. This option would depart the existing New England Highway about 800 metres east of Bimbadeen Drive. The bypass would head north-west on a new bridge crossing

Muscle Creek on the eastern boundary of the Muswellbrook Golf Course and the Main North railway line. The bypass would then run parallel to Coal Road and continue north on a new bridge crossing Coal Road between Weeraman Fields and the Muswellbrook Waste Management Facility.

The bypass would then continue north on new bridges crossing Sandy Creek Road, Sandy Creek and the Main North railway line then overpass and connect with the existing New England Highway about 1.2 kilometres north of Sandy Creek Road.

Option C (yellow option)

Option C would be about 7.7 kilometres long. This option would depart the existing New England Highway about 300 metres west of Muscle Creek Road. The bypass would head north on a new bridge crossing the Main North railway line, before heading north-west towards Muswellbrook. The bypass would then head north, parallel to Coal Road, before crossing Coal Road on a new bridge between Weeraman Fields and Muswellbrook Waste Management Facility.

The bypass would then continue north on new bridges crossing Sandy Creek Road, Sandy Creek and the Main North railway line, then overpass and connect with the existing New England Highway about 1.2 kilometres north of Sandy Creek Road.

Option D (green option)

Option D would be about 7.1 kilometres long and uses new and existing roads. This option would depart the existing New England Highway at Bell Street. The bypass would head north on Bell Street which is an existing OSOM heavy vehicle route. This option would require an upgrade of the intersection of Bell Street and the existing New England Highway.

After Bell Street, the bypass would continue east along Victoria Street before joining Coal Road. Coal Road would need minor alignment improvements to meet minimum heavy vehicle design standards.

The bypass would leave Coal Road on a new road section, and head north between Weeraman Fields and Muswellbrook Waste Management Facility.

The bypass would then continue north on new bridges crossing Sandy Creek Road, Sandy Creek and the Main North railway line, then overpass and connect with the existing New England Highway about 1.2 kilometres north of Sandy Creek Road.

Option E (orange option)

Option E would be about seven kilometres long. This option would follow the same alignment as the green option but would require more changes to the existing road network, including a new bridge on Bell Street over the Main North railway line and a realigned section of Coal Road.

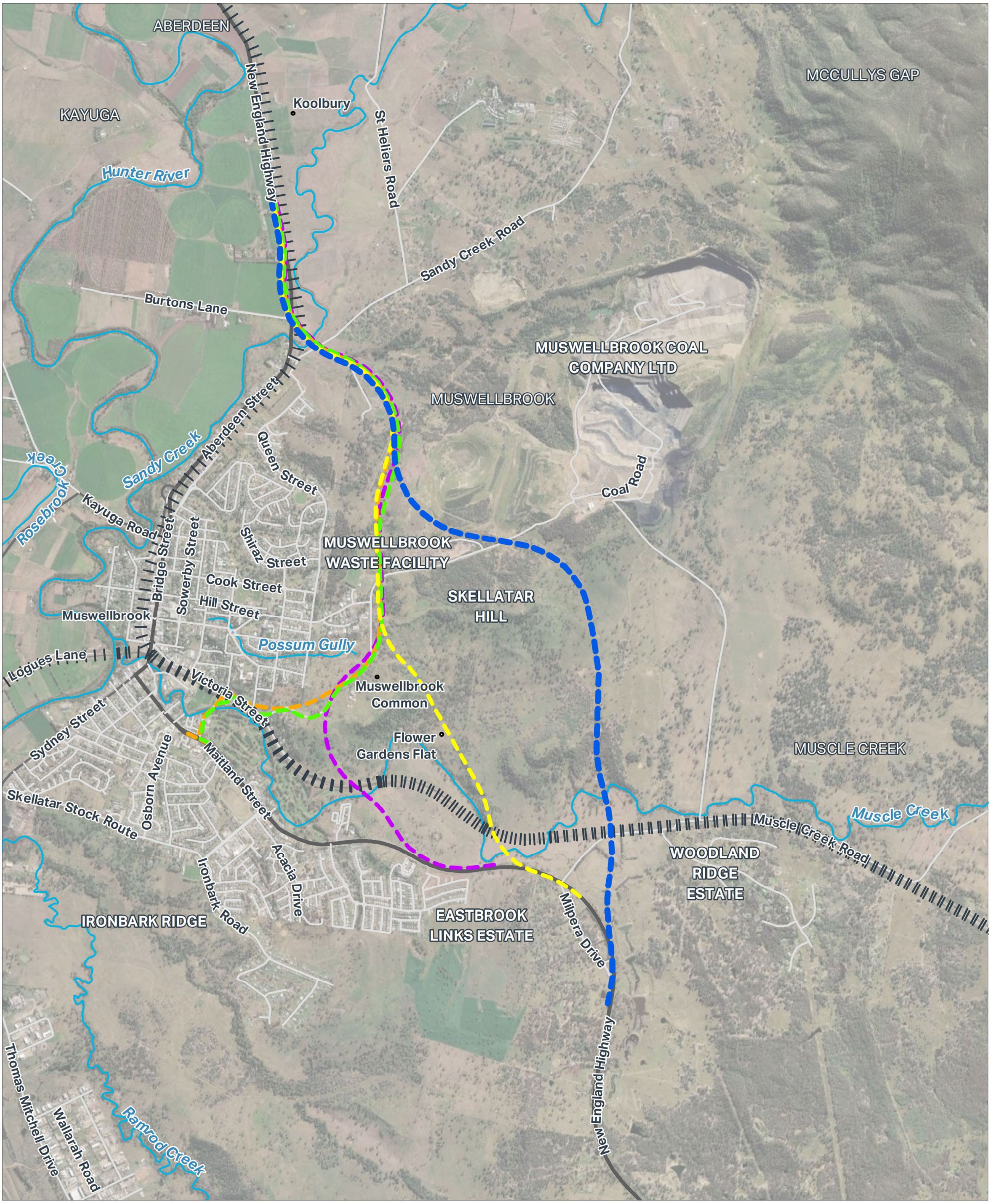


FIGURE 2-1: ROUTE OPTIONS 2018

N 0 0.5 1 km

AECOM

Legend

- State Road
- Regional Road
- Local Road
- Railway
- Watercourse
- Blue Option
- Green Option
- Orange Option
- Purple Option
- Yellow Option

Route options 2020

Transport completed a detailed review and refinement of the 2018 preferred option (blue option) to identify potential design modifications based on engineering, environmental, geotechnical, social, economic, constructability and functional considerations. Developing the preferred option included:

- Site investigations to identify geotechnical and environmental constraints to minimise potential impacts
- Consultation and investigations to better understand any potential heritage impacts
- Production of design options for the alignment and connections to the existing New England Highway.

The alternate option (2020) was shortlisted as a refinement to the blue option (2018). The main features of the alternate option (2020) are described below, and the two options are shown in Figure 2-2.

In comparison to the blue option (2018), the alternate option would depart from the existing New England Highway further to the north. Similar to the blue option, the bypass would head north on new bridges crossing Muscle Creek Road and the Main North railway line, and another bridge further north crossing Muscle Creek. All three bridges would be further to the east compared to the blue option.

The bypass would continue north of Muscle Creek with the refined alignment shifted substantially further to the east to reduce environmental impacts. The refined alignment also improved the road geometry with the maximum grade reduced from eight per cent to five per cent, and the earthworks cut and fill volumes better balanced.

The bypass would continue north on the eastern side of Skellatar Hill before curving north-west and crossing Coal Road between the Muswellbrook Waste Management Facility and the Muswellbrook Coal Mine. The refined alignment minimises both cut and fill over the mine affected area, reducing settlement risk. The bypass would also pass further to the east providing greater separation to the existing Ausgrid substation.

In comparison to the blue option (2018), in lieu of four individual bridges, the bypass would then continue north on a new single bridge crossing Sandy Creek Road, Sandy Creek, the Main North railway line and then an overpass, before connecting with the existing New England Highway just north of Koolbury Flats Row.

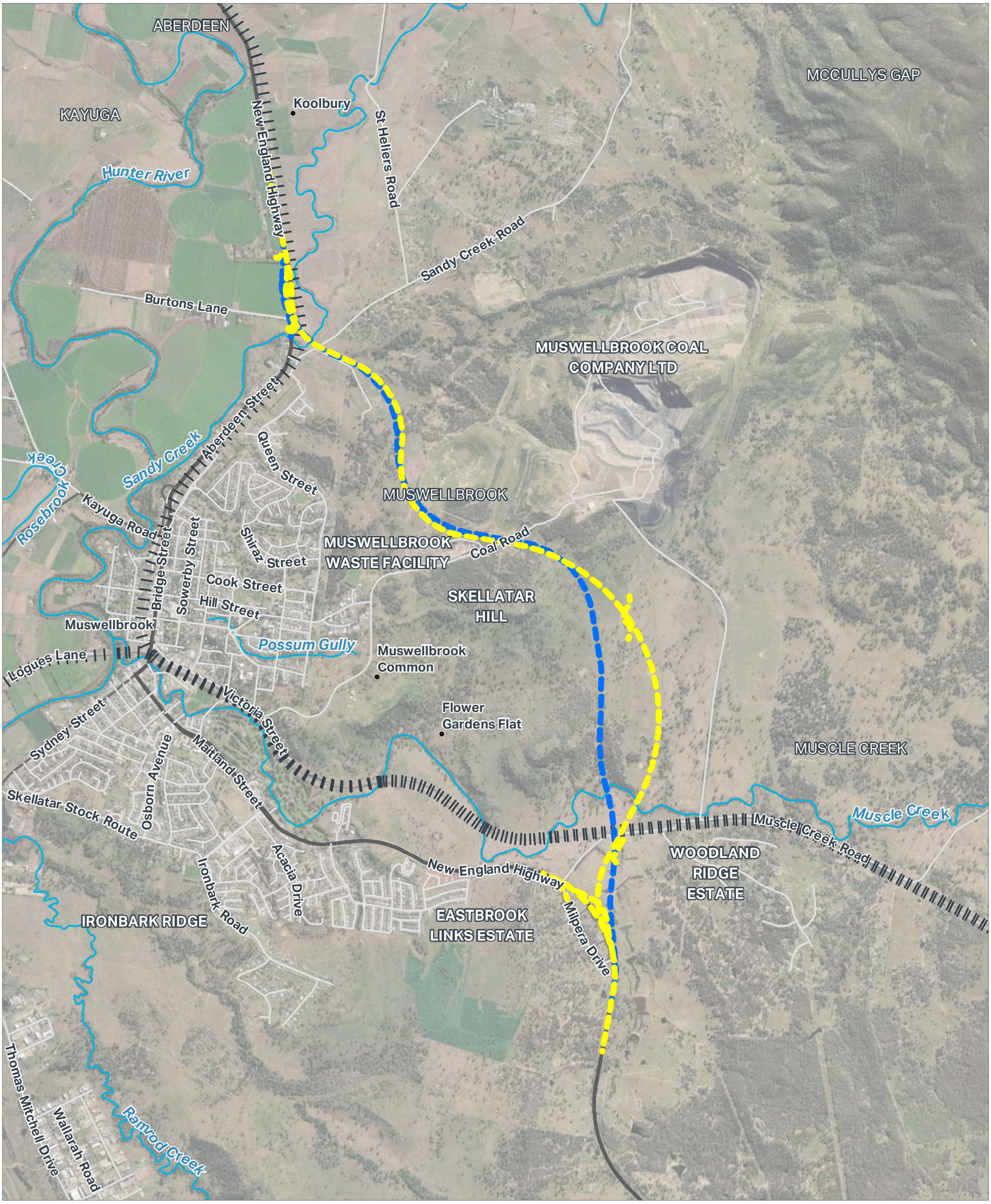


FIGURE 2-2: ROUTE OPTIONS 2020

N 0 0.5 1 km

AECOM

Legend

- State Road
- Regional Road
- Local Road
- Railway
- Watercourse
- Alternate option (2020)
- Blue option (2018)

2.4.3 Analysis of options

Route options 2018

The options were reviewed against the proposal objectives (refer to Section 2.3.1) and their social, economic and environmental benefits.

The do nothing option would not meet the proposal objectives as it would allow large numbers of heavy vehicles and road users to continue travelling through Muswellbrook. There are some advantages of the do nothing option, including no costs incurred or funding required and no construction traffic disruption or noise impacts. However, the large number of heavy vehicles and road users travelling through Muswellbrook would continue to increase and there would be no improvements to existing traffic congestion.

Options B, C, D and E

All four options cross within about 400 metres of underground mine workings contributing to increased costs and delivery timeframes. These options would pose greater property impacts as they are closer to residential properties than Option A. They would also result in higher amenity impacts such as noise, vibration and air pollution, and could constrain future land release areas.

Option A (blue option) – preferred option (2018)

Option A provides positive outcomes in terms of traffic efficiency and economic benefits. This option has reduced property impacts and is furthest away from residential areas and future land releases. It therefore performs more favourably on amenity grounds such as noise, vibration and air pollution during construction and operational phases.

Option A is also the least exposed to identified geological risks from underground mine workings. This option crosses about 50 metres of underground mine workings, compared to Options B, C, D and E which cross about 400 metres.

Option A is the most economically viable and presents an enhanced travel time saving compared with the majority of options. Option A (blue option) was therefore recommended as the preferred route corridor for further development and refinement in the next phase.

Route options 2020

The two shortlisted options were reviewed against the proposal objectives (refer to Section 2.3.1) and their technical/functional, social and environmental attributes as detailed in Table 2-2.

The alternate option (2020) was considered to provide substantial improvements across technical / functional, social and environmental considerations. The alternate option (2020) was assessed as better meeting the proposal objectives, providing the best value for money and was therefore recommended as the preferred option (2020) to be adopted when progressing the concept design for the Muswellbrook Bypass.

Table 2-2: Muswellbrook bypass options assessment

Assessment category	Proposed assessment criteria	Blue Option (2018)	Alternate Option (2020)	Comment
Technical / functional	Maximise travel time benefits on the bypass for all road users by minimising steep grades for road freight / heavy vehicles		Preferred	The alternate option (2020) has maximum 5% grade compared to 8% for the blue option (2018)
	Maximise safety for all road users on the bypass by providing a consistent high speed road geometry		Preferred	The alternate option (2020) is preferred. The blue option (2018) contains vertical geometry suitable for design speeds <100 km/h in areas
	Minimise geotechnical risks, including mine subsidence		Preferred	The alternate option (2020) minimises both cut and fill over the former Muswellbrook Coal Open Cut No.1, reducing spontaneous combustion and settlement risk
Socio-economic	Minimise community amenity impacts (including noise, air quality and traffic impacts on local residential streets)	Neutral	Neutral	The alternate option (2020) improves access to properties at the northern tie-in. The blue option (2018) is further away from some properties at the southern tie-in
	Minimise property acquisition impacts (including access provisions and impact on high quality agricultural land)		Preferred	The alternate option (2020) provides safe property and local road access, whilst no provision has been made in the blue option (2020)
Environmental	Minimise biodiversity impacts (including endangered ecological communities (EEC), threatened species, and bushland fragmentation / fauna connectivity)		Preferred	The alternate option (2020) is preferred. The blue option (2018) passes directly through a large area of moderate condition Central Hunter Grey Box-Ironbark Woodland EEC north of Muscle Creek, whilst the alternate option (2020) passes to the west, largely avoiding the EEC
	Minimise impact on Aboriginal heritage		Preferred	The alternate option (2020) is preferred. The blue option (2018) has a larger impact on Potential Archaeological Deposits (PADs)
	Minimise the visual impact of the bypass by integrating it with the surrounding		Preferred	The alternate option (2020) is preferred. Both options are largely similar north of Coal Road as a result of land use constraints. South of Coal Road, the alternate option (2020)

Assessment category	Proposed assessment criteria	Blue Option (2018)	Alternate Option (2020)	Comment
	landform (eg impacts on ridges, valleys and watercourses)			travels around the side of the hill north of Muscle Creek, minimising the footprint and blending into the topography. The blue option (2018) travels straight over Muscle Creek and up a gully with large fill embankments on approach

In addition, the preferred option (2020) includes full southern and northern connections with the existing New England Highway, which provide for all traffic movements. At the southern connection this includes a relocated entry / exit for Milpera Drive. At the northern connection, this includes a relocated entry / exit for Koolbury Flats Row, and a new entry / exit for Burtons Lane.

As part of the development of the preferred option, additional bypass connection options were considered at Sandy Creek Road and Coal Road.

The northern connection included consideration of exit and entry ramps at Sandy Creek Road. All traffic movements are proposed to be provided at the northern connection, which provides greater benefit to the overall road network than exit and entry ramps at Sandy Creek Road. It was not proposed to provide a connection at Sandy Creek Road, as this was assessed as providing minimal benefit to the overall road network.

Consideration was given to a connection at Coal Road. A Coal Road connection would increase the project footprint, environmental impacts and cost. All traffic movements are available at the northern connection and southern connection and therefore no central connection (Coal Road) was proposed. While the preferred option did not include a connection at Coal Road, the proposal was designed to be compatible with a Coal Road Connection, allowing a connection to be built at this location in the future.

2.5 Preferred option

The alternate option (2020) was selected as the preferred option, as it provided the best functional, social, environmental and economic outcomes including:

- Maximises travel time benefits on the bypass
- Maximises safety for all road users on the bypass
- Minimises geotechnical risks
- Minimises property impacts
- Minimises biodiversity impacts
- Minimises impact on Aboriginal heritage
- Minimises visual impact of the bypass
- Provides good economic benefits.

2.6 Design refinements

The preferred option was displayed for community comment from 23 November to 18 December 2020. Feedback received on the preferred option (refer to Section 5) was considered to further refine and prepare the concept design and environmental assessment for the bypass.

Table 2-3 provides a summary of key design refinements that have occurred during the concept design phase, following the public display of the preferred option.

Table 2-3: Key design refinements

Proposal element	Design refinement	Reason
Northern connection	Northbound exit ramp loop moved about 30 m north	To provide greater deceleration length prior to the loop curve and greater separation from the mainline
	Southbound exit ramp loop moved about 60 m north	To provide greater separation from the northbound exit ramp to improve safety
Koolbury Flats Row access road	Moved about 75 m north, with the addition of a left turn deceleration lane	To provide increased safety for motorists entering Koolbury Flats Row and greater separation from the mainline merge
Burtons Lane access road	Moved to provide a fourth leg at the proposed roundabout	To provide increased safety for motorists entering or exiting Burtons Lane
Alignment between Coal Road and Sandy Creek Road	Increase horizontal curve radii and adjusted vertical geometry	To avoid legless lizard habitat and reduce geotechnical risk over the mine affected area, whilst also providing improved horizontal and vertical road geometry
Coal Road connection	Included a full connection with Coal Road, which provides for all traffic movements (Coal Road connection). Includes new northbound and southbound acceleration ramps to enter the bypass, along with northbound and southbound left turn deceleration lanes to exit the bypass	Following feedback on the preferred option display and further site investigations, the NSW Government committed to include a connection to Coal Road in the concept design
Property access from Muscle Creek Road	Relocated further south-east	To provide increased safety for motorists entering or exiting the property.
Southern connection	Raised concrete median provided between the northbound exit and southbound entry ramps	To provide greater delineation between ramps, particularly for vehicles using the northbound entry ramp

3. Description of the proposal

This chapter describes the proposal and provides descriptions of existing conditions, the design parameters including major design features, the construction method and associated infrastructure and activities.

3.1 The proposal

Transport proposes to build a New England Highway bypass of Muswellbrook. The proposal is located to the east of Muswellbrook and connects the New England Highway to the north and south of Muswellbrook. An overview of the construction footprint for the proposal is shown in Figure 3-1. The proposal has been developed to concept design level and would be further refined subject to detailed design development and innovation.

Key features of the proposal are shown in Figure 3-2, Figure 3-3 and Figure 3-4 and would include:

- About nine kilometres of new highway (the bypass) with a single lane in each direction and a wide centreline treatment
- Connection with the New England Highway at the southern end of the proposal, which provides all traffic movements (southern connection)
- A 38 metre bridge over the bypass at the southern connection
- A 76 metre long bridge over Muscle Creek Road and Main North railway line
- A 114 metre long bridge over Muscle Creek
- Connection with Coal Road, which provides all traffic movements (Coal Road connection)
- A 43 metre long bridge over Coal Road
- A 367 metre long bridge over Sandy Creek Road, Sandy Creek, Main North railway line and southbound exit ramp
- Connection with the New England Highway at the northern end of the proposal, which provides all traffic movements (northern connection).

Additional features and aspects of the proposal include:

- Demolition of buildings
- Vegetation clearing
- Tie-in with the New England Highway at the northern and southern ends of the proposal
- Utility adjustment or relocation, including electricity, water and telecommunications
- Operational spill containment basins
- Drainage infrastructure including permanent basins
- Property adjustments
- Provision of permanent access roads for maintenance activities
- Property access and local road adjustments including Burtons Lane, Koolbury Flats Row, Milpera Drive, Muscle Creek Road and Coal Road
- Earthworks including construction of embankments
- Temporary ancillary facilities during construction including site offices, site compounds, stockpile sites, laydown areas, concrete and asphalt batch plants, and temporary access tracks including creek crossings

- Fauna infrastructure
- Finishing roadwork including pavement, road stabilisation, kerb and gutter, signage, lighting and line marking works
- Demobilisation of ancillary facilities following the completion of the construction of the proposal
- Landscaping works
- Processing of materials
- Minor creek diversions
- Relocation of the overhead vehicle classifier at the northern connection.

Timing for construction of the proposal is subject to project approval. However, construction is expected to start in late 2022 with enabling work. The main work is expected to commence in 2023 and would take about three and a half years to complete. The NSW Government has committed full funding for the proposal. Construction of the proposal may be staged.

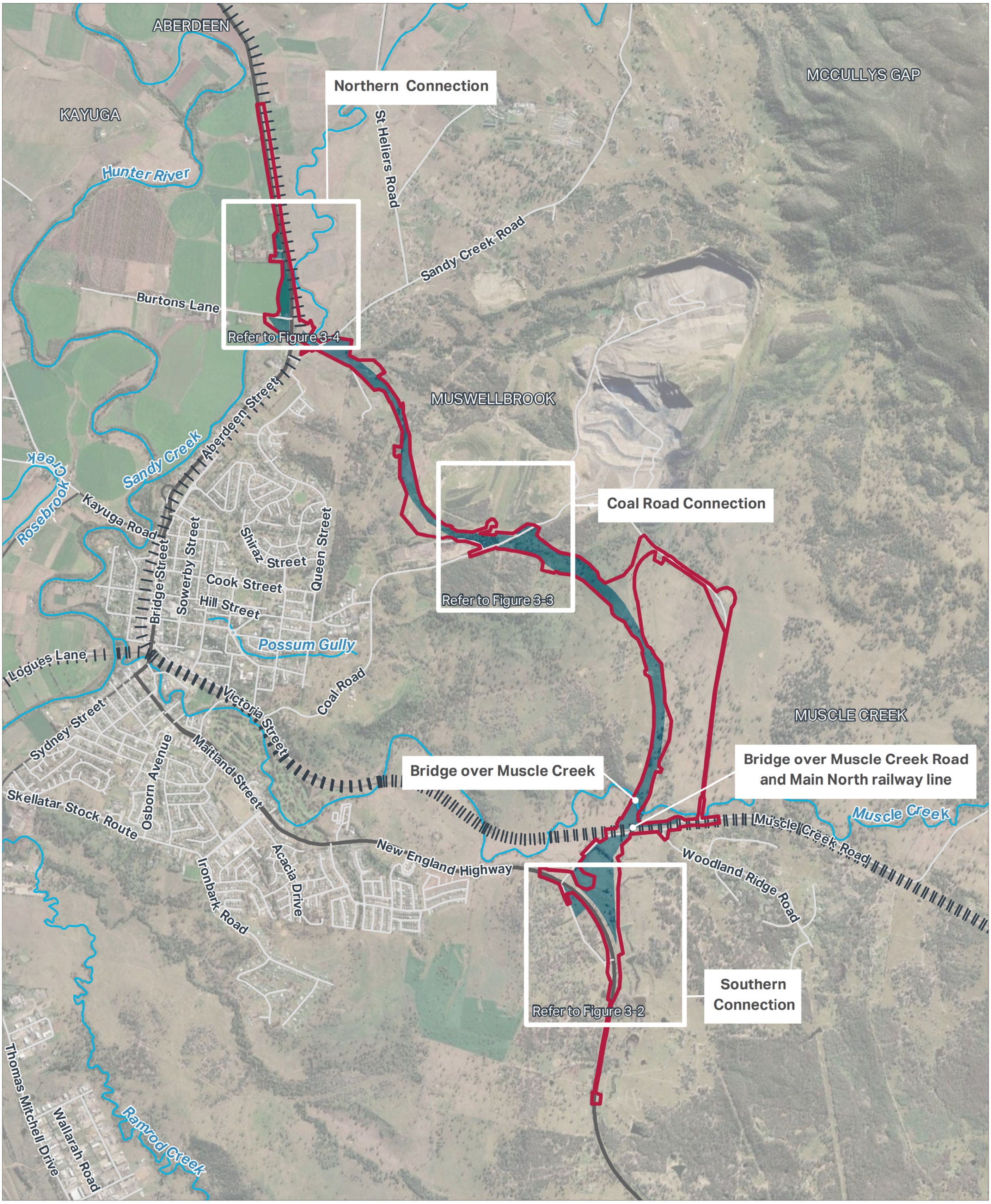


FIGURE 3-1: OVERVIEW OF THE KEY FEATURES OF THE PROPOSAL

N

0 0.5 1 km

AECOM

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse

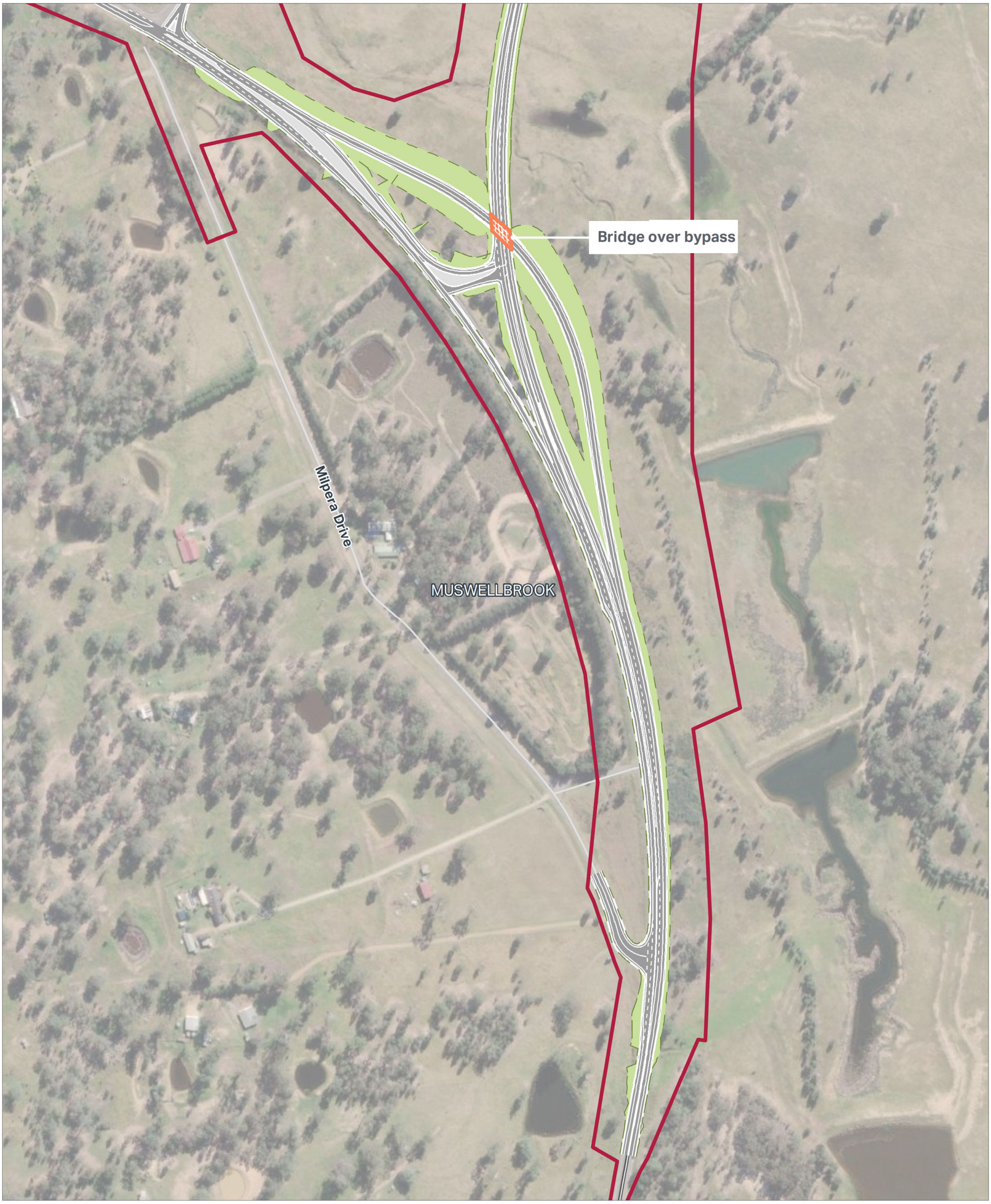


FIGURE 3-2: THE SOUTHERN CONNECTION

N
0 0.1 0.2 km

Legend
- Construction footprint
- State Road
- Local Road
- Railway
- Watercourse
- Bridge
- Median
- Earthworks
- Proposed road surface

AECOM

0 0.05 0.1 km

FIGURE 3-3: THE COAL ROAD CONNECTION

Legend

- Construction footprint
- Bridge
- Median
- Earthworks
- Proposed road surface
- State Road
- Local Road
- Railway
- Watercourse

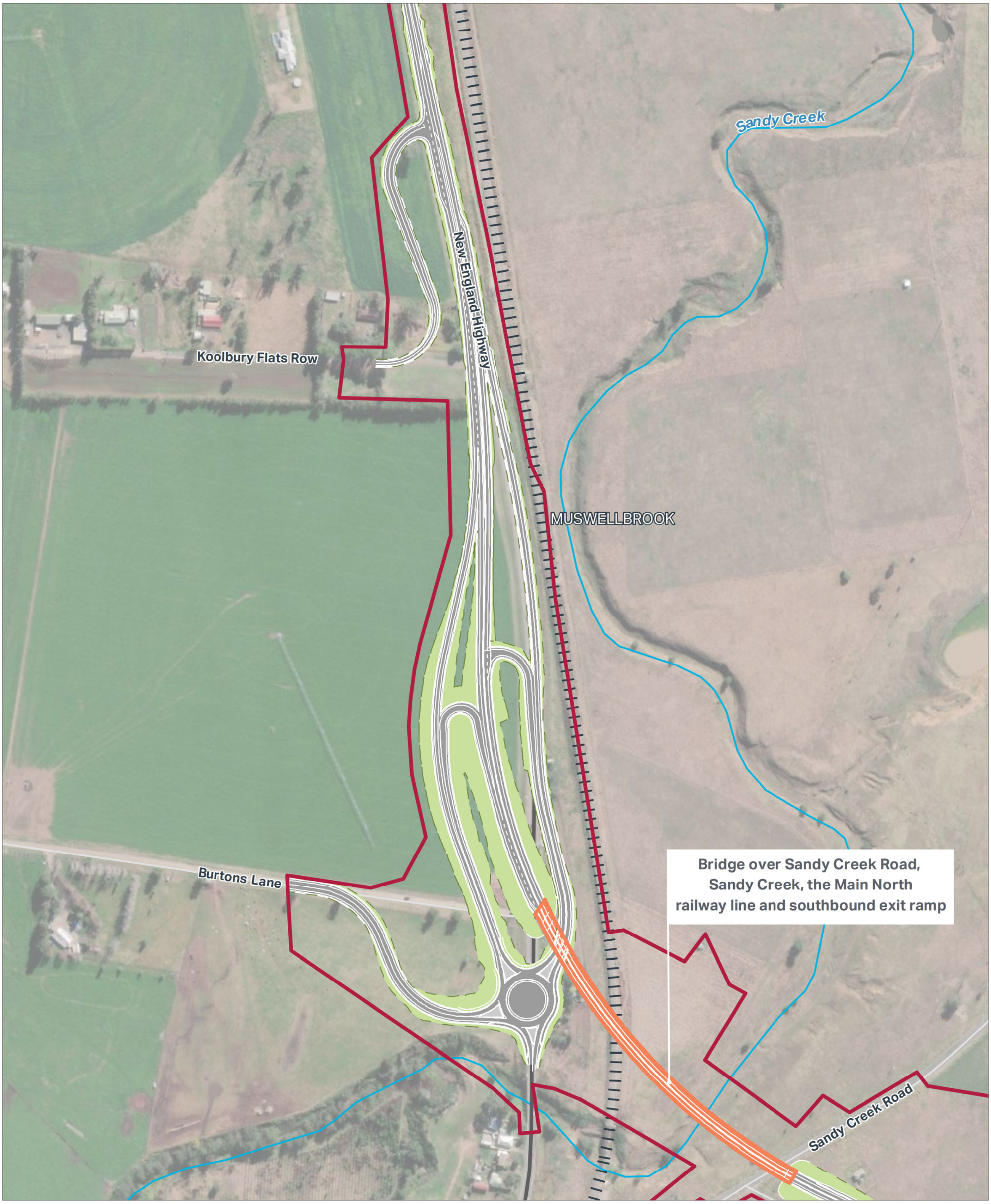


FIGURE 3-4: THE NORTHERN CONNECTION

N

0 0.1 0.2 km

Legend

- Construction footprint
- State Road
- Local Road
- Railway
- Watercourse
- Bridge
- Median
- Earthworks
- Proposed road surface

3.2 Design

3.2.1 Design criteria

Standards

The concept design was prepared in accordance with a number of road and bridge standards as outlined in Table 3-1.

Table 3-1: Road and bridge standards relevant to the design

Road Standards	Bridge Standards
Austroads Guide to Road Design Parts 1-8 (Austroads, 2009-2021) Roads and Maritime Supplements to Austroads Guide to Road Design Parts 1-8 (Roads and Maritime Services), 2015-2020) 2009)	Australian Standard 5100 Bridge Design
	Roads and Maritime Bridge and Geotechnical Technical Direction Manual
Australian Standard 1742 Manual of Uniform Traffic Control Devices Parts 1-15 (Standards Australia) Roads and Maritime Supplements to Australian Standard 1742 Parts 1-15 (Roads and Maritime Services), 2019	Roads and Maritime Bridge Waterway Manual (Roads and Maritime, 1994)
	Austroads Waterway Design (A Guide to the Hydraulic Design of Bridges, Culverts and Floodways) (Austroads, 1994)
	Roads and Maritime Structural Drafting and Detailing Manual
Austroads Guide to Traffic Management Parts 1-13 (Austroads, 2020) Roads and Maritime Supplements to Austroads Guide to Traffic Management Parts 1-13 (Roads and Maritime Services), 2008-2016)	Roads and Maritime Aesthetics of Bridges – Design Guidelines to Improve the Appearance of Bridges in NSW (Roads and Maritime, 2004)
Roads and Maritime Delineation Manual (Roads and Maritime, 2008-2015)	Roads and Maritime PS261 – Concept Design of Bridges
	Roads and Maritime Bridge Technical Directions
Roads and Maritime Technical Directions	Roads and Maritime QA Specifications – Bridge
	Roads and Maritime Bridge Standard Drawings
Road Safety Audit Process Guide (Transport for NSW, 2020)	Austroads Guide to Bridge Technology (including Roads and Maritime supplement)
	Australian Rail Track Corporation (ARTC) Heavy Haul Infrastructure Guidelines
NSW Speed Zone Guidelines (Roads and Traffic Authority of NSW, 2011)	Australian Standard 2159 Pile design
Beyond the Pavement: Urban design approach and procedures for road and maritime infrastructure planning, design and construction (Transport for NSW, 2020)	Australian Standard 1170 Design actions

Design criteria

The key design criteria for the proposal are summarised in Table 3-2. These criteria generally apply to the main alignment of the bypass. Other relevant criteria in the guidance listed in Table 3-1 have been applied to other components of the proposal including the connections and bridges.

Table 3-2: Design criteria

Design element	Design criteria
Roadway	• One lane in each direction, undivided with wide centreline treatment
Posted speed	• 100 kilometres per hour
Design speed	• 110 kilometres per hour (desirable minimum) • 100 kilometres per hour (absolute minimum)
Lane width (through lanes)	• 3.5 metres (minimum)
Shoulder widths	• 2.5 metres (generally)
Median widths	• Minimum 1 metre (linemarked)
Minimum horizontal radius	• 750 metres (desirable minimum) • 620 metres (absolute minimum)
Maximum vertical grade	• 8 per cent maximum (the actual maximum grade for the proposal is around 5 per cent) • 0.5 per cent minimum
Minimum vertical clearance to overhead bridge	• 6.5 metres over the bypass • 5.4 metres over local roads • 5.15 metres over railway at BR02 • 7.1 metres over railway at BR05
Design vehicle	• 25 metre B-double design vehicle • 30 metre Super B-double check vehicle
Cut batters slopes	• 2 Horizontal: 1 Vertical or flatter (typical batter slope) • 0.5 Horizontal: 1 Vertical (in rock material) • Minimum 4.5 metre wide bench at minimum 7 metre height increment
Fill batter slopes	• 2 Horizontal: 1 Vertical or flatter (typical batter slopes with barrier) • 6 Horizontal: 1 Vertical (typical batter slopes without barrier) • Minimum 4.0-metre-wide bench at each 10 metre height increment
Pavement type	• Flexible pavement
Safety barriers	• Test level 3

3.2.2 Engineering constraints

The key constraints to the design and construction of the proposal include:

- Integrating into the undulating terrain to minimise grades for heavy vehicles on the bypass
- Balancing earthworks where feasible to reduce unnecessary import of fill or excess spoil material
- Minimising impacts from mine workings, including minimising cut and fill over former Muswellbrook Coal Company (MCC) Open Cut No. 1
- Catering for movements of heavy / oversized vehicles on the bypass
- Minimising property acquisition, adjustment and access impacts
- Minimising impacts on existing utilities, including the Ausgrid substation
- Minimising flooding impacts associated with the construction and operation of the bypass
- Avoiding impacts on the Muswellbrook waste management facility and the Aboriginal land grant
- Constructing the bypass to cross over the Main North railway line, Muscle Creek, Sandy Creek, Muscle Creek Road, Sandy Creek Road, and the New England Highway
- Maintaining traffic flow on the New England Highway during construction, including access for heavy vehicles.

3.2.3 Major design features

The major design features of the proposal are described in the following sections. These features have been developed to concept design level and would be further refined subject to detailed design development and innovation.

Southern connection

The bypass would depart the existing New England Highway at the southern connection in an easterly direction. The southern connection would be a full connection providing for all traffic movements.

An exit ramp would be provided for vehicles travelling northbound into Muswellbrook. Vehicles would then travel along the existing New England Highway to Muswellbrook.

Vehicles travelling southbound from Muswellbrook would use the southbound entry ramp to continue along the New England Highway towards Singleton and would merge with vehicles travelling southbound on the bypass. The southbound entry ramp passes over the bypass via a bridge structure. The bridge would be a single span, industry standard super-T girder bridge and would be about 38 metres long and 6.7 metres above the bypass. The bridge abutments would be located behind reinforced soil walls.

An at-grade intersection featuring a channelised right turn would enable southbound bypass traffic to access Muswellbrook. A left turn would allow traffic travelling southbound from Muswellbrook to turn northbound onto the bypass.

Muscle Creek Road intersection would be reconfigured to accommodate the connection to the bypass.

A new, relocated Milpera Drive intersection with the New England Highway would also be provided around 190 metres south of the existing intersection and would enable all traffic movements. The intersection would include a channelised right-turn for southbound traffic into Milpera Drive and a dedicated northbound left turn deceleration lane into Milpera Drive. The existing intersection providing access to Milpera Drive would be closed.

The southern connection is shown in Figure 3-2.

Bridge over Muscle Creek Road and Main North railway line

North of the southern connection, the bypass would rise up on an embankment to provide for a bridge across both Muscle Creek Road and the Main North railway line. The southern abutment of the bridge would be located to the south of Muscle Creek Road behind a reinforced soil wall and the northern abutment located to the north of the Main North railway line behind a reinforced concrete protection wall.

The central pier would lie between the railway line and Muscle Creek Road and is protected by deflection walls either side of the pier.

The bridge would be a two span, industry standard super-T girder bridge and would be about 76 metres long, eight metres above Muscle Creek Road and 5.6 metres above the Main North railway line.

Bridge over Muscle Creek

The embankment on the northern side of the bridge over Muscle Creek Road would continue and provide for a bridge across Muscle Creek.

The bridge would be a four span, industry standard super-T girder bridge and would be about 114 metres long and up to about 14 metres above creek level with spill through abutments.

Coal Road connection

The Coal Road connection would comprise a full connection providing for all traffic movements.

A northbound exit ramp and entry ramp would be provided on the western side of the bypass and a southbound exit and entry ramp on the eastern side. Two roundabouts, to the east and west of the bypass, would connect the existing Coal Road to the connection ramps.

The northbound exit ramp on the western side of the bypass would provide access to the proposed roundabout. From here, traffic can continue westbound along Coal Road to Muswellbrook.

The northbound entry ramp, also on the western side of the bypass, would be accessed from the existing Coal Road via the proposed roundabout. Traffic would merge with vehicles travelling northbound on the bypass.

Traffic from Muswellbrook travelling south on the bypass would access a southbound entry ramp from Coal Road via the proposed roundabout.

The southbound exit ramp would diverge from the bypass to the roundabout for access to Muswellbrook.

The existing Coal Road, between the proposed roundabouts would be widened. The proposal does not include further upgrades to Coal Road, as Coal Road is under the care control and management of Muswellbrook Shire Council.

The Coal Road connection is shown in Figure 3-3.

Bridge over Coal Road

A bridge over Coal Road would be constructed east of the Muswellbrook Waste Management Facility.

The bridge would be a single span bulb-T girder bridge and would be about 43 metres long and 5.6 metres above Coal Road. The bridge abutments would be located behind reinforced soil walls.

Bridge over Sandy Creek Road, Sandy Creek and the Main North railway line

A bridge over Sandy Creek Road, Sandy Creek, the Main North railway line and the southbound entry/exit ramp would be constructed at the northern end of the bypass. The bridge would also cross the southbound entry/exit ramp at the northern connection.

The bridge would be a 12 span girder bridge, consisting of nine spans with industry standard super-T girders and three spans with bulb-T girders. The bridge would be about 376 metres long and measuring 5.9 metres above Sandy Creek Road, 7.4 metres above the Main North railway line, 7.1 metres above the southbound entry / exit ramp and about 20 metres over Sandy Creek with spill through abutments. The piers on both sides of the Main North railway line would include deflection walls.

Northern connection

The northern connection located north of Sandy Creek Road would comprise a full connection providing for all traffic movements.

A northbound exit ramp and entry ramp would be provided on the western side of the bypass and a southbound exit and entry ramp on the eastern side. A roundabout would connect the existing New England Highway at the Sandy Creek bridge to the connection ramps.

The northbound exit ramp on the western side of the bypass would provide access to the proposed roundabout. From here, traffic can continue southbound along the New England Highway to Muswellbrook.

The northbound entry ramp, also on the western side of the bypass, would be accessed from the existing New England Highway via the proposed roundabout. Traffic would merge with vehicles travelling northbound on the bypass until the tie-in with the existing New England Highway near Koolbury Flats Row.

Traffic from Muswellbrook travelling south on the bypass would access an at-grade left turn from the New England Highway via the proposed roundabout.

The southbound exit ramp would diverge from the highway near Koolbury Flats Row and continue under the bypass, which would be on a bridge at this location, to the roundabout for access to Muswellbrook.

A new relocated Koolbury Flats Row intersection with the New England Highway would also be provided about 260 metres north of the existing intersection and would enable all traffic movements. There would be a dedicated south-bound right turn lane into Koolbury Flats Row and a dedicated northbound left turn deceleration lane into Koolbury Flats Row. The existing intersection providing access to Koolbury Flats Row would be closed.

The Burtons Lane intersection with the New England Highway would be reconfigured to connect into the western side of the proposed roundabout. From here, traffic can continue south along the existing New England Highway into Muswellbrook, or north or south along the bypass.

The northern connection is shown in

Figure 3-4

3.2.4 Design features

Typical road and bridge cross sections are shown in Figure 3-5.

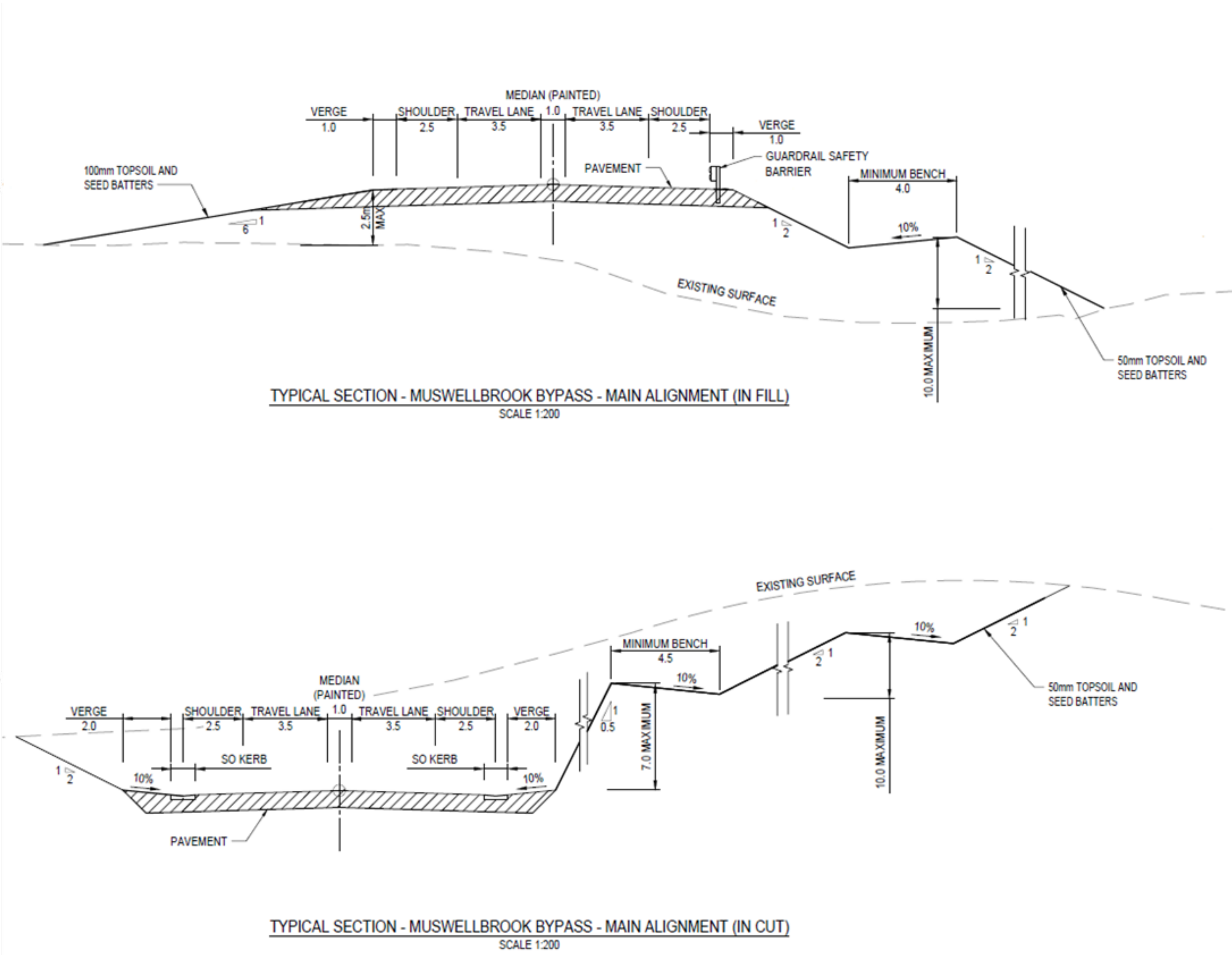


Figure 3-5: Typical road cross sections of the bypass

Tie-ins

The proposal would tie into the existing alignment of the following roads:

- The New England Highway at the southern connection
- Milpera Drive and Muscle Creek Road near the southern connection
- Coal Road at the Coal Road connection
- Koolbury Flats Row and Burtons Lane near the northern connection
- The New England Highway at the northern connection.

Activities to tie the proposal into the existing roads would include pavement work to create consistent levels between existing and new surfaces. The extent of tie-in work would be further refined during detailed design.

Drainage

The proposal crosses both Muscle Creek and Sandy Creek and a number of their tributaries.

The drainage design considers:

- Transverse drainage (e.g. transverse culverts) to convey run-off from upslope catchments beneath the bypass

- Longitudinal drainage to convey flows either towards swales or transverse culverts
- Bridge drainage which would be piped and provide adequate drainage of surface water. Runoff would be discharged via a spill containment basin or to existing drainage infrastructure depending on the location and subject to detailed design
- Operational spill containment, including spill containment basins.

Property access

Any properties affected by changed access arrangements as a result of the proposal, would be provided with restored or new permanent access arrangements. Refer to Section 3.3.7 for further details.

Parking facilities

No permanent parking facilities would be removed or provided by the proposal.

Pedestrian and bicycle facilities

The proposal would not provide any new pedestrian or dedicated bicycle facilities along the proposed road corridor. Cyclists would be able to use the road shoulders on the bypass.

Bus facilities

No dedicated bus facilities would be removed or provided by the proposal.

Public utilities

There are a number of public utilities within the construction footprint that would require adjustment or relocation as part of the proposal. Refer to Section 3.5 for further details.

Lighting

Lighting would be designed in accordance with relevant guidelines and standards to minimise light spillage into residential properties and minimise glare that could impact on driver visibility. Although the bypass itself would not be lit, the following sections would be lit to a Category V5:

- The intersections associated with the bypass at the southern and northern connections
- The exit / entry ramps where they join the bypass
- The roundabouts at the Coal Road connection
- The roundabout at the northern connection.

The lighting design would be further refined during the detailed design.

Urban and landscape design

A Landscape Character, Visual Impact Assessment and Urban Design Principles and Objectives Report was prepared for the proposal as discussed in Section 6.11. In recognition of the potential impacts of the proposal, six urban design objectives were developed as follows:

- Objective 1 – Respond to the landform: Embrace the undulating hills and gullies descending from Skellatar Hill to the Hunter River pastural floodplains
- Objective 2 – Contribute to the urban structure: Acknowledge the connection the proposal has to Muswellbrook township physically and visually
- Objective 3 – Maximise the travel experience: Utilise the unique characteristics of the region to provide an enjoyable travel experience

- Objective 4 – Respond to landscape patterns: Reflect the historic mining land-use and respond to the colours and shapes in the pastural floodplains, vegetated ridge lines and hills surrounding the proposal
- Objective 5 – Design for minimal lifestyle costs: Design a low maintenance, long-living and sustainable landscape
- Objective 6 – Coordinate a simple and consistent design language along the road corridor: Coordinate the urban design treatments for bridges, walls, barriers, landscaping and standard roadside furniture and infrastructure.

The urban design objectives were developed with reference to principles contained in the New England Highway Urban Design Framework (Transport for NSW, 2016). The objectives have been integrated into the concept design and would be considered further in the detailed design phase of the proposal.

Signage and line marking

Appropriate signage and line marking would be provided to suit the proposal, including a wide centreline treatment and audio-tactile linemarking for the bypass.

Safety barriers

The proposal would include the modification of existing safety barriers as required. New safety barriers would be provided in accordance with relevant standards and guidelines.

Throw screens

Throw screens would be required to bridges over:

- Southern connection (BR01) – full length
- Main Northern Railway line (BR02) – full length
- Main Northern Railway line (BR05) – a small length over the rail.

The throw screens would be visually and materially consistent with those existing along the Hunter Expressway and previous upgrades of the New England Highway, and generally consist of the following design principles:

- Screens should be fully integrated with other bridge and abutment elements
- There should be a neat, elegant transition of the bridge barrier safety screen (e.g. tapered end)
- The anti-throw screen should extend to the end of the bridge span.

The profile and materiality of the throw screens would consist of:

- Modular closed steel mesh screen panels integrated with the bridge parapet design and integral with the bridge design
- Regular and consistently spaced steel posts with an angled profile.

Fauna Infrastructure

Fauna infrastructure would include an aerial crossing and underpass. The aerial fauna crossing would be installed in the vicinity of where Squirrel Gliders have been recorded. Fauna exclusion fencing would also be considered near the fauna crossing and known habitat for the Striped Legless Lizard. The final location, design and types of structures would be determined during detailed design. The bridge over Muscle Creek would provide an underpass crossing for terrestrial fauna species.

‘Koala Warning Signs’ or ‘Injured Native Wildlife Signs’ would also be installed. More detail on fauna infrastructure is provided in Chapter 6.1.

3.3 Construction activities

Construction activities would be guided by a construction environmental management plan (CEMP) to ensure work is carried out to Transport specifications within the construction footprint (refer to Figure 3-1).

3.3.1 Work methodology

Detailed work methodologies would be determined during detailed design and construction planning. The indicative work methodology is described below, however activities may vary to suit the construction staging plans, which would be determined by the construction contractor. The proposal is anticipated to involve the following general work methodologies and sequencing:

- Site establishment including set up of temporary ancillary facilities including site offices, site compounds, stockpile sites, laydown areas, concrete and asphalt batch plants, and temporary access tracks including creek crossings
- Utility adjustments
- Building demolition
- Vegetation clearing
- Earthworks and drainage
- Processing of materials
- Bridge construction including approaches
- Pavement construction
- Landscaping and finishing work
- Removal of ancillary facilities and site rehabilitation.

Site establishment work including set up of ancillary facilities

A number of ancillary facilities would be set up and would remain in operation for the duration of the construction period. Ancillary facilities included as part of the proposal are further described in Section 3.4.

Establishment work would include:

- Identification and marking out of sensitive areas as defined by this REF and the CEMP
- Installation of traffic management measures including temporary traffic signs and barricades
- Installation of fencing
- Property adjustment work including relocation of fences, accesses and boundary features
- Minor earthworks to establish temporary construction roads (including temporary diversion roads for Muscle Creek Road and Sandy Creek Road), temporary bridges (where required) and level areas for construction compounds
- Utility connection work
- Establishment of construction compounds and ancillary facilities
- Sediment and erosion control work including installation of temporary sediment basins together with localised treatments such as sediment fences and earth bunds/channels to separate on-site and off-site water
- Minor road work to establish access points.

Utility adjustments

Services and utilities identified within the construction footprint that may require relocation or protection include overhead and underground electricity (owned by Ausgrid), water and sewage services (owned by Muswellbrook Shire Council), telecommunications (owned by Telstra and the National Broadband Network

(NBN) Corporation, optic fibre and signal cables (owned by ARTC) and various utilities owned by MCC including waste water and raw water and overhead electrical utilities.

Utility relocation is further discussed in Section 3.5.

Activities that would be carried out to relocate utilities include:

- Identification and removal of redundant asbestos cement pipes
- Installation of new poles to carry overhead services
- Excavation of trenches along new utility routes
- Installation of bedding material and new utilities within the trenches or onto new poles
- Testing and cutover of utilities into new infrastructure
- Decommissioning and removal of redundant utilities where required.

Building demolition

Two buildings on properties which are already owned by Transport would be demolished(refer to Section 3.6).

Demolition activities would generally include:

- Identification and removal of asbestos
- Removal of fittings and other reusable elements using hand tools
- Progressive demolition of the building structures using modified excavators
- Sorting and temporary storage of demolition material into recyclable and waste components
- Loading and transporting recyclable and waste material to a licenced facility.

Vegetation clearing

Vegetation clearing would include:

- Identification and marking out of clearing limits and hollow bearing trees
- Identification of suitable habitat nearby for release of fauna that may be encountered
- Checking for the presence of fauna species onsite and relocate if there is the potential for the animal to be disturbed or injured
- Clearing of non-hollow bearing trees including removal of stumps (trees in riparian zones would have their stumps retained wherever possible)
- Checking tree hollows for fauna and then removal of the habitat trees
- Reuse of native vegetation or mulch for use in rehabilitation.

Earthworks and drainage

Earthworks are required to achieve the design levels along the entire length of the proposed road corridor, including raised embankments and sections of cutting. Blasting is currently proposed to take place for excavation of material for earthworks.

Some existing drainage systems such as culverts may need to be extended across the new road formation at tie in points with the existing road system. Completely new drainage structures and systems would be installed along the entire length of the proposed road corridor. One dam located along the proposed road corridor would be filled.

Earthworks and drainage work would include:

- Stripping, stockpiling and management of grass, topsoil and unsuitable material

- Excavating and filling the road formation levels, including excavation for embankments and cuttings and boxing out of new pavements
- Disposal of unsuitable and surplus material
- Installing new drainage lines, temporary and permanent sediment basins, sediment fences, earth bunds and channels and protection of existing stormwater pits.

Processing of materials

Processing of materials would include crushing and grading of site materials for material reuse.

Bridge construction

As described in Section 3.2.3, a number of bridges would be constructed for the proposal. The construction methodology for the bridges including approaches would include:

- Removal, relocation or protection of impacted existing utilities
- Stripping, stockpiling and management of grass, topsoil and unsuitable material
- Hauling and compaction of fill material for the embankment at each bridge abutment
- Foundation construction including:
    - Piling (pile driving for steel tube piles and boring for cast in place piles)
    - Pile cap construction including localised excavation
- Cast insitu bridge pier construction
- Reinforced soil wall construction
- Superstructure construction through the placement of pre-cast girders lifted into place using a crane
- Cast insitu concrete deck placement
- Installation of parapets, guardrails and throw screens where required.

The bridge construction would interface with some local roads and with the Main North railway line, and may require temporary diversions, construction during rail shutdowns, night works and temporary barriers to manage safety.

Pavement construction

Pavement would be laid along the entire length of the proposed road corridor (including bridges) and would tie into existing roads at each connection.

Pavement construction work would include:

- Rolling and grading of road formation foundation
- Placement and compaction of bound gravel road pavement
- Installation of subsoil inter-pavement drainage with connections to existing and new drainage pits where required
- Placement of a bitumen material over the road formation and/or bound gravel road pavement
- Placement of an asphalt wearing course and compaction with a roller.

Landscaping and finishing work

Landscape and finishing work would include:

- Installation of new streetlights
- Installation of road furniture including signage and roadside barriers as required
- Rehabilitation of disturbed areas and landscaping in accordance with the urban design and landscape plan

- Line marking and installation of raised reflective pavement markers.

Removal of ancillary facilities and site rehabilitation

Upon completion of construction, construction advisory and warning signage would be removed, and the road would be opened to traffic. The ancillary facilities would be removed, and areas disturbed during construction would be rehabilitated. Once disturbed areas are established, erosion and sediment control measures such as sediment fencing would be removed.

3.3.2 Construction workforce

The construction workforce would fluctuate depending on the stage of construction. Final workforce numbers would be confirmed by the construction contractor.

3.3.3 Construction hours and duration

Construction would largely be carried out during standard construction working hours in accordance with the Interim Construction Noise Guideline (DECC, 2009):

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- Sundays and public holidays: no work.

Construction activities that involve impulsive or tonal noise emissions would be limited to the following hours in accordance with the Construction Noise and Vibration Guideline (Transport for NSW, 2016):

- Monday to Friday: 8am to 5pm
- Saturday: 9am to 1pm
- Sundays and public holidays: no work.

To minimise disruption to daily traffic and disturbance to surrounding landowners and businesses, it would be necessary to carry out some work outside of these hours.

The following activities are likely to take place outside standard construction working hours:

- Construction activities within the rail corridor during rail possessions
- Delivery of construction materials such as precast bridge structures
- Intersection and tie-in activities, of the bypass to existing roads
- Installation and adjustment of barriers and signage for construction zones during each construction stage
- Construction of the bridge over Sandy Creek Road and the bridge over Muscle Creek Road
- Operation of construction compounds to support the above work.

Construction is expected to start in late 2022 with enabling works. The main works are expected to start in 2023 and would take about three and a half years to complete.

3.3.4 Plant and equipment

A range of plant and equipment would be used during construction. The final equipment and plant requirements would be determined by the construction contractor. An indicative list of plant and equipment which would be used in each construction stage is provided below in Table 3-3.

Table 3-3: Indicative plant and equipment to be used during the construction period

Stage	Equipment
Site establishment work including set up of construction compounds, ancillary facilities and temporary infrastructure such as fencing	• Franna crane • Grader • Vibratory roller • Dump truck • Front end loader
Utility adjustments	• 35 tonne tracked excavator • Crane (up to 300 tonne) • Pneumatic hammer • Concrete saw • Vacuum truck • Backhoe
Building demolition	• 35 tonne tracked excavator • Chainsaw • Dump truck • Hydraulic hammer • 23 tonne front end loader
Vegetation clearing	• Bulldozer D9 • 35 tonne tracked excavator • Chainsaw • Mulcher • Dump truck
Earthworks and drainage	• Backhoe • 80 tonne tracked excavator • Grader • Excavator with hydraulic hammers
Processing of materials	• Crushing and screening equipment • 30-40 tonne excavators • Wheel loaders
Bridge construction	• Crane (up to 600 tonne) • Pilling rig (driven and bored) • Concrete pump and track • Compressor • Pneumatic hammer • Welding equipment
Pavement construction (including local roads)	• Pavement laying machine • Asphalt truck and sprayer • Concrete truck • Concrete saw • Grader
Landscaping and finishing works	• Road truck • 20 tonne franna crane

Stage	Equipment
Removal of ancillary facilities and site rehabilitation	• Medium rigid truck • Road truck • Franna crane • Front end loader

3.3.5 Earthworks

Earthworks activities required for the proposal include excavation where the design of the road is lower than the existing ground level, construction of fill embankments where the design of the road is above the existing ground level (such as approaches for bridges) and boring into the ground for bridge structural supports.

The estimated quantities of materials associated with earthworks are provided in Table 3-4. Quantities would be refined during detailed design.

Suitable fill material may be sourced from within the proposed construction footprint where the material is of suitable quality or imported to site. Excavated material from the Skellatar cutting may be suitable for reuse as selected fill material, however quantities are not known at this stage.

Cut or other material that is deemed unsuitable or considered in excess to requirements would be stockpiled and stabilised until needed as part of the landscaping works. If additional temporary stockpile sites are identified during detailed design or at a later stage during construction, they would be selected having regard to the matters outlined in Section 3.4.6.

Table 3-4: Indicative earthwork quantities

Area	Cut (m^3)	Fill (m^3)
Southern connection to Muscle Creek Road	3,950	174,447
Muscle Creek Road to Muscle Creek	750	85,125
Muscle Creek to Coal Road	479,475	137,666
Coal Road to mine affected area	182,056	151,885
Mine affected area to Sandy Creek Road	19,130	56,344
Northern connection	7,857	81,442
Total	693,218	686,909
Balance	6,309 surplus	

3.3.6 Source and quantity of materials

The construction of the proposal would require (but is not limited to) the materials listed in Table 3-5. The exact quantities of materials required would be confirmed during the detailed design.

Imported materials would be sourced from Transport pre-qualified commercial suppliers in nearby areas, wherever possible. As part of the concept design, a preliminary assessment of potential sources of material was completed and identified that suitable material is available at local quarries.

Table 3-5: Source and quantities of materials required for the proposal

Material	Quantity	Source
Earthworks materials (limited to select material zone, other fill to be sourced from excavations)	73,000 m^3	Transport prequalified suppliers and locally, where practical
Road base for the construction of a flexible road surface	6,500 m^3	
Asphalt	51,000 tonnes	
Precast concrete elements for drainage construction (culverts, pits and headwalls) and miscellaneous work	6,700 tonnes	
Structural steel	NA	
Conduits, pits, cables and pipes	5,100 metres	
Bridge materials (concrete)	27,100 tonnes inclusive of girders	
Bridge materials (steel reinforcement)	2,300 tonnes inclusive of girders	
Linemarking, raised reflective pavement markers and signs, and safety barriers	Painted area – 8,750 m^2 Reflective markers – 3,300 Signs – 185	
Safety barriers	Steel post and rail – 9,350 metres Wire rope – 700 metres Concrete – 910 metres	
Steel for barrier railings and reinforcement in concrete	1,200 tonnes	
Noise wall materials (concrete)	N/A	
Noise wall materials (steel reinforcement)	N/A	

Material	Quantity	Source
Water	The quantity of water that would be required during construction is unknown at this stage and would depend on available sources and methodologies applied by the contractor	Construction sources such as sediment basins or alternatively from the local water supply network
Concrete for drainage construction, road surface construction, and miscellaneous work such as barrier kerbs, paving, kerbs and gutters and signpost footings	16,200 tonnes	Transport prequalified suppliers and locally, where practical

Re-use opportunities

General fill material excavated from the Skellatar Ridge cutting (south of the bridge over Coal Road) would be used as a source of fill material across the proposal, reducing the need to import general fill material. Other excess material from the proposal would also be used on site where possible. Excess fill left over from other local road projects or elsewhere on site could also be used for this proposal where suitable.

3.3.7 Traffic management and access

Construction traffic numbers

Construction of the proposal would generate a peak of up to 220 light and 300 heavy vehicle movements per day. These construction vehicle movements would mainly be associated with:

- Movement of construction workers
- Delivery of construction materials
- Spoil and waste removal
- Delivery and removal of construction equipment and machinery.

These additional movements are not expected to significantly impact existing traffic on the New England Highway, where there are about 12,900 and 15,000 vehicles daily (2019 survey, ARCADIS) near the Muscle Creek Road and Sandy Creek Road intersection respectively.

Access for construction vehicles

Construction vehicles would access the construction footprint via arterial roads wherever possible. The MCC mine access road, Muscle Creek Road, Coal Road and Sandy Creek Road have been identified as potential heavy vehicle haulage routes. Indicative construction traffic access points are shown on Figure 3-6.

Indicative heavy vehicle haulage routes have been identified for the movement of spoil between different locations within the construction footprint during construction. The routes to and from the New England Highway are shown on Figure 3-6. The haulage routes have been designed to minimise use of local roads where possible.

Traffic management measures

It is expected that temporary signage, speed limits and lane closures would be required during construction. Final construction methods would be refined to minimise traffic and transport impacts, however traffic restrictions would be unavoidable during some construction activities, such as:

- Intersection and tie-in activities, of the bypass to existing roads
- Installation and adjustment of barriers and signage for construction zones during each construction stage
- Construction of the bridge over Sandy Creek Road and the bridge over Muscle Creek Road.

Local property access management

Property access would be maintained as far as practicable throughout construction. However, there may be temporary disruptions to private property access. The management of property access would be considered by the construction contractor and detailed as part of the final staging plan for the proposal.

Commercial and private property access roads would be reinstated and/or relocated as required. Private accesses include a residential access south of Muscle Creek Road and a farm access culvert under the proposed bypass. Access to the MCC and Ausgrid substations off Coal Road, would be relocated. Ausgrid access tracks would also be relocated to maintain access to assets and for fire safety.

Temporary construction access tracks

Temporary access tracks including creek crossings would be built to facilitate the movements of construction vehicles and construction materials (e.g. girders for bridges) to key construction work areas for bridges and bypass connection points.

Travelling stock routes (TSR) and stock routes

There are three TSRs and one stock route that are in the vicinity of the proposal namely the St Heliers TSR which is on land that is leased, Muswellbrook Town TSR, Black Hill TSR (leased) and Black Hill Stock Route.

It is proposed to extend the existing “farm access” culvert beneath the New England Highway at the start of the southbound entry ramp to ensure access to the Black Hill TSR is maintained once the bypass is operational. The extension of the “farm access” culvert would be constructed in a manner to minimise or avoid where feasible impacts to stock travel during construction. Potential impacts to stock water in the dam located on the Black Hill TSR would be avoided with construction work limited to within the construction footprint.

Rail access and management

Bridge construction activities would occur within and adjacent to the Main North railway line corridor and may be required to be carried out during rail possessions. Work zones would be set up to enable construction of bridge piers outside rail possessions where possible.

3.4 Ancillary facilities

Construction ancillary facilities, including construction compounds and laydown areas are shown in Figure 3-6 and described further below. The proposed ancillary facility locations were selected using the following criteria:

- Proximity to the proposal
- Where possible, away from residential and sensitive receivers
- Where possible, outside of the 1 in 10 year Average Recurrence Interval (ARI) floodplain
- At least 40 metres away from the nearest waterway

- On land of low heritage conservation significance
- Away from ecologically sensitive areas, including the Striped Legless Lizard habitat
- On land which does not require clearing of native vegetation
- Relatively flat ground that does not require substantial reshaping
- In plain view of the public to deter theft and illegal dumping.

Should additional or alternative ancillary facilities be required, the positioning of these would also be based on the above criteria.

Site construction compounds would include portable buildings with amenities such as toilets, secure and bunded storage areas for site materials including fuel and chemicals, office space for on-site personnel and associated parking.

The main site construction compounds may also include asphalt and concrete batching plants and associated facilities such as material storage areas and stockpiles.

The main site construction compounds would be securely fenced with temporary fencing. Signage would be erected advising the general public of access restrictions. Upon completion of construction, the site construction compounds, laydown areas, work areas and stockpiles would be removed, and the sites cleared of all rubbish and materials. They would then be rehabilitated.

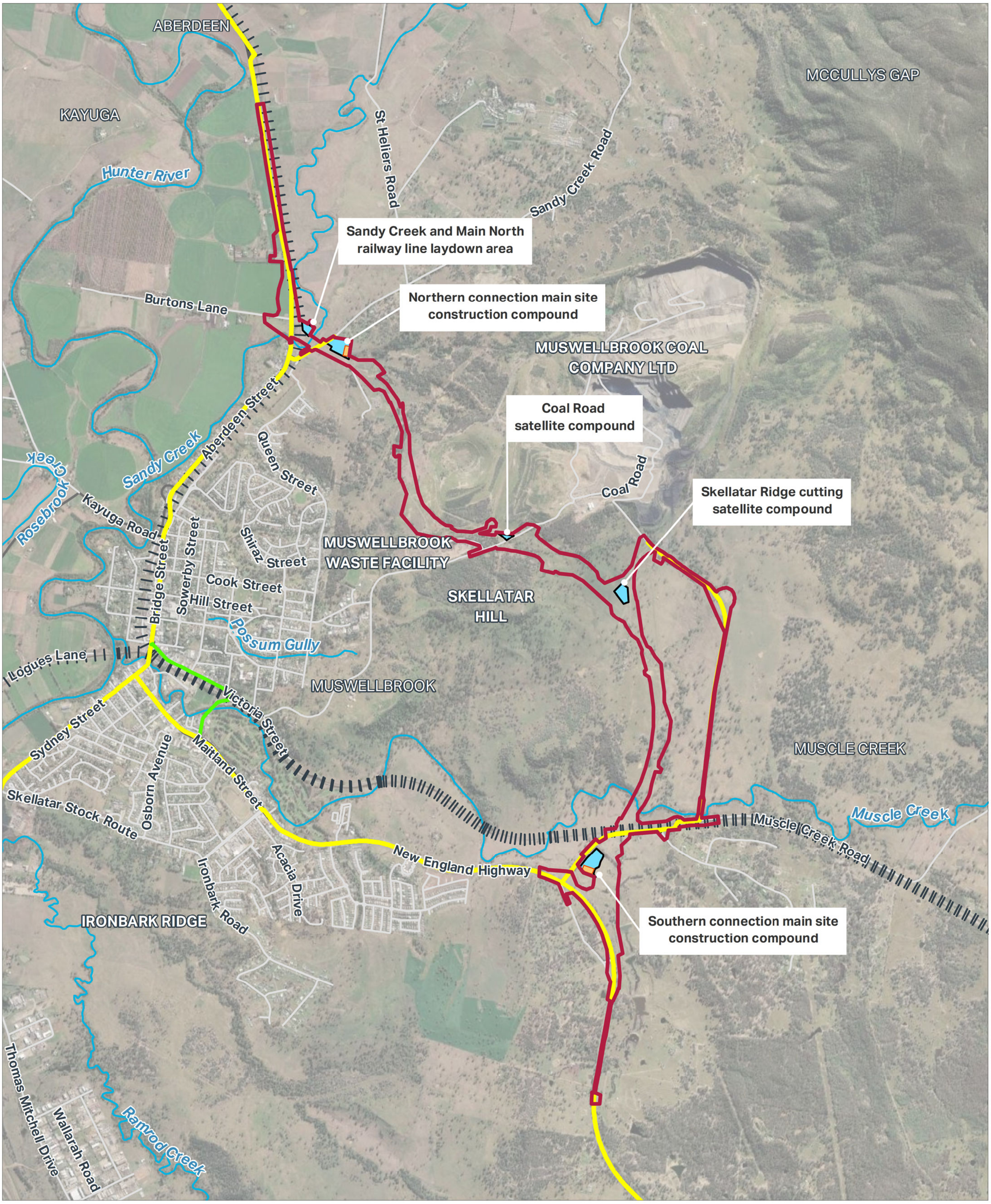


FIGURE 3-6: CONSTRUCTION ANCILLARY FACILITIES AND HAULAGE ROUTES

N

0 0.5 1 km

AECOM

Legend

- Construction footprint
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse
- Haulage route
- >4.6m High heavy vehicles
- Stockpile - Topsoil
- Construction ancillary facilities

3.4.1 Southern connection main site construction compound

The southern connection main site construction compound would be located east of the New England Highway just north of the southern connection. The compound would be located within a large grassed paddock.

This would be a main construction compound and site establishment activities at this location would include installation of environmental controls, fencing and signage, construction of hard stand and establishment of site office, amenities, bunded fuel storage, and car parking. This construction compound may also include concrete and/or asphalt batching plant(s). Construction activities at this location would include laydown of construction materials and equipment required to support the southern connection, bridge over Muscle Creek Road and bridge over Muscle Creek as well as stockpiling of topsoil material, processing of materials and concrete batching.

This construction compound would be about 30,600 m^2 in size. Access would be provided off Muscle Creek Road.

3.4.2 Northern connection main site construction compound

The northern connection main site construction compound would be located south of Sandy Creek Road to the east of the bridge over Sandy Creek. The compound would be located on land previously used for agricultural purposes that has already been acquired by Transport.

This would be a main construction compound and site establishment activities at this location would include installation of environmental controls, fencing and signage, construction of hard stand and establishment of site office, amenities, bunded fuel storage, and car parking. This construction compound may also include concrete and/or asphalt batching plant(s). Construction activities at this location would include laydown of construction materials and equipment required to support the northern connection and bridge over Sandy Creek as well as stockpiling of topsoil material, processing of materials and concrete batching.

This construction compound would be about 28,800 m^2 in size and access would be provided off Sandy Creek Road.

3.4.3 Skellatar Ridge cutting satellite compound

The Skellatar Ridge cutting satellite compound would be located about halfway along the construction footprint. The compound would be located within a large grassed paddock.

This would be a satellite construction compound and site establishment activities at this location would include installation of environmental controls, fencing and signage, construction of hard stand, establishment of amenities and bunded fuel storage. Construction activities to be carried out at this location would include the laydown of construction materials and equipment required to support the Skellatar Ridge cutting, as well as stockpiling of materials.

This satellite compound would be about 15,200 m^2 in size and access would be via a private property access track off the MCC mine access road running between Muscle Creek Road and Coal Road.

3.4.4 Coal Road satellite compound

The Coal Road satellite compound would be located north of Coal Road to the east of the bridge over Coal Road. The compound would be located on disturbed land near the MCC substation.

This would be a satellite construction compound and site establishment activities at this location would include installation of environmental controls, fencing and signage, construction of hard stand, establishment of amenities and bunded fuel storage. Construction activities to be carried out at this location would include the laydown of construction materials and equipment required to support the bridge over Coal Road and Coal Road connection, as well as stockpiling of materials.

The satellite compound would be about 3,800 m^2 in size and access would be provided off Coal Road.

3.4.5 Sandy Creek and Main North rail line laydown area

The Sandy Creek and Main North rail line laydown area would be located between Sandy Creek and the Main North rail line to the east of the bridge over Sandy Creek. The construction compound would be located on land currently used for agricultural purposes.

Site establishment activities at this location would include installation of environmental controls, fencing and signage, construction of hard stand, establishment of amenities and bunded fuel storage. Construction activities to be carried out at this location would primarily include the laydown of construction materials and equipment required to support the northern connection and bridge over Sandy Creek, as well as stockpiling of materials.

The laydown area would be about 8350m^2 in size. Access to the laydown area would be provided off Sandy Creek Road.

An overview of the key construction activities to be carried out at the ancillary facilities above is provided in Table 3-6.

Table 3-6: Summary of construction activities at ancillary facilities

Construction activities	Southern connection	Northern connection	Skellatar Ridge cutting	Coal Road	Sandy Creek and Main North railway line
Native vegetation clearing	No	No	No	No	No
Utility works including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities	Yes	Yes	No	No	Yes
Establishment of site offices, amenities and temporary infrastructure including fencing	Yes	Yes	Yes	Yes	Yes
Laydown and storage of materials	Yes	Yes	Yes	Yes	Yes
Secure and bunded storage areas for refuelling and chemical storage	Yes	Yes	Yes	Yes	Yes
Processing of materials	Yes	Yes	No	No	No
Concrete batching plant	Yes (possibly)	Yes (possibly)	No	No	No
Delivery of materials, plant and equipment	Yes	Yes	Yes	Yes	Yes
Stockpiling	Yes	Yes	Yes	Yes	Yes
Demobilisation	Yes	Yes	Yes	Yes	Yes

3.4.6 Stockpile sites

Stockpiling of materials would occur in site construction compounds and throughout the construction footprint. All stockpiles would be managed in accordance with Roads and Maritime Stockpile Management Guideline (RTA, 2011) and the QA Specification R44 Earthworks which include guidance around distance from waterways, stabilisation and bunding. Contaminated soil that may be exposed during construction, would be stockpiled with appropriate sediment and erosion control measures in place prior to off-site disposal.

Additional temporary stockpile sites identified during construction would be located:

- Within the proposed road corridor or directly adjacent to the proposal where possible
- On land that is in Transport ownership or if unavailable on land that can be leased
- Outside the 1 in 10 year ARI floodplain
- On slopes with a gradient less than 2:1 horizontal to vertical
- On land of existing low conservation significance for flora and fauna and with no substantial vegetation clearing
- On sites that have a low likelihood of having Aboriginal or non-Aboriginal heritage significance
- At least 40 metres from drainage lines.

3.5 Public utility adjustment

Consultation with public utility authorities has been carried out as part of the development of the concept design to identify and locate existing utilities and incorporate utility authority requirements for relocations and/or adjustments. Preliminary investigations have indicated that the following existing utilities were found to be within the extents of the proposal and would need relocating or protection:

- Overhead and underground electricity – Ausgrid
- Water services – Muswellbrook Shire Council
- Telecommunications – Telstra and the NBN Corporation
- MCC utilities including electricity, telecommunications (Telstra) and water supply
- Rail infrastructure – ARTC telecommunications and signals.

The proposal may also impact on the ability of utility providers to access maintenance locations for their utilities and services. Consultation would continue with the public utility authorities during the detailed design phase. This consultation would allow the public utility authorities to provide input into the most appropriate relocation options for the services and utilities. Modifications to the affected utilities would be in accordance with the design and construction methods approved by the relevant utility stakeholder.

The construction footprint assessed as part of this REF includes areas likely to be required for utility adjustments. If it is determined during detailed design that utility work is required outside of the construction footprint, then a separate environmental assessment may be required.

3.6 Property acquisition

Based on the concept design and subject to negotiations in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW) and the reforms announced in October 2016 (NSW Government 2016), the acquisition or temporary lease of the properties in Table 3-7 would be required. These properties are shown on Figure 3-7.

The need for property acquisition would be further refined during the detailed design phase. Transport owns five properties and would carry out ongoing consultation with affected landholders of the remaining properties to be fully or partially acquired.

Table 3-7: Proposed property acquisition (July 2021)

Lot and DP	Estimated Land Area to be Acquired (m^2)	Acquisition type	Current owner	Land use zone (LEP)[1]
Lot 1A DP16352	10,528	Partial	Private Owner	RU1 / SP2
Lot 400 DP1034562	2,741	Partial	Private Owner	RU1/SP2
Lot 302 DP715492	40,796	Partial	Commercial Owner	RU1/SP2
Lot 1 DP396313	1,012	Whole	Commercial Owner	RU1/SP2
Lot 56 DP1025497	19,332	Partial	Private Owner	RU1/SP2
Lot 101 DP1167081	8,568	Partial	Private Owner	RU1/SP2
-	3,891	Partial	NSW Government	E3/SP2
Lot 12 DP839233	70,220	Partial	TfNSW	E3
Lot 4 DP1220491	92,985	Partial	MCC	E3/RU1/SP2
Lot 3 DP1220491	1,358	Partial	MCC	SP2
Lot 4 DP1220491	51,735	Partial	MCC	E3/SP2
Lot 1 DP 46760	901	Partial	MCC	SP2
Lot 71 DP629631	14,587	Partial	MCC	E3/SP2
Lot 5 DP26760	142,139	Partial	MCC	E3/SP2
Lot 6 DP26760	163,988	Partial	MCC	E3/R1/SP2
Lot 101 DP1148216	42,000	Partial	MCC	E3/RU1/SP2
Lot 5 DP1134398	55,548	Partial	MCC	E3/SP2
Lot 40 DP793463	51,113	Partial	MCC	RU1

Lot and DP	Estimated Land Area to be Acquired (m^2)	Acquisition type	Current owner	Land use zone (LEP)[1]
Lot 1 DP249566	217,065	Partial	MCC	RU1/SP2
Lot 1 DP449384	532	Partial	TfNSW (Sydney Trains)	SP2

Note 1: Muswellbrook LEP 2009

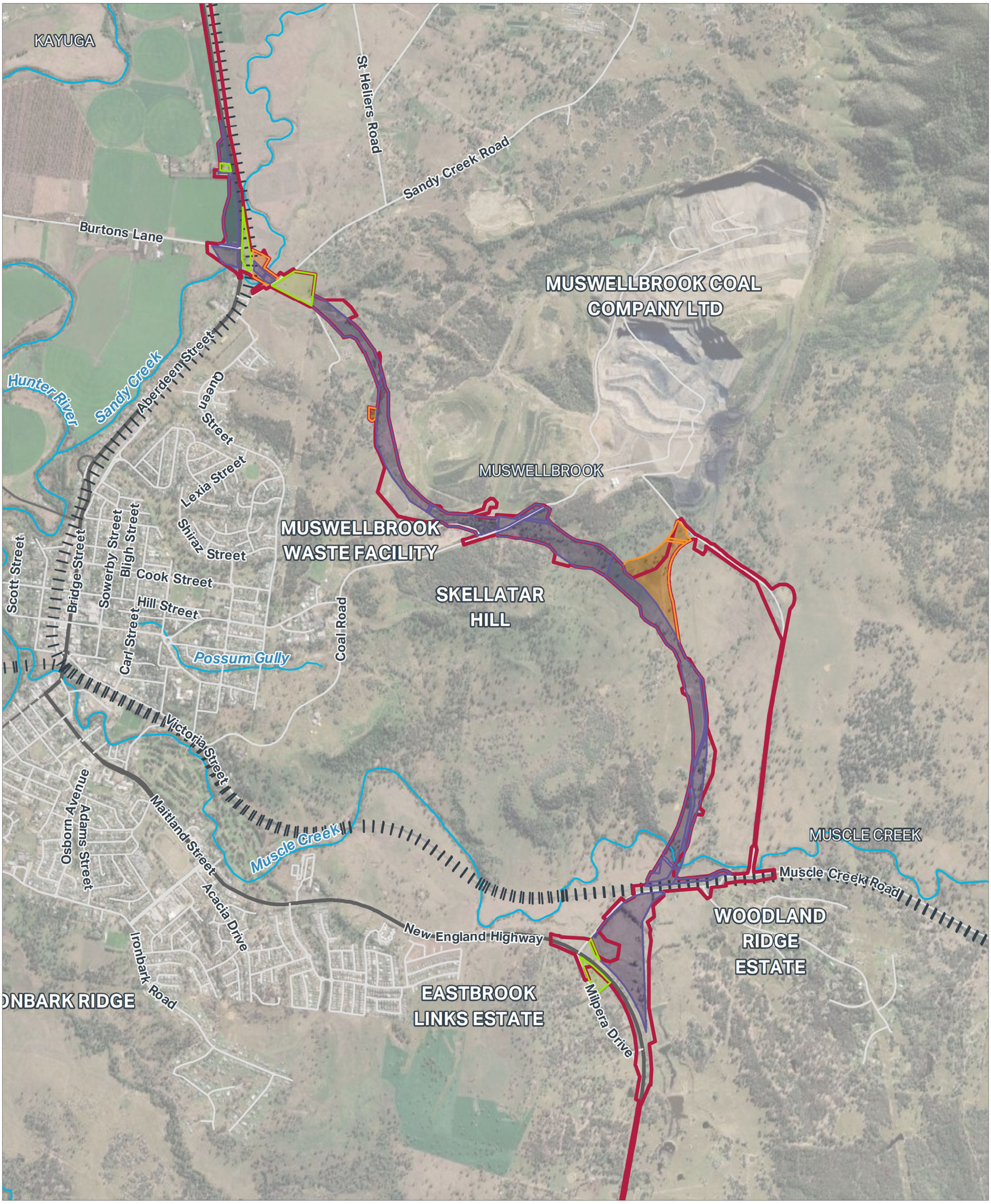


FIGURE 3-7: PROPERTY ACQUISITION

Legend

- Construction footprint
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse
- To be leased
- To be acquired
- Already owned by TfNSW

AECOM

4. Statutory and planning framework

This chapter provides the statutory and planning framework for the proposal and considers the provisions of relevant state environmental planning policies, local environmental plans and other legislation.

4.1 Environmental Planning and Assessment Act 1979

4.1.1 State Environmental Planning Policies

State Environmental Planning Policy (Infrastructure) 2007

State Environmental Planning Policy (Infrastructure) 2007 (ISEPP) aims to facilitate the effective delivery of infrastructure across the State.

Clause 94 of ISEPP permits development on any land for the purpose of a road or road infrastructure facilities to be carried out by or on behalf of a public authority without consent.

As the proposal is for a road and is to be carried out by Transport, it can be assessed under Division 5.1 of the EP&A Act 1*979*. Development consent from council is not required.

The proposal is not located on land reserved under the *National Parks and Wildlife Act 1974* (NP&W Act) and does not require development consent or approval under State Environmental Planning Policy (Coastal Management) 2018, State Environmental Planning Policy (State and Regional Development) 2011 or State Environmental Planning Policy (State Significant Precincts) 2005.

Part 2 of ISEPP contains provisions for public authorities to consult with local councils and other public authorities prior to the commencement of certain types of development. Consultation, including consultation as required by ISEPP (where applicable), is discussed in Section 5 of this REF.

4.1.2 Local Environmental Plans

Muswellbrook Local Environmental Plan 2009

The proposal is located within the Muswellbrook local government area (LGA). The planning instrument that applies to the Muswellbrook LGA is the Muswellbrook LEP 2009.

As outlined in Section 4.1.1, Clause 94 of ISEPP overrides the requirement for development consent from Muswellbrook Shire Council and therefore the consent requirements of the Muswellbrook LEP do not apply. Nevertheless, the land uses prescribed by the Muswellbrook LEP which the proposal would be located on have been considered in the development of the proposal and are described in Table 4-1.

As discussed in Section 2.4.1, a preferred option alignment for the bypass was included in Muswellbrook LEP 2009 and zoned as SP1 Infrastructure. The proposal outlined in this REF reaffirms the corridor preserved in the Muswellbrook LEP. Minor alignment changes have however occurred during development of the concept design and the environmental assessments in this REF. These amendments provide improved environmental outcomes from a biodiversity and cultural heritage perspective and enable improved connections to properties and Muswellbrook town centre, with minor additional impacts to existing land use. These amendments would require corrections to the Muswellbrook LEP zoning maps to confirm the extent of land affected by the proposal alignment.

The proposed road corridor traverses a small area of both R1 General Residential and R5 Large Lot Residential land zonings adjacent to the SP1 Infrastructure land zoning. The proposal would not fragment these land zonings and the impact to these land zonings is considered negligible. Therefore, the proposal is considered unlikely to impact on the objectives of these land zonings and is not discussed in the table below.

Table 4-1: Land uses impacted by the proposal

Land zoning	Objectives	Proposal consistency
RU1 Primary Production	• To encourage diverse and sustainable primary industry production • To minimise the fragmentation of resource lands • To minimise conflict between land uses • To protect the agricultural potential of rural land and maintain the long term rural landscape character • To protect or conserve soil stability; trees and other vegetation; water resources, water quality and wetland areas; and valuable deposits of minerals and extractive materials	The proposal has been designed to minimise the extent of land fragmentation where possible, however the proposal would involve the acquisition of some properties zoned and used for agricultural purposes The design has also minimised, where possible, the impact on environment aspects including soil, vegetation, water and mining land. These aspects have been assessed through Section 6
SP2 Infrastructure	• To provide for infrastructure and related land uses • To prevent development that is not compatible with infrastructure • To recognise existing railway land, major roads and existing land to enable future development	The proposal would meet the objectives of this zone
E3 Environmental Management	• To protect, manage and restore areas with special ecological, scientific, cultural or aesthetic values • To provide for a limited range of development that does not have an adverse effect on those values • To maintain or improve the ecological values of existing remnant vegetation of significance • To limit development that is visually intrusive and ensuring compatibility with the existing landscape character • To allow agricultural activities that will not have an adverse impact on the environmental and scenic quality of the existing landscape • To promote ecologically sustainable development	Environmental assessments have been carried out to identify potential impacts and provide appropriate management measures The construction footprint has been refined to reduce impacts on sensitive ecological areas (i.e. Striped Legless Lizard habitat) and Aboriginal heritage sites A Landscape Character, Visual Impact Assessment and Urban Design Report has also been prepared to identify and mitigate potential visual impacts Ecologically sustainable development (ESD) is discussed in Section 8.2.1

4.2 Other relevant NSW legislation

4.2.1 Roads Act 1993

The objects of the Roads Act 1993 (Roads Act) include classifying roads, declaring Transport and other public authorities as roads authorities, and regulation of various activities on public roads.

Under section 143 of the Roads Act, a roads authority can use a public road in the exercise of a function conferred by the Roads Act, so long as the function is exercised in a way that would not unduly interfere with the rights of passage and access that exist with respect to the public road. As outlined in Section 6.5 of this REF, there would be short term construction impacts to traffic movements as a result of the proposal, however safe access would be maintained throughout the construction period.

4.2.2 Biodiversity Conservation Act 2016

The purpose of the BC Act is to maintain a healthy, productive and resilient environment for the greatest well-being of the community consistent with the principles of ESD.

Under Part 2 of the BC Act it is an offence to harm animals and plants; damage areas of outstanding biodiversity value; damage habitat of threatened species or ecological communities. Under Part 2, Division 2 of the BC Act it is a defence to a prosecution if the harm or damage was necessary for the carrying out of a Division 5.1 EP&A Act activity undertaken in compliance with the determination, or undertaken consistent with a state significant infrastructure approval under Division 5.2 of the EP&A Act.

Section 7.3 of the BC Act establishes a test to determine whether a proposed development or activity is 'likely to significantly affect threatened species'. If an activity under Division 5.1 of the EP&A Act is likely to significantly affect threatened species then a Species Impact Statement (SIS) or a Biodiversity Development Assessment Report (BDAR) is required to be prepared.

An assessment of the potential impacts to biodiversity and measures to manage potential impacts are discussed in Section 6.1. The assessment found that the proposal is unlikely to have a significant impact on any threatened species or communities under the BC Act, therefore an SIS or BDAR is not required for the proposal.

4.2.3 Biosecurity Act 2015

The Biosecurity Act 2015 (Biosecurity Act) covers all biosecurity risks, including pest animals, plant diseases and noxious weeds and introduces the legally enforceable concept of a General Biosecurity Duty. As outlined in Section 6.1 of this REF, a number of weed species have been identified in the construction footprint during biodiversity inspections. Management measures have been recommended to manage these weed species in accordance with the requirements of the Biosecurity Act.

4.2.4 Coal Mine Subsidence Compensation Act 2017

The *Coal Mine Subsidence Compensation Act 2017* (CMSC Act) provides controls for certain development within mine subsidence districts. Clause 21 of the CMSC Act specifies that a person must not carry out work, or cause work to be done, in connection with the erection or alteration of an improvement within a mine subsidence district, except in accordance with the approval of the Chief Executive.

An improvement as defined by the Act includes any building or work erected or constructed on land or infrastructure whether above or below the surface of the land.

The proposal is located within the Muswellbrook subsidence district and constitutes ‘improvements’ as it is for the purpose of constructing infrastructure. As such, approval for the proposal would be sought from the Chief Executive of Subsidence Advisory, pursuant to Clause 21 of the CMSC Act.

A Mining Assessment Report was prepared by AECOM in 2021 to facilitate the approval process with Subsidence Advisory (refer to Section 6.4).

4.2.5 Fisheries Management Act 1994

The FM Act provides for the protection of threatened fish and marine vegetation and for the management of associated threatening processes. Part 7A Division 4 of the FM Act prohibits, without a licence or permit, activities that damage habitats or harm threatened species, populations or ecological communities.

The proposal would impact Muscle Creek and Sandy Creek, both of which are identified as ‘Key Fish Habitat’ under the FM Act. Activities which may require a permit under the FM Act include, but are not limited to, dredging works, reclamation work and works that would block fish passage.

The installation of temporary in stream structures may be considered to be reclamation work in accordance with the definition at s198A of the FM Act. Section 199 of the FM Act states the public authority is required to give the Minister written notice of the proposed work and consider any matter received from the Minister within 21 days of the notice. Section 219 of the FM Act makes it an offence to obstruct fish passage without a permit issued under Part 7 of the FM Act. The proposal would not obstruct fish passage. Bridge piers would be located outside main creek channels. Rock platforms or silt fencing across waterways for sediment and erosion control would be designed so that fish passage would be maintained at all times.

Consultation regarding the proposal has already been carried out with the Department of Primary Industries and the Department of Planning, Industry and Environment (DPIE) as summarised in Section 5.5.

4.2.6 Water Management Act 2000

The Water Management Act 2000 (WM Act) provides for the management of surface water and groundwater in NSW. The proposal is located within the area of the Water Sharing Plan for the Hunter Regulated River.

Section 56 of the WM Act establishes access licences for the take of water within a particular water management area. Under clause 21(1) of the Water Management (General) Regulation 2018 (Water Management Regulation) and schedule 4 part 1, Transport, as a ‘roads authority’, is exempt from the need to obtain an access licence in relation to water required for road construction and road maintenance.

Sections 89 to 91 of the WM Act establish three types of approvals that a proponent may be required to obtain. These are water use approvals, water management work approvals (including water supply work approvals, drainage work approvals and flood work approvals) and activity approvals (including controlled activity approvals and aquifer interference approvals).

‘Controlled activities’ include the erection of a building or carrying out of a work, removal of material or vegetation, the deposition of material, and the carrying out of an activity that affects the quantity or flow of water in a water source. Typically a controlled activity approval would be required under section 91E(1) of the WM Act to allow for construction within 40 metres of a watercourse. However, Clause 41 of the Water Management Regulation, exempts public authorities such as Transport from section 91E(1) of the WM Act in relation to all controlled activities that it carries out in, on or under waterfront land. This allows Transport to carry out controlled activities on waterfront land.

Under the NSW Aquifer Interference Policy, the proposal is exempt from requiring an aquifer interference approval. Section 3.3 of the policy states that cuttings, trenches and pipelines (intersecting the water table) would be considered as having a minimal impact on water-dependent assets, if a water access licence is not required. Therefore, the proposal would be defined as a minimal impact aquifer interference activity given that a water access licence is not required.

An assessment of the potential impacts to surface water and groundwater and measures to manage potential impacts are discussed in Section 6.2.

4.2.7 National Parks and Wildlife Act 1974

The NP&W Act governs the establishment, preservation and management of national parks, state reserves, historic sites and certain other areas, and the protection of certain fauna, native plants and Aboriginal heritage.

The NP&W Act, administered by the Heritage Division, Department of Premier & Cabinet, is the primary legislation for the protection of Aboriginal cultural heritage in NSW. The NP&W Act gives the Secretary of the Department of Premier & Cabinet responsibility for the proper care, preservation and protection of 'Aboriginal objects' and 'Aboriginal places'. Section 86 of the NP&W Act identifies offences relating to the harm of Aboriginal objects or places. An Aboriginal Heritage Impact Permit (AHIP) issued under section 90 of the NP&W Act is required if impacts to Aboriginal objects and/or places cannot be avoided.

Potential impacts to Aboriginal cultural heritage as a result of the proposal have been assessed in accordance with Transport's Procedure for Aboriginal Cultural Heritage Consultation and Investigation (NSW Roads and Maritime Services, 2011) (PACHCI).

An online AHIMS search was completed on the 13 June 2019 to identify registered Aboriginal sites or declared Aboriginal places within or adjacent to the study area. An archaeological survey was then carried out on 23 and 24 July 2019 where 12 archaeological sites (AFT)s were identified. This included 10 new AFTs and two AFTs whose area was associated with (or incorporated) previously recorded AHIMS sites. An updated AHIMS conducted on 24 November 2020 confirmed the study area contains 12 AHIMS registrations (comprises eight Aboriginal archaeological sites).

An AHIP would be required for sites to be impacted by the proposal. The Aboriginal cultural heritage assessment undertaken for the proposal is summarised in Section 6.7.

4.2.8 Heritage Act 1977

The Heritage Act 1977 (Heritage Act) aims to protect and conserve non-Aboriginal cultural heritage, including scheduled heritage items, sites and relics. The Heritage Act makes provision for a place, building, work, relic, moveable object, precinct, or land to be listed on the State Heritage Register. If an item is the subject of an interim listing, or is listed on the State Heritage Register, a person must obtain approval under section 60 of the Heritage Act for works or activities that may impact on these items.

Searches of relevant historic heritage registers and lists, both statutory and non-statutory, were conducted on 20 May 2020 to identify previously recorded historic heritage items within and 200 metres from the construction footprint. The search identified one item with a curtilage immediately adjacent to the construction footprint. Although the curtilage was immediately adjacent, the buildings associated with the listing were approximately 1.3 kilometres away. This item (St Heliers) had two listings associated with the same item, one in the Muswellbrook LEP 2009 and the other on the Corrective Services NSW S170 Heritage Conservation Register. Another listing, for the Muswellbrook Brick Works (former), was identified as being 130 metres to the east of the construction footprint. A non-Aboriginal heritage assessment was completed to inform the REF and is summarised in Section 6.8.

Under section 139 of the Heritage Act, approval is also required prior to the disturbance or excavation of land if it would, or is likely to, result in a relic being discovered, exposed or damaged.

4.2.9 Contaminated Lands Management Act 1997

The Contaminated Lands Management Act 1997 (CLM Act) establishes a process for investigating and remediating land where required. The CLM Act allows the NSW Environmental Protection Authority (EPA) to declare land as significantly contaminated land. The EPA may order a public authority to carry out actions or prepare a plan of management for significantly contaminated land. The CLM Act imposes a duty on landowners to notify the EPA and potentially investigate and remediate land contamination if levels are above EPA guidelines.

A search of the NSW EPA Contaminated land register on 3 May 2020 indicated there are no previously registered contaminated lands within the study area or within the Muswellbrook LGA (refer to Section 6.4).

4.2.10 Protection of the Environment and Operations Act 1997

The NSW Protection of the Environment Operations Act 1997 (POEO Act) aims to protect, restore and enhance the environments of NSW and reduce potential risks to human health and the environment. The POEO Act outlines pollution offences relating to land, water, air and noise pollution and includes a duty to report pollution incidents.

Under the provisions of the POEO Act, Transport is required to notify the EPA if a 'pollution incident' occurs that causes or threatens 'material harm' to the environment.

Under Section 120 of the POEO Act, a person who pollutes any waters is guilty of an offence and Transport is obliged not to pollute during the construction period or when the site is operational.

Under Part 3.2 of the POEO Act, an environmental protection licence (EPL) is required for scheduled activities or scheduled development work as defined in Schedule 1. Road construction is defined by Clause 35(1) as '…the construction, widening or re-routing of roads, but does not apply to the maintenance or operation of any such road'. Road construction is considered a scheduled activity under Clause 35(3)(a)(i) where extraction of more than 50,000 tonnes of materials is proposed over the life of the proposal, where the proposal would be carried out in the regulated area. The POEO Act regulated area definition includes the Muswellbrook LGA and the proposal is expected to require extraction of approximately 693,218 cubic metres of material, which is over the 50,000 tonnes threshold. This would require the proposal to be carried out under an EPL.

4.2.11 Land Acquisition (Just Terms Compensation) Act 1991

The Land Acquisition (Just Terms Compensation) Act 1991 (The Land Acquisition Act) applies to the acquisition of land (by agreement or compulsory process) by a public authority authorised to acquire the land by compulsory process. It provides a guarantee that, when a public authority requires the acquisition of land, the amount of compensation would not be less than the market value of the land. The Land Acquisition Act would apply to the acquisition of any land required for the proposal. Property acquisition is further discussed in Section 6.11.

4.2.12 Aboriginal Land Rights Act 1983

The Aboriginal Land Rights Act 1983 (ALR Act) provides for the land rights for Aboriginal persons and for representative Aboriginal Land Councils in New South Wales. Crown Land that is not lawfully being used or occupied, not (likely) needed for residential or essential public purposes and not the subject of a registered native title claim or determination can be claimed under the ALR Act.

One parcel of Crown Land adjacent to Coal Road would be subject to partial acquisition as a result of the proposal. This parcel of land is Crown Road and is therefore unable to be claimed under the ALR Act. Further, there are no active Aboriginal land claims under the ALR Act on this parcel of Crown Land.

4.3 Commonwealth legislation

4.3.1 Environment Protection and Biodiversity Conservation Act 1999

Under the EPBC Act, a referral is required to the Australian Government for proposed actions that have the potential to significantly impact on matters of national environmental significance or the environment of Commonwealth land. These are considered in Appendix A and Section 6 of this REF.

A referral is not required for proposed road activities that may affect nationally listed threatened species, EEC and migratory species. This is because requirements for considering impacts to these biodiversity matters are the subject of a strategic assessment approval granted under the EPBC Act by the Australian Government in September 2015.

Potential impacts to biodiversity matters are considered in Section 6.1 of the REF and Appendix A.

Findings – matters of national environmental significance

The assessment of the proposal's impact on matters of national environmental significance and the environment of Commonwealth land found that there is unlikely to be a significant impact on relevant matters of national environmental significance or on Commonwealth land. Accordingly, the proposal has not been referred to the Australian Government Department of Agriculture, Water and the Environment under the EPBC Act.

Findings – nationally listed biodiversity matters (where the strategic assessment applies)

The assessment of the proposal's impact on nationally listed threatened species, EECs and migratory species found that there is unlikely to be a significant impact on relevant matters of national environmental significance. Section 6 of the REF describes the safeguards and management measures to be applied to minimise or mitigate impacts. Section 6 also details the Biodiversity Offset Strategy to be implemented to address residual significant impacts on nationally listed biodiversity matters.

4.3.2 Other relevant Commonwealth legislation

Native Title Act 1993

The Native Title Act 1993 recognises and protects native title. The Act covers actions affecting native title and the processes for determining whether native title exists and compensation for actions affecting native title. It establishes the Native Title Registrar, the National Native Title Tribunal, the Register of Native Title Claims and the Register of Indigenous Land Use Agreements, and the National Native Title Register. Under the Act, a future act includes proposed public infrastructure on land or waters that affects native title rights or interest.

A search of the Native Title Tribunal Native Title Vision website was undertaken, with no Native Title holders/claimants identified.

4.4 Confirmation of statutory position

The proposal is categorised as development for the purpose of a road and road infrastructure facilities and is being carried out by or on behalf of a public authority. Under clause 94 of ISEPP, the proposal is permissible without consent. The proposal is not State significant infrastructure or State significant development. The proposal can be assessed under Division 5.1 of the EP&A Act.

Transport is the determining authority for the proposal. This REF fulfils Transport's obligation under section 5.5 of the EP&A Act including to examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the activity.

Under the POEO Act, an EPL would be required from the NSW EPA for road construction.

Under the NP&W Act, an AHIP is required for the proposal.

5. Consultation

This chapter discusses the consultation carried out to date for the proposal, and the consultation proposed into the future.

5.1 Consultation strategy

Transport has kept the community and stakeholders informed and proactively consulted throughout the development of the proposal. Consultation has been carried out in accordance with the Community and Stakeholder Engagement Plan prepared for the proposal.

The purpose of consultation is to:

- Keep the community informed and increase understanding of the proposal
- Gain local knowledge and consider comments and issues relating to the proposal and preferred route option
- Ensure stakeholders potentially impacted by the proposal are provided with clear information about possible property impacts
- Provide clear and timely information
- Advise the community on how they may obtain information, and communicate concerns, complaints and suggestions.

The REF would be displayed for a minimum four week period. During the display period, stakeholders and the community would be encouraged to participate, provide feedback and make a submission on the REF.

5.2 Community involvement

5.2.1 Community engagement to select preferred bypass route

Consultation with community and stakeholders on proposed routes for a potential bypass has been carried out since the Australian Government first announced a preferred option for a Muswellbrook bypass in 2005. Feedback has been considered as route options have been further developed and refined.

In 2016, community consultation was carried out on a draft corridor strategy for the New England Highway, including the Muswellbrook bypass.

A preferred option for the bypass was displayed for community and stakeholder feedback between 23 November and 18 December 2020 and 22 submissions were received in response to the display.

5.2.2 Consultation activities since selection of a preferred bypass route

Transport has involved the community during the concept design planning phase and the REF preparation phase of the proposal. Consultation activities which have been carried out during the preparation of the concept design and REF, include:

- Community updates distributed in November 2020
- Operation of a dedicated web page for the proposal
- Operation of a dedicated proposal phone number and email address to allow the community to ask questions and provide feedback
- Meetings with landowners and local businesses
- Consultation with government agencies

- Briefings with Muswellbrook Shire Council and local Members of Parliament.

Key issues raised during this phase are summarised in Table 5-1.

Table 5-1: Summary of issues raised by the community between 23 November and 18 December 2020

Issue category	Issues raised	Our response
Lane Arrangements	Suggestion for the bypass to be dual carriageway with two lanes in each direction	Transport has carried out detailed traffic investigations and modelling to understand likely future traffic volumes on the existing highway and proposed bypass. The modelling indicates traffic volumes on the bypass would not reach levels where a dual carriageway would be justified. The predicted maximum peak hourly traffic flow in 2044 is only about 20 per cent of the total capacity for the proposed single lane carriageway. This demonstrates a single lane in each direction can meet the forecast demand long term.
	Suggestion for bypass to include overtaking/ passing lanes	Transport assessed the need for inclusion of overtaking or passing lanes as part of the development process. The traffic volume on the bypass at the year of opening is approximately 5000 vehicles per day which is considered to be a low traffic volume. Transport has reviewed the grades on the bypass and completed an analysis of associated truck speeds. Based on Australian Road Design Guidelines (Austroads), the bypass does not meet the requirements for providing climbing lanes. Existing overtaking opportunities (single broken line) are available immediately north and south of the bypass. In addition, within about two kilometres north and three kilometres south of the bypass, there are northbound and southbound overtaking lanes.
Coal Road Connection	Suggestion for a bypass connection at Coal Road to link to Muswellbrook town centre and to provide emergency services access	Following feedback on the preferred option display, the NSW Government committed to include a connection to Coal Road in the concept design. Transport has updated the design to include a full connection at Coal Road that allows for all traffic movements to be made.
Northern Connection	Concern that the project impacts on the safety of access between the New England Highway and Burtons Lane	Following feedback on the preferred option display, the proposal has been amended so that Burtons Lane connects to the proposed roundabout at the northern connection. This arrangement provides safer access to and from Burtons Lane.

Issue category	Issues raised	Our response
		This update will be included as part of the design and environmental assessment for the proposal to be displayed in late 2021.
	Concern that the project impacts on the safety of access between the New England Highway and Koolbury Flats Row	Transport has moved the connection of Koolbury Flats Row with the New England Highway further north. Moving the intersection further north provides greater separation from the merge on the New England Highway providing increased safety for both New England Highway motorists and those entering Koolbury Flats Row. Transport has updated the design to include a dedicated left turn deceleration lane for traffic entering Koolbury Flats Row.
	Concern regarding property acquisition impacting an agricultural business	The need for some property acquisition has been identified as part of the proposal. Efforts have been made in the development of the design to reduce the extent of property acquisition that would be required. The environmental assessment will consider impacts on the local community and businesses, as well as address potential mitigation measures primarily through a socio-economic assessment.
	Concern regarding amenity (Noise and dust) impacts on residential areas due to proximity of the Northern connection (during operation and construction)	Environmental studies including noise and vibration and air quality impact assessments would be completed as part of the environmental assessment as well as address potential mitigation measures.
	Suggestion to amend bypass route to use land on eastern side of the New England Highway	The proposed design alignment at the northern connection is constrained by existing infrastructure such as the Main North railway line, the New England Highway, property accesses, flooding impacts and road design requirements. Due to these constraints, the alignment for the bypass impacts land on both the eastern and western sides of the existing New England Highway.

Issue category	Issues raised	Our response
		This proposed design alignment at the northern connection is consistent with the 2005 preferred option alignment for a bypass of Muswellbrook which was subsequently included in the Muswellbrook LEP.
	Suggestion for an additional bypass connection at Sandy Creek Road	The proposal development included consideration of exit and entry ramps at Sandy Creek Road. All traffic movements are proposed to be provided at the Northern connection, which provides greater benefit to the overall road network than exit and entry ramps at Sandy Creek Road. A connection at Sandy Creek Road was assessed as providing minimal benefit to the overall road network.
Southern Connection	Concern that the project impacts on the safety of access between the New England Highway and Milpera Drive	The proposed connection of Milpera Drive with the New England Highway is to the south of the existing connection to provide a safer intersection arrangement. Right and left turning lanes have been provided to assist vehicle turning movements and improve the safety of access between the New England Highway and Milpera Drive.
	Supports the proposed southern connection location near Muscle Creek Road	Transport acknowledges this support for the proposed southern connection.
Environment	Concern regarding water flow runoff impacts to Muscle Creek	The environmental assessment will include a Surface and Groundwater Assessment taking into consideration potential impacts on Muscle Creek, as well as address potential mitigation measures. Refer to Section 6.2.
Design features	Suggestion for: • A 3.0 m shoulder • Acceleration lanes at the northern and southern connections • Application of safety in design principles	The proposed design has been developed with 2.5 metre shoulders alongside a one metre centre line. Together these features provide space to comfortably pass other vehicles stopped on the shoulder. The shoulder width is consistent with the design of Scone and Singleton bypasses. Transport has carried out detailed traffic investigations and modelling to understand likely future traffic volumes at the connections. The investigations indicate very low traffic volumes for both the northbound left turn onto the bypass at the southern connection and the southbound

Issue category	Issues raised	Our response
		left turn movements onto the bypass at the northern connection. Acceleration lanes were not deemed to be justified at these locations, given the low traffic volumes and significant increase in scope and cost required to provide. The proposed design has been developed with application of safety in design principles, and in accordance with relevant design standards and guidelines.
	Suggestions to cater for Over Sized/Over Mass (OSOM) vehicles on the bypass.	The proposal caters for OSOM vehicles on the bypass. A one metre wide line marked centreline has been provided for the full length of the proposal to enable greater separation of opposing traffic reducing the likelihood of a head-on crash, without restricting OSOM vehicles.
Other	Suggestion to accelerate the proposal timeline	Transport is finalising the concept design and environmental assessment for the proposal which will be displayed for feedback in late 2021. Transport will then carry out the final stage of design incorporating feedback, with construction planned to start in late 2022.
	Suggestion to seek Federal government funding for the proposal	The NSW Government has committed to fully fund the Muswellbrook bypass. Federal funding is not required for the proposal to progress.
	Requests for information on employment opportunities	The proposal is likely to facilitate significant economic opportunities and growth for the local area. This would include opportunities for employment on the proposal following approval and commencement.
	Request for additional information on the proposal	Transport has provided the information requested.
	Request for ongoing consultation with Muswellbrook Shire Council	Transport will continue to consult Muswellbrook Shire Council during the development of the proposal.

Issue category	Issues raised	Our response
	Request for the reclassification of local roads and consideration of the impact of OSOM vehicles on local roads	Consideration of local road reclassifications including OSOM movements will be carried out by Transport in consultation with Muswellbrook Shire Council.
Out of scope items	Suggestion for upgrade of Sandy Creek Bridge	While this is out of scope for the proposal, the issue has been raised with the appropriate Transport department for investigation.
	Suggestion to remove the Sandy Creek Road level crossing	While this is out of scope for the proposal, the issue has been raised with the appropriate Transport department for investigation.

Community and stakeholder consultation was carried out as part of the Socio-Economic Impact Assessment Technical Working Paper (AECOM, 2021) which was prepared to identify the potential socioeconomic impacts that may arise as a result of the proposal and to inform Section 6.12 of this REF. The community and stakeholder consultation included business surveys of 60 businesses and 120 stopper surveys in November 2020.

The findings of the business impact survey and stopper survey are provided in more detail in Section 6.12 and Appendix B.

5.3 Aboriginal community involvement

The Aboriginal community has been involved throughout the development of the proposal in accordance with the requirements of the DPIE Aboriginal Cultural Heritage Consultation Requirements for Proponents (DECCW, 2010) (Consultation Requirements) and Transport 's PACHCI. This is a staged process for investigating potential impacts to Aboriginal cultural heritage as a result of Transport road planning, development, construction and maintenance activities.

The four stages of the PACHCI and the Aboriginal community consultation carried out in each stage are shown in Table 5-2. Consultation carried out with the Aboriginal community is further documented in Appendix C.

Table 5-2: Transport Procedure for Aboriginal Cultural Heritage Consultation and Investigation

Stage	Description
Stage 1 – Initial Transport assessment	An initial desktop risk assessment was carried out by Transport as part of the initial scoping to determine if the proposal is likely to harm Aboriginal cultural heritage or not. No direct consultation with the Aboriginal community was completed during this stage
Stage 2 – Site survey and further assessment	Stage 2 involved further assessment and a survey to assess the proposal's potential to harm Aboriginal cultural heritage, and to determine whether widespread Aboriginal community consultation and a cultural heritage assessment report is required Aboriginal stakeholders consulted as part of the Stage 2 PACHCI assessment included Wanaruah Local Aboriginal Land Council (LALC) and the (then) registered Native Title Claimant Group. Both parties participated in an archaeological survey of the study area carried out in July 2019
Stage 3 – Formal consultation and preparation of a cultural heritage assessment report	Stage 3 of the PACHCI involved a formal program of Aboriginal community consultation in accordance with legislative requirements and DPIE's 'Aboriginal Cultural Heritage Consultation Requirements for Proponents' (DECCW, 2010), subsurface investigations and the preparation of an Aboriginal Cultural Heritage Assessment Report (CHAR) Consultation activities carried out as part of Stage 3 have included: • PACHCI Stage 2 findings and proposed test excavation methodology (under PACHCI Stage 3) provided to Registered Aboriginal Parties (RAPs) for review (allowing a minimum 28 day review) • an Aboriginal Focus Group (AFG) meeting held on 17 June 2020 to discuss investigation results and development of the proposed PACHCI Stage 3 assessment methodology

Stage	Description
	• draft CHAR provided to RAPS for review and feedback (28 day review period provided) • an AFG meeting held during CHAR review period on 3 February 2021 • finalisation of the CHAR • ongoing consultation with the local Aboriginal community including a proposal information update Investigations for the proposal have included consultation with 46 Aboriginal community groups and individuals
Stage 4 – Implement environmental impact assessment recommendations	Implement environmental impact assessment recommendations. This stage will be implemented after proposal approval and issue of an AHIP

5.4 ISEPP consultation

Consultation with councils and other public authorities is provided for by Clause 13 to 16 of the ISEPP, which applies to development carried out by or on behalf of a public authority that may be carried out without consent. Consultation is required in relation to development that impacts on:

- Council related infrastructure or services (Clause 13)
- Local heritage (Clause 14)
- Flood liable land (Clause 15)

Consultation is also required with public authorities other than councils (Clause 16).

Appendix D contains an ISEPP consultation checklist that documents how ISEPP consultation requirements have been considered.

Table 5-3 outlines ISEPP consultation required for the proposal.

Table 5-3: ISEPP consultation required for the proposal

Agency	ISEPP clause	Date of response
Muswellbrook Shire Council	Clause 13, 14 and 15	No response received
NSW State Emergency Services (SES)	Clause 15AA	15 March 2021
Subsidence Advisory NSW	Clause 16	30 March 2021

Issues that have been raised as a result of this consultation are outlined below in Table 5-4.

Table 5-4: Issues raised through ISEPP consultation

Agency	Issue raised	Response / where addressed in REF
NSW SES	Requested that the Flood Impact Assessment (Appendix E) be referred to NSW SES for review and advice, once finalised	The Flood Risk Assessment would be available for review as part of the exhibition of the REF

Agency	Issue raised	Response / where addressed in REF
Subsidence Advisory NSW	Recommended updates to the Mining Assessment Report (Appendix F) which was sent for review on 10 February 2021	These recommendations have been addressed in the Mining Assessment Report

5.5 Government agency and stakeholder involvement

Various other government agencies and stakeholders have been consulted about the proposal, including:

- ARTC
- DPI – Fisheries
- EPA
- Hunter Local Land Services
- DPI – Agriculture
- Water group, DPIE
- Environment, Energy and Science (EES), DPIE
- Natural Resources Access Regulator (NRAR).

A letter was sent to each agency on 25 March 2021. A copy of the responses received is provided in Appendix G and a summary of the issues raised are in Table 5-5.

Table 5-5: Issues raised through stakeholder consultation

Agency	Issue raised	Response / where addressed in REF
Department of Primary Industries – Fisheries	The main areas of concerns included the bridge crossings on Muscle Creek and Sandy Creek Confirmed both streams are considered as Key Fish Habitat and therefore require the following: • Any structures in place shall not block the free movement of fish • All structures should not reduce the cross sectional area of the stream and should include low flow channels for culverts and scour protection at bed level • The floodplain of Sandy Creek should not be constricted by structures any more than are present downstream	Drawings of the bridge crossings on Muscle Creek and Sandy Creek were sent to DPI – Fisheries for information on 27 April 2021 • Key fish habitat is addressed in Section 6.1 • As noted in Section 4.2.5, the proposal would not obstruct fish passage. Drainage structures would be designed to allow for the natural flow and existing overland paths to be maintained post-construction where possible • Bridge structures are provided over Muscle Creek and Sandy Creek, with piers located outside areas of low flows, to minimise flood impacts and allow for the free movement of fish • For tributaries of Muscle Creek and Sandy Creek, large culvert structures have been provided, which will incorporate fish-friendly low-flow passages into their design
Environment Protection Authority	The EPA key information requirements for the proposal include an adequate description and assessment of:	• Section 6.2 (Surface water, hydrology and flooding) • Section 6.6 (Noise and vibration)

Agency	Issue raised	Response / where addressed in REF
	• Impacts on water quality and site water management, with specific reference to potential impacts on local watercourses and an assessment of background water quality • Potential noise impacts due to construction and operation with specific reference to proposed community consultation and management measures during the construction phase The EPA also provided an attachment (Attachment A) which included recommended REF requirements. The attachment included requirements for: • Environmental impacts of the proposal • Licencing requirements • The proposal and premises • Air issues • Noise and vibration • Water and soils • Waste • Dangerous goods, chemical storage and bunding • Monitoring programs Further, the EPA requested Transport refer to the relevant guidelines listed in Attachment B and any relevant industry codes of practice and best practice management guidelines	Transport has reviewed both attachments (Attachment A and B) and the requirements relevant to this stage of the proposal have been addressed in this REF
Hunter Local Land Services	Hunter Local Land Services identified several environmental factors that should be included and assessed in the REF that may subsequently require mitigation measures and/or offsets implemented to avoid or minimise environmental impacts on key natural resource management assets during construction and operation of the proposal The environmental factors include (but may not be limited to): • Riparian vegetation, instream channel and aquatic health	• Section 3.3.7(Traffic management and access) • Section 6.1 (Biodiversity) • Section 6.4 (Soils) The TSRs and Stock Routes are not expected to be affected by the proposal. It is recommended that consultation occur between stakeholders using the stock route to ensure extension works are planned to avoid impacting stock travel The construction of the proposal has the potential to exacerbate dryland salinity where the groundwater table is impacted by construction works. Given that impacts

Agency	Issue raised	Response / where addressed in REF
	• Terrestrial vegetation including Critically Endangered Ecological Communities (CEECs) and EECs • Potential salinity impacts through design and construction • TSRs and Stock Routes	to the groundwater table are anticipated to be minor, the proposal is unlikely to contribute to dryland salinity
Department of Primary Industries – Agriculture	DPI – Agriculture recommends that the proposal undertakes a Land Use Conflict Risk Assessment (LUCRA) DPI – Agriculture noted information in the *Guideline for Infrastructure Proposals on Rural Land* may assist in preparation of the REF	The assessment of construction and operational environmental impacts in Section 6 of the REF contains a risk assessment relevant to certain environmental matters addressing the same likelihood and consequence rating proposed in the LUCRA The *Guideline for Infrastructure Proposals on Rural Land* applies to infrastructure facilities and does not apply to classified roads. Notwithstanding Transport has addressed many of the headline items in the Guideline in the REF
Natural Resources Access Regulator	Key aspects identified by NRAR include: • Potential for groundwater interception due to proposed excavation • Management of erosion and sediment control to mitigate impacts on downstream water sources • Water demands and sources for dust suppression and road construction • Construction within 40m of watercourses including watercourse crossings, which may result in impacts to bank stability, water quality and the riparian vegetation. NRAR recommended that the REF include: • Identification and impact assessment of all works/activities that may intercept, extract, use, divert or receive water • The identification of all water take for the project. Include details of water sources that water will be taken from where water entitlements need to be acquired to account for the water take • A detailed and consolidated site water balance • Details of Water Access Licences (WALs) held to account for any take	Key aspects are addressed in: • Section 6.3 (Groundwater) • Section 6.2 (Surface water, hydrology and flooding) • Section 3.3.6 (Source and quantity of materials) • Section 6.1(Biodiversity) All works/activities that may intercept, extract, use, divert or receive water are assessed in Section 4 of the Surface Water and Groundwater Assessment Report (Appendix I). The quantity of water that would be required during construction is unknown at this stage and would depend on available sources and methodologies applied by the contractor. Construction sources would include sediment basins or alternatively the local water supply network (refer to Table 3-5) A detailed water balance would not be required for this Proposal. Under section 18(1) of the Water Management (General) Regulation 2011 and schedule 5 part 1, Transport for NSW, as a ‘roads authority’, is exempt from the

Agency	Issue raised	Response / where addressed in REF
	of water, or demonstration that WALs can be obtained prior to take of water occurring • Assessment of the project's compliance with any exemptions or exclusions to requiring approvals or licenses under the Water Management Act 2000 • Identification and impact assessment of all works located on waterfront land including consideration of the NRAR Guidelines for Controlled Activities on Waterfront Land (2018) • Assessment of the project against relevant policy and guidelines, eg Water Sharing Plans, Floodplain Management Plans, NSW Aquifer Interference Policy, NSW Floodplain Harvesting Policy, Guidelines for Controlled Activities on Waterfront Land (2018).	need to obtain an access licence in relation to water required for road construction and road maintenance. Approval and licence requirements are addressed in Section 4.2.6. Clause 41 of the Water Management Regulation exempts public authorities such as Transport from section 91E(1) of the WM Act in relation to all controlled activities that it carries out in, on or under waterfront land. This allows Transport to carry out controlled activities on waterfront land.

5.6 Consultation during the public display of the REF

Transport is committed to continuing the engagement with the community and stakeholders throughout the development of the proposal. The REF would be placed on public display and comments invited. Consultation activities during this display period may include:

- Briefings with Muswellbrook Shire Council and other relevant stakeholders
- Community information sessions, including online sessions
- Advertisement in local newspapers
- An online community engagement portal and update to the webpage
- Proposal updates distributed to the community and stakeholders inviting feedback on the proposal.

5.7 Consultation following public display of the REF

Following the public display of the REF, Transport would prepare a submissions report which would summarise and provide a response to submissions received for the proposal. The submissions report would include a summary of any changes to the proposal in response to the submissions and other feedback during the display period.

The community would continue to be informed during the development and construction of the proposal if approved. Transport would also continue to consult with Muswellbrook Shire Council as well as other relevant stakeholders and government agencies as the proposal develops.

6. Environmental assessment

This section of the REF 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:

- Potential impacts on matters of national environmental significance under the EPBC Act
- The factors specified in the guidelines Is an EIS required? (DUAP 1995/1996), as required under clause 228(1) *of the* Environmental Planning and Assessment Regulation 2000 and the *Roads and Related Facilities EIS Guideline (DUAP 1996)*. The factors specified in clause 228(2) of the Environmental Planning and Assessment Regulation 2000 are also considered in Appendix H.

Site-specific safeguards and management measures are provided to mitigate the identified potential impacts.

6.1 Biodiversity

A Biodiversity Assessment Report (BAR) was prepared by WSP (2021) to assess the potential terrestrial and aquatic biodiversity impacts associated with the proposal and detail the management measures proposed to mitigate these impacts (refer Appendix A).

6.1.1 Methodology

Study area

The study area for the BAR includes the construction footprint and the areas surveyed as part of the biodiversity assessment (refer to Figure 6-1). The locality is taken to be a 10 kilometre radius surrounding the study area.

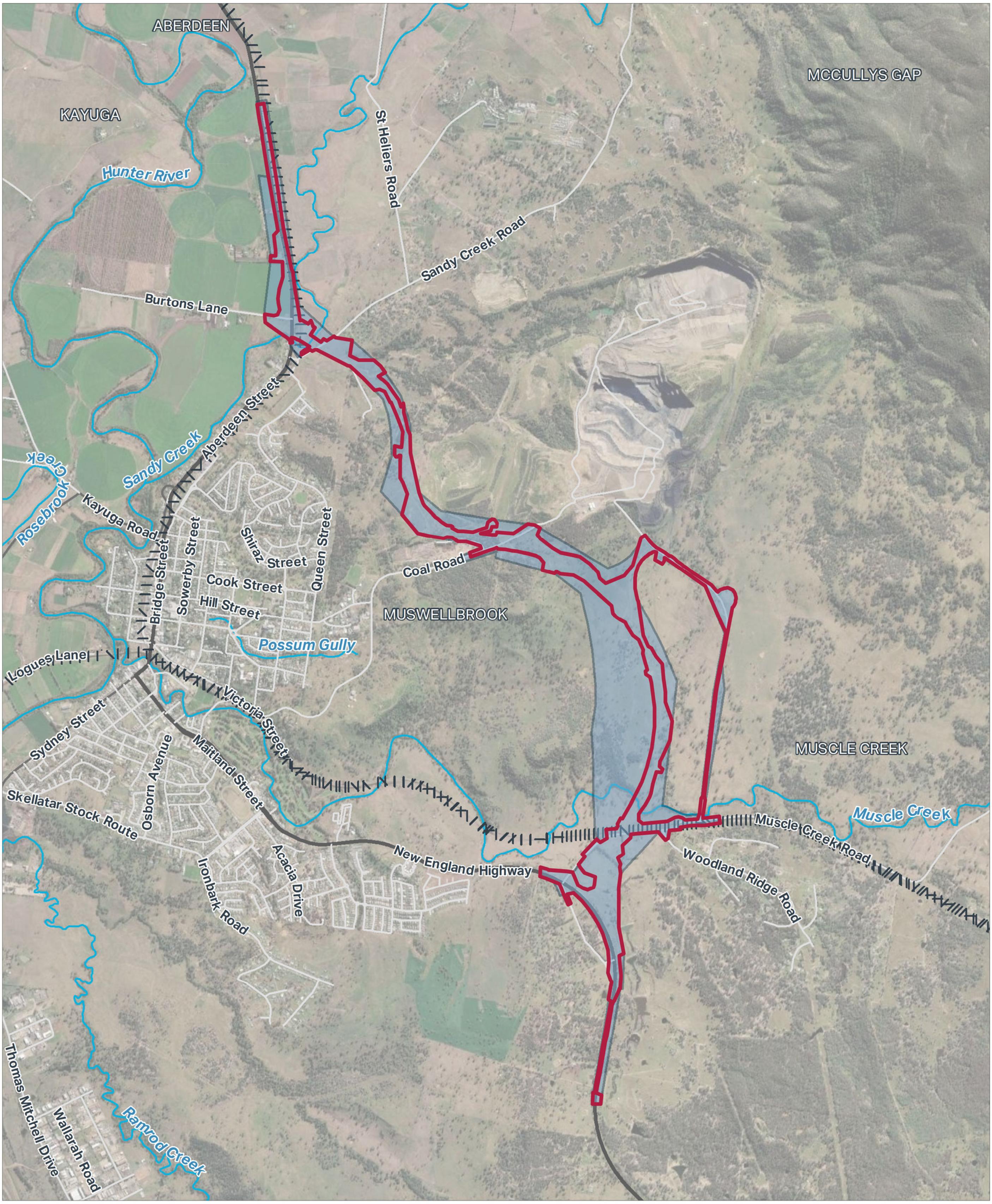


FIGURE 6-1: STUDY AREA FOR BIODIVERSITY ASSESSMENT

N

km
0 0.5 1

Legend
- Construction footprint
- Study area
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse

Background searches

A background review of existing information was completed to identify the existing environment within the locality. The background review included analysis of biodiversity reports previously prepared for the proposal and local broad-scale vegetation mapping of the study area.

A range of database searches were also carried out to obtain records of threatened species, populations and ecological communities known or predicted to occur in the locality of the study area (refer to Table 6-1).

Table 6-1: Database searches completed

Database	Area searched
BioNet Atlas of NSW Wildlife (Environment Energy and Science Group, 2020a)	10 km buffer around the study area and subregion
Protected Matters Search Tool (Department of Environment and Energy, 2020)	10 km buffer around the study area
PlantNet (Royal Botanic Gardens, 2020)	Muswellbrook LGA
Fishing and Aquaculture spatial data (Department of Primary Industries, 2020a)	10 km buffer around the study area
Coastal SEPP search (Department of Planning and Environment, 2018)	10 km buffer around the study area
NSW Areas of Outstanding Biodiversity Value Register (Environmental Energy and Science Group, 2020b)	10 km buffer around the study area
Australian Government Critical Habitat register (Department of Agriculture Water and the Environment, 2020)	10 km buffer around the study area
Critical Habitat Register (Department of Primary Industries, 2020b)	10 km buffer around the study area
Atlas of Groundwater Dependent Ecosystems (Bureau of Meteorology, 2020)	10 km buffer around the study area

Habitat assessment and likelihood of occurrence

A habitat assessment was completed to assess the likelihood of occurrence of each threatened species, population and community (threatened biodiversity) identified with the potential to occur in the study area. All threatened biodiversity identified during the background research were considered.

The likelihood of occurrence criteria used for the assessment is shown in Table 6-2 below.

Table 6-2: Likelihood of occurrence classification and criteria

Likelihood	Criteria
Recorded	The species was observed in the study area during the current survey
High	It is highly likely that a species inhabits the study area and is dependent on identified suitable habitat

Likelihood	Criteria
Moderate	Potential habitat is present in the study area
Low	It is unlikely that the species inhabits the study area and has not been recorded recently in the locality
None	Suitable habitat is absent from the study area

Field survey

Field surveys aimed to ground-truth the results of the background research. As such, all threatened biodiversity that were considered likely to occur within the study area were targeted during the field survey to determine presence or likely occurrence.

Surveys generally adhered to the methods described in the following guidelines:

- NSW Guide to Surveying Threatened Plants (Office of Environment & Heritage, 2016)
- Surveying threatened plants and their habitats (Department of Planning Industry and Environment, 2020)
- Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft (Department of Environment and Conservation, 2004).

A description of all field surveys completed is provided below with further detail included in Appendix A.

Vegetation surveys

Vegetation surveys were carried out, using a combination of survey techniques, to verify existing vegetation mapping, map derived native grasslands (DNG) and assess the condition of vegetation.

Native vegetation recorded within the study area was aligned to Plant Community Types (PCTs) and corresponding Threatened Ecological Communities (TEC) (where applicable). This was achieved by identifying native vegetation by formation, class and type.

Areas of non-native vegetation were also identified and mapped.

Targeted flora surveys

Targeted threatened flora surveys were conducted for candidate species that were considered to have a moderate or higher likelihood of occurrence.

Targeted fauna surveys

Fauna surveys were conducted within the study area during all survey periods in 2019 and 2020. Surveys were undertaken for threatened species identified during desktop assessments, that were considered likely to use habitats within the study area. Survey session seasonality was selected to target candidate species with seasonal survey requirements and activity.

Habitat assessments were also conducted to assess the value of the habitats present for threatened fauna.

A range of fauna surveys were undertaken across the proposed construction footprint, including:

- Nocturnal surveys
- Spotlighting
- Call playback
- Stag watches
- Diurnal bird surveys

- Koala spot assessments
- Artificial shelter site surveys
- Arboreal and terrestrial mammal trapping
- Yangochiroptera bat surveys
- Opportunistic sightings.

Comprehensive hollow-bearing tree survey

A comprehensive hollow-bearing tree (HBT) survey was undertaken within the 20 per cent design construction footprint. The aim of the survey was to identify all habitat trees within the 20 per cent design construction footprint, due to their importance to diversity of threatened fauna species. Key design refinements which have occurred from the 20 per cent design to the 80 per cent design are discussed in Section 2.6.

Aquatic surveys

Aquatic habitat assessments were completed at Sandy Creek, Muscle Creek and some of their unnamed tributaries to confirm potential habitat for threatened aquatic species. No threatened aquatic habitat was identified and as such no targeted surveys were required.

6.1.2 Existing environment

Plant community types

Seven native PCTs were recorded within the study area, including:

- PCT 1691 Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter (PCT 1691)
- PCT 1604 Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter (PCT 1604)
- PCT 1605 Narrow-leaved Ironbark - Native Olive shrubby open forest of the central and upper Hunter (PCT 1605)
- PCT 1607 Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter (PCT 1607)
- PCT 1693 Yellow Box - Rough-barked Apple grassy woodland of the upper Hunter and Liverpool Plains (PCT 1693)
- PCT 42 River Red Gum / River Oak riparian woodland wetland in the Hunter Valley (PCT 42)
- PCT 485 River Oak riparian grassy tall woodland of the western Hunter Valley (Brigalow Belt South Bioregion and Sydney Basin Bioregion) (PCT 485).

The area for each PCT within the construction footprint is provided in Table 6-3 along with associated TECs, where applicable.

Table 6-3: PCT's and associated TECs identified within the construction footprint

PCT	Condition class	TEC (BC Act)	TEC (EPBC Act)	Area (ha) in construction footprint
PCT 1691	Moderate	Central Hunter Grey Box-Ironbark Woodland	Central Hunter Valley eucalypt forest and woodland	8.82
	Low (remnant)		-	4.93

PCT	Condition class	TEC (BC Act)	TEC (EPBC Act)	Area (ha) in construction footprint
	Low (DNG)		-	38.39
PCT 1604	Low (remnant)	Central Hunter Ironbark - Spotted Gum -Grey Box Forest	-	0.67
PCT 1605	Moderate	Central Hunter Grey Box - Ironbark Woodland	Central Hunter Valley eucalypt forest and woodland	0.06
PCT 1607	Good	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland	0.56
	Low (remnant)		-	0.09
	Low (DNG)		-	1.02
PCT 1693	Good	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland	White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland	0.00
	Moderate			0.02
	Low (remnant)		-	5.07
	Low (DNG)		-	31.19
PCT 42	Low (remnant)	Hunter Floodplain Red Gum Woodland	-	0.08
	Low (DNG)		-	3.38
PCT 485	Moderate	-	-	1.78
	Low (remnant)	-	-	0.18
	Low (DNG)	-	-	1.68
Total extent of DNG				75.66
Total extent of remnant vegetation				22.26
Total extent of native vegetation				97.92

Four non-native miscellaneous ecosystems were also recorded within the construction footprint as outlined in Table 6-4.

Table 6-4: Non-native miscellaneous ecosystems recorded in the construction footprint

Non-native miscellaneous ecosystems	Area (ha) in construction footprint
Highly disturbed areas with no or limited native vegetation	78.46
Urban/exotic plantings	0.48

Non-native miscellaneous ecosystems	Area (ha) in construction footprint
Native plantings (including mine rehabilitation)	5.87
Cropping	5.36
Total	90.17

Flora and fauna

Flora species

Within the study area, a total of 345 flora species were recorded. Of these, 138 species were exotic species or native planted ornamental species and 207 species were native. Of the 138 exotic species recorded, 10 are listed as Priority Weeds under the Biosecurity Act for the Greater Hunter Local Land Service region and seven are listed as Weeds of National Significance.

Fauna species

A total of 153 fauna species were recorded within the study area of which 144 were native and nine were introduced. This included a total of 113 bird species, 23 mammals, nine reptiles, seven amphibians and one fish species.

Fauna habitat

Terrestrial fauna

Habitat features recorded within the study area were largely dominated by open forest/woodland, riparian woodland, native grasslands and cleared land with scattered trees and/or native plantings. Although some of the terrestrial fauna habitat is highly disturbed and modified, it protects the integrity of adjoining remnants and supports wildlife movement within a fragmented mosaic landscape which many fauna species locally depend upon.

Aquatic fauna

Most waterways within the study area are typical of a highly modified agricultural landscape and are largely ephemeral. The waterways were either not classified as Key Fish Habitat (Department of Primary Industries, 2013) and/or based on observations were likely to align to Class 4 (unlikely key fish habitat). Aquatic habitats within these waterways are largely absent and unlikely to support aquatic or wetland vegetation. Two exceptions to this include:

- Sandy Creek
- Muscle Creek.

Sandy Creek is a tributary of the Hunter River and is recognised as Key Fish Habitat (Department of Primary Industries, 2013). Within the study area, Sandy Creek is considered a Class 3 watercourse (i.e. minimal key fish habitat). Although the creek has defined banks, it is ephemeral in nature and does not appear to support native aquatic or wetland vegetation given its highly disturbed nature. As such, Sandy Creek and its tributaries within the study area are likely to align to Type 3 (minimally sensitive key fish habitat).

Muscle Creek is a tributary of the Hunter River and is also recognised as Key Fish Habitat (Department of Primary Industries, 2013). Within the study area, Muscle Creek is considered a Class 2 watercourse (i.e. moderate key fish habitat) as it has well defined banks, semi-permanent to permanent water, pools and contains freshwater aquatic vegetation. Muscle Creek is likely to align to Type 1 (highly sensitive key fish habitat) given the presence of microhabitats such as rocks, snags and gravel.

No threatened species listed under the FM Act are considered likely to occur within any of the aquatic habitat identified due to its poor condition which is largely the result of past and current land uses.

Fauna microhabitats

A total of 65 hollow-bearing trees were recorded within the 20 per cent design construction footprint. The number and size of each hollow identified is presented in Figure 6-2.

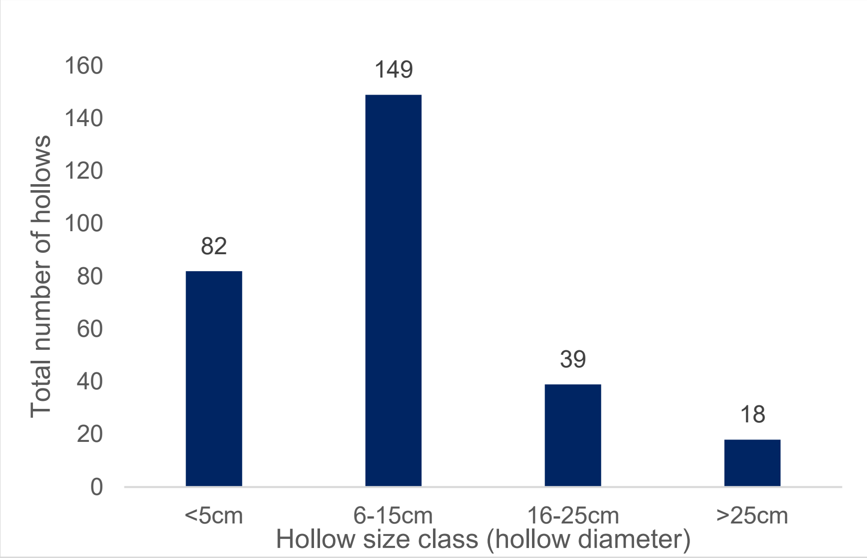


Figure 6-2: Hollows within the 20 per cent design construction footprint

Since the completion of the comprehensive hollow-bearing tree survey, the construction footprint has been expanded to encompass areas needed for temporary works such as sedimentation basins, drainage channels, access roads, construction compounds and ancillary sites to support the construction of the proposal. A total of 42 hollow bearing trees were recorded within the 80 per cent construction footprint, based on data collected as part of the comprehensive hollow-bearing tree survey of the 20 per cent construction footprint and the large hollow tree survey. There is however potential for more hollow-bearing trees to occur within the 80 per cent construction footprint where it extends past the 20 per cent construction footprint as comprehensive surveys have not been conducted in these areas. Despite comprehensive hollow-bearing tree surveys having not been completed throughout the 80 per cent construction footprint, it is anticipated that no more than 42 hollow-bearing trees would be impacted by the proposal. Given the temporary nature of the works to occur in areas which have not been subjected to comprehensive surveys, it is anticipated that trees containing hollow resources would be able to be avoided through careful site selection. Furthermore, impacts to the 42 hollow-bearing trees assessed in this report may also be reduced through further design changes and site selection.

Numerous bird nests were recorded, largely focused around Muscle Creek in the south of the study area where vegetation was in higher condition. One large predatory stick nest was also recorded in the study area.

Although varied, foraging resources within the study area were largely restricted to canopy, sub-canopy and groundcover species. Shrub stratum was either absent or sparse in cover, except for vegetation along and immediately north of Muscle Creek.

The study area includes several built structures that are known to occasionally provide habitat opportunities for threatened species such as Yangochiroptera bats. These structures include:

- A single lane old wooden rail bridge
- Two concrete box culverts

No bats were observed roosting under the bridge and no evidence of usage was observed, however access was limited. Two Southern Myotis (*Myotis macropus*) individuals were recorded roosting within one of the concrete box culverts.

Threatened ecological communities

The following four BC Act listed TECs were identified within the study area:

- Central Hunter Grey Box - Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions (Endangered)
- Central Hunter Ironbark - Spotted Gum - Grey Box Forest in the New South Wales North Coast and Sydney Basin Bioregions (Endangered)
- White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grasslands (Critically Endangered)
- Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions (Endangered).

Two EPBC Act listed TECs were also identified within the study area. These are discussed further under 'Matters of National Environmental Significance'. Table 6-3 shows conditions of the PCTs identified within the construction footprint and the associated TEC under both the BC Act and EPBC Act. Figure 6-3 and Figure 6-4 shows the locations of the TECs.

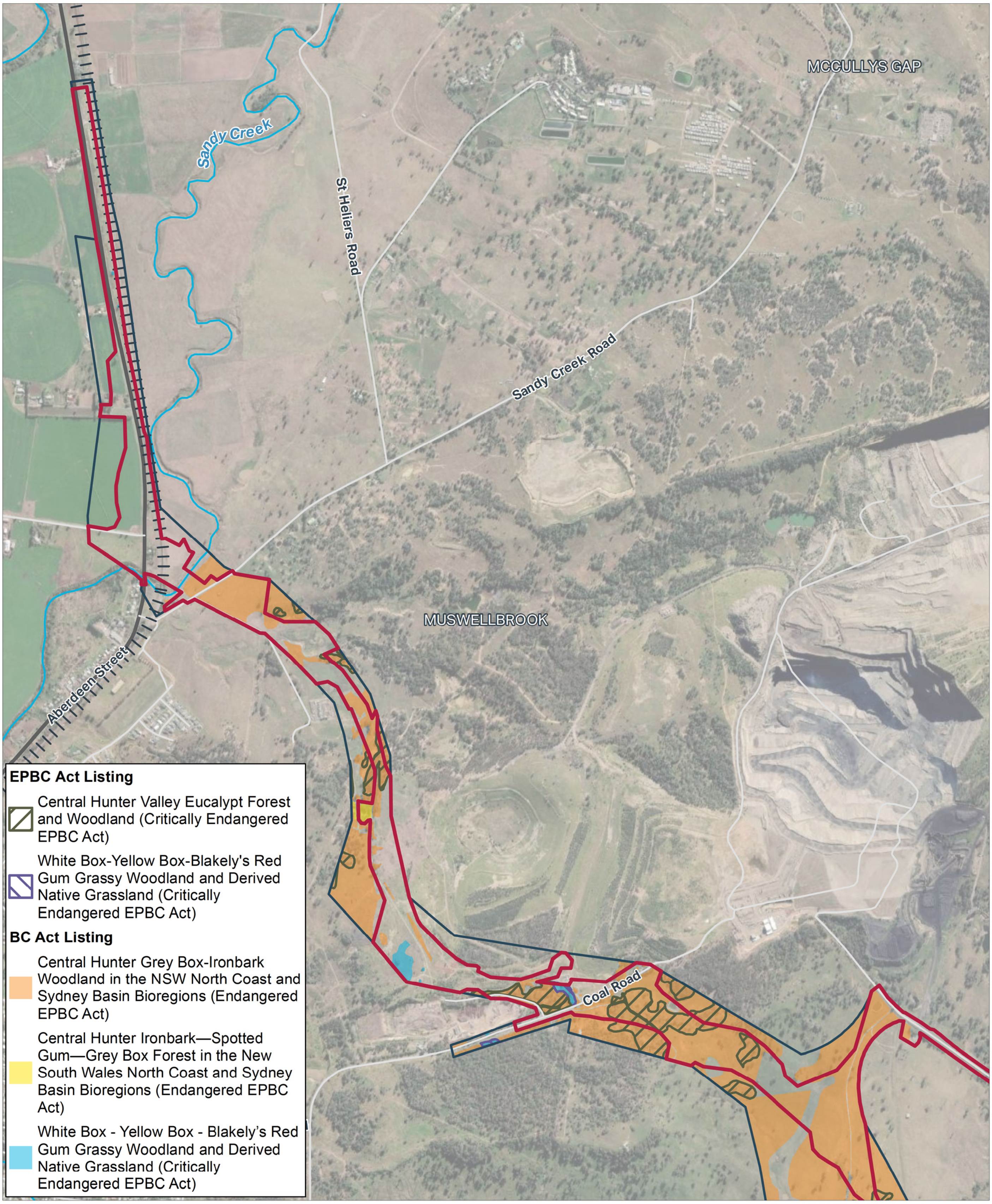


FIGURE 6-3: THREATENED ECOLOGICAL COMMUNITIES
NORTHERN SECTION

N 0 0.5 1 km

AECOM

Legend
- Construction footprint
- Study area
- State Road
- Local Road
- Railway
- Watercourse

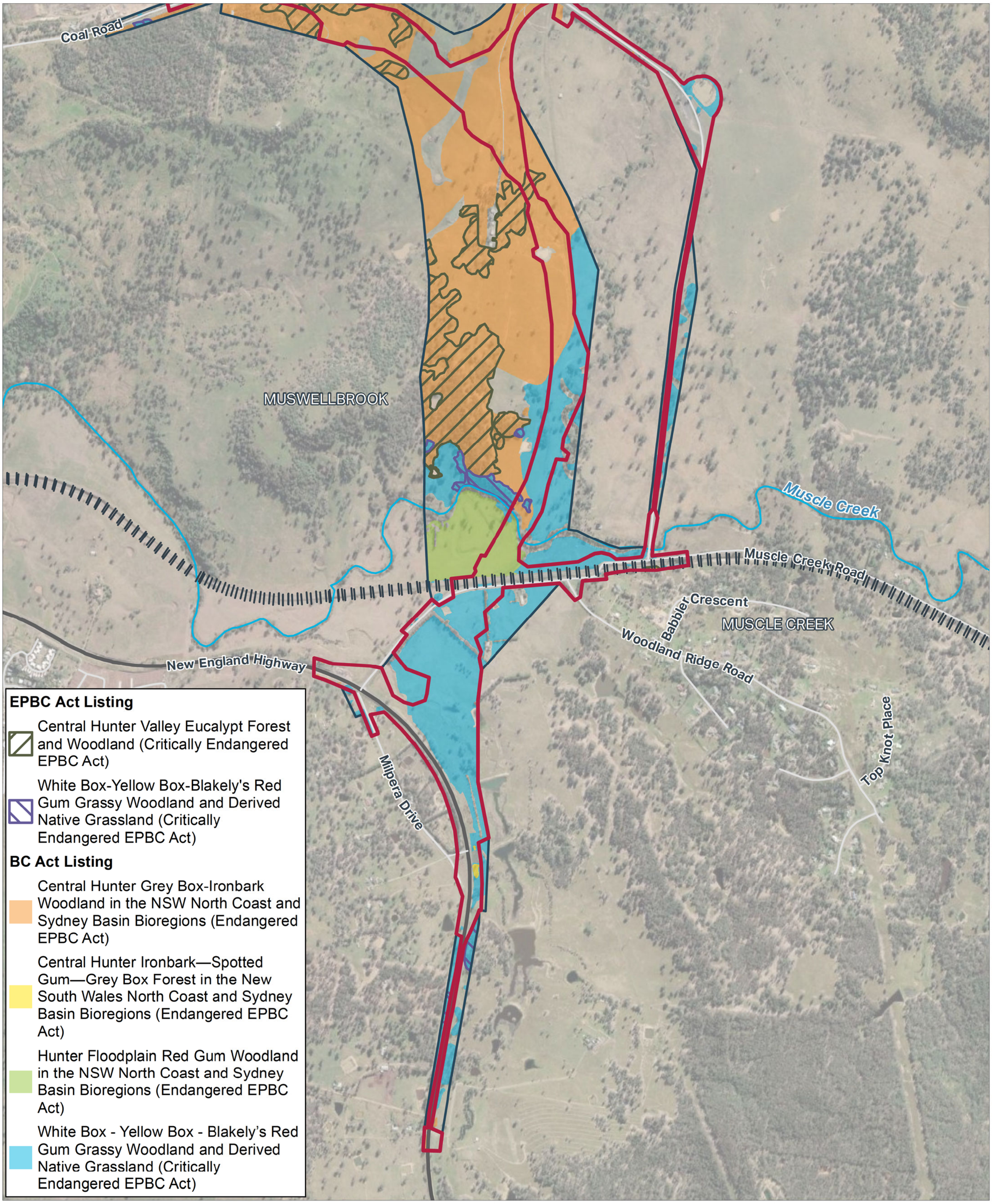


FIGURE 6-4: THREATENED ECOLOGICAL COMMUNITIES
SOUTHERN SECTION

N
0 0.5 1 km

AECOM

Legend

- Construction footprint
- Study area
- State Road
- Local Road
- Railway
- Watercourse

Groundwater dependent ecosystems

Although Muscle Creek, Sandy Creek and their tributaries have not been mapped as having groundwater dependent ecosystems (GDE) potential within the study area, they have been mapped downstream within the locality as having high GDE potential (Bureau of Meteorology, 2020). Considering this, riparian vegetation along these waterways are considered to have high GDE potential.

Based on regional studies:

- PCT 42 and PCT 485 are highly likely to be GDEs
- PCT 1604, PCT 1605, PCT 1607 and PCT 1691 have low GDE potential
- PCT 1693 is likely a terrestrial GDE which may access the water table on an intermittent basis.

An artificially modified wetland was identified bordering the northern boundary of the study area between Muscle Creek Road and the New England Highway (outside of the construction footprint). No groundwater aquifer or cave systems were identified within the study area.

Threatened species and populations

Threatened flora species

Under the BC Act, 10 listed threatened flora species were considered to have a moderate likelihood of occurrence based on the habitat available within the study area. Table 6-5 outlines these species, their conservation status and potential occurrence based on detailed targeted surveys. Threatened flora species recorded within the study area are shown on Figure 6-5.

Table 6-5: Threatened flora habitat and survey results

Scientific name	Common name	BC Act[1]	EPBC Act[2]	Potential occurrence
Acacia pendula	Weeping Myall, Boree	E2	-	Moderate
Cymbidium canaliculatum	Tiger Orchid	E2	-	Moderate
Diuris tricolor	Pine Donkey Orchid, Painted Diuris	V, E2	-	Moderate
Eucalyptus camaldulensis	River Red Gum	E2	-	Recorded
Eucalyptus glaucina	Slaty Red Gum	V	V	Moderate
Ozothamnus tesselatus	-	V	V	Moderate
Pomaderris queenslandica	Scant Pomaderris	E1	-	Moderate
Prasophyllum petilum	Tarengo Leek Orchid	E	E	Moderate
Pterostylis chaetophora	-	V	V	Moderate
Thesium australe	Austral Toadflax	V	V	Moderate

1. Vulnerable (V), Endangered (E), Endangered Population (E2), Critically Endangered (CE) as listed on the BC Act
2. Vulnerable (V), Endangered (E), Critically Endangered (CE) as listed on the EPBC Act.

One Endangered Population was recorded within the study area, being River Red Gum (*Eucalyptus camaldulensis*) which is listed as an Endangered Population in the Hunter catchment under the BC Act. A population of 12 *Eucalyptus camaldulensis* individuals were recorded.

EPBC Act listed threatened flora species are discussed below under 'Matters of National Environmental Significance'.

Threatened fauna species

Under the BC Act, 45 listed threatened fauna species were considered to have a moderate to high likelihood of occurrence based on the habitat available within the study area. Table 6-6 lists these species, their conservation status and potential occurrence based on detailed targeted fauna surveys.

Threatened fauna species recorded within the study area are shown on Figure 6-5.

Table 6-6: Threatened fauna habitat and survey results

Scientific name	Common Name	BC Act[1]	EPBC Act[2]	Potential occurrence
Birds				
Anseranas semipalmata	Magpie Goose	V	-	Moderate
Anthochaera phrygia	Regent Honeyeater	CE	CE	Moderate
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V	-	Recorded
Callocephalon fimbriatum	Gang-Gang Cockatoo	V	-	Moderate
Chthonicola sagittata	Speckled Warbler	V	-	Recorded
Circus assimilis	Spotted Harrier	V	-	Moderate
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	-	Moderate
Daphoenositta chrysoptera	Varied Sittella	V	-	Recorded
Ephippiorhynchus asiaticus	Black-necked Stork	E	-	Moderate
Falco subniger	Black Falcon	V	-	Moderate
Glossopsitta pusilla	Little Lorikeet	V	-	Recorded
Grantiella picta	Painted Honeyeater	V	V	Moderate
Haliaeetus leucogaster	White-bellied Sea-eagle	V	-	Recorded
Hieraaetus morphnoides	Little Eagle	V	-	Recorded
Lathamus discolor	Swift Parrot	CE	CE	Moderate
Lophoictinia isura	Square-tailed Kite	V	-	Moderate
Melanodryas cucullata cucullata	Hooded Robin	V	-	Moderate
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	-	Moderate
Neophema pulchella	Turquoise Parrot	V	-	Moderate
Ninox connivens	Barking Owl	V	-	Moderate
Ninox strenua	Powerful Owl	V	-	Moderate
Petroica boodang	Scarlet Robin	V	-	Moderate

Scientific name	Common Name	BC Act[1]	EPBC Act[2]	Potential occurrence
Petroica phoenicea	Flame Robin	V	-	Moderate
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-	High
Rostratula australis	Australian Painted Snipe	E	E	Moderate
Stagonopleura guttata	Diamond Firetail	V	-	Moderate
Tyto novaehollandiae novaehollandiae	Masked Owl (southern mainland)	V	-	Moderate
Mammals				
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Moderate
Dasyurus maculatus maculatus	Spotted-tailed Quoll	V	E	Moderate
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	-	High
Miniopterus australis	Little Bent-wing Bat	V	-	High
Miniopterus orianae oceanensis	Large Bent-winged Bat	V	-	High
Mormopterus norfolkensis	Eastern Coastal Free-tailed Bat	V	-	High
Myotis macropus	Southern Myotis	V	-	Recorded
Nyctophilus corbeni	Corben's Long-eared bat	V	V	Moderate
Petauroides volans	Greater Glider	-	V	Moderate
Petaurus norfolcensis	Squirrel Glider	V	-	Recorded
Phascogale tapoatafa	Brush-tailed Phascogale	V	-	Moderate
Phascolarctos cinereus	Koala	V	V	Recorded
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Recorded
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-	Moderate
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	Moderate
Vespadelus troughtoni	Eastern Cave Bat	V	-	Moderate
Reptiles				
Delma impar	Striped Legless Lizard	V	V	Recorded
Hoplocephalus bitorquatus	Pale-headed Snake	V	-	Moderate

1. Vulnerable (V), Endangered (E), Critically Endangered (CE) as listed on the BC Act
2. Vulnerable (V), Endangered (E), Critically Endangered (CE) as listed on the EPBC Act.

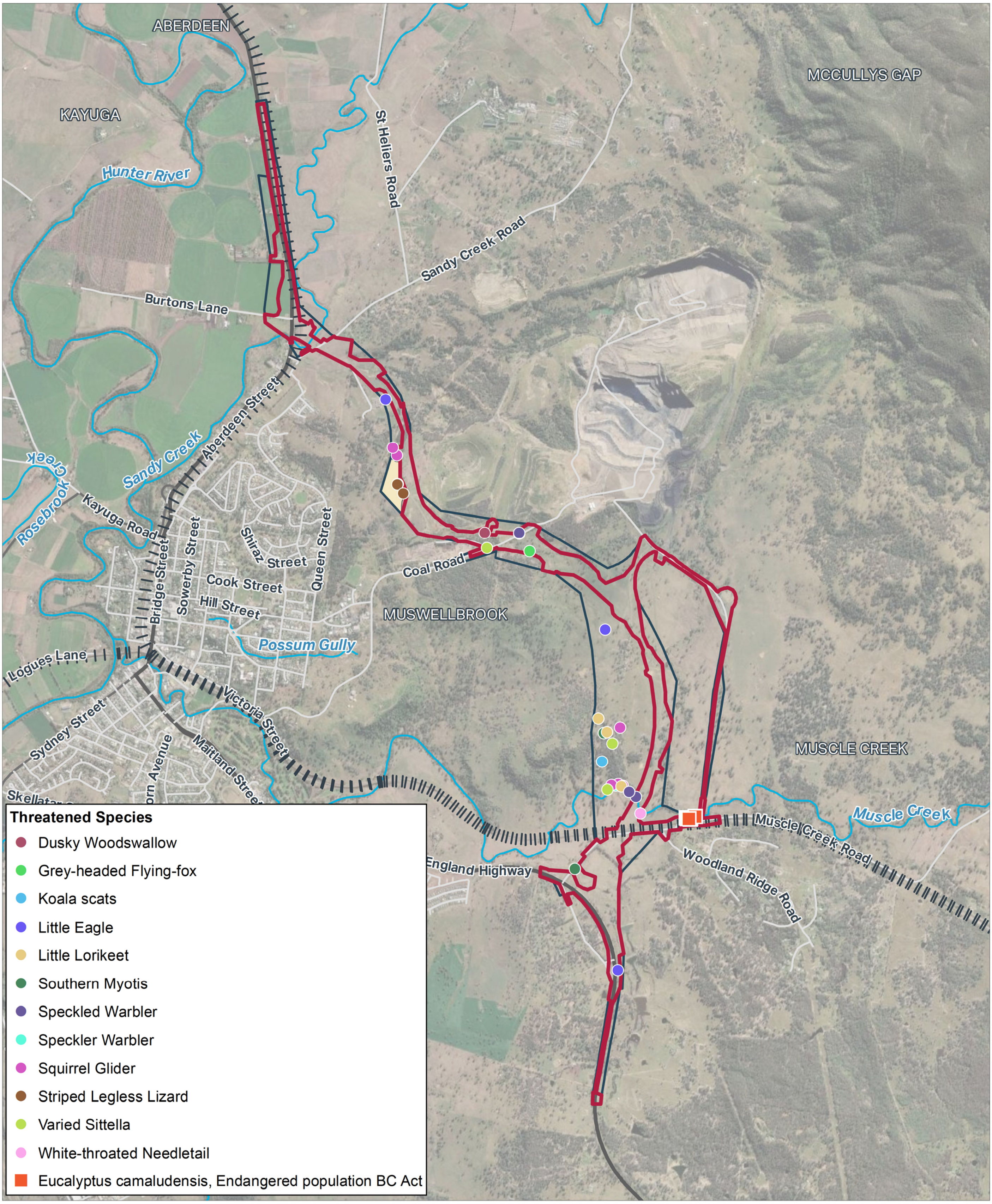


FIGURE 6-5: THREATENED FLORA AND FAUNA SPECIES

N

0 0.5 1 km

AECOM

Legend

- Construction footprint
- Study area
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse

Critical habitat

No critical habitat was found to occur within or in the locality of the study area.

Wildlife connectivity corridors

Wildlife corridors within the study area are already subject to fragmentation due to the existing road and rail infrastructure, which may already limit regular fauna movement. Similarly, most native vegetation in the locality has been historically cleared or thinned, which has also fragmented local wildlife connectivity.

The main remaining connected wildlife corridors are:

- Along Muscle Creek and associated areas
- In areas to the north and south of Coal Road
- Remnant treed areas between Sandy Creek and Coal Road.

Matters of National Environmental Significance

Threatened communities listed under the EPBC Act

The two EPBC Act listed TECs identified within the study area included:

- Central Hunter Valley eucalypt forest and woodland (Critically Endangered under EPBC Act)
- White Box - Yellow Box - Blakely’s Red Gum Grassy Woodland and Derived Native Grasslands (Critically Endangered under EPBC Act).

Threatened flora listed under the EPBC Act

Five listed threatened flora species under the EPBC Act were considered to have a moderate likelihood of occurrence based on the habitat available within the study area. Table 6-5 outlines these species. No EPBC Act listed threatened flora species were recorded within the study area during targeted surveys.

Threatened fauna listed under the EPBC Act

Eleven listed threatened fauna species were considered to have a moderate likelihood of occurrence based on the habitat available within the study area. Table 6-6 lists these species (as they are also listed under the BC Act), their conservation status and potential occurrence based on detailed targeted fauna surveys.

The other EPBC Act listed species is White-throated Needletail (*Hirundapus caudacutus*) which is not listed under the BC Act, but listed as vulnerable under the EPBC Act.

Four EPBC Act listed threatened fauna species were recorded within the study area during targeted surveys, including:

- Striped Legless Lizard (*Delma impar*)
- White-throated Needletail (*Hirundapus caudacutus*)
- Koala (*Phascolarctos cinereus*)
- Grey-headed Flying-fox (*Pteropus poliocephalus*).

Migratory species

One migratory species listed under the EPBC Act was recorded within the study area and six migratory species are considered to have a moderate likelihood of occurring within the study area as outlined in Table 6-7.

Table 6-7: Migratory fauna species recorded or with a moderate or higher likelihood of occurrence

Scientific name	Common name	BC Act[1]	EPBC Act[2]	Potential occurrence
Anthochaera phrygia	Regent Honeyeater	CE	CE, M	Moderate
Gallinago hardwickii	Latham's Snipe	-	M	Moderate
Hirundapus caudacutus	White-throated Needletail	-	V, M	Recorded
Monarcha melanopsis	Black-faced Monarch	-	M	Moderate
Myiagra cyanoleuca	Satin Flycatcher	-	M	Moderate
Rhipidura rufifrons	Rufous Fantail	-	M	Moderate
Rostratula australis	Australian Painted Snipe	E	E, M	Moderate

1. Critically Endangered (CE) as listed on the BC Act
2. Migratory (M), Critically Endangered (CE), Vulnerable (V) as listed on the EPBC Act

Wetlands of international importance

Databases searches revealed one wetland of international importance within proximity to the study area, being The Hunter Estuary Wetlands. This wetland is located about 50 to 100 kilometres downstream from the study area. The study area does not contain waterways that are connected to the above wetland of international importance and therefore the proposal is considered unlikely to impact upon these wetlands.

World or national heritage

Databases searches revealed one national heritage place within 10 kilometres of the study area, being the Muswellbrook Post Office. This national heritage place is not located within the study area and is therefore unlikely to be impacted by the proposal.

Priority weeds

Of the 138 exotic species recorded, 10 are listed as Priority Weeds under the NSW Biosecurity Act 2015 (Biosecurity Act) for the Greater Hunter Local Land Service region and seven are listed Weeds of National Significance (WONS). Weeds of concern are identified in Table 6-8.

Table 6-8: Weeds of concern recorded within the study area

Scientific name	Common name	Priority weed duty	WONS
Lycium ferocissimum	African bothorn	<u>Prohibition on dealings</u> Must not be imported into the state or sold.	Yes
Tamarix aphylla	Athel pine		Yes
Senecio madagascariensis	Fireweed		Yes
Opuntia stricta	Prickly Pear		Yes
Salix sp.	Willow		Yes

Scientific name	Common name	Priority weed duty	WONS
Bryophyllum x hoghtonii	-	Regional recommended measure Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. The plant should not be bought, sold, grown, carried or released into the environment. Land managers reduce impacts from the plant on priority assets	-
Echium plantagineum	Paterson's curse		-
Hyparrhenia hirta	Coolatai grass		-
Opuntia aurantiaca	Tiger Pear	Prohibition on dealings Must not be imported into the state or sold	Yes
Rubus fruticosus species aggregate	Blackberry	Regional recommended measure Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. The plant should not be bought, sold, grown, carried or released into the environment. Land managers reduce impacts from the plant on priority assets	Yes

6.1.3 Potential impacts

Construction

Removal of native vegetation

It is estimated that up to 97.92 hectares of native vegetation would require removal. Of this, 75.66 hectares is comprised of DNG and 22.26 hectares consists of remnant vegetation (refer to Table 6-3).

The proposal would also result in the removal of 90.17 hectares of the non-native miscellaneous ecosystems identified in Table 6-4.

Removal of threatened flora

There would be no direct impacts on threatened flora species listed under the BC Act or the EPBC Act. All direct impacts to the River Red Gum (*Eucalyptus camaldulensis*) Endangered Population have also been avoided through design.

Removal of threatened fauna habitat

Vegetation requiring removal provides suitable habitat and habitat features for a range of threatened fauna species listed under the BC Act and/or EPBC Act. As such, direct impacts to habitat for threatened fauna species would occur during construction. The direct impacts of the proposal on threatened fauna habitat has been estimated based on a worst-case scenario (i.e. removal of all vegetation within the construction footprint) (refer to Appendix A for breakdown of direct impacts).

Aquatic impacts

The proposal has potential to have minor impacts to Type 1 (highly sensitive key fish habitat - Muscle Creek) and Type 3 (minimally sensitive key fish habitat - Sandy Creek). Impacts on both Sandy Creek and

Muscle Creek would include construction of bridges over the waterways. Specific impacts which may arise from the construction of the bridges could include:

- Alterations to hydrology of the immediate area via the construction of drainage designed to convey flows towards catchments, culverts and containment basins
- Direct impacts on substrate and groundcover vegetation which may induce sedimentation, erosion and edge effects
- Long-term shading of waterway
- Aquatic vegetation and microhabitat (such as snags, river pebbles etc.) removal.

Invasion and spread of weeds

The spread of weed and pest species is likely to occur during construction as an indirect impact of the proposal. Impacts would be greatest during vegetation clearing with the most likely causes of weed dispersal and importation being associated with earthworks, movement of soil, and attachment of seed (and other propagules) to vehicles and machinery.

Managing the spread of weed species is particularly important in areas immediately adjacent to Striped Legless Lizard habitat towards the north of the construction footprint. Although currently exposed to weed incursion edge effects, the results of the field investigations identified that the species did not occur in nearby areas dominated by exotic grasses (i.e. within areas of mine rehabilitation).

Invasion and spread of pests

The study area provides habitat for a range of commonly occurring pest species and the proposal has the potential to disperse pest species out of the construction footprint across the surrounding landscape, however the magnitude of this impact would be low and mitigation measures are not deemed necessary.

Invasion and spread of pathogens and disease

The following pathogens are considered to have potential to affect biodiversity within the construction footprint:

- Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*)
- Exotic Rust Fungi (order *Pucciniales*, e.g. Myrtle rust fungus *Uredo rangelii*)
- Phytophthora Root Rot Fungus (*Phytophthora cinnamomi*).

The construction and operation of the proposal may increase the risk of disturbing and spreading these pathogens. With the implementation of appropriate mitigation measures, the risk of introducing these pathogens would be low.

Changes to hydrology

The study area’s natural soil infiltration features and properties has been used as a drainage design philosophy to minimise impacts associated with hydrology, however the proposal would result in further alteration to hydrology due to an increase in surface runoff.

Groundwater dependent ecosystems

The proposal has potential to directly and indirectly interfere with subsurface and/or groundwater flows associated with the GDEs identified within the study area. These impacts would be largely associated with construction activities within proximity to Muscle Creek, Sandy Creek and their tributaries. The proposal also has potential to indirectly impact the wetland identified north of the construction footprint via changes to hydrology and sedimentation.

Noise, light and vibration

There is potential for impacts to fauna from noise and vibration during construction, however these species would already be impacted from existing traffic noise, therefore the magnitude of this impact would be low and specific mitigation measures are not deemed necessary.

Injury and mortality

Injury and mortality of fauna could occur during construction activities, when:

- Vegetation and habitat are being cleared and when trenches are dug
- Machinery and plant are moved to, from and on site.

Operation

Alteration to wildlife connectivity and habitat fragmentation

The proposal would fragment habitat, as it would create a new linear barrier through the landscape and would also result in an increase in isolation of habitats by increasing physical distance between some habitat fragments. This is unlikely to have a substantial impact on nomadic or migratory species, however is likely to be detrimental to the dispersal of arboreal mammals and other species. These effects however would only be marginally greater than that which is already experienced.

The proposal would not completely prevent fauna movement between habitat fragments as no impassable barriers such as solid concrete median barriers would be constructed.

The predicted level of isolation is not likely to be enough to prevent the breeding and dispersal of plant pollinators or the dispersal of plant propagules (i.e. seed or other vegetative reproductive material) between habitat patches.

Edge effects on adjacent native vegetation and habitat

The proposal would likely introduce new edge effects and incrementally increase existing edge effects within the study area. However, given the highly modified nature of large areas which would be impacted, this increase is likely to be of low magnitude.

Noise, light and vibration

Even though noise and vibration levels would increase during operation of the proposal, biodiversity are unlikely to be significantly affected given the existing levels of noise and vibration from the surrounding land uses (i.e. mine activities, existing roads and road traffic, existing rail corridors).

New roadway lighting or adjustments to existing lighting would be provided as part of the proposal. Lighting throughout the evening/night associated with the operational phase of the proposal may result in impacts on nocturnal fauna. The magnitude of this impact would be low and mitigation measures are not deemed necessary. Additionally, there are species which forage on insects attracted to lights, thereby lighting as part of the proposal may benefit some species.

Injury and mortality

Injury and mortality of fauna could occur when the road is operational (i.e. roadkill). As there is no definitive data on current rates of roadkill or fauna population densities in the study area, the consequences of vehicle strike on local populations of fauna is relatively unknown.

Summary of potential impacts

A summary of the potential impacts is presented in Table 6-9.

Table 6-9: Summary of potential biodiversity impacts

Impact	Biodiversity values	Nature of impact	Extent of impact	Duration
Removal of native vegetation (including TECs)	All native vegetation	Direct	Up to 97.92 ha including 22.6 ha of remnant and 75.66 ha of DNG	Long term
Removal of fauna habitat and habitat features	Threatened fauna species	Direct	Up to 97.92 ha including 42 HBTs	Long term
Aquatic impacts	Muscle Creek, Sandy Creek and their unnamed tributaries	Direct / Indirect	Site based	Short term
Injury and mortality of fauna	Less mobile or sedentary fauna	Direct	Site based	Short term / Long term
Wildlife connectivity and habitat fragmentation	Less mobile or sedentary fauna	Direct / Indirect	Local	Long term
Edge effects on adjacent native vegetation and habitat	All areas of native vegetation adjacent to the construction footprint	Indirect	Local	Long term
Invasion and spread of weeds	All areas of native vegetation and areas of Striped Legless Lizard habitat	Indirect	Local / Regional	Long term
Invasion and spread of pests	All flora and fauna species and habitat	Indirect	Local / Regional	Long term
Invasion and spread of pathogens and disease	All flora and fauna species and habitat	Indirect	Local / Regional	Long term
GDEs	All native vegetation	Indirect	Local	Long term
Changes to hydrology	All native vegetation	Direct / Indirect	Local	Long term
Noise, light and vibration	All fauna species	Direct / Indirect	Local	Short term / Long-term

Conclusion on significance of impacts

The proposal is not likely to significantly impact threatened species or ecological communities or their habitats, within the meaning of the BC Act or FM Act and therefore a SIS or BDAR is not required.

The proposal is not likely to significantly impact threatened species, ecological communities or migratory species, within the meaning of the EPBC Act.

6.1.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Biodiversity	A Flora and Fauna Management Plan (FFMP) will be prepared in accordance with Transport for NSW's *Biodiversity Guidelines: Protecting and Managing Biodiversity on Projects* (RMS, 2011) and implemented as part of the CEMP. The FFMP will include, but not be limited to: • Plans showing areas to be cleared and areas to be protected, including exclusion zones, protected habitat features and revegetation areas • Requirements set out in the *Landscape Guideline* (RMS, 2008) • Pre-clearing survey requirements • Procedures for unexpected threatened species finds and fauna handling • Procedures addressing relevant matters specified in the *Policy and guidelines for fish habitat conservation and management* (DPI Fisheries, 2013) • Protocols to manage weeds and pathogens	Construction contractor	Detailed design / pre-construction	Additional safeguard
Biodiversity	Measures to further avoid and minimise the construction footprint and native vegetation or habitat removal will be investigated during detailed design and implemented where practicable and feasible	Construction contractor	Detailed design / pre-construction	Additional safeguard
Removal of native vegetation	Native vegetation removal will be minimised through detailed design	Transport	Detailed design	Additional safeguard
Removal of native vegetation	Native vegetation removal will be minimised via selective placement of temporary ancillary facilities i.e. preference is to avoid areas of higher biodiversity value and to select areas already subject to disturbance	Construction contractor	Pre-construction and construction	Additional safeguard
Removal of native vegetation	Pre-clearing surveys will be undertaken in accordance with Guide 1: Pre-clearing process of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Pre-construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
Removal of native vegetation	Exclusion zones will be set up at the limit of clearing or where areas containing pathogens or disease are identified in accordance with Guide 2: Exclusion zones of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction	Additional safeguard
Removal of native vegetation	Vegetation removal will be undertaken in accordance with Guide 4: Clearing of vegetation and removal of bushrock of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction	Additional safeguard
Removal of native vegetation	Native vegetation will be re-established (particularly along new road verge within proximity to known Striped Legless Lizard habitat) in accordance with Guide 3: Re-establishment of native vegetation of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011) to minimise weed encroachment (in particular perennial grass species)	Construction contractor	Construction and post construction	Additional safeguard
Removal of native vegetation	The unexpected species find procedure is to be followed under Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011) if threatened entities, not assessed in the biodiversity assessment, are identified in the construction footprint	Construction contractor	Construction	Additional safeguard
Removal of threatened species habitat and habitat features	Habitat will be replaced or re-instated in accordance with Guide 5: Re-use of woody debris and bushrock and Guide 8: Nest boxes of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction	Additional safeguard
Removal of threatened species habitat and habitat features	Site personnel working within proximity of Striped Legless Lizard habitat will be provided with an information sheet and/or induction. An exclusion zone will be set up around known Striped Legless Lizard habitat during construction in accordance with Guide 2: Exclusion zones of the Biodiversity Guidelines: Protecting and managing	Construction contractor	Pre-construction and construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	biodiversity on RTA projects (Roads and maritime Authority, 2011)			
Removal of threatened species habitat and habitat features	A nest box strategy will be developed in accordance with Guide 8: Nest boxes of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011). The nest box strategy will primarily target the replacement of hollow resources being removed by the proposal on the Squirrel Glider. Final hollow resource impacts and subsequent nest boxes required will be informed by the tree clearing program	Construction contractor	Pre-construction	Additional safeguard
Aquatic impacts	Aquatic habitat will be protected in accordance with Guide 10: Aquatic habitats and riparian zones of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011) and Section 3.3.2 Standard precautions and mitigation measures of the Policy and guidelines for fish habitat conservation and management Update 2013 (Department of Primary Industries, 2013)	Construction contractor	Construction	Additional safeguard
Injury and mortality of fauna and fragmentation of identified habitat corridors	Fauna will be managed in accordance with Guide 9: Fauna handling of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction	Additional safeguard
Injury and mortality of fauna and fragmentation of identified habitat corridors	Road-kill and connectivity impacts will be minimised via: • installation of one aerial fauna crossing structure to retain fauna connectivity in the vicinity of where Squirrel Gliders have been recorded. The final location, design and type of structure will be determined during detailed design • Construction of a bridge over Muscle Creek to provide underpass fauna crossing for terrestrial fauna species such as the Koala • Consideration of fauna exclusion fencing in areas where fauna crossing structures are proposed for example near Muscle Creek	Construction contractor	Detailed design, construction and post construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	and/or near known habitat for Striped Legless Lizard • Installation of 'Koala Warning Signs' or 'Injured Native Wildlife Signs' in areas of potential wildlife conflict areas or crossing points			
Invasion and spread of weeds	Priority weed species will be managed in accordance with Guide 6: Weed management of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction	Additional safeguard
Invasion and spread of pests	Pest species will be managed within the construction footprint	Construction contractor	Construction	Additional safeguard
Invasion and spread of pathogens and disease	Hygiene procedures will be implemented for the use of vehicles and the importation of materials to the proposal footprint in accordance with Guide 7: Pathogen management of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction	Additional safeguard
Groundwater dependant ecosystems	Interruptions to water flows associated with GDEs will be minimised through detailed design	Transport	Detailed design	Additional safeguard
Habitat removal	A Biodiversity Offset Strategy will be prepared for the proposal in accordance with Guidelines for Biodiversity Offsets (Roads and Maritime Services, 2016)	Construction contractor	Pre-construction	Additional safeguard

6.1.5 Biodiversity offsets

Transport's Guideline for Biodiversity Offsets (Roads and Maritime, 2016) requires consideration of biodiversity offsets (or where offsets are not reasonable or feasible, supplementary measures) where impacts exceed predetermined thresholds, as detailed in Table 6-10.

Table 6-10: Offsetting thresholds for REFs (Roads and Maritime 2016)

Description of Activity or Impact	Consider Offsets of Supplementary Measures
Works involving clearing of national or NSW listed critically endangered ecological communities (CEEC)	Where there is any clearing of a CEEC in moderate to good condition

Description of Activity or Impact	Consider Offsets of Supplementary Measures
Works involving clearing of nationally listed threatened ecological community (TEC) or nationally listed threatened species habitat	Where clearing greater than one hectare of a TEC or habitat in moderate to good condition
Works involving clearing of NSW endangered or vulnerable ecological community	Where clearing greater than five hectares or where the ecological community is subject to an SIS
Works involving clearing of NSW listed threatened species habitat where the species is a species credit species as defined in the EES's Threatened Species Profile Database	Where clearing greater than one hectare or where the species is the subject of an SIS
Works involving clearing of NSW listed threatened species habitat and the species is an ecosystem credit species as defined in EES's Threatened Species Profile Database	Where clearing greater than five hectares or where the species is the subject of an SIS
Type 1 or Type 2 key fish habitats (as defined by NSW Fisheries)	Where there is any net loss of habitat

The proposal triggers the offsetting thresholds for the following matters:

- Clearing of 22.96 hectares of White box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland CEEC in moderate to good condition
- Clearing of 55.24 hectares of Central Hunter Valley Grey Box – Ironbark Woodland TEC in moderate to good condition (at least 28.72 hectares consistent with EPBC Act listing for Central Hunter Valley eucalypt forest and woodland)
- Clearing of 66.78 hectares of habitat for Barking Owl, Powerful Owl, Masked Owl, Spotted Harrier, Black Falcon, Little Eagle, Square-tailed Kite, Black-chinned Honeyeater, Swift Parrot, Regent Honeyeater, Little Lorikeet, Painted Honeyeater, Brown Treecreeper, Dusky Woodswallow, Diamond Firetail, Flame Robin, Scarlet Robin, Grey-crowned Babbler (eastern subspecies), Hooded Robin, Speckled Warbler, Turquoise Parrot, Varied Sittella, Gang-Gang Cockatoo, Corben's Long-eared Bat, Eastern Cave Bat, Eastern Coastal Freetail Bat, Eastern False Pipistrelle, Greater Broad-nosed Bat, Large-eared Pied-bat, Large Bent-winged Bat, Little Bent-wing Bat, Yellow-bellied Sheathtail-bat, Grey-headed Flying-fox, Koala, Spotted-tailed Quoll, White-bellied Sea-eagle and White-throated Needletail.
- Clearing of 36.81 hectares of habitat for Southern Myotis
- Clearing of 0.16 hectares of Type 1 key fish habitat.

A Biodiversity Offset Strategy would be considered to identify biodiversity credits and/or supplementary measures for those entities impacted.

6.2 Surface water, hydrology and flooding

A Surface and Groundwater Assessment was prepared by AECOM (2021) for the proposal (refer to Appendix I). A Flood Risk Assessment was also undertaken by BMT Commercial Australia Pty Ltd (2021) (refer to Appendix E). Surface water, hydrology and flooding aspects are outlined in this chapter and groundwater aspects covered in Section 6.3.

6.2.1 Methodology

Surface water quality

The surface water assessment adopted the following methodology:

- Review available water quality, flooding data and existing conditions to obtain background information on catchment history and land use and define the existing environment
- Review the legislative context within which the proposal sits and relevant guidelines
- Define the area that influences the surface water environment
- Review existing flood conditions and design flood simulations
- Identify potential impacts of construction and operational activities and potential cumulative impacts on water quality with reference to the ANZECC/ARMCANZ (2000) water quality guidelines for protection of relevant environmental values
- Nominate water quality treatment measures to mitigate the impact of construction on water quality, following the principles of the Managing Urban Stormwater: Soils and Construction, Volume 1 (Landcom 2004) and Volume 2D (DECC 2008)
- Identify water quality treatment measures to mitigate the impact of the operation of the proposal on water quality following the principles set out in Procedure for Selecting Treatment Strategies to Control Road Runoff (RTA 2003) and Transport's Water Policy (RTA 1997)
- Nominate additional measures to manage potential cumulative impacts resulting from the proposal
- Provide a consolidated list of measures to be applied during the construction and operational phase to mitigate potential impacts to surface water.

An accidental spills assessment was undertaken to identify potential spills that may result in impacts to water quality within the receiving environment as a result of the proposal and assess if an incident could be managed appropriately with standard emergency response procedures, or if additional control measures are required.

The potential for accidental spills exists for both construction and operation phases. Potential spills during construction would be managed by the CEMP, and therefore are not discussed further.

To determine baseline water quality impacts associated with the proposal, a water quality monitoring plan (WQMP) was developed and initiated in July 2020. The objective of the WQMP was to establish the baseline water quality conditions of watercourses that could potentially be impacted by the proposal. Monthly sampling was carried out at 15 sampling points located along the Hunter River and its associated tributaries.

The initial water quality information gathered prior to construction would be used as baseline conditions when applying for an EPL.

Flooding

A flood risk assessment was undertaken to establish pre- and post- bypass flood conditions for the proposal and identify associated potential flood impacts.

Potential flood impacts that were considered included:

- Changes in peak flood level
- Changes in peak flood velocity
- Scour potential associated with proposed infrastructure.

Hydrologic and hydraulic models were developed for the proposal to determine design floods for annual exceedance probabilities (AEPs) for the 20 per cent (one in five AEP), five per cent (one in 20 AEP), two per cent (one in 50 AEP), one per cent (one in 100 AEP), 0.5 per cent (one in 200 AEP), 0.2 per cent (one in 500 AEP) and the 0.05 per cent AEP (one in 2000 AEP). The hydraulic models were developed for the

Sandy Creek and Muscle Creek catchments but also allowed for backwater flooding from the Hunter River. The Probable Maximum Flood (PMF) was also modelled to represent an estimated upper limit of flood magnitude.

Study area

The study area for the surface water assessment is broadly defined by the area depicted in Figure 6-6, comprising the contributing catchments associated with Sandy Creek and Muscle Creek as well as the proposed road corridor.

The study area for the flooding assessment includes the township of Muswellbrook and the floodplain of the Hunter River including its tributaries Sandy Creek and Muscle Creek.

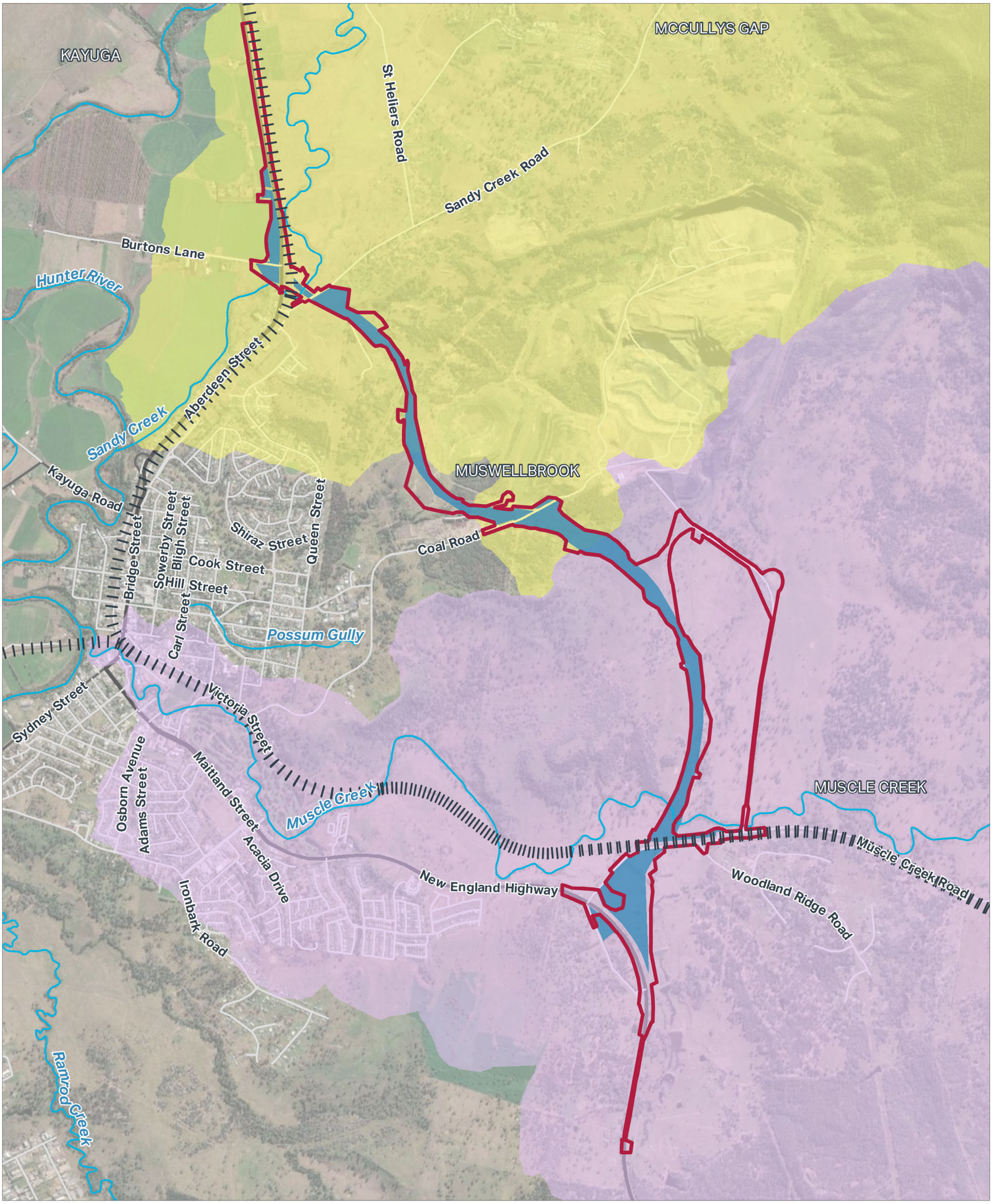


FIGURE 6-6: WATERCOURSES AND THEIR CATCHMENTS AROUND THE PROPOSAL

AECOM

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse
- Sandy Creek catchment
- Muscle Creek catchment

N

0 0.5 1 km

6.2.2 Existing environment

Hydrology

The Hunter River rises on the western slopes of the Mount Royal Range, part of the Great Dividing Range, east of Murrurundi, and flows generally south-west and then south-east before flowing into the Pacific Ocean at Newcastle. The contributing catchment of the Hunter River upstream of the proposal, referred to as the Upper Hunter catchment, covers about 4,220 square kilometres. Lake Glenbawn is located about 37 kilometres upstream of the town of Muswellbrook. The Upper Hunter Catchment can be split into three broad catchments:

- Dart Brook (incorporating Middle Brook)
- Isis River (incorporating Pages River)
- Hunter River.

The Hunter River is located to the west of Muswellbrook. The western bank of the Hunter River comprises predominantly agricultural land use. Along the reach adjacent to Muswellbrook, the Hunter River flows in a southerly/south westerly direction.

The proposed road corridor traverses a number of watercourses associated with Sandy Creek and Muscle Creek which confluence with the Hunter River shown on Figure 6-6. The proposal is located to the east of the Hunter River and, at its closest point, is about 650 metres away. The Sandy Creek catchment drains an area of about 162 square kilometres whilst the Muscle Creek catchment covers an area of about 93 square kilometres. Land use within both the Sandy Creek and Muscle Creek catchments is typically grazing or farmland, with a small portion of urbanised land in the lower reaches associated with the town of Muswellbrook.

Surface water quality

Upstream of the proposal, land use that could potentially impact water quality within the Hunter River predominantly comprises agriculture and localised mining activities.

The report card for the Muswellbrook water source (NSW Department of Water and Energy, August 2009) states that:

- There is low economic dependence of the local community on water extracted for irrigation
- Instream values are at medium risk of being impacted by extractions within the water source
- There is low relative instream value (within catchment) given:
  - The presence of one threatened bird species and one endangered ecological community
  - Platypus have been identified
  - Moderate fish community integrity
- The ecology value for invertebrates is deemed to be moderate.

In order to determine the most appropriate level of protection[1] and guideline values for physical and chemical stressors (including toxicants), the ecosystem condition category of the surface water receiving environment has been assessed according to the categories outlined in the *Australian and New Zealand Water Quality Guidelines for Fresh and Marine Water Quality* (ANZG 2018) and using information from the Biodiversity Assessment Report (WSP Australia 2021) (refer to Appendix A).

[1] Defined in ANZG (2018) as "*the degree of protection afforded to a water body based on its ecosystem condition (current or desired health status of an ecosystem relative to the degree of human disturbance).*"

Whilst the surface water environment sits within some highly modified landscapes with relatively low value in terms of supporting aquatic ecosystems, some higher value areas exist. For this reason, a precautionary approach has been adopted and the ecosystem condition category is assumed to fall into the ‘slightly to moderately disturbed’ category. Refer to Table 3-4 in Appendix I which outlines the ecosystem condition categories and associated attributes.

The baseline water quality results obtained from the July to December 2020 monthly sampling events carried out by Transport are summarised as follows:

Hunter River

- Surface water quality conditions indicate that water within the Hunter River are slightly to moderately turbid
- Geochemical conditions of the Hunter River suggest slightly alkaline freshwater conditions with an average electrical conductivity of 542 μS/cm and pH ranging from 7.80 to 8.07
- Analysis of heavy metals reported concentrations for arsenic, chromium lead (total only) nickel and zinc to be present within the Hunter River with concentrations of copper, lead (total) and zinc reported slightly above the adopted screening criteria. Where concentrations of heavy metals were reported, there was little, or no variance observed between the upstream and downstream concentrations along the associated river reach. As such sampling of heavy metals within Sandy and Muscle Creek was not considered critical (i.e. tributaries not significantly contributing to heavy metal concentrations within the Hunter River).

Muscle Creek

- Surface water quality conditions within Muscle Creek suggest that these contributing catchment waters are slightly turbid
- Geochemical conditions observed upstream of the confluence with the Hunter River suggest fairly pH neutral, slightly saline water conditions with an average electrical conductivity of 1,293 μS/cm and pH of 7.48
- No inorganic sampling was undertaken at this location as the metal concentrations between the upstream and downstream sampling points within the Hunter River remain largely unchanged.

Sandy Creek

- Surface water quality conditions within Sandy Creek suggest that these contributing catchment waters are slightly turbid
- Geochemical conditions observed upstream of the confluence with the Hunter River suggest fairly pH neutral, slightly saline water conditions with an average electrical conductivity of 1,135 μS/cm and pH of 7.58.

Flooding

Sandy Creek and the Hunter River

Flood events under existing conditions at the northern connection may be affected by flooding from Sandy Creek and/or the Hunter River. Both local (Sandy Creek dominated) and regional (Hunter River dominated) events have been considered in the Flood Risk Assessment (BMT 2021) (refer to Appendix E).

Sandy Creek passes below the Main North railway line and New England Highway bridges before entering the Hunter River to the southwest. During flood events up to the five per cent AEP, the local roads, highway and railway at the northern connection are not impacted by flood waters, apart from Burtons Lane. Elsewhere, properties in the Sandy Creek and Hunter River floodplains are impacted largely due to Hunter River backwater effects.

However, flood events larger than five per cent AEP result in the intersection of Sandy Creek and the New England Highway being submerged, along with the New England Highway north of Burtons Lane, Burtons Lane and Koolbury Flats Row. Extensive flooding of properties also occurs within the Sandy Creek and Hunter River catchments. The Flood Risk Assessment (BMT 2021) in Appendix E provides more information regarding existing flood conditions at the northern connection.

Muscle Creek

At Muscle Creek, near the southern connection, flood waters are largely contained within the existing channel up to a 0.05 per cent AEP event. During this event, the roads, highway and Main North railway line are not directly impacted by floodwater, however minor impacts to grass paddocks are experienced at properties adjacent to Muscle Creek and tributaries of Muscle Creek. Refer to the Flood Risk Assessment (BMT 2021) (refer to Appendix E) for more information regarding existing flood conditions near the southern connection.

6.2.3 Potential impacts

Construction

Surface water quality

Construction activities represent a risk to surface water quality within the Hunter River, Sandy Creek and Muscle Creek. During runoff events or flood conditions, sediment laden waters, chemicals stored on site, and construction waste have the potential to mobilise and enter waterways.

Generation of sediment laden waters and offsite discharge can occur during construction activities such as:

- Clearing and grubbing
- Stockpiling of materials
- General earthworks
- Temporary works (i.e. access roads, compounds, laydown areas and pads)
- Construction of bridge piers and abutments in and adjacent to the Hunter River
- Instream drainage works
- Placement of fill for embankments.

Sediment laden waters pose a potential risk to downstream surface water quality. Water quality impacts include (but are not limited to) increased turbidity and elevated concentrations of nutrients and other pollutants, such as heavy metals and organic chemicals.

Other potential sources that may impact surface water quality during construction include:

- Fuel or oils used by construction plant and equipment
- Concrete batching plant and associated concrete wastes
- Waste and litter from building activities and personnel
- Release of nutrients from fertilisers, herbicides and pesticides (e.g. used in site landscaping)
- Paint and paint wastes
- Acids from acid-based washes
- Disturbance of contaminated soils and/or acid sulfate soils, which may adversely affect water chemistry including pH and dissolved solids.

The potential impacts to water quality during construction of the bypass were qualified according to the water quality indicators provided in Section 3.5.2 of Appendix I. A description of the potential impact associated with the proposed construction phase activities and expected likelihood of the impact is provided in Table 6-11.

Table 6-11: Assessment of the impact on key water quality indicators

Key indicator	Likelihood of impact
Chlorophyll-a	Chlorophyll-a is not expected to be present in site runoff as a result of construction activities. **Negligible** impact
Total Phosphorus (TP) and Total Nitrogen (TN)	Mobilisation of topsoil in runoff during construction has potential to cause an increase of both TP and TN in receiving waters. Whilst elevated TP and TN has the potential to cause harm, with the implementation of appropriate management measures and safeguards, the risk is considered **low**
Dissolved Oxygen (DO)	No substantial change is expected in DO concentrations from construction site runoff or sediment basin discharges. Direct impacts are therefore considered **low** Indirectly, a reduction in DO concentrations downstream could occur if site runoff presents elevated levels of nutrients (TN and TP) or total suspended sediments (TSS). However, with the implementation of appropriate management measures and safeguards, the risk is considered **low**
pH	Based on the geological properties and soil landscape of the study area, preliminary sampling and available monitoring data which indicates generally more alkaline pH levels in water, there is a low probability of encountering potential acid sulfate soils which can release acid if disturbed. Therefore, the construction activities have a **low** likelihood of impacting pH of receiving waters
Electrical Conductivity (EC)	The EC of surface water from construction activities is likely to be consistent with the range of salinity historically observed in the Hunter River. Therefore, the construction activities have a **low** likelihood of impacting EC of receiving waters
Turbidity	Construction activities have the potential to increase turbidity and TSS in local waterways through the exposure of topsoils and subsoils. Whilst elevated turbidity and TSS has the potential to cause harm, with the implementation of appropriate management measures and safeguards, the risk is considered **low**
Temperature	Temperature of stormwater runoff or discharge from sediment basins would be similar to that in nearby waterways. Hence, potential impact of temperature changes from site runoff or releases of sediment basin discharges is considered to be **negligible**
Chemical contaminants	There is potential for chemical contamination from spills or other sources associated with construction activities. Whilst contamination in surface waters has the potential to cause harm, with the implementation of appropriate management measures and safeguards, the risk associated is considered **low**
Faecal coliforms	There is a **low** likelihood of environmental impact due to faecal coliforms in surface water from construction activities
Algae and blue green algae	Elevated temperature and nutrients (TN and TP) have the potential to contribute to algal blooms in the receiving waters downstream. This increased likelihood is considered small when comparing the contributing catchment size with the size of the Upper Hunter River catchment, as well as taking into consideration contributing land uses (i.e. agriculture, urban development)

Key indicator	Likelihood of impact
	Given the proposed management measures and safeguards, the risk of this potential impact is considered **low**
Visual clarity and colour	This indicator is largely assessed above in relation to turbidity and TSS. There is limited baseline information on the natural visual clarity, hue and reflectivity of the receiving environments to determine whether there is likely to be a predicted change in the nominated indicator Given the proposed management measures and safeguards, there is a **low** likelihood of adverse impact on this environmental value
Enterococci	There is a very **low** likelihood of environmental impact due to enterococci in surface water from construction activities
Protozoans	There is a very **low** likelihood of environmental impact due to protozoans in surface water from construction activities

The potential for accidental spills (e.g. chemicals or fuels) during construction would be managed within the CEMP developed for the construction phase of the proposal. For spill management during construction activities, the CEMP should consider the following, amongst others:

- Principal sources that may result in chemical spills during construction activities
- Location of sources in relation to environmentally sensitive areas (e.g. watercourses)
- The probability of potential spills
- Construction stormwater management measures and associated drainage
- Bunding requirements and temporary drainage basins at points of discharge associated with the proposal.

Flooding

The construction of a road embankment across a floodplain and the bridging of watercourses can potentially increase flood levels, redistribute flows, increase inundation times and increase velocities. Potential impacts associated with flooding could occur where construction activities are located within the flood affected zones. If inundated during a flood, material, fuel, chemicals and equipment stored in stockpile and compound sites could wash away. This could impact the surrounding environment, particularly adjacent waterbodies. Compounds and stockpiles could also affect flood flow paths, if inappropriately located.

Flood behaviour of the study area is well understood, with adequate advance flood warning likely to be available to enable the removal of staff and equipment and protection of the works prior to inundation.

Ancillary facilities such as construction compounds, laydown areas and stockpiles would be located outside of areas where they would have the potential to impact on major natural flow paths or exacerbate flood conditions.

Mitigation measures would be included in the CEMP as outlined in Section 6.2.4.

Operation

Surface water quality

A potential impact to surface water quality during the operation of the proposal would be from pollutants and contaminants from the surface of the road being conveyed during runoff events to receiving waters.

Contaminants could include litter, sediment and suspended solids, nutrients, heavy metals, toxic organics, oils and surfactants. Potential sources include:

- Exhaust particles from vehicle engines
- Wear products from brakes, tyres and other mechanical parts
- Minor discharges from vehicle engines, including fluids, lubricants and other similar materials
- Minor discharges from leaking or damaged loads
- Litter or other waste
- Loss of goods and other materials due to vehicle incidents and accidents.

The principal source of accidental spills during operation would be from the transport of chemicals and could occur following a crash. However, the probability of potential spills is considered low because:

- The bypass provides a higher standard of road design when compared to the existing road
- The proposal is considered to reduce the potential risk of traffic incidents occurring and therefore associated spill incidents
- Legislative controls on the transport of dangerous goods require that safeguards are installed on vehicles transporting hazardous liquids to avoid spillage.

Whilst the likelihood of a chemical spill is low, if an incident occurred there would be potential for environmental harm.

Should a spill occur away from Muscle Creek and Sandy Creek, there would be sufficient time and storage for the spill to be contained and treated through standard emergency response procedures. Therefore, the spill would be unlikely to reach Muscle Creek and Sandy Creek and subsequently the Hunter River. However, if a spill occurred in the sections spanning Muscle Creek and Sandy Creek or their respective flood plains, there is a risk that the spill could make its way into the Hunter River.

To manage spills that occur on the bridge over Muscle Creek and Sandy Creek, a pit and piped drainage system is required to transport the runoff, and therefore any spill, to the spill containment measures where it would be appropriately removed and treated. Spill containment basins have been provided near Muscle Creek and Sandy Creek where the road drainage discharges.

The management of spills, minor discharges and litter or other waste would be addressed using standard operational mitigation measures. Spills would be managed by a combination of grass-lined swales and spill containment basins. Stormwater from the bridge over Muscle Creek and Sandy Creek would be captured and piped to provide drainage of surface water.

Flooding

Sandy Creek and Hunter River

The proposal would have the potential to impact flood levels where it crosses the Sandy Creek and Hunter River floodplains at the northern connection. The potential for impacts has been minimised through the inclusion of a 375 metre long bridge which extends across Sandy Creek and its floodplain. Piers located within the flow path would be aligned so as to minimise disruption to the flow, with scour protection provided to minimise bed and bank scour.

Drainage culverts would be provided through the bypass embankment at various locations to maintain natural flow paths. At the northern connection, the Sandy Creek and Hunter River flood waters may change the characteristics of flow through the culverts, including the direction of flow due to backwater effects.

Whilst the potential for flood impacts has been minimised through the design of the proposal, relatively minor impacts remain. These are primarily due to the embankments associated with the bypass resulting in localised redistributions of flow. The obstruction of a secondary flow path to the north of Sandy Creek causes water to back up to slightly higher levels than occur under existing conditions. This increase in flood levels extends into the floodplain on the eastern side of the proposed bypass.

The embankments also cause a minor constriction to flow across the broad floodplain of the Hunter River this creates minor increases in flood levels on the western side of the proposed bypass.

Refer to the Flood Risk Assessment (BMT 2021) (Appendix E) for more information regarding potential flood impacts at the northern connection during operation of the bypass.

An extreme (probable maximum) flood (PMF) has been modelled as part of the assessment. Flood impacts due to the bypass in this event are noted, however the Sandy Creek and Hunter River floodplains would already be inundated across a wide area and to significant depths. The small additional increase in flood level is considered to make minimal material difference.

Muscle Creek

The design of the bypass would minimise the potential for flood impacts by providing a bridge structure over Muscle Creek. Piers located within the flow path would be aligned to minimise disruption to the flow, with scour protection provided to minimise bed and bank scour. Modelling shows no significant peak flood level or velocity impacts on the main channel of Muscle Creek for all events up to and including the 0.5 per cent AEP with only minor impacts (up to a 0.05 metre increase in peak level) for the 0.2 per cent and 0.05 per cent AEP.

The proposal would have the potential to impact a tributary of Muscle Creek near the southern connection where natural flows are restricted by the bypass embankment. A large box culvert structure would be provided at this location to minimise impacts, however there would be a slight redistribution in flows which would cause localised increases and decreases to peak flood levels and velocities.

The changes in peak flood levels and velocities for Sandy Creek and Muscle Creek are summarised in Table 6-12: and Table 6-13: respectively. Further detail is provided in the Flood Risk Assessment (2021) (refer to Appendix E).

Flood levels and velocities

An overview of changes to flood levels and velocities for assessed flood events ranging from the 20 per cent AEP to the PMF event on Sandy Creek is provided in Table 6-12:.

Table 6-12: Changes in peak flood levels and velocities for Sandy Creek

AEP event	Aspect	Changes
20%	Flood level	• No notable changes to modelled peak flood levels or velocities due to the minimal extent of out-of-bank flooding
	Flood velocity	• Some highly localised increases immediately upstream of the bypass on the southern tributary of Sandy Creek, immediately upstream of the bypass where flow backs up behind a culvert under the bypass
5%	Flood level	• Increase of up to 0.5 m between the Main North railway line and the New England Highway associated with the effective removal of the alternative flow path • Increase of up to 0.7 m on the southern tributary of Sandy Creek.
	Flood velocity	• No notable velocity changes other than localised increases and decreases adjacent to and within 100 m of the bypass.

AEP event	Aspect	Changes
2% and 1%	Flood level	• Increase of up to 0.22 m on the floodplain up to one kilometre upstream (east) of the bypass (1% AEP) • Increase of up to 0.06 m on the floodplain downstream (west) of the bypass at Burtons Lane (1% AEP) • Highly localised increases of up to 0.5 m to the north of Sandy Creek between the Main North railway line and the New England Highway
	Flood velocity	• Increases on the western side of the bypass due to changes in the distribution of Hunter River floodplain flow • Increases of up to 0.5 m/s along a 100 m length of Burtons Lane where existing velocities are about 1.5 to 2.0 m/s • Decreases in peak velocity on Burtons Lane of up to 0.5 m/s are also apparent
0.5%, 0.2% and 0.05%	Flood level	• Increases ranging from about 0.4 m adjacent to the bypass to 0.06 m along Burtons Lane • Increase of about 0.1 m on the eastern side of the bypass, increasing to 0.2 m immediately upstream of the Sandy Creek crossing • Highly localised increases of up to 1.5 m immediately upstream of the bypass on the southern tributary of Sandy Creek
	Flood velocity	• Similar changes to those of the 1% AEP event, except flood velocity reduces slightly as the size of the flood event increases
PMF	Flood level and velocity	• Shows the most extensive impacts although the magnitude of impact is similar to that of smaller events • Increase of up to 0.2 m with a flood depth typically between 3.5 and 4.0 m on the eastern side of the bypass • Peak flood level impacts near Koolbury Flats Row with increases of up to 0.35 m with a flood depth typically between 3.5 and 4.0 m on the western side of the bypass

An overview of changes to flood levels and velocities for assessed flood events ranging from the 20 per cent AEP to the PMF event on Muscle Creek is provided in Table 6-13:.

Table 6-13: Changes in peak flood levels and velocities for Muscle Creek

AEP event	Aspect	Changes
AEP events up to 0.5%	Flood level	• Flow contained within creek channel • Increase of up to 0.5 m where the southern tributary of Muscle Creek passes through the bypass (localised within about 150 m)
	Flood velocity	• No notable changes
AEP events beyond 0.5%	Flood level	• Increase of up to 0.05 m where the bypass crosses Muscle Creek • Increase of up to 0.15 m on the northern tributary of Muscle Creek immediately adjacent to the bypass, diminishes with distance upstream along approximately 150 m of channel

AEP event	Aspect	Changes
	Flood velocity	• Similar to flood level changes outlined above with increases associated with a southern tributary of Muscle Creek as it passes through the bypass. Water would back up behind a bypass culvert with a slight redistribution of flow downstream of this culvert
PMF	Flood level	• Increase of up to 2.0 m immediately upstream of the bypass • Increases within a one km radius of the crossing of Muscle Creek • Decreases up to 0.5 m on the northern side of the Main North railway line • Increases up to 0.8 m on the southern side of the Main North railway line, downstream of Muscle Creek
	Flood velocity	• Similar to flood level changes outlined above with large increases and decreases due to a redistribution of flow

Impact to property and infrastructure

Sandy Creek

The proposal with its large bridge crossing of Sandy Creek would have limited potential to affect flood levels for Sandy Creek. Flood impacts to property and local roads in the surrounding area, and to the Main North railway line, are considered minor except for the PMF event where impacts would be more pronounced. It should be noted that, in this extreme event, impacted roads and properties would already be inundated to significant depths.

Flood modelling for a one per cent event showed that for 28 out of 33 properties located near the Sandy Creek impact zone, the proposal would result in either no increase or very minor increases in peak flood level (less than 0.03 metres). Of the remaining five properties, only two showed an increase above 0.1 m (one of which is an agricultural lot containing a groundwater bore well).

Muscle Creek

For Muscle Creek, the potential flood impacts resulting from the proposal would be minimal as the flow in the main creek would remain largely ‘in bank’ for events up to and including the 0.05 per cent AEP.

In the PMF event, two properties would be impacted:

- One previously flooded to a depth of 0.8 metres would have a peak water level increase of 1.48 metres.
- One property previously dry in the PMF would be inundated to a depth of 0.7 metres.

Scour

The scour assessment concluded that the greatest local pier scour depth for Sandy Creek in the 1 per cent AEP event would occur at Pier 3, with a scour depth estimate of 2.14 metres. In the 0.05 per cent AEP event, the greatest scour depth occurs for Pier 8 with a scour depth estimate of 2.36 metres.

For Muscle Creek, the deepest point at Pier 2 provided a scour depth estimate of 1.91 metres for the one per cent AEP event and 2.30 metres for the 0.05 per cent AEP event.

There would also be a potential for increased scour and erosion due to increased flow velocities at partially blocked culverts or bridge openings. This could affect ecosystems, impact on flood levels and could ultimately affect the structural integrity of the road infrastructure.

Detailed design of the proposal would consider scour protection to ensure impacts to the road and other infrastructure would be minimised. Transport would also carry out a detailed survey of floor levels for dwellings to validate the flood study where required.

6.2.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
General	A Soil and Water Management Plan (SWMP) will be prepared in accordance with QA Specification G38 and implemented as part of the CEMP. The Plan will identify all reasonably foreseeable risks relating to soil erosion and water pollution associated with undertaking the activity and describe how these risks will be managed and minimised during construction. The SWMP will include arrangements for managing pollution risks associated with spillage or contamination within the construction footprint and adjoining areas, and monitoring during and post-construction. The SWMP will address the following: • Code of Practice for Water Management, the Roads and Maritime Erosion and Sedimentation Procedure • The NSW Soils and Construction – Managing Urban Stormwater Volume 1 “the Blue Book” (Landcom, 2004) and Volume 2 (DECC, 2008) • Technical Guideline: Temporary Stormwater Drainage for Road Construction, 2011 • Technical Guideline: Environmental Management of Construction Site Dewatering, 2011	Construction contractor	Pre-construction and construction	Core standard safeguard GEN1
Erosion and sediment control mitigation	A site-specific Erosion and Sediment Control Plan (ESCP) will be prepared and implemented and included in the SWMP. The ESCP will identify detailed measures and controls to be applied to minimise erosion and sediment control risks including, but not necessarily limited to: • Runoff, diversion and drainage points • Sediment management devices, such as fencing, hay bales or sandbags	Construction contractor	Construction	Core standard safeguard E1

Impact	Environmental safeguards	Responsibility	Timing	Reference
	• Scour protection and energy dissipaters at locations of high erosion risk • Stabilising disturbed areas as soon as possible, check dams, fencing and swales • Staged implementation arrangements The ESCP will also include arrangements for managing wet weather events, including monitoring of potential high-risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather			
Contamination of surface water quality	Sediment control basins will be provided at flow discharge points associated with the bypass and bridges over Muscle Creek and Sandy Creek. The requirements for erosion control measures and sediment basins (i.e. number, location and size) will be determined during the proposal detailed design phase	Construction contractor	Detailed design and construction	Additional safeguard
Contamination of surface water quality	A Spill Management Plan (SMP) will be prepared and implemented as part of the CEMP to minimise the risk of pollution arising from spillage or contamination on the site and adjoining areas. The SMP will address, but not necessarily be limited to: • Management of chemicals and potentially polluting materials • Appropriate location and storage of construction materials, fuels and chemicals, including bunding where appropriate • Maintenance of plant and equipment • Emergency management, including notification, response and clean-up procedures	Construction contractor	Pre-construction and construction	Additional safeguard
Surface water quality	Water quality requirements will form part of the conditions stipulated in the environment protection licence (EPL) for the proposal. The current water quality monitoring program results will be used for baseline purposes	Construction contractor	Construction	Core standard safeguard W2

Impact	Environmental safeguards	Responsibility	Timing	Reference
Flood mitigation	A Flood Risk Management Plan (FRMP) will be prepared as part of the CEMP. The FRMP will address, but not necessarily be limited to: • Processes for monitoring and mitigation flood risk • Steps to be taken in the event of a flood warning including removal or securing of loose material, equipment, fuels and chemicals	Construction contractor	Construction	Additional safeguard

6.3 Groundwater

A Surface and Groundwater Assessment was prepared by AECOM (2021) for the proposal (refer to Appendix I).

6.3.1 Methodology

The groundwater assessment adopted the following methodology:

- Review of the legislative context within which the proposal lies and relevant guidelines
- Define the area that influences the groundwater environment
- Collate registered bores from the NSW Department of Industry – Water Division groundwater database
- Identify GDEs from the National Atlas of GDEs (Australian Bureau of Meteorology (BoM))
- Define the area that influences both the surface and groundwater environments
- Assess construction and operational impacts to groundwater users, groundwater quality and GDEs
- Provide a consolidated list of measures to be applied during the construction and operational phase to mitigate potential impact to groundwater.

Study area

For the purpose of the groundwater assessment, the study area included a 500 metre buffer around the construction footprint, to allow for the evaluation of groundwater related influences directly and indirectly related to the proposal.

6.3.2 Existing environment

Regional and local hydrogeology

The hydrogeology of the Upper Hunter Valley is dominated by two regional aquifers:

- An unconfined superficial aquifer hosted by alluvial deposits of Quaternary age
- A bedrock aquifer hosted by consolidated sedimentary rocks and coal measures of Permian age.

The unconfined superficial aquifer is highly permeable and is comprised of sandy gravel and gravel deposits ranging between three metres and nine metres in thickness. Groundwater is found between 4.3 metres and 15.0 metres below ground surface. Water quality is fresh to brackish. It is recharged predominantly through percolated rainwater through unsaturated soils and discharges to the Hunter River (and tributaries) as baseflow.

The bedrock aquifer is comprised of fractured, slightly to moderately weathered siltstone and sandstone. This aquifer is recharged regionally and directly by rainfall infiltration through fractures and weathered outcrops. Water quality is brackish to saline.

The unconfined superficial aquifer is present in low-lying areas along the northern sections of the study area (i.e. Hunter River floodplain) and along Muscle Creek. The bedrock aquifer is predominantly found in the central high lying portion of the study area.

Registered groundwater bores

The WaterNSW website identified 20 registered groundwater extraction bores within the study area, with three being located within the construction footprint. Of the registered extraction bores within the construction footprint, two are licensed for commercial and industrial purposes and three are licensed for irrigation purposes. Final installed depths of groundwater bores ranged between 6.7 metres to 24.0 metres.

Groundwater users within the study area use the unconfined superficial aquifer for agricultural, stock and domestic purposes. As mentioned above, water quality in this aquifer is generally fresh to brackish making it potable or suitable for stock watering purposes.

Groundwater dependent ecosystems

The dependence (or interaction) of vegetation communities identified within the construction footprint, on groundwater is determined by aligning them with the GDE types identified in Section 6.1.2. Two GDEs, PCT 42 River Red Gum / River oak riparian woodland wetland in the Hunter Valley and PCT 485 River oak riparian grassy tall woodland of the western Hunter Valley (Brigalow Belt South Bioregion and Sydney Basin Bioregion), are highly likely to be GDEs reliant on surface expressions of groundwater or on subsurface groundwater. PCT 1693 Yellow Box – Rough-barked Apple grassy woodland of the Upper Hunter and Liverpool Plains is likely to be a terrestrial GDE which may access the water table on an intermittent basis.

Groundwater quality

Potential contamination sources within the study area include restored mining land, a former timber mill, dairy farms, Muswellbrook substation and former power station, an open cut coal mine operated by MCC, a quarry and the Muswellbrook Waste Management Facility. These locations have the potential to leach contaminates into the groundwater although no evidence of this was found in the publicly listed data reviewed.

6.3.3 Potential impacts

Construction

Cuts in the topography, to achieve the required road grades, can result in groundwater discharge (dewatering) if the cuts extend below the water table. There is however a low potential for interaction with groundwater during construction, as groundwater has generally been reported to be at four metres below ground surface. There may be some interaction with groundwater during construction in areas of perched (seasonal) groundwater or close to the surface water – groundwater interaction zone(s). Additional geotechnical investigations would be undertaken during the detailed design phase of the proposal to determine the need for dewatering, the likely dewatering volumes, the impacts on draw down and the quality of groundwater that would be encountered during construction. The manner in which extracted groundwater would be discharged would depend on the groundwater quality and if it would require treatment prior to discharge. Options include discharge to creeks, temporary storage in detention basins to reduce turbidity prior to discharge, or re-use for dust suppression.

Piling activities required for the five bridges have the potential to impact on groundwater flow patterns, where shallow groundwater can mound on the upgradient side of the piles and drawdown on the downgradient side. Cast-in-place piling results in the removal of groundwater with sediment intersected in the pile location. The removal of groundwater associated with a typical 20 metre to 25 metre deep pile is only around 10 litres. Accordingly, the impact of groundwater removal due to construction of the piles would be temporary and not have a marked impact on groundwater levels.

Potential sources of contamination are from leaching of spills into groundwater. Impacts could potentially occur from fuel and oils used by construction plant and equipment, concrete batching plant, waste, fertilisers, herbicides and pesticides (used in site landscaping), paint and paint wastes, acid from acid-based washes and the disturbance of contaminated soils.

Spill occurrences would be readily cleaned up as part of routine construction activities and addressed by the proposed sediment basin discharge limits. The potential for impacts to groundwater from surface spills is considered low with the implementation of management measures and safeguards.

Two groundwater bores located within the construction footprint would be impacted during construction, while a third may be impacted. The two groundwater bores not able to be retained during construction would be capped and the owner would be compensated. Groundwater use from the bores located outside the construction footprint but within the study area is not expected to be disturbed during construction.

Construction activities within proximity of Muscle Creek, Sandy Creek and their tributaries have the potential to impact GDEs as discussed in Section 6.3.2. Mitigation measures which would be included in the proposal to reduce impacts on GDEs include minimising interruptions to water flows during detailed design (refer to Section 6.3.4).

Operation

The introduction of hard road surface areas into mostly greenfield environments would increase runoff and decrease groundwater recharge, due to the loss of permeability. The decrease in recharge rates would however be minor, given the small road surface of the proposal compared to the remainder of the catchment.

Road runoff could contain pollutants associated with vehicular movements, leaks, spills and crashes, which could lead to the contamination of groundwater. The contaminants could include hydrocarbons (petrol, diesel and oils), metals and suspended solids. Measures to minimise surface water impacts (as described in Section 6.2.4) would contain the risk to groundwater quality.

Aquatic GDEs within the study area are considered a sensitive receiving environment in connectivity with the Hunter River, Sandy Creek and Muscle Creek, which would receive runoff, both directly and indirectly, from the proposal. Therefore, if an incident were to occur, there is potential for environmental harm. The potential for interaction with groundwater during operation is considered to be low given the expected depth to groundwater along the proposal alignment.

Under normal operating conditions, the proposal is not expected to result in changes to the quality of groundwater in the local or regional aquifers. Similarly, impacts to groundwater availability would be negligible as the proposal does not require substantial groundwater extraction or inhibit recharge. Operation of the proposal would not impact GDEs.

6.3.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Groundwater dewatering	Any dewatering activities will be undertaken in accordance with the RTA Technical Guideline:	Construction contractor	Detailed design and construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	Environmental management of construction site dewatering in a manner that prevents pollution of waters			
Groundwater dewatering	If required, groundwater abstraction requirements during the development phase of the proposal will form part of the condition stipulated in the EPL for the proposal	Construction contractor	Detailed design and construction	Additional safeguard
Groundwater impact mitigation	Any dewatering activities will be undertaken in accordance with the RTA Technical Guideline: Environmental management of construction site dewatering in a manner that prevents pollution of waters	Construction contractor	Detailed design and construction	Additional safeguard
Groundwater impact mitigation	Additional geotechnical investigations will be undertaken to determine the: • Need for dewatering • Likely dewatering volumes • Impacts on draw down • Quality of groundwater that would be encountered during construction	Construction contractor	Detailed design	Additional safeguard
Groundwater impact mitigation	To minimise the potential of encountering groundwater during construction, pile holes should be installed by advancing steel casing into the ground as they are advanced	Construction contractor	Detailed design and construction	Additional safeguard

Other safeguards and management measures that would address groundwater impacts are identified in Section 6.2.

6.4 Soils and mine workings

6.4.1 Methodology

The desktop investigation of geology and soils included a review of publicly available information to obtain an understanding of the geological formations and soils landscapes within the proposed road corridor. Reference was made to:

- Regional geology: the Hunter Coalfield Regional Geology 1:100 000 map, the Muswellbrook 1:25,000 geological map and the Singleton 1:250,000 geological sheet SI/56-01
- The Soil Landscapes of the Singleton 1:250,000 which provides an inventory of soil and landscape properties of the study area and identifies major soil and landscape qualities and constraints

- The Soil and Land Resources of the Hunter Region which upgrades the soil landscape mapping for the Singleton area to a 1:100,000 scale and provides more land and soil information across the study area.

To address potential sources of contamination within and in proximity of the construction footprint a Contaminated Soils Phase 1 Assessment was prepared by AECOM (2021) for the proposal (refer Appendix J) which:

- Reviewed the land use history of the study area through the review of publicly available information including historic aerial photography
- Reviewed geotechnical investigations for the proposal
- Developed a conceptual site model to describe potential sources of contamination, pathways by which contaminants may be transmitted through the environment and the receivers that may be exposed to the contaminants
- Carried out a qualitative risk assessment based on the conceptual site model
- Identified environmental safeguards to manage potential contamination impacts.

Geotechnical investigations were carried out as part of a program of works during mid 2020 for the concept design. A number of these investigations targeted the former underground workings at the Muswellbrook Coal Mine in the Muswellbrook, St Heliers and Lewis Seams, including:

- Geotechnical boreholes to intercept the Muswellbrook and St Heliers Seams and the Lewis Seam workings, including four boreholes drilled along the alignment to determine the stratigraphy associated with the coal seams and where possible to identify the workings
- Down hole sonar probing where mine voids associated with the former workings in the Lewis Seam were intercepted to obtain more details of the geometry of the workings in this seam
- Review of mine tracings
- Assessment of pillar stability in the Lewis Seam.

Four soil vapour wells were installed as part of the geotechnical investigation works. These wells serve as indicators for spontaneous combustion to monitor dangerous gasses (CO, CO2, CH4 and SO2) in the former open cut immediately south of the underground workings. Interferometric Synthetic Aperture Radar (InSAR) surveys were carried out in the mid to late 2020 by Sixense Soldata SAS over the mine area, with a number of settlement points in this vicinity.

A Mining Assessment Report has also been prepared to assess the potential impacts of the former underground mine workings on the performance of the proposed road infrastructure (refer to Appendix F). The assessment has been carried out to facilitate the approval process with Subsidence Advisory NSW (SA NSW) for construction of the section of the bypass over the former underground mine workings at the Muswellbrook Coal Mine.

A pillar strength assessment was carried out for the Lewis Seam using the Power Law developed by the University of NSW and developed in *Anderson* (1999). The pillar assessment concluded that no further works would be required to stabilise workings in the Lewis Seam. Refer to Appendix F for the full methodology regarding pillar stability.

Study area

The study area for the soils assessment is shown in Figure 6-7. It extends beyond the construction footprint in order to identify potential contamination sources (both historical and current) which may result in potential contamination impact within the construction footprint.

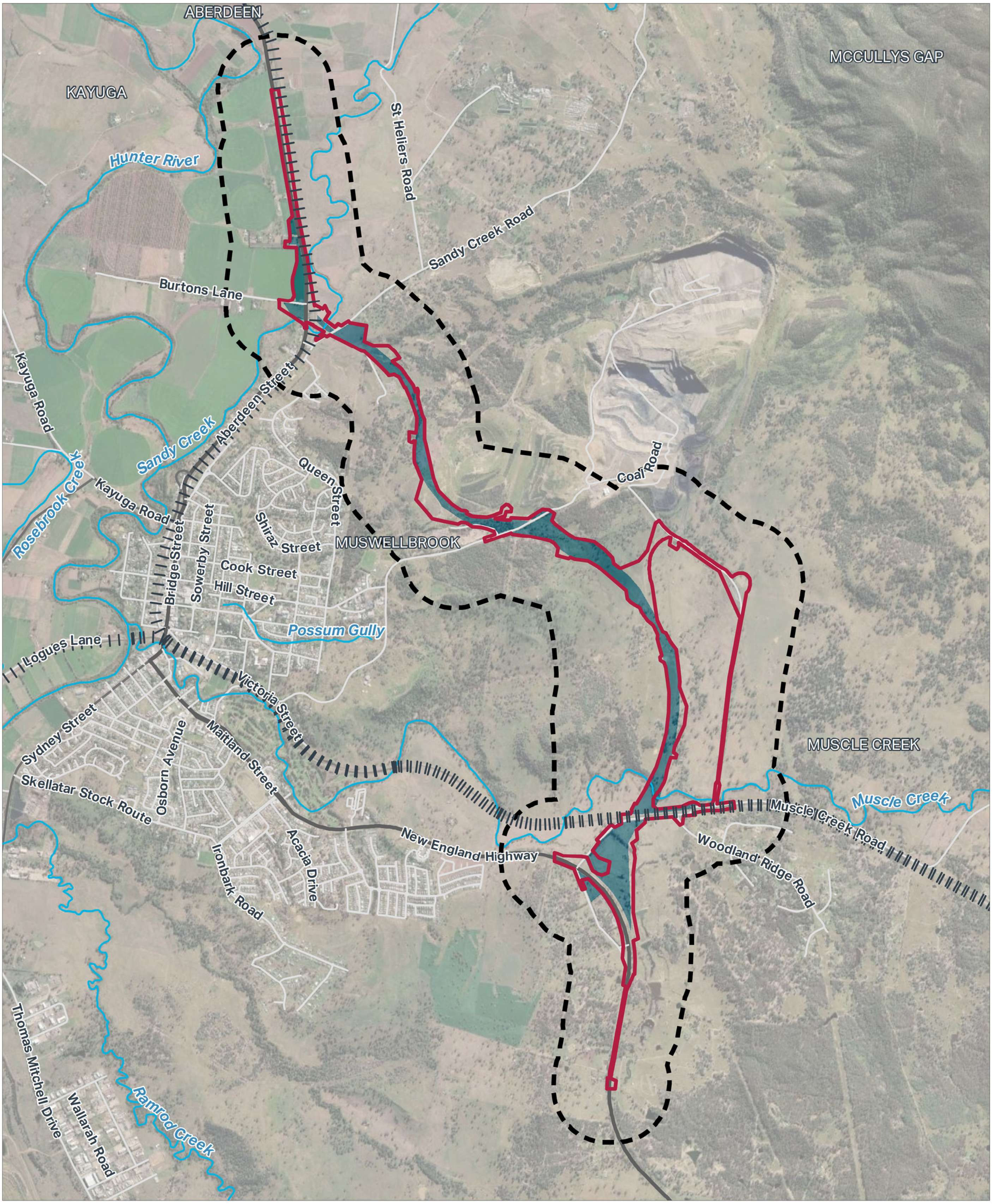


FIGURE 6-7: STUDY AREA FOR SOILS ASSESSMENT

N

0 0.5 1 km

AECOM

Legend

- Construction footprint
- Study area
- Proposed road corridor
- Watercourse
- State Road
- Regional Road
- Local Road
- Railway

6.4.2 Existing environment

Regional geology

The regional geology along the proposed road corridor is outlined in Table 6-14.

Table 6-14: Regional Geology

Unit	Geological Group	Sub-unit	Stratigraphy	Lithology description
1	Quaternary	1.1	Man-made fill	Mine waste
		1.2	Alluvium (Qa)	Gravel, sand, silt, clay
2	Maitland Group	2.1	Mulbring Siltstone (Pmm)	Sedimentary bedrock of dark-grey shale and siltstone. Potentially bioturbated and fossiliferous
		2.2	Branxton Formation (Pmb)	Sedimentary bedrock of sandstone, siltstone and conglomerate. Sandstone varies in thickness and may be pebbly or silty. Conglomerate appears as lens
3	Greta Coal Measures	3.1	Rowan Formation (Pgr)	Sedimentary bedrock of sandstone, siltstone, shale and mudstone with intercalated coal seams and subordinate conglomerate. Coal seams include: • Fleming Seam • Hallet Seam • Muswellbrook Seam • St Heliers Seam • Lewis Seam • Loder Seam
		3.2	Skeletar Formation (Pgk)	Rhyolite, chert and white tuffaceous shale
4	Dalwood Group	4.1	Undifferentiated including Gyarran Volcanics (Pdz)	Igneous bedrock of rhyolite, breccia and amygdaloidal basalt with minor felsite, grading to dark marine shale and mudstone

Soils

The soil landscapes of the Singleton and Hunter Region through which the proposal traverses have been split into sections as shown in Table 6-15 and illustrated in Figure 6-8 and Figure 6-9.

Table 6-15: Soil Landscape

Section[1]	Singleton 1:250,000	Hunter Region 1:100,000	Soil Landscape	Soils
1	Hunter (hu)	Foy Brook (fyz) – Alluvial	Level plain to gently undulating alluvial plain. Slopes 0 - 3%, local relief <5 m, elevation 160 - 165 m. Extensively cleared riparian forests	Brown Clays, Black Earths and Alluvial Soils comprising sand, silt and clay derived from the Branxton Formation
	Dartbrook (db)	Donalds Gully (dnz) - Transferal	Gently undulating plains. Slopes 1 - 5%, local relief <30 m, elevation 200 – 260 m. Extensively cleared woodland	Brown Clays with some Black Earths comprising alluvium and colluvium derived from moderately to strongly weathered, sandstone, conglomerate, mudstone, calcareous shale, coal and basalt
		Cressfield Road (cfz) - Erosional	Undulating rises to undulating low hills. Slopes 3 - 10%, local relief 20 - 50 m, elevation 190 - 210 m. Extensively cleared open-woodland	Red Podzolic Soils, Non-calcic Brown Soils and Red-Brown Earths comprising clayey sand
		Cressfield Road variant a (cfza) - Erosional	Rolling low hills to rolling hills. Slopes 10 - 33%, local relief 20 - 50 m, elevation 175 - 260 m. Extensively cleared open-woodland	Red Podzolic Soils, Non-calcic Brown Soils and Red-Brown Earths comprising clayey sand
	Roxburgh (rx)	Lovedale (lvv) - Transferal	Gently undulating plains. Slopes 2 - 5%, elevation 160 - 170 m. Tall woodland partially cleared for grazing	Yellow podzolic soils on upper to mid slopes and red solodic soils on more rounded hills. Brown podzolic soils on slopes with conglomerate outcrop
		Dochra (dot) - Erosional	Undulating low hills on Permian siltstones and mudstones. Slopes 5 - 10% elevation 230 - 260 m. Extensively cleared open-forest	
2	Roxburgh (rx)	Disturbed Terrain variant a (xxza) - Disturbed	Areas of reshaped and revegetated land associated with mine spoil. Made land consisting of embankments, mounds, cut features and fill features. Slopes are generally simple and often traversed by contour banks and terrace features. Elevation 190 – 230 m	Derived from Permian sediments of the Greta Coal Measures

Section[1]	Singleton 1:250,000	Hunter Region 1:100,000	Soil Landscape	Soils
3	Roxburgh (rx)	Little Grasstree Hill (lgw) – Erosional	Rolling low hills to rolling hills on Permian siltstones, sandstone and conglomerate of the Maitland Group. Slopes 10 - 32%, local relief 40 m, elevation 150 – 190 m. Extensively cleared open-woodlands	Red and Brown Solodic soils dominate crests and hillslopes
		Donalds Gully (dnz) - Transferal	Gently undulating plains. Slopes 1 - 5%, local relief <30 m, elevation 140 - 160 m. Extensively cleared woodland	Brown Clays with some Black Earths comprising alluvium and colluvium derived from moderately to strongly weathered, sandstone, conglomerate, mudstone, calcareous shale, coal and basals
		Dochra (dot) – Erosional	Undulating low hills on Permian siltstones and mudstones. Slopes 5 - 10% elevation 150 – 190 m. Extensively cleared open-forest	Yellow podzolic soils on upper to mid slopes and red solodic soils on more rounded hills. Brown podzolic soils on slopes with conglomerate outcrop
	Hunter (hu)	Singleton (sgw) - Alluvial	Alluvial plain of variable width with both high and low terraces. Slopes 0 -3%, local relief <10 metres and elevation 140 - 150 m	Quaternary alluvium valley deposits consisting mostly of clays and silts with minor sands and gravels

1 Refer to Figure 6-8 and Figure 6-9

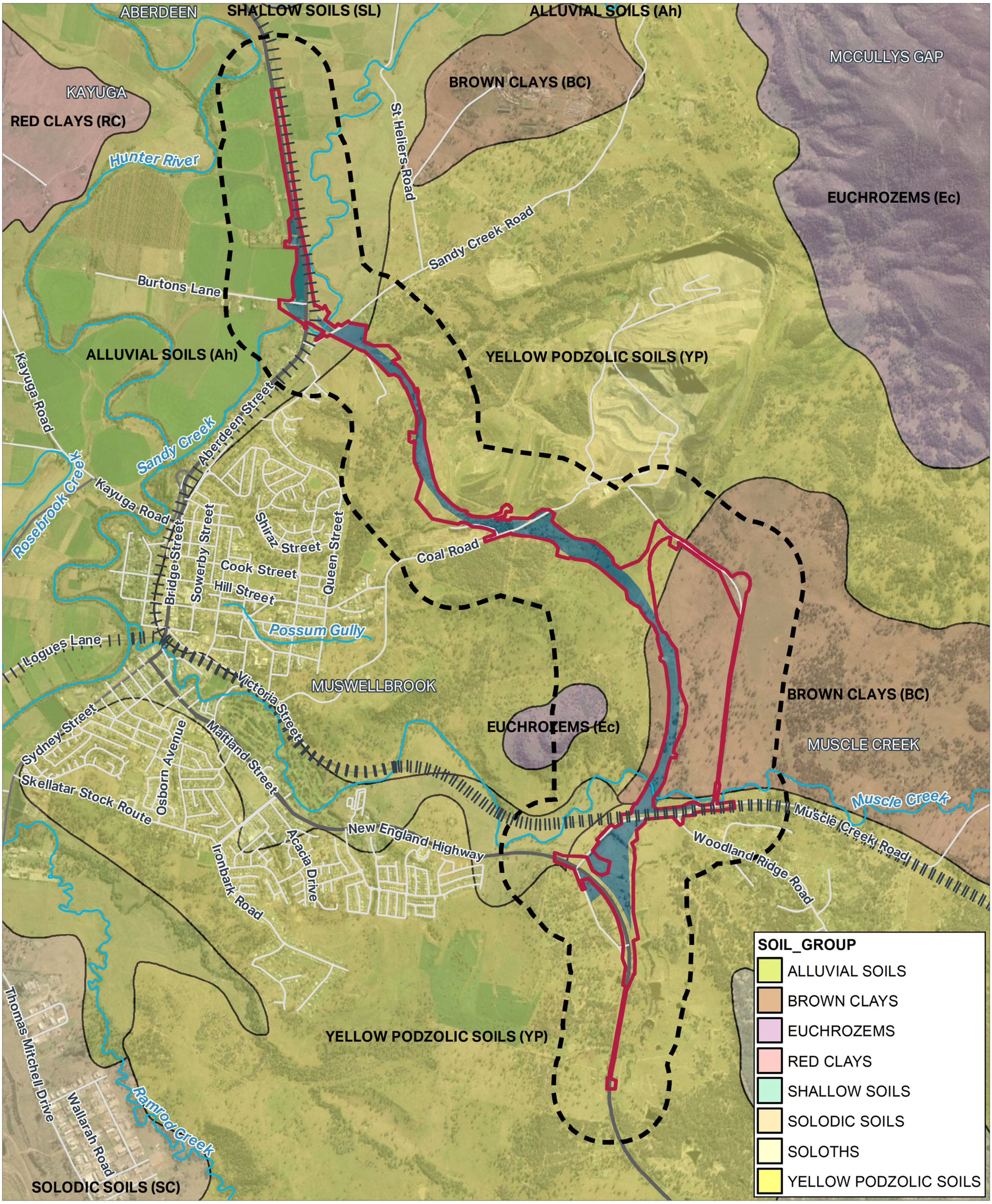


FIGURE 6-8: SOIL LANDSCAPES OF THE SINGLETON REGION

AECOM

Legend
- Construction footprint
- Study area
- Proposed road corridor
- Watercourse
- State Road
- Regional Road
- Local Road
- Railway

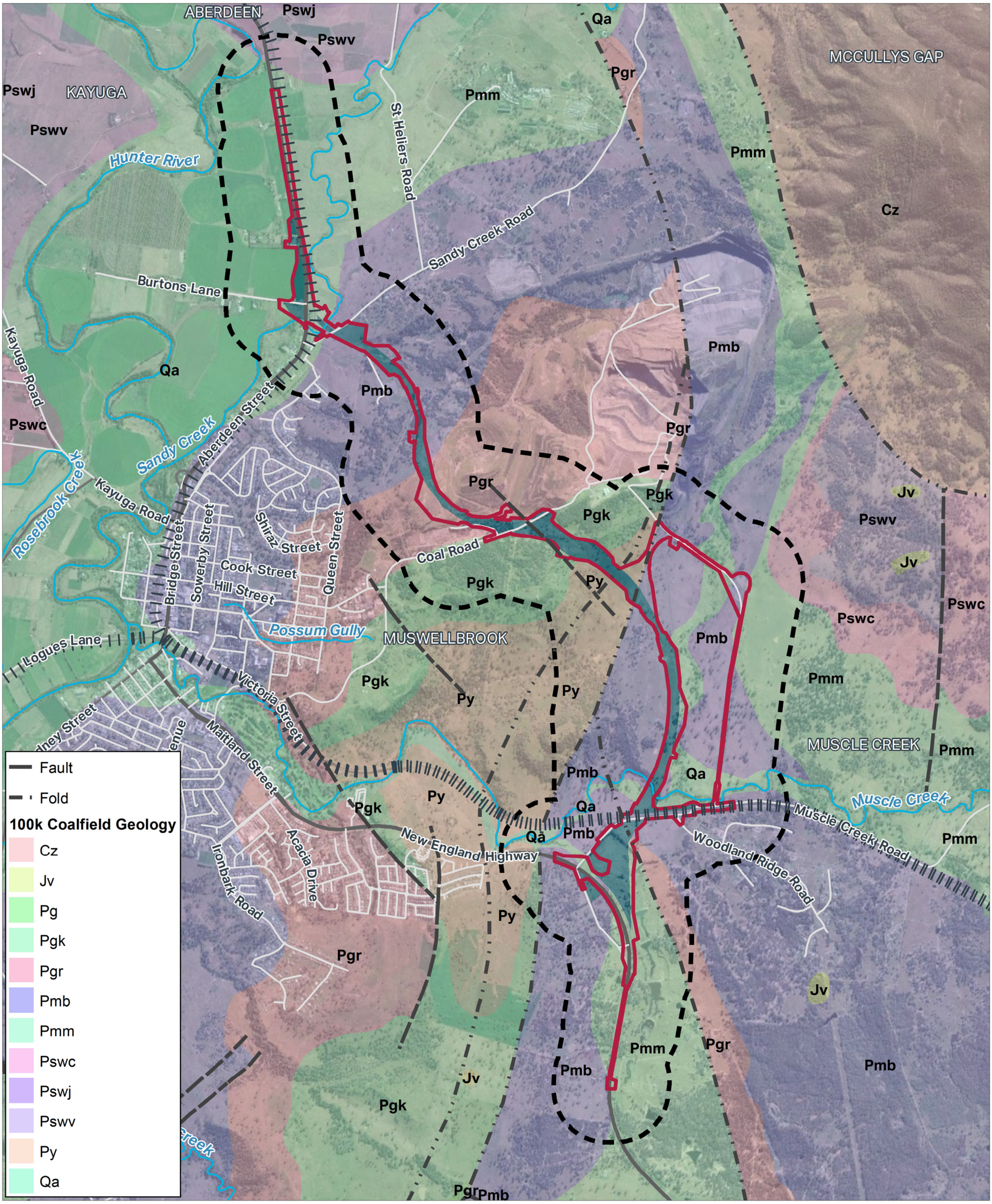


FIGURE 6-9: SOIL AND LAND RESOURCES OF HUNTER REGION

N 0 0.5 1 km

AECOM

Legend

- Construction footprint
- Study area
- Proposed road corridor
- Watercourse
- State Road
- Regional Road
- Local Road
- Railway

Acid sulfate soils

Acid sulphate soils are not identified in the study area in publicly available acid sulphate soils mapping including the Muswellbrook LEP 2009. The results of the geotechnical investigations for the proposal (AECOM, 2020) identified no known occurrence of acid sulfate soils in the study area. Ground levels along the proposed road corridor range from 150 metres to 242 metres and it is considered unlikely that acid sulfate soils would be encountered.

The ASRIS Atlas of Australian Acid Sulfate soils indicates a low (6-70 per cent) to extremely low (1-5 per cent) probability of potential acid sulfate soil (sulfidic material) to occur within inland lakes, waterways, wetlands and riparian areas located within the study area.

Unexploded ordnance

A review of the Department of Defence (DoD) unexploded ordnance (UXO) map was completed on 31 March 2020. This review indicates that the township of Muswellbrook was once used as an advanced ordnance depot during WWII. The closest known location of an UXO is located within the study area to the west of the northern connection.

Per and Poly Fluoro Alkyl Substances

The Australian potential per- and poly-fluoroalkyl substances (PFAS) Chemicals Map was viewed on 31 March 2020. There were no sites identified as impacted by PFAS contamination within the study area.

The Contaminated Soils Phase 1 Assessment (AECOM, 2021) found Aqueous Film Forming Foams containing PFAS could historically have been used during fire fighting and/or fire training exercises.

Salinity

Dryland salinity has been observed in the Upper Hunter area; however no salinity hazard maps are listed in the Muswellbrook LEP 2009. The Salinity hazard report for Catchment Action Plan upgrade – Hunter-Central Rivers CMA (Nicholson et al., 2012) identified a very high hazard risk of salinity around Muswellbrook. The area encompasses the major coal extraction areas of the Hunter area, including the Muswellbrook Coal Mine.

Contamination

The Contaminated Soils Phase 1 Assessment in Appendix J identified potential contamination sources within or in proximity to the study area.

Locations or structures identified as potentially containing contamination include market gardens; agricultural land (including dairy farms and pastoral land); the existing New England Highway and associated connecting roads; the Main North railway line and a former rail line; a former timber mill, former Muswellbrook Brick Works, Muswellbrook substation and Muswellbrook Waste Management Facility; Muswellbrook Coal Mine; a former power station as well as existing buildings and historical structures which may contain potential asbestos containing material.

The potential contamination sources are mapped in the Contaminated Soils Phase 1 Assessment in Appendix J.

Mine workings

Areas of backfill

The proposal passes over the old backfilled Open Cut No.1 at Muswellbrook Coal Mine including the highwall and low wall where potential for differential compaction is high, and where the old single seam underground workings in the Lewis seam are located. The Open Cut No. 1 has been backfilled with various types of uncompacted mine waste from former open cut operations up to a depth of 70 metres.

Underground mine workings

Three underground mine workings are located north of Coal Road, in the Lewis, St Heliers and Muswellbrook Seams.

Geotechnical investigations carried out as part of a program of works during mid 2020 for the concept design indicated that the proposal would pass directly over the Lewis Seam workings (see Section 6.4.3).

The geotechnical investigations encountered solid coal in the boreholes in the Muswellbrook and St Heliers Seams. The mine tracings indicate that the workings in these seams are 100 metres or more from the alignment and therefore are unlikely to pose a risk to the proposal. In addition, the open cut high wall was constructed with a 25 metre to 30 metre barrier between the open cut and the high wall. This barrier of solid coal would also inhibit the spread of fire between the open cut and the underground workings.

Spontaneous combustion and gas venting (underground fires)

The InSAR surveys carried out in mid to late 2020 over Muswellbrook Coal Mine, surveyed a number of settlement points in the vicinity of the underground workings. These points are stable and show no signs of ongoing settlement that could be attributed to underground fires.

With the water table being about eight metres above the roof level of the workings of the Lewis Seam, underground fires are not considered to be a potential issue in this seam.

The potential for underground fires to extend to coal seams from either the existing workings or from the former open cut is unlikely and has not been considered further.

6.4.3 Potential impacts

Construction

Erosion and sedimentation

The proposal would involve removal of topsoil, earthworks associated with filling for the new road and stockpiling of spoil for construction. If not adequately managed, earthworks, stockpiling and transportation of spoil could potentially have the following impacts:

- Erosion of exposed soil and stockpiled materials
- An increase in sediment loads entering nearby watercourses.

With the implementation of erosion and sedimentation control outlined in Section 6.4.4, potential construction related erosion and sedimentation impacts would be appropriately managed and would be minor.

Acid sulphate soils

Acid sulphate soils are unlikely to be encountered during construction.

Salinity

The construction of the proposal has the potential to exacerbate dryland salinity in the proposed road corridor where the groundwater table is impacted by construction works. Given that impacts to the groundwater table are anticipated to be minor, the proposal is unlikely to contribute to dryland salinity.

Contamination

The Contaminated Soils Phase 1 Assessment in Appendix J found there is a moderate risk of contamination from a range of potential contaminants and sources within and adjacent to the proposed road corridor that may present an unacceptable risk to human health and/or the environment. Contamination risks would be managed in accordance with the environmental safeguards provided in Section 6.4.4.

Soil contamination could occur as a result of any accidental spills or leaks of fuels, oils and other chemicals from equipment and vehicles during construction. To avoid this potential impact, fuels and chemicals would be managed in accordance with the management measures provided in Section 6.4.4.

Mine subsidence risk

Areas of backfill

Due to the uncompacted and variable nature of the mine waste below the proposed road alignment, differential settlement of the pavement is anticipated over relatively short distances. This can lead to the formation of small-scale settlement bowls in the pavement that exceed differential settlement (ride comfort) criteria. This would be managed through geotechnical treatments included in the Concept Design.

Underground mine workings

Underground mine workings may cause ground subsidence due to the following mechanisms:

- Failure of the roof, delamination of overlying strata.
- Failure of board and pillar workings due to spontaneous combustion fires removing the pillar support.

The geotechnical investigations determined that the angle of draw from the workings in the Lewis Seam would have the potential to affect the proposal, as shown in Figure 6-10. However, the workings in the Lewis Seam are considered to have a low risk of pillar collapse and a low risk of caving failure reaching the surface.

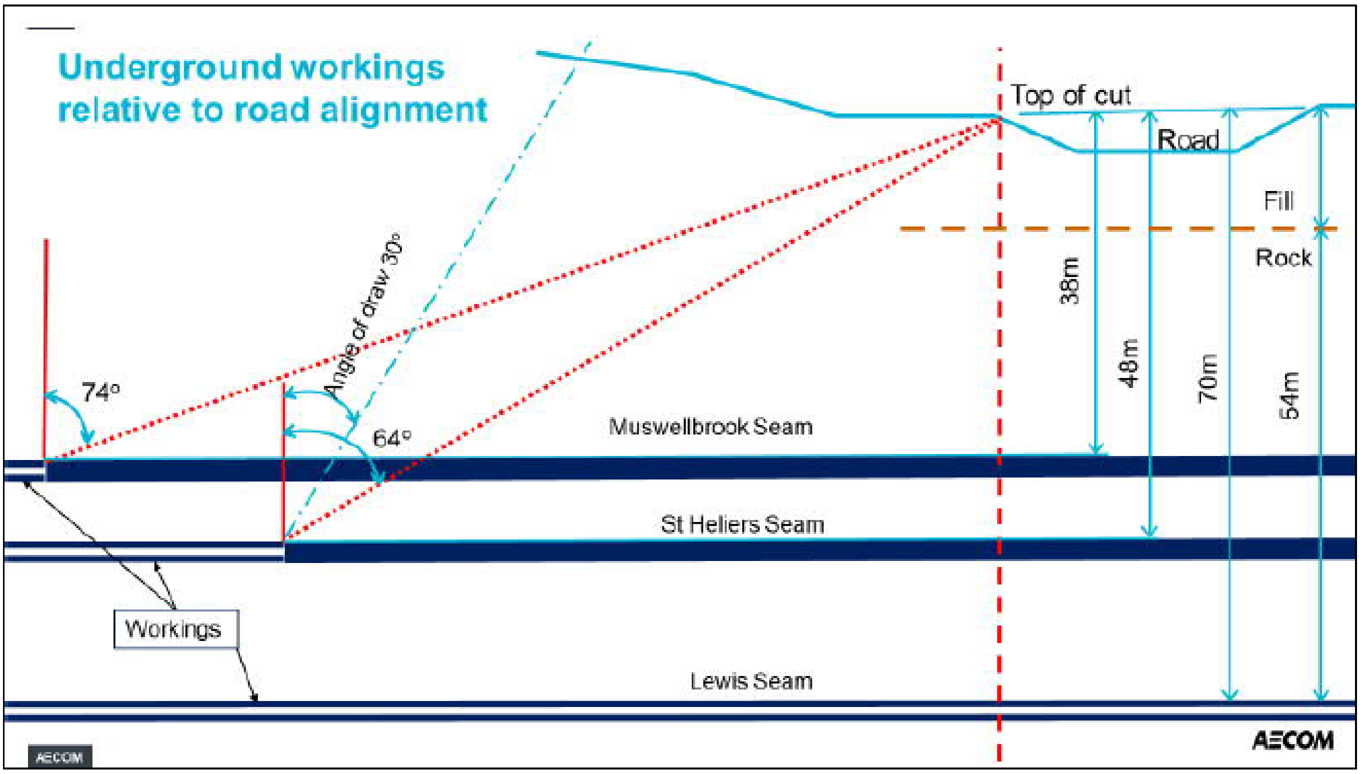


Figure 6-10: Former underground workings relative to the proposed road corridor/alignment

Operation

During the operation of the proposal, the risk of soil erosion would be minor as all areas impacted during construction would be sealed or rehabilitated and landscaped to prevent soil erosion from occurring. There are minor contamination risks associated with the operation of the proposal which would be limited to:

- Spills from industrial heavy vehicles such as oil tankers

- Accidents causing oil and petrol spills.

Spills and other contamination sources during operation would be appropriately managed by implementing standard emergency spill environmental safeguards.

6.4.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Excess spoil	Excess spoil not required or able to be used for backfilling will be stockpiled in a suitable location before being reused or removed from the site, and disposed of appropriately in accordance with the NSW EPA Waste Classification Guidelines (2014)	Construction contractor	Construction	Additional safeguard
Erosion and sedimentation	Erosion and sediment controls will be implemented before any construction starts and inspected regularly, particularly after a rainfall event. Maintenance work will be carried out as needed	Construction contractor	Construction	Additional safeguard
Erosion and sedimentation	Site stabilisation of disturbed areas will be carried out progressively as stages are completed	Construction contractor	Construction	Additional safeguard
Erosion and sedimentation	All stockpiles will be designed, established, operated and decommissioned in accordance with Roads and Maritime Stockpile Management Guideline (RTA, 2011)	Construction contractor	Construction	Additional safeguard
Erosion and sedimentation	The rehabilitation of disturbed areas will be undertaken progressively as construction stages are completed, in accordance with: • The NSW Soils and Construction – Managing Urban Stormwater Volume 1 “the Blue Book” (Landcom, 2004) and Volume 2 (DECC, 2008) • Landscape Guideline (RTA 2018) • Guideline for Batter Stabilisation using Vegetation (Roads and Maritime 2015)	Construction contractor	Construction	Additional safeguard
Erosion and sedimentation	Batters will be designed and constructed to minimise risk of exposure, instability and erosion, and to support long-term, on-going best practice management, in accordance with *Guideline for Batter Surface Stabilisation using Vegetation* (Roads and Maritime 2015)	Transport and Construction contractor	Detailed design and construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
Tracking of soil off site	Controls will be implemented at exit points to minimise the tracking of soil and particulates onto pavement surfaces	Construction contractor	Construction	Additional safeguard
Contamination	A Phase II Environmental Site Assessment (ESA) will be prepared to quantify potential areas of contamination and to better inform the CEMP	Transport	Pre-construction	Additional safeguard
Contamination	The CEMP will include an unexpected finds protocol for potentially contaminated material encountered during construction work	Construction contractor	Construction	Additional safeguard
Contamination	Should contamination which may pose potential risk to human health and the environment be encountered during construction, further assessment may be required following consultation with Transport environmental staff	Construction contractor	Construction	Additional safeguard
Contamination	If contaminated areas are encountered during construction, appropriate control measures will be implemented to manage the immediate risks of contamination. This may include but not be limited to: • Diversion of surface runoff • Capture of any contaminated runoff • Temporary capping All other works that may impact on the contaminated area will cease until the nature and extent of the contamination has been confirmed and any necessary site-specific controls (for the proposed road corridor) or further actions identified in consultation with the Transport Environment Manager and/or the EPA are implemented	Construction contractor	Construction	Additional safeguard
Contamination	An Asbestos Management Plan (AMP) will be developed and implemented to manage asbestos and asbestos containing material if encountered during the construction. The AMP will include: • Identification of potential asbestos on site • Procedures to manage and handle any asbestos • Mitigation measures if asbestos is encountered during construction • Procedures for disposal of asbestos in accordance with the NSW EPA	Construction contractor	Construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	guidelines, Australian Standards and relevant industry codes of practice			

Other safeguards and management measures that would address potential impacts to soil and contamination are identified in Section 6.2 and 6.3.

6.5 Traffic and Transport

6.5.1 Methodology

A comprehensive traffic study was carried out which involved analysing traffic data, updating, recalibrating and revalidating an existing road based Paramics traffic model for the morning (AM) and afternoon (PM) peak traffic conditions and assessing future traffic performance of bypass options. Refer to *Muswellbrook Bypass, Traffic and Options Modelling Report* (Arcadis, 2018) and *Addendum No. 1 – The Proposal: Additional Traffic Modelling* (Arcadis, July 2021) (Appendix K).

6.5.2 Existing environment

Existing road network

The New England Highway is a key strategic road forming part of the Sydney to Brisbane corridor of the National Land Transport Network. It is a major freight and commuter route between Newcastle and the Upper Hunter with about 14 per cent of traffic movements being heavy vehicles. The route of the New England Highway through Muswellbrook causes safety and local amenity concerns, does not cater well for the movement of over-dimension loads, and reduces heavy vehicle efficiency. Within the town centre, there are conflicting demands on the New England Highway (Bridge Street), between light vehicles undertaking local trips (shopping, employment and school), and heavy vehicles, particularly longer articulated vehicles which predominantly undertake long haul trips.

The highway currently passes through multiple sets of traffic signals and a roundabout, through a school zone and under a narrow railway overpass.

The highway largely has a four-lane cross-section for the majority of the route through Muswellbrook, but includes a two-lane section between the Sydney Street (Denman Road) intersection, and the Bridge Street roundabout, passing over Muscle Creek, and under the Main North railway line.

Key Roads

The New England Highway, shown in Figure 6-11 runs north-south through the centre of Muswellbrook, and is the major road corridor in the area. From the southern extent of the bypass corridor near the Muscle Creek Road intersection, the highway traverses undulating terrain on the approach to the southern outskirts of the town. After making a 90 degree right turn at the Muswellbrook – Denman Road/Sydney Street intersection, it passes under the railway before proceeding through the CBD. Further north, it again crosses the railway and traverses the river flats on the approach to Sandy Creek Road and the effective highway departure from Muswellbrook continuing toward Aberdeen and Scone.

In addition to the highway there are two major roads that run west of the town along the Hunter River, namely Denman Road to Denman and Wybong Road to Wybong.

There are two local road accesses to Muswellbrook from the east, effectively joining the existing highway at either end of the bypass corridor namely Muscle Creek Road and Sandy Creek Road. They provide highway connections for farming properties south and north of the town respectively, and in the case of Sandy Creek Road, access to the St Helliers Correctional Centre on the northern outskirts of town.

A third road to the east of the township is Coal Road which provides access to Muswellbrook Waste Management Facility. Bell Street and Victoria Street, also to the east of the township, provide the current heavy vehicle bypass due to access constraints from the rail underpass. Further to the south-east, Muscle Creek Road connects to Muswellbrook Coal Mine for access to its operations via a section of private haul road within the mine property holdings.

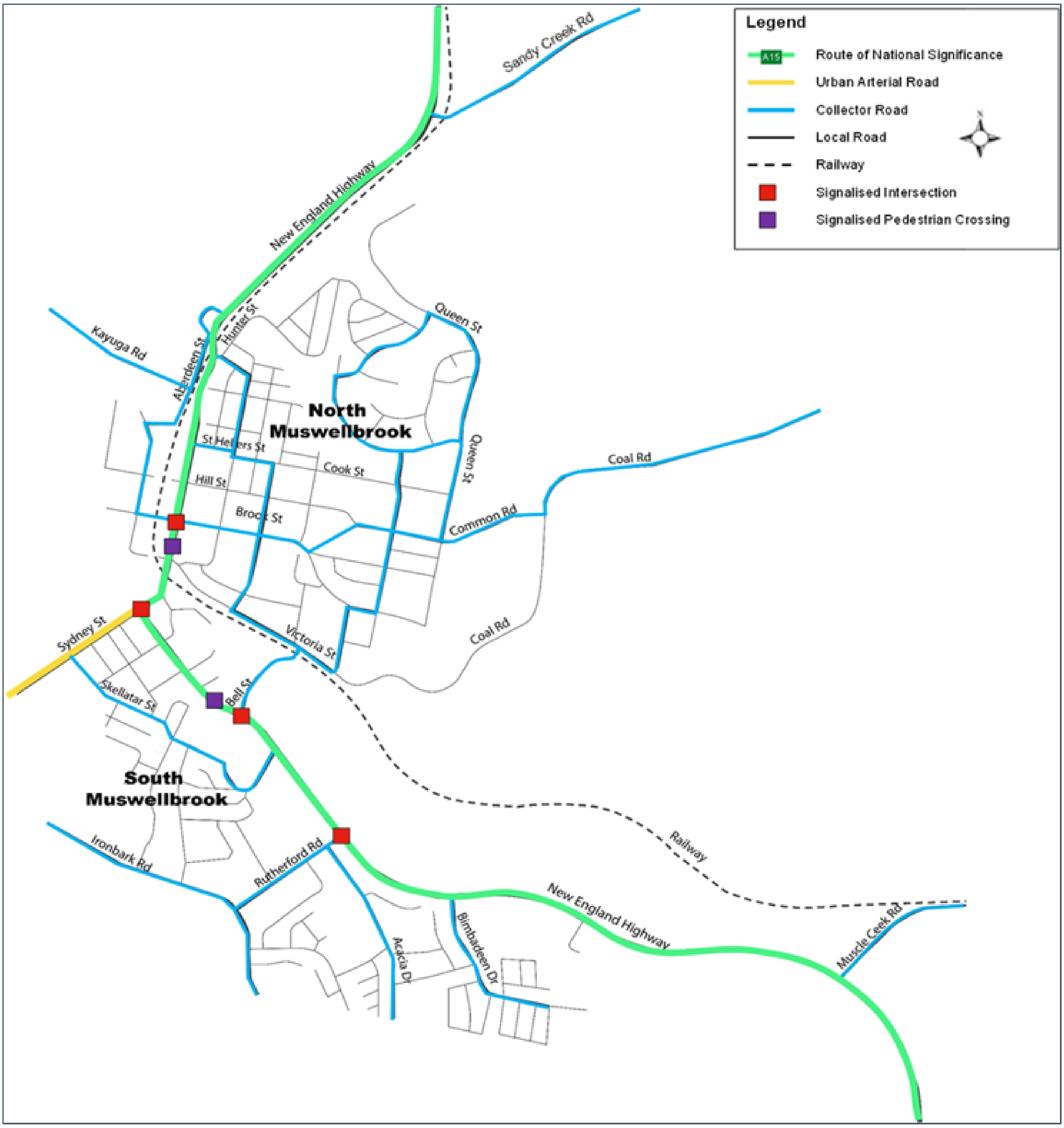


Figure 6-11: Existing road network for the Muswellbrook area

Parking facilities

On-street kerbside parking (parallel) is provided on one or both sides of New England Highway as it passes through the commercial area of Muswellbrook. The majority of the on-street kerbside parking has timed restrictions in place as it serves retail establishments.

Heavy vehicles

The New England Highway is a major freight route between Newcastle, Maitland and the Upper Hunter. It is classified as a B-double route for trucks up to 25/26 metres in length, as shown in Figure 6-12. Sandy Creek Road is also classified as a B-double route for trucks up to 19 metres in length, with some time-of-day restrictions on school days.

Figure 6-12: B-double routes

Existing traffic conditions

Traffic volumes

Traffic data including daily midblock traffic counts, intersection turning movement counts, travel time surveys and 24-hour origin destination (OD) surveys were collected to support the development of the proposal traffic modelling. The results are documented in the *Muswellbrook Bypass, Traffic and Options Modelling Report*, 2018 (refer to Appendix K) and summarised in Table 6-16 and Source Arcadis 2018 Figure 6-13.

The traffic surveys (light and heavy vehicles) identified:

- On an average weekday, the New England Highway carried 9,600 and 19,500 vehicles per day depending on locations
- Daily traffic on the New England Highway in the southern part of Muswellbrook varied significantly, with 9,600 vehicles per day south of Muscle Creek Road increasing to about 18,900 vehicles per

day west of Rutherford Road. The increase in traffic along the New England Highway is contributed to by local traffic predominately generated to and from the southern Muswellbrook urban area

- Traffic on New England Highway (Bridge Street) increases from about 18,900 to 19,500 vehicles per day through the Muswellbrook town centre, south of Brook Street. The higher traffic volumes on this section of New England Highway, compared to those to the north and south, demonstrate the high contribution made by local trips within the study area, particularly from Muswellbrook South via Denman Road and Sydney Street
- Denman Road and Sydney Street provide key access between local mining and agricultural industries and the New England Highway and Muswellbrook Town Centre. The roads carry about 10,200 vehicles per day on the average weekday.

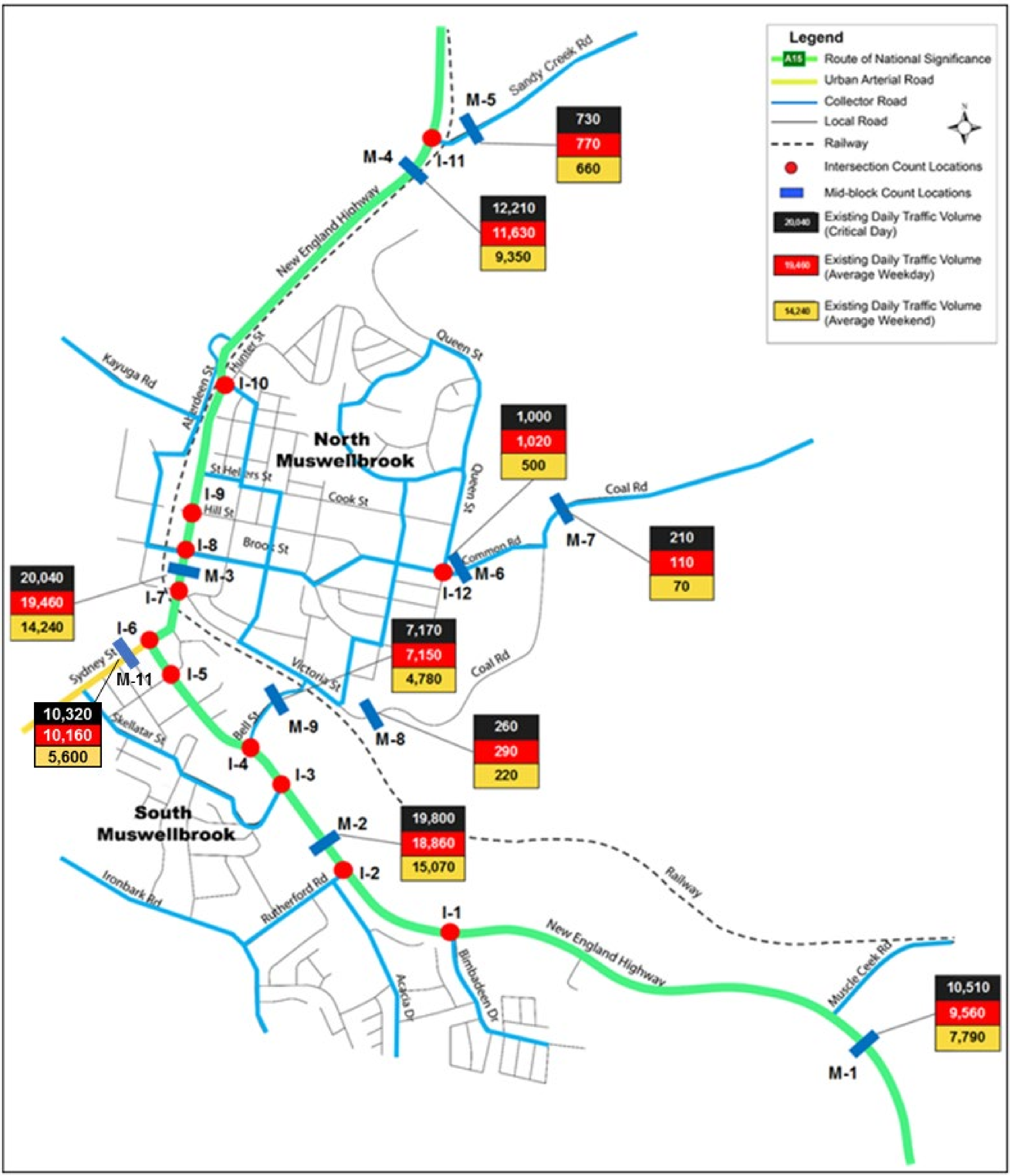
Table 6-16: 2016 traffic volumes – all vehicles

Site ID[1]	**Road Sections**	**Average Weekday**	**Average Weekend**	**Critical day (Friday)**
New England Highway				
M-1	South of Muscle Creek Road	9,560	7,790	10,510
M-2	West of Rutherford Road	18,860	15,070	19,800
M-3	(Bridge Street), South of Brook Street	19,460	14,240	20,040
M-4	South of Sandy Creek Road	11,630	9,350	12,210
Local roads				
M-5	Sandy Creek Road, East of rail crossing	770	660	730
M-6	Common Road, East of Queen Street	1,020	500	1,000
M-7	Coal Road, East of Common Road	220	140	210
M-8	Coal Road, East of Victoria Street	290	220	260
M-9	Bell Street, South of Victoria Street	7,150	4,780	7,170
M-11	Sydney Street, South of Jordan Street(1)	10,160	5,600	10,320

Source: Arcadis, 2018

Note: Volumes are rounded to the nearest ten units. (1) Traffic volumes on Sydney Street, south of Jordan Street (M-11) were obtained from supplemented traffic counts collected in December 2017

1. The location of traffic surveys are illustrated in Source Arcadis 2018
2. Figure 6-13



Source Arcadis 2018

Figure 6-13: Muswellbrook traffic volumes

Heavy vehicles

The New England Highway in Muswellbrook carries a relatively high volume of heavy vehicles. Heavy vehicle analysis showed that on an average weekday:

- The number of heavy vehicles recorded on the New England Highway varied between 1,600 and 2,700 vehicles per day (see Table 6-17)
- On the New England Highway north and south of Muswellbrook, heavy vehicles represented about 24 per cent on the southern side and about 14 per cent on the northern side of the Muswellbrook town centre
- Through the town centre, the proportion of heavy vehicles on the New England Highway, west of Rutherford Road and south of Brook Street was found to be between 10 and 14 per cent of total traffic. The lower proportion of heavy vehicles at these locations is a result of a higher proportion of local light vehicles.

Table 6-17: 2016 traffic volumes – heavy vehicles

Site ID	Road Sections	Average Weekday	Average Weekend	Critical day (Friday)	% Heavy vehicles of total volume	
					Average weekday	Critical Friday
New England Highway						
M-1	South of Muscle Creek Road	2,290	1,030	2,340	24%	22%
M-2	West of Rutherford Road	1,780	890	1,780	10%	9%
M-3	(Bridge Street), South of Brook Street	2,740	1,230	2,710	14%	14%
M-4	South of Sandy Creek Road	1,630	720	1,540	14%	13%
Local Roads						
M-5	Sandy Creek Road, East of rail crossing	100	10	80	13%	11%
M-6	Common Road, East of Queen Street	110	10	130	11%	13%
M-7	Coal Road, East of Common Road	80	5	70	35%	33%
M-8	Coal Road, East of Victoria Street	70	10	50	24%	19%
M-9	Bell Street, South of Victoria Street	450	230	470	6%	7%
M-11	Sydney Street, South of Jordan Street(1)	610	170	570	6%	6%

Source: Arcadis, 2018

Origin destination survey

- OD surveys were carried out for the development of the traffic model. For all traffic (heavy and light vehicles), the through traffic proportion on the New England Highway was found to be about 35 per cent in the northbound direction and about 29 per cent in the southbound direction
- Heavy vehicle through traffic contributed over half, with 56 per cent northbound and 59 per cent in the southbound direction.

Travel times and speeds

- Travel time analysis of the existing highway through Muswellbrook shows that vehicles took between 10 and 11 minutes to travel on the New England Highway between Muscle Creek Road and Sandy Creek Road. The average travel speed was between 49 and 51 kilometres per hour, less than the posted speeds of 50 and 60 kilometres per hour in urban areas, and 100 kilometres per hour on the urban fringe
- The travel speed on the New England Highway between Lorne Street and Brook Street (through the town centre) was lower still at between 18 kilometres per hour and 28 kilometres per hour, which is considerably lower than the posted speed limit of 50 kilometres per hour.

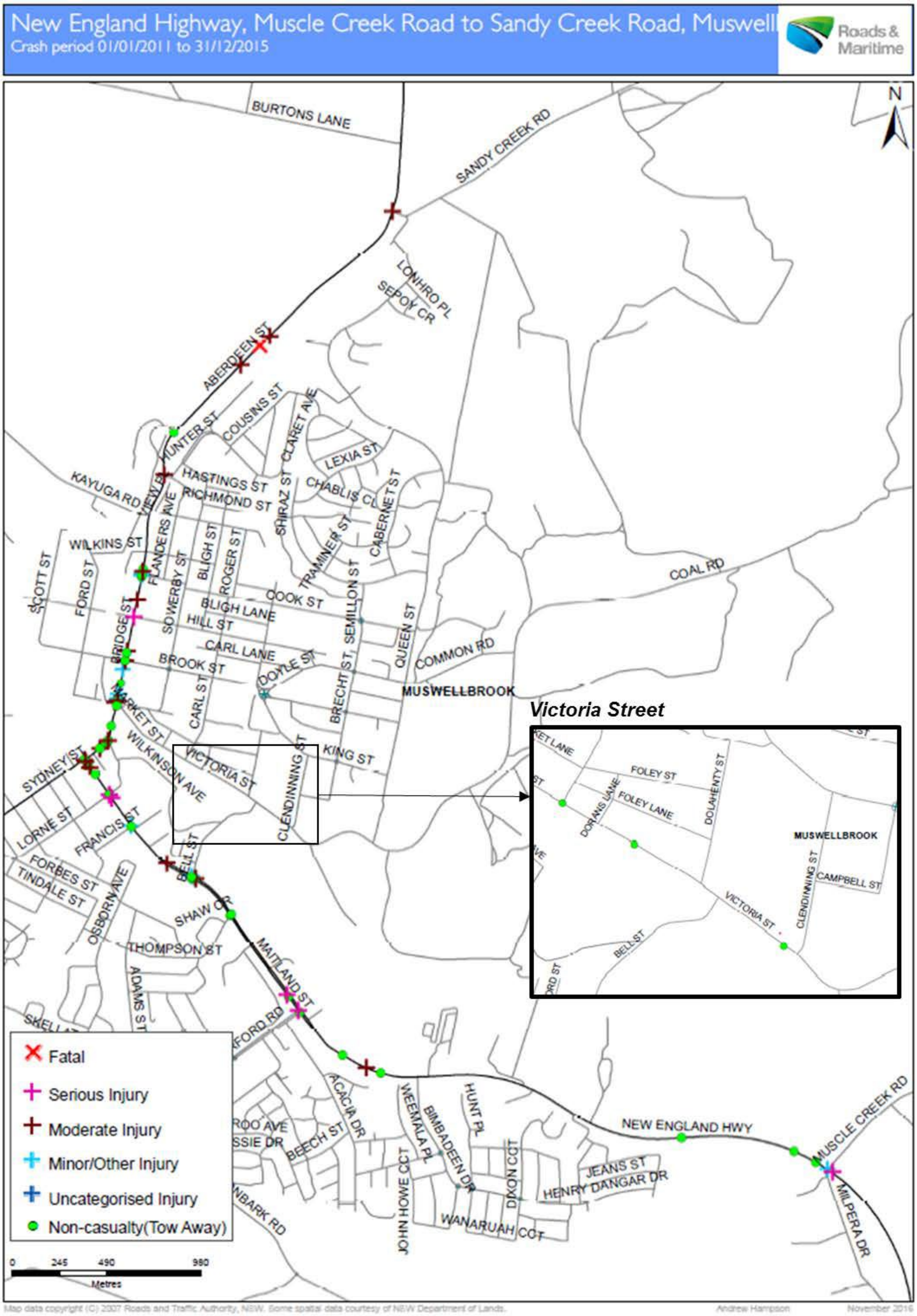
Existing intersection performance

Level of service (LoS) is the standard measure, based on the average delay per vehicle, used to assess the operational performance of intersections. There are six levels of service, ranging from LoS A (the best) to LoS F (the worst). LoS D or better is considered to be an acceptable level of service. Traffic modelling shows that intersections within the study area along the New England Highway currently operate at acceptable LoS of D or better.

Crash data

Source: Arcadis 2018

Figure 6-14 summarises crash data between January 2011 and December 2015 along the New England Highway, and on Victoria Street between Bridge Street and Coal Road within the proposed road corridor. A total of 77 crashes were recorded, which involved 47 casualties. One fatality was recorded during this period. A breakdown of crash severity along the New England Highway is shown in Table 6-18.



Source: Arcadis 2018

Figure 6-14: Crash location and types between 2011 and 2015

Table 6-18: Crash data summary between January 2011 and December 2015

Type	Crashes	Casualties
New England Highway, between Muscle Creek Road and Sandy Creek Road		
Fatal	1	1
Injury	34	46
Non-casualty	42	-
Total – New England Highway	77	47

Source: Arcadis, 2018

Analysis of the crash data for the New England Highway between Muscle Creek Road and Sandy Creek Road indicated the following:

- About 30 per cent of crashes were rear-ends
- About 58 per cent of crashes occurred at an intersection
- More than half of casualty crashes on the New England Highway involved heavy vehicles despite heavy vehicles constituting only about 10 to 20 per cent of the vehicle fleet.

Mode of travel

Travel characteristics for Muswellbrook were based on 2016 Census data. This data provides details on the mode of transport by which residents travelled to work on the day of the Census. The assessment of traffic and transport impacts considered the traffic environment within the boundary of Muswellbrook statistical area SA2 and the Muswellbrook Region statistical area SA2 shown in Figure 6-15. The mode of travel shared for these two key areas are summarised in Table 6-19.

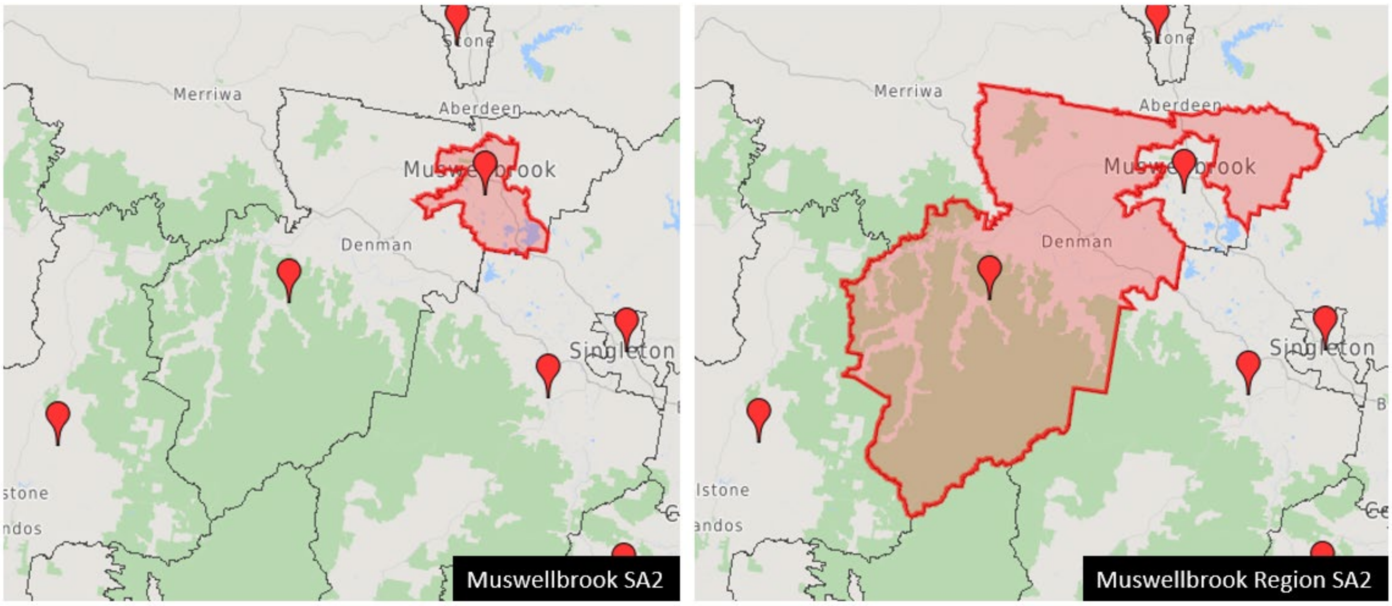


Figure 6-15: Muswellbrook and Muswellbrook Region statistical area boundaries

Private vehicles are the predominant mode of transport for travel to work in Muswellbrook, accounting for about 97 per cent of trips. This could be attributed to the limited public transport services to key employment areas, which is reflected by the low reliance on public transport, accounting for less than one per cent of commuter trips.

Table 6-19: Method of travel to work (2016 Census)

Boundary	Walked	Public transport	Car – driver or passenger	Other
Muswellbrook (SA2)	2%	<1%	97%	<1%
Muswellbrook Region (SA2)	5%	<1%	93%	1%

Source: Australian Bureau of Statistics Interactive Map – Journey to Work Place of Work
Note: excludes those who worked from home or whose mode was not stated

Walking and cycling facilities

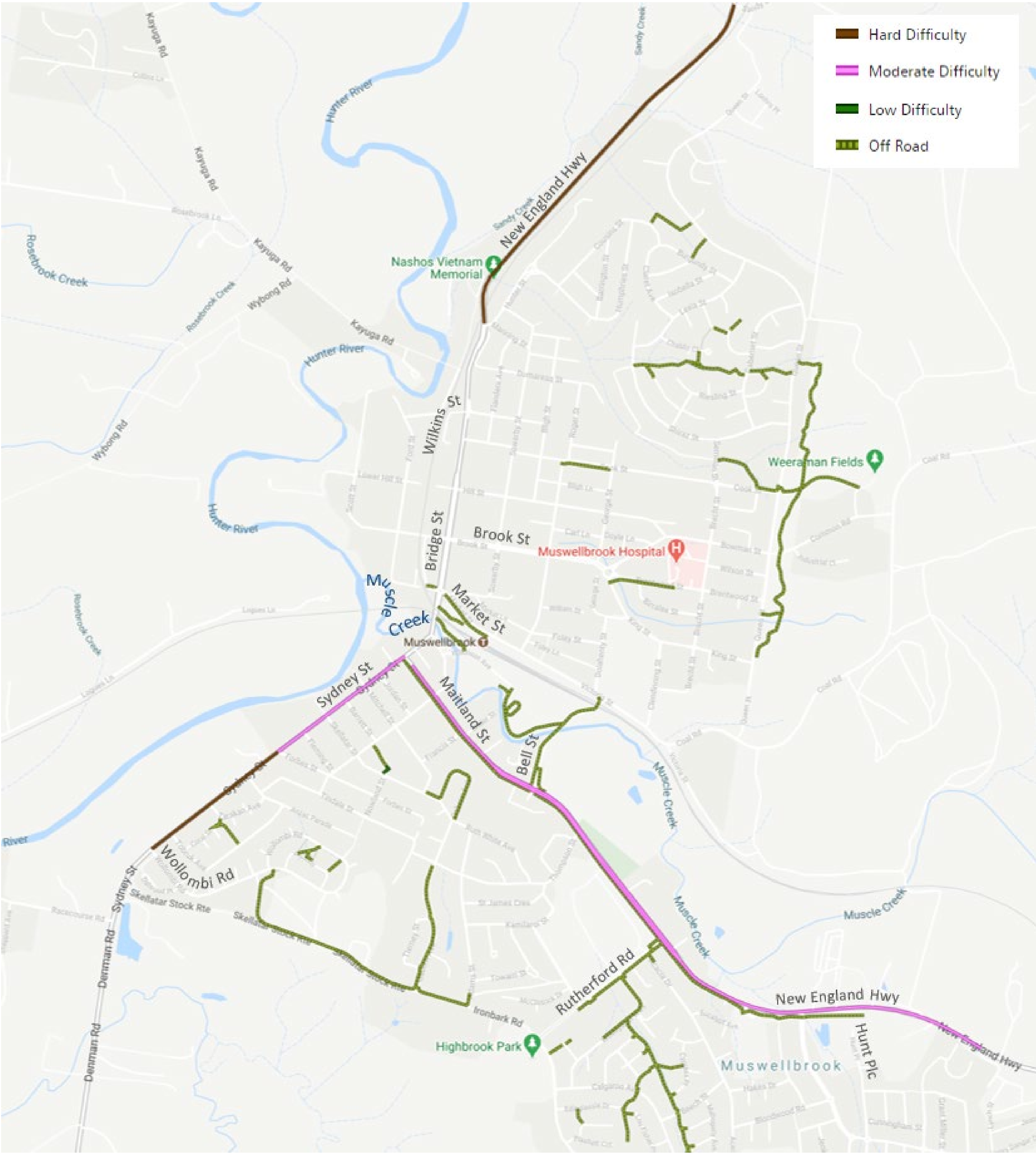
Pedestrian footpaths are provided on both sides of the New England Highway as it passes through Muswellbrook, between Bell Street in the south and Wilkins Street in the north. Footpaths on one side of the New England Highway are also provided as the highway enters Muswellbrook from the east, between Hunt Place and Bell Street.

Along the New England Highway, marked (signalised) pedestrian crossings are provided at the Maitland Street/Bell Street intersection, in front of Muswellbrook South Public School, at the Maitland Street/Sydney Street intersection, and at the Bridge Street/Brook Street intersection.

Cycle routes are provided in select locations close to the New England Highway as shown in Source: Transport for NSW Roads and Maritime Services Cycleway Finder

Figure 6-16:

- An off-road shared path provides cycle access along the southern side of the New England Highway between Hunt Place and Sydney Street
- On-road marked cycle lanes provide an on-road route connecting to the New England Highway from the west along Sydney Street between Wollombi Road and Maitland Street
- Several off-road cycle paths connect into the New England Highway including a connection from the residential area south of the New England Highway at Rutherford Road, and short connections from the north at Bell Street, Muscle Creek and Market Street.



Source: Transport for NSW Roads and Maritime Services Cycleway Finder

Figure 6-16: Bicycle network near Muswellbrook

Public transport services

Rail services

Muswellbrook Station, which is served by the Hunter Line and North Western NSW Line, both operated by NSW TrainLink, is adjacent to the proposed road corridor:

- The Hunter Line through Muswellbrook provides an intercity service between Newcastle and Scone

- The North Western NSW Line is a regional service through the Hunter, New England and North West Slopes and Plains regions.

Table 6-20 summarises the number of train services at Muswellbrook Station.

Table 6-20: Rail services at Muswellbrook Station

Boundary	Description	No. of weekday services	No. of weekend services
Hunter Line	Scone to Newcastle	4	2
	Newcastle to Scone	4	2
North Western NSW Line	Central to Armidale	1	1
	Armidale to Central	1	1

Bus services

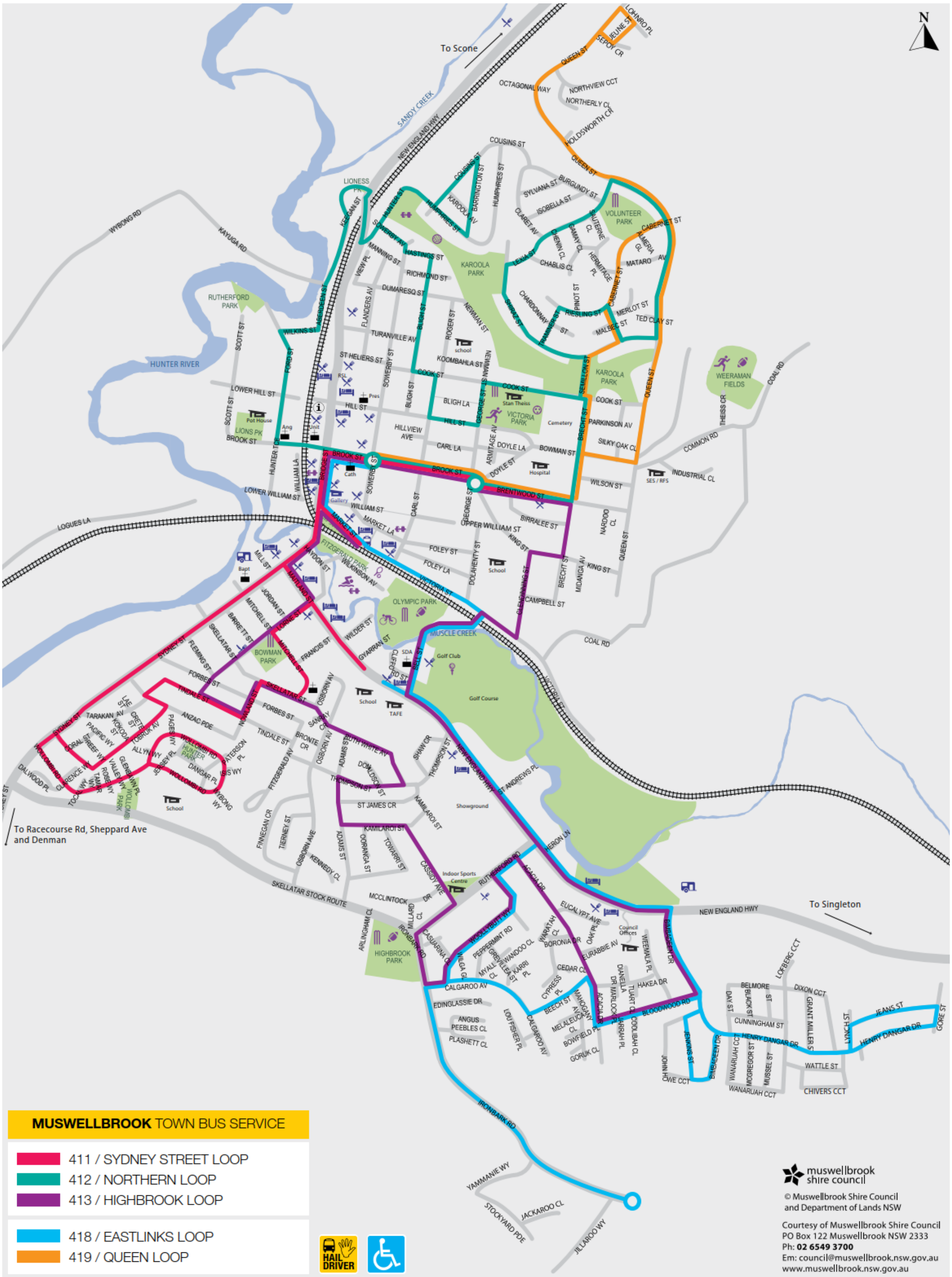
Table 6-21 shows the local bus routes and services provided by Osborn's Transport. These are illustrated in Source: Osborn's Transport Muswellbrook Town Bus Service Timetable (routes to Scone, Denman and Aberdeen not shown on map)

Figure 6-17.

Regional connections to Scone, Aberdeen and Dennam and the number of weekday services are also shown on Table 6-21.

Table 6-21: Bus services at Muswellbrook

Route	Description	No. of weekday services	No. of Saturday services
Muswellbrook town services			
411	Sydney Street Loop (Central town area)	4	3
412	Northern Loop (Northern Town area)	4	3
413	Highbrook Loop (Central town area)	5	3
418	Eastlinks Loop (Southern town area)	5	3
419	Queen Loop (Northern Town area)	4	3
Muswellbrook regional services			
414	Muswellbrook to Scone via Aberdeen	2	-
	Scone to Muswellbrook via Aberdeen	2	-
415	Muswellbrook to Denman Loop	2	-
	Muswellbrook to Denman via Aberdeen and Scone Loop	1	-



Source: Osborn’s Transport Muswellbrook Town Bus Service Timetable (routes to Scone, Denman and Aberdeen not shown on map)

Figure 6-17: Bus routes serving Muswellbrook and surrounding areas

6.5.3 Potential impacts

Construction

A qualitative traffic impact assessment has been carried out and is summarised below.

Construction footprint and construction site locations

The construction footprint for the proposal is shown in Figure 3-6 along with construction compounds and facilities at the following locations:

- Southern connection main site construction compound
- Northern connection main site construction compound
- Skellatar Ridge cutting satellite compound
- Coal Road satellite compound
- Sandy Creek and Main North rail line laydown area.

Traffic impacts

Construction vehicles would access the site via arterial roads wherever possible. Indicative construction traffic access points are shown in Figure 3-6 and would generally be via the New England Highway and Denman Road, with use of Sandy Creek Road and Muscle Creek Road to access the construction footprint.

Indicative heavy vehicle haulage routes have been identified for the movement of spoil between different areas of the proposal. The routes to and from the New England Highway are also shown Figure 3-6. The haulage routes have been designed to avoid use of local roads, where possible. As shown in Figure 6-12, the New England Highway, Denman Road and the section of Muscle Creek Road utilised for the proposed haulage routes are classified as B-double routes for vehicles 25 to 26 meters in length. Sandy Creek Road is also classified as a B-double route but with a restriction to 19 meter B-double trucks only, and with travel not permitted between 7.30 am and 8.30 am, and 3.45 pm and 4.45 pm on school days.

The number of construction vehicle movements has been estimated to be up to 220 light and 300 heavy vehicles per day during peak construction periods across all ancillary facilities.

Heavy vehicle movements, which are likely to have the largest impact, would mainly be related to earthworks or spoil movement, but would also include other movements such as girder delivery and plant delivery. As noted, heavy vehicles would only access construction sites from approved heavy vehicle routes.

Existing traffic flows on the New England Highway are substantially greater than the proposed construction traffic numbers. The existing traffic flows are over 1,500 heavy vehicles from 7am to 6pm each weekday and over 350 heavy vehicles from 8am to 1pm each Saturday. During peak construction periods, it is expected that 300 heavy vehicle movements would be generated by construction works along the proposal per day. Broken down across the 11-hour weekday construction period, from 7am to 6pm, this means that on average there would be one heavy vehicle movement every two minutes. Modelling results for existing intersection performance shows that the intersections which would be used by heavy vehicles to access the construction sites from the New England Highway, have excess capacity and generally perform at LoS A or B. Therefore, construction traffic, including earthworks truck movement, is likely to have a minor impact on existing traffic operations.

While it is expected that construction activities would generate fewer light vehicles compared to heavy vehicles, the light vehicle movements are likely to occur during the AM and PM peak periods as workers access the northern connection main site construction compound and the southern connection main site construction compound, which are the two construction sites with parking. These two construction compounds would need to be accessed via the New England Highway/Sandy Creek Road and the New England Highway/Muscle Creek Road intersections. As previously mentioned, it is expected that these intersections would have excess capacity, and it is therefore expected that they would have enough capacity to accommodate the additional light vehicle movements generated by construction activities.

Most construction work would be carried out separate to the existing road network, during standard working hours and so would be unlikely to impact traffic operations. It is expected that some work, including tie-in work would be undertaken outside of standard working hours under a Road Occupancy Licence (ROL) to avoid impacts during peak traffic periods. Where practical, heavy vehicle movements would be outside the traffic peak hours to minimise impacts on the existing road network operation during construction.

Impacts to traffic on the New England Highway during construction would be temporary in nature. The movement of construction and service vehicles along New England Highway and access roads, for the haulage of construction materials would give rise to traffic impacts. As described above, construction sites would be primarily accessed via approved heavy vehicle routes.

Potential traffic impacts arising from the construction of the proposal include:

- Increased travel time due to reduced speed limits around construction sites
- Increased travel time due to increased truck and construction machinery movements
- Temporary lane closure and altered property accesses during construction. Property access would be maintained as far as practicable throughout construction.

Measures to manage potential construction traffic impacts are listed in Section 6.5.4.

Walking and cycling facilities

It is not expected construction work would impact any existing pedestrian access routes or crossings. Construction work is also not expected to impact off-road cycle paths or on-road cycle lanes with the exception of the on-road cycle route shown in Source: Transport for NSW Roads and Maritime Services Cycleway Finder

Figure 6-16, along the New England Highway, near the intersection of Sandy Creek Road. This route could be temporarily impacted during activities required for the tie-in of the New England Highway at the northern connection.

It is anticipated that construction work would be carried out in a manner to ensure that public access routes are maintained and pedestrian and cyclist diversions are minimised. This would be documented in the Traffic Management Plan (TMP) for the proposal.

Public transport

The proposal is not expected to disrupt public transport. All existing bus and train services would be maintained during construction, with potential for minor delays to bus services due to construction speed limits. Through the implementation of the community engagement plan, the community, including public transport operators, would be informed of upcoming activities that may affect the operation of public transport.

Operational

Traffic impacts

The traffic assessment included modelling for future years 2027, 2034 and 2044 to assess the impact of the proposal once operational. On year of opening (2027), the proposal is expected to remove up to 4,800 vehicles per day (including about 1,900 heavy vehicles).

Table 6-22 shows forecast average weekday traffic volumes and heavy vehicles on the bypass.

Table 6-22: Daily traffic forecasts on bypass

Road section	Vehicle type	Forecast average weekday traffic (vehicles)	
		2027	2044
Bypass – northern section between Sandy Creek Road and Coal Road	All vehicles	5,080	6,420
	Heavy vehicles	1,920	2,710
	% Heavy vehicles	38%	42%
Bypass – southern section between Coal Road and Muscle Creek Road	All vehicles	4,770	6,040
	Heavy vehicles	1,870	2,650
	% Heavy vehicles	39%	44%

Figure 6-18 and Table 6-23 summarise traffic forecast (all vehicles) in future year 2044 at key locations with and without the bypass.

In 2044, the proposal would reduce through traffic volumes by up to 5,900 vehicles per day from New England Highway between Muscle Creek Road and Sandy Creek Road. This represents an expected traffic reduction of between 23 and 46 per cent, along sections of the New England Highway through Muswellbrook Town Centre. The bypass would reduce traffic flows on Bell Street by about 14 per cent. Traffic increase is predicted on Common Road and Coal Road by about 2,060 vehicles per day.

Table 6-23: Forecast 2044 daily traffic volumes

Site ID	Road / Location	Forecast Average Weekday Traffic (All Vehicles) in 2044			
		Without Bypass	With Bypass	Change	% Change
M-1	New England Highway, South of Muscle Creek Road	12,900	12,900	0	0%
M-10	New England Highway, East of Bimbadeen Drive	11,700	6,260	▼-5,440	▼-46%
M-2	New England Highway, West of Rutherford Road	24,900	19,460	▼-5,440	▼-22%
M-3	New England Highway, South of Brook Street	26,000	20,070	▼-5,930	▼-23%
M-4	New England Highway, South of Sandy Creek Road	15,000	10,180	▼-4,820	▼-32%
M-9	Bell Street, South of Victoria Street	10,000	8,670	▼-1330	▼-14%

Site ID	Road / Location	Forecast Average Weekday Traffic (All Vehicles) in 2044			
		Without Bypass	With Bypass	Change	% Change
M-6	Common Road, East of Queen Street	1,160	3,220	▲2,060	▲178%
M-7	Coal Road, east of Common Road	260	2,320	▲2060	▲792%
B-1	Bypass, between Muscle Creek Road and Coal Road	-	6,420	6,420	-
B-2	Bypass, between Coal Road and Sandy Creek Road	-	6,040	6,040	-

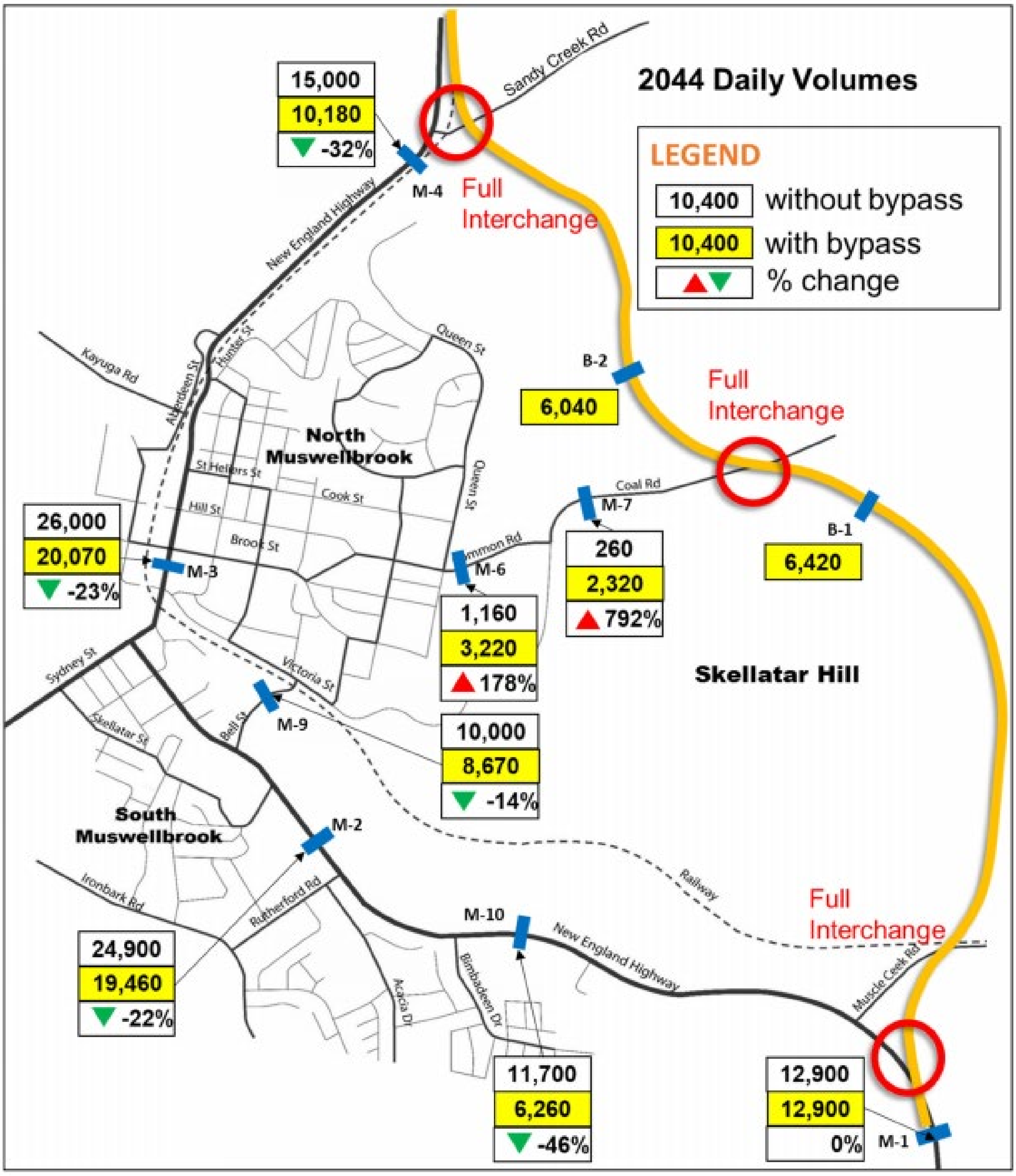


Figure 6-18: Impact of bypass on New England Highway

Forecast heavy vehicles on Bypass

Table 6-24 summarises forecast heavy vehicles at key locations with and without the bypass in 2044. The heavy vehicle reductions on the New England Highway are shown in Figure 6-19.

In 2044, the bypass would remove up to 2,500 heavy vehicles per day from the New England Highway between Muscle Creek Road and Sandy Creek Road. The heavy vehicle reductions are estimated to be between 58 and 86 per cent on the New England Highway through the Muswellbrook Town Centre.

As a consequence, the bypass would:

- Improve network efficiency on the New England Highway; particularly travel times for long haul freight movements.
- Improve safety for all road users in the town centre, particularly relating to heavy/light vehicle interaction.

- Improve amenity of Muswellbrook Town Centre.

The bypass would fundamentally change the traffic conditions on the existing New England Highway through Muswellbrook, reducing traffic and noise, reducing traffic-related mental and physical health impacts for both motorists and residents living near major arterial surface roads in the area such as Maitland Road and Bridge Street, and enable urban revitalisation, in line with council's Muswellbrook Town Centre Strategy (2017). The bypass would also be likely to reduce the number of casualty crashes in Muswellbrook, considering more than half of casualty crashes currently involve a heavy vehicle.

Table 6-24: Forecast 2044 daily heavy traffic volumes

Site ID	Road / Location	Forecast Average Weekday Traffic (All Vehicles) in 2044			
		Without Bypass	With Bypass	Change	% Change
M-1	New England Highway, South of Muscle Creek Road	3,580	3,580	0	0%
M-10	New England Highway, East of Bimbadeen Drive	3,470	1,320	▼-2,150	▼-62%
M-2	New England Highway, West of Rutherford Road	2,770	620	▼-2150	▼-78%
M-3	New England Highway, South of Brook Street	4,370	1,830	▼-2,540	▼-58%
M-4	New England Highway, South of Sandy Creek Road	2,680	370	▼-2,310	▼-86%
M-9	Bell Street, South of Victoria Street	710	430	▼-280	▼-39%
M-6	Common Road, East of Queen Street	160	440	▲280	▲175%
M-7	Coal Road, east of Common Road	130	410	▲280	▲215%
B-1	Bypass, between Muscle Creek Road and Coal Road	-	2,710	2710	-
B-2	Bypass, between Coal Road and Sandy Creek Road	-	2,650	2650	-

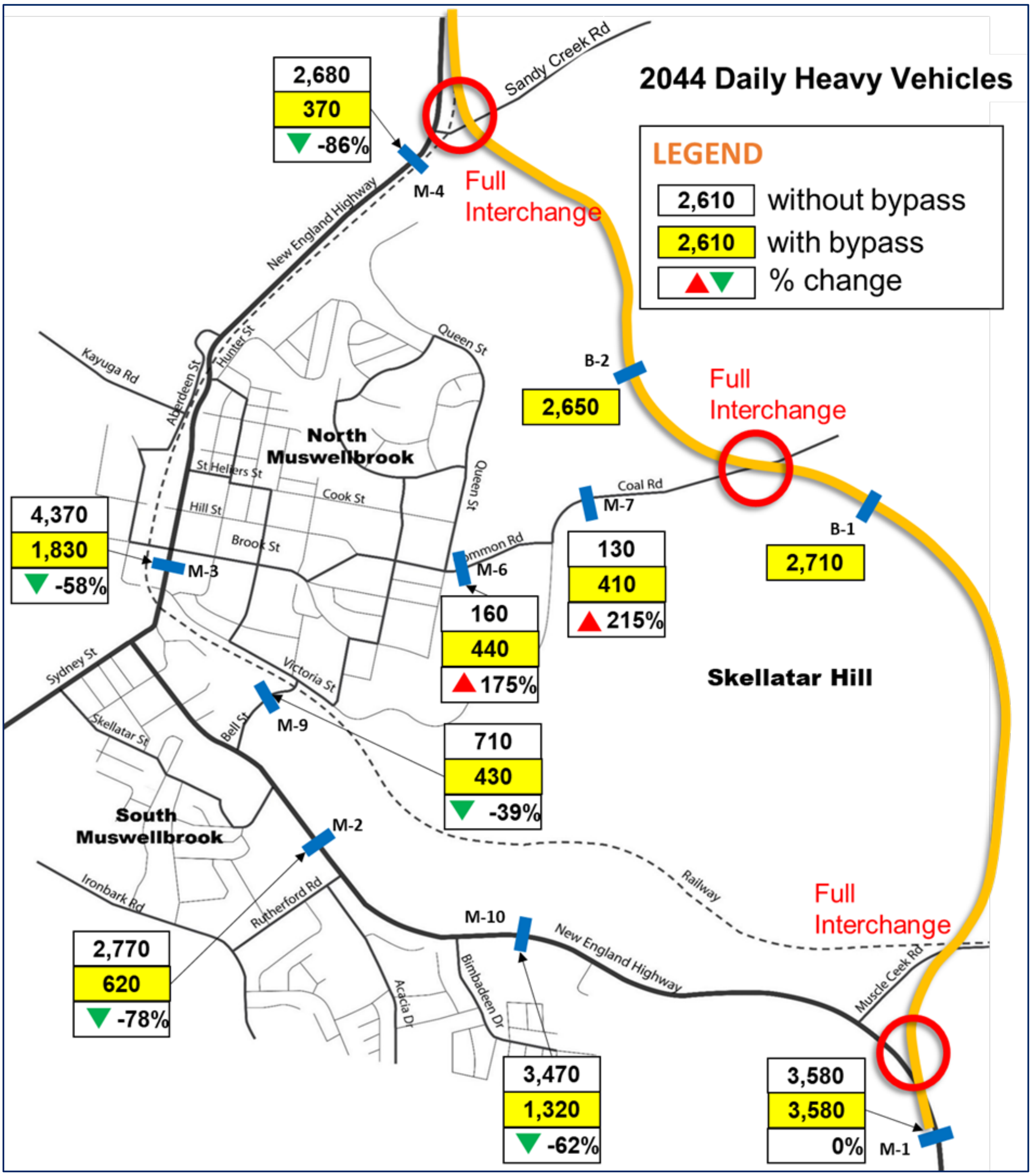


Figure 6-19: Forecast 2044 daily heavy vehicles with bypass

Future intersection performance

Traffic modelling indicates without the proposal in 2044, there would be significant delays for vehicles with the New England Highway/Hill Street intersection operating at LoS F in the AM peak and LoS F at several intersections along the New England Highway within the study area in the PM peak. With the proposal, an overall improvement in the performance of key intersections in the study area including Muswellbrook town centre is expected, with most forecast to operate at LoS C or better during the peak periods assessed.

Travel time savings

The forecasted travel times for the base case and travel time saving with the proposal for the 2044 AM and PM peak are shown in Table 6-25.

Table 6-25: Forecast 2044 Travel Time Saving for Bypass vs Base Case

Travel time via	**Distance***	**Forecast 2044 Travel Time (minutes)**			
		AM Peak		PM Peak	
		Northbound	Southbound	Northbound	Southbound
New England Highway	10.7 km	13.6	13.2	14.8	13.9
Full bypass (the proposal)	9.5 km	7.4	7.9	7.7	8.4
Travel time savings		6.1 ▼	5.3 ▼	7.1 ▼	5.5 ▼

* New England Highway between 1.3 kilometres south of Muscle Creek Road and 1.1 kilometres north of Sandy Creek Road

On the existing New England Highway (base case), motorists travel 10.7 kilometres between 1.3 kilometres south of Muscle Creek Road and 1.1 kilometres north of Sandy Creek Road, and pass multiple sets of traffic signals with speed limits between 50 kilometres per hour and 70 kilometres per hour (including a temporary 40 kilometres per hour school zone). On the bypass, motorists would travel 9.5 kilometres at a posted speed limit of 100 kilometres per hour.

In 2044, base case journey time during peak periods on the New England Highway between Muscle Creek Road and Sandy Creek Road without the proposal is predicted to vary between 13.2 and 14.8 minutes.

The bypass provides a shorter travel distance (9.5 kilometres) and with a posted speed limit of 100 kilometres per hour is predicted to save between 5.3 and 7.1 minutes during peak travel times by 2044. The highest travel time saving is predicted in the PM peak (northbound) of 7.1 minutes.

On-street parking

The operation of the proposal would not impact on-street parking.

Pedestrian and cycling facilities

There are no anticipated impacts on existing pedestrian and cyclist facilities because of the proposal.

The reduction of traffic along the New England Highway through Muswellbrook could improve traffic conditions for cyclists, potentially allowing this section of the New England Highway to form part of the on-road cycle route. Cyclists would be able to use the road shoulders on the bypass.

Public transport

There are no anticipated impacts on local public transport because of the proposal. No dedicated bus facilities would be removed or provided by the proposal.

Some bus services could experience travel time improvements due to the reduction in traffic volumes along the New England Highway.

Road user safety

The safety of all road users including pedestrians, cyclists and motorists would be expected to improve once the bypass is operational. The diversion of traffic, in particular heavy vehicles, to the bypass would reduce the volume of traffic through Muswellbrook and this in turn is expected to reduce the number of crashes.

Property access

Any properties affected by changed access arrangements, as a result of the proposal, would be provided with restored or new permanent access arrangements. This includes modifications to the existing connections of the New England Highway with Milpera Drive, Muscle Creek Road, Burtons Lane and Koolbury Flats Row, as detailed in Section 3.

6.5.4 Safeguards and management measures

Impact	Environmental Safeguards	Responsibility	Timing	Reference
Traffic and Transport	A Traffic Management Plan (TMP) will be prepared and implemented as part of the CEMP. The TMP will be prepared in accordance with the Transport for NSW *Traffic Control at Work Sites Manual* (Transport for NSW, 2020) and *QA Specification G10 Control of Traffic* (Transport for NSW, 2020). The TMP will include: • Confirmation of haulage routes • Measures to maintain access to local roads and properties • Site specific traffic control measures (including signage) to manage and regulate traffic movement • Measures to maintain pedestrian and cyclist access • Requirements and methods to consult and inform the local community of impacts on the local road network • Access to construction sites including entry and exit locations and measures to prevent construction vehicles queuing on public roads. • A response plan for any construction traffic incident • Consideration of other developments that may be under construction to minimise traffic conflict and congestion that may occur due to the	Construction contractor	Pre-construction	Additional safeguard

Impact	Environmental Safeguards	Responsibility	Timing	Reference
	cumulative increase in construction vehicle traffic • Monitoring, review and amendment mechanisms			
Access to properties	Disruptions to property access and traffic will be notified to landowners at least five days prior in accordance with the relevant community consultation processes outlined in the TMP	Transport	Detailed design	Additional safeguard
Access to properties	Where any legal access to property is permanently affected, arrangements for appropriate alternative access will be determined in consultation with the affected landowner and local road authority	Construction contractor and Transport	Detailed design	Additional safeguard
Access to properties	Access to properties will be maintained during construction. Where that is not feasible or necessary, temporary alternative access arrangements will be provided following consultation with affected landowners and the relevant local road authority	Construction contractor and Transport	Construction	Additional safeguard
Local road condition	Pre-construction and post construction road condition reports for local roads likely to be used during construction will be prepared. Any damage resulting from construction (not normal wear and tear) will be repaired unless alternative arrangements are made with the relevant road authority. Copies of road condition reports will be provided to the local roads authority	Construction contractor	Pre and post construction	Additional safeguard
Pedestrian and cyclist access	Pedestrian and cyclist access will be maintained throughout construction. Where that is not feasible or necessary, temporary alternative access arrangements will be provided following consultation with affected landowners and the local road authority	Construction contractor	Construction	Additional safeguard

6.6 Noise and vibration

This section summarises the results of the noise and vibration technical report prepared for the proposal which is provided in Appendix L.

6.6.1 Methodology

The assessment involved a quantitative assessment of construction noise and vibration and operational noise, prepared with consideration of the following key guidelines:

- Construction noise:
  - Construction Noise and Vibration Guidelines (Roads and Maritime, 2016)
  - Interim Construction Noise Guideline (ICNG) (DECC, 2009)
- Construction vibration:
  - Assessing Vibration: a technical guideline (NSW DEC, 2006)
  - DIN 4150:Part 3-1999 Structural vibration – Effects of vibration on structures (Deutsches Institut für Normung, 1999)
  - Evaluation and Measurement for Vibration in Buildings Part 2, (British Standard (BS) 7385:Part 2-1993) (BS 7385)
- Operational traffic noise:
  - NSW Road Noise Policy (DECCW 2011)
  - Noise Criteria Guideline (Roads and Maritime, 2015a)
  - Noise Mitigation Guideline (Roads and Maritime, 2015b)
  - Model Validation Guideline (Roads and Maritime, 2018)
  - Application Notes – Noise Criteria Guideline (Roads and Maritime, 2015a)
  - Environmental Noise Management Manual (Roads and Maritime, 2001)
  - Procedure for Preparing an Operational Noise and Vibration Assessment (Roads and Maritime, 2011b)
  - Draft At-Receiver Treatment Guideline (Roads and Maritime, 2017)
- Sleep disturbance during construction:
  - NSW Road Noise Policy (DECCW, 2011)
  - Noise Policy for Industry (NSW Environment Protection Authority (NSW EPA), 2017).

The assessment involved:

- Identifying sensitive receivers
- Monitoring background noise levels including traffic counts for background road traffic noise
- Assessing potential noise and vibration impacts by comparing predictions against relevant criteria
- Providing mitigation where required.

6.6.2 Existing environment

The noise and vibration impact assessment has considered two study areas:

- Construction noise assessment study area which comprises three noise catchment areas (NCAs) as identified in Figure 6-20. Receivers within each NCA are expected to experience similar existing background noise levels based on the results of site observations and background noise monitoring.
- The operational road traffic noise study area extends to where noise levels are dominated by other roads that are not being assessed as part of this proposal, as detailed in the Noise Criteria Guideline. This is up to a maximum distance of 600 m from the centre line of the outermost traffic lane on each side of the road under consideration and is shown in Figure 6-21.

At the southern and northern ends of the construction footprint, the noise environment is dominated by traffic flows on the New England Highway. Mining activities also contribute to the noise environment towards the northern section and rail movements on the Main North railway line contribute to the noise environment throughout the noise study area.

The noise environment in the mid-northern section of the construction footprint is rural/suburban. Noise sources include local traffic within Muswellbrook and rail movements on the Main North railway line and mining activities to the north-east.

Noise sensitive receivers

Noise sensitive receivers were identified using aerial photography. The uses of all buildings within the study area were determined through a ground-truthing site survey exercise completed on Thursday 20 July 2020. This exercise, in conjunction with cadastral information, was used to determine the classification of residential, commercial, industrial, recreational and other uses (e.g. unoccupied sheds). These noise sensitive receivers are presented in Appendix A of Appendix L.

Non-residential receivers sensitive to the proposal are identified in Table 6-26.

Table 6-26: Non-residential receivers

Receiver	Address	Receiver Type
Kingdom Hall of Jehovah's Witnesses	88 Sandy Creek Road, Muswellbrook	Place of Worship
Weeraman Fields	8 Thiess Crescent, Muswellbrook	Active Recreation
Shelley's Family Day Care	82 Aberdeen Street, Muswellbrook	Childcare Centre

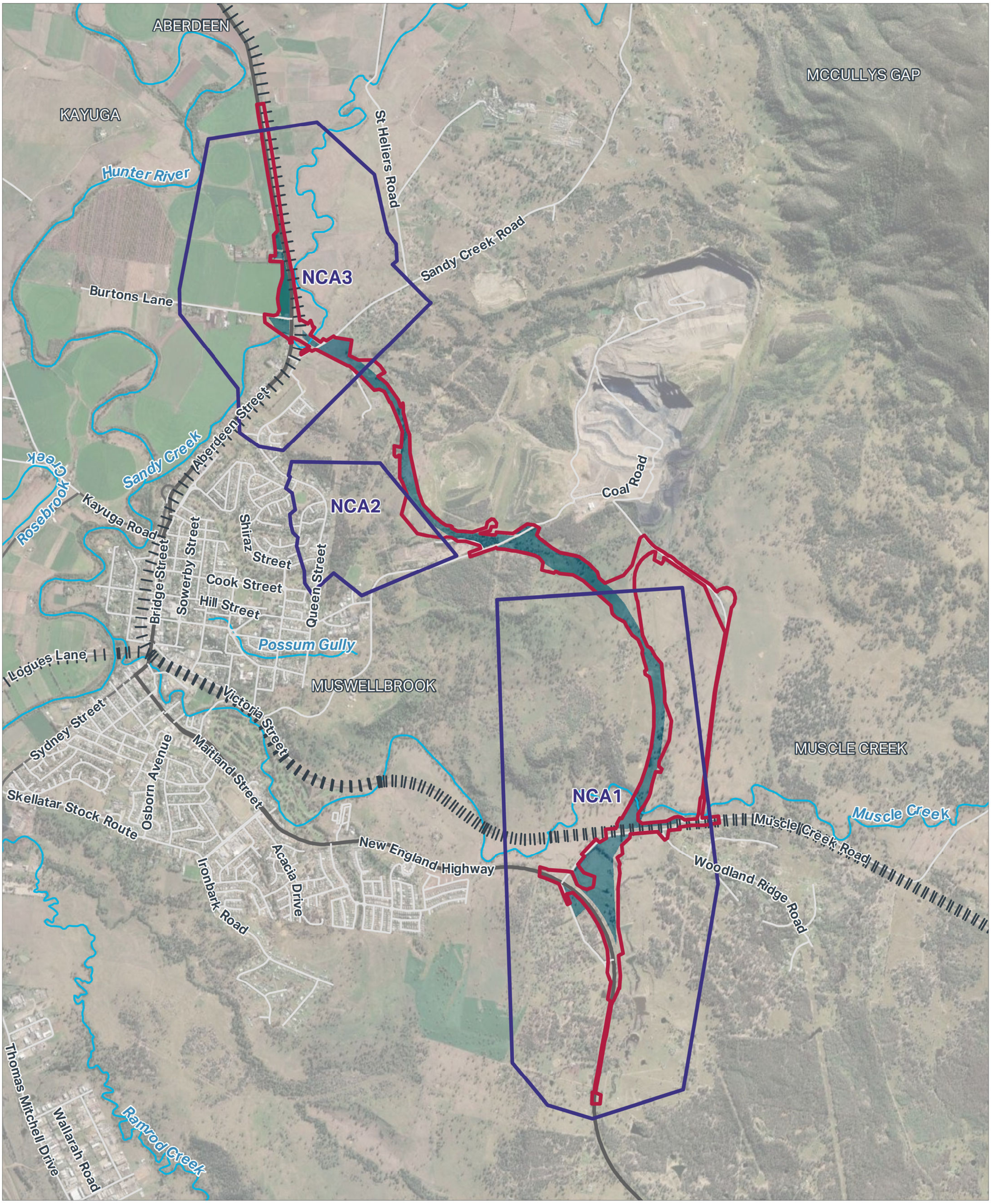


FIGURE 6-20: CONSTRUCTION NOISE CATCHMENT AREAS

0 0.5 1 km

AECOM

Legend

- Construction footprint
- Proposed road corridor
- Noise catchment area
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse

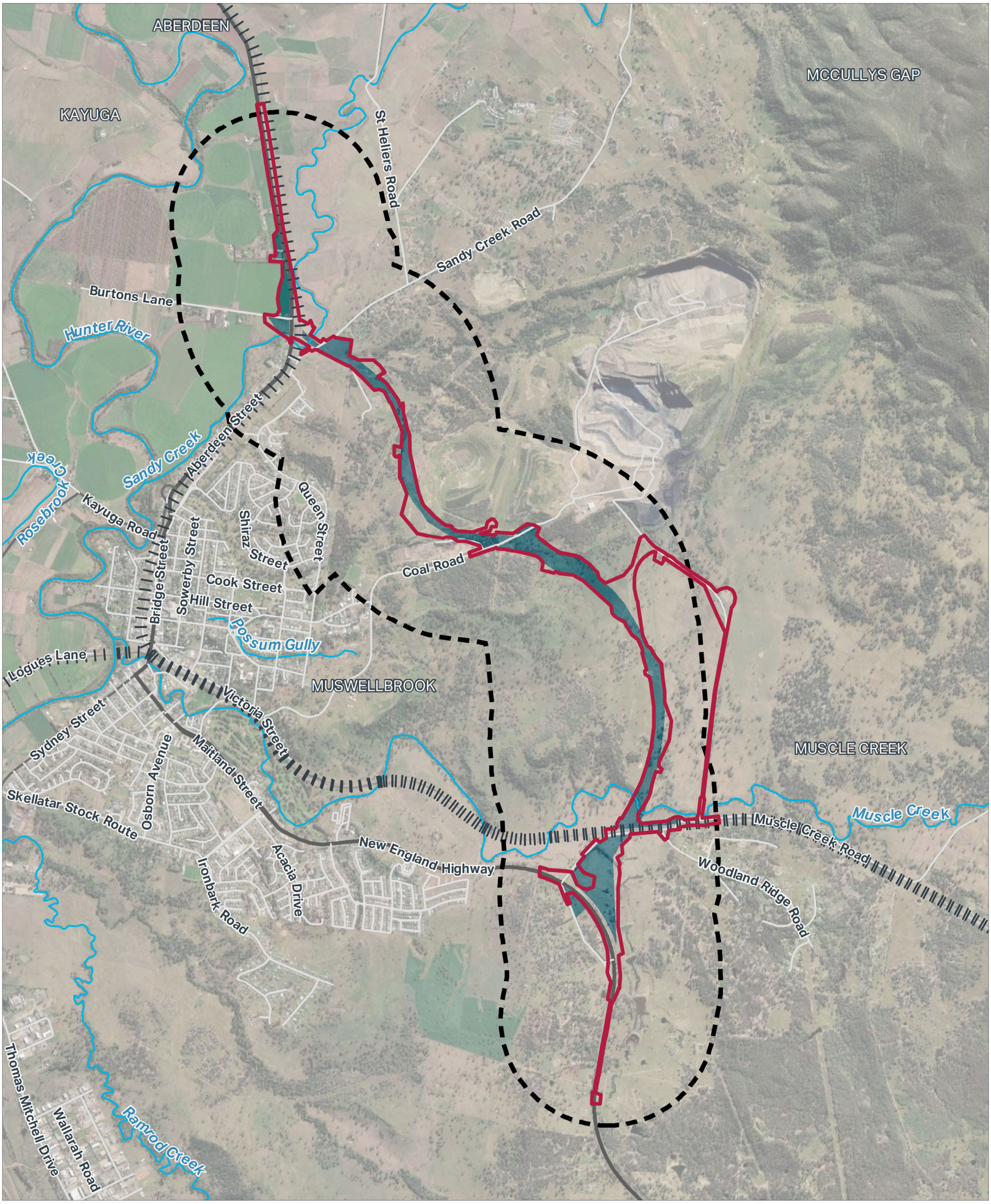


FIGURE 6-21: OPERATIONAL NOISE STUDY AREA

0 0.5 1 km

Legend

- Construction footprint
- Proposed road corridor
- Study area
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse

Background noise levels

Ambient noise monitoring was carried out at six locations as listed in Table 6-27 between 30 July and 26 August 2020. Concurrent traffic counts were carried out during the monitoring period. These data have been used to validate the operational road traffic noise model. Results from the monitoring period have also been used to establish construction noise management levels.

The locations for the unattended noise loggers were determined through examination of aerial photography and site inspections. Attended noise measurements were also carried out to determine the nature of the local noise environment and confirm road traffic as the controlling noise source (for the validation of the operational noise model).

A noise logger measures the noise level over a 15 minute sample period and then determines L_{A1}, L_{A10}, L_{A90}, L_{Amax} and L_{Aeq} levels of the noise environment. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for one per cent, 10 per cent and 90 per cent of the sample period respectively. The L_{Amax} level is the maximum noise level due to individual noise events. The L_{A90} level is taken as the background noise level. The L_{Aeq} level is the energy averaged noise level over the 15 minute period.

The noise logging locations are shown in Appendix A of Appendix L. Photos of the noise loggers and the noise logging results are provided in Appendix B of Appendix L.

Details of each noise logging location and the purpose of each noise logger are provided in Table 6-27 below. As the study areas include receivers at varying distances from the proposed road corridor, noise loggers have similarly been located at varying distances from the existing road alignments. An example of this is NL5 and NL6 below, where noise monitoring was conducted at two setback distances on the same property. This allows the accuracy of the model to be confirmed over the extent of the proposal as recommended in the *Model Validation Guideline*.

Table 6-27: Noise logging locations

Ref No.	Address	Purpose			Measurement period
		Construction	Operational road noise	Maximum noise events	
NL1	8667 New England Highway, Muswellbrook		✓	✓	30 July to 10 August 2020
NL2	56 Woodland Ridge Road, Muscle Creek	✓			30 July to 8 August 2020
NL3	65 Queen Street, Muswellbrook	✓			11 August to 26 August 2020
NL4	18A Lonhro Place, Muswellbrook	✓			30 July to 10 August 2020
NL5	449 New England Highway, Muswellbrook		✓	✓	29 July to 10 August 2020
NL6	449 New England Highway, Muswellbrook		✓		29 July to 10 August 2020

Background noise monitoring results are provided in Table 6-28. These noise levels were used to define the appropriate construction noise management levels, consistent with the *Interim Construction Noise Guideline*.

The assessment background levels (ABL) were established by determining the lowest tenth-percentile level of the L_{A90} noise data acquired over each assessment period of interest. The background noise level or rating background levels (RBL) representing the day, evening and night-time assessment periods were based on the median of individual ABLs determined over the entire monitoring duration.

Table 6-28 presents the ambient L_{Aeq} levels at each monitoring location. The L_{Aeq} level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels.

The noise levels presented in Table 6-28 indicate the noise environment at the measurement locations are typical of those located along major transport corridors in rural/suburban areas.

Table 6-28: Ambient and background noise measurements

Noise catchment area	Noise logger	Location	Rating background level, dB(A)			Ambient noise level, dB(A)		
			Day[1] $L_{A90,15min}$	Evening[1] $L_{A90,15min}$	Night[1] $L_{A90,15min}$	Day[1] $L_{Aeq,15hr}$	Evening[1] $L_{Aeq.4\ hr}$	Night[1] $L_{Aeq,9\ hr}$
NCA1	NL2	56 Woodland Ridge Road, Muscle Creek	33	32	29	55	52	49
NCA2	NL3	65 Queen Street, Muswellbrook	36	36	35	55	51	46
NCA3	NL4	18A Lonhro Place, Muswellbrook	32	35	32	51	47	46

Notes:

1. *Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays and public holidays; Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday and public holidays; Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays and public holidays.*

Table 6-29 presents the logarithmically averaged noise levels measured at each noise monitoring location which have been used for the assessment of road traffic noise. Monitoring locations 1, 5 and 6 (Table 6-27) were used to validate the road traffic noise model as road traffic noise was dominant at these locations and there was a good angle of view to the road to facilitate accurate road traffic noise measurements.

Table 6-29: Measured road traffic noise levels

Noise logger	Location	Measured road traffic noise level, dB(A)	
		Day (7am to 10pm), $L_{Aeq,15hr}$	Day (10pm to 7am), $L_{Aeq,9hr}$
NL2	8667 New England Highway, Muswellbrook	67	63
NL3	449 New England Highway, Muswellbrook	69	65
NL4	449 New England Highway, Muswellbrook	57	55

6.6.3 Criteria

Construction noise criteria were developed in accordance with the *Interim Construction Noise Guideline* for each noise catchment area. Standard construction hours defined in the *Interim Construction Noise Guideline* are:

- 7am to 6pm Monday to Friday
- 8am to 1pm on Saturday
- No work on Sundays or public holidays.

The proposed construction activities are expected to generally occur during standard construction hours. However, some activities would be required to be carried out outside of standard hours. Refer to Section 3.3.3 for further information.

Construction noise management levels have been developed for standard construction hours (day) and outside of standard construction hours (evening and night) based on the background noise levels in Table 6-30. The noise management level represents the point above which there may be some community reaction to noise. The noise management levels are summarised in Table 6-30.

A receiver is considered to be highly noise affected where predicted noise levels exceed 75 dB(A). As outlined in the ICNG, the highly noise affected level represents the point above which there may be strong community reaction to noise.

Table 6-30: Noise catchment areas and construction noise management levels

Noise logger	Location	Period[1]	Rating background level, dB(A)[3]	Construction noise management level
NCA1	NL2 - 56 Woodland Ridge Road, Muscle Creek	Day	33	43
		Evening	32	37
		Night	30[2]	35
NCA2	NL3 - 65 Queen Street, Muswellbrook	Day	36	46
		Evening	36	41
		Night	35	40
NCA3	NL4 – 18A Lonhro Place, Muswellbrook	Day	32	42
		Evening	32[2]	37
		Night	32	37

Notes:

1. *Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays and public holidays; Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday and public holidays; Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays and public holidays.*
2. *In accordance with Noise Policy for Industry Table 2.1, a minimum RBL has been adopted where the measured RBL is less than 35 dB(A) during the day, 30 dB(A) in the evening, or 30 dB(A) at night.*
3. *The Noise Policy for Industry notes that the community generally expects a greater control of noise during the evening and night as compared to the daytime. Therefore, the evening RBL is set to no more than that for the daytime and the night time to no more than the evening.*

The construction noise management levels that apply to other sensitive receivers (when in use) include:

- Schools, hospital, and places of worship – 45 dB(A) internal noise level

- Active recreation – 65 dB(A) external noise level
- Passive recreation – 60dB(A) external noise level
- Industrial properties – 75 dBA(A) external noise level
- Commercial properties – 70 dB(A) external noise level.

Construction road traffic noise

In accordance with the Road Noise Policy a screening test has been carried out to evaluate whether existing road traffic noise levels would increase by more than two dB(A) as a result of the construction of the proposal.

Based on the Road Noise Policy, it is considered where road traffic noise levels already exceed the assessment criteria, an increase of less than two dB(A) represents a minor impact which is barely perceptible to the average person.

Construction vibration criteria

At present, no Australian Standards exist for the assessment of building damage caused by vibration. The *German Standard Structural Vibration Part 3: Effects of vibration on structures, DIN 4150-3 -1999* (DIN 4150) and BS 7385-2 are the relevant standards for construction vibration and are summarised in Table 6-31 and Table 6-32. Structural damage criteria for heritage items have been taken from DIN 4150, while criteria for commercial/residential items have been taken from BS 7385.

Table 6-31: DIN 4150: Structural damage safe limits for building vibration

Group	Type of structure	At foundation at a frequency of:			Vibration at the horizontal plane of the highest floor
		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 (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Table 6-32 BS 7385-2: Transient vibration guide values for cosmetic damage

Group	Type of structure	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	4 Hz to 15 Hz
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	

Group	Type of structure	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	4 Hz to 15 Hz
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Humans are sensitive to vibration such that they can detect vibration levels well below those required to cause any risk of damage to a building or its contents. Criteria to avoid annoyance for intermittent and continuous vibration are provided in *Assessing Vibration: A Technical Guideline* (DEC 2006) and detailed discussion regarding criteria for human comfort is provided in Appendix L.

Ground-borne noise

Vibration generated by activities such as piling may enter buildings via the ground. This may cause the floors, walls and ceilings to vibrate and to radiate noise. This noise is commonly referred to as ground-borne noise. Ground-borne noise is typically low frequency and if audible, is perceived as a 'rumble'.

In general, ground-borne noise level values are relevant only where they are higher than the airborne noise, such as where construction work is being carried out within a cutting which would provide shielding to airborne noise. Ground-borne noise from construction would typically be masked by airborne noise associated with construction activities and/or traffic.

The ground-borne noise management levels as outlined in the *Interim Construction Noise Guideline* are presented in Table 6-33. These levels are applicable during the evening and night-time periods only in residential properties, as the objective is to protect the amenity and sleep of people when they are at home.

Table 6-33: Recommended ground-borne noise goals for construction

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

Blasting

Blasting is currently proposed to take place for excavation of material for earthworks. Construction blasting can result in two adverse environmental effects – airblast and ground vibration. The airblast and ground vibration produced may cause human discomfort and may have the potential to cause damage to structures, architectural elements, and services.

Three guidelines have been considered as part of this assessment:

- Australian and New Zealand Environment Council (ANZEC) Guidelines – Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration
- Australian Standard 2187.2-2006 Explosives - Storage and Use Part 2: Use of Explosives – Appendix J
- T0083 – NEG-SM22 Blasting Near Ausgrid Substations and Power Lines.

The ANZEC Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration has been adopted by the EPA, as it includes comfort criteria to minimise annoyance and discomfort to persons at noise sensitive sites (e.g. residences, hospitals, schools etc) as a result of blasting. The guidelines are not intended to provide structural damage criteria. However, they do provide a conservative approach to the assessment of potential impacts on structures, as minimising human annoyance and comfort would inherently minimise structural damage.

AS 2187.2 recommends ground vibration limits which are consistent with the ANZEC guidelines but provides more detail with respect to criteria for human comfort and structural damage. This includes consideration of different types of structures such as more sensitive masonry and plasterboard buildings and less sensitive reinforced concrete buildings. AS 2187.2-2006 notes that damage (even of a cosmetic nature) has not been found to occur at air blast levels below 133 dB (linear peak).

TransGrid guideline T0083 provides specific criteria to minimise the likelihood of damage to Ausgrid's assets where blasting is being carried out. TransGrid guideline T0083 recommends both air blast overpressure and peak particle velocity (PPV) limits for substation equipment and/or buildings.

The air blast overpressure for substation equipment or buildings should not exceed:

- 133 dB (linear) peak for any blasts.

The following site asset protection PPV limit should apply within the substation boundary:

- 20 mm/s for 90 per cent of blasting events over a rolling period of 12 months
- Maximum 25 mm/s for any one blasting event.

A detailed discussion regarding criteria for blasting is provided in Appendix M.

Sleep disturbance

Guidance provided in the Road Noise Policy for assessing the potential for sleep disturbance recommends to minimise the risk of sleep disturbance during the night-time period (10pm to 7am), the noise level outside a bedroom window should not exceed the background noise level by more than 15 dB(A). Construction noise sleep disturbance criteria have been developed in accordance with the Road Noise Policy and are summarised in Table 6-34.

The Road Noise Policy contains a review of research into sleep disturbance which represents NSW EPA advice on the subject of sleep disturbance due to noise events. It concludes 'Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions'. Therefore, given a conservative minimum outside-to-inside attenuation of 10 dB(A) on the basis of open windows for natural ventilation , external noise levels of 60-65 dB(A) are unlikely to result in awakening reactions.

Table 6-34: Construction noise sleep disturbance criteria

NCA	Rating background level, dB(A)	Sleep disturbance screening LA1(1min) criteria, dB(A)	Sleep disturbance awakening reaction LA1(1min) criteria, dB(A)
NCA1	30	45	65
NCA2	35	50	65
NCA3	32	47	65

Operational road traffic noise criteria

Operational road traffic noise criteria are assigned to sensitive receivers using the Roads and Maritime's Noise Criteria Guideline. The Noise Criteria Guideline provides guidance on how to apply the Road Noise Policy. Criteria are based on the road development type which is affecting the residential receiver. The operational criteria for residential land use are summarised in Table 6-35.

In some instances, residential receivers may be exposed to noise from both new and redeveloped roads. Where this occurs, the proportion of noise from each road is used to establish transition zone criteria. Noise contours were developed to calculate transition zones in accordance with the Noise Criteria Guideline (refer to Appendix E of Appendix L).

Table 6-35: Operational noise criteria

Noise logger	Type of proposal/land use	Measured road traffic noise level, dB(A)	
		Day (7am to 10pm),	Night (10pm to 7am),
Freeway/ arterial/ sub arterial	Existing residences affected by noise from new freeways/arterial/sub-arterial road corridors	LAeq(15 hr) 55 (external)	LAeq(9 hr) 50 (external)
	Existing residences affected by noise from redevelopment of existing freeways/arterial/sub-arterial roads	LAeq(15 hr) 60 (external)	LAeq(9 hr) 55 (external)
	Existing residences affected by both new roads and the redevelopment of existing freeway/arterial/sub-arterial roads in a Transition Zone[1]	Between LAeq(15 hr) 55-60 (external)	Between LAeq(9 hr) 50-55 (external)
	Existing residences affected by increases in traffic noise of 12 dB(A) or more from new freeway/arterial/sub-arterial roads[2]	Ranges between LAeq(15 hr) 42-55 dependent on existing traffic noise level (external)	Ranges between LAeq(15 hr) 42-50 dependent on existing traffic noise level (external)

Notes:

1. *The criteria assigned to a façade depend on the proportion of noise coming from the existing road. Refer Roads and Maritimes' Noise Criteria Guideline for further information*
2. *The criteria at each façade are determined from the existing traffic noise level plus 12 dB(A).*

The criteria for non-residential sensitive receivers are summarised in Table 6-36. For schools, places of worship and childcare facilities, the Noise Criteria Guideline criteria are based on internal noise levels when in use.

Table 6-36: Road traffic noise assessment criteria for non-residential land use

Existing sensitive land use	Assessment criteria		Additional considerations
	Day (7am to 10pm),	Night (10pm to 7am),	
1. School classrooms	$L_{Aeq(1\ hr)}$ 40 (internal)	-	In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000)
3. Places of worship	$L_{Aeq(1\ hr)}$ 40 (internal)	$L_{Aeq(1\ hr)}$ 40 (internal)	The criteria are internal, i.e. 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

Existing sensitive land use	Assessment criteria		Additional considerations
	Day (7am to 10pm),	Night (10pm to 7am),	
			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 passive recreation criteria (see row 5 Open space (passive use) of this table) may be applied
4. Open space (active use)	$L_{Aeq(15\ hr)}$ 60 (external)	-	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading 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, e.g. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses
8. Child care facilities	Sleeping rooms $L_{Aeq(1\ hr)}$ 35 (internal) Indoor play Areas $L_{Aeq(1\ hr)}$ 40 (internal) Outdoor play Areas $L_{Aeq(1\ hr)}$ 55 (external)		Multi-purpose spaces, e.g. 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

6.6.4 Potential impacts

Construction

The following work would be carried out along the length of the proposed alignment:

- Vegetation clearing
- Earthworks and drainage

- Processing of materials
- Site establishment including setting up of ancillary facilities
- Utility adjustments/ relocation
- Bridge construction
- Pavement works
- Finishing works including landscaping, asphalting, line marking and signage as well as street furniture installation
- Removal of ancillary facilities.

For each ancillary facility and along the construction footprint, predicted noise levels for each construction scenario have been assessed against the relevant noise criteria. A summary of the results of the assessment is provided below and detailed noise predictions are provided in Section 4 of Appendix L.

Standard hours

Potential exceedances of noise management levels at residential receivers would occur in all NCAs. Activities along the proposal alignment area and activities at the northern connection main site construction compound are likely to affect the greatest number of residential receivers. Receivers closest to the proposal have the highest potential for impact.

The earthworks and pavement works are likely to cause the largest number of exceedances of the noise management levels. Most exceedances would be less than 10 dB(A). However, a number of exceedances of greater than 20 dB(A) are predicted. Residential receivers in NCA3 have the greatest potential for impact. Up to four receivers in NCA3 are predicted to be highly noise affected during earthworks and one receiver during pavement works along the alignment area. Up to two receivers in NCA1 are also predicted to be highly noise affected during earthworks along the alignment area.

It should be noted that due to the proximity of the northern connection main site construction compound and the Sandy Creek and main north rail line laydown area, simultaneous operation of these sites may result in higher noise levels than predicted for each site individually. Therefore, the cumulative impacts of these facilities have also been assessed in addition to their individual construction noise contribution (see Section 4.3 of Appendix L). The affected catchment for both facilities would be NCA3. Most exceedances would be less than 10 dB(A) however some exceedances between 10 dB(A) and 20 dB(A) are predicted during each stage, with one receiver potentially experiencing exceedances over 20 dB(A) during the utility relocation and vegetation clearing works.

Other potential noise impacts from construction activities during standard hours include:

- Noise levels at one non-residential receiver (Shelley's Family Day-care) is expected to exceed the noise management levels during earthworks along the construction footprint. During this stage of construction, noise levels are predicted to be 80 dB(A) LAeq,15min.
- Noise levels at the Kingdom Hall of Jehovah's Witnesses, are expected to exceed the relevant noise management level. This exceedance is predicted to be less than five dB(A) during works at the northern connection main site construction compound.

Out of hours work

Construction activities have the potential to exceed noise management levels at residential receivers outside of standard hours in all NCAs. Consistent with the activities during standard hours, activities outside of standard hours along the proposal alignment area and activities at the northern connection main site construction compound are likely to affect the greatest number of residential receivers.

For the alignment work, 162 receivers across all NCAs would be impacted by the bridge construction work and 171 receivers across all NCAs would be impacted by finishing work when conducted outside of standard hours. Noise management level exceedances are generally less than 15 dB(A), however a number of exceedances of greater than 25 dB(A) are predicted. The bridgeworks and finishing works along the proposal alignment are likely to cause exceedances of the noise management levels at about 109 residential receivers for each activity in NCA3. It should be noted the majority of work along the alignment would be carried out during standard hours. However, work may be carried out outside these hours to minimise traffic and rail disruptions and to offset wet weather delays.

Noise levels from the work associated with the Coal Road satellite compound are not predicted to exceed the noise management levels at any nearby receivers during out-of-hours work.

Predicted noise levels are representative of the worst case 15 minute period of construction activity, while the construction equipment is at the nearest location to each sensitive receiver location. The assessed scenario does not represent the ongoing day to day noise impact at noise sensitive receivers for an extended period of time.

Particularly noisy activities are those which include 'annoying' characteristics such as tonality, low frequency noise, impulsive or intermittent noise events at nearby residences. Such activities include piling and use of concrete saws, which would not persist for the entire construction period. In addition, the predictions use the shortest separation distance to each sensitive receiver. However, in reality separation distances would vary between plant and sensitive receivers.

For linear work (work which moves along the road alignment, rather than work located at a construction ancillary facility), noise exposure at each receiver would reduce as the work progress along the alignment. The reported maximum noise level is for the highest noise level during that construction scenario.

The reported number of receivers where noise levels are expected to exceed the noise management levels is based on the reported maximum noise level. The maximum noise level is based on reasonable worst-case instantaneous operating conditions (occurring over a short duration). However, typically noise levels would be substantially less than this and therefore noise impacts from maximum noise level events would be of a reduced magnitude.

A range of safeguards and management measures would be implemented to manage potential noise impacts during and outside of standard hours. The measures are outlined in Section 6.6.5.

Construction sleep disturbance

Exceedances of the sleep disturbance and awakening reaction criteria are predicted at a number of properties in each NCA. The largest numbers of these exceedances are associated with bridge and finishing work along the proposal alignment in the vicinity of NCA1, NCA2 and NCA3. Sleep disturbance exceedances are predicted for about 164 properties for the bridge construction, with noise levels at nine properties exceeding the awakening reaction criterion.

For the finishing work, disturbance exceedances are predicted for 71 properties, with noise levels at three properties exceeding the awakening reaction criterion.

NCA 3 is the worst affected catchment area, with sleep disturbances predicted at up to 109 properties during the bridge construction and at up to 52 properties during the finishing work. It should be noted the alignment works are progressive in nature, and therefore receivers would not be affected for the whole duration of construction works.

The simultaneous operation of the northern connection main site construction compound and the Sandy Creek and main north rail line laydown area, would exceed the sleep disturbance criterion at about 60 properties in NCA3, with one property exceeding the awakening reaction criterion.

A range of safeguards and management measures would be implemented to manage potential sleep disturbance impacts. The measures are outlined in Section 6.6.5.

Construction road traffic noise

Construction vehicle movements would be in the order of 220 light and 300 heavy vehicles per day during peak construction periods across all ancillary facilities. Vehicles would access an ancillary facility primarily via the New England Highway. Heavy vehicles would only access a facility from approved heavy vehicle routes.

Construction traffic is not anticipated to exceed the +2 dB(A) screening criterion for construction road traffic noise. Therefore, no further consideration of construction traffic noise is necessary in this assessment. The full assessment is shown in Section 4.5 of Appendix L.

Construction vibration

Construction activities would result in a short-term increase in localised vibration levels. Vibration impacts focus on potential structural damage in close proximity to construction activities. Furthermore, it is possible that local sensitive receivers may perceive construction vibration at times. The level of annoyance, however, would depend on individuals.

Plant and equipment needed for the proposal would be determined during the construction planning phase. Table 6-37 provides safe working buffer distances required to comply with the human comfort, cosmetic damage, standard dwelling and heritage building structural damage criteria for equipment likely to be used for the proposal. Other equipment may be used, however it is anticipated that they would produce similar vibration levels. It is considered unlikely that vibration intensive plant would be operated within the minimum safe working distances for heritage structures and cosmetic damage outlined below.

Table 6-37: Recommended minimum working distances for vibration intensive plant

Plant item	Rating background level, dB(A)	Minimum working distances		
		Cosmetic damage (BS 7385) Light-framed structures	Cosmetic damage (DIN 4150) Heritage and other sensitive structures	Human response (EPA's Vibration guideline)[2]
Vibratory Roller	< 50 kN (Typically 1-2 t)	5 m	14 m	15 m to 20 m
	< 100 kN (Typically 2-4 t)	6 m	16 m	20 m
	< 200 kN (Typically 4-6 t)	12 m	33 m	40 m
	< 300 kN (Typically 7-13 t)	15 m	41 m	100 m
	> 300 kN (Typically 13-18 t)	20 m	54 m	100 m
	> 300 kN (> 18 t)	25 m	68 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12 t excavator)	2 m	5 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18 t excavator)	7 m	19 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34 t excavator)	22 m	60 m	73 m

Plant item	Rating background level, dB(A)	Minimum working distances		
		Cosmetic damage (BS 7385) Light-framed structures	Cosmetic damage (DIN 4150) Heritage and other sensitive structures	Human response (EPA's Vibration guideline)[2]
Vibratory Pile Driver	Sheet piles	20 m	50 m	100 m
Pile Boring	≤800 mm	2 m (nominal)	40 m	4 m
Jackhammer	Hand held	1 m (nominal)	2 m	2 m

Note:
1. *More stringent conditions may apply to heritage or other sensitive structures. Any heritage property would need to be considered on a case by case basis and assessed in accordance with DIN4150:3 Structural vibration - Effects of vibration on structures.*
2. *Assessing Vibration; a technical guideline (DEC 2006)*

Blasting

Blasting is currently proposed to take place for excavation of material from Skellatar Hill. Impacts created by blasting are largely dependent on the blast methodology. Using the equation J7.2 provided in AS2187.2-2006, the maximum effective charge mass per delay to achieve compliance with the airblast overpressure criteria is calculated to be 0.8 kilograms at a distance from charge of 875 metres, which is the location of the nearest sensitive receiver. This is based on site and rock property constants as recommended in AS2187.2-2006 for confined blasthole charges. With this maximum effective charge mass per delay, the airblast overpressure criterion for the Ausgrid substation would also be met.

Operation

Operational road traffic noise

The Road Noise Policy requires the assessment of road traffic noise at the year of opening (2027 indicative) and at the design year (2037 indicative) for daytime and night time periods. The operational noise scenarios which have been assessed therefore include:

- 'Do minimum' (2027 and 2037), representing the future road network if the proposal was not to be built
- Design (2027 and 2037), incorporating the proposal including on and off ramps and road infrastructure.

The relevant 'do minimum' and design scenarios were compared to identify the operational noise impact of the proposal.

Considering the impacts in both Year 2027 and Year 2037 with the proposal during the daytime and night-time periods, the greatest impacts were identified during Year 2037 and are summarised as follows:

- Road traffic noise levels are predicted to exceed the LAeq controlling noise criterion at a total of 34 sensitive receivers
- Of these 34 noise sensitive receivers:
  - Noise levels are predicted to increase by more than two dB(A) at 23 sensitive receivers
  - Noise levels are predicted to exceed the cumulative limit at 11 sensitive receivers. (i.e. ≥ LAeq(15 hr) or LAeq(9 hr) noise criterion + 5 dB(A))
  - No noise sensitive receivers have been identified as being acute (i.e. the proposal contributes less than 2.0 dB(A) to the overall level and noise levels are equal to or greater than LAeq(15 hr) 65 dB(A) or LAeq(9 hr) 60 dB(A).

The noise and vibration technical report in Appendix L found 24 sensitive receivers eligible for the consideration of feasible and reasonable noise mitigation (see Section 6.6.5) including 23 residential receivers and one childcare centre. Fifteen of these receivers are grouped in two main areas, five receivers on Aberdeen Street, Muswellbrook and ten receivers on Lonhro Place, Muswellbrook (refer to Table 51 in Appendix L). This would be confirmed during detailed design.

Noise barrier assessment

The Noise Mitigation Guideline advises that noise barriers should be considered where there are four or more closely spaced receivers.

Two barriers across two precincts were considered in this assessment as shown in Figure 6-22.

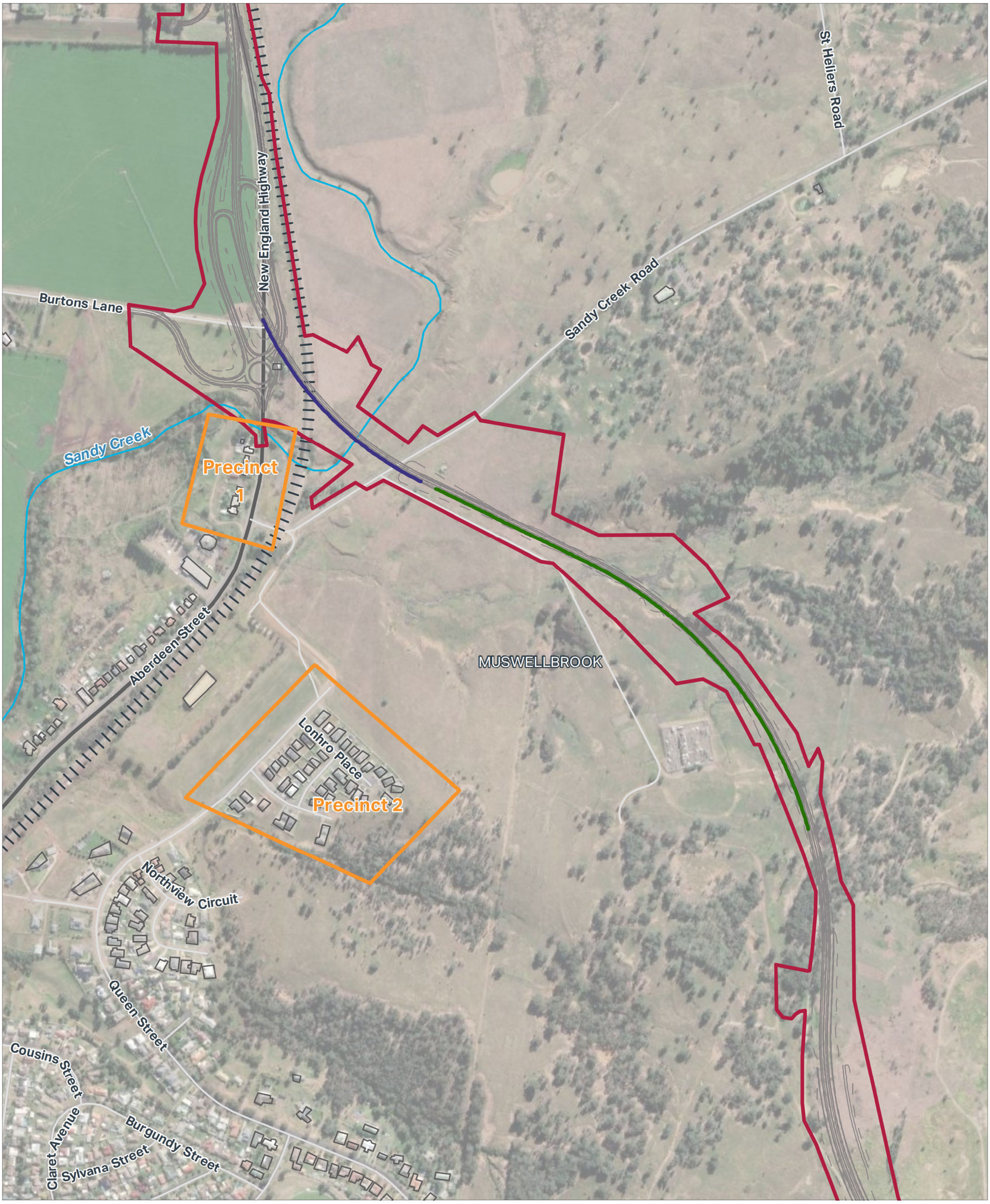


FIGURE 6-22: NOISE BARRIER ASSESSMENT

N

0 150 300 m

AECOM

Legend

- Construction footprint
- State Road
- Local Road
- Railway
- Watercourse
- Precinct
- Building
- Noise Barrier N1
- Noise Barrier N2
- Proposal design

For Precinct 1, results of the barrier assessment show that the minimum 5 dB(A) insertion loss is not achieved at any of the receivers due to the fact that road traffic noise on existing roads remains the dominant noise source for these receivers. Furthermore, the assessment indicates that, with a maximum height barrier (8 metres), the number of receivers requiring at-property treatment would not reduce. Without a noise barrier seven receivers would be eligible for consideration of at-property treatment. Even with an eight metre high barrier, those seven receivers would remain eligible for consideration of at-property treatment.

A noise barrier at this location has not been considered any further as it would not be reasonable, this is due to level of road traffic noise levels from existing roads (see Section 5.1.5 of Appendix L).

For Precinct 2, results of the barrier assessment show that the minimum 5 dB(A) insertion loss is not achieved at any of the receivers. However, the exceedances are less than 5 dB(A), therefore a barrier with a lower insertion loss can be considered in accordance with Section 8.9 of the *Noise Mitigation Guideline*. A 4.1 metre noise barrier was therefore assessed as the design barrier for this assessment. Rounding this barrier height up to 4.5 metres, three receivers would still require at-property treatment. The maximum insertion loss of a 4.5 metre high noise barrier is 1.9 dB(A).

Given that the design barrier did not meet the minimum insertion loss, even with consideration of the relatively low exceedances, and three receivers would still require at-property treatment, a noise barrier is not considered reasonable for Precinct 2. A noise barrier would provide a noise benefit ie a noise reduction of 1.9 dB(A), which would be barely noticeable at residences (see Section 5.1.5 of Appendix L).

Maximum noise level assessment

The *Road Noise Policy* includes a review of international sleep arousal research and 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 *Environmental Noise Management Manual* considers a maximum noise level event to be defined as a vehicle pass-by event for which the $L_{A,max}$ noise level is equal to or greater than 15 dB(A) above the $L_{Aeq(1hr)}$. Maximum noise level events have been considered at NL1 – 8667 New England Highway, Muswellbrook and NL5 – 449 New England Highway, Muswellbrook. These locations are considered to be representative of receivers along the future proposed alignment.

Maximum noise levels are generally dependent on truck engine braking events, however loud exhausts and horns may also contribute. A truck may engage its engine brakes at any location on the proposal alignment, however the likelihood is dependent on a range of factors, such as road gradient, proximity to junctions, truck condition and individual driver behaviour. Maximum noise events are less likely further away from the alignment, as maximum noise levels decrease at a faster rate with distance than is the case for L_{Aeq} road traffic noise levels.

An assessment of maximum noise level events was completed for the proposal and is provided in Section 5.1.6 of Appendix L. The assessment shows the area is already exposed to maximum noise level events that have the potential for awakening reactions.

One of the main goals of this proposal is to reduce heavy vehicle traffic through Muswellbrook town centre. It is expected that the maximum noise events would decrease in both number and duration with the proposal due to reduced congestion, better alignments and gradients. It is also expected that the maximum noise events would decrease overall in both number and duration with the proposal due to reduced traffic volumes, particularly heavy vehicles, on the existing route and reduced congestion for receivers within Muswellbrook.

6.6.5 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Noise and vibration	The Noise and Vibration Technical Report will be re-evaluated based on the detailed design in order to reaffirm noise predictions and potential impacts as a result of the proposal	Transport	Pre-construction	Additional safeguard
Noise and vibration	A Construction Noise and Vibration Management Plan (CNVMP) will be prepared and implemented as part of the CEMP. The CNVMP will identify: • Key potential noise and vibration generating activities associated with the activity • Noise and vibration sensitive receivers • Measures to be implemented during construction to minimise noise and vibration impacts, such as restrictions on working hours, staging, placement and operation of work compounds, parking and storage areas, temporary noise barriers, haul road maintenance and controlling the location and use of vibration generating equipment. • Feasible and reasonable mitigation measures to be implemented, taking into account Beyond the Pavement: urban design policy, process and principles (Transport for NSW, 2014). • A monitoring program to assess performance against relevant noise and vibration criteria • Arrangements for consultation with affected neighbours and sensitive receivers, including notification and complaint handling procedures • An out of hours works procedure, including approval process and proposed mitigation measures	Construction contractor	Pre-construction and construction	Additional safeguard
Noise and vibration	All sensitive receivers likely to be affected will be notified at least five days prior to commencement of any works associated with the scenario that may have an adverse noise or vibration impact. The notification will include details of: • The proposal	Construction contractor	Construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	• Construction period and construction hours • Contact information for proposal management staff • Complaint and incident report and how to obtain further information			
Noise and vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant proposal specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on high noise generating activities • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures	Construction contractor	Construction	Additional safeguard
Noise and vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Works generating high noise and/or vibration levels should be scheduled during less sensitive time periods Any variations to the standard construction hours will follow the approach in Roads and Maritime Services – Construction Noise and Vibration Guideline, including consultation with the affected local community	Construction contractor	Construction	Additional safeguard
High noise generating work – standard construction hours	Where feasible and reasonable, high noise generating work (75 dB(A) L_{Aeq} at receiver) will be carried out during standard construction hours and in continuous blocks of no more than three hours, with at least one hour respite between each block of work generating	Construction contractor	Construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	high noise impact, where the location of the work is likely to impact the same receiver			
High noise generating activities – out of hours	Where high noise generating activities (75 dB(A) L_{Aeq} at receiver) are required out of hours, the following will be implemented: • The equipment will be used prior to 10pm where feasible and reasonable • Where the above cannot be achieved the equipment will be used prior to midnight where feasible and reasonable • It is not proposed to apply a three hour on and a one hour off respite approach in an effort to ensure that the use of such equipment is completed as early in the night as possible	Construction contractor	Construction	Additional safeguard
Noise	Where properties have been identified for architectural treatment and these properties will be impacted by noise from construction works, Transport will consult with those property owners on the early installation of treatments to provide noise mitigation during the construction of the proposal, where feasible	Transport	Pre-construction	Additional safeguard
Noise from deliveries	The following will be implemented for deliveries to and from the proposal: • Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers • Dedicated loading/unloading areas are to be shielded if close to sensitive receivers. • Delivery vehicles are to be fitted with straps rather than chains for unloading, wherever possible. • Construction sites will be arranged to limit the need for reversing associated with regular/repeatable movements	Construction contractor	Construction	Additional safeguard
Noise from construction vehicles/ plant	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles	Construction contractor	Construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	and mobile plant regularly used on site and for any out of hours work			
Noise from construction ancillary facilities	The noise associated with the operation of construction ancillary facilities will primarily result from the operation of fixed and mobile plant and truck movements. Consideration will be given to the layout of the site (positioning of site sheds, earth bunds and hoarding) in order to maximise distance and shielding to nearby receivers	Construction contractor	Pre-construction and construction	Additional safeguard
Noise	Where practicable, work should be scheduled to avoid major student examination periods such as before or during Higher School Certificate and at the end of higher education semesters.	Construction contractor	Construction	Additional safeguard
Noise	In circumstances where the noise levels are predicted to exceed construction noise management levels after implementation of the general work practices, additional mitigation measures are required. These measures include the following: • Monitoring • Notification (letterbox drop or equivalent) • Specific notifications • Phone calls • Individual briefings • Respite offers • Respite periods • Duration respite • Alternative accommodation	Contractor	Construction	Additional safeguard
Vibration	Vibration intensive equipment size will be considered to avoid working within the structural damage minimum working distances. The use of less vibration intensive methods of construction or equipment will be considered where feasible and reasonable	Contractor	Construction	Additional safeguard
Vibration	Where the use of vibration intensive equipment within the relevant minimum working distances cannot be avoided, prior to the commencement of vibration intensive work, a detailed inspection will be carried out and a written and photographic report prepared to	Contractor	Pre-Construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	document the condition of buildings and structures within the minimum working distances. A copy of the report will be provided to the relevant landowner or land manager			
Operational noise	To confirm that the noise levels targets are achieved, a post-construction noise monitoring program will be carried out in accordance with the *Noise Mitigation Guideline* within 12 months of opening to traffic	Contractor	Operation	Additional safeguard

6.7 Aboriginal cultural heritage

An Aboriginal Cultural Heritage Assessment Report (CHAR) was prepared by Kelleher Nightingale Consulting Pty Ltd (KNC) (2021) to assess potential impacts to Aboriginal cultural heritage as a result of the proposal (refer to Appendix C). An Aboriginal Cultural Values Assessment was also undertaken for the proposal by Waters Consultancy (2020). Relevant sections and findings have been integrated throughout the CHAR.

The CHAR has been prepared in accordance with the Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW (OEH 2011a) and other relevant guidelines, as well as Transport's PACHCI.

6.7.1 Methodology

Aboriginal cultural heritage assessment

The proposal has been subject to two archaeological investigations specific to the current construction footprint, including an archaeological field survey and archaeological test excavation program.

Searches of the AHIMS database were carried out to identify any registered Aboriginal archaeological sites (Aboriginal objects, as defined under the NP&W Act) and declared Aboriginal places (as defined under the NP&W Act) located in the study area.

An Aboriginal archaeological field survey was then carried out in July 2019 with representatives from Wanaruah LALC and the (then) registered Native Title Claimant Group, to clarify records obtained from the AHIMS search and to determine whether any previously unrecorded sites were located in the study area. The results of the survey informed the initial design development and environmental assessment. This is in accordance with the Stage 2 PACHCI requirements (refer to Section 5.3).

Following completion of the PACHCI Stage 2 assessment, it was determined that further information on the nature and extent of the archaeological sites would be required to inform the PACHCI Stage 3 assessment. Accordingly, an archaeological test excavation program was recommended. Test excavation was subsequently undertaken by KNC and registered stakeholder representatives across a five week period between August and October 2020.

An updated AHIMS search was conducted on 24 November 2020 to identify registered (known) Aboriginal sites or declared Aboriginal places within or adjacent to the study area for the PACHCI Stage 3 assessment.

Other heritage registers and lists searched for known Aboriginal heritage in the vicinity of the study area, included:

- Muswellbrook LEP 2009
- Transport for NSW s. 170 Heritage and Conservation Register
- RailCorp s. 170 Heritage and Conservation Register
- State Heritage Register
- State Heritage Inventory
- Commonwealth Heritage List
- National Heritage List
- Australian Heritage Places Inventory
- Register of the National Estate (non-statutory list).

The Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales (OEH 2010) requires significance assessment to be carried out in accordance with the Australia ICOMOS Burra Charter (Australia ICOMOS 2013). Significance assessments were carried out for all Aboriginal archaeological and cultural values sites identified to be impacted by the proposal.

Aboriginal cultural values assessment

The Aboriginal cultural values assessment was undertaken collaboratively with the Aboriginal community and identified Aboriginal cultural knowledge holders, as nominated by the RAPs.

Archival research was undertaken in a range of national, state, and local institutions to provide the historical and ethnographic context for the assessment. An analysis of the ethnographic literature and historical record was undertaken to provide a contextual understanding to allow for the interpretation and assessment of the cultural information.

Ten individuals were identified as Aboriginal cultural knowledge holders.

Aboriginal cultural knowledge holders were consulted as follows:

- Three individuals took part in detailed interviews (via Zoom and/or in person)
- Two individuals were spoken with, but due to illness were unable to attend face-to-face interviews
- Two individuals were spoken with on a number of occasions, but despite repeated attempts, it was not possible to meet with them
- One individual was not able to be contacted
- Two individuals were represented by one of those spoken with.

The identified Aboriginal cultural knowledge holders spoken with provided cultural and historical information on the broader cultural landscape of the region. This information informed the assessment process in relation to the cultural heritage values and significance of the broader region.

Consultation

Consultation with Aboriginal stakeholders has been undertaken in accordance with the PACHCI and the Heritage NSW *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010.*

6.7.2 Existing environment

Aboriginal cultural heritage

Aboriginal sites and places identified by the AHIMS search (2020) in the study area are listed in Table 6-38, with the frequency and site types listed in Table 6-39.

Table 6-38: Aboriginal sites and places identified by the AHIMS search

Number identified	Aboriginal site / place
117	Aboriginal sites are recorded in or near the above location
0	Aboriginal places have been declared in or near the above location

Table 6-39: Frequency of site types and context from the AHIMS search

Site context	Site feature	Frequency
Open	Artefact	108
	Artefact (Potential Archaeological Deposit (PAD))	2
	Modified Tree (carved or scarred)	7
Total		117

The AHIMS search results revealed that there were 18 AHIMS registrations (comprising 12 Aboriginal archaeological sites) located within the original PACHCI Stage 3 assessment study area. The study area was subsequently refined (refer to Figure 3-1) and now contains 12 AHIMS registrations (comprising eight Aboriginal archaeological sites). The sites/places listed below are shown on Figure 6-23 and Figure 6-24:

- Muswellbrook Bypass AFT 1
- Muswellbrook Bypass AFT 2
- Muswellbrook Bypass AFT 3
- Muswellbrook Bypass AFT 4
- Muswellbrook Bypass AFT 5
- Muswellbrook Bypass AFT 6
- Muswellbrook Bypass AFT 7
- Muswellbrook Bypass AFT 8 (includes NH 1, NH 2 and NH 3)
- Muswellbrook Bypass AFT 9
- Muswellbrook Bypass AFT 10 (includes DMC 1, DMC 2 and DMC 3)
- Muswellbrook Bypass IF 1
- Muscle Creek.

No Aboriginal heritage items or places were listed on any other registers within or in the vicinity of the study area.

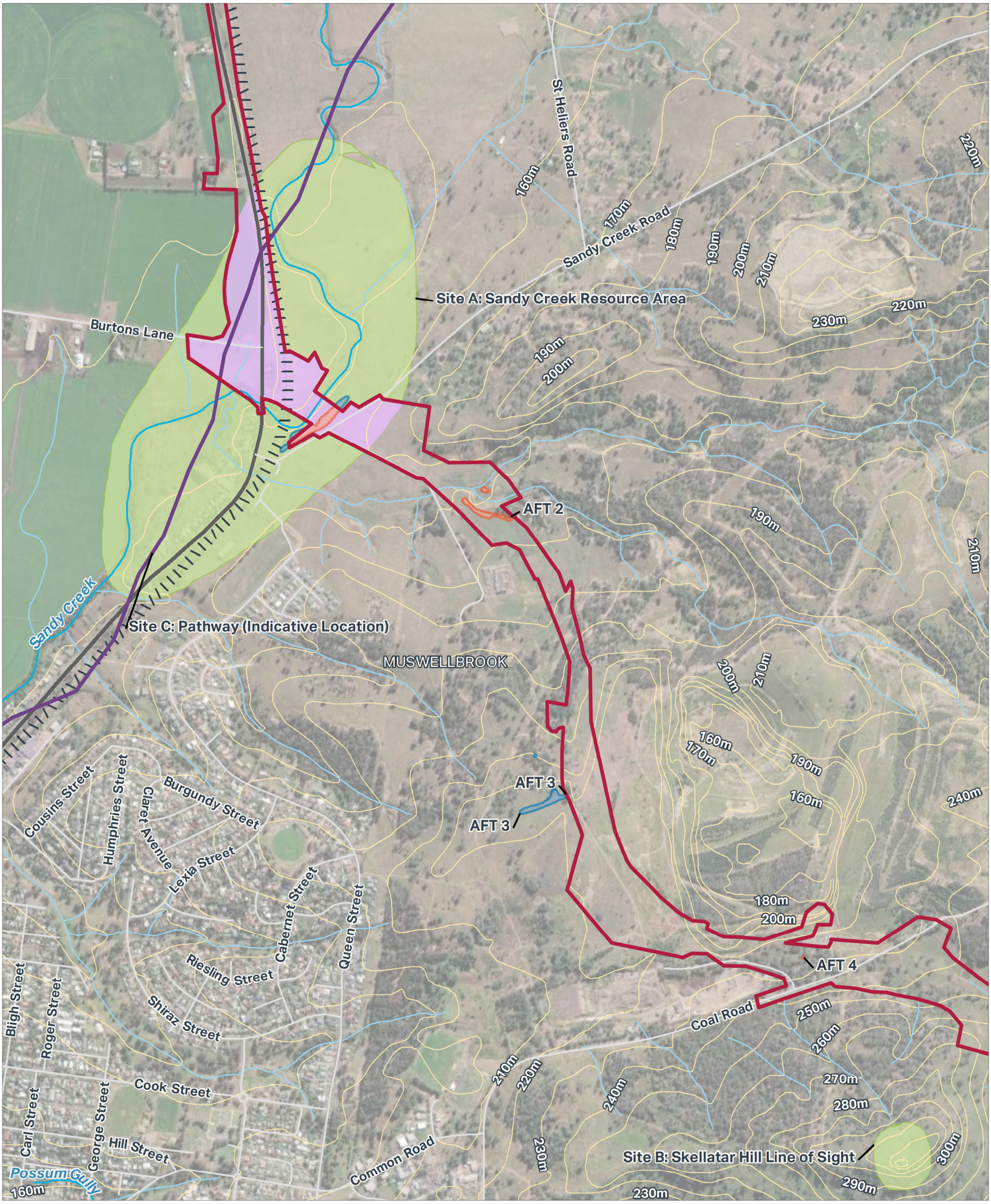


FIGURE 6-23: ABORIGINAL CULTURAL HERITAGE IMPACT ASSESSMENT - NORTHERN SECTION

0 0.25 0.5 km

Legend

Archaeological Site

- Impacted
- Not Impacted

Cultural area

- Impacted
- Not Impacted

- Construction footprint
- Railway
- 10m contour
- Watercourse
- Drainage line
- State Road
- Local Road

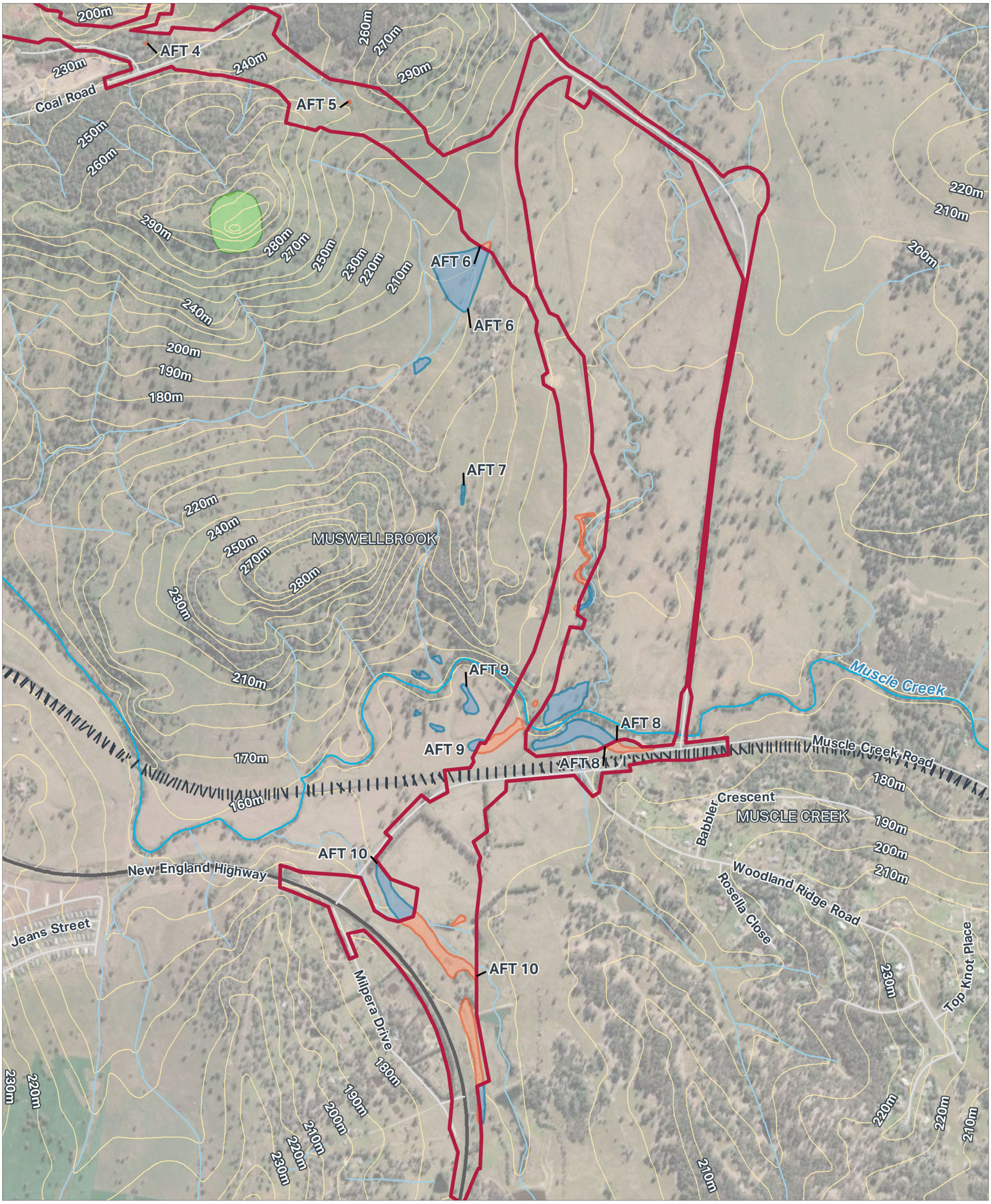


FIGURE 6-24: ABORIGINAL CULTURAL HERITAGE IMPACT ASSESSMENT - SOUTHERN SECTION

N

0 0.25 0.5 km

AECOM

Legend

Archaeological Site
- Impacted
- Not Impacted

Cultural area
- Not Impacted

- Construction footprint
- State Road
- Local Road
- Railway
- Watercourse
- Drainage line
- 10m contour

Test excavations

As part of the PACHCI Stage 3 assessment, 11 of the 12 sites identified were subject to test excavation. Testing was not undertaken at Muswellbrook Bypass IF 1, as the site was determined to be located within a highly disturbed context and the recorded object was unlikely to be associated with any subsurface deposits.

The test excavation program confirmed the presence of subsurface archaeological deposit of varying density and integrity at all 11 of the tested areas. The nature and extent of the archaeology was variable and illustrates the diverse array of Aboriginal activities which took place across the landforms contained within the study area.

Aboriginal cultural values

The Muswellbrook area and wider Upper Hunter region remains important to local Aboriginal people, who have maintained their traditional ties to the area through the sharing of knowledge and lore down generations. Aboriginal people continue to use and care for the natural resources available to them across Country and have an intimate understanding and respect for the landscape.

Particular locations of intangible cultural significance as identified by knowledge-holders during the cultural values assessment include:

- Site A: Sandy Creek Cultural Resource Area
- Site B: Skellatar Hill Line of Sight
- Site C: Pathway.

Sites A and C intersect the study area and site B is about 370 metres to the west (refer to Figure 6-23).

6.7.3 Potential impacts

Construction

Aboriginal cultural heritage

Refinement of the construction footprint subsequent to the test excavation program has avoided impact to one moderately significant site (Muswellbrook Bypass AFT 7) and reduced the extent of the proposed impact at five other moderately significant sites. At three of these (Muswellbrook Bypass AFT 6, Muswellbrook Bypass AFT 8 and Muscle Creek), the construction footprint would avoid impacting on the higher-archaeological value portions of the sites, with impacts restricted to marginal, low value areas on the fringes of the sites.

The impact assessment for identified Aboriginal archaeological sites is shown in Table 6-40 and shown on Figure 6-23 and Figure 6-24.

Table 6-40: Impact assessment for identified Aboriginal archaeological sites

Site name	AHIMS	Significance	Type / degree of harm	Consequence of harm
Muswellbrook Bypass AFT 1	37-2-5952	Moderate	Direct / partial	Partial loss of value
Muswellbrook Bypass AFT 2	37-2-5953	Low	Direct / total	Total loss of value
Muswellbrook Bypass AFT 3	37-2-5954	Low	Direct / partial	Partial loss of value

Site name	AHIMS	Significance	Type / degree of harm	Consequence of harm
Muswellbrook Bypass AFT 4	37-2-5955	Low	Direct / total	Total loss of value
Muswellbrook Bypass AFT 5	37-2-5957	Low	Direct / total	Total loss of value
Muswellbrook Bypass AFT 6	37-2-5956	Moderate	Direct / partial	Partial loss of value
Muswellbrook Bypass AFT 7	37-2-5958	Moderate	None / none	No loss of value
Muswellbrook Bypass AFT 8 (includes NH 1, NH 2 & NH 3)	37-2-5959 (includes 37-2-1454, 37-2-1455 & 37-2-1456)	Moderate	Direct / partial	Partial loss of value
Muswellbrook Bypass AFT 9	37-2-5960	Moderate	Direct / partial	Partial loss of value
Muswellbrook Bypass AFT 10 (includes DMC 1, DMC 2 & DMC 3)	37-2-5961 (includes 37-2-2631, 37-2-2632 and 37-2-2633)	Low	Direct / partial	Partial loss of value
Muswellbrook Bypass IF 1	37-2-5962	Low	Direct / total	Total loss of value
Muscle Creek	37-2-0139	Moderate	Direct / partial	Partial loss of value

An AHIP issued under Section 90 of the NP&W Act is required for the proposal. The AHIP should be sought for the entirety of the lands subject to the proposed works (the study area) and Aboriginal objects associated with the archaeological sites that would be impacted.

The AHIP would include a mitigation program comprising archaeological salvage which would be undertaken prior to construction where substantial portions of moderately significant Aboriginal archaeological sites would be impacted by the proposal. Mitigative salvage excavation would be required for two sites: Muswellbrook Bypass AFT 1 and Muswellbrook Bypass AFT 9.

Salvage excavation at moderately significant sites Muswellbrook Bypass AFT 6, Muswellbrook Bypass AFT 7, Muswellbrook Bypass AFT 8 (includes NH 1, NH 2 and NH 3) and Muscle Creek is not required as these sites would be either avoided or only marginally impacted by the proposal.

Surface collection of artefacts is proposed for all impacted site areas as detailed in Section 6.7.4.

Aboriginal cultural values

Impact assessment for the identified cultural sites was undertaken as part of the cultural values assessment. Two of the cultural sites are partially located within the construction footprint, and one is located adjacent to the construction footprint. A summary of identified impacts are provided in Table 6-41: and shown on Figure 6-23 and Figure 6-24.

Table 6-41: Impact assessment for identified Aboriginal cultural sites

Item	Description	Cultural significance	Impact
Site A: Sandy Creek Cultural Resource Area	A traditional cultural resource area associated with nearby camps and pathways	This cultural resource area has **Medium Significance** to the local Aboriginal community as a traditional cultural resource gathering place with associated patterns of movement and residence	Yes
Site B: Skellatar Hill Line of Sight	A high point that provides a cultural line of sight to a number of key pathways and locations	The Skellatar Hill line of sight has **High Significance** to the local Aboriginal community as a traditional location for orienting people within the cultural landscape and making visible the links between significant cultural places	No
Site C: Pathway	A pathway associated with traditional movement patterns	This movement corridor has **Medium Significance** to the local Aboriginal community as the patterns of movement hold cultural value for their association with resource use, community gatherings and ceremonial cycles	Yes

Operation

The proposal is not expected to impact on any items of Aboriginal heritage or cultural values when it is operational.

6.7.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Aboriginal cultural heritage	An application for an AHIP will be made under section 90A of the NP&W Act. The application will be prepared in accordance with the Heritage NSW Applying for an Aboriginal Heritage Impact Permit: Guide for Applicants (OEH 2011b). An AHIP will be sought for the land and associated objects within the boundaries of the construction footprint	Transport	Pre-construction	Additional safeguard
Aboriginal cultural heritage	The AHIP will include provision for impact mitigation through archaeological salvage excavation at Muswellbrook Bypass AFT 1 and Muswellbrook Bypass AFT 9 Salvage excavations will be completed prior to any activities (including pre-construction activities) which may harm Aboriginal objects at these site locations. Salvage excavation activities will be undertaken in accordance with the approved methodology	Transport	Pre-construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
Aboriginal cultural heritage	The AHIP will also include provision for community surface collection at all impacted site areas. The collection must be completed prior to any activities which may harm Aboriginal objects at these site locations and will be conducted as part of the overall salvage program, following the issue of the AHIP The collected objects will be recorded as part of the excavation report and included in the excavation assemblage for long term storage. The collection of surface artefacts will be undertaken in accordance with the approved methodology	Transport	Pre-construction	Additional safeguard
Aboriginal cultural heritage	The short term management of collected Aboriginal objects will be as follows: • Any Aboriginal objects that are removed from the land by actions authorised by an AHIP, must be moved as soon as practicable to the temporary storage location pending any agreement reached about the long term management of the Aboriginal objects • The temporary storage location will be KNC, Level 10, 25 Bligh Street, Sydney NSW 2000 • Any Aboriginal objects stored at the temporary storage location must not be further harmed, except in accordance with the conditions of the AHIP The long term management of collected Aboriginal objects is as follows: • Recovered objects will be lodged with the Australian Museum in the first instance in accordance with the Australian Museum Archaeological Collection Deposition Policy • If required, a variation will be sought for recovered objects to be held by the Aboriginal community or reburied. If reburial is to take place, registered Aboriginal parties will be notified and given the opportunity to attend. • Requirement 26 "Stone artefact deposition and storage" in the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW must be complied with	Transport	Pre-construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
Aboriginal cultural heritage	An Aboriginal Heritage Management Plan (AHMP) will be prepared and implemented as part of the CEMP The AHMP will provide specific guidance on measures and controls to be undertaken to avoid and mitigate impacts on Aboriginal cultural heritage during construction. This should include protection measures to be applied during construction, including but not limited to the recommendations set out in this table, as well as contractor training in general Aboriginal cultural heritage awareness and management of Aboriginal heritage values	Construction contractor	Pre-construction and construction	Section 4.9 of QA *G36 Environment Protection*
Aboriginal cultural heritage	The non-impacted portion of partially impacted sites (outside of construction footprint and AHIP boundary) will be marked on the CEMP prior to construction activities to ensure these parts of the sites are avoided and not impacted by the proposal. The site areas will be marked as environmentally sensitive “no-go zones”. Temporary fencing will be installed around the edge of the non-impacted archaeological site areas and AHIP boundary during construction to provide a physical barrier against accidental access or impact Workers will be inducted as to appropriate Aboriginal heritage protection measures	Construction contractor	Pre-construction	Additional safeguard
Aboriginal cultural heritage	An Aboriginal cultural heritage awareness training package will be delivered as part of the site induction for all contractor(s) and maintenance personnel involved in the construction works The training package will be developed by a cultural heritage specialist in consultation with the RAPs and Aboriginal cultural knowledge holders. The training package will at a minimum ensure awareness of the cultural significance of the construction footprint, the requirements of the AHMP and relevant statutory responsibilities, and the identification of unexpected heritage items and appropriate management procedures	Construction contractor	Pre-construction and construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
Aboriginal cultural heritage	A cultural heritage specialist will be engaged to develop interpretative materials on the cultural values and historical records relating to the Site A: Sandy Creek Cultural Resource Area; Site B: Skellatar Hill Line of Sight; and Site C: Pathway cultural sites and the cultural landscape they sit within The form of the interpretative materials will be determined in consultation with the Aboriginal cultural knowledge holders and RAPs following investigation of options with Muswellbrook Shire Council Options to be considered include interpretative signage, an educational booklet, and input into (aesthetic) design elements to reflect the Aboriginal cultural values of the area	Transport	Pre-construction	Additional safeguard
Aboriginal cultural heritage	The proposed bridge to be constructed near Site A: Sandy Creek Resource Area will be named in recognition of the Aboriginal cultural values and history of the region A range of potential names with supporting explanations will be developed by a cultural heritage specialist in consultation with the Aboriginal cultural knowledge holders and RAPs, with the options to be presented to the Aboriginal cultural knowledge holders and RAPs for their review and nomination of a preferred option to Transport	Transport	Pre-construction	Additional safeguard
Aboriginal cultural heritage	The AHMP will include an Unexpected Heritage Items Procedure (Roads and Maritime 2015) requiring notification of the identified knowledge holders within 48 hours of any discovery of potential archaeological Aboriginal skeletal remains during the proposed works	Transport	As required	Section 4.9 of QA *G36 Environment Protection*
Aboriginal cultural heritage	If there is a confirmed discovery of archaeological Aboriginal human remains, consultation will occur with the RAPS and Aboriginal cultural knowledge holders in relation to: the development of a management plan for proposed works in the relevant area; cultural ceremonies in relation to the human remains and the site of their occurrence; and repatriation of the human remains	Transport	As required	Additional safeguard

Site name	AHIMS number	Assessed significance	Management and mitigation
Muswellbrook Bypass AFT 1	37-2-5952	Moderate	• Community collection • Archaeological salvage excavation • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 2	37-2-5953	Low	• Community collection • Archaeological mitigation not required • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 3	37-2-5954	Low	• Community collection • Archaeological mitigation not required • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 4	37-2-5955	Low	• Community collection • Archaeological mitigation not required • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 5	37-2-5957	Low	• Community collection • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 6	37-2-5956	Moderate	• Community collection • Archaeological mitigation not required (marginal impact to low-value portion of site) • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 8 (includes NH 1, NH 2 & NH 3)	37-2-5959 (includes 37-2-1454, 37-2-1455 & 37-2-1456)	Moderate	• Community collection • Archaeological mitigation not required (marginal impact to low-value portion of site) • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 9	37-2-5960	Moderate	• Community collection • Archaeological salvage excavation • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 10	37-2-5961 (includes 37-2-2631, 37-2-	Low	• Community collection • Archaeological mitigation not required

Site name	AHIMS number	Assessed significance	Management and mitigation
(includes DMC 1, DMC 2 & DMC 3)	2632 and 37-2-2633)		• AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass IF 1	37-2-5962	Low	• Community collection • Archaeological mitigation not required • AHIP required prior to commencement of works affecting the site
Muscle Creek	37-2-0139	Moderate	• Community collection • Archaeological mitigation not required (marginal impact to low-value portion of site) • AHIP required prior to commencement of works affecting the site

6.8 Non-Aboriginal heritage

6.8.1 Methodology

The non-Aboriginal heritage assessment was undertaken in accordance with the documents *Assessing Heritage Significance* (NSW Heritage Office, 2001) and *Statements of Heritage Impact* (NSW Heritage Office, 2002). It included both desktop research and archaeological field survey.

Desktop Research

Heritage database searches were conducted on 20 May 2020 to identify heritage items located within or in proximity to the construction footprint. The following registers were reviewed during the search:

- World Heritage List
- National Heritage List
- Commonwealth Heritage List
- NSW State Heritage Register
- NSW Section 170 Heritage and Conservation Registers (S170 Registers)
- Muswellbrook LEP 2009
- Register of the National Estate (non-statutory).

In addition to the heritage register searches, the desktop assessment also included background research into the historical development of the construction footprint using historical plans, aerials, photographs, newspapers and other primary and secondary historical sources, as relevant. This research was used to determine the historic context of the construction footprint and identify any potential for additional heritage items to be present within or adjacent to the construction footprint.

Field Survey

An archaeological field survey of the construction footprint was undertaken over one day on 23 July 2020 by AECOM archaeologist Dr Darran Jordan. The survey was conducted on foot, with a linear transect walked across all accessible sections of the construction footprint.

Data was recorded using a handheld differential GPS unit. All known and newly identified historic sites and items observed during the survey were recorded and comprehensively photographed.

Review of Potential Impacts to Items of Heritage Significance

Results from the desktop research and field survey components of the assessment were utilised to identify the curtilages of heritage items within the vicinity of the proposed works and identify the heritage significance of each item. Following this, the assessment determined whether the proposed works would result in direct or indirect impacts to the identified significance of non-Aboriginal heritage.

A Heritage Assessment and Statement of Heritage Impact (SoHI) was prepared for the old coal rail spur bridge which crosses Muscle Creek (refer to Appendix M).

6.8.2 Existing environment

History

The Hunter region was first explored by Europeans in 1797, when Lieutenant John Shortland discovered coal at the mouth of the Hunter River. Subsequent explorations, such as the overland journeys of Chief Constable John Howe and Benjamin Singleton, pushed further into the Lower Hunter Valley, and the area around present-day Muswellbrook was reached in 1820. From 1822, assistant Colonial surveyor, Henry Dangar and his successor George Boyle White, were tasked with surveying and reserving the vast plains within the region, opening the way for free selection and settlement. By 1825, the major estates of Merton, Pickering, St. Heliers and Overton had been granted (Turner, 1995).

In 1833, surveyor Robert Dixon drafted a plan for a village reserve at the junction of Muscle Creek and the Hunter River. The reserve, formed with a rectilinear grid of mostly half acre allotments, was gazetted as the town of ‘Musclebrook’, (eventually given the revised spelling Muswellbrook). The first lots were sold in 1834, with the construction of houses following soon after. The town grew steadily, in part due to its central location along the main road between the other emerging towns of Merton and Invermein (Scone). A private subdivision, named Forbestown, was opened to the south of Muscle Creek and in 1848, Forbestown was incorporated into the town of Muswellbrook as ‘South Muswellbrook’ (Turner, 1995). Muswellbrook continued to develop, with influxes in population growth attributed to the discovery of gold in the Hunter and Bathurst regions in the 1850s and the completion of the Great Northern Railway to Muswellbrook in 1869. The main road passing through Muswellbrook developed into the Great Northern Road, which was gazetted as part of State Highway 9 in August 1928 and renamed the New England Highway in 1933.

Early in its history, the principal industries in Muswellbrook were agricultural, including the grazing of cattle and sheep, breeding horses, growing wheat, flour milling and the early production of wine. By the 1900s, following improvements in irrigation and refrigeration technologies, a number of dairies were established in the region, particularly concentrated on the alluvial flats and terraces between Scone, Gundy and Muswellbrook as a result of the higher quality pasture lands. After WWI, many of the larger rural estates were subdivided into smaller farms and dairying replaced with wheat and wool as the main rural industry. This continued into the 1970s.

The greatest impact, both economically and geographically, however, resulted from the development of the power and mining industries in the area. Coal was discovered in the Muswellbrook district in the 1860s, with a small seam uncovered to the south during the construction of the rail line (Jo McDonald Cultural Heritage Management Pty Ltd, 1999). Mining began in earnest with the formation of the Muswellbrook Coal Company Ltd (MCC) and the discovery of the Greta Coal Measures in 1907. No.1 Colliery began operations shortly after. In 1933, MCC merged with St Heliers Coal Company Ltd and established the No. 2 Colliery. Following the depression in the 1930s, the coal industry faced a downturn throughout NSW. Despite this, MCC opened a third colliery in 1944 on the public Common, which would become the largest open cut coal mine in Australia for a time. From the 1950s, coal mined from Muswellbrook was a growing export that was used in nearby power stations, such as the Liddell Power Station and a smaller station along McCullys Gap Road (Turner, 1995).

Desktop research results

Searches of relevant historic heritage registers and lists, both statutory and non-statutory, were conducted on 20 May 2020 to identify previously recorded historic heritage items within and 200 metres from the construction footprint. The search identified one item with a curtilage immediately adjacent to the construction footprint. Although the curtilage was immediately adjacent, the buildings associated with the listing were about 1.3 kilometres away. This item (St Heliers) had two listings associated with the same item, one on the Muswellbrook LEP 2009 and the other on the Corrective Services NSW S170 Heritage Conservation Register. Another listing, for the Muswellbrook Brick Works (former), was identified as being 130 metres to the east of the construction footprint. Search results are provided below in Table 6-42 with item locations shown on Figure 6-25.

An archaeological survey was subsequently undertaken to ground-truth known items and identify and record any additional heritage items located in proximity to the construction footprint. In addition to the historic items identified in historic registers (Table 6-42), one additional item (Rail bridge) was identified during the field survey, as shown on Figure 6-25.

Descriptions of all items identified during the register searches and recorded during the survey are presented in the following subsections, including details of their heritage significance.

Table 6-42: Registered historic sites within 200 metres of the construction footprint

Item	Item ID	Listing	Significance	Proximity to construction footprint
St Heliers	I113	Muswellbrook LEP 2009	Local	0 metres east (immediately adjacent)
St Heliers Correctional Centre • Admin & Outbuildings • Officers Accommodation • Stables	n/a	Corrective Services NSW S170 Heritage Conservation Register	Local	c.1.3 kilometres east
Muswellbrook Brick Works (former)	I112	Muswellbrook LEP 2009	Local	c.130 metres east
Old Coal Rail Spur Bridge, embankment and culverts	N/A	N/A	Local	0 metres (direct intersect)

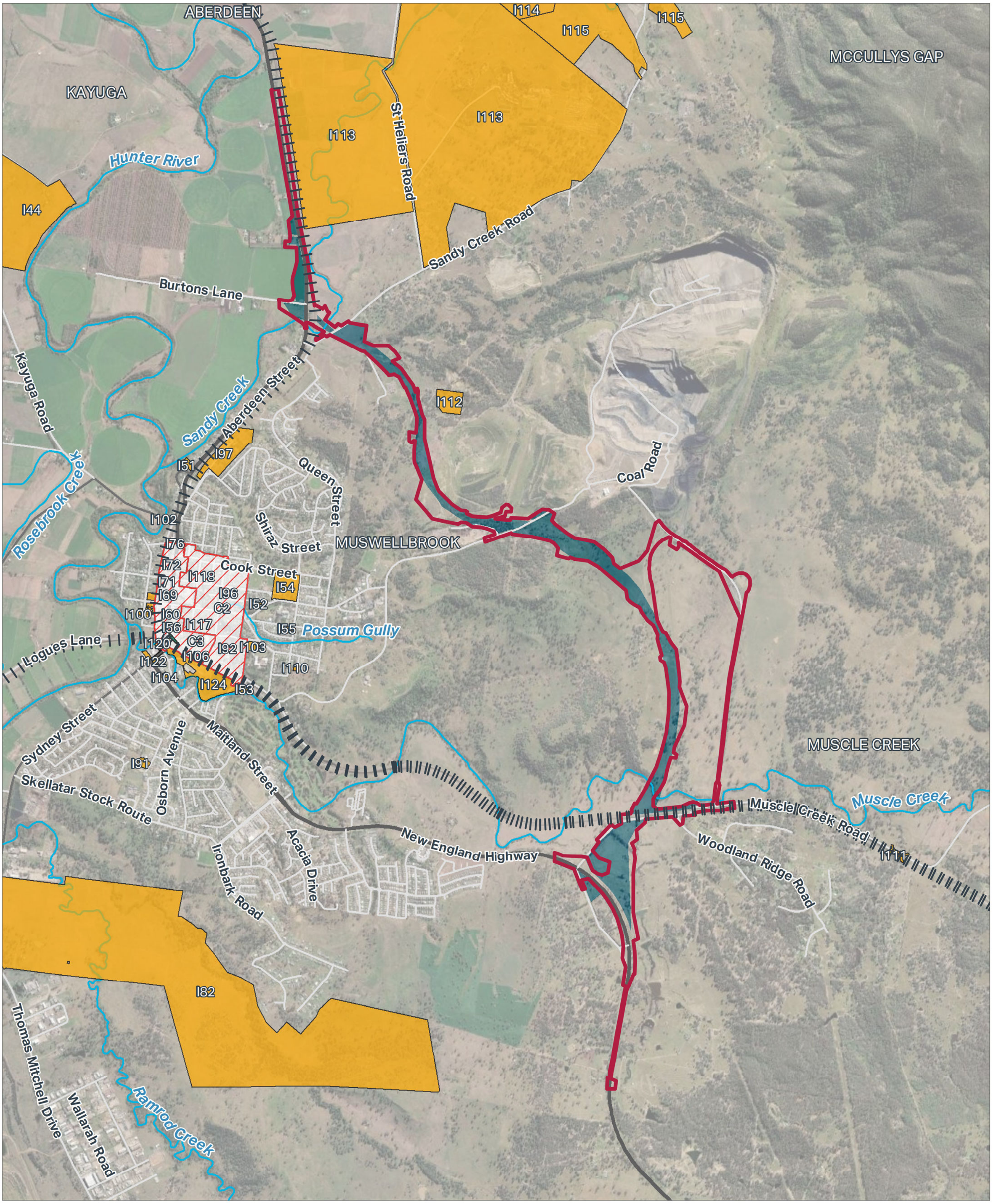


FIGURE 6-25: NON-ABORIGINAL HERITAGE ITEMS IN PROXIMITY TO THE CONSTRUCTION FOOTPRINT

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse
- Conservation Area - General
- Item - General
- Item - Landscape

0 0.5 1 km

St Heliers

The item ‘St Heliers’ (I113) is listed on the Muswellbrook LEP 2009 as containing local significance. The same item is listed on the Corrective Services NSW S170 Heritage Conservation Register under the name ‘St Heliers Correctional Centre’ and contains additional listings for separate elements within the complex, including the ‘Admin & Outbuildings’, ‘Officers Accommodation’ and ‘Stables’.

The item listing refers to the homestead built by Malcolm Campbell, founder of Campbells Stores, on a portion of the St Heliers estate. St Heliers was originally granted to Colonel Henry Dumaresq in 1826; however, nothing but plantings remain of the original Dumaresq homestead, which was located to the north east of the Campbell home. The main Campbell home, built between 1895 and 1900, was designed by Pender of Maitland architects, and comprises a single-storey brick and stucco structure featuring design elements of Victorian and Federation periods. The homestead is located on a rise overlooking the surrounding landscape, and includes later additions to the main house, outbuildings, a carriage loop and cultural plantings.

Following its initial grant, St Heliers was used for agricultural purposes and contained vineyards and orchards. In 1945, the current site was bought by the NSW State Government, and the homestead and surrounding grounds were converted into a Child Welfare facility used to house and train delinquent boys. The site was bought by the NSW Corrective Services Department in 1988 to be used as a minimum-security prison, after which developments included restoration of the main house for use as an administration building and construction of new facilities to the east.

St Heliers has been identified as being of local significance for all heritage significance criteria. This significance is largely tied to its historical development, associations with prominent individuals, their social connections and the building’s architecture. While the LEP 2009 curtilage of the item extends across the entire cadastral boundary of the lot (and lies adjacent to the construction footprint to the east of the New England Highway), descriptions and maps provided in the LEP 2009 and S170 listings indicate that the item predominately comprises of the main Campbell home and the structures and landscape features immediately surrounding it. The visual curtilage of St Heliers is defined in the Hunter Regional Study (Walker, 1980) as extending from the main house to the base of the hill on the western side. The physical and visual curtilages as described in the study and listings are therefore some 1.3 kilometres to the east of the construction footprint.

While it is possible that the land immediately adjacent to the eastern boundary of the construction footprint may have contained outbuildings and structures, such as sheds, stables and fencing, associated with the pastoral and/or agricultural use of St Heliers, there is no information currently available regarding any such works or improvements.

Source: Heritage NSW, 2020

Figure 6-26: St Heliers homestead (undated image)

Statement of Significance

"*Although not the original St. Heliers homestead, historically this home is nevertheless of significance to the region because of its representing the locational choice of the region's most successful 19th century retailer; the home was built for Malcolm Campbell. Aesthetically it is also regionally significant as it was designed by eminent Maitland Architects and features design elements of both the Victorian and Federation periods, finely detailed and of a scale unusual in the region. Its current regional social significance relates to its ownership by the Department of Corrective Services. Scientifically it is of regional significance for its potential to reveal information which could contribute to an understanding of the lifestyle of the prominent businessman of the late 19th century, to the spatial and particular needs of child welfare institutions and also to those of current owners*" (Heritage NSW, 2020).

"*St. Heliers Correctional Centre is historically significant as part of a large pastoral estate granted to Henry Dumaresq in 1825. It is also important for its associations with the expansion of pastoralism and associated settlement across NSW after the Napoleonic Wars, and the commercial development of the Muswellbrook and Upper Hunter areas. The site contains fabric relating to its mid-late 19th century pastoral use, in particular an impressive homestead constructed in 1895-1900 for Malcolm Campbell, designed by Pender of Maitland. It is likely that the site may contain archaeological evidence of its earliest European occupation, dating from 1825. St Heliers Correctional Centre has associative significance for its links to Henry Dumaresq, secretary to Ralph Darling (Governor of NSW, 1825-1831), commissioner of the Australian Agricultural Co, and pastoralist, as well as containing a fine example of the work of Pender of Maitland. St Heliers Correctional Centre is aesthetically significant as an attractive rural site with a number of well-sited buildings, particularly the impressive Pender homestead. At a local level, St Heliers Correctional Centre is socially significant for its role in law and order in the local area, as well as being an important local employer since the mid 20th century*" (Heritage NSW, 2020).

Assessment of Significance

The assessment of significance is from this item's listing on the NSW State Heritage Register (Heritage NSW, 2020).

Criterion	Assessment
SHR Criteria a) Historical significance	Historically significant to the region because of its representation of the local choice of the region's most successful 19th century retailer: Malcolm Campbell. St. Heliers Correctional Centre is historically significant as part of a large pastoral estate granted to Henry Dumaresq in 1825. It is also important for its associations with the expansion of pastoralism and associated settlement across NSW after the Napoleonic Wars, and the commercial development of the Muswellbrook and Upper Hunter areas. From 1945 - 1986, St. Heliers was used as a rural training institution, initially for delinquent boys and later state wards. Since 1989, the site has been used as a minimum-security prison. The site contains fabric relating to its mid-late 19th century pastoral use, in particular an impressive homestead constructed in 1895-1900 for Malcolm Campbell, designed by Pender of Maitland.
SHR Criteria b) Associative significance	St Heliers Correctional Centre has associative significance for its links to Henry Dumaresq, secretary to Ralph Darling (Governor of NSW, 1825-1831), commissioner of the Australian Agricultural Co, and pastoralist, as well as containing a fine example of the work of Pender of Maitland, a house designed for Malcolm Campbell and constructed in 1895-1900.
SHR Criteria c) Aesthetic significance	Aesthetically significant as it has been designed by eminent Maitland Architects and features design elements of both Victorian and Federation periods. St Heliers Correctional Centre is aesthetically significant as a rural site with a number of well-sited buildings, particularly the impressive homestead constructed in 1895-1900 for Malcolm Campbell, designed by Pender of Maitland, located on a rise overlooking the surrounding landscape.
SHR Criteria d) Social significance	Social significance relates to the ownership by the Department of Corrective Services. At a local level, St Heliers Correctional Centre is socially significant for its role in law and order in the local area, as well as being an important local employer since the mid 20th century, when the site was used for detention of juvenile boys, training of state wards and as a minimum security prison.
SHR Criteria e) Research potential	Scientifically of regional significance for its potential to reveal information which could contribute to an understanding of the lifestyle of the prominent businessmen of the late 19th century. St Heliers Correctional Centre has research potential regarding information on the first stages of development on the site from the mid 1820s.
Rarity/Intactness	St Heliers Correctional Centre has a moderate degree of intactness.

Muswellbrook Brick Works

The item 'Muswellbrook Brick Works' is listed on the Muswellbrook LEP 2009 as having local significance. The LEP 2009 curtilage of the item comprises a plot of land about.2.6 ha located on Coal Road, about 130 metres from the construction footprint at its closest point.

The Brick Works were approved for demolition by Muswellbrook Council in 2009 to allow for the expansion of the Muswellbrook Coal Mine. A letter from Muswellbrook Shire Council dated 16 December 2009 appended to a previous assessment (AECOM, 2010) indicates that the site was to be recorded by the Local Historical Society prior to its demolition. The LEP 2009 listing has not been updated to reflect the demolition of the item.

The Brick Works were thought to have been established in 1949 by Muswellbrook Industries to exploit clay deposits located at the Muswellbrook Coal Company's open cut mine. The Brick Works were a small, traditional coal fired operation, supplying bricks locally and to Newcastle. At the time of its original listing, the Brick Works were still in operation and were being restored for use in the production of bricks for heritage buildings. The site was described as comprising of a series of buildings, including a portable fibre office, a press shed, three brick downdraught brick kilns and one updraught brick kiln. The site also contained several brick hand-presses made in England in the 1860s.

The LEP listing indicates that the Brick Works contain significance for the almost continuous use of the site since its opening, its ability to represent traditional coal fired brick work operations, and its potential to reveal information about brick making techniques in the Upper Hunter Valley. The 1996 Muswellbrook Heritage Study (EJE, 1996) indicates that the Brick Works contain regional [sic] historic and scientific significance and local aesthetic significance. As the site has now been demolished, this significance may no longer be applicable. Archaeological remains could still be present depending on the nature of impacts undertaken at this site since its demolition.

Source: Muswellbrook Shire Council, 2020

Figure 6-27: Muswellbrook Brick Works 21 February 1995

Statement of Significance

"A working example of downdraft brick kilns using traditional coal firing methods for the production of dry pressed bricks. In almost continuous use over a forty five year period, it is of regional historic significance in type, and is of similar scientific significance for its potential to reveal information about brickmaking methods in the Upper Hunter area over the past century" (Heritage NSW, 2020).

Assessment of Significance

The below assessment of significance is from this item's 1996 listing on the Muswellbrook Heritage Study Inventory (Muswellbrook Shire Council, 2020).

Criterion	Assessment
SHR Criteria a) Historical significance	The item meets this criterion as representative on a regional level
SHR Criteria c) Aesthetic significance	The item meets this criterion as representative on a local level
SHR Criteria e) Research potential	The item meets this criterion as representative on a regional level

Old Coal Rail Spur Bridge – Muscle Creek

An old coal rail spur bridge is located within the construction footprint on Lot 101, DP1148216, crossing Muscle Creek at a point approximately 100 metres from Muscle Creek Road. This item has not been listed on any heritage registers. The old coal rail spur bridge is associated with the Muswellbrook Coal Mine. Reference to early maps of the Parish of Rowan indicate that the bridge was built between 1942 and 1968, most likely in association with the establishment of the Open Cut mine in 1944. Although this bridge is not listed as a heritage item, other bridges in the surrounding region have been listed for their heritage values, the closest two being Kayuga Bridge and Stone Bridge. Stone Bridge (also known as Grass Tree Road Bridge) is located on Muscle Creek Road, Muswellbrook, outside the construction footprint, about two kilometres to the southeast of the old coal rail spur bridge. Stone Bridge is listed on the Muswellbrook LEP 2009 due to its significance for the opening up of Muswellbrook in the 1870s to rail transport and for the rarity of its design. Similarly, Kayuga Bridge (located outside the construction footprint, about 5.3 kilometres to the north-west of the old coal rail spur bridge) is listed on the Muswellbrook LEP 2009 due to its significance relating to the emerging town of Muswellbrook in the late 19th century, and its rare iron bridge design. The listing of other bridges in the vicinity supports the possibility that this bridge may also have heritage values.

As the bridge is not a listed heritage item, no statement of significance or assessment of significance have previously been undertaken for it. This item is discussed further below in relation to the survey findings.

Areas of Archaeological Potential

Background research identified a number of areas that have previously been identified as having archaeological potential (i.e., the potential to contain historical deposits in subsurface contexts). Each of these areas are summarised below in relation to the construction footprint and are shown on Figure 6-28 as numbers 1 to 5:

1. Muswellbrook Electric Power Co. (1923)
2. No. 1 Colliery
3. The Common (1888)
4. No. 2 Colliery
5. First Open Cut Mine (1944).

Muswellbrook Shire Heritage Study

The Muswellbrook Shire Heritage Study (the Study) (EJE, 1996) listed 18 'Archaeologically-sensitive areas' within Muswellbrook to be included within its Conservation Management Recommendations. The Heritage

Study was undertaken to inform the preparation of the Muswellbrook LEP 2009; however, these areas of archaeological sensitivity were not included within the LEP.

The Study did not ascribe levels of significance to these archaeologically sensitive areas or provide any information as to the curtilages or likely materials present within them. For this assessment, the general locations of these areas have been indicated to determine their proximity to the construction footprint.

The construction footprint is located within or adjacent to archaeologically sensitive areas associated with the power station, the public Common and Muswellbrook mines (numbers 1 to 5 above). Considerations of the land use and potential archaeology associated with these areas are described in the following subsections.

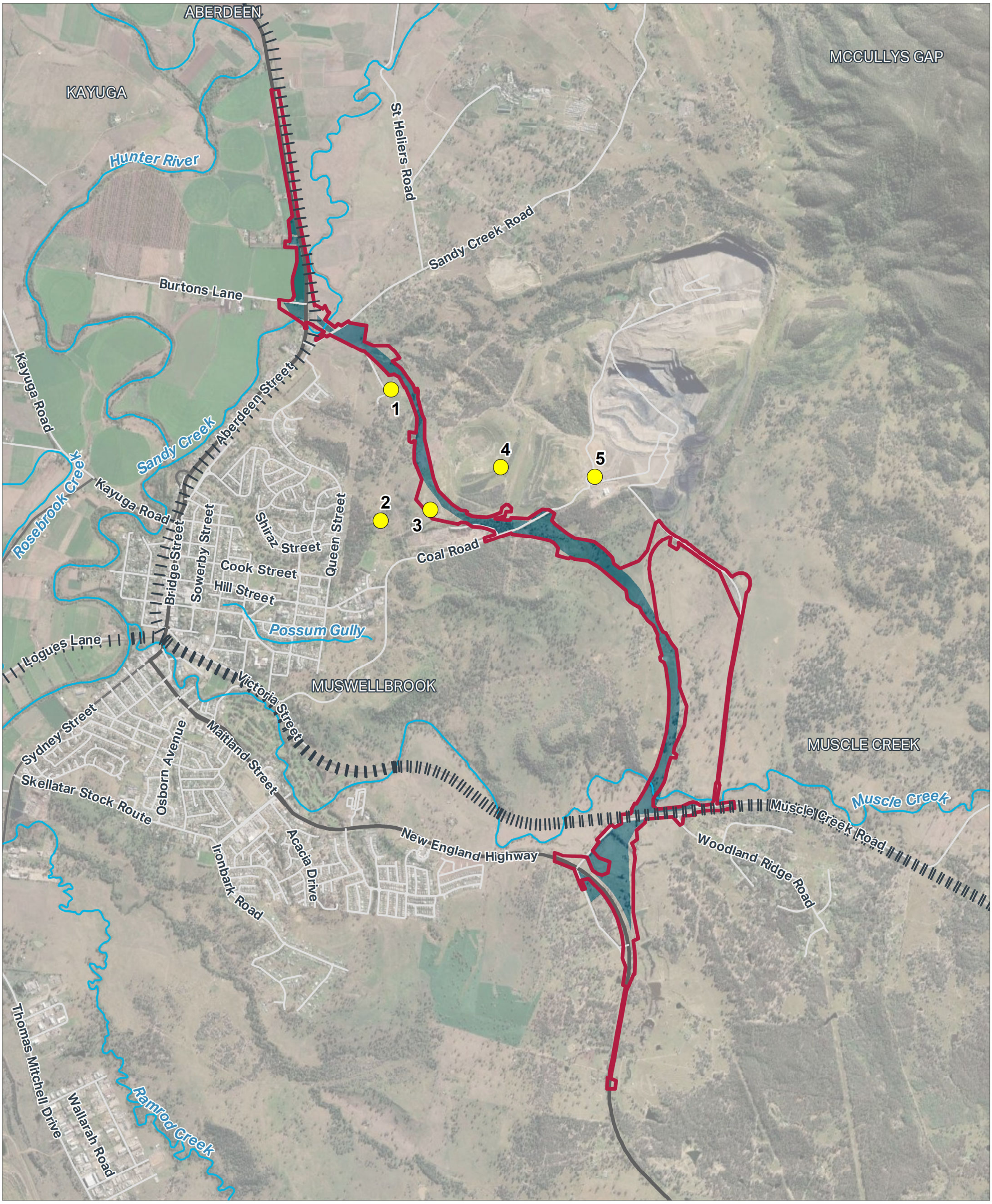


FIGURE 6-28: GENERAL LOCATIONS OF ARCHAEOLOGICALLY-SENSITIVE AREAS IN PROXIMITY TO THE CONSTRUCTION FOOTPRINT, AS LISTED IN THE 1996 MUSWELLBROOK SHIRE HERITAGE STUDY (EJE, 1996)

Legend
- Construction footprint
- Watercourse
- Proposed road corridor
- Archeologically - sensitive area
- State Road
- Regional Road
- Local Road
- Railway

N

0 0.5 1 km

Muswellbrook Electric Power Co. (1923) (Area 1)

The 1996 Heritage Study inventory listing for the Muswellbrook Brick Works includes a map and a sketch that shows infrastructure associated with a disused power station located in proximity to the construction footprint. This power station could represent the location of the 'Muswellbrook Electric Power Co. (1923)' shown in the 1996 Heritage Study. Current aerial images indicate that the 'Power Substation' noted on the map is located partially within the construction footprint.

Archaeology potentially associated with the power station and substation would include remnant machinery, chimneys and electrical infrastructure.

No. 1 Colliery (Area 2)

The mine sites identified in the 1996 Heritage Study that are located in proximity to the construction footprint include the No. 1 Colliery, which began operations after 1907. Archaeology potentially associated with the colliery could include remnant and current machinery, mine entrances and exits, roads and rail lines used to transport materials, water and power supplies, amenities and processing areas. Greater impacts to surface conditions from historic and recent mining activity are anticipated to have occurred reducing the potential for remnant deposits in this area.

The Common (1888) (Area 3)

In 1888, a c.410 hectare rectangular area of land to the east of the town of Muswellbrook was reserved as the 'Permanent Common'. It is likely that this area was originally used for grazing stock or town gardens. By 1907, the Common was used for other activities, such as mining, as indicated in an early news article from *The Maitland Weekly Mercury*, dated Saturday 20 July 1907. Early and subsequent Parish maps document the subdivision and use of this area, with uses and improvements within the construction footprint including a night soil deposit area, a rifle range, a mine site, a power station, easements for electrical supply and roads.

The construction footprint has the potential to expose archaeological resources associated with these land uses, although areas where open cut mining has occurred are unlikely to retain evidence of former uses. While the area may contain the potential for the type of archaeology listed above, this material is likely to be in poor condition and be of limited research value.

No. 2 Colliery (Area 4)

The mine sites identified in the 1996 Heritage Study that are located in proximity to the construction footprint include the No. 2 Colliery, established in 1933. Archaeology potentially associated with the colliery could include remnant and current machinery, mine entrances and exits, roads and rail lines used to transport materials, water and power supplies, amenities and processing areas. Greater impacts to surface conditions from historic and recent mining activity are anticipated to have occurred reducing the potential for remnant deposits in this area.

First Open Cut Mine (1944) (Area 5) – Coal Road

The mine sites identified in the 1996 Heritage Study that are located in proximity to the construction footprint include the Open Cut Mine, opened in 1944. Archaeology potentially associated with the Open Cut could include remnant and current machinery, mine entrances and exits, roads and rail lines used to transport materials, water and power supplies, amenities and processing areas. In the intervening period, historic and recent mining activity would have given rise to further impacts to surface conditions reducing the potential for remnant deposits in this area.

Additional Areas

In addition to the above areas of archaeological potential, other relics or subsurface archaeology may be present within the construction footprint relating to the pastoral and agricultural use of the landscape. Where the construction footprint crosses properties that have retained their pastoral/agricultural land use since their first European occupancy, these areas have the potential to contain features such as fences, dams, irrigation systems, culverts, roads, outbuildings (such as sheds and stables), sheep and cattle dips, artificial contour banks, furrow lines and remnant vegetation (e.g., orchards). Domestic areas within pastoral/agricultural properties may also contain remains of buildings or foundations, cultural plantings, water pipelines and electrical supply systems.

With reference to parish maps and current aerials, a large portion of the construction footprint is verified as crossing through land that has retained its early pastoral/agricultural use. While these areas may contain the potential for the type of archaeology listed above, this material is likely to be in poor condition and be of limited research value.

Archaeological field survey

A pedestrian archaeological field survey was undertaken on 23 July 2020, consisting of one linear transect walked along the centre line of the construction footprint across all accessible sections. A 700 metre section of the construction footprint on MCC land was not able to be accessed as mining works were in progress and a section pf the Main North railway line corridor was similarly not traversed at the time of the survey. However, no historic constraints were visible in these areas when viewed from outside the 700 metre study area. The remaining construction footprint was walked in full.

Ground surface visibility was generally good across the construction footprint, but some sections did have dense vegetation obscuring visibility during the inspection. The areas of densest vegetation were adjacent to the road corridor at the southern end of the construction footprint, and adjacent to the rail corridor at the northern end of the construction footprint. Generally, the majority of the construction footprint consisted of cleared grasslands with sufficient visibility to discern the presence of historical items.

Features associated with agricultural land use were noted across the construction footprint, including fences, dams, tracks/roads, cleared and ploughed areas, tanks, animal enclosures, troughs, houses and sheds (see Plate 1 to Plate 7). In one instance a tree had been modified for use as part of a fence and gate enclosure (see Plate 8). While each of these features provided evidence of land use across the area, they were all determined to be evidence of contemporary use rather than elements of historical significance. No heritage constraints were identified in relation to these items.

Plate 1: Abandoned house fenced due to asbestos (photo AECOM)

Plate 2: Concrete tank (photo AECOM)

 Plate 3: Animal enclosure (photo AECOM)	 Plate 4: Dilapidated timber and metal shed (photo AECOM)
 Plate 5: Concrete trough (photo AECOM)	 Plate 6: Dam (photo AECOM)
 Plate 7: Water tank (photo AECOM)	 Plate 8: Tree modified to be part of fenced enclosure with gate (photo AECOM)

St Heliers

The survey did not identify any physical fabric associated with St Heliers in the section of its curtilage immediately adjacent to the construction footprint at its northern end (Plate 9). Although the construction footprint is adjacent to its curtilage, the features that are listed as contributing to the item’s heritage significance (the 1895-1900 constructed homestead for Malcolm Campbell, other “well-sited” buildings and potential archaeological deposits associated with these structures) are not visible from the road, and are likely to be contained within the curtilage associated with the heritage item. As such no direct impacts were identified (the construction footprint is adjacent to but outside the registered curtilage of this item) and no indirect visual impacts were identified.

Plate 9: View north towards the St Heliers curtilage from the construction footprint (photo AECOM)

Muswellbrook Brick Works

The survey also verified that the construction footprint is outside the curtilage of the Muswellbrook Brick Works, which is about 130 metres to the east of the construction footprint (Plate 10). No direct impacts were identified and, as the brickworks area was not visible from the construction footprint, there would be no indirect visual impacts to this item.

Plate 10: General view east towards the Muswellbrook Brick Works from the construction footprint (photo AECOM)

Old coal rail spur bridge

The old coal rail spur bridge was identified as being part of a linked assemblage of heritage features, all associated with the Muswellbrook Coal Mine. It is likely that all these features were built after the establishment of the Open Cut mine in 1944 as a transport corridor to link the coal mine to the Great Northern Railway. The features included the bridge itself, consisting of concrete earth embankments either side of the river supporting a timber bridge on three timber trestles, one based on the northern bank of the river, the other two mounted on concrete whalings within the channel of Muscle Creek. The bridge design, including the timber trestles, appears to be of a standard rail design used in NSW from the 1860s through to the 1930s. The timber trestles include five timber piers, three under the bridge and two raked at the ends, with long cross beams and whalings present at the top and bottom of the trestle. The deck rests on deck beams and headstocks that are attached to the timber trestles.

The rails formerly on the deck of the bridge have been removed, but some metal plates remain.

Beneath the bridge on the northern bank building refuse was noted, predominantly comprised of broken brick, suggesting a brick structure may have previously been associated with the railway and bridge but has since been demolished. This may have been associated with the bridge abutment wall or similar retaining wall used to stop erosion to the approaches of the bridge. A concrete base to the north of the bridge is also suggestive of a past structure associated with the railway in this area. In addition to these features, a raised linear earth embankment extends in a northern direction from the bridge towards the coal mine. The embankment has remnant pieces of railway material (metal and wood) on top of it, but the rails that it would have supported have been removed. This may have been a former siding, however, its proximity to the bridge, and water source, also suggest it may have been used as a former water topping up point for steam engines. Further north along the linear embankment two culverts were identified draining water beneath it. Both culverts were small in size. The one closest to the bridge (850 metres north of it) was comprised of wood, metal and stone. Rough hewn and in a dilapidated state, it still functioned to drain water as evidenced during the survey. The culvert furthest from the bridge (1.3 kilometres to the north of the bridge) was composed of concrete and remained in a fair condition. The earth embankment continued north, but as it passed beyond the bounds of the construction footprint it was not investigated further.

The entirety of all these features (the bridge, embankment, culverts, concrete base and remnants of demolition/removal) all constitute parts of one heritage item (refer Plate 11 to Plate 20). The NSW heritage theme of economy for developing local, regional and national economies, both for mining activities and transport, is applicable, indicating local heritage significance values may be appropriate for this item. A SoHI prepared for this item is in Appendix M.

 Plate 11: View south across bridge (photo AECOM)	 Plate 12: View south-east towards bridge (photo AECOM)
 Plate 13: View south from beneath bridge (photo AECOM)	 Plate 14: View north at concrete base (photo AECOM)

 Plate 15: Rubble beneath bridge (photo AECOM)	 Plate 16: View north along embankment (photo AECOM)
 Plate 17: View east at culvert 1 (850 metres north of bridge) (photo AECOM)	 Plate 18: View west at culvert 1 (850 metres north of bridge) (photo AECOM)
 Plate 19: View east at culvert 2 (1.3 kilometres from bridge) (photo AECOM)	 Plate 20: View through culvert 2 (1.3 kilometres from bridge) (photo AECOM)

Areas of archaeological potential

The areas previously identified as having potential archaeological sensitivity in the 1996 Muswellbrook Shire Heritage Study were assessed during the survey for surface signs of archaeology and any surrounding context indicative of historical values with research potential. The two areas that were within or in close proximity to the construction footprint (The Common (1888) and the Muswellbrook Electric Power

Co. (1923)), did not demonstrate evidence of intact historical subsurface deposits in the sections inspected for this assessment. Ground surfaces in these areas had been subject to vegetation clearance, track grading and erosion. There were no surface expressions of artefacts or relics and no indications of intact deposits with research potential. The archaeological sensitive areas associated with the Mine Sites (No. 1 Colliery, No. 2 Colliery, First Open Cut Mine (1944)) were both highly disturbed and beyond the bounds of the construction footprint. It is considered unlikely that intact subsurface deposits with heritage significance and research potential would be present in these sections of the construction footprint.

6.8.3 Potential impacts

The NSW Heritage Division uses standardised terms to define impact to heritage items. The terms and their definitions are provided in Table 6-43.

Table 6-43: Heritage impact terms and conditions

Impact term	Definition
Major negative impact	Substantially affects fabric or values of state significance
Moderate negative impact	Irreversible loss of fabric or values of local significance; minor impact on State significance
Minor negative impact	Reversible loss of local significance fabric or where mitigation retrieves some value of significance; loss of fabric not of significance but which supports or buffers local significance values
Negligible or no impact	Does not affect heritage values either negatively or positively
Minor positive impact	Enhances access to, understanding or conservation of fabric or values of local significance
Major positive impact	Enhances access to, understanding or conservation of fabric or values of State significance

Construction

It is anticipated that direct impacts during construction would include ground disturbance activities, while indirect impacts may include vibration or ground settlement generated by construction activity. Visual impacts may also arise.

St Heliers

No visual impacts were identified in relation to the St Heliers listing, given the buffer of existing landscape between the proposed road corridor and the buildings.

No direct or indirect impacts to St Heliers are considered likely during the construction of the proposal. The LEP curtilage is adjacent to the construction footprint; however, descriptions of significance represented in the LEP and S170 listings indicate that the S170 curtilage (comprising the main Campbell homestead and the grounds to the base of the hill) are a more appropriate curtilage for this item. The St Heliers Correctional Centre including the Campbell homestead are located at least 1.3 kilometres from the construction footprint. As a consequence, the physical fabric elements of the item are located well outside the construction footprint and would not be impacted.

Muswellbrook Brick Works Site

No visual impacts were identified in relation to the Muswellbrook Brick Works site, as the majority of the site is not visible from the construction footprint due to distance, intervening landform and vegetation.

No direct or indirect impacts to the Muswellbrook Brick Works site are considered likely during the construction of the proposal. The LEP curtilage of the Muswellbrook Brick Works site is located about 130 metres from the construction footprint at its closest point. The Muswellbrook Brick Works item has also been demolished following the expansion of the Muswellbrook Coal Mine.

Old coal rail spur bridge

The proposal is not expected to have any direct impact on the old coal rail spur bridge. The bypass would be located greater than 50 metres to the west of the bridge's location. The proposal would directly impact on a separate concrete culvert rail bridge located approximately 200 metres to the south of the former old coal rail spur bridge. The culvert bridge has been assessed as having no heritage significance, and direct impacts to this bridge are considered to be acceptable.

There is the potential for indirect impacts from activities causing vibrations to the old coal rail spur bridge over Muscle Creek. The use of heavy machinery for the construction of the proposal may have the potential to cause vibrations that could affect the structural stability of the bridge. The potential for this to occur is considered low, as the bypass and associated embankment would be located approximately 60 metres from the bridge. Potential for vibration impact may be expected if additional heavy machinery works were to occur in closer proximity to the bridge. This would include any requirement for services, service roads, stockpiles, or if any associated construction occurs for landscaping works in this area. An exclusion zone around the location of the bridge would minimise the risk associated with potential vibration impacts. Service roads would be located outside the exclusion zone.

The bridge is also not considered to be a landscape feature as it is obscured from view by the trees lining Muscle Creek. Also, views to the bridge from the surrounding roads is limited, at best. The construction of the new bypass is not expected to visually dominate the heritage item, as the item would still be contained within its current setting.

There is also the potential for indirect impacts to occur to two other culverts located 850 metres and 1.3 kilometres to the north of the old rail spur bridge. Both of these culverts have been assessed as having no heritage significance. If vibration impacts were to occur to these two items, the impact would be considered acceptable.

Areas of Archaeological Potential

It is considered unlikely that potential archaeological deposits containing intact, in situ historic relics with research potential, would be impacted by the proposed works.

Operation

During operation impacts may include alterations to the visual landscape character, increased noise, increased vibration and a reduction in air quality.

St Heliers

No direct or indirect impacts to St Heliers are considered likely during the operation of the proposal as there is sufficient buffer of unaffected landscape around the buildings to maintain existing views and vistas. These features are not visible from the road and if any parts of the road can be viewed from the property, it is unlikely these views would alter the existing visible landscape in a way that would impact upon the existing heritage significance. The operation of the proposal is not anticipated to affect the existing significance of this site.

Muswellbrook Brick Works

No direct or indirect impacts to the Muswellbrook Brick Works site are considered likely during the operation of the proposal.

Old Coal Rail Spur Bridge

No direct or indirect impacts to old coal rail spur Bbidge are considered likely during the operation of the proposal.

Impact summary

Consideration of impacts associated with construction and operation activities in relation to the identified historical sites in proximity to the construction footprint are summarised in Table 6-44.

Table 6-44: Impact summary for historic sites

Impact	St Heliers	Muswellbrook Brick Works	Old Coal Rail Spur Bridge	Archaeological potential
Major negative	None	None	None	None
Moderate negative	None	None	None	None
Minor negative	None	None	None	None
Negligible or no impact	No direct or indirect impacts are proposed within the curtilage of St Heliers	No direct or indirect impacts are proposed within the curtilage of Muswellbrook Brick Works site	The proposal is not expected to have any direct impact on the old coal rail spur bridge over Muscle Creek	No areas of likely archaeological potential were identified within the construction footprint during the survey
Minor positive	None	None	None	None
Major positive	None	None	None	None

6.8.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Non-Aboriginal Heritage	A Non-Aboriginal Heritage Management Plan (NAHMP) will be prepared and implemented as part of the CEMP. The NAHMP will provide specific guidance on measures and controls to be implemented to avoid and mitigate impacts to Non-Aboriginal heritage	Construction contractor	Pre-construction	Additional safeguard
Non-Aboriginal heritage	The *Standard Management Procedure - Unexpected Heritage Items* (Transport for NSW, 2015) will be followed in the event that any unexpected heritage items, archaeological remains or potential relics of Non-Aboriginal origin	Construction contractor	During construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	are encountered. Work will only re-commence once the requirements of that Procedure have been satisfied			
Non-Aboriginal heritage	Two buffer zones will be set up around the old coal rail spur bridge over Muscle Creek and its associated elements, including: • a 25 metre radius exclusion zone that is made known to all workers operating near the site • a 50 metre radius limited works area All those operating within the area will be made aware of the existence of the heritage items and that they are not to be disturbed An archival recording of the former bridge, to be carried out on the bridge prior to the commencement of works, will be considered in consultation with the landowner, MCC. This recording will record, in detail, the bridge and all fabric associated with it. This recording will also be used as a baseline assessment that will allow for a comparison of the bridge and specific elements before and after construction works Vibration monitoring will be undertaken within close proximity of the bridge. This is to record any actual vibration that is encountered in the vicinity of the bridge from construction. This monitoring will be done in conjunction with a visual inspection of the bridge to assess any potential vibration impacts. This monitoring will be added to the CEMP for the proposal	Construction contractor	During construction	Additional safeguard

6.9 Air quality

This chapter presents the methodology and results of the construction and operational air quality impact assessment for the proposal. Further detail regarding the methodology and the results for the assessment is provided in Appendix N.

6.9.1 Methodology

Construction impacts

Potential impacts from dust generation during construction have been assessed using the UK Institute of Air Quality Management (IAQM), 2014 *Guidance on the assessment of dust from demolition and construction*. The IAQM methodology assesses the risk of impacts associated with demolition and construction without the application of any mitigation measures. The assessment provides a classification of the risk of dust impacts which then allows the identification of appropriate mitigation measures commensurate with the level of risk.

The IAQM guidance process is a four-step risk-based assessment of dust emissions associated with demolition, land clearing and earth moving, and construction activities. The IAQM assessment process is described in detail in Appendix N and a summary of the process is described in the following sections.

Step 1 – Screening assessment

A screening assessment is undertaken to identify both 'human' and 'ecological receptors' within close proximity to the construction footprint and the routes used by construction vehicles on public roads.

Step 2 – Dust risk assessment

Step 2 in the IAQM methodology is a risk assessment tool designed to appraise the potential for dust impacts due to unmitigated dust emissions during construction. The key components of the risk assessment are defining the dust emission magnitudes (Step 2A) and the surrounding area sensitivity (Step 2B) which are combined in a risk matrix (Step 2C), to determine an overall unmitigated risk of dust impacts.

Step 2A – Dust emission magnitude

Dust emission magnitudes are estimated according to the scale of works being undertaken and are classified as either Small, Medium or Large.

Step 2B – Sensitivity of surrounding area

The "sensitivity" component of the risk assessment is determined by defining the surrounding area's sensitivity to dust soiling, human health effects and ecological impacts. Here the sensitivity of the surrounding area is rated high, medium, or low.

Step 2C – Unmitigated risks of impacts

The dust emission magnitudes determined in Step 2A are combined with the sensitivities in Step 2B to ascertain the risk of impacts with no mitigation applied. Table 6-45, reproduced from the IAQM guidance, provides the risk of dust impacts from demolition, earthworks, construction and track-out for each scale of activity listed.

Table 6-45: Risk of dust impacts

Activity	Surrounding Area Sensitivity	Dust Emission Magnitude		
		Large	Medium	Small
Demolition	High	High	Medium	Medium
	Medium	High	Medium	Low
	Low	Medium	Low	Negligible
Earthworks	High	High	Medium	Low

Activity	Surrounding Area Sensitivity	Dust Emission Magnitude		
		Large	Medium	Small
	Medium	Medium	Medium	Low
	Low	Low	Low	Negligible
Construction	High	High	Medium	Low
	Medium	Medium	Medium	Low
	Low	Low	Low	Negligible
Track-out	High	High	Medium	Low
	Medium	Medium	Low	Negligible
	Low	Low	Low	Negligible

Step 3 – Management strategies

The outcome of Step 2C is used to determine the level of management that is required to ensure that dust impacts on surrounding sensitive receptors are maintained at an acceptable level. A high or medium-level risk rating means that suitable management measures must be implemented during construction.

Step 4 – Reassessment

The final step of the IAQM methodology is to determine whether there are significant residual impacts, post mitigation, arising from the proposal.

Operational impacts

To assess operational air quality impacts, a Level 1 Screening Assessment was undertaken in accordance with the NSW Approved Methods (EPA 2017) using the Tool for Roadside Air Quality (TRAQ) (Version 1.3) developed by Transport. TRAQ is considered a conservative approach to estimate pollutant concentrations near roadways.

Traffic forecast data from the traffic modelling was used to estimate vehicle emissions to enable the quantification of potential air quality impacts attributed to operation of the proposal. Average Annual Daily Traffic (AADT) volumes forecast for the design opening year (2027) and the years 2034 and 2044 were used as the basis for the estimate of vehicle emissions for daily average traffic (taking into account the traffic volume, traffic mix, speed, number of lanes and road grade). Both a ‘Build’ and ‘No Build’ option were assessed for the modelled years also to assess the potential air quality impact along the New England Highway both with and without the proposed bypass.

Details of the construction and operational impacts from the proposal are provided in Section 6.9.3.

6.9.2 Existing environment

Climate and weather

The climate and weather at Muswellbrook are affected by several factors such as terrain and land use. Wind speed and direction are largely affected by topography on a small scale, while factors such as regional scale winds affect wind speed and direction on a larger scale. Wind speed and direction are important variables in assessing potential air quality impacts, as they dictate the direction and distance air pollutants travel.

DPIE operates two ambient air quality monitoring stations in proximity to the proposed road corridor that collect wind speed and wind directional data. DPIE monitoring stations include the:

- Muswellbrook northwest station located about 2.5 kilometres southwest of where the northern end of the proposed bypass re-joins the New England Highway
- Muswellbrook station located about 2.7 kilometres south southwest of where the northern end of the proposed bypass re-joins the New England Highway.

A review of 2018 hourly wind speed and wind direction data for the Muswellbrook northwest and Muswellbrook DPIE monitoring stations found annual average wind patterns are relatively similar between the two locations, with predominant wind directions from the southeast (which follows the axis of the of the Hunter Valley). Annual average wind speeds are relatively low for both stations ranging from 2.1 metres per second at Muswellbrook northwest and 2.0 metres per second at Muswellbrook. A 2018 annual wind rose for Muswellbrook monitoring station is shown in Figure 6-29.

Given the relatively low wind speeds observed at the monitoring stations, there would be the potential for periods during the year when low wind speeds and calm conditions may result in higher pollution levels (as these conditions commonly correspond to poor dispersion conditions). The screening assessment in Section 6.9.3 adopts a conservative approach through the use of unfavourable weather conditions typically not conducive to rapid dispersion of air pollutants. Weather conditions are based on a wind speed of one metre per second, temperature of 15 degrees Celsius and pascal stability class F (typical of stable night-time conditions).

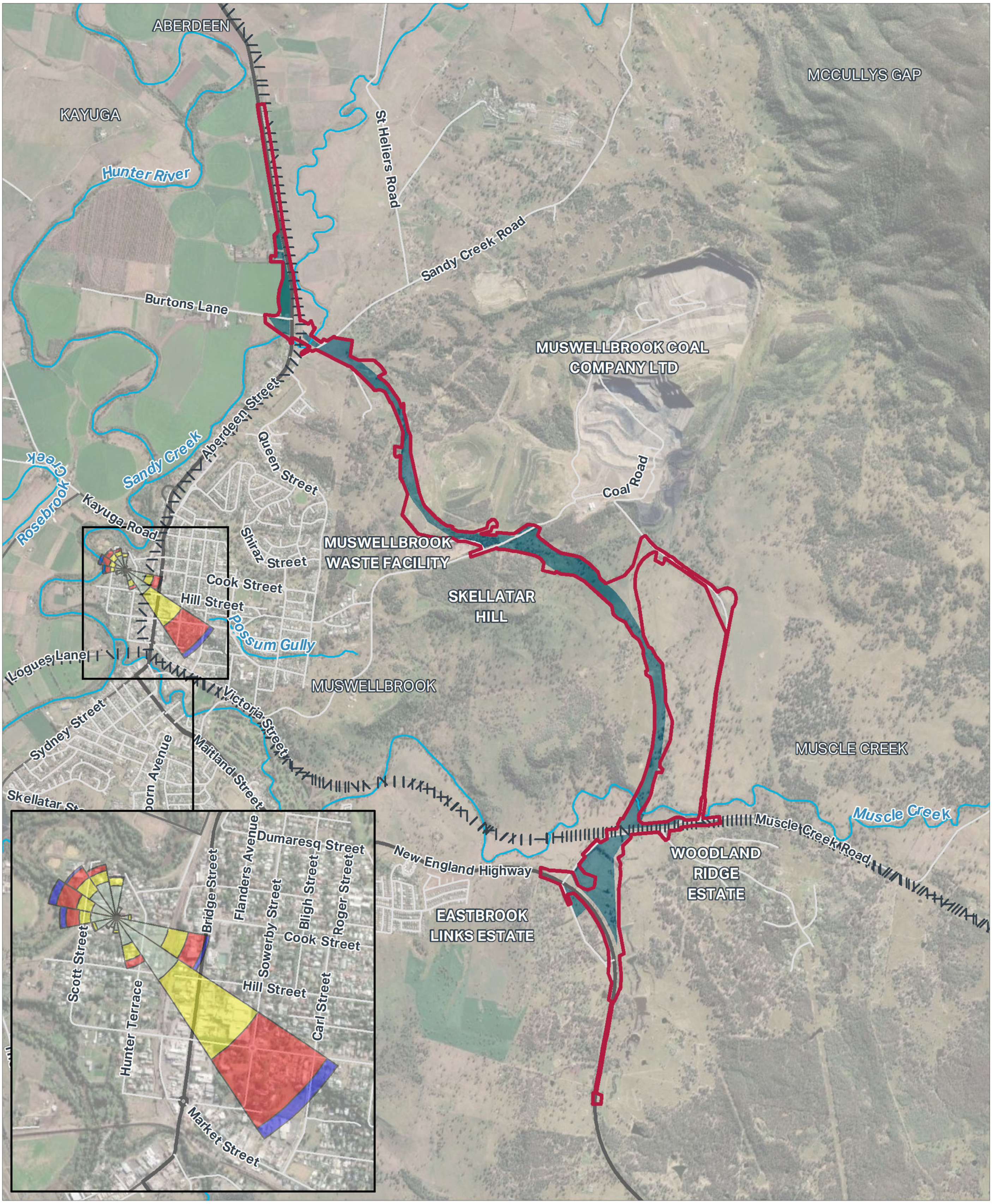


FIGURE 6-29: ANNUAL 2018 WIND ROSE FOR DPIE MUSWELLBROOK MONITORING STATION (DPIE 2020)

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse

Wind Speed (m/s)

- >=11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

0 0.5 1 km

Ambient air quality

Ambient air refers to atmospheric air in its natural state. For ambient air quality within and around the proposed road corridor, pollutants of concern include carbon monoxide (CO), oxides of nitrogen (NOx) and particulate matter equal to or less than 10 microns in diameter (PM_{10}) and less than 2.5 microns in diameter ($PM_{2.5}$)

The Muswellbrook air shed can be considered one of the most sensitive areas to air pollution; especially particulates within the Hunter Region due to the high level of sources of air emissions within the air shed including mining operations, coal-fired power generation, diesel vehicle emissions, road and rail transport emissions and use of solid fuel heaters. Both ambient air quality monitoring stations operated by DPIE monitor for PM_{10}. Nitrogen dioxide (NO_2) and $PM_{2.5}$ are only monitored at the Muswellbrook monitoring station.

Monitoring data for 2018 at each monitoring station is shown in Table 6-46 against the appropriate ambient air quality criteria as stated under the NSW *Approved Methods for Modelling and Assessment of Air Pollutants* (EPA 2017) (the Approved Methods) for the appropriate averaging periods. The year 2018 has been chosen as the most recent complete data set that is representative of typical background air quality concentrations. The years 2019 and 2020 data are not considered representative of existing background concentrations. This is due to extreme particulate concentrations recorded over the 2019-2020 'Black Summer' period characterised by an unprecedented and catastrophic bushfire season, followed by potentially lower than average levels of NO_2; PM_{10} and $PM_{2.5}$ concentrations due to reduced activity (including vehicle movements) and as a consequence of Covid-19.

Ambient air quality criterion set by NSW EPA under the Approved Methods for NOx and particulates mirror the ambient air quality standards set by National Environmental Protection Council (NEPC) under the *National Environmental Protection (Ambient Air Quality) Measure* (Ambient Air Quality NEPM). The NEPC is currently proposing changes to the 1-hour maximum and annual average NO_2 standards which have also been provided in Table 6-46. Taking a conservative approach, predicted ground level NO_2 concentrations in Section 6.9.3. have been assessed against the more stringent ambient air quality standards proposed by the NEPC.

TRAQ utilises 90th percentile background data to calculate potential cumulative impacts from vehicle emissions (as discussed in Section 6.9.3). Table 6-46 shows the 90th percentile concentration for NO_2, PM_{10} and $PM_{2.5}$ as in the absence of local CO data at Muswellbrook, default CO background concentrations from the TRAQ database have been used in this assessment.

Table 6-46 shows that both the 1-hour maximum and annual average NO_2 concentrations recorded at the Muswellbrook station for 2018 were under the relevant EPA criteria and the proposed NEPM standard.

The PM_{10} 24 hour maximum concentrations were well above the EPA criterion at all stations in the Muswellbrook area. These concentrations are attributed to dust storms occurring in November 2018, however the 90th percentile concentrations used in TRAQ are below the maximum 24 hour EPA criterion at both stations. Annual average PM_{10} concentrations for the area were above the criterion at both monitoring stations and are likely attributed to both local mining activities and vehicle emissions based on the proximity to the existing New England Highway. Similarly, the maximum 24-hour $PM_{2.5}$ concentration was above the EPA criteria; however, the 90th percentile concentration at Muswellbrook was below the criterion. The record annual average $PM_{2.5}$ concentration was also elevated, slightly exceeding the ambient air quality criterion.

Table 6-46: Ambient air quality data at EPA monitoring stations at Muswellbrook, NSW (EPA 2020)

Pollutant	Averaging Period	Concentration (µg/m³)		EPA Criteria (µg/m³)	Proposed NEPM Standard (µg/m³)
		Muswellbrook Northwest	Muswellbrook		
NO_2	1-hour (maximum)	No data	96.4	246	185
	1-hour (90th percentile)	No data	43.1	Not applicable	Not applicable
	Annual Average	No data	21.5	62	40
PM_{10}	24-hour (maximum)	195.4	185.9	50	Not applicable
	24-hour (90th percentile)	39.0	42.5	Not applicable	Not applicable
	Annual Average	25.3	27.3	25	Not applicable
$PM_{2.5}$	24-hour (maximum)	No data	26.5	25	20
	24-hour (90th percentile)	No data	16.9	Not applicable	Not applicable
	Annual Average	No data	9.5	8	7

µg/m³ = Micrograms per metre cubic metre

Sensitive receptors and land use

Land use surrounding the study area is comprised of low density rural residential and agriculture, mining activities and associated infrastructure and remnant vegetation. Residential sensitive receptors adjacent to the proposed road corridor are generally more than 50 metres from the kerb.

Several properties have been identified that lie within 50 metres including:

- Properties off Muscle Creek Road and along Koolbury Flats Row (within 40 metres)
- Residential receptors at Sandy Creek on the New England Highway near the on and off ramps at the northern end of the proposed alignment (within 50 metres).

The nearest sensitive receptor[2] is located about 36 metres from the kerb of the proposal.

Higher density residential and commercial properties follow the New England Highway through the township of Muswellbrook; west of the proposal. The residential area contains a mix of sensitive land uses including houses, schools and sporting fields. Sensitive receptors along the New England Highway generally lie within 10 metres of the existing kerb.

The TRAQ model calculates pollutant concentrations directly downwind of vehicle emissions from the proposed road corridor at pre-specified distances. Typically, the nearest sensitive or commercial receptor is located at least 10 metres or more from the kerb of the road; noting that both higher density and close proximity receptors are generally limited to the existing New England Highway. For most of the proposed road alignment sensitive receptors are generally over 50 metres from the kerb. For this assessment the

[2] Properties acquired as part of the project have been excluded from the list of identified sensitive receptors

modelled concentrations directly downwind of the proposal have been modelled at discrete receptor locations at 10 metres, 20 metres, 30 metres and 50 metres from the kerb.

6.9.3 Potential impacts

Construction

Step 1 – Screening assessment

An initial screening assessment in accordance with the IAQM method identified several sensitive 'human' receptors located within 350 metres of the study area; and within 50 metres of construction haulage routes Sensitive 'ecological' receptors are located within a disturbed landscape with only fragmented and modified vegetation remnants as discussed in the Biodiversity Impact Assessment provided in Section 6.1. As detailed in Section 6.1, there are EEC listed under the BC Act and EPBC Act within 50 metres of the construction footprint and 50 metres of construction haulage routes. The Muswellbrook region is also home to a population of Striped Legless Lizard which is listed as vulnerable under the BC Act and EPBC Act.

Based on the proximity of both residential and ecological receptors to the construction footprint, a Stage 2 assessment was triggered.

Step 2 – Risk assessment of unmitigated impacts

A Stage 2 assessment considers the construction footprint as shown in Figure 6-29. Construction of the proposal is anticipated to take about 36 months. Potential dust impacts during the construction period have been determined based on the IAQM construction dust assessment guidance documentation and the expected scale of the construction activities outlined in Section 3.3.

Step 2A – Dust emission magnitude

Potential dust emission magnitudes for the proposal were estimated based on the indicative construction work methodology described in Section 3.3. Potential dust generating activities and associated magnitudes are included in Table 6-47. The magnitude of the unmitigated emissions from the construction footprint activities are rated as large for demolition, earthworks, construction and trackout activities due to the expected extent of construction activities.

Table 6-47: Dust emissions magnitude

Activity	Potential dust generating activities	Magnitude
Demolition	• Two existing buildings owned by Transport within the construction footprint would require removal. Progressive demolition of building structures would occur using modified excavators. Details of building removal and demolition works are outlined in Section 3.3.1	Large
Earthworks	• Large scale earthworks would be required as part of the proposal with most earthworks associated with filling for the new road and embankments and excavation where the proposed road alignment is lower than the existing ground level. The estimated quantities of materials associated with earthworks are provided in Section 3.3.5 • Other earthworks would be associated with utility adjustment or relocation, including electricity, water and sewerage, gas and telecommunications, boring for bridge structural supports and landscaping works • Stockpiling would occur at several locations as described in Section 3.4 including: ○ Northern Connection main site construction compound	Large

Activity	Potential dust generating activities	Magnitude
	○ Southern Connection main site construction compound ○ Skellatar Ridge cutting satellite compound ○ Coal Road satellite compound ○ Sandy Creek and Main North railway line laydown area • A number of heavy earth moving vehicles would be required during earthworks. An indicative list of plant and equipment is provided in Section 3.3.4	
Construction	• The construction footprint area is shown in Figure 6-29 • Construction activities are described in detail in Section 3.3 and would include construction of about nine kilometres of new highway; bridges, connections to existing road infrastructure, utility adjustments or relocation, drainage infrastructure and urban design and landscaping works • Construction of ancillary facilities would include construction compounds and laydown/stockpiling areas as described in Section 3.4 • Crushing and concrete batching activities would occur at the Southern Connection main site and Sandy Creek construction compounds • A number of dust generating materials would be required for construction including aggregates, sand, concrete and fly ash. Estimated quantities of construction materials are provided in Section 3.3.6 • A range of plant and equipment would be used during construction. An indicative list of plant and equipment is provided in Section 3.3.4	Large
Trackout	• Construction would generate a large number of light and heavy vehicles movements. Estimated heavy vehicle movements are provided in Section 3.3.7 • Construction vehicle activities would include the movement of construction workers, delivery of construction materials, spoil movement and waste removal and delivery of construction equipment and machinery • Temporary unsealed access roads would be built to facilitate the movements of construction vehicles and construction materials to key construction work areas for bridges and bypass connection points within the construction footprint. Construction vehicle and light vehicle access routes are shown in Figure 3-6	Large

Step 2B – Sensitivity of surrounding area

The sensitivities of receptors to unmitigated dust emissions for the various construction activities are provided in Table 6-48. Due to the rural nature of the area there are few residential properties located within 50 metres of the proposed road corridor with the exception of:

- Where additional property access roads are required off Muscle Creek Road and along Koolbury Flats Row
- Existing receptors on the New England Highway near the on and off ramps at the northern end of the proposal alignment.

Given the residential nature of these landuses, where members of the public are likely to be exposed to dust impacts for more than eight hours a day, a receptor sensitivity rating of 'High' applies. When taking into account the low housing density within 50 metres of the construction footprint, the surrounding area sensitivity to dust spoiling effects on people and property was rated ‘Medium’. Based on the elevated annual average concentrations of PM_{10} within the Muswellbrook Airshed, the sensitivity to human health effects was rated ‘High’.

With regard to ecological receptors the study is located within a disturbed landscape with only fragmented and modified vegetation remnants. The Biodiversity Impact Assessment as summarised in Section 6.1 found that despite the presence of biodiversity values listed under the BC Act and the EPBC Act, the proposal is considered unlikely to have significant impacts on any vulnerable or threatened species or EEC as most of the vegetation is already disturbed, modified and/or fragmented in nature by existing and past land uses. As such the ecological sensitivity of the area was considered ‘Low’.

Step 2C – Unmitigated risks of impacts

The potential risks for the overall construction footprint were found to be “medium” to “high” for construction activities as shown in Table 6-48 in relation to potential unmitigated impacts relating to dust soiling and human health within 50 metres of the proposal. The majority of residential receptors are situated over 50 metres from the proposal and would have a medium to low risk given their offset distance from the proposal. The potential unmitigated ecological risks from the proposal were found to range from “low” to “medium”.

Table 6-48: Summary of dust emission risk assessment for construction footprint

Activity	Step 2A: Potential for dust emissions	Step 2B: Sensitivity of area			Step 2C: Risk of dust impacts		
		Dust soiling	Human health	Ecological	Dust soiling	Human health	Ecological
Demolition	Large	Medium	High	Low	High	High	Medium
Earthworks	Large	Medium	High	Low	Medium	High	Low
Construction	Large	Medium	High	Low	Medium	High	Low
Trackout	Large	Medium	High	Low	Medium	High	Low

Step 3 – Mitigation strategies

The outcome of Step 2C was used to determine the level of management that is required to ensure that dust impacts on surrounding sensitive receptors are maintained at an acceptable level. A high or medium-level risk rating suggests that suitable management measures must be implemented during construction. A range of mitigation strategies aimed at reducing the likelihood of air quality impacts to off-site sensitive receptors are included in Section 6.9.4.

Step 4 – Reassessment

The final step of the IAQM methodology is to determine whether there are significant residual impacts, post mitigation, arising from the proposal. The guidance states:

“For almost all construction activity, the aim should be to prevent significant effects on receptors through the use of effective mitigation. Experience shows that this is normally possible. Hence the residual effect would normally be ‘not significant’.”

It is anticipated that, with the implementation of the recommended mitigation strategies provided in Section 6.9.4 which are consistent with the standard dust mitigation measures used on large road construction projects, the residual effect (impacts) of the proposal would be ‘not significant’ at all locations for dust soiling, human health and ecological impacts.

Operation

Traffic Forecast Data

Traffic movements along the proposed road corridor have the potential to result in motor vehicle emissions from fuel combustion, fluid evaporation, brake and tyre wear, and re-suspended road dust.

Emissions from motor vehicles would comprise mainly hydrocarbons, CO, NO_x and PM_{10}. Traffic activity including the number of vehicles, the vehicle type mix and vehicle speeds can directly influence the near roadside air pollutant concentrations. Vehicle emissions would vary based on the vehicle type mix or ratio of light to heavy vehicles, fuel type mix (for example, petrol and diesel), and the distribution of vehicles by age of manufacture. Traffic forecast data as detailed in Section 6.5 have been used to estimate vehicle emissions and to quantify air quality impacts attributed to operation of the proposal.

The AADT volumes discussed earlier in section 6.9.1 were then used to estimate vehicle emissions for daily average traffic considering the traffic volume, vehicle mix, speed, number of lanes and road grade. Peak hourly traffic speed has been based on an average of measured weekday morning (7am to 9am) and afternoon (4pm to 6pm) peak traffic volumes for the New England Highway. The proposed road grades would be highly variable throughout the proposed road alignment with a maximum grade of eight per cent. For each section of road modelled, an average positive and negative road grade has been estimated for both the north and southbound lanes based on local terrain information. The traffic data used for this assessment is provided in Appendix K.

Dispersion Calculations

For the purpose of this assessment, a Level 1 Screening Assessment has been carried out in accordance with the Approved Methods using the TRAQ (Version 1.3) developed by Transport. Air emissions from key sections along the proposal that would experience changes in traffic have been generated using the total traffic volume with percentages of vehicles in each age bracket and type category. Road grade and speed information was also included in the calculations.

Vehicle emission factors from the World Road Association, referred to as PIARC (formerly the Permanent International Association of Road Congress) are used by TRAQ to estimate emissions from relevant roads in the vicinity of Muswellbrook bypass. In 2004, PIARC (2004) published a document with comprehensive vehicle emissions factors for different road gradients, vehicle speeds and for vehicles conforming to different European emission standards. The emission data in TRAQ have been modified to take into account the age, vehicle mix and emission control technology of the Australian vehicle fleet using DPIE data.

To assess air quality impacts, 90th percentile background data for CO (one hour and eight hour), NO_2 (one hour) and PM_{10} (24 hour) in the Lower Hunter as well as annual averages were obtained from the TRAQ database. In the absence of local data at Muswellbrook for CO (one and eight hour), 90th percentile, background concentrations for the Lower Hunter have been adopted for CO. Local air quality data for NO_2 and PM_{10} was added to the TRAQ background air quality database and incorporated into the dispersion model.

Carbon Monoxide

Predicted 2027 and 2037 incremental and cumulative maximum one hour and eight hour CO concentrations are presented in Appendix N and show that predicted CO concentrations comply with EPA criteria both incrementally and cumulatively for the design opening year (2027) and ten years after opening (2037). The proposal would also result in a reduction in maximum 1-hour and 8-hour CO_2 ground level concentrations along the New England Highway through Muswellbrook due to both reduced total traffic volumes and the proportion of heavy vehicles.

Nitrogen Dioxide

Predicted 2027 and 2037 incremental and cumulative maximum one hour and annual average NO_2 concentrations are presented in Appendix N and show that predicted NO_2 concentrations comply with both the EPA criteria and the proposed more stringent NEPM standards both incrementally and cumulatively for 2027 and 2037. The Proposal also would result in a reduction in maximum 1-hour and annual average NO_2 ground level concentrations along the New England Highway through Muswellbrook due to both reduced total traffic volumes and the proportion of heavy vehicles.

Particulate Matter

Predicted 2027 and 2037 incremental and cumulative maximum 24-hour and annual average PM_{10} concentrations presented in Appendix N indicate the potential for maximum 24 hour average exceedances along the main alignment. Predicted cumulative 24-hour exceedances are limited to the area within 20-30 metres of the proposed kerb; while annual average exceedances are attributed to measured background concentration's which exceed the PM criterion in isolation. Predicted exceedances are largely due to existing high background concentrations as follows:

- Background data from the Muswellbrook station has been used for the calculation of all cumulative concentrations. Muswellbrook station has generally higher particulate concentrations than the station at Muswellbrook north west attributed to its proximity to the New England Highway and as such the use of this station provides a worst-case indication of background particulate concentration. A degree of double counting must also be taken into consideration as existing background concentrations would include vehicle emissions from existing operations along the New England Highway.
- Predicted emission concentrations consider both the emissions that come out of a car on a cold morning whilst it is warming up and worst-case meteorological conditions typical of winter nights. These assumptions are also considered worst case and result in a conservative estimation of the pollutant concentrations.
- The nearest sensitive receptors adjacent to the proposed road corridor is about 36 metres from the road kerb; with the majority of sensitive receptors in excess of 50 metres from the kerb. Given that estimated maximum ground level 24-hour PM^{10} concentrations are only predicted to be exceeded within 20 to 30 metres of the kerb, emissions at the nearest sensitive receptors are likely to be compliant with the EPA criterion.

The proposal is designed to improve the network efficiency of the New England Highway; particularly with regards to network efficiency and travel times for long haul freight vehicles. A comparison of predicted ground level concentrations for the Build and No Build scenarios show a reduction in incremental PM_{10} maximum 24-hour concentrations and annual averages with inclusion of the bypass. Without the bypass, maximum 24-hour cumulative concentrations are in exceedance of the EPA criteria within 50 metres from the kerb. With the introduction of the proposal, these exceedances along the New England Highway at both east of Bimbadeen Drive and South of Sandy Creek Road are reduced to 20 metres from the curb for 2027 and 2037. This would notably reduce the number of sensitive receptors subjected to elevated concentrations of particulates.

The TRAQ is limited to the assessment of PM_{10} emissions. These PM_{10} emissions from vehicles however are predominantly made up of the finer $PM_{2.5}$ particle fraction (about 95 per cent). To enable an estimate of potential $PM_{2.5}$ impacts, predicted PM_{10} have been scaled to provide an indicative estimate of $PM_{2.5}$ contributions from the proposal and provided in Appendix N).

Predicted $PM_{2.5}$ concentrations for the proposal yield similar results to those reported for PM_{10}. Here the maximum 24-hour $PM_{2.5}$ concentrations along the alignment would exceed the EPA criteria within 20 metres of the kerb. The nearest sensitive receptor adjacent to the proposed bypass however is about 36 metres of the road kerb; with most sensitive receptors in excess of 50 metres from the kerb. Predicted cumulative annual average $PM_{2.5}$ concentrations were above the EPA criteria; however, this is largely attributed to the elevated background concentrations within the air shed that are already in exceedance of the recommended guidelines.

Despite the exceedances in the ambient air quality criteria for $PM_{2.5}$, the redistribution of traffic and improved network efficiency as a result of the proposal would reduce incremental $PM_{2.5}$ ground level concentrations along the New England Highway. As a result of the proposal predicted exceedances adjacent to the New England Highway would be limited to within about 20 metres of the kerb. This is less than predicted exceedances under the 'no build scenario' which are predicted to extend up 40 to 50 metres from the kerb.

6.9.4 Safeguards and management measures

Given the background particulate concentration in the region surrounding the proposal, careful consideration of the design and implementation of the mitigation measures is needed. The measures outlined below are recommended to minimise the potential for generation of dust during construction.

Impact	Environmental safeguards	Responsibility	Timing	Reference
Air Quality	An Air Quality Management Plan (AQMP) will be prepared and implemented as part of the CEMP. The AQMP will identify: • Potential sources of air pollution (such as dust, vehicles transporting waste, plant and equipment) during construction • Air quality management objectives consistent with relevant published EPA and/or DPIE guidelines including: o No Dust, No Fuss – Guidelines for controlling dust from construction sites. NSW EPA o Best Practice Erosion and Sediment Control. IECA, November 2008 o The "Blue Book" - Managing Urban Stormwater: Soils and Construction, Landcom (2004) 4th Ed • Mitigation and suppression measures to be implemented, such as spraying or covering exposed surfaces, provision of vehicle clean down areas, covering of loads, road cleaning, use of dust screens, maintenance of plant in accordance with manufacturer's instructions • Methods to manage works during strong winds or other adverse weather conditions • A progressive rehabilitation strategy for exposed surfaces • When the air quality, suppression and management measures need to be applied, who is responsible, and how the effectiveness of measures will be assessed • Community notification and complaint handling procedures	Construction contractor	During construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
Air Quality	As part of the AQMP, a monitoring program will be developed to monitor construction dust from the proposal. The monitoring plan will be implemented prior to construction and during the construction period, to assess effective implementation of air quality safeguards, identify any unexpected or inadvertent impacts, and identify recommended revisions or improvements	Construction Contractor	During Construction	Additional safeguard

6.10 Landscape character and visual impacts

6.10.1 Methodology

A landscape character and visual impact assessment (LCVIA) has been prepared by AECOM as part of the Urban Design, Landscape Character and Visual Impact Assessment Report (2021) (refer Appendix O). The LCVIA has been undertaken in accordance with Transport's *Environmental Impacts Assessment Practice Note – Guideline for Landscape Character and Visual Impact Assessment EIA-N04* (2020).

In accordance with this guideline and other relevant guidelines, key steps in the LCVIA include:

- Analysis of the regional and local context as well as the landscape character with the identification of specific landscape character zones (LCZs)
- Development of urban design principles that align with the overall vision for the proposal (refer section 3.2.4)
- Preparation of an illustrative urban design concept that reflects the urban design strategy (refer Appendix O)
- Evaluation of the existing landscape character within the construction footprint to inform the early stages of the urban design process, and to assess the anticipated landscape effects
- Mapping the extent of visibility of the proposal to identify sensitive receivers from publicly accessible areas, as well as a selection of representative viewpoints
- Evaluation of the existing views and visual amenity along the construction footprint to identify and assess possible impacts placed on the community
- Development of mitigation measures to reduce adverse impacts that the proposal may impose within the study area.

Landscape design for the proposal

A key aspect of landscape design is to develop a consistent character and elements that are fully integrated with the surrounding environment and reduces the visual impact of the proposal. The landscape treatments proposed are based on an assessment of the existing landscape character and the nature of the proposal.

Collaboration between the urban design team and the proposal design team has developed a coordinated and consistent design approach for the urban design components in accordance with New England Highway Urban Design Framework (Roads and Maritime Services, October 2016). The urban design principles in Section 3.2.4 of this REF were also considered as part of development of the proposal. This approach has enabled urban design solutions to be developed into the overall design response for the proposal.

Landscape character impact assessment

A LCZ is best described as an area, or component of a landscape area, that is relatively homogeneous in character, sharing broadly similar combinations of geology, topography, drainage patterns, vegetation and historical land use and settlement patterns and aesthetic attributes.

The landscape character assessment examines the effect of change on the landscape and the aesthetic and distinctive character of a particular LCZ. The two primary factors used to determine the extent of impact to a particular LCZ are outlined in Table 6-49.

Table 6-49: Primary factors to determine the extent of impact to a Landscape Character Zone

Factor	Description
Sensitivity	Based upon the extent to which it can accept change of a particular type and scale without adverse impacts upon its character or value
Magnitude	Depends on factors such as: • Loss, change or addition of any feature or element • Duration over which the landscape effects would be felt (short, medium or long term) • Change to the landscape itself or one nearby that affects its character • Quality and extent of the concept design solution

Once the sensitivity and magnitude is determined, the rating matrix outlined in Table 6-50 is used to determine an overall rating of effect.

Table 6-50: Overall significance of landscape character effects

		MAGNITUDE OF EFFECT			
		High	Moderate	Low	Negligible
SENSITIVTY	High	High	High to Moderate	Moderate	Negligible
	Moderate	High to Moderate	Moderate	Moderate to Low	Negligible
	Low	Moderate	Moderate to Low	Low	Negligible
	Negligible	Negligible	Negligible	Negligible	Negligible

Visual impact assessment

The visual impact assessment analysed the effects of changes in views seen by receptors as a result of the proposal. Similar to the landscape character impact assessment, sensitivity and magnitude factors (refer to Table 6-50) are used to determine an overall rating of effect using the matrix shown in Table 6-51.

Table 6-51: Primary factors to determine the extent of impact to visual receptors

Factor	Description
Sensitivity	Depends on factors such as:

Factor	Description
	• Location and context of the receptor location • Expectations and activity of the receptor • Type and number of receptors • Quality of the existing view • Temporal duration of the view
Magnitude	Depends on factors such as: • Extent of visibility of the change as per the visual envelope • Scale, size and character of the proposal • Degree of obstruction of existing features and contrast with the existing view • Quality of the design outcome • Angle of the existing view • Distance of view from the proposal

The visual impact assessment focuses on landscape outcomes around 12 to 18 months after road opening, which is considered a conservative assessment.

6.10.2 Existing environment

Landscape context

Muswellbrook township is located to the west of the proposed road corridor. The town centre features commercial activities, retail and local services, while the rest of the township is mostly characterised by low density residential with rural lifestyle blocks in its periphery providing the transition to rural areas.

Key elements of the landscape surrounding Muswellbrook include the agricultural Hunter River floodplain, large patches of regrowth and remnant forest communities, coal mining activities and open pastureland primarily subject to grazing.

The proposed road corridor would travel along flat to undulating stretches of landscape with open views over the Muswellbrook mining area, rolling plains and forested hills in the distance. The proposed road corridor would also cross the Main North railway line, Muscle Creek and Sandy Creek.

Landscape character zones

Ten LCZs have been identified within and surrounding the construction footprint, as outlined in Table 6-52 and shown on Figure 6-30.

Table 6-52: Landscape character zones

LCZ	Description
LCZ 1 Industrial	• Land use – SP2 Infrastructure and E3 Environmental Management • Topography and drainage – steep, man-made cuttings with artificial fill and ponding water • Vegetation – limited to edges of zones • Built form – limited to temporary amenity blocks, sheds and entry facilities • Spatial form – typically visually contained (some distant views available)

LCZ	Description
LCZ 2 Agricultural floodplain	• Land use – predominantly RU1 Primary Production • Topography and drainage – flat with riparian corridors • Vegetation – Swamp Oak Forest community aligning the Hunter River and agricultural crops and pasture within the floodplain • Built form – occasional farmhouses, sheds and outbuildings • Spatial form – wide open expanses with extensive views
LCZ 3 Open rural landscape	• Land use – RU1 Primary Production and E3 Environmental Management • Topography and drainage – undulating foothills and hills • Vegetation – cleared understorey with scattered Ironbark-Spotted Gum-Grey Box trees • Built form – occasional rural dwellings with associated sheds and farming infrastructure, accessed by long gravel driveways and stock fences • Spatial form – partially enclosed to expansive and open
LCZ 4 Recreational open space	• Land use – RE1 Public Recreation and RE2 Private Recreation • Topography and drainage – typically flat to gently undulating, some parks and reserves associated with drainage lines • Vegetation – managed/mown turf with taller vegetation/trees at edges • Built form – limited to amenity blocks and changing sheds • Spatial form – open
LCZ 5 Riparian corridor	• Land use – W1 Natural Waterways and RE1 Public Recreation • Topography and drainage – incised drainage channel / river / creeks • Vegetation – heavily vegetated, including an EEC (River Red Gum / River Oak grassy riparian woodland of the Hunter Valley) and weeds • Built form – none • Spatial form – river corridor enclosed but visible from surrounding landscape
LCZ 6 General residential	• Land use – R1 General Residential • Topography and drainage – gently to steeply undulating • Vegetation – native remnant paddock vegetation with exotic landscaped gardens surrounding houses • Built form – single and some double storey housing (typically brick) • Spatial form – streets laid out to follow contours of the landscape. View corridors along streets and across sparsely vegetated paddocks
LCZ 7 New residential suburbs	• Land use – R1 General Residential • Topography and drainage – steep to gently undulating • Vegetation – predominantly turf surrounding houses • Built form – typically single storey housing with setbacks from the street • Spatial form – streets laid out to follow contours of the landscape. View corridors along streets
LCZ 8 Rural residential	• Land use – R5 - Large Lot Residential • Topography and drainage – gently undulating to steeper land • Vegetation – mix of remnant native trees, gardens and open, manicured lawns • Built form – detached dwellings and large sheds • Spatial form – mostly enclosed with some elevated areas having a sense of openness with views to distant forested ranges

LCZ	Description
LCZ 9 Commercial	• Land use – B2 Local Centre and B5 Business Development • Topography and drainage – flat with one drainage corridor (Muscle Creek) • Vegetation – mix of introduced and native tree plantings and some decorative shrub beds • Built form – multi storey commercial/retail • Spatial form – linear patterns and moderately enclosed
LCZ 10 Transport corridor	• Land use – SP2 Infrastructure • Topography and drainage – flat to undulating • Vegetation – limited to turf and some trees • Built form – gantries, signage, bridges, bunding, guard rails and safety fencing • Spatial form – open

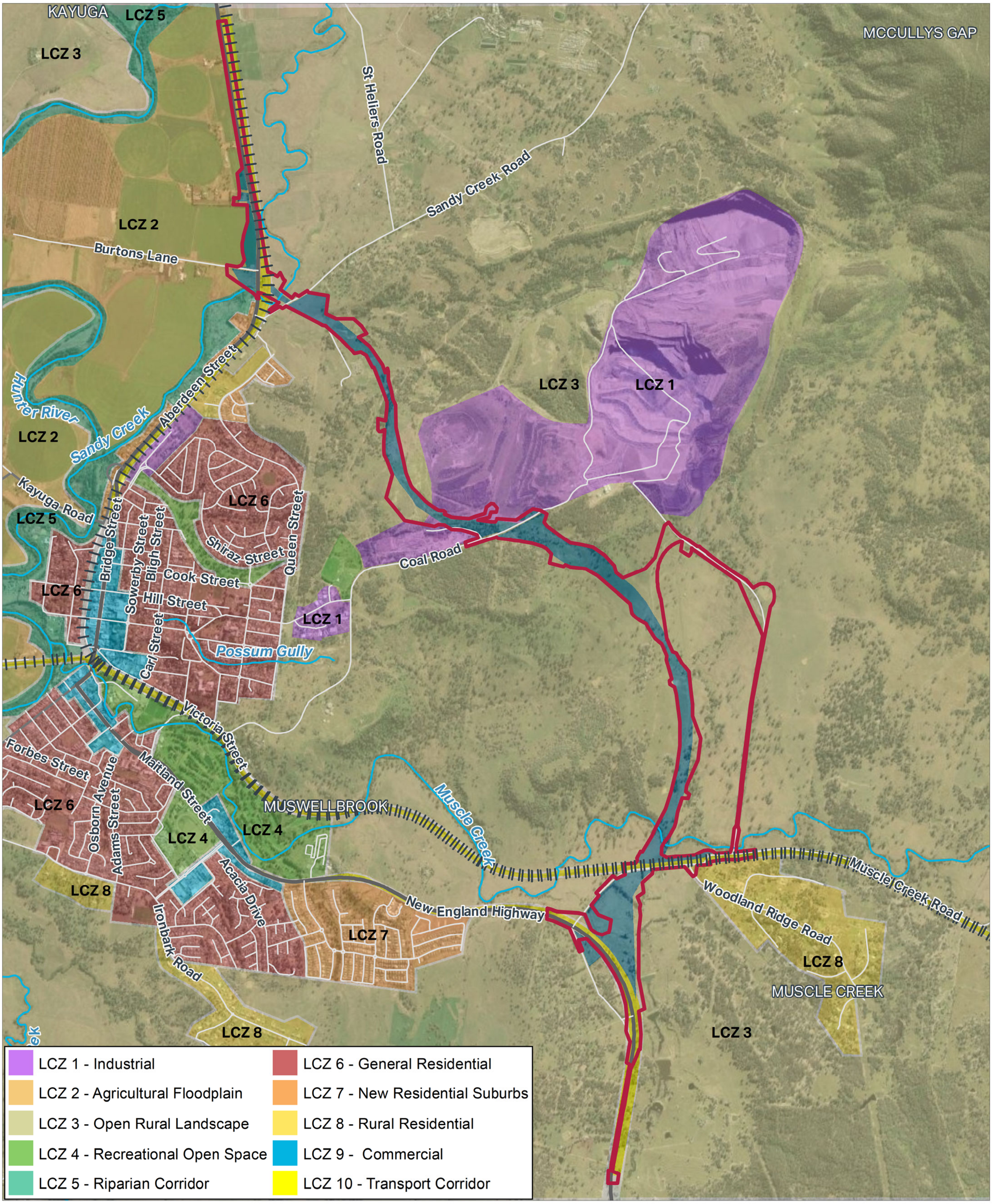


FIGURE 6-30: LANDSCAPE CHARACTER ZONE MAP

N

0 0.5 1 km

AECOM

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse

Visual receptors

Ten representative viewpoints have been used to assess potential impacts from the proposal on existing views seen by receptors, as outlined in Table 6-53 and shown on Figure 6-31.

Table 6-53: Viewpoints for visual receptors

Viewpoints	Description
Viewpoint 1: New England Highway South (heading north)	Motorists approaching Muswellbrook from the south
Viewpoint 2: Milpera Drive North	Residents on Milpera Drive looking east
Viewpoint 3: New England Highway South (heading south)	Motorists leaving Muswellbrook heading south
Viewpoint 4: Muscle Creek Road	Residents and motorists on Muscle Creek Road looking west
Viewpoint 5: Private Road, Muswellbrook Coal Mine Access	Motorists travelling north on the private access road to Muswellbrook Coal Mine looking west
Viewpoint 6: Public recreation area	Receptors in an area zoned for public recreation
Viewpoint 7: Queen Street	Residents in a new housing estate looking north
Viewpoint 8: Sandy Creek Road	Residents and motorists on Sandy Creek Road near the rail corridor looking north
Viewpoint 9: Sandy Creek Road East	Church members and motorists on Sandy Creek Road looking west
Viewpoint 10: New England Highway North	Church members and motorists on the New England Highway looking south

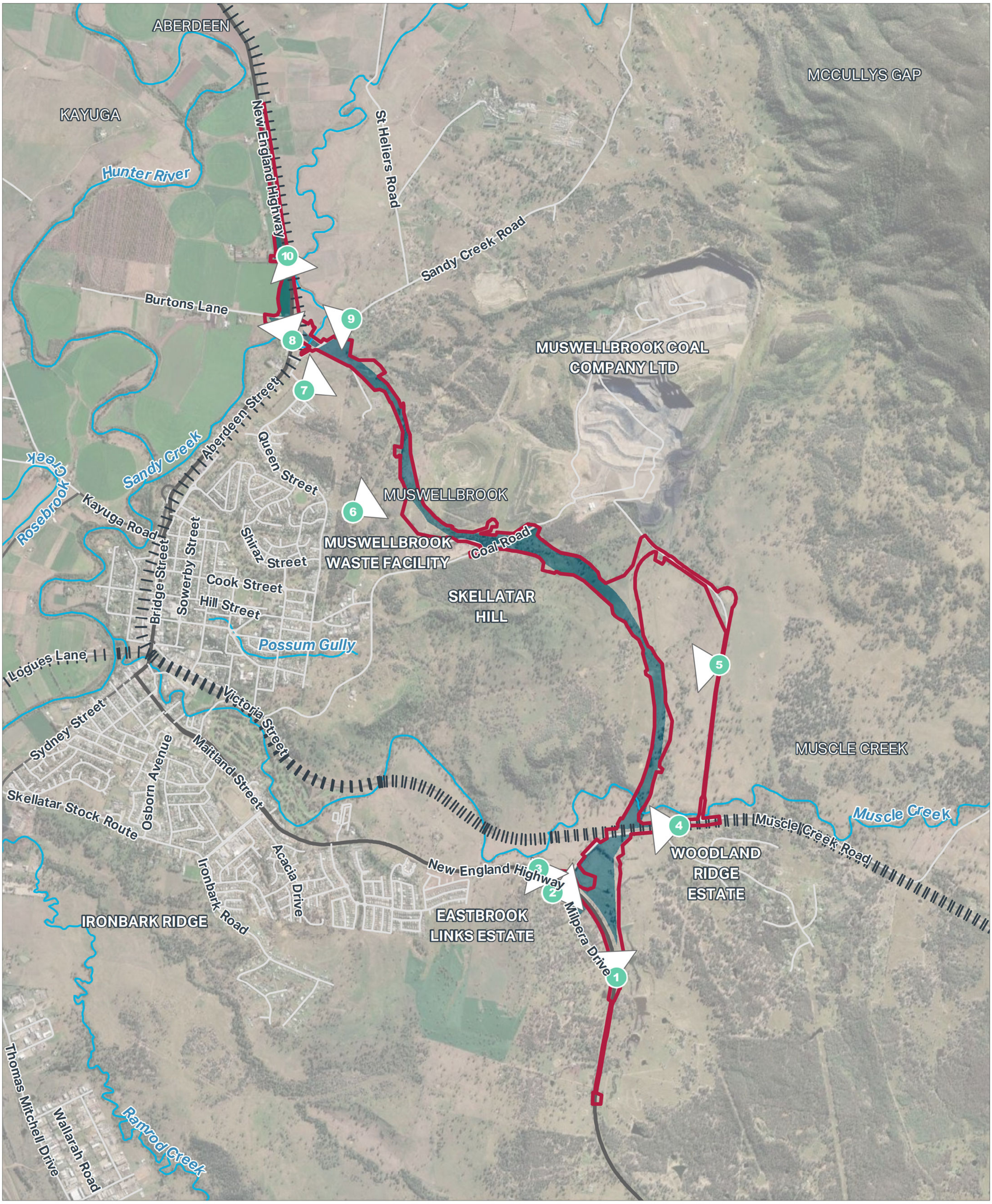


FIGURE 6-31: VISUAL RECEPTOR LOCATION MAP

N

0 0.5 1 km

AECOM

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Regional Road
- Local Road
- Railway
- Watercourse
- View point location

6.10.3 Potential impacts

Construction

Landscape character

The construction of the proposal would not impact on identified LCZs.

Visual

During construction, receivers expected to experience visual impacts include residents along the New England Highway, Muscle Creek Road, Sandy Creek Road, Koolbury Flats Row and Burtons Lane. The introduction of construction sites would reduce the privacy of some properties and construction of the bridges would be visible from a number of receivers, given their height. The positioning of plant and equipment within the view of surrounding properties and existing road users would result in temporary visual impacts. The proposal would require earthworks which would expose subsoil and the removal of vegetation within the construction footprint including some planted and remnant native trees. Some of this vegetation contributes to the amenity and character of the area. This would lead to temporary visual impacts during construction until the works are complete and disturbed areas rehabilitated.

Operation

Landscape character

As shown in Table 6-54:, operation of the proposal would give rise to negligible or low landscape character impacts at six LCZs. Two LCZs would be subject to a moderate landscape character impacts and the remaining two LCZs would be subject to high to moderate landscape character impacts which are considered to comprise considerable impacts on the landscape character given the high landscape value of the agricultural landscape.

Table 6-54: Summary of landscape character impacts

LCZ	Sensitivity	Magnitude	Landscape character impact
LCZ 1 Industrial	Low	Low	Low
LCZ 2 Agricultural floodplain	High	Moderate	High to Moderate
LCZ 3 Open rural landscape	Moderate	High	High to Moderate
LCZ 4 Recreational open space	High	Negligible	Negligible
LCZ 5 Riparian corridor	Moderate	Negligible	Negligible
LCZ 6 General residential	Moderate	Negligible	Negligible
LCZ 7 New residential suburbs	Moderate	Negligible	Negligible
LCZ 8 Rural residential	Moderate	Negligible	Negligible
LCZ 9 Commercial	High	Low	Moderate

LCZ	Sensitivity	Magnitude	Landscape character impact
LCZ 10 Transport corridor	High	Low	Moderate

Visual

As shown in Table 6-55, two visual receptor locations would be subject to low visual impact and four would be subject to moderate and moderate to low visual impact. The remaining four visual receptor locations would be subject to visual impact ratings of high and high to moderate which are considered to comprise considerable impact on the views from those locations.

Indicative photomontages of the viewpoints with visual impact ratings of high to moderate, high or moderate are shown below in Plate 21 to Plate 32.

Table 6-55: Summary of visual impacts

Visual receptor location	Sensitivity	Magnitude	Visual impact
V1 New England Highway South (heading north)	Low	Moderate	Moderate to Low
V2 Milpera Drive North	Moderate	Moderate	Moderate
V3 New England Highway South (heading south)	Low	Moderate	Moderate to Low
V4 Muscle Creek Road	High	High	High
V5 Private Road, Muswellbrook Coal Mine Access	Low	Low	Low
V6 Public recreation area	Low	Low	Low
V7 Queen Street	Moderate	High	High to Moderate
V8 Sandy Creek Road	Moderate	High	High to Moderate
V9 Sandy Creek Road East	Low	High	Moderate
V10 New England Highway North	Moderate	High	High to Moderate

At Muscle Creek Road, two existing residences would receive clear views to the proposal, including views to large batters where the bypass road connects to the southern connection, a bridge spanning the Main North railway line and the removal of existing trees. These receptors would experience a high visual impact from the proposal. At the northern connection, existing residences on the New England Highway would have views to the proposed bridge over Sandy Creek, the Main North railway line and Sandy Creek Road. The proposal would however be viewed by a low number of receptors in this location and as a consequence the visual impact is considered moderate. Away from these areas, the magnitude of operational visual impact on the local community would be moderate given the geographical area of impact, the open, flat to undulating landscape and low number of visual receptors. The socio-economic impact attributed to visual impacts for the majority of the proposal is rated as moderate.

Specific mitigation measures have been proposed in Section 6.10.4 to address these impacts.

Plate 21: Viewpoint 3 – existing view from the eastern verge of the New England Highway, looking south

Plate 22: Viewpoint 3 – proposed changes to the view seen in plate 21

Plate 23: Viewpoint 4 – existing view from Muscle Creek Road at the rail overpass, looking west

Plate 24: Viewpoint 4 – proposed changes to the view seen in plate 23

Plate 25: Viewpoint 7 – existing view from the northern end of Queen Street, looking north

Plate 26: Viewpoint 7 – proposed changes to the view seen in plate 25

Plate 27: Viewpoint 8 – existing view from the intersection of the rail corridor and Sandy Creek Road, looking north

Plate 28: Viewpoint 8 – proposed changes to the view seen in plate 27

Plate 29: Viewpoint 9 – existing view from Sandy Creek Road, looking west

Plate 30: Viewpoint 9 – proposed changes to the view seen in plate 29

Plate 31: Viewpoint 10 – existing view from the New England Highway, looking south

Plate 32: Viewpoint 10 – proposed changes to the view seen in plate 31

Removal of heavy vehicles from the streetscape would afford an opportunity for Muswellbrook Shire Council to pursue initiatives for a revitalised town centre and presents opportunities to improve the public domain along the main road.

The landscape treatment south from the northern connection along the New England Highway will include rows of ornamental trees to assist in screening the changes within the view and increase visual amenity. Ornamental trees provide a 'gateway' landscape treatment to the township of Muswellbrook.

The landscape treatment to the central connection (at Coal Road) would be more visually recessive, with scattered tree and shrub planting to match the length of the bypass and suggest a more local entry point to the township, rather than the 'gateway' statement at the northern and southern connections.

6.10.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Landscape and visual	Visual impact mitigation at Muscle Creek Road will include: • Tree planting along the proposed relocated driveway on Muscle Creek Road which will assist in reducing the visual impact of the proposal on receptors by partially screening the view to the bypass from these locations. Semi mature trees and shrubs will provide immediate screening post construction • Scattered tree or shrub planting to the batters of the proposed bypass road, particularly between Muscle Creek Road and Muscle Creek, which will visually 'break up' the flat expanse of the batter planted with pasture grasses	Construction contractor	Detailed design	Additional safeguard
Landscape and visual	The landscape treatment south from the northern connection along the New England Highway will include rows of ornamental trees to assist in screening the changes within the view and increase visual amenity. Ornamental trees provide a 'gateway' landscape treatment to the township of Muswellbrook The landscape treatment to the central connection (at Coal Road) will be more visually recessive, with scattered tree and shrub planting to match the length of the bypass and suggest a more local entry point to the township, rather than the 'gateway' statement at the northern and southern connections	Construction contractor	Detailed design	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
Landscape and visual	All plant material will be locally sourced (seed collection preferred), with any seed collection to commence within three months of construction contract award, where possible	Construction contractor	Detailed design	Additional safeguard
Landscape and visual	An Urban Design Plan will be prepared as part of the CEMP. The Plan will include: • Location and identification of vegetation in the proposed road corridor to be retained and proposed landscaped areas • Details of the staging of built elements including bridges and concrete barriers • Details of the staging of landscape works • Maintenance measures for landscaped or rehabilitated areas, including timing of maintenance works • A landscape monitoring program including an inspection program and frequency of inspection	Construction contractor	Detailed design and Pre-construction	Additional safeguard

Other safeguards and management measures that would address visual impacts are identified in sections 6.5, 6.9 and 6.12 of this REF.

6.11 Property and land use

6.11.1 Existing environment

The proposal is located predominately across greenfield land, with the construction footprint passing through MCC property, Ausgrid property and several private properties, many of which are used for agricultural purposes. Transport has already acquired five properties within the construction footprint, including adjacent to the southern connection, Sandy Creek Road and the northern connection. Refer to Section 3.6 for details of proposed property acquisition.

The Muswellbrook town centre is located to the west of the construction footprint along the New England Highway.

Key infrastructure near or intersecting the construction footprint include the Main North railway line, the existing New England Highway, the Ausgrid and MCC substations and the Muswellbrook Waste Management Facility. The operational section of Muswellbrook Coal Mine is located to the north east of the construction footprint.

There are a number of utility services within the construction footprint as described in Section 3.5.

Land use zones that occur within the construction footprint include:

- RU1 Primary production

- SP2 Infrastructure
- E3 Environmental management
- R1 General residential
- R5 Large lot residential.

Most of the land within the construction footprint is zoned SP2 Infrastructure and E3 Environmental management. Land use zoning within and surrounding the proposal is shown on Figure 6-32.

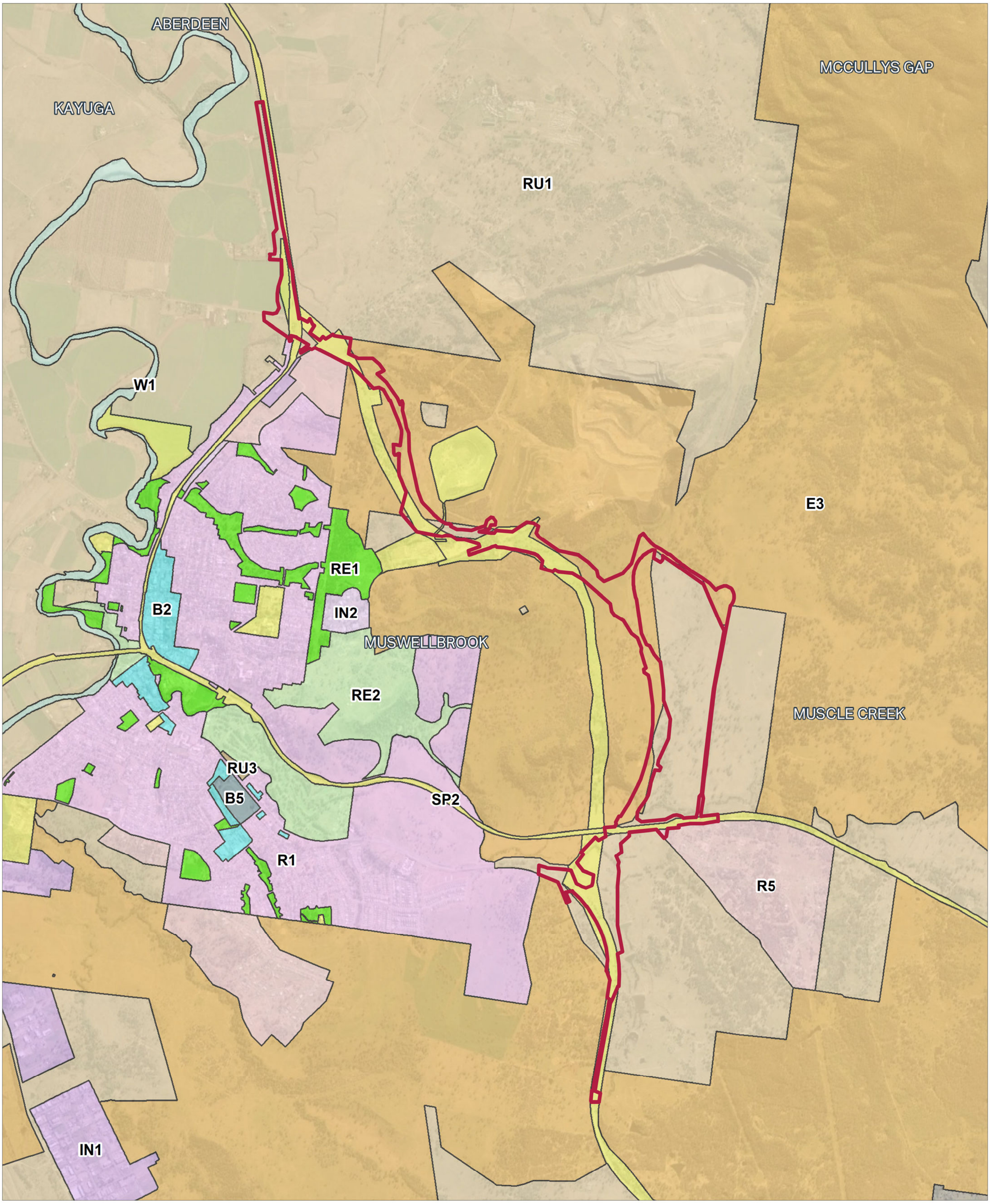


FIGURE 6-32: LAND USE ZONES WITHIN AND AROUND THE CONSTRUCTION FOOTPRINT

N

0 0.5 1 km

AECOM

Legend

- Construction footprint
- B2 Local Centre
- B5 Business Develoment
- E3 Environmental Management
- IN1 General Industrial
- IN2 Light Industrial
- R1 General Residential
- R5 Large Lot Residential
- RE1 Public Recreation
- RE2 Private Recreation
- RU1 Primary Production
- RU3 Forestry
- SP2 Infrastructure
- W1 Natural Waterways

6.11.2 Potential impacts

Construction

Long term impacts on land use and property would occur from the commencement of construction following acquisition of the land. This would result in some properties subject to partial acquisition requiring new or alternate property access arrangements. Property acquisition for the proposal is summarised in Table 3-7 and discussed in more detail below.

The construction footprint encompasses an area of around 188 hectares. Table 6-56 outlines the extent of impact to land use zones within the construction footprint.

Table 6-56: Impact to land use within the construction footprint

Land use zone	Indicative impacted area (hectares)
RU1 Primary production	50.80
SP2 Infrastructure	70.90
E3 Environmental management	65.40
R1 General residential	0.03
R5 Large lot residential	0.80

Land for ancillary facilities would be leased by Transport for the construction of the proposal or located on land already acquired by Transport for the proposal. Lease arrangements would be negotiated with the property owner.

Impacts to adjacent land uses during construction, such as amenity impacts, are discussed throughout Section 6.12.

Operation

A proposed property acquisition boundary was completed for the concept design. Areas to be acquired are provided in Table 3-7 and shown on Figure 3-7. The proposal would require the partial acquisition of 19 lots. One lot, approximately 0.01ha in size, used for agricultural purposes (producing pasture and fodder to supply its dairy farm) would be subject to full acquisition.

Property acquisition would be confirmed during detailed design.

The proposal would result in a permanent change in land use from the existing land uses to a road corridor. This would remove the ability of the land to be developed for residential or agricultural purposes in the future.

The proposal would result in the fragmentation of one agricultural property, owned by MCC. A farm access culvert would be provided under the proposed bypass to enable continuity of farm operations on this property.

All properties affected by changed access arrangements as a result of the proposal would be provided with restored or new permanent access arrangements during operation.

Impacts to adjacent land uses during operation, such as amenity impacts, are discussed throughout Section 6.12.

6.11.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Property acquisition	All property acquisition will be carried out in accordance with the *Land Acquisition Information Guide* (Transport for NSW, 2012) and the *Land Acquisition (Just Terms Compensation) Act 1991*	Transport	Detailed design	Additional safeguard
Property acquisition	Transport will complete property adjustments including fencing, driveways/access and adjustments to other property infrastructure impacted by the proposal in consultation with affected property owners	Transport	Detailed design	Additional safeguard
Property acquisition	Transport will investigate the possibility of licencing land beneath the bridge to be situated over Sandy Creek to impacted landowners to enable continued access for fragmented properties	Transport	Detailed design	Property acquisition

Other safeguards and management measures that would address property and land use impacts are identified in Section 6.5 and 6.12.

6.12 Socio-economic

This section summarises the results of the Socio-economic impact assessment (SEIA) that was completed for the proposal. The detailed assessment is provided in Appendix B.

6.12.1 Methodology

The SEIA was completed in accordance with the *Environmental Impact Assessment Practice Note – Socio-economic assessment* (EIA-N05) (Transport for NSW, 2020) (Practice Note).

The Practice Note outlines the requirements for establishing the socio-economic baseline and guides the process for assessing socio-economic impacts of Transport activities. In accordance with the Practice Note, the assessment included the following methodology:

- Definition of the study area. Two study areas comprising the LGA and Muswellbrook Statistical Area Level 2 (SA2) were used in the SEIA. Refer to Appendix B for further detail
- Desktop assessment including review of background socio-economic impact assessments
- Identification of the appropriate scope of the SEIA. The appropriate level of socio-economic assessment was identified as 'comprehensive'
- Identification and consultation with local communities and stakeholders who could be affected by the proposal
- Development of a baseline profile of the existing socio-economic environment based on information available from the Australian Bureau of Statistics (ABS), relevant local, regional and State policies and plans, as well as the outcomes of consultation carried out for the proposal

- Assessment of the potential construction, operation and cumulative impacts of the proposal on socioeconomic matters, including an assessment of the significance of these impacts
- Identification of management measures for managing and monitoring the potential socio-economic impacts of the proposal.

The SEIA is also informed by the outcomes of various other technical reports and assessments including the assessment of impacts to air quality, traffic and transport, noise and vibration, urban design, property and land use, landscape character and visual amenity.

Business surveys, stopper surveys (people stopping in Muswellbrook who do not live in the town), landowner surveys and an OD survey were carried out for the proposal. Feedback received during the survey period has been analysed, along with local community plans, to gain an understanding of the key issues, perceptions and concerns of the local and wider community with regard to the proposal's construction and operation and to provide insights into community identity, values and goals. The results of the surveys and other feedback have been compiled and are summarised in Appendix B.

The SEIA has been informed by stakeholder and community consultation carried out for the proposal. Consultation activities carried out for the proposal are detailed in Section 5 of the REF.

Issues raised applicable to the socio-economic environment have been considered in the SEIA.

The assessment of the significance of socio-economic impacts in accordance with the Practice Note includes consideration of the magnitude of the impact and the sensitivity of the receivers. The criteria for assessing each impact was established based on:

- Magnitude of impact which comprises the scale and intensity, spatial extent and duration of an impact
- Sensitivity of affected stakeholders which was defined by the susceptibility or vulnerability of people, receivers or receiving environments to adverse changes caused by the impact, or the importance placed on the matter being affected.

The assessment matrix provided in Table 6-57 has been used to determine the significance of each social impact as a function of the magnitude of the impact and the sensitivity of potentially affected stakeholders.

Table 6-57: Significance of socio-economic impacts

Sensitivity	Magnitude			
	High	Moderate	Low	Negligible
High	High impact	High-Moderate	Moderate	Negligible
Moderate	High-Moderate	Moderate	Moderate-Low	Negligible
Low	Moderate	Moderate-Low	Low	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

A summary of the magnitude, sensitivity and significance ratings are included in this section. Detail regarding the justification for these ratings is provided in full in Appendix B.

6.12.2 Existing environment

Demographics

Muswellbrook is located in the Upper Hunter Region of New South Wales. The population of the Muswellbrook LGA in 2016 was 16,086 of which 12,075 lived in the township of Muswellbrook. The wider LGA and Muswellbrook have relatively low cultural diversity with only three per cent of Muswellbrook SA2 speaking another language at home in 2016 (consistent with 3.48 per cent in the Muswellbrook LGA). About 58.6 per cent of the population was employed full time in 2016, with an unemployment rate of 9.6 per cent, both of which are consistent with the LGA average (59.2 per cent and 8.2 per cent). Almost a quarter of the jobs within Muswellbrook SA2 (23 per cent) were concentrated in the mining sector in 2016 and about 30 per cent in retail, healthcare, public administration, accommodation and food services.

Economy

The economy of Muswellbrook and the LGA is quite diverse. The main economic drivers are mining, agriculture, power and energy generation, thoroughbred studs, retail, accommodation and food services. In the Muswellbrook LGA, the two largest generators of economic value are the mining sector and the electricity, gas, water and waste services sector. The construction, rental, hiring and real estate and administration and safety industry sectors are likely to benefit from the presence of the large mining operations in the shire.

There are over 200 businesses located within Muswellbrook, including an industrial area and shopping centres. The range of businesses indicates that Muswellbrook, serves a variety of industries for residents of Muswellbrook and the wider region.

Social infrastructure

Social infrastructure comprises social services or facilities that are used for the physical, social, cultural or intellectual development or welfare of the community. Social infrastructure includes educational facilities, childcare centres, hospital and medical facilities, aged care, sporting and recreational facilities, community halls, clubs, libraries as well as services, activities and programs that operate within these facilities. Open spaces, parks and sporting fields used for sport, recreational and leisure are also identified as social infrastructure.

Social infrastructure located within 400 metres of the construction footprint includes:

- Shelley’s Family Day Care Centre – which occupies two buildings, with one building located at about six metres west and the second building located about 18 metres south of the construction footprint
- The Kingdom Hall of Jehovah’s Witness - which is located about 300 metres north east of the construction footprint.

The location of key infrastructure in proximity to the proposal is shown in Figure 6-33 to Figure 6-36.

Muswellbrook is home to a number of health care, emergency services and aged care facilities to meet the needs of local and regional communities. It has about 17 medical facilities and one district hospital none of which are located within 400 metres of the proposal. No community services facilities or sporting or recreational facilities are located within 400 metres of the proposed road corridor or construction footprint.

Access and connectivity

The New England Highway forms the spine of the local traffic network, providing direct access to the Muswellbrook town centre as well as connectivity to Aberdeen and Scone to the north and Singleton to the south-east.

Key public transport facilities, as described in Section 6.5 of the REF, include rail and bus services. Transport and Countrylink offer rail services to Muswellbrook, which is located on the Hunter rail line. The bus network within Muswellbrook provides connections between Muswellbrook, Denman, Aberdeen and Scone, and provides a town service around the Muswellbrook town centre stopping at places such as the hospital. Muswellbrook is also serviced by a local taxi service.

Pedestrian footpaths provide access along the New England Highway to the town centre and surrounding areas. On and off road cycle routes facilitate access to the town centre, residential areas and recreational facilities.

Community identity, values

A review of community strategic planning documents relevant to Muswellbrook LGA was carried out to identify values and aspirations specific to the local and regional community.

Key community values and aspirations identified in the Muswellbrook Shire Council Community Strategic Plan 2017-2027 include:

- *We want community wellbeing to be at the heart of everything we do and every consideration we make*
- *We want to be inclusive. We want everyone to enjoy full participation in our community*
- *We want to be culturally rich and diverse with our Shire's communities having strong identities and a shared 'sense of place'*
- *We want a local economy with full employment in a diverse range of high value industries.*
- *We want to be leaders in environmental sustainability.*

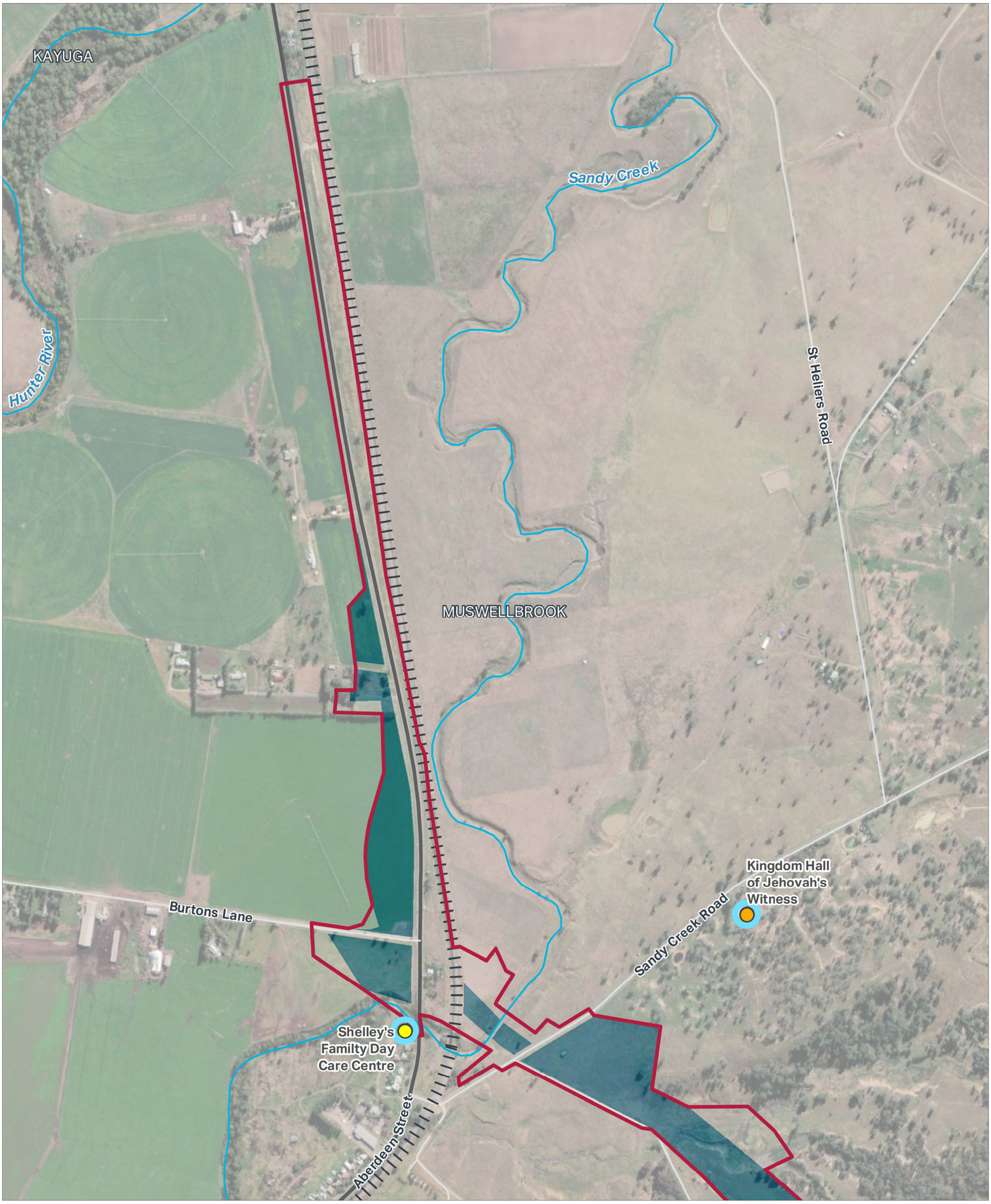


FIGURE 6-33: SOCIAL INFRASTRUCTURE SURROUNDING THE PROPOSED ROAD CORRIDOR (1 OF 4)

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Local Road
- Railway
- Watercourse

Social Infrastructure

- Educational facilities
- Places of worship
- Within 400m of the proposal

N

0 0.1 0.2 km

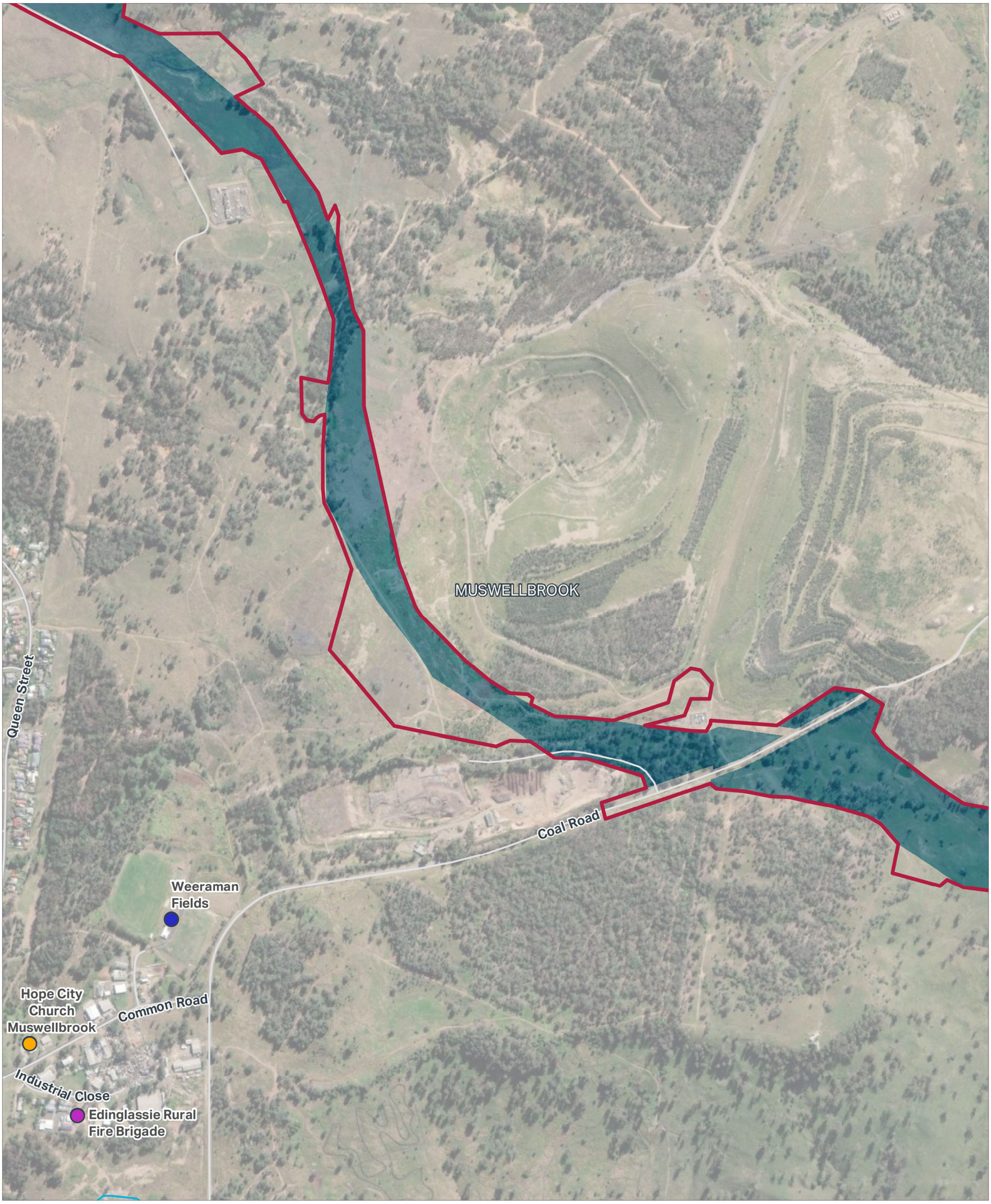


FIGURE 6-34: SOCIAL INFRASTRUCTURE SURROUNDING THE PROPOSED ROAD CORRIDOR (2 OF 4)

Legend
- Construction footprint
- Proposed road corridor
- Local Road
- Railway
- Watercourse

Social Infrastructure
- Places of worship
- Sporting and recreational facilities
- Emergency Services

N
0 0.1 0.2 km

AECOM

FIGURE 6-35: SOCIAL INFRASTRUCTURE SURROUNDING THE PROPOSED ROAD CORRIDOR (3 OF 4)

N
0 0.1 0.2 km

Legend
- Construction footprint
- Proposed road corridor
- Local Road
- Railway
- Watercourse

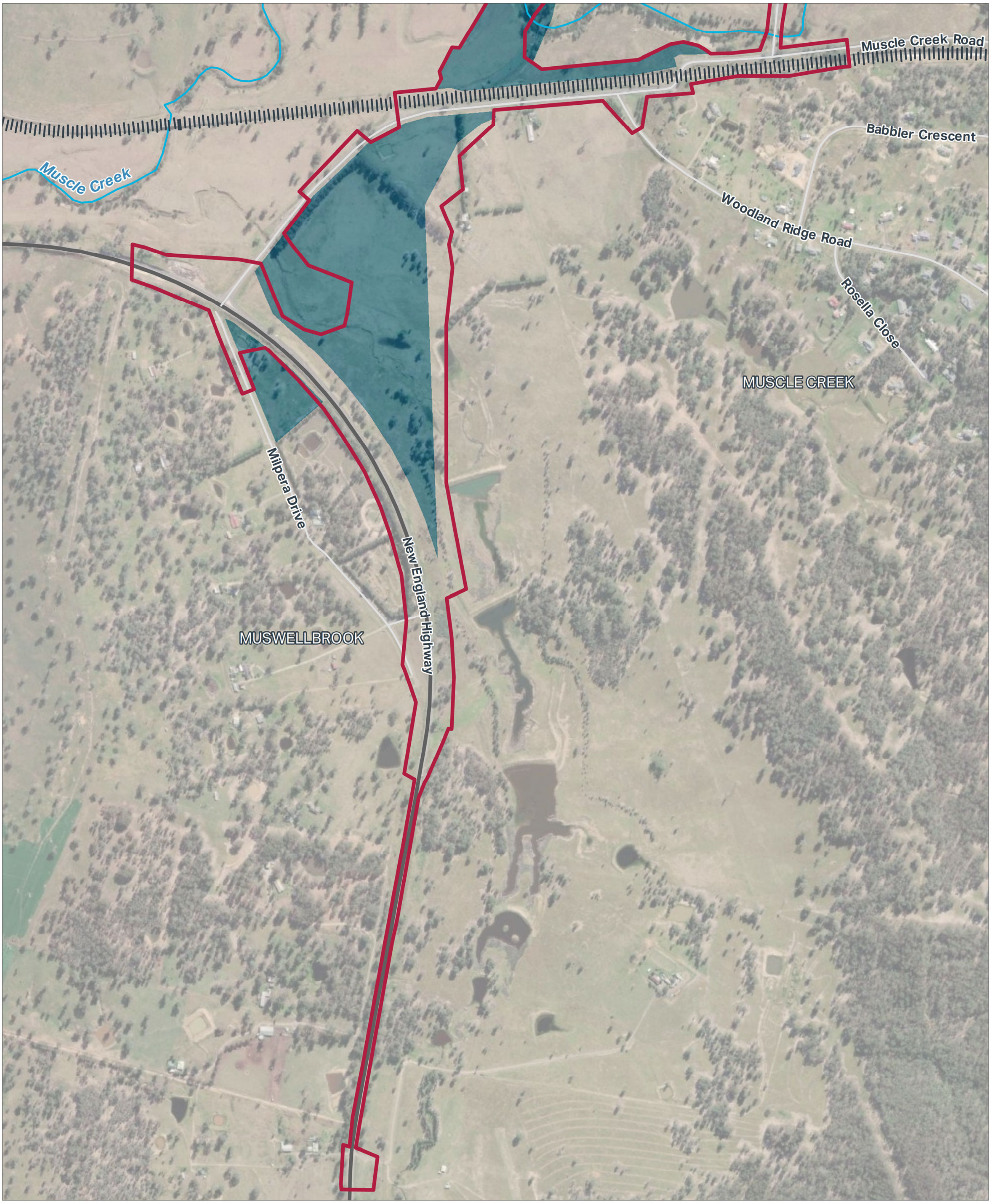


FIGURE 6-36: SOCIAL INFRASTRUCTURE SURROUNDING THE PROPOSED ROAD CORRIDOR (4 OF 4)

Legend

- Construction footprint
- Proposed road corridor
- State Road
- Local Road
- Railway
- Watercourse

AECOM

\\na.aecomnet.com\lfs\APAC\Sydney-AUSYD1\Secure\Groups\GIS\7_Small_Jobs_INTERSTATE_PROJECTS\NTL_60619756\02_Maps_REF\G009_A4P_02_REF_Social_Infrastructure_210827.mxd Date Saved: 27/08/2021

6.12.3 Potential impacts

Construction

Property

Property impacts, including details of property acquisitions and temporary occupation of land for ancillary facilities are discussed in Section 6.11. This section assesses the socio-economic implications of property impacts.

The proposal would fragment one agricultural property, owned by MCC, to be partially acquired. A farm access culvert would be provided under the proposed bypass to enable continuity of farm operations on this property.

The proposal would require the partial acquisition of 19 lots. One lot (about 1000m^2) used for agricultural purposes (producing pasture and fodder to supply its dairy farm) would be subject to full acquisition Five properties are owned by Transport. Tenants on one of these properties would be required to relocate. Transport would provide sufficient notice of the requirement to vacate.

The magnitude of properties acquired is moderate. The sensitivity of affected individuals and households is considered to be low. As a result, the significance of partial acquisition of residential properties on the socio-economic environment is considered to be moderate-low.

Amenity

Amenity refers to the quality of a place, its appearance, feel and sound, and the way its community experiences the place. Potential impacts have been addressed in this REF as follows:

- Noise and vibration (refer to Section 6.6) - Impacts are expected to be greatest during earthworks and pavement works. Up to six receivers are predicted to be highly noise affected. One non-residential receiver is expected to exceed the NML during earthworks
- Air quality (refer to Section 6.9) - Impacts include:
  - Annoyance due to dust deposition on surfaces and visible dust plumes
  - Elevated particulate (PM_{10}) concentrations due to dust-generating activities
  - Exhaust emissions from diesel-powered plant and equipment
- Landscape character and visual amenity (Section 6.10) - Construction activities would only be visible to those with views of the proposal which is primarily limited to motorists and some residents located along the New England Highway, Muscle Creek Road, Coal Road, Sandy Creek Road and Aberdeen Street.

The significance assessment for these impacts is summarised in Table 6-58 and is discussed in detail in section 6.2 of Appendix B.

Table 6-58: Summary of significance assessment for amenity impacts during construction

Impact	Magnitude of impact	Sensitivity of receivers	Significance
Noise and vibration	Moderate	Moderate	Moderate
Air quality	Moderate	Moderate	Moderate
Visual amenity	Moderate	Moderate	Moderate

Access and connectivity

The proposal could potentially give rise to increased travel time due to reduced speed limits and temporary lane closures on the New England Highway, Muscle Creek Road, Sandy Creek Road, Koolbury Flats Row and Burtons Lane (refer to Section 6.5).

Some existing accesses to residential properties on Muscle Creek Road and Milpera Drive for the southern interchange works and Burtons Lane and Koolbury Flats Row for the northern interchange works may be temporarily impacted during the construction period with residents inconvenienced through changes in pedestrian and vehicle access to their properties. Most of these impacts would be limited to short term restrictions and/or closures with alternate access arrangements provided.

The management of property access would be considered during detailed design and as part of the staging plan.

Commercial and private property access roads would be reinstated and/or relocated as required. Private accesses include a residential access south off Muscle Creek Road and a farm access culvert under the proposed bypass. Commercial access includes a relocated access to the MCC substation off Coal Road. Ausgrid access tracks would be relocated to maintain access to assets and for fire safety.

The sensitivity of receptors to property access changes is considered to be moderate. Given that the magnitude of change is considered to be low, the socio-economic significance of this impact would be moderate-low.

Public and active transport connectivity

The proposal is not expected to change any public transport services or routes. All existing bus services would be maintained during construction, with potential for minor delays to bus services due to construction speed limits and an increase in heavy vehicle movements using the nominated haulage routes.

Construction activities within or adjacent to the Main North railway line corridor would be undertaken during rail possessions, thereby limiting impact to train services. Given the low number of public transport services which could potentially be impacted by the proposal, the socio-economic impact is considered to be negligible.

There are no formal pedestrian or cycle paths along the bypass route. Existing paths would be maintained during the construction period. Therefore, impacts to active transport connectivity are considered negligible.

Table 6-59: Summary of significance assessment for access and connectivity during construction

Impact	Magnitude of impact	Sensitivity of receivers	Significance
Access to properties	Low	Moderate	Moderate-low
Public and active transport connectivity	Negligible	Negligible	Negligible

Impacts to community values

A summary of the assessment of impacts to community values during the construction of the proposal is provided in Table 6-60.

Table 6-60: Assessment of impacts to community values

Value	Assessment
Economic Prosperity	The bypass is expected to support business opportunities during the construction period. Existing businesses along the New England Highway would be able to continue to operate Local benefits are expected to flow from construction worker expenditure to businesses in Muswellbrook town centre and neighbouring areas. Potential delays during construction are not expected to impact turnover as existing traffic arrangements would continue during construction
Social Equity and Inclusion	The proposal is generally located outside of the township of Muswellbrook and so is unlikely to directly impact the ability of the community to be creative, vibrant, inclusive, safe and healthy. The main amenity impacts are expected to arise from noise and visual effects Access to existing community infrastructure such as educational facilities, health services and places of worship, which are fundamental to creating and maintaining a sense of community cohesion and wellbeing, would be maintained during construction
Environmental Sustainability	Sustainability initiatives have been embedded in project planning and design and would be further considered in detailed design and procurement. Sustainability initiatives would address waste and materials, biodiversity conservation, carbon and energy management, climate change resilience, water efficiency, pollution control, supply chain amongst a range of other initiatives Sustainability and climate change are addressed in Section 6.14 of the REF
Cultural Vitality	Non-Aboriginal Heritage As discussed in Section 6.8, the proposal is not expected to have any direct impact on heritage items Aboriginal Heritage As discussed in Section 6.7, the cultural values and heritage assessments identified 12 Aboriginal archaeological sites Two sites would be subject to salvage with all sites subject to surface collection of artefacts. Two cultural sites at Sandy Creek would be directly impacted. Mitigation measures are outlined in Section 6.7
Community Infrastructure	Potential impacts would be limited to indirect amenity impacts
Community Leadership	Transport engaged in early consultation with the community throughout the preferred option selection process and continues to keep the community and stakeholders informed and proactively consulted throughout the development of the proposal. The REF would also be on public display and invitations would be sent to the community to comment on the Muswellbrook Bypass

Overall, the magnitude of impact upon community values and aspirations is deemed to be low, given that potential impacts that would conflict with the values above would be temporary and mitigation measures would be implemented to manage these impacts. The sensitivity of the community to these matters is considered to be moderate due to the potential changes to amenity, traffic and access, heritage impacts and economic impacts. The overall socio-economic significance is moderate-low.

Business impacts

The proposal has the potential to impact local businesses as a result of temporary increases in travel times and impacts to local amenity.

Construction worker expenditure during the three-year construction period would benefit local services such as cafes and takeaways, service stations, trades and services suppliers and potentially some accommodation providers.

Construction staging would minimise impacts on the road network. Temporary changes to speed limits would be limited to outside of the town centre.

Property access would be maintained as far as practicable throughout construction including access to MCC, Muswellbrook Waste Management facility and for maintenance and other purposes along the Main North railway line. Heavy vehicles would only access construction sites from approved heavy vehicle routes.

Given the majority of the construction works would be carried out offline and that existing traffic arrangements would be for the most part maintained, the magnitude and sensitivity of impacts to travel time for deliveries and employees travelling to work is considered to be negligible. Similarly as maintenance of property access would be a key focus of construction management, there would be negligible socio economic impacts to property owners. The overall socio-economic significance is therefore considered to be negligible.

Many businesses such as accommodation providers, restaurants, cafes, and health and beauty businesses rely to an extent upon high levels of local amenity. As most businesses in the local area are located in the town of Muswellbrook and at some distance from construction works, there would be a minimal impact on the business environment.

The magnitude of construction activity on amenity for business is considered to be low given the temporary nature of impacts, the proximity of construction works to only two businesses and as these businesses are located near a heavy rail line where rail movements contribute to the existing noise environment. The sensitivity of affected businesses is considered to be moderate, as these businesses would rely on a certain level of amenity to provide a particular customer experience. As a result, the socio-economic significance of construction activity on the amenity for businesses is considered to be moderate - low. The significance assessment for these impacts is summarised in Table 6-61 and is discussed in detail in section 6.5 of Appendix B.

Table 6-61: Summary of significance assessment for business impacts during construction

Impact	Magnitude of impact	Sensitivity of receivers	Significance
Access and travel time	Negligible	Negligible	Negligible
Business amenity	Low	Moderate	Moderate-low

Agricultural sector impacts

Where the proposal requires acquisition of agricultural land, it has the potential to affect agricultural businesses. The productivity of agricultural businesses could be affected by the following:

- Directed loss of productive land
- Internal access changes between parts of a property
- Changes to the sizes and shape of paddocks.

Under the Muswellbrook LEP, land use for agricultural activities is zoned RU1 Primary Production. Table 6-62 shows the extent of RU1 land to be acquired, the total area of that rural zone within the Muswellbrook LGA and the percentage of rural land in the LGA to be acquired by the proposal.

Table 6-62: Agricultural land to be acquired by the proposal

Land Zone	Area within the proposed road corridor (hectares)	Area within Muswellbrook LGA (hectares)	Percentage acquired by the proposal
RU1 – Primary Production	31.2	134669.0	0.02 %

The magnitude of impacts to the agricultural sector within Muswellbrook would be low. One property used for agricultural purposes would be fragmented.

One property, an agricultural business, at the northern interchange would be affected by both total and partial acquisition. However, this is not expected to impact the viability of the operation to a great extent as the area to be acquired (whole and partial) represents in the order of seven per cent of the agricultural operation.

The land to be acquired is at the margin of a much larger dairy farm and as a consequence the impact to farming practices is considered to be moderate.

Overall, the magnitude of impact to agricultural operations is considered to be low. The sensitivity to change is also low given the ability to adapt farm practices to change following partial acquisition, the restoration of land leased for construction compounds and laydown areas following construction and well managed mitigation during construction. On this basis, the socio-economic significance of the Muswellbrook bypass on the regions agricultural sector is considered to be low.

Economic impacts

The economic benefit of construction is multi-dimensional, including:

- Increased expenditure at local and regional businesses by construction workers
- Direct employment of around 120 workers in peak periods through on-site construction activities
- Direct expenditure associated with on-site construction activities
- Indirect employment and expenditure through the provision of goods and services required for construction.

Operation

Property

Land leased for construction compounds and laydown areas would be restored following the construction period and would be available for future agricultural or other use. As a result, the socio-economic significance of impact on land use is considered to be low.

The full or partial acquisition of land may result in changes to the lives of those affected giving rise to a sense of anxiety or uncertainty, a loss of amenity and financial costs. Acquisition has the potential to affect people with a deep connection to their property, which may have been in the family for generations. In some instances, it may be difficult to find another property with equivalent facilities and amenity to that being acquired. Given that only one property would be acquired and the low number of partial acquisitions, the overall magnitude of the socio-economic impact of property acquisition is considered to be low. The overall sensitivity of affected property owners to full and partial acquisition is considered to be moderate given the emotional stress property acquisition may cause to some individuals. On this basis the overall socio-economic significance of property acquisition on community wellbeing associated with the proposal would be moderate-low.

The significance assessment for these impacts is summarised in Table 6-63 and is discussed in detail in section 7.1 of Appendix B.

Table 6-63: Summary of significance assessment for property acquisition impacts

Impact	Magnitude of impact	Sensitivity of receivers	Significance
Land use	Low	Low	Low
Community wellbeing	Low	Moderate	Moderate-low

Amenity

Operation of the proposal may impact the local amenity of the area. This would primarily relate to amenity impacts from road traffic noise, changed traffic patterns, change in air quality and visual impacts where views of the pastoral and wider landscape may be obstructed by the road infrastructure. These potential impacts have been addressed in this REF as follows:

- Noise and vibration (refer to Section 6.6) - there would be increases in road traffic noise at residential receivers and one childcare centre located in proximity to the bypass, on Muscle Creek Road, Woodland Ridge Road, Coal Road, Lonhro Place, Aberdeen Street, Burtons Lane and New England Highway. A decrease in heavy traffic volumes through town would provide a corresponding reduction in traffic noise levels with amenity benefits.
- Air quality (refer to Section 6.9) - once operational the proposal is unlikely to impact on air quality
- Landscape character and visual amenity (refer to Section 6.10) - impacts to visual amenity are generally considered to be high-moderate particularly at its northern extremity given the proposal would result in a long-term visual impact that would impact a number of residential receivers and road users.

Amenity impacts would be appropriately managed with the relevant safeguards provided in each section above. The significance assessment for these impacts is summarised in Table 6-64 and is discussed in detail in section 7.2 of Appendix B.

Table 6-64: Summary of significance assessment for amenity impacts

Impact	Magnitude of impact	Sensitivity of receivers	Significance
Noise and vibration	Low	Moderate	Moderate-low
Air quality	Low	Low	Low
Visual amenity	High (at northern connection and Muscle Creek Road otherwise moderate /low)	Moderate or low (High at Muscle Creek Road)	High (at Muscle Creek Road) and high to moderate (at the northern connection) otherwise the rating is moderate/low)

Access and connectivity

All properties affected by changed access arrangements as a result of the proposal would be provided with restored or new permanent access arrangements.

The proposal is forecast to improve travel times, reduce congestion, reduce travel costs and reduce traffic-related mental and physical health impacts for both motorists and residents living near major arterial roads in the area such as Maitland Street and New England Highway/Bridge Street. The reduction in traffic volumes on key roads with the proposal is expected to improve the reliability of bus services and access to public transport (i.e. train station). Similarly, the proposal would cut journey times, improve driver safety and boost freight productivity by providing free flow conditions on the bypass.

Impacts to parking availability, public transport and active transport connectivity are considered negligible. The reduction of traffic along the New England Highway/Bridge Street through Muswellbrook could improve traffic conditions for cyclists, allowing this section of the New England Highway/Bridge Street to form part of the on-road cycle route. It would also reduce the potential for pedestrian /vehicular conflict providing a safer and more pleasant walking environment along this main thoroughfare through Muswellbrook town centre.

The significance assessment for these impacts is summarised in Table 6-65 and is discussed in detail in section 7.2 of Appendix B.

Table 6-65: Summary of significance assessment for access and connectivity

Impact	Magnitude of impact	Sensitivity of receivers	Significance
Access to properties	Negligible	Negligible	Negligible
Traffic and transport	Negligible	Negligible	Negligible
Public and active transport connectivity	Negligible	Negligible	Negligible

Social infrastructure

Shelley’s Family Day Care Centre and The Kingdom Hall of Jehovah’s Witness are located within 400 metres of the proposed road corridor.

The operational impacts at these locations include noise exceedances and visual impacts from the bypass. The significance assessment for these impacts is summarised in Table 6-66:.

Table 6-66: Summary of significance assessment for social infrastructure

Social infrastructure	Magnitude of impact	Sensitivity of receivers	Significance
Shelley’s Family Day Care Centre	Moderate	High	High-moderate
The Kingdom Hall of Jehovah’s Witness	Low	Moderate	Moderate-low

Shelley’s Family Day Care Centre is one of 24 properties at which operational noise exceeds the cumulative noise limit (refer Section 6.6). It is therefore eligible for at-receiver mitigation measures including architectural treatments. Without acoustic treatment, the socio-economic significance of noise impacts would be high-moderate. Should acoustic treatment proceed at this property, the magnitude and sensitivity of the operational impact on Shelley’s Family Day Care Centre is reduced to low and the socio-economic impact is low.

Business impacts

Studies of other highway bypass impacts in NSW identify that the most affected businesses are those directly serving the needs of the motorists. These include service stations, food and beverage outlets, and accommodation establishments (to a lesser extent).

Half of respondents surveyed during the stopper surveys indicated they would be visiting food/beverage businesses during their stop in Muswellbrook. Nineteen per cent said they would buy fuel at a service station during the stop and thirty-seven per cent of stoppers said they would not visit any businesses or services in Muswellbrook.

During the business impact surveys conducted for the proposal, 47 per cent of businesses said they were highly dependent on passing trade (visibility to passing traffic or pedestrians), while 28 per cent said their business was moderately dependent on passing trade. These businesses mostly consisted of food/beverage places, hotels/motels and service stations.

Business owners may experience a level of uncertainty about the impact the proposal would have on through traffic and trade. While some businesses would experience a decrease in turnover and reduced employment, at least in the short term, evidence from bypassed towns indicates that some highway dependent businesses have been able to reposition themselves and become sustainable in the longer term. Respondents to the stopper survey were asked if they would stop in Muswellbrook once the bypass was operational. Over 60 per cent advised they would continue to stop, with nine per cent unsure or it would depend on the journey. Two thirds of stoppers noted this rate was not different from the rate at which they currently stop.

The magnitude of impacts on passing trade are considered to be moderate on the balance of potential short-term turnover impacts, the need to make business adjustments and potential benefits associated with improvements to amenity. The sensitivity of businesses to impacts to passing trade is considered to be moderate as nearly half of businesses surveyed said they are highly dependent on passing trade. On this basis the socio-economic significance of this impact would be moderate.

In recognition of the long running discussion with regard to impacts to bypassed towns, Transport has launched a ‘Bypass Town signage initiative’ in partnership with Destination NSW, which aims to encourage travellers to stop and visit bypassed towns in rural and regional NSW. The signs are a first for NSW and feature colour images depicting the features of bypassed towns. The Bypassed Town signs would form part of the NSW wayfinding signage and would be included as part of the directional signage strategy for future bypass proposals, including Muswellbrook.

Improved local amenity in the Muswellbrook township is likely to result in positive business impacts through the support of new business development opportunities which may encourage motorists to continue to stop in Muswellbrook. The reduction of heavy vehicles from the town centre could enable businesses to vary how they function and attract customers, for example by providing outdoor dining. In addition, removal of heavy vehicles from the streetscape would afford an opportunity for Muswellbrook Shire Council to pursue initiatives for a revitalised town centre outlined in Muswellbrook Town Centre Strategy.

Economic impacts

As outlined in Section 6.5, the New England Highway through the Muswellbrook town centre is a major transport artery for freight travelling between the Port of Newcastle and the Hunter Valley and has supported the significant growth in transportation for coal and agricultural industries and employment in NSW.

One objective of the proposal, in alignment with strategic planning at a national and state level, is to reduce the impediments caused by heavy vehicle traffic along the inland Sydney to Brisbane corridor of the National Land Transport Network (New England Highway).

On year of opening, with the removal of up to 4800 vehicles per day (including about 1900 heavy vehicles) through the Muswellbrook town centre, the bypass would have significant benefits to freight movement and traffic movements in and through Muswellbrook. Improvements in the efficiency and reliability of these transport networks would likely result in increased productivity, reduced costs and broader economic benefits for the freight industry.

The NSW Government is committed to delivering an efficient and effective transport system which reduces the time it takes to travel across NSW. The proposal would also improve transport connections and lower vehicle operating costs between employment and tourist destinations. It would enable increased average speeds for freight and passenger movements on the New England Highway, with the proposed bypass predicted to save between 5.3 and 7.1 minutes during peak travel times by 2044.

6.12.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Community information	A Communication Plan (CP) will be prepared and implemented as part of the CEMP to ensure provision of timely and accurate information to the community during construction. The CP will include (as a minimum): • Mechanisms to provide details and timing of proposed activities to affected residents, including changed traffic and access conditions • Contact name and number for complaints • How the proposal webpage will be maintained for the duration of the proposal. • Minimum consultation activities to be carried out • A complaints handling procedure	Construction contractor	Pre-construction and construction	Additional safeguard
Business impacts	Transport will develop a signage strategy for the entrances to Muswellbrook, in consultation with Muswellbrook Shire Council to encourage motorists to visit Muswellbrook. This will include signage showing: • The travel distances and estimated times for travelling routes via the bypass compared to travelling via the Muswellbrook town centre • Services and facilities available within the Muswellbrook township • Any visitor attractions within the Muswellbrook township	Transport	Detailed design and operation	Additional safeguard
Business impacts	Transport will engage with Muswellbrook Shire Council and local businesses regarding the progress of the proposal to allow businesses time to prepare for	Transport	Detailed design and construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	changed traffic conditions through the town			
Employment	Construction workers will be sourced from the local area where feasible	Contractor	Construction	Additional safeguard
Business impacts	Access to businesses will be maintained throughout the proposal	Contractor	Construction	Additional safeguard

6.13 Resource use and waste management

Various waste streams would be generated during the construction and operational phases of the proposal. These would include demolition wastes, green waste (vegetative matter), packaging materials, liquid wastes and excavated material.

6.13.1 Methodology

A qualitative assessment of potential resource use and waste management has been carried out for the proposal.

6.13.2 Existing environment

Existing waste streams within the construction footprint are limited to household and agricultural waste as well as roadside litter and other waste material associated with roadside maintenance. Run of Mine (ROM) and inert materials used to cover areas of potential spontaneous combustion may also be visible in areas previously operated by MCC.

6.13.3 Potential impacts

Construction

Resource use

The proposal would require the use of a number of resources which include (but are not limited to):

- Resources associated with the operation of construction vehicles and machinery, such as diesel and petrol
- Material required for drainage construction, road surface construction and bridgework including road base, asphalt, spray seal, sand, concrete and aggregate
- Materials for earthworks, such as topsoil, mulch, general fill and select fill
- Materials required for road signage, linemarking, roadside barriers and guideposts
- Construction water (for concrete mixing and dust suppression).

The initial estimated source and quantities for these materials are outlined in Section 3.3.6. The materials required for construction of the proposal are not currently limited in availability, however any non-renewable materials would be used conservatively.

The reuse of waste on-site would assist in minimising resources required for construction. Where possible, excavated spoil would be re-used again onsite in construction and landscaping activities. Excess spoil, not suitable for reuse, would be disposed of in accordance with safeguards and mitigation measures outlined below in Section 6.13.4.

Transport contractors are required to use recycled-content materials where they are cost and performance competitive and are the environmental equivalent (or better) than non-recycled alternatives as described in the *Roads and Maritime Environmental Sustainability Strategy 2019-2023*.

Waste management

The proposal has the potential to generate waste from the following activities:

- Vegetation removal (including native vegetation and noxious weeds)
- Earthworks
- Utility adjustments
- Removal of the existing pavement
- Demolition of structures.

Waste streams likely to be generated during construction of the proposal include:

- Excess spoil unsuitable for reuse - excavated wastes, such as soil and rock, that are unable to be reused within the proposal as it would not meet engineering specifications or are in excess of the proposal requirements
- Demolition waste such as pipe work, bricks, corrugated iron and pavements
- Surplus material from construction and general site reinstatement – including fencing, sediment, concrete, reclaimed asphalt, sand bags and scrap metal
- Packaging materials from items delivered to the site such as pallets, crates, cartons, plastics and wrapping materials
- Green waste as a result of vegetation clearing. Noxious weed material would be separated from native green waste
- Packaging and general waste from staff (lunch packaging, beverage containers)
- Effluent generated at site amenities during construction including portable toilets
- Chemicals and oils used for plant and vehicle maintenance such as fuel, oil and chemical containers
- Wastewater from wash-down and bunded areas
- Redundant erosion and sediment controls
- Asphalt waste from the removal of the existing pavement
- Potential asbestos and other hazardous waste.

Waste would be managed in accordance with the guidance in the *Re-use of waste off-site: Waste Fact Sheet 9* which identifies potential off-site reuses for typical wastes and the *Management of Wastes on Roads and Maritime Services Land* procedure which includes best practice and contingency planning for construction wastes on sites.

Transport is committed to ensuring responsible management of unavoidable waste and to promoting the reuse of such waste through appropriate measures in accordance with the resource management hierarchy principles embodied in the *Waste Avoidance and Resource Recovery Act 2001* (WARR Act 2001). The resource management hierarchy principles in order of priority as outlined in the WARR Act are:

- Avoidance of unnecessary resource consumption
- Resource recovery (including reuse, reprocessing, recycling and energy recovery)
- Disposal.

By adopting the above principles, Transport encourages the most efficient use of resources and reduces cost and environmental harm in accordance with the principles of ESD.

Surplus or contaminated material would be classified and disposed of at a licensed waste facility in accordance with EPA Waste Classification Guidelines (EPA, 2014) or reused in accordance with EPA resource recovery orders and exemptions. The transport and disposal of contaminated and hazardous waste would be carried out in accordance with the Protection of the Environment Operations (Waste) Regulation 2014 which includes notification and tracking requirements.

As discussed in Section 6.4, an unexpected finds procedure would be developed as part of the CEMP for the construction area and would be implemented during the construction phase. An asbestos management plan would also be developed and implemented during the construction phase. The plan would include procedures to identify, manage and handle asbestos and would outline procedures for correct disposal of asbestos in accordance with NSW EPA guidelines, Australian Standards and relevant industry codes of practice.

Operation

During the operational phase of the project, roadside litter would also be found along the length of the bypass. Additional wastes would be generated during routine maintenance and repair activities required over time. The type and volume of wastes generated would be dependent on the nature of the activity, but would predominately consist of green waste, oils, road materials used in repair and maintenance works as well as contaminated waste resulting from fuel spills and leaks.

With the implementation of standard work practices during routine maintenance and repair activities, the overall impact of operational waste streams and volumes would be minimal.

Construction and operational waste impacts would be managed in accordance with the relevant State legislation and government policies including the *WARR Act 2001* and *Waste Avoidance and Resource Recovery Strategy 2014-21* (NSW EPA, 2014).

6.13.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing
Resource use	Use of recycled-content materials will be considered during the detailed design	Transport	Detailed design
Construction waste	A Waste Management Plan (WMP) will be prepared and implemented as part of the CEMP. The WMP will provide specific guidance on measures and controls to be implemented to support minimising the amount of waste produced and appropriate handling and disposal of unavoidable waste. The WMP will include, but will not necessarily be limited to: • Measures to avoid and minimise waste associated with the proposal • Classification of wastes generated by the proposal and management options (re-use, recycle, stockpile, disposal) • Classification of wastes received from off-site for use in the proposal and management options	Construction contractor	Pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
	• Identify any statutory approvals required for managing both on and off-site waste, or application of any relevant resource recovery exemptions • Procedures for storage, transport and disposal • Monitoring, record keeping and reporting, including any documentation management obligations arising from resource recovery exemptions The WMP will be prepared taking into account the *Roads and Maritime Environmental Procedure – Management of Wastes on Roads and Maritime Services Land* and relevant Transport Waste Fact Sheets		
Construction waste	The following resource management hierarchy principles will be followed: • Avoid unnecessary resource consumption as a priority • Avoidance will be followed by resource recovery (including reuse of materials, reprocessing, and recycling and energy recovery) • Disposal will be a last report (in accordance with the *WARR Act 2001*)	Construction contractor	Pre-construction and construction
Contamination	The CEMP will include an unexpected finds protocol for potentially contaminated material encountered during construction work	Construction contractor	Construction
Contamination	An Asbestos Management Plan will be developed and implemented to manage asbestos and asbestos containing material if encountered during the construction. The plan will include: • Identification of potential asbestos on site • Procedures to manage and handle any asbestos • Mitigation measures if asbestos is encountered during construction • Procedures for disposal of asbestos in accordance with the NSW EPA guidelines, Australian Standards and relevant industry codes of practice	Construction contractor	Construction

6.14 Climate change

6.14.1 Methodology

Climate change has the potential to impact on the proposal through changes to weather events and be impacted by the proposal through the emission of greenhouse gases (GHG), which contribute to climate change.

The impact of the proposal on climate change has been considered in a qualitative assessment guided by the emissions scopes described below and by considering the likely construction methods, materials, and maintenance activities.

The impact of climate change on the proposal has been reviewed in consideration of the existing climate conditions and forecast climate conditions. Forecast climate conditions were taken from the Hunter Climate change snapshot of the NSW and Australian Capital Territory (ACT) Regional Climate Modelling (NARCliM) project in collaboration with the Environment, Energy and Science Group, DPIE.

GHG have been categorised into scopes which relate to whether they were a direct or indirect emission and their origin. There are three scopes of GHG emissions:

- **Scope 1**: GHG emissions released directly from on-site activities associated with the proposal, such as the combustion of fossil fuels in vehicles and motors and from the removal of vegetation
- **Scope 2**: GHG emissions released indirectly from an off-site activity, for example the generation of electricity which is used during the construction and operation of the proposal
- **Scope 3**: GHG emissions released indirectly as a result of acquiring and disposing of materials for the proposal, for example the combustion of fossil fuels to transport building materials to a construction site, and the consequent break down of building wastes such as vegetation and wood releasing carbon dioxide emissions in the decay process. GHG emissions would also be associated with the offsite production and transport of materials used in the maintenance of the road.

6.14.2 Existing environment

The existing climate within the Muswellbrook area is characterised by hot summer days and cool dry winters with considerably more intense rainfall in the summer months. Muswellbrook LGA is in a summer dominated rainfall pattern, however heavy isolated falls have been known during winter. Average maximum and minimum temperatures and average rainfall for the Muswellbrook area are provided in Table 6-67. It should be noted that the closest bureau station is based in Scone.

Based on the climate change projections from the NARCliM project, the Hunter is expected to experience an increase in all temperature variables (average, maximum and minimum) for the near and far future (OEH, 2014). Rainfall is projected to decrease in the period between 2020 and 2039 in spring and winter and to increase in autumn (OEH, 2014). The projections are shown in Table 6-67 alongside the existing environment.

In general, the climate in Muswellbrook is expected to become hotter and drier which is likely to result in more intense storms, floods, droughts and bushfire events.

Table 6-67: Existing and forecast climate at Muswellbrook

Climate Variable	Existing	Projected increase or decrease[1]	
		2020-2039 (Near Future)	2060-2079 (Far Future)
Average maximum temperatures	24.5°C	0.7°C	2.1°C
Average minimum temperatures	10.1°C	0.7°C	2.1°C
Average rainfall (Summer)	192.5mm	-5 to 0%	10 to 20%
Average rainfall (Autumn)	126.4mm	10 to 20%	10 to 20%
Average rainfall (Winter)	118.7mm	-5 to 0%	0 to 5%
Average rainfall (Spring)	152.6mm	-5 to 0%	0 to 5%

1 Office of Environment and Heritage, 2014. *Hunter Climate Change snapshot*.

6.14.3 Potential impacts

Construction

Impact of the proposal on climate change

The likely sources of GHG emissions during construction of the proposal are listed in Table 6-68.

While measures would be carried out where possible to reduce GHG emissions, most of the emissions would be largely unavoidable. Therefore, the proposal would contribute to climate change. However, the volume of GHG emissions would be negligible on a national and global scale and the proposal is anticipated to have a negligible impact on climate change during construction.

Table 6-68: Likely GHG emissions during the construction of the proposal

GHG sources	Details	Assessment
Scope 1 emissions		
Construction equipment	GHGs would be generated from fossil fuel combustion in plant, equipment and vehicles used for construction activities	Construction activities would be planned to minimise movements on-site and use lower emission equipment, however GHG emissions related to construction activities would be unavoidable
Generator use	Generators may be required during construction. This would create GHG emissions through the combustion of diesel or other fossil fuels	The use of generators would be limited to circumstances that would reduce the overall length of the construction program, for example to power lights during night works or to power equipment prior to connection to the local power supply. By reducing the overall length of construction, other sources of emissions would be reduced
Vegetation removal	Around 97.92 hectares of native vegetation and 90.17 hectares of non-native vegetation would need to be cleared to accommodate the proposal	The proposal has been designed to minimise the amount of vegetation clearing that would otherwise release stored carbon and reduce the ongoing GHG retention within vegetated areas
Scope 2 emissions		
Electricity	It is expected that a small amount of electricity would be required during construction, which would be associated with power for the on-site construction buildings and worker facilities	Electricity would be purchased from the grid, which largely comprises electricity generated from fossil fuels
Scope 3 emissions		
Construction materials	Extraction and production of materials used for construction of the proposal, such as concrete, steel, road base, pipes, cables,	Recycled materials or materials left over from other projects would be used where possible,

GHG sources	Details	Assessment
	conduits and other materials would result in GHG emissions	however GHG emissions related to the production of materials would be unavoidable
Construction waste	The mulching of cleared vegetation would result in increased GHG emissions, as the breakdown of organic matter to waste material directly releases stored carbon dioxide to the atmosphere	GHG emissions related to the processing of construction waste would be unavoidable
Construction transport	GHGs would be generated by staff travelling to and from the construction site and by any transportation related to the movement of construction materials, equipment or plant to the proposed road corridor	Construction staging would be developed to minimise haulage and other construction vehicle movements, however GHG emissions would be unavoidable

Impact of the proposal on climate change

Climate change projections for the near future represent an average of projections for the period of 2020 to 2039 (refer to Table 6-67). Construction of the proposal is expected to commence in late 2022 and therefore the near future projections are relevant to the proposal.

Construction of the proposal may be susceptible to climate change impacts, including changes in frequency of temperature extremes, and frequency and intensity of rainfall events. The potential impacts associated with these changes include:

- Effect of extreme temperatures on the health and safety of construction workers
- Delays in expected timeframes as a result of weather including rainfall and flooding events
- Increase in risk of erosion and sedimentation, and other environmental impacts from extreme rainfall and flooding.

Operation

Impact of the proposal on climate change

The likely sources of GHG emissions during the operation of the proposal are listed in Table 6-69.

Table 6-69: Likely GHG emissions during the operation of the proposal

GHG sources	Details	Assessment
Scope 2 emissions		
Electricity	Electricity would be required during the operation of the proposal for lighting at new intersections	Electricity would be purchased from the grid, which largely comprises electricity generated from fossil fuels. Lighting would only be installed at the proposal's connections and not along the entire alignment, minimising electricity use
Scope 3 emissions		

GHG sources	Details	Assessment
Traffic	The proposal is not expected to increase traffic volumes, therefore there is not anticipated to be an increase in vehicle emissions as a result of the proposal The proposal would cater for a projected growth in traffic volumes which would occur independent of the proposal	The proposal would enable traffic to continue at a more consistent speed rather than slowing and increasing speed when travelling through the town of Muswellbrook. This would result in a more efficient use of fuel
Road infrastructure maintenance	Diesel fuel use for the operation of maintenance equipment and the delivery of maintenance materials	Maintenance activities would be planned to minimise movements on-site and use lower emission equipment. Recycled materials or materials left over from other projects would be used where possible Emissions generated from maintenance activities would be relatively small in comparison with the indirect emissions associated with the fuel consumed by vehicles using the bypass
Road infrastructure maintenance	Use of materials for maintaining the road pavement	

Impact of climate change on the proposal

Climate and weather can have an impact on the road surface and the safety of a road. The biggest influences on road surface are moisture and temperature, both of which can lead to faster rates of deterioration.

As rainfall decreases overall, the rate of moisture related road surface deterioration should slow (Austroads, 2004). However, this could be offset by an increase in ambient temperatures, which may accelerate the rate of deterioration of any seal binders. Drier conditions may also cause pavements to age more quickly due to oxidation and embrittlement (Austroads, 2004). However, these effects are expected to be minor over time and in combination with the Transport maintenance regime are likely to have a negligible impact.

More intense rainfall and flooding events could put pressure on drainage infrastructure for the road including culverts and open drainage channels. Recognising this, the drainage design for the proposal provides the required flood immunity for the proposal, minimises potential flooding impacts on upstream and downstream properties and has factored in an increase in rainfall intensity to consider the effect of climate change.

6.14.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Climate Change	Construction equipment, plant and vehicles will be appropriately sized for the	Construction Contractor	Construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	task, serviced frequently and will not be left idling when not in use			
Climate Change	Opportunities to use low emission construction materials, such as recycled aggregates in road pavement and surfacing, and cement replacement materials will be investigated and incorporated where feasible and cost-effective	Construction Contractor	Construction	Additional safeguard
Climate Change	Construction site layouts will be designed to reduce travel distances and double handling of materials to reduce fuel usage and emission generation	Construction Contractor	Construction	Additional safeguard
Climate Change	Raw materials will be managed to reduce energy requirements for their processing. For example, stockpiled materials will be covered or provided undercover storage where possible to reduce moisture content of materials, and therefore the process and handling requirements	Construction Contractor	Construction	Additional safeguard
Climate Change	Locally produced goods and services will be procured where feasible and cost effective to reduce transport fuel emissions	Construction Contractor	Construction	Additional safeguard
Climate Change	Materials with lower emissions intensity will be specified in the selection of maintenance materials	Transport	Operation	Additional safeguard
Climate Change	The most energy efficient street lighting appropriate for project needs will be specified	Transport	Operation	Additional safeguard

6.15 Hazard and risk

6.15.1 Existing environment

Existing hazards and risks in the vicinity of the proposal are generally associated with the operation of the existing road network and the Main North railway line. As discussed in Section 6.4, there is a moderate risk of contamination from a range of potential contaminants and sources within and adjacent to the proposed road corridor. The proposal also passes over the old backfilled MCC Open Cut No.1 including the highwall and low wall.

As discussed in Section 6.2, the northern section of the proposal extends into the floodplain of the Hunter River near its confluence with Sandy Creek. The proposal crosses Sandy Creek about 2.4 kilometres upstream of its confluence with the Hunter River.

The proposed road corridor up to Sandy Creek Road is mapped as Vegetation Category 1 and 2 and vegetation buffer bushfire prone land. Vegetation Category 1 is considered to be the highest risk for bush fire. This vegetation category has the highest combustibility and likelihood of forming fully developed fires including heavy ember production. Vegetation Category 2 is considered to be a lower bush fire risk than Category 1. This Vegetation Category has lower combustibility and/or limited potential fire size due to the vegetation area shape and size, land geography and management practices. The vegetation buffer is the buffer zone around each category. For Vegetation Category 1, a 100 metre external buffer zone applies and for Vegetation Category 2, a 30 metre external buffer.

6.15.2 Potential impacts

Construction

Hazards and risks relating to the construction of the proposal would include:

- Spills or leakage of contaminants such as fuels, chemicals and hazardous substances entering the surface and groundwater or contaminating soils
- Discharge of turbid run-off, resulting in pollution of waterways
- Encountering unexpected utilities or contaminated material during earthworks
- Spread of noxious weeds
- Flooding during extreme rain events
- Changed traffic conditions leading to incidents
- Subsidence and spontaneous combustion risks associated with previous MCC operations.

The following bushfire/grassfire risks are identified for the proposal:

- Insufficient training of construction workers dealing with bushfire/grassfire risk and
- Fire from offsite or caused as a result of construction activities such as hot works.

Hazards arising from incidents during proposal construction could also pose a risk to health and safety of workers, as well as that of the environment. These potential risks and appropriate management measures are addressed in other sections of this REF, including:

- Biodiversity (refer to Section 6.1)
- Surface water, hydrology and flooding (refer to Section 6.2)
- Groundwater (refer to Section 6.3)
- Soils and contamination, subsidence and spontaneous combustion (refer to Section 6.4)
- Traffic and transport (refer to Section 6.5)
- Resource use and waste management (refer to Section 6.13).

Post construction bushfire/grassfire risks would remain similar to the existing situation, however new bypass infrastructure would require ongoing protection. A Bushfire Management Plan would be prepared and included in the CEMP.

Overall, the hazards and risks associated with the proposal during construction are considered low and would be managed with the implementation of the standard management and mitigation measures such as those identified in Section 6.15.3.

Operation

Operational hazards and risks relating to the proposal could include:

- Fuel and oil spills during maintenance activities or vehicle incidents polluting the natural environment
- Vehicle incidents.

Fuel and oil spills during operation are discussed in Section 6.2. Vehicle crashes are an inherent aspect of the operation of any road. During the design of the proposal, Transport has adopted the requirements of all relevant standards as listed in Section 3.2.1. During operation, it is anticipated that hazards and risks associated with the proposal would be low and would be managed with the implementation of standard management and mitigation measures identified below.

6.15.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Hazard and risk	Emergency response plans will be incorporated into the CEMP	Construction contractor	Preconstruction and construction	Additional safeguard
Hazard and risk	A Hazard and Risk Management Plan will be prepared and implemented as part of the CEMP. The Plan will identify: • Hazards and risks associated with the activity • Measures to be implemented during construction to minimise these risks • Record keeping arrangements, including information on the materials present on the site, material safety data sheets, and personnel trained and authorised to use such materials • A monitoring program to assess performance in managing the identified risks, including equipment checking and maintenance requirements • Contingency measures to be implemented in the event of unexpected hazards or risks arising, including emergency situations	Construction contractor	Preconstruction and construction	Additional safeguard
Bushfires	A Bushfire Management Plan will be prepared and included as part of the CEMP. The Plan will identify: • Asset protection zone locations and management details • Landscaping requirements including indicative design layout and vegetation density thresholds • Access provisions such as locations, passing bays and alternate emergency access • Water supplies and bush fire suppression systems • Details regarding the Bush Fire Emergency Management and Evacuation Plan and any other essential bush fire safety requirements	Construction contractor	Preconstruction and construction	Additional safeguard
Bushfires	Construction activities involving flammable materials and ignition sources (for	Construction contractor	Construction	Additional safeguard

Impact	Environmental safeguards	Responsibility	Timing	Reference
	example, welding) will be proactively managed to ensure that the potential for fire is effectively minimised. High risk construction activities, such as welding and metal work, will be subject to a risk assessment on total fire ban days and restricted or ceased as appropriate. Construction personnel will be inducted into the requirement to safely dispose of cigarette butts			

6.16 Cumulative impacts

6.16.1 Study area

Cumulative impacts could be experienced if construction or operation of the proposal coincides with construction or operation of other local development, such as other road upgrades, public work or private development.

A desktop review of the major project register on the DPIE website completed on 2 September 2021 identified major projects within the Muswellbrook LGA which have the potential to contribute to cumulative impacts with the proposal. These projects are listed in Table 6-70.

Table 6-70: Major projects within the potential to contribute to cumulative impacts with the proposal (major projects register)

Project	Description	Status and timing	Distance from the proposal
Muswellbrook Waste Management Facility	This project involves the development of a new Muswellbrook Waste Management Facility comprising an upgrade to the existing waste management facility integrated with a new landfill development encompassed by the Facility The project involves the design and construction of a new landfill void within Muswellbrook Waste Management Facility and the upgrade of existing infrastructure	EIS preparation stage. Secretary's Environmental Assessment Requirements (SEARs) have been issued. As yet no approval issued for the project Timing not confirmed	Ten metres - adjacent to the proposal
Pacific Brook Christian School	The project involves the construction of a Christian school catering for up to 600 students. The current school site is located at 30 Sowerby Street, Muswellbrook. The school proposes to relocate to a permanent location at 72-74 Maitland Street (New England	EIS preparation stage. SEARs have been issued. As yet no approval issued for the project Timing not confirmed	Three kilometres to the west

Project	Description	Status and timing	Distance from the proposal
	Highway), Muswellbrook and establish a new school at this site.		
Mount Pleasant Optimisation Project	This project proposes to optimise the Mount Pleasant Operation, including access to additional run-of-mine (ROM) coal reserves, and to extend approved life of the mine from 2026 to 2048	More information required. EIS and response to submissions have both been prepared. As yet no approval issued for the project Timing not confirmed	Three kilometres to the west
Bayswater Power Station Upgrade	This project proposes to improve the management of ancillary processes over the remaining operating life of Bayswater and to facilitate an improved rehabilitation outcome for the ash disposal area The project involves: • Augmenting the existing ash disposal area • Creation of a salt cake disposal landfill • Improvements to water management around the coal handling plant	Assessment stage. As yet no approval issued for the project Timing not confirmed	11 kilometres to the south
Bowmans Creek Wind Farm	This project proposes to install around 70 – 80 wind turbines. A new powerline and local road upgrades to Hebden Road, Muscle Creek Road and Rouchel Road/Stoney Creek Road are proposed to provide access from the New England Highway	Response to submissions stage. As yet no approval issued for the project Timing not confirmed	Nine kilometres to the east
Maxwell Solar Farm	The project proposes to develop a new 25 megawatt solar project. The project is located on a rehabilitated overburden emplacement area associated with the former Drayton coal mine, which ceased operations in December 2017	Approved / Determined in August 2020 Construction to last 12-18 months.	6 kilometres south
Singleton Bypass – New England Highway	This project proposes to construct a New England Hwy bypass around the township of Singleton	Project determined in August 2020 Timing for construction of the bypass is expected to	30 kilometres to the south east

Project	Description	Status and timing	Distance from the proposal
		be from Mid 2022 to mid 2026	

The Muswellbrook Council website identifies Development Applications recently determined within the LGA, including major developments and Council infrastructure maintenance work. Approved projects generally include upgrades to residential properties, residential subdivisions and Council water infrastructure upgrades that would not have a cumulative impact with the proposal.

6.16.2 Potential impacts

The construction of the proposal is expected to commence in late 2022 and is anticipated to finish in about three and a half years. The extent of potential cumulative impacts can only be assessed in regard to project information and schedules available at time of publication.

Construction

Cumulative impacts could occur where construction of the proposal and other developments are being carried out in parallel. The key cumulative impacts during construction could include:

- Increased construction vehicle traffic on local roads
- Cumulative air and noise impacts associated with multiple construction activities
- Temporary changes to visual amenity.

Potential cumulative impacts would be temporary and environmental safeguards and management measures would be implemented as appropriate.

The severity of potential cumulative impacts would vary between locations and would generally be dependent on the types of work being carried out, the timing and duration of the work relative to each other, the distance between the work and the receivers and sensitivity of the receiver. In relation to the identified mining and power projects these are ongoing operations or extensions to operations at existing sites which would have low potential to result in cumulative impacts. The nominated road projects may have the potential to cause cumulative construction traffic delays at other locations on the New England Highway or in the vicinity of the highway, however as the timing of the upgrades to roads as part of the Bowmans Creek Wind Farm project are currently unknown, there is a low potential for cumulative impacts to occur. Cumulative impacts associated with consecutive construction with the Singleton Bypass proposal would be likely as both proposal construction timeframes would overlap.

Table 6-71 provides a summary of the potential cumulative impacts associated with each identified proposal during construction.

Table 6-71: Anticipated cumulative impacts during construction

Project	Cumulative impacts
Muswellbrook Landfill	Depending on the timing of each construction phase, the ongoing and cumulative impacts of multiple projects being undertaken back to back or over similar timeframes may result in construction fatigue impacts on residents and for non-residential premises in the region. There may also be an increase in construction related impacts (ie noise and dust), particularly as the Waste Management Facility is directly adjacent to the proposed alignment. Given the location of the nearest sensitive receivers, cumulative impacts are expected to be minimal

Project	Cumulative impacts
Pacific Brook Christian School	Similar to the potential impacts identified above, depending on construction timeframes, there is potential for construction fatigue impacts as well as construction traffic impacts. It is considered likely that this project would also use New England Highway as a haulage route for construction vehicles (refer to Figure 3-6). If construction timeframes overlap, potential traffic impacts would be addressed in the TMP.
Mount Pleasant Optimisation Project	Mount Pleasant is an existing operation west of the proposal. The modifications and life extension of the mine is identified to occur away from Muswellbrook. Further, the activities carried out in the expansion would be generally consistent with current operations of the Mount Pleasant Mine and is not anticipated to result in cumulative impacts with the proposal during the extension phase of the project
Bayswater Power Station Upgrade	Bayswater Power Station is about 11 kilometres south east of Muswellbrook and is situated between Muswellbrook and Singleton. No noticeable cumulative impacts are anticipated to occur with this proposal
Bowmans Creek Wind Farm	Access to the site would be via the New England Highway and then on designated local roads. Given the construction stages of each project are unlikely to overlap, cumulative impacts with this project are not likely to occur
Maxwell Solar Farm	No noticeable cumulative impacts are anticipated to occur with the project
Singleton Bypass – New England Highway	Given the construction stages of each project are likely to overlap, cumulative impacts with this project may occur. Depending on the timing of each construction phase, the ongoing and cumulative impacts of multiple construction stages along sections of the New England Highway being undertaken back to back may result in construction fatigue impacts on motorists frequently using the new England highway, residents and businesses in the region. Consecutive construction of the proposal with Singleton Bypass could potentially have the following impacts: • Prolonged construction vehicle movements between Singleton and the proposal • Prolonged traffic delays and disruptions along the New England as a result of construction activities • Demand for similar materials and generation of waste materials at the same time • Construction fatigue at sensitive residential receivers located in close proximity to the proposals and for road users travelling between Scone and Singleton

Operation

The proposal, combined with other approved and proposed road upgrade projects would result in cumulative traffic benefits on the New England Highway and surrounds through the increased capacity of the road network, improved traffic flow and journey times and improved road safety.

The proposal, combined with other approved and proposed road upgrade projects may contribute to a cumulative loss of rural and agricultural land, however impacts are anticipated to be minor.

There are not anticipated to be any negative cumulative impacts associated with the concurrent operation of the proposal and the projects listed in Table 6-70. The operation of the Singleton Bypass and Muswellbrook Bypass would provide an improved road user experience, improved travel time reliability and Level of Service.

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 Section 6 of this REF and summarised in Section 7.2.

7. Environmental management

This chapter describes how the proposal would be managed to reduce potential environmental impacts throughout detailed design, construction and operation. A framework for managing the potential impacts is provided. A summary of site-specific environmental safeguards is provided and the licence and/or approvals required prior to construction are also listed.

7.1 Environmental management plans (or system)

A number of safeguards and management measures have been identified in the REF in order to minimise adverse environmental impacts, including social impacts, which could potentially arise as a result of the proposal. Should the proposal proceed, these safeguards and management measures would be incorporated into the detailed design and applied during the construction and operation of the proposal.

A CEMP would be prepared to describe the safeguards and management measures identified. The CEMP would provide a framework for establishing how these measures would be implemented and who would be responsible for their implementation.

The CEMP would be prepared prior to construction of the proposal and must be reviewed and certified by the Transport Environment Officer, Hunter Region, prior to the commencement of any on-site works. The CEMP would be a working document, subject to ongoing change and updated as necessary to respond to specific requirements. The CEMP would be developed in accordance with the specifications set out in the QA Specification *G36 – Environmental Protection (Management System)*, QA Specification *G38 – Soil and Water Management (Soil and Water Plan)*, QA Specification *G40 – Clearing and Grubbing*, QA Specification *G10 – Traffic Management.*

7.2 Summary of safeguards and management measures

Environmental safeguards and management measures outlined in this REF would be incorporated into the detailed design phase of the proposal and during construction and operation of the proposal, should it proceed. These safeguards and management measures would minimise any potential adverse impacts arising from the proposed works on the surrounding environment. The safeguards and management measures are summarised in Table 7-1.

Table 7-1: Summary of safeguards and management measures

No.	Impact	Environmental safeguards	Responsibility	Timing
	General			
GEN1	Minimise environmental impacts during construction	A Construction Environmental Management Plan (CEMP) will be prepared and submitted for review and endorsement of the Transport Environment Manager prior to commencement of the activity As a minimum, the CEMP will include the following: • Any requirements associated with statutory approvals • Details of how the proposal will implement the identified safeguards outlined in the REF • Issue-specific environmental management plans • Roles and responsibilities • Communication requirements • Induction and training requirements • Procedures for monitoring and evaluating environmental performance, and for corrective action • Reporting requirements and record-keeping • Procedures for emergency and incident management • Procedures for audit and review. The endorsed CEMP will be implemented during the undertaking of the proposal	Construction contractor and Transport	Pre-construction
GEN2	Environmental awareness	All personnel working on site will receive training to ensure awareness of environment protection requirements to be implemented during the proposal. This will include up-front site induction and regular "toolbox" style briefings	Construction contractor and Transport	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		Site-specific training will be provided to personnel engaged in activities or areas of higher risk. These include (the following are examples only): • Areas of Aboriginal heritage sensitivity • Threatened species habitat • Adjoining residential areas requiring particular noise management measures		
	Biodiversity			
B1	Biodiversity	A Flora and Fauna Management Plan (FFMP) will be prepared in accordance with Transport for NSW's *Biodiversity Guidelines: Protecting and Managing Biodiversity on Projects* (RMS, 2011) and implemented as part of the CEMP. The FFMP will include, but not be limited to: • Plans showing areas to be cleared and areas to be protected, including exclusion zones, protected habitat features and revegetation areas • Requirements set out in the *Landscape Guideline* (RMS, 2008) • Pre-clearing survey requirements • Procedures for unexpected threatened species finds and fauna handling • Procedures addressing relevant matters specified in the *Policy and guidelines for fish habitat conservation and management* (DPI Fisheries, 2013) • Protocols to manage weeds and pathogens	Construction contractor	Detailed design and pre-construction
B2	Biodiversity	Measures to further avoid and minimise the construction footprint and native vegetation or habitat removal will be investigated during detailed design and implemented where practicable and feasible	Construction contractor	Detailed design and pre-construction
B3	Removal of native vegetation	Native vegetation removal will be minimised through detailed design	Transport	Detailed design
B4	Removal of native vegetation	Native vegetation removal will be minimised via selective placement of temporary ancillary facilities i.e. preference is to avoid areas of higher biodiversity value and to select areas already subject to disturbance	Construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
B5	Removal of native vegetation	Pre-clearing surveys will be undertaken in accordance with Guide 1: Pre-clearing process of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Pre-construction
B6	Removal of native vegetation	Exclusion zones will be set up at the limit of clearing or where areas containing pathogens or disease are identified in accordance with Guide 2: Exclusion zones of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction
B7	Removal of native vegetation	Vegetation removal will be undertaken in accordance with Guide 4: Clearing of vegetation and removal of bushrock of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction
B8	Removal of native vegetation	Native vegetation will be re-established (particularly along new road verges within proximity to known Striped Legless Lizard habitat) in accordance with Guide 3: Re-establishment of native vegetation of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011) to minimise weed encroachment (in particular perennial grass species)	Construction contractor	Construction and post construction
B9	Removal of native vegetation	The unexpected species find procedure is to be followed under Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011) if threatened entities, not assessed in the biodiversity assessment, are identified in the construction footprint	Construction contractor	Construction
B10	Removal of threatened species habitat and habitat features	Habitat will be replaced or re-instated in accordance with Guide 5: Re-use of woody debris and bushrock and Guide 8: Nest boxes of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction
B11	Removal of threatened species habitat and habitat features	Site personnel working within proximity of Striped Legless Lizard habitat will be provided with an information sheet and/or induction. An exclusion zone will be set up around known Striped Legless Lizard habitat during construction in accordance with Guide 2: Exclusion zones of the Biodiversity Guidelines -	Construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		Protecting and managing biodiversity on RTA projects (Roads and maritime Authority, 2011)		
B12	Removal of threatened species habitat and habitat features	A nest box strategy will be developed in accordance with Guide 8: Nest boxes of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011). The nest box strategy will primarily target the replacement of hollow resources being removed by the proposal on the Squirrel Glider. Final hollow resource impacts and subsequent nest boxes required will be informed by the tree clearing program	Construction contractor	Pre-construction
B13	Aquatic impacts	Aquatic habitat will be protected in accordance with Guide 10: Aquatic habitats and riparian zones of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011) and Section 3.3.2 Standard precautions and mitigation measures of the Policy and guidelines for fish habitat conservation and management Update 2013 (Department of Primary Industries, 2013)	Construction contractor	Construction
B14	Injury and mortality of fauna and fragmentation of identified habitat corridors	Fauna will be managed in accordance with Guide 9: Fauna handling of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction
B15	Injury and mortality of fauna and fragmentation of identified habitat corridors	Road-kill and connectivity impacts will be minimised via: • Installation of one aerial fauna crossing structure to retain fauna connectivity in the vicinity of where Squirrel Gliders have been recorded. The final location, design and type of structure will be determined during detailed design • Construction of a bridge over Muscle Creek to provide underpass fauna crossing for terrestrial fauna species such as the Koala • Consideration of fauna exclusion fencing in areas where fauna crossing structures are proposed for example near Muscle Creek and/or near known habitat for Striped Legless Lizard	Construction contractor	Detailed design, construction and post construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		• Installation of 'Koala Warning Signs' or 'Injured Native Wildlife Signs' in areas of potential wildlife conflict areas or crossing points		
B16	Invasion and spread of weeds	Priority weed species will be managed in accordance with Guide 6: Weed management of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction
B17	Invasion and spread of pests	Pest species will be managed within the construction footprint	Construction contractor	Construction
B18	Invasion and spread of pathogens and disease	Hygiene procedures will be implemented for the use of vehicles and the importation of materials to the proposal footprint in accordance with Guide 7: Pathogen management of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)	Construction contractor	Construction
B19	Groundwater dependant ecosystems (GDE)	Interruptions to water flows associated with GDEs will be minimised through detailed design	Transport	Detailed design
B20	Habitat removal	A Biodiversity Offset Strategy will be prepared for the proposal in accordance with Guidelines for Biodiversity Offsets (Roads and Maritime Services, 2016)	Construction contractor	Pre-construction
	Surface water and flooding			
W1	General	A Soil and Water Management Plan (SWMP) will be prepared in accordance with QA Specification G38 and implemented as part of the CEMP. The SWMP will identify all reasonably foreseeable risks relating to soil erosion and water pollution associated with undertaking the activity and describe how these risks will be managed and minimised during construction, including arrangements for managing pollution risks associated with spillage or contamination on the site and adjoining areas, and monitoring during and post-construction The Soil and Water Management Plan will address the following:	Construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		• Code of Practice for Water Management, the Roads and Maritime Erosion and Sedimentation Procedure • The NSW Soils and Construction – Managing Urban Stormwater Volume 1 "the Blue Book" (Landcom, 2004) and Volume 2 (DECC, 2008) • Technical Guideline: Temporary Stormwater Drainage for Road Construction, 2011 • Technical Guideline: Environmental Management of Construction Site Dewatering, 2011		
W2	Soil erosion and sedimentation	A site-specific Erosion and Sediment Control Plan (ESCP) will be prepared and implemented and included in the SWMP. The ESCP will identify detailed measures and controls to be applied to minimise erosion and sediment control risks including, but not necessarily limited to: • Runoff, diversion and drainage points • Sediment management devices, such as fencing, hay bales or sandbags • Scour protection and energy dissipaters at locations of high erosion risk • Stabilising disturbed areas as soon as possible, check dams, fencing and swales • Staged implementation arrangements The ESCP will also include arrangements for managing wet weather events, including monitoring of potential high-risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather	Construction contractor	Construction
W3	Contamination of surface water quality	Sediment control basins will be provided at flow discharge points associated with the bypass and bridges over Muscle Creek and Sandy Creek. The requirements for erosion control measures and sediment basins (i.e. number, location and size) will be determined during the proposal detailed design phase	Construction contractor	Detailed design and construction
W4	Contamination of surface water quality	A Spill Management Plan (SMP) will be prepared and implemented as part of the CEMP to minimise the risk of pollution arising from spillage or contamination on	Construction contractor	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		the site and adjoining areas. The SMP will address, but not necessarily be limited to: • Management of chemicals and potentially polluting materials • Appropriate location and storage of construction materials, fuels and chemicals, including bunding where appropriate • Maintenance of plant and equipment • Emergency management, including notification, response and clean-up procedures.		and construction
W5	Surface water quality	Water quality requirements will form part of the conditions stipulated in the environment protection licence (EPL) for the proposal. The current water quality monitoring program results will be used for baseline purposes	Construction contractor	Construction
W6	Flood mitigation	A Flood Risk Management Plan (FRMP) will be prepared as part of the CEMP. The FRMP will address, but not necessarily be limited to: • Processes for monitoring and mitigating flood risk • Steps to be taken in the event of a flood warning including removal or securing of loose material, equipment, fuels and chemicals	Construction contractor	Construction
	Groundwater			
GW1	Groundwater dewatering	Any dewatering activities will be undertaken in accordance with the RTA Technical Guideline: Environmental management of construction site dewatering in a manner that prevents pollution of waters	Construction contractor	Detailed design and construction
GW2	Groundwater dewatering	If required, groundwater abstraction requirements during the development phase of the proposal will form part of the condition stipulated in the EPL for the proposal	Construction contractor	Detailed design and construction
GW3	Groundwater impact mitigation	Any dewatering activities will be undertaken in accordance with the RTA Technical Guideline: Environmental management of construction site dewatering in a manner that prevents pollution of waters	Construction Contractor	Detailed design and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
GW4	Groundwater impact mitigation	Additional geotechnical investigations will be undertaken to determine the: • Need for dewatering • Likely dewatering volumes • Impacts on draw down • Quality of groundwater that would be encountered during construction	Contractor	Detailed design
GW5	Groundwater impact mitigation	To minimise the potential of encountering groundwater during construction, pile holes should be installed by advancing steel casing into the ground as they are advanced	Construction contractor	Detailed design and construction
	Soils and contamination			
E1	Excess spoil	Excess spoil not required or able to be used for backfilling will be stockpiled in a suitable location before being reused or removed from the site, and disposed of appropriately in accordance with the NSW EPA Waste Classification Guidelines (2014)	Construction contractor	Construction
E2	Erosion and sedimentation	Erosion and sediment controls will be implemented before any construction starts and inspected regularly, particularly after a rainfall event. Maintenance work will be carried out as needed	Construction contractor	Construction
E3	Erosion and sedimentation	Site stabilisation of disturbed areas will be carried out progressively as stages are completed	Construction contractor	Construction
E4	Erosion and sedimentation	All stockpiles will be designed, established, operated and decommissioned in accordance with Roads and Maritime Stockpile Management Guideline (RTA, 2011)	Construction contractor	Construction
E5	Erosion and sedimentation	The rehabilitation of disturbed areas will be undertaken progressively as construction stages are completed, in accordance with:	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		• The NSW Soils and Construction – Managing Urban Stormwater Volume 1 "the Blue Book" (Landcom, 2004) and Volume 2 (DECC, 2008) • Landscape Guideline (RTA 2018) • Guideline for Batter Stabilisation using Vegetation (Roads and Maritime 2015)		
E6	Erosion and sedimentation	Batters will be designed and constructed to minimise risk of exposure, instability and erosion, and to support long-term, on-going best practice management, in accordance with *Guideline for Batter Surface Stabilisation using Vegetation* (Roads and Maritime 2015)	Transport and Construction contractor	Detailed design and construction
E7	Tracking of soil off site	Controls will be implemented at exit points to minimise the tracking of soil and particulates onto pavement surfaces	Construction contractor	Construction
E8	Contamination	A Phase II Environmental Site Assessment (ESA) will be prepared to quantify potential areas of contamination identified within the Preliminary CSM of this the Phase I Contamination Assessment and to better inform the CEMP	Transport	Pre-construction
E9	Contamination	The CEMP will include an unexpected finds protocol for potentially contaminated material encountered during construction work	Construction contractor	Construction
E10	Contamination	Should contamination which may pose potential risk to human health and the environment be encountered during construction, further assessment may be required following consultation with Transport environmental staff	Construction contractor	Construction
E11	Contamination	If contaminated areas are encountered during construction, appropriate control measures will be implemented to manage the immediate risks of contamination. This may include but not be limited to: • Diversion of surface runoff • Capture of any contaminated runoff • Temporary capping. All other works that may impact on the contaminated area will cease until the nature and extent of the contamination has been confirmed and any necessary	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		site-specific controls (for the proposed road corridor) or further actions identified in consultation with the Transport Environment Manager and/or the EPA are implemented		
E12	Contamination	An Asbestos Management Plan will be developed and implemented to manage asbestos and asbestos containing material if encountered during the construction. The plan will include: • Identification of potential asbestos on site • Procedures to manage and handle any asbestos • Mitigation measures if asbestos is encountered during construction • Procedures for disposal of asbestos in accordance with the NSW EPA guidelines, Australian Standards and relevant industry codes of practice	Construction contractor	Construction
	Traffic and Transport			
T1	Construction traffic management	A Traffic Management Plan (TMP) will be prepared and implemented as part of the CEMP. The TMP will be prepared in accordance with the Transport for NSW *Traffic Control at Work Sites Manual* (Transport for NSW, 2020) and *QA Specification G10 Control of Traffic* (Transport for NSW, 2020). The TMP will include: • Confirmation of haulage routes • Measures to maintain access to local roads and properties • Site specific traffic control measures (including signage) to manage and regulate traffic movement • Measures to maintain pedestrian and cyclist access • Requirements and methods to consult and inform the local community of impacts on the local road network • Access to construction sites including entry and exit locations and measures to prevent construction vehicles queuing on public roads. • A response plan for any construction traffic incident	Construction contractor	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		• Consideration of other developments that may be under construction to minimise traffic conflict and congestion that may occur due to the cumulative increase in construction vehicle traffic • Monitoring, review and amendment mechanisms		
T2	Access to properties	Disruptions to property access and traffic will be notified to landowners at least five days prior in accordance with the relevant community consultation processes outlined in the TMP	Transport	Detailed design
T3	Access to properties	Where any legal access to property is permanently affected, arrangements for appropriate alternative access will be determined in consultation with the affected landowner and local road authority	Construction contractor and Transport	Detailed design
T4	Access to properties	Access to properties will be maintained during construction. Where that is not feasible or necessary, temporary alternative access arrangements will be provided following consultation with affected landowners and the relevant local road authority	Construction contractor and Transport	Construction
T5	Local road condition	Pre-construction and post construction road condition reports for local roads likely to be used during construction will be prepared. Any damage resulting from construction (not normal wear and tear) will be repaired unless alternative arrangements are made with the relevant road authority. Copies of road condition reports will be provided to the local roads authority	Construction contractor	Pre and post construction
T6	Pedestrian and cyclist access	Pedestrian and cyclist access will be maintained throughout construction. Where that is not feasible or necessary, temporary alternative access arrangements will be provided following consultation with affected landowners and the local road authority	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
	Noise and vibration			
NV1	Noise and vibration	The Noise and Vibration Technical Report will be re-evaluated based on the detailed design in order to reaffirm noise predictions and potential impacts as a result of the proposal	Transport	Pre-construction
NV2	Noise and vibration	A Construction Noise and Vibration Management Plan (CNVMP) will be prepared and implemented as part of the CEMP. The CNVMP will identify: • All potential significant noise and vibration generating activities associated with the activity • Noise and vibration sensitive receivers • Measures to be implemented during construction to minimise noise and vibration impacts, such as restrictions on working hours, staging, placement and operation of work compounds, parking and storage areas, temporary noise barriers, haul road maintenance and controlling the location and use of vibration generating equipment • Feasible and reasonable mitigation measures to be implemented, taking into account Beyond the Pavement: urban design policy, process and principles (Transport for NSW, 2014) • A monitoring program to assess performance against relevant noise and vibration criteria • Arrangements for consultation with affected neighbours and sensitive receivers, including notification and complaint handling procedures • An out of hours works procedure, including approval process and proposed mitigation measures	Construction contactor	Pre-construction and construction
NV3	Noise and vibration	All sensitive receivers likely to be affected will be notified at least five days prior to commencement of any works associated with the scenario that may have an adverse noise or vibration impact. The notification will include details of: • The proposal • Construction period and construction hours • Contact information for proposal management staff	Construction contactor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		• Complaint and incident reporting and how to obtain further information		
NV4	Noise and vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant proposal specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on high noise generating activities • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures	Construction contactor	Construction
NV5	Noise and vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Works generating high noise and/or vibration levels should be scheduled during less sensitive time periods Any variations to the standard construction hours will follow the approach in Roads and Maritime Services – Construction Noise and Vibration Guideline, including consultation with the affected local community	Construction contactor	Construction
NV6	High noise generating work – standard construction hours	Where feasible and reasonable, high noise generating work (75 dB(A) L_{Aeq} at receiver) will be carried out during standard construction hours and in continuous blocks of no more than three hours with at least one hour respite between each block of work generating high noise impact, where the location of the work is likely to impact the same receiver	Construction contactor	Construction
NV7	High noise generating activities – out of hours	Where high noise generating activities (75 dB(A) LAeq at receiver) are required out of hours, the following will be implemented: • The equipment will be used prior to 10pm where feasible and reasonable	Construction contactor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		• Where the above cannot be achieved the equipment will be used prior to midnight where feasible and reasonable • It is not proposed apply a three hour on and a one hour off respite approach in an effort to ensure that the use of such equipment is completed as early in the night as possible		
NV8	Noise	Where properties have been identified for architectural treatment and these properties will be impacted by noise from construction works, Transport will consult with those property owners on the early installation of treatments to provide noise mitigation during the construction of the proposal, where feasible	Transport	Pre-construction
NV9	Noise from deliveries	The following will be implemented for deliveries to and from the proposal: • Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers • Dedicated loading/unloading areas are to be shielded if close to sensitive receivers • Delivery vehicles are to be fitted with straps rather than chains for unloading, wherever possible • Construction sites will be arranged to limit the need for reversing associated with regular/repeatable movements	Construction contactor	Construction
NV10	Noise from construction vehicles/plant	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work	Construction contactor	Construction
NV11	Noise from construction ancillary facilities	The noise associated with the operation of construction ancillary facilities will primarily result from the operation of fixed and mobile plant and truck movements. Consideration will be given to the layout of the site (positioning of site sheds, earth bunds and hoarding) in order to maximise distance and shielding to nearby receivers	Construction contactor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
NV12	Noise	Where practicable, work should be scheduled to avoid major student examination periods such as before or during Higher School Certificate and at the end of higher education semesters	Construction contactor	Construction
NV13	Noise	In circumstances where the noise levels are predicted to exceed construction noise management levels after implementation of the general work practices, additional mitigation measures are required. These measures include the following: • Monitoring • Notification (letterbox drop or equivalent) • Specific notifications • Phone calls • Individual briefings • Respite offers • Respite periods • Duration respite • Alternative accommodation	Construction contactor	Construction
NV14	Vibration	Vibration intensive equipment size will be considered to avoid working within the structural damage minimum working distances. The use of less vibration intensive methods of construction or equipment will be considered where feasible and reasonable	Construction contactor	Construction
NV15	Vibration	Where the use of vibration intensive equipment within the relevant minimum working distances cannot be avoided, prior to the commencement of vibration intensive work, a detailed inspection will be carried out and a written and photographic report prepared to document the condition of buildings and structures within the minimum working distances. A copy of the report will be provided to the relevant landowner or land manager	Construction contactor	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
NV16	Operational noise	To confirm that the noise levels targets are achieved, a post-construction noise monitoring program will be carried out in accordance with the *Noise Mitigation Guideline* within 12 months of opening to traffic	Contractor	Operation
	Aboriginal cultural heritage			
A1	Aboriginal cultural heritage	An application for an Aboriginal heritage Impact Permit (AHIP) will be made under section 90A of the NP&W Act. The application will be prepared in accordance with the Heritage NSW Applying for an *Aboriginal Heritage Impact Permit: Guide for Applicants* (OEH 2011b). An AHIP will be sought for the land and associated objects within the boundaries of the construction footprint	Transport	Pre-construction
A2	Aboriginal cultural heritage	The AHIP will include provision for impact mitigation through archaeological salvage excavation at Muswellbrook Bypass AFT 1 and Muswellbrook Bypass AFT 9 Salvage excavations will be completed prior to any activities (including pre-construction activities) which may harm Aboriginal objects at these site locations. Salvage excavation activities will be undertaken in accordance with the approved methodology	Transport	Pre-construction
A3	Aboriginal cultural heritage	The AHIP will also include provision for community surface collection at all impacted site areas. The collection must be completed prior to any activities which may harm Aboriginal objects at these site locations and will be conducted as part of the overall salvage program, following the issue of the AHIP The collected objects will be recorded as part of the excavation report and included in the excavation assemblage for long term storage. The collection of surface artefacts will be undertaken in accordance with the approved methodology	Transport	Pre-construction
A4	Aboriginal cultural heritage	The short term management of collected Aboriginal objects will be as follows:	Transport	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		• Any Aboriginal objects that are removed from the land by actions authorised by an AHIP, must be moved as soon as practicable to the temporary storage location pending any agreement reached about the long term management of the Aboriginal objects • The temporary storage location will be KNC, Level 10, 25 Bligh Street, Sydney NSW 2000 • Any Aboriginal objects stored at the temporary storage location must not be further harmed, except in accordance with the conditions of the AHIP. The long term management of collected Aboriginal objects is as follows: • Recovered objects will be lodged with the Australian Museum in the first instance in accordance with the Australian Museum Archaeological Collection Deposition Policy • If required, a variation will be sought for recovered objects to be held by the Aboriginal community or reburied. If reburial is to take place, registered Aboriginal parties will be notified and given the opportunity to attend • Requirement 26 "Stone artefact deposition and storage" in the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW must be complied with		
A5	Aboriginal cultural heritage	An Aboriginal Heritage Management Plan(AHMP) will be prepared and implemented as part of the CEMP The AHMP will provide specific guidance on measures and controls to be undertaken to avoid and mitigate impacts on Aboriginal cultural heritage during construction. This should include protection measures to be applied during construction, including but not limited to the recommendations set out in this table, as well as contractor training in general Aboriginal cultural heritage awareness and management of Aboriginal heritage values	Construction contractor	Pre-construction and construction
A6	Aboriginal cultural heritage	The non-impacted portion of partially impacted sites (outside of construction footprint and AHIP boundary) will be marked on the CEMP prior to construction activities to ensure these parts of the sites are avoided and not impacted by the	Construction contractor	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		proposal. The site areas will be marked as environmentally sensitive “no-go zones” Temporary fencing will be installed around the edge of the non-impacted archaeological site areas and AHIP boundary during construction to provide a physical barrier against accidental access or impact Workers will be inducted as to appropriate Aboriginal heritage protection measures		
A7	Aboriginal cultural heritage	An Aboriginal cultural heritage awareness training package will be delivered as part of the site induction for all contractor(s) and maintenance personnel involved in the construction works The training package will be developed by a cultural heritage specialist in consultation with the RAPs and Aboriginal cultural knowledge holders. The training package will at a minimum ensure awareness of the cultural significance of the construction footprint, the requirements of the AHMP and relevant statutory responsibilities, and the identification of unexpected heritage items and appropriate management procedures	Construction contractor	Pre-construction and construction
A8	Aboriginal cultural heritage	A cultural heritage specialist will be engaged to develop interpretative materials on the cultural values and historical records relating to Site A: Sandy Creek Cultural Resource Area; Site B Skellatar Hill Line of Sight; and Site C Pathway cultural sites and the cultural landscape they sit within The form of the interpretative materials will be determined in consultation with the Aboriginal cultural knowledge holders and registered Aboriginal persons (RAPs) following investigation of options with Muswellbrook Shire Council. Options to be considered include interpretative signage, an educational booklet, and input into (aesthetic) design elements to reflect the Aboriginal cultural values of the area	Transport	Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
A9	Aboriginal cultural heritage	The proposed bridge to be constructed near Site A: Sandy Creek Resource Area will be named in recognition of the Aboriginal cultural values and history of the region A range of potential names with supporting explanations will be developed by a cultural heritage specialist in consultation with the Aboriginal cultural knowledge holders and RAPs, with the options to be presented to the Aboriginal cultural knowledge holders and RAPs for their review and nomination of a preferred option to Transport	Transport	Pre-construction
A10	Aboriginal cultural heritage	The AHMP will include an *Unexpected Heritage Items Procedure* (Roads and Maritime 2015) requiring notification of the identified knowledge holders within 48 hours of any discovery of potential archaeological Aboriginal skeletal remains during the proposed works	Transport	As required
A11	Aboriginal cultural heritage	If there is a confirmed discovery of archaeological Aboriginal human remains, consultation will occur with the RAPS and Aboriginal cultural knowledge holders in relation to: the development of a Management Plan for proposed works in the relevant area; cultural ceremonies in relation to the human remains and the site of their occurrence; and repatriation of the human remains	Transport	As required
	Non-Aboriginal Heritage			
H1	Non-Aboriginal Heritage	A Non-Aboriginal Heritage Management Plan (NAHMP) will be prepared and implemented as part of the CEMP. The NAHMP will provide specific guidance on measures and controls to be implemented to avoid and mitigate impacts to Non-Aboriginal heritage	Construction contractor	Pre-construction
H2	Non-Aboriginal heritage	The *Standard Management Procedure - Unexpected Heritage Items* (Transport for NSW, 2015) will be followed in the event that any unexpected heritage items, archaeological remains or potential relics of Non-Aboriginal origin are	Construction contractor	During construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		encountered. Work will only re-commence once the requirements of that Procedure have been satisfied		
H3	Non-Aboriginal heritage	Two buffer zones will be set up around the old coal rail spur bridge over Muscle Creek and its associated elements, including: • a 25 metre radius exclusion zone that is made known to all workers operating near the site • a 50 metre radius limited works area All those operating within the area will be made aware of the existence of the heritage items and that they are not to be disturbed An archival recording of the former bridge, to be carried out on the bridge prior to the commencement of works, will be considered in consultation with the landowner, MCC. This recording will record, in detail, the bridge and all fabric associated with it. This recording will also be used as a baseline assessment that will allow for a comparison of the bridge and specific elements before and after construction works Vibration monitoring will be undertaken within close proximity of the bridge. This is to record any actual vibration that is encountered in the vicinity of the bridge from construction. This monitoring will be done in conjunction with a visual inspection of the bridge to assess any potential vibration impacts. This monitoring will be added to the CEMP for the proposal.	Construction contractor	During construction
	Air Quality			
AQ1	Air Quality	An Air Quality Management Plan (AQMP)will be prepared and implemented as part of the CEMP. The AQMP will identify: • Potential sources of air pollution (such as dust, vehicles transporting waste, plant and equipment) during construction	Construction contractor	During construction

No.	Impact	Environmental safeguards	Responsibility	Timing

		• Air quality management objectives consistent with relevant published EPA and/or DPIE guidelines including:
		   o No Dust, No Fuss – Guidelines for controlling dust from construction sites. NSW EPA
		   o Best Practice Erosion and Sediment Control. IECA, November 2008
		   o The "Blue Book" - Managing Urban Stormwater: Soils and Construction, Landcom (2004) 4th Ed.
		• Mitigation and suppression measures to be implemented, such as spraying or covering exposed surfaces, provision of vehicle clean down areas, covering of loads, road cleaning, use of dust screens, maintenance of plant in accordance with manufacturer's instructions
		• Methods to manage works during strong winds or other adverse weather conditions
		• A progressive rehabilitation strategy for exposed surfaces
		• When the air quality, suppression and management measures need to be applied, who is responsible, and how the effectiveness of measures will be assessed
		• Community notification and complaint handling procedures		

AQ2	Air Quality	As part of the AQMP, a monitoring program will be developed to monitor construction dust from the proposal. The monitoring plan will be implemented prior to construction and during the construction period, to assess effective implementation of air quality safeguards, identify any unexpected or inadvertent impacts, and identify recommended revisions or improvements	Construction contractor	During construction
	Landscape and visual			
LV1	Landscape and visual	Visual impact mitigation at Muscle Creek Road will include: • Tree planting along the proposed relocated driveway which will assist in reducing the visual impact of the proposal on receptors by partially screening	Construction contractor	Detailed design

No.	Impact	Environmental safeguards	Responsibility	Timing
		the view to the bypass from these locations. Semi mature trees and shrubs will provide immediate screening post construction • Scattered tree or shrub planting to the batters of the proposed bypass road, particularly between Muscle Creek Road and Muscle Creek, which will visually 'break up' the flat expanse of the batter planted with pasture grasses		
LV2	Landscape and visual	The landscape treatment south from the northern connection along the New England Highway will include rows of ornamental trees to assist in screening the changes within the view and increase visual amenity. Ornamental trees provide a 'gateway' landscape treatment to the township of Muswellbrook The landscape treatment to the central connection (at Coal Road) will be more visually recessive, with scattered tree and shrub planting to match the length of the bypass and suggest a more local entry point to the township, rather than the 'gateway' statement at the northern and southern connections	Construction contractor	Detailed design
LV3	Landscape and visual	All plant material will be locally sourced (seed collection preferred), with any seed collection to commence within three months of construction contract award, where possible	Construction contractor	Detailed design
LV4	Landscape and visual	An Urban Design Plan will be prepared as part of the CEMP. The Plan will include: • Location and identification of vegetation in the proposal area to be retained and proposed landscaped areas • Details of the staging of built elements including bridges and concrete barriers • Details of the staging of landscape works • Maintenance measures for landscaped or rehabilitated areas, including timing of maintenance works • A landscape monitoring program including an inspection program and frequency of inspection	Construction contractor	Detailed design and Pre-construction

No.	Impact	Environmental safeguards	Responsibility	Timing
	Property and land use			
P1	Property acquisition	All property acquisition will be carried out in accordance with the *Land Acquisition Information Guide* (Transport for NSW, 2012) and the *Land Acquisition (Just Terms Compensation) Act 1991*	Transport	Detailed design
P2	Property acquisition	Transport will complete property adjustments to areas impacted by the proposal, including to fencing and driveways/access in consultation with affected property owners	Transport	Detailed design
P3	Property acquisition	Transport will investigate the possibility of licencing land beneath the bridge to be situated over Sandy Creek to impacted landowners to enable continued access for fragmented properties	Transport	Detailed design
	Socio-economic			
SE1	Community information	A Communication Plan (CP) will be prepared and implemented as part of the CEMP to ensure provision of timely and accurate information to the community during construction. The CP will include (as a minimum): • Mechanisms to provide details and timing of proposed activities to affected residents, including changed traffic and access conditions • Contact name and number for complaints • How the proposal webpage will be maintained for the duration of the proposal. • Minimum consultation activities to be carried out • A complaints handling procedure	Construction contractor	Pre-construction and construction
SE2	Business impacts	Transport will develop a signage strategy for the entrances to Muswellbrook, in consultation with Muswellbrook Shire Council to encourage motorists to visit Muswellbrook. This will include signage showing: • The travel distances and estimated times for travelling routes via the bypass compared to travelling via the Muswellbrook town centre	Transport	Detailed design and operation

No.	Impact	Environmental safeguards	Responsibility	Timing
		• Services and facilities available within the Muswellbrook township • Visitor attractions within the Muswellbrook township		
SE3	Business impacts	Transport will engage with Muswellbrook Shire Council and local businesses regarding the progress of the proposal to allow businesses time to prepare for changed traffic conditions through the town	Transport	Detailed design and construction
SE4	Employment	Construction workers will be sourced from the local area where feasible	Construction contractor	Construction
SE5	Business impacts	Access to businesses will be maintained throughout the proposal	Construction contractor	Construction
	Waste and material management			
M1	Resource use	Use of recycled-content materials will be considered during the detailed design	Transport	Detailed design
M2	Construction waste	A Waste Management Plan (WMP) will be prepared and implemented as part of the CEMP. The WMP will provide specific guidance on measures and controls to be implemented to support minimising the amount of waste produced and appropriate handling and disposal of unavoidable waste. The WMP will include, but will not necessarily be limited to: • Measures to avoid and minimise waste associated with the proposal • Classification of wastes generated by the proposal and management options (re-use, recycle, stockpile, disposal) • Classification of wastes received from off-site for use in the proposal and management options • Any statutory approvals required for managing both on and off-site waste, or application of any relevant resource recovery exemptions • Procedures for storage, transport and disposal	Construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		• Monitoring, record keeping and reporting, including any documentation management obligations arising from resource recovery exemptions The WMP will be prepared taking into account the Transport *Environmental Procedure – Management of Wastes on Roads and Maritime Services Land* and relevant Transport Waste Fact Sheets		
M3	Construction waste	The following resource management hierarchy principles will be followed: • Avoid unnecessary resource consumption as a priority • Avoidance will be followed by resource recovery (including reuse of materials, reprocessing, and recycling and energy recovery) • Disposal will be a last report (in accordance with the Waste Avoidance and Resource Recovery Act 2001)	Construction contractor	Pre-construction and construction
M4	Contamination	The CEMP will include an unexpected finds protocol for potentially contaminated material encountered during construction work	Construction contractor	Construction
M5	Contamination	An Asbestos Management Plan will be developed and implemented to manage asbestos and asbestos containing material if encountered during the construction. The plan will include: • Identification of potential asbestos on site • Procedures to manage and handle any asbestos • Mitigation measures if asbestos is encountered during construction • Procedures for disposal of asbestos in accordance with the NSW EPA guidelines, Australian Standards and relevant industry codes of practice	Construction contractor	Construction
	Climate change			
CC1	Climate change	Construction equipment, plant and vehicles will be appropriately sized for the task, serviced frequently and will not be left idling when not in use	Construction contractor	Construction

No.	Impact	Environmental safeguards	Responsibility	Timing
CC2	Climate change	Opportunities to use low emission construction materials, such as recycled aggregates in road pavement and surfacing, and cement replacement materials will be investigated and incorporated where feasible and cost-effective	Construction contractor	Construction
CC3	Climate change	Construction site layouts will be designed to reduce travel distances and double handling of materials to reduce fuel usage and emission generation	Construction contractor	Construction
CC4	Climate change	Raw materials will be managed to reduce energy requirements for their processing. For example, stockpiled materials will be covered or provided undercover storage where possible to reduce moisture content of materials, and therefore the processing and handling requirements	Construction contractor	Construction
CC5	Climate change	Locally produced goods and services will be procured where feasible and cost effective to reduce transport fuel emissions	Construction contractor	Construction
CC6	Climate change	Materials with lower emissions intensity will be specified in the selection of maintenance materials	Transport	Operation
CC7	Climate change	The most energy efficient street lighting will be specified appropriate for proposal needs will be specified.	Transport	Operation
	Hazard and risk			
R1	Hazard and risk	Emergency response plans will be incorporated into the CEMP	Construction contractor	Pre-construction and construction
R2	Hazard and risk	A Hazard and Risk Management Plan will be prepared and implemented as part of the CEMP. The Plan will identify: • Hazards and risks associated with the activity • Measures to be implemented during construction to minimise these risks	Construction contractor	Pre-construction and construction

No.	Impact	Environmental safeguards	Responsibility	Timing
		• Record keeping arrangements, including information on the materials present on the site, material safety data sheets, and personnel trained and authorised to use such materials • A monitoring program to assess performance in managing the identified risks, including equipment checking and maintenance requirements • Contingency measures to be implemented in the event of unexpected hazards or risks arising, including emergency situations		
R3	Bushfires	A Bushfire Management Plan will be prepared and included as part of the CEMP. The Plan will identify: • Asset protection zone locations and management details • Landscaping requirements including indicative design layout and vegetation density thresholds • Access provisions such as locations, passing bays and alternate emergency access • Water supplies and bush fire suppression systems • Details regarding the Bush Fire Emergency Management and Evacuation Plan and any other essential bush fire safety requirements	Construction contractor	Pre-construction and construction
R4	Bushfires	Construction activities involving flammable materials and ignition sources (for example, welding) will be proactively managed to ensure that the potential for fire is effectively minimised. High risk construction activities, such as welding and metal work, will be subject to a risk assessment on total fire ban days and restricted or ceased as appropriate. Construction personnel will be inducted into the requirement to safely dispose of cigarette butts	Construction contractor	Construction

Table 7-2: Mitigation measures for impacted Aboriginal archaeological sites

Site name	AHIMS number	Assessed significance	Management and mitigation
Muswellbrook Bypass AFT 1	37-2-5952	Moderate	• Community collection • Archaeological salvage excavation • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 2	37-2-5953	Low	• Community collection • Archaeological mitigation not required • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 3	37-2-5954	Low	• Community collection • Archaeological mitigation not required • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 4	37-2-5955	Low	• Community collection • Archaeological mitigation not required • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 5	37-2-5957	Low	• Community collection • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 6	37-2-5956	Moderate	• Community collection • Archaeological mitigation not required (marginal impact to low-value portion of site) • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 8 (includes NH 1, NH 2 & NH 3)	37-2-5959 (includes 37-2-1454, 37-2-1455 & 37-2-1456)	Moderate	• Community collection • Archaeological mitigation not required (marginal impact to low-value portion of site) • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass AFT 9	37-2-5960	Moderate	• Community collection • Archaeological salvage excavation • AHIP required prior to commencement of works affecting the site

Site name	AHIMS number	Assessed significance	Management and mitigation
Muswellbrook Bypass AFT 10 (includes DMC 1, DMC 2 & DMC 3)	37-2-5961 (includes 37-2-2631, 37-2-2632 and 37-2-2633)	Low	• Community collection • Archaeological mitigation not required • AHIP required prior to commencement of works affecting the site
Muswellbrook Bypass IF 1	37-2-5962	Low	• Community collection • Archaeological mitigation not required • AHIP required prior to commencement of works affecting the site
Muscle Creek	37-2-0139	Moderate	• Community collection • Archaeological mitigation not required (marginal impact to low-value portion of site) • AHIP required prior to commencement of works affecting the site

7.3 Licensing and approvals

Table 7-3: Summary of licensing and approvals

Instrument	Requirement	Timing
Protection of the Environment Operations Act 1997 (s43)	Environment protection licence (EPL) for scheduled activities from the EPA	Prior to start of the relevant activity
Fisheries Management Act 1994 (s199)	Notification to the Minister prior to any reclamation works	A minimum of 28 days prior to the start of work
National Parks and Wildlife Act 1974 (s90)	An AHIP from the Chief Executive of EES for the disturbance of the Aboriginal sites that would be impacted by the proposal	Prior to start of the relevant activity
Coal Mine Subsidence Compensation Act 2017	Approval to alter or erect improvements within a mine subsidence district from the Chief Executive of Subsidence Advisory, pursuant to Clause 21 of the CMSC Act	Prior to start of the relevant activity

8. Conclusion

This chapter provides the justification for the proposal taking into account its biophysical, social and economic impacts, the suitability of the site and whether or not the proposal is in the public interest. The proposal is also considered in the context of the objectives of the EP&A Act, including the principles of ESD as defined in Schedule 2 of the Environmental Planning and Assessment Regulation 2000.

8.1 Justification

The New England Highway is recognised for its strategic importance to national and regional economic growth, development and connectivity. The strategic need for the proposal stems from the importance of the New England Highway in providing safe and efficient access as a major freight and commuter route for the Upper and Lower Hunter. The proposal is considered consistent with a number of relevant strategic planning and policy frameworks, as listed in Section 2.1.

The proposal meets the objectives identified in Section 2.3.1 as it would:

- Reduce traffic volumes along the existing New England Highway through Muswellbook
- Improve average travel times on the New England Highway
- Improve road safety along the existing New England Highway through Muswellbrook
- Support growth in the Hunter region through improved freight movements.

The REF has assessed the potential biophysical, social and economic impacts of the proposal. The proposal would result in some adverse environmental impacts to biodiversity, Aboriginal cultural heritage and visual amenity along with air quality (dust) and noise impacts. However, these have been avoided or minimised through design where possible and site-specific safeguards have been provided in Section 7 to further reduce these impacts.

Overall, the proposal is justified on the basis that the adverse impacts of the proposal would be outweighed by the long-term beneficial impacts of improved traffic flow, reduced congestion and improved safety for roads users and residents within Muswellbrook.

8.1.1 Social factors

Potential social impacts as a result of the proposal include acquisition of one property and partial acquisition of 19 properties, temporary disruptions to private property access, amenity impacts including noise and air emissions, landscape and visual changes and a reduction in passing trade for businesses within the town centre of Muswellbrook. A Socio-economic Impact Assessment was conducted for the proposal as discussed in Section 6.12.

Long-term benefits of the proposal include maintaining the New England Highway as an important freight and commuter route and improving travel reliability through Muswellbrook. The proposal would also provide better access to the town centre by providing a heavy vehicle bypass, thus removing freight traffic through the town centre. This would reduce travel times and improve road safety and efficiency for through and local traffic in Muswellbrook. The amenity of the town centre would also be improved providing opportunity for town centre revitalisation and growth.

The proposal has been designed to reduce social impacts on the community as far as possible, and the remaining impacts would be managed by the safeguards identified in Section 7.

8.1.2 Biophysical factors

Potential impacts to a range of biophysical factors have been assessed in Section 6 and mitigation measures proposed to manage identified residual impacts.

The key impact on biodiversity associated with the proposal is the direct removal of up to 97.92 hectares of native vegetation and associated habitats. This would result in a reduction of habitat for a range of birds and mammals, including threatened species, and loss of fauna habitat connectivity. An aerial fauna crossing over the New England Highway would be provided to help reduce potential impacts.

Assessments of significance have been conducted for threatened species, populations or ecological communities which have been positively identified within or surrounding the proposal area or that are considered to have a moderate or high likelihood of using habitat which would be affected by the proposal.

The overall outcome of the assessments of significance indicates that the impacts to threatened biodiversity are unlikely to be significant under the BC Act or EPBC Act. Transport would consider biodiversity offsets, or where offsets are not reasonable or feasible, supplementary measures for impacts that exceed the thresholds in the 'Guideline for Biodiversity Offsets' (Roads and Maritime Services, 2016).

8.1.3 Economic factors

The proposal has been designed to be low maintenance and economically viable.

The proposal would improve transport connections, reduce commuting times and lower vehicle operating costs between employment and tourist destinations. This section of the New England Highway is a major transport artery for freight travelling between the Port of Newcastle and the Hunter Valley and has supported the substantial growth in transportation for coal and agricultural industries and employment in NSW.

8.1.4 Public interest

The proposal is considered to be in the public interest as it would improve road safety, traffic efficiency and access through the Hunter Valley and the town centre of Muswellbrook, while also improving amenity such as air and noise emissions within the township. Whilst the community would experience some negative impacts as a result of the proposal, most would be temporary and would be minimised with the safeguards provided in Section 7.

The diversion of traffic, in particular heavy vehicles, to the bypass would reduce the volume of traffic through Muswellbrook and this in turn is expected to reduce the number of crashes and the existing conflict between pedestrians and vehicles.

8.2 Objects of the EP&A Act

Object	Comment
1.3(a) To promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources.	The proposal would provide better access through the town centre of Muswellbrook and would reduce travel times and improve road safety and efficiency for through and local traffic. The proposal would, where feasible, limit its use of natural and artificial resources and would source materials and product locally where possible. Socio-economic impacts are assessed in Section 6.12. The assessment includes

Object	Comment
	management measures to avoid and/or minimise impacts.
1.3(b) To facilitate ecologically sustainable development by integrating relevant economic, environmental and social considerations in decision-making about environmental planning and assessment.	The proposal has considered relevant economic, environmental and social considerations. ESD is considered in Section 8.2.1 below. Potential impacts have been minimised through design and would be further mitigated using the mitigation measures in Section 7.
1.3(c) To promote the orderly and economic use and development of land.	The proposal is needed to improve safety on the New England Highway and in Muswellbrook. The proposal would provide for future growth and development in Muswellbrook due to reduced traffic volumes and improved movement of heavy freight vehicles. Potential impacts to the development of land have been minimised through design and are discussed in Section 6.11.
1.3(d) To promote the delivery and maintenance of affordable housing.	Not relevant to the proposal.
1.3(e) To protect the environment, including the conservation of threatened and other species of native animals and plants, ecological communities and their habitats.	The proposal would result in a loss of around 97.92 hectares of native vegetation and associated habitats. Assessments of significance have been conducted for the proposal and indicate that impacts to threatened biodiversity are unlikely to be significant under the BC Act or EPBC Act. Nonetheless, Transport's 'Guideline for Biodiversity Offsets' has been applied to the proposal. Impacts to biodiversity are discussed in Section 6.1.
1.3(f) To promote the sustainable management of built and cultural heritage (including Aboriginal cultural heritage).	The proposal would result in potential impacts to Aboriginal cultural heritage. After test excavations, the proposal area was refined to reduce the impact/harm to Aboriginal sites and has enabled avoidance of impact to a substantial amount of higher value archaeological deposit, representing an improved heritage outcome. The management of Aboriginal heritage and non-Aboriginal heritage is considered in Section 6.7 and Section 6.8 respectively.
1.3(g) To promote good design and amenity of the built environment.	The proposal would promote good design and amenity of the built environment. As noted in Section 3.2.1, the proposal would be constructed in accordance with current road and bridge standards. Other design features of the proposal are discussed in Section 3.2.4, including urban and landscape design objectives.

Object	Comment
1.3(h) To promote the proper construction and maintenance of buildings, including the protection of the health and safety of their occupants.	Not relevant to the proposal.
1.3(i) To promote the sharing of the responsibility for environmental planning and assessment between the different levels of government in the State.	Not relevant to the proposal.
1.3(j) To provide increased opportunity for community participation in environmental planning and assessment.	Transport has carried out consultation with the community and relevant key stakeholders during the development of the proposal. Details of this consultation can be found in Section 5.

8.2.1 Ecologically sustainable development

ESD is development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. The principles of ESD have been an integral consideration throughout the development of the proposal.

ESD requires the effective integration of economic and environmental considerations in decision-making processes. The four main principles supporting the achievement of ESD are discussed below.

The precautionary principle

The precautionary principle deals with reconciling scientific uncertainty about environmental impacts with certainty in decision-making. It provides that where there is a threat of serious or irreversible environmental damage, the absence of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation.

This principle was considered during route options development (refer to Section 2). The precautionary principle has guided the assessment of environmental impacts for this REF and the development of mitigation measures.

The precautionary principle was applied to the proposal in the following ways:

- Best available technical information, environmental standards and measures have been used to minimise environmental risks
- Preferred route alignment that minimises vegetation clearance, with particular consideration of sensitive areas (i.e. Striped Legless Lizard habitat), was selected
- Preferred route alignment to avoid or minimise potential damage to known items or areas of cultural significance was selected
- Conservative 'worst case' scenarios were considered while assessing environmental impact
- Specialist studies were incorporated to gain a detailed understanding of the existing environment.

Intergenerational equity

Social equity is concerned with the distribution of economic, social and environmental costs and benefits. Inter-generational equity introduces a temporal element with a focus on minimising the distribution of costs to future generations.

Intergenerational equity was applied to the proposal in the following ways:

- A preferred route alignment that minimises vegetation clearance within sensitive ecological areas to ensure that such areas are conserved for future generations was selected
- Water quality, fauna connectivity and hydrological measures were included into the design to ensure that impacts on the distribution of flora, fauna and ecological communities within sensitive ecological areas are minimised both for the short and long term
- Biodiversity offsets for unavoidable residual impacts as a result of the proposal have been identified
- An Aboriginal cultural heritage assessment, including consultation with the local Aboriginal community, was carried out as part of the route selection process and during the environmental assessment phase to avoid or minimise the potential for irreparable damage to occur to Aboriginal cultural heritage and cultural values during the construction
- Benefits that the proposal provides to current and future generations of local communities and the surrounding region that would maintain or enhance the health, diversity and productivity of the environment were identified.

Conservation of biological diversity and ecological integrity

Conservation of biological diversity and ecological integrity was applied to the proposal in the following ways:

- The biodiversity assessment considered connectivity and key corridors for species likely to occur within and surrounding the proposal
- Design features that would allow safe movement patterns for native fauna species were incorporated (i.e. aerial fauna crossing over the New England Highway)
- Site selection criteria were established for construction phase facilities that include minimising native vegetation clearance
- Biodiversity offsets for unavoidable residual impacts as a result of the proposal have been identified.

Improved valuation, pricing and incentive mechanisms

The principle of internalising environmental costs into decision making requires consideration of all environmental resources which may be affected by the carrying out of a project, including air, water, land and living things.

Improved valuation, pricing and incentive mechanisms was applied to the proposal in the following ways:

- Environmental issues were considered as key matters in the route selection process
- Impacts to properties and the subsequent potential economic impacts on affected property owners was considered
- Value of the proposal to the community in terms of improved safety was recognised
- Mitigation measures for the avoidance, reuse, recycling and management of waste during construction and operation would be implemented.

8.3 Conclusion

The proposed New England Highway bypass of Muswellbrook, NSW, is subject to assessment under Division 5.1 of the EP&A Act. The REF has examined and taken into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposed activity.

This has included consideration (where relevant) of conservation agreements and plans of management under the NPW Act, biodiversity stewardship sites under the BC Act, wilderness areas, areas of outstanding value, impacts on threatened species and ecological communities and their habitats and other protected fauna and native plants. It has also considered potential impacts to matters of national environmental significance listed under the Federal EPBC Act.

A number of potential environmental impacts from the proposal have been avoided or reduced during the concept design development and options assessment. The proposal as described in the REF best meets the proposal objectives but would still result in some impacts on:

- Traffic and transport
- Noise and air emissions
- Biodiversity
- Flooding
- Surface water and groundwater
- Landscape and visual amenity
- Aboriginal heritage
- Property and land use
- Community (socio-economic).

Safeguards and management measures as detailed in this REF would ameliorate or minimise these expected impacts. The proposal would also result in long-term beneficial impacts including improved road safety, improved freight efficiency and access through the Hunter Valley and the town centre of Muswellbrook. It would also improve amenity within Muswellbrook. On balance the proposal is considered justified and the following conclusions are made.

8.3.1 Significance of impact under NSW legislation

The proposal would be unlikely to cause a significant impact on the environment. Therefore, it is not necessary for an environmental impact statement to be prepared and approval to be sought from the Minister for Planning and Public Spaces under Division 5.2 of the EP&A Act. A Biodiversity Development Assessment Report or Species Impact Statement is not required. The proposal is subject to assessment under Division 5.1 of the EP&A Act. Consent from Council is not required.

8.3.2 Significance of impact under Australian legislation

The proposal is not likely to have a significant impact on matters of national environmental significance or the environment of Commonwealth land within the meaning of the *EPBC Act 1999*. A referral to the Australian Department of Agriculture, Water and the Environment is not required.

9. Certification

This review of environmental factors provides a true and fair review of the proposal in relation to its potential effects on the environment. It addresses to the fullest extent possible all matters affecting or likely to affect the environment as a result of the proposal.

Catherine Brady

Technical Director, Environment

AECOM

Date: 14 September 2021

I have examined this review of environmental factors and accept it on behalf of Transport for NSW.

Hannah Gilbert

Project Development Manager

Date:

10. References

AECOM 2020, Geotechnical Investigation Proposal Plan.

Australian and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000, Guidelines for Fresh and Marine Water Quality'.

Austroads 2004, Technical Basis of Austroads pavement Design Guide

Bureau of Meteorology, 2020, Bureau of Meteorology - Groundwater Dependent Ecosystems Atlas. Available at: http://www.bom.gov.au/water/groundwater/gde/

Bureau of Meteorology, 2021, Climate statistics Scone Airport AWS, Available at: http://www.bom.gov.au/climate/averages/tables/cw_061363.shtml

Bureau of Meteorology, Groundwater Dependent Ecosystems Atlas Available at: http://www.bom.gov.au/water/groundwater/gde/map.shtml

CSIRO, 2020, Australian Soil Resource Information System, Available at: https://www.asris.csiro.au/#

DECC 2008, Managing Urban Stormwater-Volume 2D Main Road Construction, NSW Department of Environment, Climate Change and Water (known as the Blue Book Volume 2), New South Wales.

Department for Planning Industry and Environment 2020. Surveying threatening plants and their habitats - NSW survey guide for the Biodiversity Assessment Method. Parramatta.

Department of Agriculture Water and the Environment 2020. Register of Critical Habitat [Online]. Available: https://www.environment.gov.au/cgi-bin/sprat/public/publicregisterofcriticalhabitat.pl [Accessed 2020].

Department of Environment and Climate Change. 2008. Managing Urban Stormwater: soils and construction, Vol 2D: main road construction. South Sydney: Department of Environment and Climate Change NSW.

Department of Environment and Conservation. 2004. Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft). Hurstville: Department of Environment and Conservation.

Department of Environment and Energy. 2020. Protected Matters Search Tool. Available at: https://www.environment.gov.au/epbc/protected-matters-search-tool.

Department of Planning and Environment. 2018. State Environmental Planning Policy (Coastal Management) 2018 - maps spatial viewer. Available at: http://webmap.environment.nsw.gov.au/PlanningHtml5Viewer/?viewer=SEPP_CoastalManagement.

Department of Planning and Infrastructure. 2012, Upper Hunter Strategic Regional Land Use Plan, NSW Government.

Department of primary industries. 2013. Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (2013 update). Wollongbar: NSW Department of Primary Industries.

Department of primary industries, 2019. Key Fish Habitat - Muswellbrook.

Department of Primary Industries. 2020a. Fisheries NSW Spatial Data Portal [Online]. Available: https://webmap.industry.nsw.gov.au/Html5Viewer/index.html?viewer=Fisheries_Data_Portal

Department of Primary Industries. 2020b. Register of critical habitat. Available: https://www.dpi.nsw.gov.au/fishing/species-protection/conservation/what/register

Dwp suters. Muswellbrook Town Centre Strategy, Muswellbrook Shire Council. Available at:

Environment Energy and Science Group. 2020a. Areas of Outstanding Biodiversity Value register. Available: https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/areas-of-outstanding-biodiversity-value/area-of-outstanding-biodiversity-value-register

Environment Energy and Science Group. 2020b. BioNet Atlas of NSW Wildlife. Available at: http://www.bionet.nsw.gov.au/

Environment Protection Authority 2014, Waste Classification Guidelines, NSW Government

Environment Protection Authority 2017, Noise Policy for Industry, NSW Government. Available at: https://www.epa.nsw.gov.au/your-environment/noise/industrial-noise/noise-policy-for-industry-(2017)

Hunter Development Corporation 2013, Hunter Economic Infrastructure Plan, NSW Government

Infrastructure Australia 2016, Australian Infrastructure Plan, Commonwealth of Australia

Infrastructure NSW 2018, State Infrastructure Strategy 2018 – 2038: Building Momentum, NSW Government

Institute of Air Quality Management, 2014. Guidance on the assessment of dust from demolition and construction. Available at:
http://iaqm.co.uk/wp-content/uploads/guidance/iaqm_guidance_report_draft1.4pdf

Landcom 2004, Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition (known as the Blue Book Volume 1).

Muswellbrook Shire Council 2017. Delivery Program 2017-2021, Muswellbrook Shire Council

Muswellbrook Shire Council 2017. Muswellbrook Shire Council Community Strategic Plan 2017-2027, Muswellbrook Shire Council.

Muswellbrook Shire Council, 2015, Muswellbrook Land Use Development Strategy.

Nicholson et al 2012. Salinity hazard report for Catchment Action Plan upgrade – Hunter-Central Rivers CMA, NSW Department of Primary Industries / NSW Office of Environment and Heritage – Department of Premier and Cabinet, Parramatta

NSW Department of Environment and Climate Change, 2009, Interim Construction Noise Guideline. Available at: https://www.environment.nsw.gov.au/resources/noise/09265cng.pdf

NSW EPA, 2016, Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Available at: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/air/approved-methods-for-modelling-and-assessment-of-air-pollutants-in-nsw-160666.pdf

NSW Government (2020). Major Projects – Bayswater Power Station Upgrade. Available at: https://www.planningportal.nsw.gov.au/major-projects/project/9791

NSW Government (2020). Major Projects – Bowmans Creek Wind Farm. Available at: https://www.planningportal.nsw.gov.au/major-projects/project/11691

NSW Government (2020). Major Projects – Maxwell Solar Farm. Available at: https://www.planningportal.nsw.gov.au/major-projects/project/9626

NSW Government (2020). Major Projects – Mount Pleasant Optimisation Project. Available at: https://www.planningportal.nsw.gov.au/major-projects/project/26611

NSW Government (2020). Major Projects – Muswellbrook Landfill. Available at: https://www.planningportal.nsw.gov.au/major-projects/project/10901

NSW Government 2018, Future Transport Strategy 2056, NSW Government

NSW Government Department Planning and Environment (2016). Hunter Regional Plan 2036, NSW Government, Available at: https://www.planning.nsw.gov.au/Plans-for-your-area/Regional-Plans/Hunter/Hunter-regional-plan

NSW Government, 2018, Regional NSW Services and Infrastructure Plan, NSW Government

NSW Government, 2021. Muswellbrook Local Environmental Plan 2009. Available at: https://www.legislation.nsw.gov.au/view/whole/html/inforce/current/epi-2009-0129

NSW Rural Fire Service 2015, Guide for Bush Fire Prone Land Mapping – Version 5b, NSW Government Available at: https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0011/4412/Guideline-for-Councils-to-Bushfire-Prone-Area-Land-Mapping.pdf

NSW Rural Fire Service 2019, Planning for Bush Fire Protection – A guide for councils, planners, fire authorities and developers. NSW Government. Available at: https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0005/174272/Planning-for-Bush-Fire-Protection-2019.pdf

OEH, 2011a. Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW. Office of Environment and Heritage, Department of Premier and Cabinet, Sydney.

OEH, 2011b. Applying for an Aboriginal Heritage Impact Permit: Guide for Applicants. Office of Environment and Heritage, Department of Premier and Cabinet, Sydney.

Office of Environment & Heritage 2016. NSW Guide to Surveying Threatened Plants. Sydney: Office of Environment and Heritage.

Office of Environment and Heritage (OEH), 2010. Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales: Part 6 National Parks and Wildlife Act 1974. Department of Environment, Climate Change and Water NSW, Sydney.

Office of Environment and Heritage, 2014. Hunter Climate Change snapshot, Available at: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Hunter-Climate-Change-Downloads

Rasmus P.L et al. 1969, Singleton 1:25 000 Geological Sheet SI/56-01, 1st edition.

Roads and Maritime 2015, Guideline for Batter Stabilisation using Vegetation.

Roads and Maritime 2016. Guideline for Biodiversity Offsets, Roads and Maritime Services.

Roads and Maritime 2018, Model Validation Guideline.

Roads and Maritime Services (now Transport for NSW), July 2015. Unexpected Heritage Items: Heritage Procedure 02. TfNSW, North Sydney.

Roads and Maritime Services (now Transport for NSW), November 2011. Procedure for Aboriginal cultural heritage consultation and investigation.

Roads and Maritime Services 2016. Guideline for Biodiversity Offsets. Roads and Maritime Services.

Roads and Maritime Services 2018. New England Highway Muswellbrook Bypass Options Report. Available at: https://www.rms.nsw.gov.au/projects/01documents/new-england-highway/muswellbrook-bypass/muswellbrook-bypass-options-report-july-2018.pdf

Roads and Maritime Services 2019. New England Highway – Muswellbrook bypass Project update 2019. Available at: https://www.rms.nsw.gov.au/projects/01documents/new-england-highway/muswellbrook-bypass/muswellbrook-bypass-project-update-feb-2019.pdf

Roads and Traffic Authority 1997, Water Policy, Roads and Traffic Authority.

Roads and Traffic Authority 2003, Procedures for Selecting Treatment Strategies to Control Road Runoff, RTA, Sydney.

Roads and Traffic Authority 2011, Stockpile Site Management Guideline, RTA, Sydney.

Roads and Traffic Authority 2011. Biodiversity Guidelines - Protecting and managing biodiversity on RTA projects. Sydney: RTA.

Royal Botanic Gardens. 2020. Plantnet - The Plant Information Network System of Botanic Gardens Trust Version 2.0. National Herbarium of NSW, Royal Botanic Garden, Sydney, Australia. Available: http://plantnet.rbgsyd.nsw.gov.au/

RTA 2011, Technical Guideline – Environmental Management of Construction Site Dewatering, Roads and Maritime Services, Technical guideline EMS-TG-011 published by Roads and Traffic Authority dated April 2011

Summerhayes G., 1983, Muswellbrook 1:25 000 Geological Map, 9033-II-N, Geological Survey of New South Wales, Sydney

Transport for NSW (2019). Freight Hub, NSW Government, Available at: https://www.transport.nsw.gov.au/operations/freight-hub

Transport for NSW 2018, NSW Freight and Ports Plan 2018 – 2023, NSW Government

Transport for NSW 2018, Road Safety Plan 2021, NSW Government.

Transport for NSW, 2016. Construction Noise and Vibration Guideline. NSW Government, Available at: https://roads-waterways.transport.nsw.gov.au/business-industry/partners-suppliers/documents/guides-manuals/construction-noise-and-vibration-guideline.pdf

Transport for NSW., 2016, New England Highway Draft Corridor Strategy, NSW Government

WaterNSW n.d., Local hydrogeological database, https://realtimedata.waternsw.com.au

Waters Consultancy Pty Ltd, 2020. Muswellbrook Bypass Cultural Values Assessment. Report to Transport for NSW.

Terms and acronyms used in this REF

Term / Acronym	Description
ABL	Assessment background levels - The overall background level for each day, evening and night period for each day of the noise monitoring.
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AEP	Annual exceedance probabilities
AFT	Archaeological sites
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
AHIP	Aboriginal Heritage Impact Permit
AHMP	Aboriginal Heritage Management Plan
Alluvium	Unconsolidated deposit of gravel, sand or mud formed by water.
AM peak period	AM peak period – 6 - 10am weekdays
Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.
Amenity	Amenity refers to the quality of a place, its appearance, feel and sound, and the way its community experiences the place. Amenity contributes to a community's identity and its sense of place.
ANZEC	Australian and New Zealand Environment Council
Archaeology	The scientific study of human history, particularly the relics and cultural remains of the distant past.
ARI	Average Recurrence Interval
ARTC	Australian Rail Track Corporation
Arterial Roads	The main or trunk roads of the State road network that carry predominantly through traffic between regions.
Asphalt or asphaltic concrete	A dense, continuously graded mixture of coarse and fine aggregates, mineral filler and bitumen usually produced hot in a mixing plant.
ASRIS	Australian Soil Resource Information System
Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L_{90} sound pressure level is used to quantify background noise.
BAR	Biodiversity Assessment Report
BC Act	*Biodiversity Conservation Act 2016*
BDAR	Biodiversity Development Assessment Report
BoM	Bureau of Meteorology

Term / Acronym	Description
Bore	A cylindrical drill hole sunk into the ground from which water is pumped for use or monitoring.
Borehole	A hole produced in the ground by drilling for the investigation and assessment of soil and rock profiles.
Bypass	New England Highway bypass of Muswellbrook
CBD	Central business district
CEMP	Construction Environmental Management Plan
CHAR	Aboriginal Cultural Heritage Assessment Report
CO	Carbon monoxide
Compound site	Facilities used to support the operation of a construction site including site offices, workshops, delivery areas, storage areas, crib sheds, staff vehicle parking, materials, plant and equipment.
Concept design	Initial functional layout design for a road or road system, to establish feasibility, to provide a basis for estimating, and to determine further investigations needed for detailed design.
Construction fatigue	Construction fatigue relates to receivers that experience construction impacts from a variety of projects over an extended period of time with few or no breaks between construction periods.
Consultation	Inviting feedback from the community and stakeholders to inform a proposal.
CP	Communication Plan
CTMP	Construction Traffic Management Plan
Cumulative Impacts	Impacts that, when considered together, have different and/or more substantial impacts than a single impact assessed on its own.
Curtilage	The land around a bridge, building or any structure or object that is essential or contributes to the value, function and enjoyment of that object (e.g. a heritage building and surrounding buildings and trees that relate to it form an entire setting).
DA	Development Applications
Day	The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays.
dB	Decibels – A scale unit used in the comparison of powers and levels of sound energy. Used for measuring noise.
dB(A)	A-weighted decibels. A-weighting is applied to instrument-measured sound levels in effort to account for the relative loudness perceived by the human ear, as the ear is less sensitive to low audio frequencies.
DECC	Department of Environmental and Climate Change.
DECCW	NSW Department of Environment, Climate Change and Water

Term / Acronym	Description
Design noise model	A model of the proposal as it was designed, that calculates road traffic noise levels.
Design option	This scenario includes the proposal design alignment. The Road Noise Policy, Noise Criteria Guideline, and Noise Mitigation Guideline refer to this as the 'Build' scenario.
Detailed design	Detailed design broadly refers to the process that the Construction Contractor undertakes (should the proposal proceed) to refine the concept design to a design suitable for construction (subject to Transport for NSW acceptance).
DNG	derived native grasslands
DO	Dissolved Oxygen
DPI	Department of Primary Industries
DPIE	Department of Planning, Infrastructure and Environment
EC	Electrical Conductivity
EEC	Endangered ecological communities
EES	Environment, Energy and Science
Environment	As defined within the *Environmental Planning and Assessment Act 1979* (NSW), all aspects of the surroundings of humans, whether affecting any human as an individual or in his or her social groupings.
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Reg	Environmental Planning and Assessment Regulation 2000 (NSW)
EPA	Environment Protect Authority
EPL	Environment protection licence
Evening	The period from 1800 to 2200 h Monday to Sunday and Public Holidays.
Existing road traffic noise model	A model of the existing roads that calculates existing road traffic noise levels. This is used for model validation purposes with concurrently measured road traffic noise levels and traffic counts.
GDE	Groundwater dependent ecosystems

Term / Acronym	Description
GHG	Greenhouse Gas
HBT	hollow-bearing tree
Heavy vehicle	A heavy vehicle is classified as a Class 3 vehicle (a two axle truck) or larger, in accordance with the Austroads Vehicle Classification System.
Hydrology	The study of rainfall and surface water runoff process
IAQM	Institute of Air Quality Management (IAQM)
ICNG	Interim Construction Noise Guideline
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
InSAR	Interferometric Synthetic Aperture Radar
ISEPP	State Environmental Planning Policy (Infrastructure) 2007
L_{10}	The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the L_{10}.
L_{90}	The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the L_{90}.
L_{Aeq}	A-weighted equivalent sound level
LALC	Local Aboriginal Land Council
LCVIA	landscape character and visual impact assessment
LCZ	Landscape character zones
LGA	Muswellbrook Local Government Area
LLS	Hunter Local Land Services
L_{max}	The maximum sound pressure level measured over the measurement period.
L_{min}	The minimum sound pressure level measured over the measurement period.
Local Road	A road or street used primarily for access to abutting properties

Term / Acronym	Description
LoS	Level of service
Magnitude of impacts	Severity or scale and intensity, spatial extent and duration of the impact.
MCC	Muswellbrook Coal Company
Muswellbrook LEP	Muswellbrook Local Environment Plan 2009
NARCLiM	NSW and Australian Capital Territory Regional Climate Modelling
NCA	Noise catchment areas
Night	The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays.
NLTN	National Land Transport Network
NML	Noise Management Level
NO_2	Nitrogen Dioxide
Northern connection	Connection with the New England Highway at the northern end of the proposal, which provides all traffic movements.
NOx	Oxides of Nitrogen
NP&W Act	National Parks and Wildlife Act 1974
NPfI	Noise Policy for Industry
NSW	New South Wales
NSW DI - Water	NSW Department of Industry – Water Division
NT	Total Nitrogen
NVMP	Construction Noise and Vibration Management Plan
OD	origin destination
OSOM	over-size over-mass
PACHCI	Procedure for Aboriginal Cultural Heritage Consultation and Investigation

Term / Acronym	Description
PAD	Potential Archaeological Deposits
Passing trade	Passing trade refers to customers who choose to visit a business because they see it when walking or driving past, or as a matter of convenience when on route to another destination, rather than an intentional trip with that business as the desired destination.
PCT	Plant Community Types
PM^{10}	Particulate matter less than 10 microns in diameter.
PMF	Probable Maximum Flood
Property	Anything that is owned by a person or entity. Land property can contain more than one lot and Deposited Plan.
Proposal	The proposal refers to the proposed ~nine kilometre long section of highway bypassing Muswellbrook, starting at the New England Highway at Whittingham and re-joining the New England Highway north of Sandy Creek Road.
Public transport	Includes train and bus (government and private) services.
RAP	Registered Aboriginal Party
RBL	Rating background levels
REF	Review of Environmental Factors
RNP	Road Noise Policy
Roads and Maritime	NSW Roads and Maritime Services
ROL	Road Occupancy Licence
ROM	run-of-mine
RTA	Roads and Traffic Authority, former Roads and Maritime
SA2	Muswellbrook Statistical Area Level 2
SEARs	Secretary’s Environmental Assessment Requirements
SEIA	Socio-economic impact assessment

Term / Acronym	Description
Sensitive receiver	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres, passive recreation areas (including outdoor grounds used for teaching), active recreation areas (including parks and sports grounds), commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, retail spaces and industrial premises).
Sensitivity of affected stakeholders	Defined by the susceptibility or vulnerability of people, receivers or receiving environments to adverse changes caused by the impact, or the importance placed on the matter being affected.
SES	State emergency consultation
SHR	State Heritage Register - A register kept by the NSW Heritage Council that lists places, buildings, works, relics, moveable objects or precincts that the Minister for Planning considers are f state heritage significance.
SIS	Species Impact Statement
Social infrastructure	Social infrastructure facilities generally operate at a local, district and/or regional level and are defined by the scale of the population catchment they serve.
Socio-economic	Involving combination of social and economic matters
SoHI	Statement of Heritage Impacts
Southern connection	Connection with the New England Highway at the southern end of the proposal, which provides all traffic movements
SWMP	Soil and water management plan
Sydney-Brisbane Corridor	This transport network is funded by the Australian and State governments and is recognised for its strategic importance to national and regional economic growth, development and connectivity.
TEC	Threatened Ecological Communities
TMP	Traffic Management Plan
TP	Total Phosphorus

Term / Acronym	Description
Traffic noise	The total noise resulting from road traffic. The L_{eq} sound pressure level is used to quantify traffic noise.
Transport	Transport for NSW
TRAQ	Tool for Roadside Air Quality
TSS	Total suspended sediments
WM Act	Water Management Act 2000
WMP	Waste Management Plan
Zoning	Zoning regulates land use within an environmental planning instrument (usually by different colour codes on a map accompanying a local environmental plan). Land use tables set out the various purposes for which land may or may not be used or developed in each zone.