CHAPTER 15

Noise and Vibration

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

INLAND RAIL

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

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15.1 Summary

The construction and operation of the Gowrie to Helidon (G2H) project (the Project) can be a potential source of noise and vibration in the surrounding environment. In accordance with the Terms of Reference (ToR), an assessment of noise and vibration and their potential impacts is to be undertaken for the Project. An overview of the assessment findings is provided below and a summary of the key outcomes detailed in Table 15.1.

15.1.1 Construction noise and vibration

The construction noise and vibration noise assessment have been carried out under relevant legislation including the *Transport Infrastructure Act 1994* (Qld) (TI Act) and the *Environmental Protection Act 1994* (Qld) (EP Act).

Within the noise and vibration study area, 3,811 sensitive receptors (e.g. residential and commercial buildings) have been identified. The existing noise and vibration environment has been described by noise and vibration monitoring conducted at 10 locations. Baseline noise measurements were used to determine applicable construction noise criteria under the Department of Transport and Main Roads (DTMR) *Transport Noise Management Code of Practice Volume 2: Construction Noise and Vibration* (CoP Vol 2) (DTMR, 2015a).

Reasonable worst-case construction scenarios have been assessed for each of the main construction activities. The assessment was undertaken in accordance with the CoP Vol 2. Construction noise and vibration impacts vary with the construction activity undertaken and the time of day in which it occurs. As the current construction methodology does not specify the times of day at which construction activities occur, impacts have been assessed against criteria for all times of day.

As outlined in Table 15.29, limiting the Project's construction hours to within the CoP Vol 2 standard hours has the potential to significantly reduce the number of sensitive receptors impacted by the construction of the Project. During CoP Vol 2 standard hours, less stringent construction noise and vibration criteria apply. Restricting works to these hours (which is in line with the planned construction hours) reduces the number of impacted receptors by approximately 40 per cent for drainage works, rail and road civil works, and up to a 65 per cent reduction for site setup/laydown and structures. A much smaller change of 20 per cent is evident for earthworks.

15.1.2 Operational railway noise

The Project will introduce new and upgraded railway infrastructure along its alignment. The daily passby of trains and trains idling at crossing loops were considered as sources of noise.

The assessment of noise from these railway operations applied railway noise criteria implemented by ARTC on Inland Rail. The railway noise criteria are more stringent than the requirements of the ToR for railway noise.

Analysis of predicted noise levels determined the railway noise criteria would be met at the majority of the identified sensitive receptors. At 32 identified sensitive receptors and the Gowrie State School the predicted noise levels were above the criteria and triggered a review of reasonable and practicable measures to reduce noise levels to within the adopted criteria.

Considerate of the surrounding environment, it is reasonable to expect that noise from railway operations could be audible, for example within 1 kilometre (km) or more of the alignment, even where the criteria are met.

Table 15.1 summarises the findings of the operational fixed infrastructure assessment.

15.1.3 Operational railway ground-borne noise and vibration

The assessment of vibration from railway operations, including within the Toowoomba Range Tunnel, determined that predicted levels would achieve the criteria for ground-borne noise and ground-borne vibration at the identified sensitive receptors. On this basis, the assessment did not identify a need for specific vibration treatments beyond the highly resilient trackform proposed for slab track, and resilient matting for retention of ballast on bridge and such elevated track sections.

Table 15.1 summarises the findings of the operational fixed infrastructure assessment.

15.1.4 Operational road traffic noise

A desktop assessment of the operational road traffic noise associated with the Project has been carried out in accordance with the DTMR *Transport Noise Management Code of Practice: Volume 1—Road Traffic Noise* (CoP Vol 1) (DTMR, 2013b) and Terms of Reference (ToR). Of the eight roads assessed, two roads near Gowrie Junction, which are categorised under the CoP Vol 1 as 'new roads', are predicted to exceed the appropriate operational road traffic noise criterion.

Table 15.1 summarises the findings of the operational road traffic noise assessment.

15.1.5 Operational fixed infrastructure noise

An assessment of the operational fixed infrastructure noise has been carried out using *ISO 9613-2: Acoustics—Attenuation of sound during propagation outdoors—Part 2: General method of calculation* (International Organization for Standardization (ISO), 1996). Operational fixed infrastructure noise is predicted to meet the Environmental Protection (Noise) Policy 2019 (EPP (Noise)) acoustic quality objectives at all sensitive receptors. Table 15.1 summarises the findings of the operational fixed infrastructure assessment.

15.1.6 Predicted impacts summary

TABLE 15.1: NOISE AND VIBRATION IMAPCT ASSESSMENT FINDINGS

Impact	Activity (highest impact)	Criterion (most stringent)	Criterion source	Worst-case unmitigated impacts
Construction				
Construction noise	Earthworks	Monday–Sunday 10:00 pm to 7:00 am: 45 dBA $L_{Aeq,\ 15\ min}$ at receptor façade	CoP Vol 2	Worst-case 15-minute construction noise impacts at 2,131 noise sensitive receptors are predicted to exceed this night-time noise limit
Construction road traffic noise	Construction traffic movements	3 dBA increase in the $L_{A10,\ 1hr}$ due to construction traffic	CoP Vol 2	Five roads are predicted to exceed this limit. The maximum predicted increase is 6 dBA
Construction vibration	Percussive (impact) piling	Non-standard hours, human comfort: 0.3 mm/s peak particle velocity (PPV) at ground level	CoP Vol 2	Vibration impacts up to 175 vibration sensitive receptors are expected to exceed this limit
Blasting ground vibration and airblast overpressure	Construction blasting	Blasting charge masses are not known at this stage; therefore, maximum allowable instantaneous charge masses have been provided at indicative distances and sensitive receptors.		
Tunnel construction ground-borne noise	Tunnel boring machine (TBM) operation	Non-standard hours: 35 dBA $L_{Aeq,\ 15\ min}$ internal	CoP Vol 2	72 residential receptors are predicted to exceed the non-standard hours noise criterion. These exceedances are only predicted while the TBM is within a 390 m diagonal distance of the receptors.
Tunnel construction vibration	TBM operation	Non-standard hours, human comfort: 0.3 mm/s PPV at ground level	CoP Vol 2	Vibration levels at the foundation of all sensitive receptors are predicted to comply with criteria
Operations				
Operational railway noise	Train passbys	Daytime $LA_{eq(15hour)}$ 60 dBA Night-time $LA_{eq(9hour)}$ 55 dBA; and Maximum (L_{Amax}) 80 dBA.	ARTC	Up to 32 identified residential receptors and the Gowrie State School where noise levels trigger the investigation of reasonable and practicable mitigation measures. Railway noise may be perceived at 1 km or more from the alignment.

Impact	Activity (highest impact)	Criterion (most stringent)	Criterion source	Worst-case unmitigated impacts
Operational railway ground-borne noise and vibration	Train passbys on the track and in the tunnel	Ground-borne vibration 0.13 m/s$^{1.75}$ (night-time) Ground-borne noise L_{ASmax} 35 dBA (night-time)	ARTC and DTMR Interim Guideline (DTMR, 2019f)	Ground-borne noise and vibration is predicted to achieve the criteria at all identified sensitive receivers
Operational road traffic noise	Traffic movements on roads undergoing works as part of the Project	New roads: 60 dBA $L_{A10,\ 18\ hr}$ at receptor façade Existing roads: 68 dBA $L_{A10,\ 18\ hr}$ at receptor façade	CoP Vol 1	Two new roads are predicted to exceed the road traffic noise criterion—Morris Road (3 sensitive receptors up to 62 dBA) and Gowrie Junction Road (18 sensitive receptors up to 69 dBA)
Operational fixed infrastructure noise	Operation of tunnel ventilation fans	30 dBA internal $L_{Aeq,\ 1\ hr}$	EPP (Noise)	Physical attenuation is specified such that all fixed infrastructure associated with the Project is predicted to comply with the noise objective

15.1.7 Mitigation

To mitigate construction noise and vibration impacts on nearby sensitive receptors, specific noise management and mitigation measures will be incorporated into the Noise and Vibration Sub-plan. Mitigation measures will include the following:

- Control of noise through design, such as source noise controls for the railway infrastructure, screening receivers from noise and at-property controls to maintain amenity
- Effective community consultation
- Training of construction site workers
- Use of temporary noise barriers
- Monitoring
- Appropriate selection and maintenance of equipment
- Scheduling of work for less sensitive time periods
- Situating plant in less noise-sensitive locations
- Construction traffic management
- Respite periods during construction.

15.1.8 Residual impacts

Based on the construction noise assessment and proposed mitigation, worst-case construction noise impacts at approximately 46 per cent of construction noise sensitive receptors are not predicted to be feasibly mitigated to below the appropriate criterion by physical attenuation alone. Where further mitigation is also similarly infeasible or unreasonable, residual impacts may need to be managed. Management of residual impacts are to be undertaken in consultation with the community and affected residents. Residual construction noise impacts present after the application of mitigation will be temporary and will cease once construction finishes. Residual construction noise impacts may be managed through:

- Temporary relocation of affected occupants
- Respite periods
- Architectural treatments.

The noise criteria for the railway operations on the Project do not require noise from railway operations, including where noise mitigation is implemented, to be inaudible at sensitive receptors. The potential for annoyance or disturbance from rail noise is subjective and can remain a potential impact even where noise mitigation is implemented, and noise levels are well within the noise criteria.

The reasonable and practicable noise mitigation for the Project is expected to be at-property treatments. The at-property treatments do not address the source emission of rollingstock noise or the external (outdoor) rail noise levels in the environment surrounding the rail corridor. On this basis, the rail noise levels can remain above the external rail noise assessment criteria, and be perceptible, at the sensitive receptors with the implementation of at-property noise mitigation measures. Nonetheless, the at-property treatments would be implemented to reduce the internal railway noise levels to achieve targeted improvements to the indoor acoustic environment of habitable rooms.

The assessment has identified the ground-borne noise and vibration assessment criteria would be met at the sensitive receptors. There is potential for ground-borne noise and vibration to be perceptible even where the assessment criteria are achieved within sensitive receptors; however, disturbance or annoyance impacts would not necessarily be experienced based on the relatively low levels of ground-borne noise and vibration predicted at the sensitive receptors.

15.2 Scope of chapter

The scope of the noise and vibration assessment was to:

- Identify nearby noise sensitive receptors potentially affected by the construction and operation of the Project
- Undertake baseline noise and vibration measurements
- Establish construction noise and vibration criteria based on the measured background noise levels, the *Transport Noise Management Code of Practice: Volume 2—Construction Noise and Vibration* (CoP Vol 2) (DTMR, 2015a)
- Establish operational road traffic criteria and construction road traffic criteria in accordance with the Department of Transport and Main Road (DTMR) *Transport Noise Management Code of Practice Volume 1—Road Traffic Noise* (CoP Vol 1) (DTMR, 2013b) and CoP Vol 2, respectively
- Establish noise assessment criteria for the railway operations of the Project with consideration to the *Policy for Development on Land Affected by Environmental Emissions from Transport and Transport Infrastructure* (DTMR Policy) (DTMR, 2013e), the DTMR Transport Noise Management Code of Practice Volume 3: *Interim Guideline Operational Railway Noise and Vibration, Government Support Transport Infrastructure* (Interim Guideline) (DTMR, 2019f) and ARTC's operational railway noise criteria for Inland Rail
- Establish assessment criteria for ground-borne noise and vibration from railway operations with consideration to the DTMR Policy, Interim Guideline and ARTC's operational railway criteria for ground-borne noise and vibration and relevant acoustic standards and guidelines
- Undertake a construction noise and vibration impact assessment of the construction works in accordance with the ToR and applicable legislation, as detailed in Section 15.4
- Assess the noise impact resulting from construction activities and potential mitigation methods, where required, including buffer distances, silencing treatment of mobile plant, management of mobile plant, community consultation and other management mitigation measures, such as respite periods
- Review vibration-intensive construction works and recommend minimum working distances and mitigation measures, where required, including the use of alternative equipment and construction methods, respite periods and other management mitigation measures
- Undertake an operational noise impact assessment of proposed steady state noise sources, such as fixed tunnel infrastructure and new or upgraded roads, as part of the Project in accordance with the ToR
- Evaluate the predicted railway noise levels against the assessment criteria to identify where railway operations could trigger an investigation of measures to control noise emissions and mitigate potential impacts
- Assess the impact from potential ground-borne noise and vibration levels associated with railway operations for the above-ground rail operations and train movements in the Toowoomba Range Tunnel
- Recommend a range of feasible and reasonable mitigation measures, as required, to assist in the control of railway noise and vibration emissions and minimise the potential for noise, ground-borne noise and vibration impacts from the railway operations on the Project
- Assess the potential residual noise and vibration impacts for the construction and operation of the Project, once mitigation measures were implemented
- Assess the potential cumulative impacts from this Project and other relevant projects during construction and operations. In addition, consider cumulative impacts from road and rail noises sources during operations.

15.3 Terms of Reference requirements

The ToR describes the matters the proponent is to address in the EIS for the Project. The matters relating to noise and vibration are contained in Table 15.2.

TABLE 15.2: TERMS OF REFERENCE REQUIREMENTS—NOISE AND VIBRATION

Terms of Reference requirements		Where addressed in this chapter and the broader EIS
Existing environment		
11.114	Describe the existing noise and vibration environment that may be affected by the project in the context of the environmental values.	Section 15.6 Appendix O: Construction Noise and Vibration, Section 3 Appendix P: Operational Railway Noise and Vibration, Sections 5 and 7
11.115	Describe and illustrate on maps at a suitable scale, the location of all sensitive noise receptors adjacent to all project components and estimate typical background noise and vibration levels based on surveys at representative sites.	Section 15.6.1, Figure 15.2 (in part) and Figure 15.3 Appendix O: Construction Noise and Vibration, Section 3.2 Appendix P: Operational Railway Noise and Vibration Appendix A
11.116	If the proposed project could adversely impact on the noise environment, undertake baseline monitoring at a selection of sensitive receptors potentially affected by the project. Describe the results of any baseline monitoring.	Section 15.6.2 and 15.6.3 Appendix O: Construction Noise and Vibration, Section 3.3 Appendix P: Operational Railway Noise and Vibration, Section 5.4
Impact assessment		
11.117	Describe the characteristics of the noise and vibration sources that would be emitted when carrying out the activity (point source and general emissions). Describe noise and vibration emissions (including fugitive sources) that may occur during construction, commissioning and operation.	Section 15.7 Appendix O: Construction Noise and Vibration, Section 5 Appendix P: Operational Railway Noise and Vibration, section 6.3
11.118	Predict and map the impacts of the noise and vibration emissions from the construction and operation of the Project on the environmental values of the receiving environment, including sensitive receptors. Noise and vibration objectives and goals should be sourced from the following: a) EPP (Noise) 2008[1], using recognised quality assured methods b) Environmentally Relevant Activities—DEHP Application requirements for activities with noise impacts (Guideline ESR/2015/1838) c) Construction—The Department of Transport and Main Roads Transport Noise Management Code of Practice: Volume 2—Construction Noise and Vibration dated March 2016 and gazetted on 29 July 2016 d) Operational Noise—The Department of Transport and Main Roads Policy for Development on Land Affected by Environmental Emissions from Transport and Transport Infrastructure Versions 2, 10 May 2013 (Rail noise external criteria contained in Table 3 of this document) e) Operational vibration—British Standard BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings—Vibration sources other than blasting. British Standards Institution, London f) Operational Noise—The Department of Transport and Main Roads *Policy for Development on Land Affected by Environmental Emissions from Transport and Transport Infrastructure Versions 2, 10 May 2013* (criteria contained in Table 6 of the document).	g) EPP (Noise) 2019[1] acoustic quality objectives have been adopted as operational fixed infrastructure objectives (Section 15.8 and Section 4.4.2 of Appendix O: Construction Noise and Vibration) h) No Environmentally Relevant Activities (ERAs) or stated conditions for ERAs are being sought as part of this approval process (i.e. EIS). Where an ERA is required to be sourced for the Project during detailed design, the required approval process will consider this guideline. i) Construction noise and vibration criteria have been developed in consideration of the CoP Vol 2 (DTMR, 2015a) (Section 15.7.1 AND Sections 4.1 to 4.3 of Appendix O: Construction Noise and Vibration) j) Appendix P: Operational Railway Noise and Vibration, Sections 3.2, 7, 8, 9 and Appendix D and Appendix E of Noise Contours k) Appendix P: Operational Railway Noise and Vibration, Sections 12 and 13 l) Appendix P: Operational Railway Noise and Vibration, Sections 12 and 13

Terms of Reference requirements		Where addressed in this chapter and the broader EIS
11.119	Discuss separately the key project components likely to present an impact on noise and vibration for the construction and operation phases of the project.	Section 15.7.1 Appendix O: Construction Noise and Vibration, Sections 5 and 6 Appendix P: Operational Railway Noise and Vibration, Section 2
11.120	Taking into account the practices and procedures that would be used to avoid or minimise impacts, the impact prediction must address the: a) activity's consistency with the objectives b) cumulative impact of the noise with other known emissions of noise associated with existing major projects and/or developments and those which are progressing through planning and approval processes publicly available c) potential impacts of any low-frequency (<200 Hz) noise emissions.	Chapter 15: Noise and Vibration, Section 15.7 Appendix O: Construction Noise and Vibration, Section 5 and Section 6 Appendix P: Operational Railway Noise and Vibration, details of the rail noise predictions are provided in Sections 7,8, 9 and 10 for airborne noise. The assessment of ground-borne vibration and ground-borne noise are detailed in Section 12 and Section 13. Cumulative noise and vibration impacts are addressed in: - Chapter 15: Noise and Vibration, Section 15.9 - Chapter 22: Cumulative Impacts, Sections 22.6 and 22.6.8 - Appendix O: Construction Noise and Vibration, Section 7 - Appendix P: Operational Railway Noise and Vibration, Section 14 Low frequency noise emissions are addressed in: - Appendix O: Construction Noise and Vibration, Table 4.3 - Low frequency noise from railway operations is provided in Appendix P: Operational Railway Noise and Vibration, Section 11.6
Mitigation measures		
11.121	Describe how the proposed project, and in particular, the key project components described above, would be managed to be consistent with best practice environmental management for the activity. Where a government plan is relevant to the activity, or the site where the activity is proposed, describe the activity's consistency with that plan.	Section 15.11 Appendix O: Construction Noise and Vibration, Section 8 Appendix P: Operational Railway Noise and Vibration, Section 15
11.122	Describe any expected exceedances of noise and vibration goals or criteria following the provision or application of mitigation measures and how any residual impacts would be addressed.	Section 15.11.3 Appendix O: Construction Noise and Vibration, Section 8.3 Appendix P: Operational Railway Noise and Vibration, Sections 7 to 13 and Section 16
11.123	Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed	Section 15.11 Appendix O: Construction Noise and Vibration, Section 8 Appendix P: Operational Railway Noise and Vibration, Section 15.6

Table note:

1. EPP (Noise) 2008 has been superseded by EPP (Noise) 2019, which has been used for this assessment.

15.4 Legislation, policies, standards and guidelines

Queensland legislation that defines requirements for the noise and vibration assessment and environmental approval processes for this Project includes:

- *Transport Infrastructure Act 1994* (Qld) (TI Act)
- *Environmental Protection Act 1994* (Qld) (EP Act)
- Environmental Protection (Noise) Policy 2019, (EPP(Noise)), subordinate to the EP Act.

Legislation of relevance to noise and vibration aspects of the Project are discussed in Chapter 3: Project Approvals, Appendix O: Construction Noise and Vibration and Appendix P: Operational Railway Noise and Vibration.

The TI Act requires the construction, operation and maintenance of all government-supported infrastructure to be carried out according to standards published by the Chief Executive. DTMR's document *Transport Noise Management Code of Practice Volume 1—Road Traffic Noise* (CoP Vol 1) (DTMR, 2013b) is implemented as a legislative requirement under the TI Act, and identifies the requirements for road traffic noise associated with completion of the Project.

DTMR's document *Transport Noise Management Code of Practice: Volume 2—Construction Noise and Vibration* (CoP Vol 2) (DTMR, 2015a) has been gazetted under s318E of the EP Act. It is also named as an applicable guideline in the ToR. The CoP Vol 2 has requirements for various stages of projects and is a means of demonstrating compliance with the General Environmental Duty under the EP Act. By complying with relevant legislation, and government plans, policies, standards and guidelines (such as the CoP Vol 1 and CoP Vol 2), the Project will be consistent with the principles of best practice environmental management.

Table 15.3 lists the policies and guidelines relevant to the Project. No other government plans were considered relevant for this assessment.

TABLE 15.3: GUIDELINES AND POLICIES RELEVANT TO THE PROJECT

Policy or guideline	Relevance to Project
DTMR's document *Transport Noise Management Code of Practice Volume 1—Road Traffic Noise* (CoP Vol 1) (DTMR, 2013b)	The CoP Vol 1 is a standard under the TI Act and its implementation is a legislative requirement. It identifies the requirements for road traffic noise associated with the completion of the Project. Applicable criteria and assessment methodologies were adopted from the CoP Vol. 1 to assess noise and vibration associated with road traffic noise.
DTMR's document *Transport Noise Management Code of Practice: Volume 2—Construction Noise and Vibration* (CoP Vol 2) (DTMR, 2015a)	The CoP Vol 2 is a code of practice under the EP Act. It identifies the noise and vibration requirements for construction activities completed for the Project. Applicable criteria and potential mitigation measures were adopted from the CoP Vol. 2 to assess noise and vibration associated with construction works.
DTMR's document *Policy for Development on Land Affected by Environmental Emissions from Transport and Transport Infrastructure.* (DTMR Policy) (DTMR, 2013e)	The DTMR Policy identifies the requirements for the development of land affected by environmental emissions, including noise and vibration, from transport corridors and infrastructure. It provides criteria for noise and vibration for development on land affected by environmental emissions from linear State transport corridors and infrastructure. This policy has been considered in the development of ARTC's noise and management criteria for the operation of Inland Rail.
DTMR's document *Transport Noise Management Code of Practice Volume 3: Interim Guideline, Operational Railway Noise and Vibration, Government Supported Infrastructure* (Interim Guideline) (DTMR, 2019f)	The DTMR's Interim Guideline provides assessment criteria for operational noise and vibration emissions generated by railway activities. It provides guidance for the prediction, assessment and management of noise and vibration and related impacts to sensitive receptors. This DTMR Interim Guideline has been considered as part of the EIS. ARTC's approach to noise and vibration assessment and management for the operation of Inland Rail is generally more stringent when compared to the DTMR's Interim Guideline. ARTC's approach allows for uniform and consistent assessments (with consideration to public health, amenity and disturbance) across the Inland Rail program.
German Standard DIN 4150: Part 3 1999 Structural Vibration in Buildings—Effects on Structures, 1999 (DIN 4150.3) (Deutsches Institut für Normung, 1999)	This standard is recommended by CoP Vol 2. It recommends maximum levels of vibration that reduce the likelihood of potential cosmetic and structural damage to buildings that have been adopted for the assessment of potential related impacts from construction works.

Policy or guideline	Relevance to Project
Australian Standard AS 1055.1-1997—*Acoustics—Description and measurement of environmental noise, Part 1: General procedures* (Standards Australia, 1997a)	The CoP Vol 2 provides that noise measurement and reporting are to be conducted in accordance with the construction and ambient noise provisions included in this standard. The environmental noise monitoring described in Section 15.6 was undertaken in accordance with this standard.
Australian Standard 2187.2-2006 *Explosives—Storage and Use Part 2: Use of Explosives*—Appendix J (Standards Australia, 2006a)	The CoP Vol 2 recommends the use of AS 2187.2 with respect to blasting vibration criteria for human comfort and structural damage. These ground vibration criteria have been adopted for this assessment.
Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration (Australian and New Zealand Environment Conservation Council, 1990)	This document specifies recommended blasting overpressure and vibration impact limits to minimise annoyance and discomfort. The CoP Vol 2 references the blasting airblast overpressure criteria contained in this document. This document also provides suggested mitigation measures for blasting noise and vibration impacts. Airblast overpressure criteria were instead sourced from the Department of Environment and Heritage Protection (DEHP) *Guideline—Noise and vibration from blasting* (DEHP, 2016a), consistent with the CoP Vol 2.
Guideline—Noise and Vibration from Blasting (DEHP, 2016a)	This guideline sets out performance criteria to be used when setting operating requirements in conditions of environmental approvals under the EP Act. The CoP Vol 2 adopts the criteria from this guideline to minimise annoyance from airblast resulting from blasting. Predicted Project blasting airblast overpressure impacts have been assessed against these criteria.
Department of Environment and Science (DES) *Guideline—Application requirements for activities with noise impacts*, (DES, 2019b)	This guideline under the EP Act provides guidance on the requirements for assessments of noise impacts, including the requirement for supplementary approvals for Environmentally Relevant Activities (ERAs). The current proposal includes no ERAs with a significant noise impact. Final ERAs and applications will be developed at later stages of the Project and, if ERAs are required, then the application will use this guideline. Refer Chapter 3: Project Approvals for further detail on ERAs.
British Standard (BS) BS 5228-1 *Code of practice for noise and vibration control on construction and open sites—Part 1: Noise* (British Standards, 2009a)	Noise source data from this standard is recommended for the modelling of construction noise impacts by the CoP Vol 2. This noise source data was used in the modelling of construction noise for this assessment.
British Standard BS 5228-2:2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 2 Vibration* (BS 5228-2) (British Standards, 2009b)	Ground vibration criteria for human comfort have been adopted for this assessment, from this guideline, consistent with the CoP Vol 2.

Policy or guideline	Relevance to Project
Environmental Protection Policy (Noise) 2019 (EPP (Noise))	This policy provides support to the operation of the EP Act by identifying environmental values (EVs) to be enhanced or protected, stating acoustics quality objectives for enhancing or protecting environmental values and providing a framework for consistent, equitable and informed decisions about the acoustic environment. The EVs under the policy include: *(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and* *(b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following—* *(i) sleep;* *(ii) study or learn;* *(iii) be involved in recreation, including relaxation and conversation; and* *(c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.* Under the policy, the acoustic quality objective, for a sensitive receptor, means the maximum level of noise that should be experienced in the acoustic environment of the sensitive receptor. Under section 1 part 1 schedule 1 of the EP Act the 'ordinary use of rail transport infrastructure' is excluded from the acoustic quality objectives. The operation of the tunnel infrastructure, however, has considered the acoustic objectives under this plan (refer Section 15.7.8.5).
Concawe *Report no.4/81 the propagation of noise from petroleum and petrochemical complexes to neighbouring communities'* (Concawe, 1981)	This report details a method of calculation of the propagation of noise that is recommended by the CoP Vol 2. This method was used for the modelling of construction noise.
ISO 9613-2:1996 *Acoustics—Attenuation of sound during propagation outdoors—Part 2: General method of calculation* (ISO, 1996)	This standard details a method of calculation of the propagation of noise recommended by the CoP Vol 2. This method was used for the modelling of operational fixed infrastructure noise.
Department of Environment and Science *Noise Measurement Manual* (DES, 2020)	This document describes the noise measurement processes for assessments under the EP Act. The noise monitoring described in 15.6 was undertaken in accordance with this document.
World Health Organisation (WHO) guideline Night Noise Guidelines for Europe (WHO, 2009) Department of Environment and Science *Noise Measurement Manual* (DES, 2020i)	This document provides commentary on environmental noise impacts during the night-time period. The document has not been used to establish criteria, objectives, limits or assessment goals, but rather provides context on contemporary approaches to considering potential night-time noise impacts. The document provides an example of applying the L_{Amax} noise level to evaluate potential for sleep disturbance within the European context. Advice from the WHO acknowledges the establishment of relationships between single event noise indicators, such as $L_{Amax,}$ and long-term health outcomes remains tentative. This document describes the noise measurement processes for assessments under the EP Act. The noise monitoring described in Section 15.6 was undertaken in accordance with this document.

Applicable criteria and potential mitigation measures are included in this document to adequately assess noise and vibration impacts associated with the construction and operation of the Project. This chapter outlines the applicable noise and vibration criteria and recommended mitigation measures.

There are no specific noise guidelines for animals (wildlife and livestock) and very few studies that seem relevant to the Project, though noise and vibration are known to impact species behaviour; however, the United States of America Federal Rail Administration has an interim guideline of 100 decibels for wildlife and livestock (Federal Railroad Administration, 2012). With studies indicating that this would be achieved within approximately 30 m from the rail track and as such the criteria would be met outside of the rail corridor within the greenfield section of the Project (i.e. minimum width of 62.5 m).

While the EPP(Noise) refers to '*protecting the health and biodiversity of ecosystems*' there is no specific acoustic quality objective, with the policy just noting the '*the level of noise that preserves the amenity of the existing area or place*'.

The impact of noise on livestock and fauna is discussed in Chapter 11: Flora and Fauna and Appendix I: Terrestrial and Aquatic Ecology.

15.5 Methodology

The assessment methodology for noise and vibration impacts has involved:

- Identification of the noise and vibration study area
- Identification and classification of noise and vibration sensitive receptors
- Baseline monitoring to establish existing environmental conditions
- Establishing relevant airborne noise, ground-borne noise, ground-borne vibration and blasting criteria
- Modelling of noise emissions associated with the construction and operation of the Project
- Assessment of noise level predictions against the adopted assessment criteria
- Assessing Project ground-borne vibration and ground-borne noise from construction and operation
- Assessing Project airblast overpressure and vibration from blasting associated with construction
- Where the assessment criteria were triggered, best practice measures were identified to reduce noise and vibration emissions and mitigate, so far as is reasonably practicable, potential noise and vibration impacts associated with the construction and operation of the Project
- Identification of residual impacts.

15.5.1 Noise and vibration study area

The noise and vibration study area is the area which falls within 2 kilometres (km) of the Project alignment, and is shown in Figure 15.1.

A summary of the methodology for each form of construction noise and vibration impacts is included below. Further details can be found in Appendix O: Construction Noise and Vibration.

15.5.2 Airborne noise

Table 15.4 lists the construction activities and associated equipment modelled in this assessment based on estimated plant schedules derived to inform the construction methodology described in Chapter 6: Project Description. The construction activities listed are reflective of a preliminary construction method, based on the EIS design. This list is not to be regarded as exhaustive.

TABLE 15.4: CONSTRUCTION STAGES AND PROPOSED EQUIPMENT

Construction stage/activity	Activities	Plant and equipment	Overall sound power level (SWL) (dBA)
Site setup/ laydown areas	‣ Establishment of site compounds/laydown areas and site facilities ‣ Potential construction of water storage dams to harvest/store construction water ‣ Haul road and access roads construction ‣ Haul road maintenance	Grader, truck, dump truck, 40 tonne (t) excavator, scraper, water cart	120
Earthworks	‣ Clearing and grubbing/topsoil stripping ‣ Cut to fill ‣ Import general fill ‣ Place and compact general fill ‣ Import structural fill ‣ Place structural fill ‣ Removal of fill and spoil ‣ intermediate ventilation shaft	Dozer, 40 t excavator, trucks, scraper, water cart, scraper, front end loader, padfoot roller, compactor, grader, 15 t roller, mulcher[1]	127—standard hours 122—non-standard hours[1]

Construction stage/activity	Activities	Plant and equipment	Overall sound power level (SWL) (dBA)
Structures—including the construction of substructures, foundations and bridge piers	▶ Substructure/foundations construction ▶ Pier construction ▶ Superstructure construction ▶ Intermediate ventilation shaft ▶ Eastern tunnel portal construction	40 t excavator, piling rig, concrete truck, crane	118
Tunnelling	▶ Tunnel boring ▶ Spoil removal (to western tunnel portal stockpile)	TBM, centrifuge, water pump	N/A—ground-borne noise[2]
Drainage—installation of cross drainage	▶ Install cross drainage	Backhoe, 30 t excavator, work truck (HIAB), compactor, concrete truck, concrete pump, Franna crane	120
Rail civil works	▶ Capping material import ▶ Capping material placement ▶ Bottom ballast ▶ Sleeper installation ▶ Rail installation ▶ Top ballast ▶ Track tamping and regulating ▶ Rail stressing ▶ Rail grinding	Tamper, regulator, 20 t excavator, water cart, trucks, dozer, 40 t excavator, 15 t roller, compactor, grader, 20 t excavator, smooth drum roller, ballast train, rail grinder	123
Road civil works	▶ Road works	Grader, 30 t excavator, compactor, water cart, trucks	120
Concrete batching	▶ Preparation, mixing and discharging of concrete	Concrete batching plant	108
Flash-butt welding	▶ Track welding	Generator for welding, welder	104

Table notes:

1. The mulcher is expected to only typically operate during standard working hours and, as such, two scenarios have been assessed to represent typical conditions during standard and non-standard hours
2. It is expected that tunnel construction will involve the operation of at least one water pump and centrifuge external to the tunnel. While these sources will generate air-borne construction noise, they have not yet been located or selected. During detailed design, these plant items will be selected and mitigated such that noise impacts will not materially increase the construction noise impacts to any sensitive receptors. As these plant items will be stationary, this is likely to be feasibly achieved through physical mitigation at the noise source, such as acoustic enclosures and engine mufflers.

Noise emissions from the plant in Table 15.4 were adopted from BS 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites—Part 1: Noise* (BS 5228-1) (British Standards, 2009a) and are detailed in Appendix O: Construction Noise and Vibration.

The potential noise levels from these construction activities were modelled using SoundPLAN (version 8.0) noise modelling software, to represent typical worst-case 15-minute periods of noise-intensive construction work.

The following features were included in the noise model:

- Ground topography (terrain)
- Ground absorption and reflection of noise by the local ground
- Identified sensitive receptors
- Construction noise sources
- Different meteorological conditions in accordance with the requirements of CoP Vol 2 and replicated in Table 15.5.

TABLE 15.5: COP VOL 2 METEOROLOGICAL CONDITIONS FOR USE IN NOISE MODELLING

Time	Temperature, °C	Humidity, %	Wind speed, m/s	Wind direction	Temperature lapse rate	Pasquil stability class (implied by temperature lapse rate)
Day	20	70	3	All	0 degrees C/100 m	E
Evening	15	70	2	Drainage flow	+3 degrees C/100 m	F
Night	15	70	None	None	F+3 degrees C/100 m	F

Table notes:
C = Celsius; m = metre; E = Slightly stable conditions; F = Moderately stable conditions; m/s = metres per second

The following assumptions were made in modelling the construction noise scenarios:

- All site equipment would be operating simultaneously, which is unlikely, and is, therefore, a conservative assumption. Noise levels associated with more realistic intermittent and non-simultaneous construction would be expected to be approximately 5 to 15 dBA lower.
- Specific equipment locations are not known at this stage. Construction activity footprints were derived for each construction activity. These are the areas within which the relevant construction activity is expected to occur. Equipment was assumed to be operating at the closest point in these construction activity footprints areas to each receptor, in order to represent the worst-case scenario. During operation, the equipment could only operate at the closest point to each receptor for a limited period and could not do so simultaneously. Noise levels associated with more realistic separation distances between noise sources and receptors would be expected to be approximately 0 to 3 dBA lower.
- All sensitive receptors are modelled at two storeys, 4.6 m above ground level. This is an estimate of the height 1.5 m above the finished floor level of a two-storey dwelling, as per CoP Vol. 2.
- At this stage, a detailed construction methodology has not been developed. Planned hours of construction are not currently known and, as such, construction noise impacts have been assessed against CoP Vol 2 noise criteria for all work periods (refer Table 15.11).

The construction noise modelling took into consideration topography and ground effects through the generation of a digital ground model based on 1-metre (m) interval LiDAR terrain elevation contours.

15.5.3 Ground-borne vibration

Formulae for the prediction of ground-borne vibration impacts were adopted from British Standard BS 5228-2:2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 2 Vibration* (BS 5228.2) (British Standards, 2009b). These formulae were used in conjunction with the construction vibration criteria outlined in Section 15.7.5 to give minimum setback distances of sensitive receptors from the following vibration-intensive activities:

- Vibratory compaction—vibration start-up/run down
- Vibratory compaction—steady state
- Vibratory piling
- Percussive (impact) piling
- Ground vibration impacts of the tunnel construction were assessed separately. The methodology for the noise and vibration assessment of tunnel construction is described in Section 15.5.6.

As with the modelling of airborne noise, vibratory plant was assumed to potentially operate anywhere within the relevant construction activity footprint.

15.5.4 Construction blasting

Formulae for the prediction of vibration and airblast overpressure due to blasting were adopted from Australian Standard *AS 2187.2-2006 Explosives—Storage and Use Part 2: Use of Explosives—Appendix J.* (AS 2187.2) (Standards Australia, 2006a). A worst-case assumption of a confined blast and geotechnical parameters for vibration transmission were used. Potential locations requiring blasting were identified based on information derived from the Project design. Maximum permissible charge weights were calculated based on the distance of each sensitive receptor from the nearest potential blasting location, and the blasting criteria outlined in Section 15.7.7.

15.5.5 Construction road traffic noise

Construction vehicle movements and existing traffic flows have been based on information derived from Appendix U: Traffic Impact Assessment. A comparative desktop assessment using these traffic flows was used to predict the $L_{A10(1hr)}$ for each year from 2022 to 2026 both with and without the expected construction traffic.

15.5.6 Tunnel construction

The Toowoomba Range Tunnel is planned to be constructed primarily using a tunnel boring machine (TBM). The TBM source vibration spectrum has been derived from that of the Melbourne Metro Rail project. As vibration propagates differently via different substrates, vibration levels were back calculated to a distance of close proximity to the source, and repropagated through the ground type relevant to the Toowoomba Range Tunnel.

Details of the modelling of vibration propagation are included in Appendix O: Construction Noise and Vibration.

For each vibration source, it has been assumed that the vibration peak particle velocity (PPV) values at each frequency all occur simultaneously, resulting in a conservative PPV sum for the purpose of assessment against the nominated criteria. For a TBM used in rock, it is assumed that the PPV will be 5.6 millimetres per second (mm/s) at 5 m.

The (diagonal) distance between the source and the building foundation of each sensitive receptor is based on the following horizontal and vertical data for the tunnel:

- LiDAR elevation terrain contours at the sensitive receptor
- Tunnel outer edge
- Rail centreline (vertical and horizontal profile)
- Shortest horizontal distance between the sensitive receptor and rail centreline (typically perpendicular, with the exception of houses near the portals).

No other vibration-intensive plant equipment has been identified in use for these tunnelling works. Ground-borne vibration due to tunnelling is assumed to be long-term vibration, as defined by DIN 4150.3 (Deutsches Institut für Normung, 1999).

Ground vibration transmission losses and typical building corrections have then been applied based on a review of relevant literature and are detailed in Appendix O: Construction Noise and Vibration.

15.5.7 Operational noise and vibration

A summary of the methodology for each operational noise and vibration impact is provided below. Project commissioning activities are expected to have commonalities with operation activities identified in this section, albeit for a smaller scale of task; therefore, activities for the commissioning phase have not been uniquely specified.

Further details can be found in Appendix P: Operational Railway Noise and Vibration and in Appendix O: Construction Noise and Vibration.

15.5.8 Operational rail noise and vibration

The assessment of airborne noise, ground-borne vibration and ground-borne noise from railway operations has adopted the following approach:

- Identification of sensitive receptors and occupancy type
- Development of a noise emissions database for the rollingstock (locomotives and wagons) proposed for the Project

- Determination of source ground-borne vibration levels for rollingstock based on measured ground-borne vibration levels on existing rail freight corridors. This included a noise and vibration monitoring survey that was undertaken by SLR to investigate the potential influence of single- and double-stacked containers (axle loads) on noise and vibration emissions from freight trains.
- Prediction of airborne noise levels at the sensitive receptors
- Comparison of the predicted airborne noise levels against the Project's railway noise criteria
- Calculation of minimum buffer distances from the rail alignment where ground-borne vibration and ground-borne noise levels would achieve the relevant assessment criteria
- Identification of any sensitive receptors within the minimum buffer distances for ground-borne vibration and ground-borne noise
- Development of management and mitigation measures to meet the airborne noise, ground-borne vibration and ground-borne noise objectives.

The following operational scenarios were included in the assessment:

- The railway operations have been assessed for the Project opening in 2027 and the future design year 2040, which represents the railway operations defined in the business case for Inland Rail
- The assessment of airborne noise from the Project considered areas where new railway infrastructure is being constructed (greenfield Project areas) and the areas where the Project represents an upgrade or redevelopment of existing railway infrastructure (brownfield Project areas)
- The railway noise and vibration levels were assessed for the train movements (trains up to 1,800 m long) on the mainline and crossing loops
- The noise and vibration levels were assessed for the daytime and night-time periods for the Project opening in 2027 and the design year 2040.

15.5.9 Operational fixed infrastructure noise

Noise impacts of the operational fixed infrastructure included in the design of the Project have been assessed under EPP (Noise). The following operational fixed infrastructure has been identified based on the design:

- Tunnel ventilation fans for purging, emergency and maintenance operations. The fans are located at the tunnel portals and the intermediate ventilation shaft.
- Pumps, pump stations and water treatment plants associated with the tunnel
- Transformers, substations and generators associated with the tunnel
- Operable tunnel portal doors.

Audible safety systems, including train horns, have not been assessed as these noise sources are exempt from airborne noise criteria due to safety obligations. This is consistent with Section 2.2.1 (Operational Airborne Noise Criteria) of Interim Guideline. Furthermore, no public level crossings are proposed, which is a key reason for train horn blasts.

Ancillary fixed infrastructure noise sources, other than tunnel ventilation fans, such as pumps, transformers and portal doors, will be located at the eastern and western tunnel portals for the Project. During detailed design, this infrastructure is to be selected and designed, and the need for noise mitigation determined. While noise from these sources are not yet known, nominal mitigation strategies (such as attenuators, solid barriers, enclosures) would be implemented, as necessary, and would be designed to meet the EPP (Noise) acoustic quality objectives at noise sensitive receptors.

The following approach has been used to assess airborne noise due to operation of fixed infrastructure associated with the tunnel:

- Identification of operational fixed infrastructure noise sources
- Identification of sensitive receptors and occupancy type
- Determination of objectives for airborne noise at nearby sensitive receptors
- Prediction of airborne noise levels at the sensitive receptors

- Calculations of fan noise emissions were undertaken with the computational software SoundPLAN (v8.0) using the noise propagation methodology in *ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO, 1996). Terrain data (in increments of 2–5 m elevation contours) was used in the assessment methodology.
- Comparison of the predicted internal airborne noise levels with the acoustic quality objectives
- Development of acoustic mitigation options to meet the environmental noise objectives
- Fan specifications have been provided as part of the Project design and the relevant fan sound power levels (SWL) have been empirically derived (American Society of Heating, Refrigerating and Air-Conditioning Engine, 2019). The sound power level (SWL) of a source is the sound energy emitted by the source. The SWL of a source cannot be measured directly but is calculated based on measured sound pressure levels at a known distance.

15.5.10 Operational road traffic noise

The Project includes a number of changes to the local road network. These have been mapped in Appendix O: Construction Noise and Vibration. A desktop assessment approach has been implemented for the assessment of operational road noise for each of the proposed changes to the road network. The assessment has been completed in accordance with CoP Vol 1.

Road changes were categorised as either new roads or upgraded roads, as per the definitions adopted from the CoP Vol 1. These definitions are provided in Table 15.6 and are acoustic terminology for this assessment only.

The required sensitive receptor setback distance from the road to comply with the new road criteria of 60 $L_{A10\,(18hr)}$ dBA has been calculated and the number of sensitive receptors within the setback distance has been determined.

TABLE 15.6: COP VOL 1 ROAD CATEGORY DEFINITIONS

Road category	CoP Vol 1 definition
New road—access controlled	A new access-controlled road in a proposed or existing unused corridor adjacent to existing residences or in a proposed corridor where formal approval by a local government or other statutory authority for adjacent land development is current at the date of acquisition, even if the development is not yet in existence. A new road may include the upgrading of a road (State or local government) to one of a higher functional road hierarchy where there is an increase in the contribution to road traffic noise exposure of at least 3 dBA. The higher functional road hierarchy must be an access-controlled road of at least a collector/distributor function. Also, a new road is applicable to the situation where land acquisition (resumption) is taken beside an existing corridor and all State-controlled road lanes fall outside the existing corridor.
Upgrading existing road	A substantial upgrading, such as duplication or additional through lanes, within some portion of the existing road corridor. Some additional lanes may fall outside the existing road corridor where land acquisition (resumption) is required.

15.6 Existing environment

The Project alignment generally follows the Gowrie to Grandchester future state transport corridor, which is protected under the *Transport Planning and Coordination Act 1994* (Qld). The Project primarily traverses attenuated rural lands associated with the Gowrie Creek floodplain north of Toowoomba city centre, along with the vegetated foothills of the Great Dividing Range.

There are several towns and residential areas located within close proximity to the Project, including Gowrie, Mount Kynoch, Harlaxton, Withcott, Postmans Ridge and Helidon. In addition, there are a number of scattered rural residential properties along the Project alignment.

The Project will be constructed within a predominantly greenfield corridor, with approximately 5.6 km of brownfield development (i.e. the Project is co-located with the Western Line for 4.8 km at the western extent and is co-located with the Main Line for 800 m at the eastern extent). The noise and vibration study area for the Project is the area that falls within 2 km of the Project alignment (refer Figure 15.1).

15.6.1 Sensitive receptors

Sensitive receptors applicable to the Project have been identified throughout the noise and vibration study area. The identification and definition of sensitive receptors applicable to the construction and operation assessments varied:

- A total of 3,811 sensitive receptors were identified in the noise and vibration study area for the construction noise assessment. The sensitive receptors were identified using a combination of land property information (Queensland Property Database) and interrogation of high-resolution aerial imagery, with sensitive receptors defined using the CoP Vol 2 definitions. Of the 3,811 sensitive receptors:
  - 56 receptors are used for industrial purposes and are not classified as noise sensitive. As such, these have only been included in the vibration and blasting assessments.
  - 12 receptors were identified in the EIS cultural heritage survey (Appendix S: Non-Indigenous Cultural Heritage) and have been considered by this assessment to be historical heritage structures and vibration sensitive receptors
  - The remaining 3,743 receptors are considered to be noise and vibration sensitive receptors
  - Six noise and vibration sensitive receptors and a further eight vibration sensitive receptors are located within the Project disturbance footprint.
- A total of 3,910 sensitive receptors were identified in the noise and vibration study area for the operational rail noise assessment. All structures above 9 m^2 were initially identified and were considered to be a sensitive receptor as defined in the DTMR Policy and Interim Guideline.

The majority of the sensitive receptors are residential dwellings that are predominantly associated with suburbs of Toowoomba, with the number of sensitive receptors in the Lockyer Valley significantly less, reflecting the local settlement patterns. There are also other sensitive receptors present, including schools, childcare facilities, places of worship, social and recreational facilities, and Baillie Henderson Hospital.

Sensitive receptors can also include;

- A protected area, an area identified under a conservation plan as a critical habitat, or an area of major interest under the *Nature Conservation 1992* (Qld)
- An outdoor recreational area (such as public park or gardens open to the public, whether or not on payment of a fee, for passive recreation other than for sport or organised entertainment) or a private open space
- Industrial land use is only classified vibration sensitive to vibration emissions and is not included in the airborne noise impact assessments.

Each sensitive receptor in the noise and vibration study area was identified and located using a combination of land property information (Queensland Property Database) and investigation of detailed aerial imagery. Sensitive receptors were identified both in townships and on scattered rural properties. This approach is consistent with the ToR requirements for construction noise and vibration and has been applied across the Inland Rail Program in Queensland. The resultant sets of construction noise and vibration sensitive receptors may differ from those of other environmental assessments of the Project. This is considered acceptable.

For a Project of this scale, it is not unusual for the location at which sensitive receptors are modelled to differ slightly from their true location. Differences of this magnitude will not materially impact the results of this assessment.

Due to the large number of sensitive receptors in the construction noise and vibration study area, nine Noise Catchment Areas (NCAs) were formed based on locality boundaries in the noise and vibration study area. The NCAs are summarised in Table 15.7 and the extent of each NCA is included in Appendix O: Construction Noise and Vibration.

TABLE 15.7: NOISE CATCHMENT AREAS

NCA	Localities	Description	Number of noise sensitive receptors
NCA_01	Gowrie Junction	Gowrie Junction township, agriculture, isolated residences	593
NCA_02	Cranley	Cranley residences, isolated residences, Baillie Henderson Hospital, agriculture	701
NCA_03	Blue Mountain Heights	Agriculture, residences	246

NCA	Localities	Description	Number of noise sensitive receptors
NCA_04	Mount Kynoch	Agriculture, Mount Kynoch residences, isolated residences	84
NCA_05	Harlaxton	North Harlaxton, Harlaxton Quarry, agriculture	759
NCA_06	Remainder of study area	Agriculture, isolated residences, Wilsonton Heights, east Harlaxton, Cotswold Hills	974
NCA_07	Postmans Ridge	Agriculture, isolated residences	74
NCA_08	Lockyer, Upper Lockyer	Agriculture, isolated residences	30
NCA_09	Helidon, Helidon Spa	Agriculture, Helidon township	282
		Total	**3,743**

15.6.2 Noise monitoring

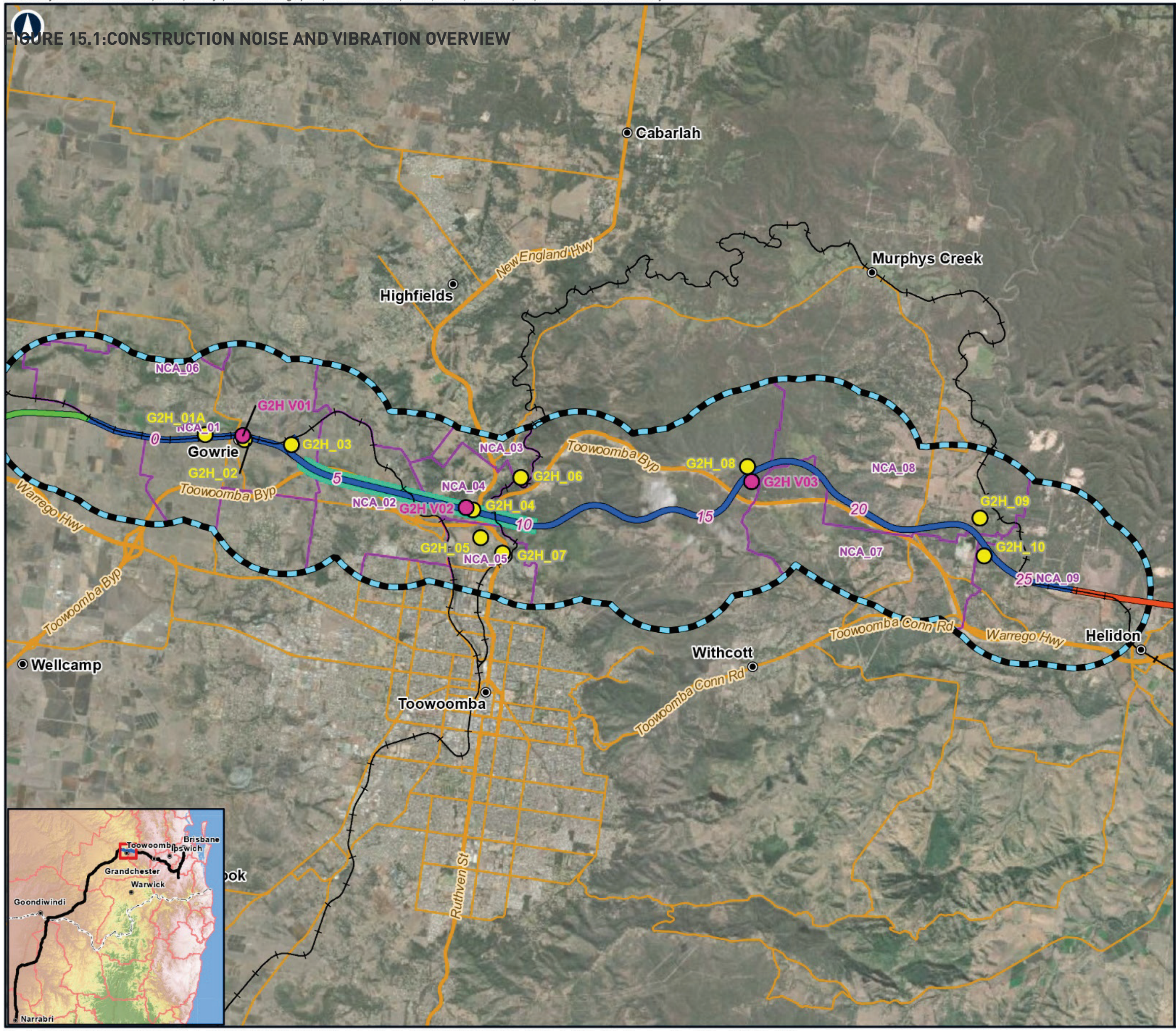
Ambient noise monitoring was conducted at 10 locations in the noise and vibration study area during December 2018. This included both long-term monitoring and short-term attended measurements. The long-term monitoring was used to identify existing sources of noise in the study areas, quantify and characterise the existing noise environment and establish background noise level referenced in establishing relevant noise criteria.

Noise monitoring locations are shown in Figure 15.1.

The locations for the noise logging were chosen through examination of aerial photography to represent the existing noise environment near sensitive receptors. Attended noise measurements were undertaken to determine the nature of the local noise environment. Noise logger locations were chosen to be representative of the noise sensitive receptors most likely to be adversely affected by the construction and operation of the Project.

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 15.1: CONSTRUCTION NOISE AND VIBRATION OVERVIEW



INLAND RAIL

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The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

GOWRIE TO HELIDON

Figure 15.1 - Construction Noise and Vibration Overview

LEGEND

- 5 Chainage (km)
- Localities
- Vibration monitoring locations
- Noise monitoring locations
- Noise and vibration study area
- NCA
- Existing rail
- B2G project alignment
- G2H project alignment
- H2C project alignment
- Tunnel
- Major roads
- Minor roads

0 3 6 km

Coordinate System: GDA 1994 MGA Zone 56

Date: 4/02/2021
Author: FFJV GIS
Data Sources: FFJV
Paper: A4
Scale: 1:140,000

Map by: NW/MEF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201908161001_G2H_Noise_Vibration\320-EAP-201908161001_ARTC_v2_A4_Fig15.1_Overview_v6.mxd Date: 4/02/2021 13:13

The results of the background noise monitoring are provided in Table 15.8. The monitoring results are typical of noise levels experienced in rural environments with typically low background noise levels that are dominated by environmental noise such as birds and insects. Additional detail on the existing noise environment can be found in Appendix O: Construction Noise and Vibration. The monitoring of the existing environment takes into consideration any potential cumulative noise impacts of existing developments in the vicinity of the Project. Cumulative impacts are further addressed in Section 15.9 and Chapter 22: Cumulative Impacts.

TABLE 15.8: EXISTING RATING BACKGROUND LEVELS

Monitoring location	Rating background level, dBA		
	Day[1]	Evening[1]	Night[1]
G2H_01	36	37	31
G2H_02	40	41	32
G2H_03	38	39	36
G2H_04	46	45	37
G2H_05	41	42	32
G2H_06	35	34	30
G2H_07	45	41	31
G2H_08	31	33	36
G2H_09	32	29	27
G2H_10	34	31	29

Table notes:

1. In accordance with the CoP Vol 2, time of day is defined as follows:
   Day: the period from 7.00 am to 6.00 pm Monday to Friday or 8.00 am to 1.00 pm on Saturday
   Evening: the period from 6.00 pm to 10.00 pm Monday to Friday, 1.00 pm to 10.00 pm on Saturday or Sunday 7.00 am to 10.00 pm on Sunday
   Night: Monday to Sunday 10.00 pm to 7.00 am

15.6.3 Existing railway noise levels

The Project is co-locating within the existing West Moreton System and the assessment of railway noise was required to consider the railway noise from both the existing rail movements, which will still operate with the Project, and the additional railway operations introduced by the Project.

For large-scale transport infrastructure such as the Project, the existing railway noise levels at sensitive receptors are often determined through detailed calculation. A noise prediction model was applied to determine the potential daytime and night-time existing railway noise levels in the noise and vibration study area. Additional detail on the existing noise environment can be found in Appendix P: Operational Railway Noise and Vibration.

15.6.4 Vibration monitoring

Vibration monitoring was conducted at three locations in the noise and vibration study area during April 2019. Table 15.9 contains the vibration measurement location summary, showing the peak particle velocity (PPV) vibration levels from the monitoring period. Sources of existing background vibration include vehicle movements.

TABLE 15.9: BACKGROUND VIBRATION MEASUREMENTS

Site	Date	Time	PPV (mm/s)
G2H_V01	4/07/2019	4:31 pm	0.24
G2H_V02	4/07/2019	5:24 pm	0.10
G2H_V03	5/07/2019	9:36 am	0.10

15.7 Assessment criteria

Noise and vibration criteria are specific to the type or source of noise or vibration. Noise criteria for different types of noise use various noise parameters, goals and limits. Each of the following categories of noise and vibration sources is assessed individually, as is consistent with the relevant legislation, policies and guidelines, which concern the assessment of noise and vibration:

- External construction noise goals applied to the assessment of construction activities and construction sites, including ground-borne noise
- Noise assessment criteria for construction traffic
- Vibration assessment standards for intensive vibration-generating construction activities
- Vibration and airblast overpressure standards for blasting activities
- Operational railway ground-borne vibration and ground-borne noise criteria
- Operational noise criteria for the fixed infrastructure associated with the Project
- Operational road traffic noise criteria for changes to public roads.

15.7.1 Construction noise assessment criteria

15.7.1.1 External construction noise criteria

Residential dwellings

For dwellings (including hotels and motels), noise impacts associated with construction activities are to be assessed using the noise criteria in Table 15.10, adapted from the CoP Vol 2. Exceeding the upper limits is considered to cause significant annoyance and the upper limits are used as noise criteria. The lower limits are generally considered to be just perceptible and the CoP Vol 2 states that all reasonable and practicable measures should be implemented to achieve the lower limit. The limits are for the noise contribution from construction only (component limit) and are defined as external façade corrected noise levels at 1.5 m above the highest floor level.

TABLE 15.10: EXTERNAL CONSTRUCTION NOISE CRITERIA

		External noise level $L_{Aeq,adj,15\,min}$ dBA			
		Day		Evening	Night
NCA	Localities	Upper limit	Lower limit		
NCA_01	Gowrie Junction	65	50	45	45
NCA_02	Cranley	65	50	45	45
NCA_03	Blue Mountain Heights	65	50	45	45
NCA_04	Mount Kynoch	70	56	50	45
NCA_05	Harlaxton	70	51	46	45
NCA_06	Remainder of Study Area	65	50	45	45
NCA_07	Postmans Ridge	65	50	45	45
NCA_08	Lockyer/Upper Lockyer	65	50	45	45
NCA_09	Helidon/Helidon Spa	65	50	45	45

Table 15.11 defines the hours at which CoP Vol 2 construction noise criteria are applicable. This table does not indicate planned hours of work, which are outlined in Chapter 6: Project Description. The majority of the construction works will occur during the standard hours, though the tunnel boring machine will operate 24 hours a day, 7 days a week, which will be supported by aboveground works at the western tunnel portal.

TABLE 15.11: COP VOL 2 CONSTRUCTION NOISE AND VIBRATION WORK PERIODS FOR CONSTRUCTION ACTIVITIES

Work period	General construction and construction traffic	Blasting
Standard hours	Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm	Monday to Friday 9.00 am to 5.00 pm Saturday 9.00 am to 1.00 pm
Non-standard hours—day/evening	Monday to Friday 6.00 pm to 10.00 pm Saturday 1.00 pm to 10.00 pm Sunday 7.00 am to 10.00 pm	Generally, blasting is not to be conducted outside standard hours. Any blasting outside of standard hours must be approved by the DTMR prior to blasting. It is noted that reduced limits may be required to be achieved.
Non-standard hours—night time	Monday to Sunday 10.00 pm to 7.00 am	

15.7.2 Other sensitive land uses

The CoP Vol 2 defines internal noise criteria for critical facilities, which are to be met, where reasonable and practicable, and which applies for the operational hours of the facility. These are presented in Table 15.12.

TABLE 15.12: COP VOL 2 INTERNAL CONSTRUCTION NOISE CRITERIA FOR CRITICAL FACILITIES

Type of occupancy/activity	Internal noise level $L_{Aeq,adj,15\ minute}$, dBA
Medical/health buildings (wards, surgeries, operating theatres, consulting rooms)	40
Educational/research facilities (rooms designated for teaching/research purposes)	45
Court of law (court rooms)	35
Court of law (court reporting and transcript areas, Judges' chambers)	40
Community buildings (libraries, places of worship)	45

Critical facilities have been identified in the noise and vibration study area. All applicable critical facilities are presented in Table 15.13 and are mapped in Appendix O: Construction Noise and Vibration.

TABLE 15.13: IDENTIFIED CRITICAL FACILITIES

Receptor type	Name	Locality	NCA	ID	Approximate distance to Project alignment (m)
Medical	Baillie Henderson Hospital (23 receptors)	Cranley	NCA_02	MED0001–MED0023	980–1,340
Community	Wilsonton Congregation of Jehovah's Witnesses	Wilsonton Heights	NCA_06	COM0001	1,740
	Toowoomba Christian Fellowship	Birnam	NCA_06	COM0002	1,480
	New Hope Church	Harlaxton	NCA_05	COM0003	1,900
	Toowoomba North Church of Christ	Harlaxton	NCA_05	COM0004	1,650
	Harlaxton Neighbourhood Centre	Harlaxton	NCA_05	COM0005	890
	Harlaxton Community Hall	Harlaxton	NCA_05	COM0006	680
	Gateway Church Toowoomba	Harlaxton	NCA_05	COM0007	820
	Postmans Ridge Pioneers Memorial Hall	Postmans Ridge	NCA_07	COM0008	1,330
	Saint Joseph's Church	Helidon	NCA_09	COM0009	1,780
Educational	Gowrie State School	Gowrie Junction	NCA_01	EDU0001	770
	Rockville Primary School	Rockville	NCA_06	EDU0002	1,890
	Youth and Community Learning Centre	Harlaxton	NCA_05	EDU0003	1,650
	Downlands College	Harlaxton	NCA_05	EDU0004	1,820

The criteria listed in Table 15.12 are applicable during the facility's hours of operation. Construction noise impacts that may result from the Project have been assessed against these criteria at all hours. Each critical facility's hours of operation are to be confirmed during detailed design based on consultation with owners and occupants.

Additional operational community noise receptors were identified as:

- Teen Challenge, Toowoomba
- Taoist Tai Chi Society of Australia
- Reg Veacock Park, Harlaxton
- Blue Mountains Reserve, Harlaxton
- North Ruthven Reserve, Harlaxton
- Perry Street Park, Harlaxton
- Harlaxton Blocks Park
- Kate Street Park, North Toowoomba
- Kate's Place Early Education and Child Care, north Toowoomba
- Parkland Hilltop Crescent, Blue Mountains Heights
- Norris Playground, Blue Mountains Heights
- Toowoomba Kart Club, Postmans Ridge.

15.7.3 Noise characteristics

Noise characteristics, such as low frequency noise, have been taken into consideration through the application of correction factors, as per the CoP Vol 2. These correction factors are listed in Table 15.14. Details of this can be found in Appendix O: Construction Noise and Vibration.

TABLE 15.14: COP VOL 2 ADJUSTMENT FACTORS

Factor	Assessment/ measurement	When to apply	Correction	Comments
Tonal noise	1/3 octave or narrow band analysis	Level of 1/3 octave band exceeds the level of the adjacent bands on both sides by: - 5 dB or more if the centre frequency of the band containing the tone is above 400 Hz - 8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive - 15 dB or more if the centre frequency of the band containing the tone is below 160 Hz.	5 dB	Narrow-band frequency analysis may be required to precisely detect presence of tonality
Low frequency noise	Measurement of C-weighted and A-weighted level	Measure/assess C and A frequency weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more.	5 dB	C-weighting is designed to be more responsive to low-frequency noise. All noise energy down to 10 Hz should be considered.
Impulsive noise	A-weighted fast response and impulse (I) response or C-weighted for low frequency noise	If difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB. If difference in C-weighted maximum noise levels between fast response and impulse response is greater than 2 dB for low frequency noise.	Apply difference in measured levels as the correction, up to a maximum of 5 dB	Impulse response is defined by a short rise time of 35 milliseconds (ms) and decay time of 1.5 seconds (s)

Factor	Assessment/ measurement	When to apply	Correction	Comments
Intermittent/ modulating noise	Measurement of difference between L_{A10} and L_{A90}, average difference between short term samples, or subjectively assessed	▸ Difference between L_{A10} and L_{A90} exceeds 5 dB repeatedly for a characteristic averaging period (e.g. 10 seconds) for intermittent sources ▸ Average difference between measured L_{Aeq} levels exceeds 5 dB for a characteristic sampling frequency (e.g. 10 Hz) for rapidly varying source ▸ Subjectively annoying for a combination not easily characterised.	5 dB	Adjustment to be applied for night-time only
Maximum adjustment	Refer to individual modifying factors	Where two or more adjustment factors are indicated	Maximum correction of 10 dBA	-

15.7.4 Construction road traffic noise criteria

Haulage/transportation associated with construction activities on public roads in the noise and vibration study area, or beyond, has the potential to increase noise levels in the vicinity of existing sensitive receptors. CoP Vol 2 specifies the following criteria to limit traffic noise caused by construction traffic:

- Construction traffic not to increase the pre-construction traffic noise level $L_{A10,\ 1\ hour}$ by more than 3 dBA.

An assessment against this limit has been undertaken to understand potential impacts and develop, where applicable, appropriate mitigation measures.

15.7.5 Construction ground-borne noise criteria

The construction ground-borne noise investigation limits set out in the CoP Vol. 2 have been applied to the Project and are presented in Table 15.15. There is no applicable ground-borne noise limit for industrial buildings.

TABLE 15.15: CONSTRUCTION GROUND-BORNE NOISE INVESTIGATION LIMITS (COP VOL 2)

Building	Ground-borne noise limit	
	Work period	L_{ASMax}, dBA
Dwellings (including hotels and motels)	(Standard hours) Monday to Friday, 7.00 am–6.00 pm Saturday, 8.00 am–1.00 pm	40
	(Non-standard hours—day/evening) Monday to Friday, 6.00 pm–10.00 pm Saturday, 1.00 pm–10.00 pm Sunday, 7.00 am–10.00 pm	35
	(Non-standard hours—night) Monday to Sunday, 10.00 pm—7.00 am	35
Medical/health buildings (wards, surgeries, operating theatres, consulting rooms)	All	35
Educational/research facilities (rooms designated for teaching/research purposes)	While in use	35
Community buildings (libraries, places of worship)		40
Commercial (offices)		40
Retail areas		45

15.7.6 Construction vibration criteria

Ground vibration criteria are defined in CoP Vol 2. The effects of ground vibration from construction activities may be split into the following two categories:

- Human comfort—disturbance to building occupants arising from vibration, which inconveniences or possibly disturbs the occupants or users of the building. The vibration criteria are based on the requirements of British Standard BS 5228-2:2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 2 Vibration* (BS 5228.2) (British Standards, 2009b).
- Building damage—vibration that may compromise the integrity of the building structure itself. The vibration criteria are based on the requirements of German Standard DIN 4150—Part 3—*Structural Vibration in Buildings—Effects on Structures 1999* (DIN 4150.3) (Deutsches Institut für Normung, 1999).

15.7.6.1 Human comfort

In order to minimise annoyance due to ground-borne construction vibration, CoP Vol 2 adopts the vibration levels that are presented in Table 15.16. The lower limits are generally considered to be just perceptible if exceeded. The upper limits under CoP Vol 2 are considered to cause significant annoyance if exceeded.

All reasonable and practicable measures are to be implemented to achieve the lower limit. The CoP Vol 2 also provides that '*exceedance of the upper limit requires immediate action and extensive community consultation to determine further mitigation measures*'.

For this assessment, all the criteria are applicable apart from the criteria relevant to 'No courts of law' (i.e. no courts of law were identified in the noise and vibration study area).

TABLE 15.16: HUMAN COMFORT VIBRATION LIMITS TO MINIMISE ANNOYANCE

<table>
<tr><th rowspan="2">Building</th><th rowspan="2">Work period</th><th colspan="2">Resultant PPV (mm/s)</th></tr>
<tr><th>Lower limit</th><th>Upper limit</th></tr>
<tr><td rowspan="3">Dwellings (including hotels and motels)</td><td>Standard hours</td><td>1.0</td><td>2.0</td></tr>
<tr><td>Non-standard hours—evening</td><td>0.3</td><td>1.0</td></tr>
<tr><td>Non-standard hours—night</td><td>0.3</td><td>1.0</td></tr>
<tr><td>Medical/health buildings (wards, surgeries, operating theatres, consulting rooms)</td><td>All</td><td rowspan="4">0.3</td><td rowspan="4">1.0</td></tr>
<tr><td>Educational facilities (rooms designated for teaching purposes)</td><td rowspan="3">While in use</td></tr>
<tr><td>Court of law (court rooms)</td></tr>
<tr><td>Court of law (court reporting and transcript areas, judges' chambers)</td></tr>
<tr><td>Community buildings (libraries, places of worship)</td><td rowspan="2">While in use</td><td rowspan="2">1.0</td><td rowspan="2">2.0</td></tr>
<tr><td>Commercial (offices) and retail areas</td></tr>
</table>

15.7.6.2 Building/structural damage

CoP Vol 2 relies on DIN 4150.3 and BS 5228.2 for building damage. DIN 4150.3 distinguishes between short-term and long-term vibration, with definitions for these forms of vibration provided in Table 15.17.

TABLE 15.17: DIN 4150.3 DEFINITIONS

Vibration type	DIN 4150.3 definition
Short-term	Vibration that does not occur often enough to cause structural fatigue and that does not produce resonance in the structure
Long-term	All types of vibration not covered by the definition of short-term vibration

DIN 4150.3 provides recommended maximum levels of vibration that reduce the likelihood of building damage caused, and are presented in Table 15.18. These criteria have been adopted for the Project as short-term vibration criteria to avoid building/structural damage.

TABLE 15.18: DIN4150.3 STRUCTURAL DAMAGE 'SAFE LIMITS' FOR SHORT-TERM BUILDING VIBRATION

Group	Type of structure	PPV in mm/s based on frequency, at building foundation		
		1 to 10 Hz	10 to 50 Hz	50 to 100 Hz[1]
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or use (i.e. residential)	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (e.g. heritage-listed)	3	3 to 8	8 to 10

Table notes:
Hz = Hertz
Frequency (f)—the repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high-pitched sound and a low frequency to a low-pitched sound.
1. For frequencies above 100 Hz, the higher values in the 50 to 100 Hz column should be used.

DIN4150.3 limits listed in Table 15.19 have been adopted as long-term vibration criteria to avoid building/structural damage. DIN 4150.3 states that buildings exposed to higher levels of vibration than recommended limits would not necessarily experience damage.

TABLE 15.19: DIN4150.3 STRUCTURAL DAMAGE 'SAFE LIMITS' FOR LONG-TERM BUILDING VIBRATION

Group	Type of structure	PPV in mm/s of vibration in horizontal plane of highest floor, at all frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	10
2	Dwellings and buildings of similar design and/or use (i.e. residential)	5
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under groups 1 or 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	2.5

'Damage' is defined by DIN 4150.3 to include even minor non-structural effects, such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load-bearing walls. DIN 4150.3 also states that when vibrations higher than the 'safe limits' are present, it does not necessarily follow that damage will occur.

DIN4150.3 also provides guideline values for evaluating the effects of vibration on buried pipework, which are summarised in Table 15.20. For consideration of long-term vibration, guideline values should be reduced by 50 per cent.

TABLE 15.20: DIN4150.3 GUIDELINE VALUES FOR EVALUATING THE EFFECTS OF VIBRATION ON BURIED PIPEWORK

Line	Pipe material	Guideline values for PPV measured on the pipe in mm/s	
		Short term vibration	Long term vibration
1	Steel (including welded pipes)	100	50
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80	40
3	Masonry, plastic	50	25

Vibration limits specific to particular underground infrastructure will be confirmed in consultation with stakeholders during detailed design, noting that consultation has already commenced within services provided intersecting the Project. The Roma Brisbane Gas Pipeline operated by APT Petroleum, a subsidiary of APA Group, is traversed by the Project at a number of locations, including in tunnel (Chainage (Ch) 7.7 km). Vibration impacts at these locations will not exceed the limits listed in Table 15.21.

TABLE 15.21: ROMA BRISBANE GAS PIPELINE VIBRATION LIMITS

Line	Pipe material	PPV limit (mm/s)
1	Coal tar enamel coated, poorly coated	10
2	Other	20

15.7.7 Construction blasting criteria

Controlled blasting is anticipated to be used in order to excavate material along some sections of the Project alignment. Construction blasting can result in two adverse environmental effects—airblast over pressure and ground vibration. The airblast over pressure and ground vibration produced may cause human discomfort, inappropriately designed and implemented blasts, may have the potential to cause damage to structures, architectural elements and services.

The DEHP *Guideline—Noise and Vibration from Blasting* (DEHP, 2016a) is adopted by the CoP Vol 2 to minimise annoyance and discomfort to persons at noise sensitive land uses as a result of blasting. The CoP Vol 2 also recommends the use of Australian Standard 2187.2-2006 *Explosives—Storage and Use Part 2: Use of Explosives—Appendix J* (Standards Australia, 2006a) 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.

15.7.7.1 Blasting criteria

In relation to airblast overpressure, the following criteria have been adopted from section 440ZB of the EP Act, which are also reflected in DEHP *Guideline—Noise and Vibration from Blasting* (DEHP, 2016a). These criteria should be used to assess the annoyance from airblast to sensitive land uses:

- Not more than 115 dB(Z) peak for 9 out of any 10 consecutive blasts
- Not more than 120 dB(Z) peak for any blasts.

For the purposes of the Project, the AS 2187.2 and CoP Vol 2 blasting ground vibration criteria have been adopted and the proposed Project criteria are summarised in Table 15.22.

TABLE 15.22: BLASTING GROUND VIBRATION CRITERIA SUMMARY

Category	Human comfort	Structural damage[1]
Sensitive structures (e.g. residential, theatres, schools)	5 mm/s for 95 per cent blasts per year; 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply[2]	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Occupied non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	25 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation.	50 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Occupied non-sensitive structures that include masonry, plaster and plasterboard in their construction (e.g. factories and commercial premises)	25 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation.	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Unoccupied non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	N/A	100 mm/s maximum unless agreement is reached with the owner that a higher limit may apply

Category	Human comfort	Structural damage[1]
Unoccupied non-sensitive structures that include masonry, plaster and plasterboard in their construction	N/A	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Buildings of special value or significance (may include historical buildings, monuments)	2 mm/s	N/A

Table notes:

1. The values above are less stringent than those in DIN 4150.3. This is because DIN 4150.3 considers resonance in buildings from continuous vibration. Due to the short duration of blasting events, the propensity for resonance in buildings is minimal, giving rise to higher criteria.
2. It should be noted that the human comfort limits should be based off the values presented above from the DEHP guideline as per the CoP Vol 2.

The criteria outlined in Table 15.22 does not apply to buildings with long span floors; specialist structures such as reservoirs, dams and hospitals; or buildings housing equipment sensitive to vibration. These require special considerations, which may necessitate taking additional measurements on the structure itself.

Critical facilities identified in the noise and vibration study area are outlined Section 15.7.1.1. Other sensitive receptors applicable to these criteria include the Roma Brisbane Gas Pipeline, along with the 12 sites of non-Indigenous cultural heritage.

These will need to be confirmed and if any additional structures with a particular sensitivity to vibration are identified these should be addressed on a case by case basis.

15.7.7.2 Proposed hours and frequency of blasting activities

The CoP Vol 2 defines the working periods for blasting activities as follows:

- Blasting should generally only be permitted during the hours of 9:00 am to 5:00 pm Monday to Friday and Saturday 9:00 am to 1:00 pm (standard hours)
- Generally, blasting is not to be conducted outside standard hours. Any blasting outside of standard hours must be approved by the DTMR prior to blasting. It is noted that reduced limits may be required to be achieved.

15.7.8 Operational noise and vibration criteria

The following noise assessment criteria are relevant to the operation of the proposed activities of the Project:

- Noise impact assessment criteria for the management of railway noise
- Noise assessment levels for operational road traffic noise impacts due to changes to the local road network
- Noise criteria applied to the fixed tunnel infrastructure required for adequate ventilation of the intermediate tunnel shaft.

15.7.8.1 Operational railway noise and assessment criteria

ARTC is implementing a consistent approach for the assessment and management of operational railway noise across the Inland Rail Program to ensure the potential noise-related impacts to public health, amenity and disturbance are managed consistently.

If the railway noise levels are predicted or measured to be above the noise criteria at sensitive receptors, reasonable and practicable mitigation measures are to be considered, with the aim to reduce the noise levels to meet criteria and ameliorate potential impacts. The rail noise criteria from the DTMR Policy, Interim Guideline and other railway noise guidelines in use in Australia were considered in the development of the airborne railway noise criteria for the Project.

On the Project, ARTC is adopting the airborne railway noise assessment criteria for residential receptors in Table 15.23. To provide an equitable and best practice approach to managing noise on the Project, the criteria implemented by ARTC are more stringent than the criteria from the DTMR Policy and the Interim Guideline. Accordingly, where the Project achieves the ARTC railway noise criteria at sensitive receptors, the railway noise criteria from the DTMR Policy and Interim Guideline would also be achieved.

The railway noise criteria are specific to the daytime period of 7.00 am to 10.00 pm and the night-time period of 10.00 pm to 7.00 am. The noise assessment criteria are lower for the night-time period due to the greater sensitivity of communities to noise during the night-time.

There are different assessment criteria for new railways and for upgrading existing railway infrastructure. The criteria for new railways are 5 dBA lower (more stringent) based on the assumption that noise mitigation can be more readily implemented on newly constructed sections of railway infrastructure. This criterion will apply to predominantly to the greenfield corridor, where there is no influence from the existing West Moreton System (offset distance of 750 m). The redevelopment criterion applies to the area where the Project is co-located with the West Moreton System (e.g. Gowrie and east of Lockyer Creek) plus the 750 offset distance.

TABLE 15.23: AIRBORNE RAILWAY NOISE ASSESSMENT CRITERIA FOR RESIDENTIAL RECEPTORS

	Noise management levels (external)	
Type of development	**Daytime (7.00 am to 10.00 pm)**	**Night time (10.00 pm to 7.00 am)**
New rail line development[1]	Predicted railway noise levels exceed:	
	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9\ hour)}$ 55 dBA
	L_{Afmax} 80 dBA	L_{Afmax} 80 dBA
Redevelopment of existing rail line[2]	Development increase existing $L_{Aeq(}$period) rail noise levels by 2 dB or more, or existing L_{Amax} rail noise levels by 3 dB or more and predicted rail noise levels exceed:	
	$L_{Aeq(15hour)}$ 65 dBA	$L_{Aeq(9\ hour)}$ 60 dBA
	L_{Afmax} 85 dBA	L_{Afmax} 85 dBA

Table notes:
1. A new rail line development is a rail infrastructure project on land that is not currently an operational rail corridor
2. A redeveloped line is a development on land that is within an existing operational rail corridor, where a line is, or has been, operational or is immediately adjacent to an existing operational rail line, which may result in the widening of an existing rail corridor.

A detailed review of the assessment criteria was undertaken in Appendix P: Operational Railway Noise and Vibration, which identified that the noise levels from ARTC's noise management criteria are more stringent than the DTMR Policy and the Interim Guideline. On this basis, the ARTC noise management criteria were applied in the assessment and, therefore, where the Project achieves these trigger levels at residential receptors, the criteria from DTMR guidelines would also be achieved.

The ARTC noise management approach also includes rail noise management levels for sensitive receptors other than residential land uses. On the Project, ARTC is adopting the noise assessment criteria for sensitive receptors other than residential land use and these are detailed in Table 15.24.

TABLE 15.24: AIRBORNE NOISE MANAGEMENT LEVELS FOR OTHER SENSITIVE RECEPTORS

	Noise management levels (when receptor premises are in use)	
Type of development	**New rail line development[1]**	**Redevelopment of existing rail line[2]**
	Resulting rail noise levels exceed:	Development increases existing rail noise levels by 2 dBA or more in L_{Aeq} for that period, and resulting rail noise levels exceed:
Schools, educational institutions and childcare centres	$L_{Aeq,(1\ hour)}$ 40 dBA (internal)	$L_{Aeq,(1\ hour)}$ 45 dBA (internal)
Places of worship	$L_{Aeq,(1\ hour)}$ 40 dBA (internal)	$L_{Aeq,(1\ hour)}$ 45 dBA (internal)
Hospital wards	$L_{Aeq,(1\ hour)}$ 35 dBA (internal)	$L_{Aeq,(1\ hour)}$ 40 dBA (internal)
Hospital other uses	$L_{Aeq,(1\ hour)}$ 60 dBA (external)	$L_{Aeq,(1\ hour)}$ 65 dBA (external)
Open space—passive use (e.g. parkland, bush reserves)	$L_{Aeq(15hour)}$ 60 dBA (external)	$L_{Aeq(15hour)}$ 65 dBA (external)
Open space—active use (e.g. sports field, golf course)	$L_{Aeq(15hour)}$ 65 dBA (external)	$L_{Aeq(15hour)}$ 65 dBA (external)

Table notes:
1. A new rail line development is a rail infrastructure project on land that is not currently an operational rail corridor
2. A redeveloped line is a development on land that is within an existing operational rail corridor, where a line is, or has been, operational or is immediately adjacent to an existing operational rail line, which may result in the widening of an existing rail corridor

15.7.8.2 Operational railway ground-borne vibration assessment criteria

People can perceive floor vibration at levels well below those likely to cause damage to buildings or their contents. For most receptors, the human comfort vibration criteria are the most stringent and it is generally not necessary to set separate criteria for vibration effects on internal building contents.

The exception can be some scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment), which can require more stringent design goals than those applicable to human comfort. A desktop survey of land uses within 2 km of the Project alignment did not identify premises expected to have these types of scientific equipment.

For intermittent events, such as train passby events, the vibration dose value (VDV) is applied as a cumulative measure of the vibration levels associated with all rollingstock operations in the assessment period. The VDV considers the combined effects of the level of the ground-borne vibration and the duration of vibration generating events; as such, it is suited for the assessment of transient sources such as rollingstock activities.

The ground-borne vibration assessment criteria for railway operations are detailed in Table 15.25 and were derived from the Interim Guideline as they are specific for the assessment of ground vibration associated with railways. *BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings—Vibration sources other than blasting* (British Standards, 2008) advises the criteria are levels of vibration that are expected to be just perceptible in typical residential environments, and likely to be tolerable to building occupants.

TABLE 15.25: RAILWAY GROUND-BORNE VIBRATION ASSESSMENT CRITERIA

		Internal ground-borne vibration criteria[2]	
Type	**Sensitive receptors**	**Use period[1]**	**Vibration dose value**
New railway or upgrading existing railway	Accommodation activities	Daytime	≤ 0.20 $m/s^{1.75}$
		Evening	
		Night-time	≤ 0.13 $m/s^{1.75}$
	Educational establishment, childcare centres, health care services, hospitals, community uses, places of worship and offices	While in use	≤ 0.40 $m/s^{1.75}$ (all areas)
			≤ 0.10 $m/s^{1.75}$ (critical areas)

Table notes:

1. Daytime 7.00 am to 6.00 pm, evening 6.00 pm to 10.00 pm and night-time 10.00 pm to 7.00 am
2 Table 2.2.3—Ground borne vibration criteria, DTMR Interim Guideline Operational Railway Noise and Vibration—Government Supported Transport Infrastructure, March 2019.

15.7.8.3 Operational railway ground-borne noise assessment criteria

The ground-borne vibration from train passby events is sufficient to cause floors or walls of the structure to vibrate, which can result in an audible low frequency rumble inside the buildings. This is termed as ground-borne or regenerated noise.

ARTC is applying the ground-borne noise criteria in Table 15.26 on the Project, which have been developed with reference to ground-borne noise assessment criteria from the Interim Guideline and other railway noise guidelines. Where ground-borne noise levels are above the trigger levels, ARTC will investigate the implementation of feasible and practicable measures to control ground-borne noise.

The ground-borne noise criteria are generally implemented where the ground-borne noise levels are higher than the airborne noise from the rail operations, and where the ground-borne noise levels are expected to be audible in habitable rooms.

TABLE 15.26: RAILWAY GROUND-BORNE NOISE ASSESSMENT CRITERIA

Type of development	Sensitive receptors	Internal ground-borne noise criteria	
		Use period[1]	SEMs[2]
New railway or upgrading existing railway	Accommodation activities	Daytime	≤ 40 dBA
		Evening/night-time	≤ 35 dBA
	Educational establishments, childcare centres, health care services, hospitals	While in use	≤ 35 dBA
	Community uses (excluding a court of law), places of worship, offices		≤ 40 dBA
	Court of law (court rooms)		≤ 30 dBA

Table notes:

1. Daytime 7.00 am to 6.00 pm, evening 6.00 pm to 10.00 pm and night-time 10.00 pm to 7.00 am
2. Single Event Maximum: Arithmetic average of L_{ASmax} levels from the 15 single highest events, or all events if less than 15, during a Use Period within a 24-hour period.

15.7.8.4 Operational road traffic noise criteria

Table 15.27 presents the applicable CoP Vol 1 assessment criteria for different noise sensitive land uses with the potential to be affected by the operation of roads subject to changes as part of the Project (refer Chapter 6: Project Description for details on these proposed changes). The external noise criteria are assessed 1 m from the façade at a height of 1.5 m from finished floor level or mid-window height, whichever is the higher. Outdoor educational and passive recreational areas are assessed in the free field. Note that due to the low existing noise levels throughout the noise and vibration study area, described in Section 15.6, the more stringent criteria of 60 $L_{A10\,(18h)}$ dBA has been adopted as a conservative measure for residential land uses.

TABLE 15.27: OPERATIONAL ROAD TRAFFIC ASSESSMENT CRITERIA (COP VOL 1)

Category	Criteria (dBA)		
	Existing residences (façade corrected)	Educational, community and health buildings (façade corrected)	Outdoor educational and passive recreational areas (including parks) (free field)
New road—access controlled	63 L_{A10} (18h), existing level > 55 L_{A10} (18h) 60 L_{A10} (18h), existing level ≤ 55 L_{A10} (18h)	58 L_{A10} (1h)	63 L_{A10} (12h)
Upgrading existing road	68 L_{A10} (18h)	65 L_{A10} (1h)	

In cases where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through reasonable and practicable measures to meet the assessment criteria.

15.7.8.5 Operational fixed infrastructure noise objectives

The potential noise emissions from the operational fixed infrastructure has been assessed against criteria adopted from the EPP (Noise). As operations can occur any time during the day or night, the most onerous criteria are during the night-time (10.00 pm to 7.00 am). The following acoustic quality objectives from the EPP (Noise) relevant to the Project have been used to assess fixed infrastructure noise impacts. These are shown in Table 15.28.

TABLE 15.28: ACOUSTIC QUALITY OBJECTIVES (EPP (NOISE))

Sensitive receptor	Internal noise objective		
	$L_{Aeq,1hr}$, dBA	$L_{A10,1hr}$, dBA	$L_{A1,1hr}$, dBA
Residential (indoors—night-time)^	30	35	40
Hospital, surgery, or other medical institutions (for indoors)—anytime, other than visiting hours^	30	-	-
Commercial and retail activity (for indoors)—when the activity is open for business*	45	-	-

Table notes:

^ Health and wellbeing, in relation to the ability to sleep

* Applies to health and wellbeing, in relation to the ability to converse.

To predict the noise levels inside a property:

- Noise levels due to simultaneous operation of the fan operating noise sources were predicted at the façade of the nearest noise sensitive property
- 7 dB was subtracted from the predicted value, corresponding to the indicative outside to inside noise reduction of an open window, resulting in the internal noise level. This is consistent with AS 3671-1989—*Acoustics—Road traffic noise intrusion—Building siting and construction* (Standards Australia, 1989).

15.8 Predicted impacts

15.8.1 Airborne construction noise impacts

A summary of the predicted construction noise impacts associated with each stage of construction are assessed against standard and non-standard hours criteria, as per the CoP Vol. 2 in Table 15.29 and Table 15.31. Appendix O: Construction Noise and Vibration presents the L_{Aeq} noise level contours for the construction activities for individual properties. Details on the airborne construction noise impact assessment methodology, including plant and equipment modelled for each construction activity and the associated noise emission characteristics, can also be found in Appendix O: Construction Noise and Vibration.

Table 15.29 and Table 15.31 present the external noise criteria and the number of sensitive receptors that exceed each of the criteria for different construction activities. Exceedances of construction noise criteria are listed for each NCA and each sensitive receptor in Appendix O: Construction Noise and Vibration.

Table 15.30 quantifies the level of exceedances during the earthworks' construction activity against the upper standard hours noise limit.

It is important to note that this assessment is representative of the worst-case 15-minute period of construction activity, while the construction equipment is at the nearest potential location within the Project disturbance footprint to each sensitive receptor location. The assessed scenario does not represent the ongoing day to day noise impact at a noise sensitive receptor for an extended period. This approach is in accordance with the CoP Vol 2, as referenced by the ToR.

Particularly noisy activities, such as piling, are likely to persist for only a portion of the overall construction period. In addition, the predictions use the shortest separation distance to each sensitive receptor; however, distances will vary between plant and sensitive receptors. For works that move along the Project alignment, rather than works located at a construction compound, noise exposure at each sensitive receptor would reduce due to an increase in the separation distance.

As outlined in Table 15.29, limiting the Project's construction hours to within the CoP Vol 2 standard hours has the potential to significantly reduce the number of sensitive receptors impacted by the construction of the Project. During CoP Vol 2 standard hours, less stringent construction noise and vibration criteria apply. Restricting works to these hours (which is in line with the planned construction hours) reduces the number of impacted receptors by approximately 40 per cent for drainage works, rail and road civil works, and up to a 65 per cent reduction for site setup/laydown and structures. A much smaller change of 20 per cent is evident for earthworks.

The construction staging is indicative but conservative and is subject to change during detailed design.

TABLE 15.29: CONSTRUCTION NOISE ASSESSMENT IMPACT SUMMARY FOR NON-CRITICAL FACILITIES—NUMBER OF EXCEEDANCES

Time of day		Standard hours		Non-standard hours
Limit: Façade $L_{A,eq(15min)}$		**Lower: 50 dBA**	**Upper: 65 dBA**	**45 dBA**
Number of sensitive receptors exceeding criterion	Drainage	715	94	1383
	Earthworks	1519	192	2131
	Site setup/laydown	492	56	1356
	Rail civil works	1132	111	1981
	Road civil works	430	64	763
	Structures	509	48	1017
	Concrete batching	11	3	18
	Flash-butt welding	1	0	1

TABLE 15.30: LEVEL OF EXCEEDANCE OF UPPER LIMIT EXTERNAL CONSTRUCTION NOISE CRITERIA FOR EARTHWORKS

NCA	Earthworks: level of exceedance above upper limit (standard hours), dBA—non-critical facilities			
	1 2	2 5	5 10	> 10
NCA_01	24	23	24	45
NCA_02	2	1	1	1
NCA_03	0	0	0	0
NCA_04	0	0	0	0
NCA_05	0	0	0	0
NCA_06	17	1	1	11
NCA_07	2	0	1	1
NCA_08	2	4	3	5
NCA_09	7	4	5	7
TOTAL	**54**	**33**	**35**	**70**

TABLE 15.31: CONSTRUCTION NOISE ASSESSMENT IMPACT SUMMARY FOR CRITICAL FACILITIES

Critical facility		Community buildings	Educational facilities	Medical facilities
Limit: Internal $L_{A,eq}$(15min)		**45 dBA**	**45 dBA**	**40 dBA**
Number of sensitive receptors exceeding criterion	Drainage	0	1	20
	Earthworks	1	1	23
	Site setup/laydown	0	1	19
	Rail civil works	0	1	23
	Road civil works	0	1	0
	Structures	0	1	0
	Concrete batching	0	0	0
	Flash-butt welding	0	0	0

Six residential noise sensitive receptors are located within the Project disturbance footprint. It is anticipated that land within the Project disturbance footprint will be acquired for the Project and, therefore, the number of noise sensitive receptors exceeding a criterion does not include these receptors.

The assessment has identified that measures to reduce and control construction noise will need to be developed and implemented for the reasonable and practicable mitigation of potential noise-related impacts at sensitive receptors. The measures will need to be developed at all major construction works.

Individuals will respond to noise differently and just because noise can be audible does not mean it will cause disturbance or annoyance impacts. The subjective response to the potential construction noise levels is discussed further in Appendix O: Construction Noise and Vibration for more detail.

15.8.2 Construction road traffic

During construction there would be a number of construction vehicle movements, increasing noise levels. The construction traffic noise is predicted to exceed the criteria for five roads in the noise and vibration study area, with a maximum predicted increase of 6 dBA.

As per the CoP Vol 2, the calculation of road traffic noise was conducted using the 1-hour basic noise level algorithm contained in the United Kingdom's Department of Transport (Welsh Office) *Calculation of Road Traffic Noise* Department of Transport, 1988). It was assumed that the traffic speeds, road surface pavement types, gradients, surrounding ground types and distances to nearby receptors will not change as a result of the Project; therefore, the corrections for these factors were omitted and the difference between the basic noise level $L_{A10\ (1hr)}$, with and without the development, were calculated solely based on predicted changes in hourly traffic volumes and the percentages of heavy vehicles.

Table 15.32 presents the roads where the increase in the $L_{A10(1hr)}$ exceeds the criterion. The $L_{A10(1hr)}$ stated are not predictions of impacts at receptors but are instead measures of road traffic noise emissions at a reference distance of 10 m from the road, corrected only for speed and percentage of heavy vehicles. Construction traffic may vary throughout the day and the results of this assessment are to be confirmed during detailed design, based on detailed construction scheduling, confirmation of construction routes and traffic analysis.

TABLE 15.32: ADDITIONAL AIRBORNE NOISE LEVELS FROM CONSTRUCTION TRAFFIC PER YEAR

		$L_{A\ 10,\ (1\ hr)}$, dBA									
		Level without Project					Increase in level by Project				
Road name	**Road section**	**2022**	**2023**	**2024**	**2025**	**2026**	**2022**	**2023**	**2024**	**2025**	**2026**
Cooby Dam Road, Meringandan	Between Klein Road and Pipeline Road	59	60	60	60	60	4	4	4	1	1
Pipeline Road^, Meringandan	Full Extent	57	57	57	57	57	6	6	5	1	1
Gittins Road, Withcott	Between McNamaras Road and Stevens Road	65	65	65	65	65	5	5	0	0	0
McNamaras Road, Withcott	Between Gittins Road and Unnamed Road	63	63	63	64	64	6	6	0	0	0
Unnamed Road, Withcott	Between Jones Road and Unnamed Road	63	63	63	64	64	0	4	1	0	0

Table notes:

^ The section of Pipeline Road north of Paton Road that is proposed to be used in the Project is a private road and may be subject to a separate access agreement.

The maximum predicted increase in airborne noise emission from five roads is greater than the 3 dBA criterion. These roads are primarily in rural locations and the existing base traffic volumes quantities are low. As such, the initial airborne road traffic noise levels are low, before the addition of construction traffic, and the criteria for these roads is stringent. Exceedance of the construction road traffic noise criterion does not necessarily result in perceptibly elevated noise levels at sensitive receptors.

Construction traffic may vary throughout the day and the results of this assessment should be confirmed during detailed design, based on detailed construction scheduling. It is also noted that the traffic impact assessment for the Project (refer Appendix U: Traffic Impact Assessment) currently assumes that all water will be sourced from Lake Cooby and distributed along the Project; however, the Project has identified a number of alternative water sources, including within the Project disturbance footprint, which may reduce impacts on Cooby Dam Road and Pipeline Road.

There are also few sensitive receptors in these areas and, as such, the predicted increase in airborne noise levels in the vicinity of the five roads is not considered to have a significant or adverse impact.

15.8.3 Construction vibration impacts

Vibration-intensive work will be associated with construction works for the Project. Such works may include the use of piling rigs and vibratory rolling activities. Vibration impacts were calculated based on formulae and parameters given by BS 5228-2, such that the predictions represent worst-case impacts. Appendix O: Construction Noise and Vibration details this methodology, including the formulae and parameters adopted.

In order to comply with the cosmetic/structural damage and human discomfort criteria presented in Section 15.5.3, the minimum working distances to the vibration sensitive receptors presented in Table 15.33 should not be encroached.

TABLE 15.33: PROPOSED MINIMUM WORKING DISTANCES FOR VIBRATION INTENSIVE EQUIPMENT

	Predicted setback distance (m)				
	Human Comfort criteria			Building Damage criteria	
	Lower limit non standard hours	Lower limit standard hours Upper limit non standard hours	Upper limit standard hours	Historical heritage building	Dwellings and similar buildings
Plant item	0.3 mm/s PPV	1.0 mm/s PPV	2.0 mm/s PPV	3 mm/s PPV	5.0 mm/s PPV
Vibratory roller—steady state	200	90	60	40	30
Vibratory roller—vibration start up/run down	330	130	80	55	40
Vibratory piling	290	110	60	40	30
Percussive piling	690	275	160	115	80

The minimum working distances presented in Table 15.33 assume individual items of plant would be operating independently. Concurrent operation of vibration intensive equipment would be avoided; however, if it is necessary to operate multiple items of equipment concurrently close to the minimum working distance then vibration monitoring is proposed.

The predicted vibration limit to individual sensitive receptors has also been calculated and detailed results included in Appendix O: Construction Noise and Vibration. A summary of the total exceedances for each construction activity is shown in Table 15.34.

The lower night-time vibration human comfort limit of 0.3 mm/s is predicted to be exceeded at up to 175 sensitive receptors adjacent to the Project due to their proximity to construction works; however, it is expected that vibration intensive equipment will rarely be operated during non-standard hours defined by the CoP Vol 2.

In this instance, the CoP Vol 2 recommends the use of practicable and reasonable mitigation to minimise vibration impacts. These mitigation measures are discussed in Section 15.11.

The primary form of mitigation of vibration would be ensuring vibration-intensive works do not occur within the minimum working distances. If vibration-intensive works are planned within the minimum working distances additional vibration management and mitigation measures may be required, such as adopting alternative construction techniques or equipment or implementing specific approaches to control vibration emissions.

TABLE 15.34: CONSTRUCTION VIBRATION EXCEEDANCES

	Number of exceedances				
	Human comfort limit standard hours		Human comfort limit non standard hours		Structural limit
Activity	Lower	Upper	Lower	Upper	
Site setup/laydown areas					
Vibratory roller—steady state vibration	19	5	40	18	2
Vibratory roller—vibration start up/run down	25	13	64	24	2

Activity	Number of exceedances: Human comfort limit standard hours – Lower	Human comfort limit standard hours – Upper	Human comfort limit non standard hours – Lower	Human comfort limit non standard hours – Upper	Structural limit
Structures					
Vibratory piling—vibration start up/run down	6	2	34	5	1
Percussive piling	33	13	175	31	2
Earthworks/drainage/rail civil works					
Vibratory roller—steady state vibration	45	32	71	41	14
Vibratory roller—vibration start up/run down	53	41	109	48	17
Road civil works					
Vibratory roller—steady state vibration	23	18	33	20	9
Vibratory roller—vibration start up/run down	27	21	60	23	12

For some construction activities, up to seven vibration sensitive receptors fall within the construction activity footprint. It is anticipated that land within the Project disturbance footprint will be acquired permanently or, in some cases, land will also be acquired temporarily to accommodate construction activities. As a result, the number of sensitive receptors exceeding a criterion does not include these receptors.

Twelve receptors were identified as being buildings of special value or significance as part of the cultural heritage assessment (refer Chapter 18: Cultural Heritage). The number of these receptors predicted to exceed the heritage building criteria outlined in Section 15.7.6.2 is given in Table 15.39. More detailed vibration impacts predicted for heritage buildings is provided in Appendix O: Construction Noise and Vibration.

TABLE 15.35: CONSTRUCTION VIBRATION HERITAGE EXCEEDANCES AGAINST STRUCTURAL LIMIT CRITERION

Activity	Number of heritage receptors exceeding 3 mm/s PPV
Site setup/laydown areas	
Vibratory roller—steady state vibration	0
Vibratory roller—vibration start up/run down	1
Structures	
Vibratory piling—vibration start up/run down	1
Percussive piling	1
Earthworks/drainage/rail civil works	
Vibratory roller—steady state vibration	2
Vibratory roller—vibration start up/run down	2
Road civil works	
Vibratory roller—steady state vibration	1
Vibratory roller—vibration start up/run down	1

Seven (7) of the 12 heritage vibration-sensitive receptors are located in the Project disturbance footprint. These buildings/structures may be permanently (demolished or relocated) or temporarily impacted by the Project. The construction methodology near these receptors, and relevant mitigation measures, will determined on a case by case basis. These receptors have not been included in Table 15.35.

15.8.3.1 Underground infrastructure

In order to meet the criteria summarised in Table 15.36, the vibration setback distances provided in Table 15.20 for underground infrastructure will be observed during construction, subject to confirmation with the service provider.

TABLE 15.36: PROPOSED VIBRATION SETBACK DISTANCES FOR BURIED PIPEWORK

	Predicted setback distance (m)			
	Roma Brisbane Gas Pipeline criteria		General buried pipework criteria	
	Coal tar enamel coating, poorly coated	Other	Masonry, plastic or metal construction	Steel construction
Plant Item	10 mm/s PPV	20 mm/s PPV	50 mm/s PPV	100 mm/s PPV
Vibratory roller—vibration start up/run down	15	< 5	< 5	< 5
Vibratory roller—steady state	25	< 5	< 5	< 5
Vibratory piling	10	< 5	< 5	< 5
Percussive piling	40	< 5	< 5	< 5

A list of approximate chainages at which the Roma Brisbane Gas Pipeline is located within 40 m of construction works is given in Table 15.37.

TABLE 15.37: ROMA BRISBANE GAS PIPELINE LOCATIONS OF PROXIMITY TO THE PROJECT

Approximate chainage (km)	Pipeline type	Nearby construction works
3.60	Transmission, distribution	Earthworks
6.70	Transmission, distribution	Access tracks
7.70	Transmission	Tunnel construction
10.60–11.10	Transmission	Rail civil works, earthworks, drainage, laydown, blasting, access tracks
11.80–12.40	Transmission	Laydown areas, access tracks
14.20	Transmission	Access tracks
24.20–25.00	Transmission	Access tracks, laydown areas, structures, road civil works, drainage, rail civil works, earthworks

ARTC have been in contact with APA regarding potential interfaces and required treatments at the locations outlined in Table 15.37. An interaction report has been developed by APA and provided to ARTC to inform the management of the works in these areas (i.e. design and treatments options, specialist studies required).

15.8.4 Construction blasting impacts

The airblast overpressure and vibration from blasting can be managed through the careful design and execution of individual blasting events. At the time of this assessment, the locations requiring blasting throughout the Project disturbance footprint are to be confirmed during detailed design.

Once the location of blasting is known, a detailed blasting assessment will be finalised. As such, the maximum permissible charge weight to meet the criteria outlined in Section 15.5.4 is shown in Table 15.38. The maximum permissible charge weight has been calculated for indicative setback distances for sensitive receptors. The below information is based on a worst-case assumption of a confined blast and geotechnical parameters for good vibration transmission.

TABLE 15.38: CHARGE MASS RANGES FOR SET DISTANCES

		Maximum permissible charge weight (kg)			
Distance to sensitive receptor	Number of receptors	Ground vibration human comfort	Ground vibration structural damage	Airblast overpressure human comfort	Airblast overpressure structural damage
0 to 200 m	0	N/A—specific blast design required or blasting not feasible at these distances			
200 to 400 m	1	45	175	<1	<5
400 to 800 m	5	180	710	<1	30
800 to 1,600 m	29	720	>2,000	<5	250

There were 12 sensitive receptors identified as being buildings of special value or significance as part of the cultural heritage assessment in Appendix S: Non-Indigenous Cultural Heritage, with each of these receptors potentially sensitive to vibration. The maximum permissible charge weight to meet the heritage building criteria outlined in Section 15.5.4 has been calculated for indicative setback distances in Table 15.39. A detailed blasting assessment can be completed once blasting locations have been finalised through detailed design. The below information is based on a worst-case assumption of a confined blast and geotechnical parameters for good vibration transmission.

TABLE 15.39: CHARGE MASS RANGES FOR SET DISTANCES FOR HERITAGE BUILDINGS

Distance to receptor	Total number of receptors for the Project in proximity to one or more blast locations	Maximum permissible charge weight (kg)
	0	N/A— Specific blast design required or blasting not feasible at these distances
200 to 400 m	1	14
400 to 800 m	2	57
800 to 1,600 m	1	230

Specific blasting locations are to be confirmed following the detailed geotechnical investigations during detailed design. Currently, blasting airblast overpressure and vibration sources are represented as areas of works. As per Table 15.39, four heritage receptors are located within 1,600 m of potential blasting locations. The remaining eight heritage vibration receptors are located more than 1,600 m away from the potential blasting locations.

15.8.5 Tunnel construction

15.8.5.1 Tunnel boring machine vibration and ground-borne noise predictions

Vibration and ground-borne noise due to the operation of the TBM have been calculated using the methodology summarised in Appendix O: Construction Noise and Vibration. The PPV (mm/s) vibration levels at the sensitive receptors in the vicinity of the tunnel, and assessment against the nominated criteria for damage and human comfort, predict exceedances against the criteria.

Vibration levels predicted at the foundations of all sensitive receptors relevant to the Toowoomba Range Tunnel were well below the applicable criteria for structural damage due to vibration.

Vibration levels predicted on the ground floor slab or floors of buildings were found to comply with the CoP Vol 2 human comfort lower limit for dwellings during non-standard hours criterion (0.3 mm/s, Table 15.16).

15.8.6 Underground infrastructure

Vibration on the existing Roma Brisbane Gas Pipeline due to use of the TBM has been assessed. The minimum distance between the TBM and the Roma Brisbane Gas Pipeline is predicted to be approximately 114 m. APA advises a notification distance of 100 m. Assuming that the pipeline is located in rock, approximately 600 mm below the ground surface, a maximum PPV of 0.3 mm/s has been predicted at the pipeline. This is compliant with the minimum APA pipeline limit of 10 mm/s and is below the 80% alarm threshold specified by APA.

As recommended by APA, a more detailed ground-borne vibration assessment will be undertaken once the construction contractor is appointed, with consideration given to detailed geotechnical data for the area and the type and size of the TBM. Depending on the outcomes of this modelling, vibration modelling and coating survey may also be required.

The DIN 4150-3 *Long-term vibration guideline values for velocity measured on the pipe—Masonry, plastic* criteria of 25 mm/s has been applied. Compliance with this criterion is predicted when the TBM is at least 5 m from the pipework. Vibration measurements are to be undertaken onsite to confirm that these predictions are representative of the vibration levels onsite.

The results of vibration predictions are less accurate when construction equipment is within 5 m of a vibration-sensitive item. Consequently, the construction team will need to undertake vibration monitoring when working within 5 m of infrastructure to assess whether the vibration from the works meet the criteria.

It is proposed that the minimum setback distance of 5 m be observed between the TBM and all buried services. No underground infrastructure has been identified within this setback distance.

With the exception of the areas around the tunnel portals, the TBM operations are likely to be at least 50 m below underground infrastructure, including the Roma Brisbane Gas Pipeline. At the tunnel portals, underground infrastructure, if present, is likely to be relocated prior to construction or is at least 5 m from the portals.

As part of ongoing consultation with the service providers, ARTC will confirm whether the criteria are applicable to all underground infrastructure and what, if any, additional measures may be required by the service provider, e.g. monitoring requirements and notification distances.

15.8.7 Ground-borne construction noise impacts

The ground-borne construction noise predictions for tunnel construction that have been undertaken are based on conservative assumptions. This includes propagation through rock, no impedance changes at below-ground formation change, foundation types and use of peak velocity values to determine L_{ASMax} noise levels. The 3D vector distance from the tunnel edge to the sensitive receptor foundation (diagonal distance[1]) has been used to calculate predicted ground-borne noise levels.

Ground-borne noise due to the TBM has been predicted to exceed the ground-borne noise criteria defined in the CoP Vol 2. Each receptor predicted to exceed the ground-borne noise criteria has been presented in Appendix O: Construction Noise and Vibration, with their respective predicted level labelled. The modelling predicted the following:

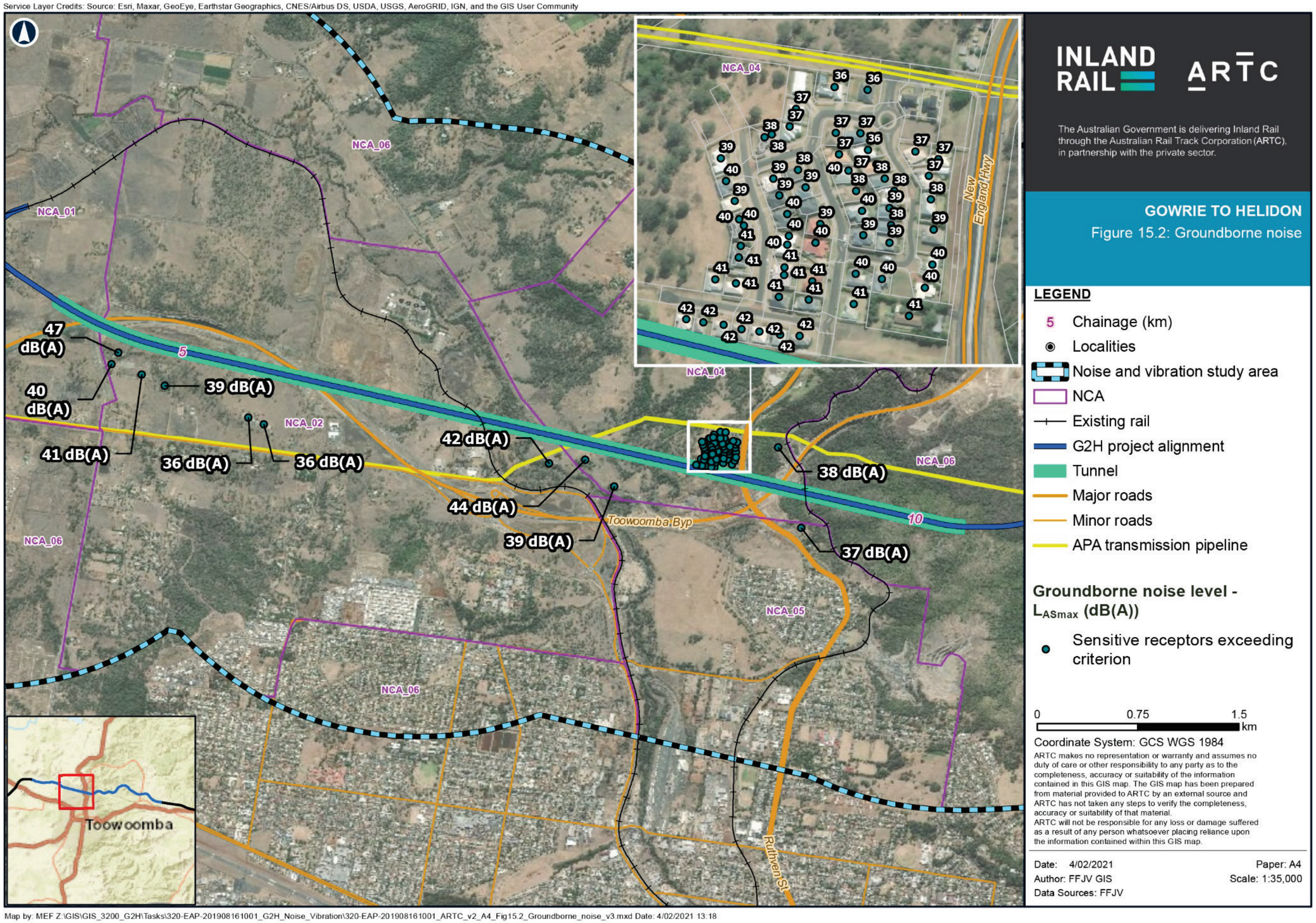
- The tunnel does not directly bore under any houses or commercial buildings
- Properties within an approximate diagonal distance of 260 m from the cutting face of the TBM will exceed the *Dwellings—Standard hours* criteria of 40 dBL_{ASMax}. There are 22 residential sensitive receptors predicted to exceed this criterion.
- Properties within an approximate diagonal distance of 390 m from the cutting face of the TBM will exceed the *Dwellings—Non-standard hours* criteria of 35 dBL_{ASMax}. There are 72 residential sensitive receptors predicted to exceed this criterion. This includes the above 22 residential sensitive receptors.
- The exceedances at an individual residential sensitive receptor are not predicted to occur for the entirety of the tunnel construction. Exceedances of the standard hour criterion are only predicted for the period during which the TBM is within a 260 m diagonal distance of the sensitive receptor. Similarly, exceedances of the non-standard hour criterion are only predicted while the TBM is within a 390 m diagonal distance of a receptor. The duration of the impacts cannot be confirmed at this stage.
- The duration of these impacts is dependent on the type of TBM, the depth of the tunnel and specific properties of the geology surrounding the tunnel. e.g. tunnelling entirely through rock, as was conservatively modelled, is both slower and propagates vibration further than tunnelling through other geotechnical conditions. A review of other similar projects has indicated that the progress of a TBM can be 10 m and 30 m per day depending on the local geology, refer Chapter 6: Project Description.
- Based on a predicated excavation rate of 10.5 m/day (as described in Chapter 6: Project Description) the duration of the impacts could be 75 days (i.e. ground-borne construction noise above the criteria may be experienced at a 390 m diagonal distance of a sensitive receptor, with it taking approximately 37 days to arrive at the closest point to the receptor and another 37 days to pass by the receptor by over 390 m).
- These impacts are to be revisited and updated during detailed design, based on more extensive geotechnical investigations (currently being undertaken)

Mitigation measures to manage ground-borne construction noise exceedances are included in Section 15.11. Construction ground-borne noise impacts have been mapped in Figure 15.2.

15.8.8 Commissioning noise and vibration impacts

The commissioning stage involves testing and checking the rail line and communication and signalling systems to ensure that all systems and infrastructure are designed, installed and operating according to ARTC's operational requirements. Due to the nature of the Project, the noise and vibration associated with commissioning would be considered as no worse than the operational impacts and have not been assessed further.

1. The nearest distance between the edge of the tunnel and the building foundation of each sensitive receptor.


Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
INLAND RAIL
ARTC
The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.
GOWRIE TO HELIDON
Figure 15.2: Groundborne noise
LEGEND
5 Chainage (km)
Localities
Noise and vibration study area
NCA
Existing rail
G2H project alignment
Tunnel
Major roads
Minor roads
APA transmission pipeline
Groundborne noise level - L_{ASmax} (dB(A))
Sensitive receptors exceeding criterion
0 0.75 1.5 km
Coordinate System: GCS WGS 1984
ARTC makes no representation or warranty and assumes no duty of care or other responsibility to any party as to the completeness, accuracy or suitability of the information contained in this GIS map. The GIS map has been prepared from material provided to ARTC by an external source and ARTC has not taken any steps to verify the completeness, accuracy or suitability of that material. ARTC will not be responsible for any loss or damage suffered as a result of any person whatsoever placing reliance upon the information contained within this GIS map.
Date: 4/02/2021
Paper: A4
Author: FFJV GIS
Scale: 1:35,000
Data Sources: FFJV
NCA_01
NCA_02
NCA_04
NCA_05
NCA_06
47 dB(A)
40 dB(A)
39 dB(A)
41 dB(A)
36 dB(A)
36 dB(A)
42 dB(A)
44 dB(A)
39 dB(A)
38 dB(A)
37 dB(A)
5
10
Toowoomba Byp
New England Hwy
Ruthven St
Toowoomba
Map by: MEF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201908161001_G2H_Noise_Vibration\320-EAP-201908161001_ARTC_v2_A4_Fig15.2_Groundborne_noise_v3.mxd Date: 4/02/2021 13:18

15.8.9 Rail freight operations

15.8.9.1 Operational rail noise and vibration

The predicted railway noise levels at the sensitive receptors are detailed in Appendix P: Operational Railway Noise and Vibration. The predicted railway noise levels are presented for the daytime and night-time railway operations for the Project opening in the year 2027 and the future design year of 2040.

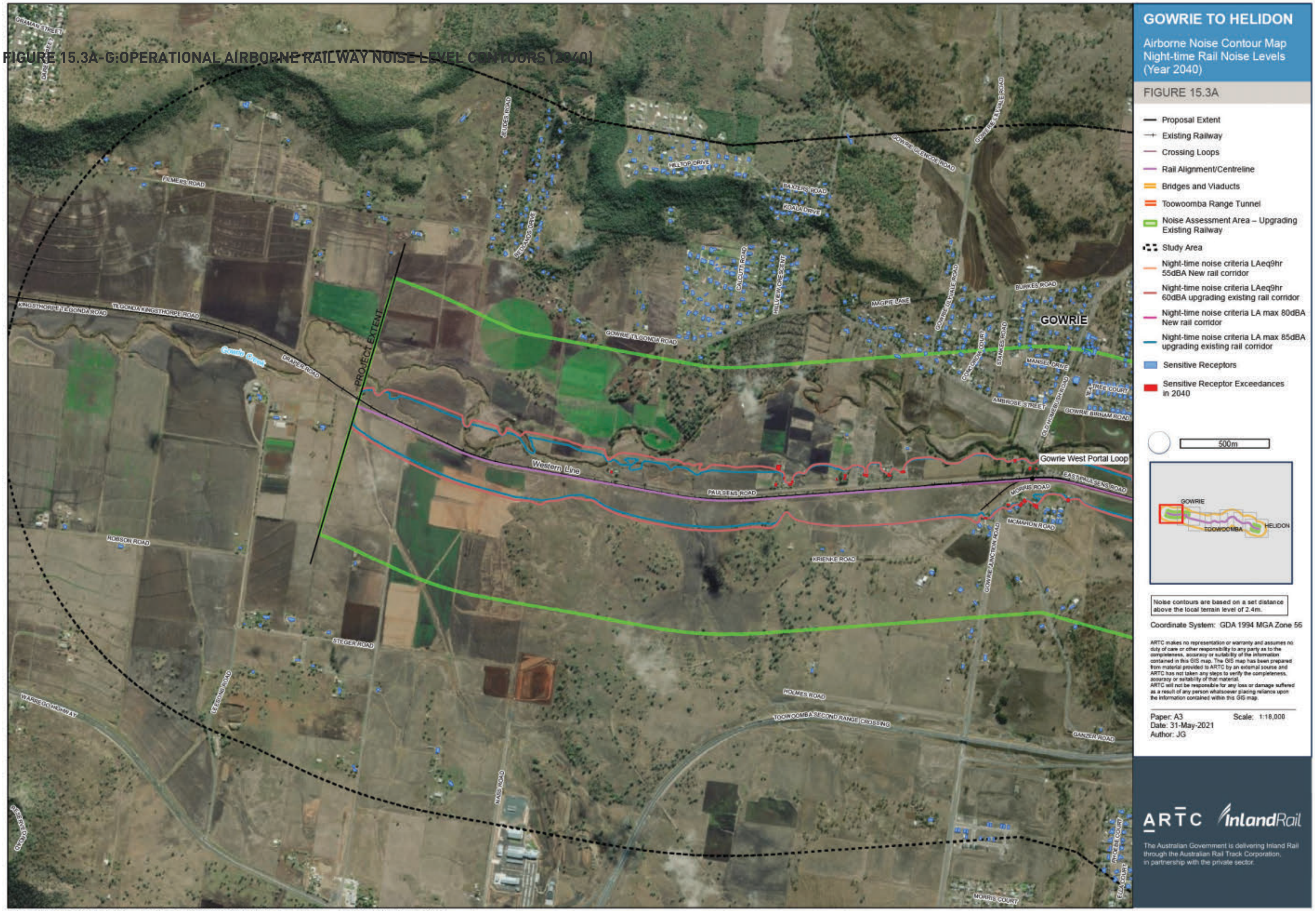
The noise levels for the daytime and night-time are reported as the L_{Aeq} and L_{Amax} noise metrics and include the contributions from the train movements (passby events) on the mainline, crossing loops and the tunnel portals.

The predicted railway noise levels for railway operations in year 2040 (airborne noise) are summarised in Figure 15.3. The railway noise levels are presented as the daytime and night-time railway noise criteria applied by ARTC to identify where investigation of railway noise mitigation is triggered on the Project alignment. The predicted railway noise levels are below the assessment criteria, and do not trigger investigation of noise mitigation, where sensitive receptors are generally located 400 m or more from the rail alignment. The predicted railway noise levels achieve the assessment criteria at the majority of the sensitive receptors.

A summary of the number of sensitive receptors where the predicted railway noise levels are above the assessment criteria, and trigger the investigation of noise mitigation, are provided in Table 15.35. The investigation of noise mitigation was primarily triggered by the night-time operations because the number of trains per hour is greater during the night-time. The night-time LA_{eq} noise criteria is 5 dBA more stringent than the daytime LA_{eq} noise criteria.

A summary of the number of sensitive receptors where the predicted rail noise levels are above the assessment criteria, and trigger the investigation of noise mitigation, is provided in Table 15.35. The investigation of noise mitigation was primarily triggered by the night-time operations because the number of trains per hour is greater during the night-time. The night-time LA_{eq} noise criteria is 5 dBA more stringent than the daytime LA_{eq} noise criteria.

FIGURE 15.3A-G:OPERATIONAL AIRBORNE RAILWAY NOISE LEVEL CONTOURS (2040)



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Service Layer Credits: ESRI Basemap

Figure 15.3b: OPERATIONAL AIRBORNE RAILWAY NOISE LEVEL CONTOURS (2040)

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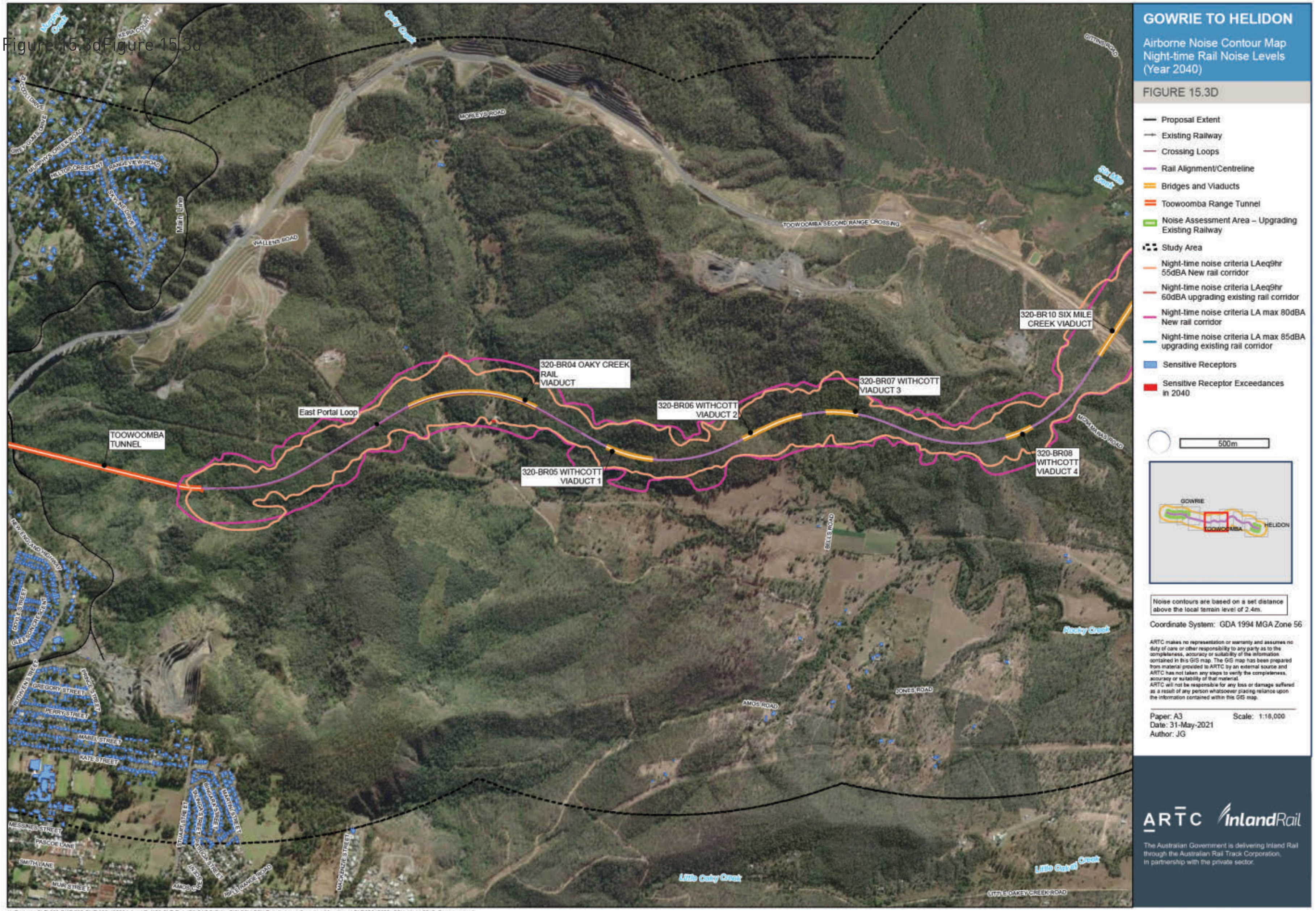
Service Layer Credits: ESRI Basemap

Figure 15.3dFigure 15.3d



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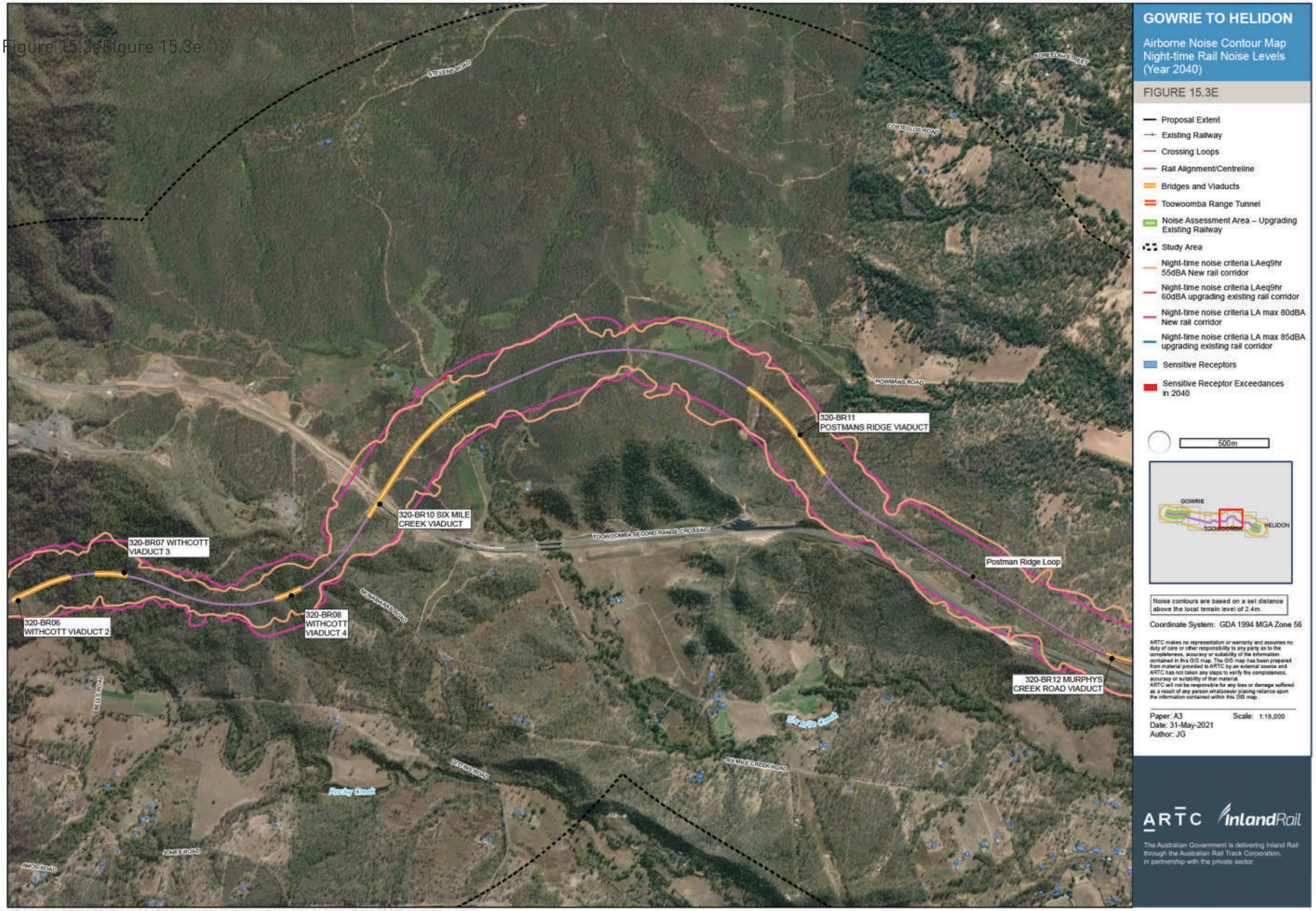
Service Layer Credits: ESRI Basemap

Figure 15.3eFigure 15.3e



Service Layer Credits: ESRI Basemap

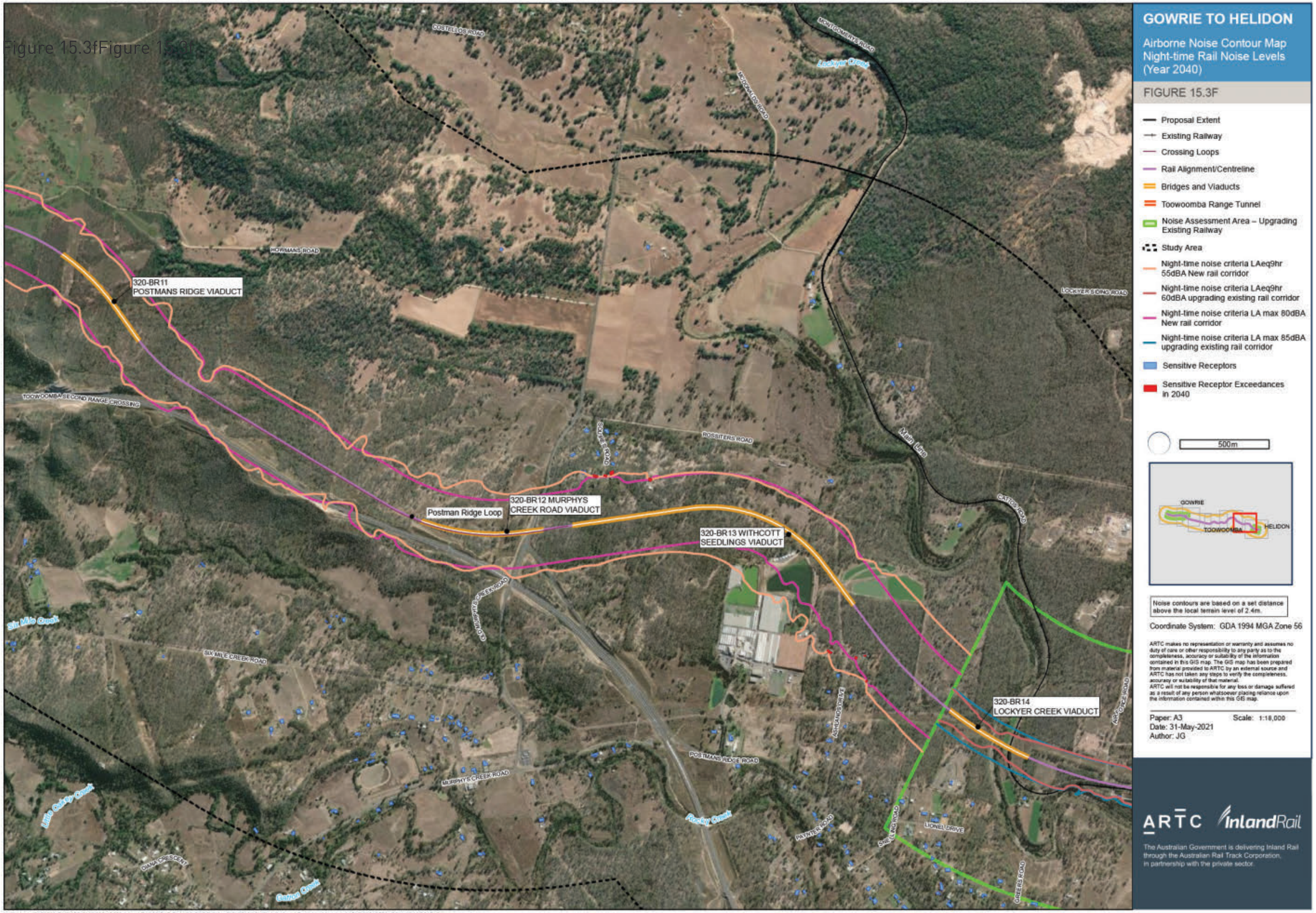

GOWRIE TO HELIDON
Airborne Noise Contour Map
Night-time Rail Noise Levels
(Year 2040)
FIGURE 15.3F
Proposal Extent
Existing Railway
Crossing Loops
Rail Alignment/Centreline
Bridges and Viaducts
Toowoomba Range Tunnel
Noise Assessment Area – Upgrading Existing Railway
Study Area
Night-time noise criteria LAeq9hr 55dBA New rail corridor
Night-time noise criteria LAeq9hr 60dBA upgrading existing rail corridor
Night-time noise criteria LA max 80dBA New rail corridor
Night-time noise criteria LA max 85dBA upgrading existing rail corridor
Sensitive Receptors
Sensitive Receptor Exceedances in 2040
500m
GOWRIE
TOOWOOMBA
HELIDON
Noise contours are based on a set distance above the local terrain level of 2.4m.
Coordinate System: GDA 1994 MGA Zone 56
Paper: A3
Date: 31-May-2021
Author: JG
Scale: 1:18,000
ARTC
InlandRail
The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation, in partnership with the private sector.
320-BR11
POSTMANS RIDGE VIADUCT
Postman Ridge Loop
320-BR12 MURPHYS CREEK ROAD VIADUCT
320-BR13 WITHCOTT SEEDLINGS VIADUCT
320-BR14
LOCKYER CREEK VIADUCT
HOWMANS ROAD
TOOWOOMBA SECOND RANGE CROSSING
ROSSITERS ROAD
LOCKYER SIDING ROAD
Main Line
POSTMANS RIDGE ROAD
MURPHYS CREEK ROAD
SIX MILE CREEK ROAD
Six Mile Creek
Lockyer Creek
Rocky Creek
Gatton Creek

Figure 15.3gFigure 15.3g

H:\Projects-SLR\620-BNE\620-BNE\620.12209 Inland Rail\06 SLR Data\06 CADGIS\ArcGIS\G2H\G2H Detailed and Overview Mapsheets\SLR62012209_G2H_Night 2040_Summary.mxd
Service Layer Credits: ESRI Basemap

At Project opening, which is expected to be 2027, there are 32 sensitive receptors where the predicted railway noise levels have triggered the investigation of feasible and reasonable noise mitigation measures. The growth in forecast rail traffic between 2027 and 2040 will trigger a noise mitigation review for one additional sensitive receptor to that predicted for 2027 (a total of 33 sensitive receptors trigger a review of mitigation).

The total number of receptors triggering mitigation is the combination of individual receptors that trigger the L_{Aeq} and L_{Amax} noise criteria, with 19 associated with the brownfield section at Gowrie Junction and 13 associated with the greenfield section. In addition, predicted noise levels trigger a review of noise mitigation at the Gowrie State School. The noise criteria were most frequently trigged by the night-time L_{Aeq} rail noise levels, as the number of trains per hour is greater during the night-time and the noise criteria are 5 dBA more stringent than the daytime.

These are presented in Table 15.40.

TABLE 15.40: OPERATIONAL RAILWAY NOISE ASSESSMENT SUMMARY

Assessment criteria margin	Sensitive receptors triggering the criteria
Year 2027 Project opening	
1 dBA to 3 dBA	18
>3 dBA to 5 dBA	8
>5 dBA to 10 dBA	5
>10 dBA	0
Total receptors triggering noise mitigation—Project opening	**31**
Year 2040 design year	
1 dBA to 3 dBA	19
>3 dBA to 5 dBA	5
>5 dBA to 10 dBA	8
>10 dBA	0
Total receptors triggering noise mitigation—design year	**32**

Table notes:
$L_{Aeq(9hour)}$—exceeded at 31 of the 32 sensitive receptors (night)
L_{AFmax}—exceeded at 22 of the 32 sensitive receptors (night)

In addition, predicted noise levels trigger a review of noise mitigation at the Gowrie State School, Gowrie Junction. The noise management level at the school is a 1-hour internal (indoor) noise level. To estimate indoor noise levels, the noise assessment applied a conservative assumption on the potential noise reductions achieved by the buildings. The internal noise criterion is expected to be achieved at Gowrie State School with windows closed or where the façade with open windows controls the intrusion of railway noise by at least 12 dBA.

TABLE 15.41: PREDICTED OPERATIONAL RAILWAY NOISE AT GOWRIE STATE SCHOOL

$L_{Aeq(1hr)}$ noise levels Year 2027, dBA				$L_{Aeq(1hr)}$ noise levels Year 2040, dBA			
Day		Night		Day		Night	
Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside
51	**44**	53	**46**	52	**45**	54	**47**

Table notes:
The numbers in bold are the predicted noise levels of up to $L_{Aeq(1hour)}$ 54 dBA at the Gowrie State School may trigger the internal assessment criterion allowing for the 7 dBA difference between external and internal railway noise.

During the future phases of the Project, properties such as the Gowrie State School will be surveyed to confirm the use and construction of the buildings. Where necessary, revised assessment of internal noise will be undertaken to confirm potential at-property noise mitigation requirements.

The predicted operational railway noise levels at the sensitive receptors triggering a review of noise mitigation (year 2040) are presented in Table 15.42 and illustrated in Figure 15.4. It should be noted that modelling indicates that the existing railway noise for the sensitive receptors within the brownfield sections are below the criteria outlined in the Interim Guideline (e.g. L_{Amax} 87dBA). Further details are provided in Appendix P: Operational Railway Noise and Vibration, including the predicted noise levels at all the sensitive receptors identified as part of the assessment.

The number of exceedances as a result of the redevelopment activities is just under 50 per cent higher (19) to the number of exceedances as a result of the new rail corridor (13). This is despite the guidelines for the new rail corridor being more stringent and may be attributed to the new rail corridor being in tunnel and located in areas that are sparsely populated.

The sensitive receptors have been assumed to be residential dwellings, including, in some instances, multiple dwellings on the same land parcel, especially along Paulsens Road, Gowrie Junction.

TABLE 15.42: SENSITIVE RECEPTORS TRIGGERING A REVIEW OF OPERATIONAL RAILWAY NOISE MITIGATION (2040)

	Overall day-time railway noise levels 2027, dBA			Overall night-time railway noise levels 2040, dBA		
Sensitive receptor ID	$L_{Aeq(15hour)}$	$L_{(9hour)}$	L_{Afmax}	$L_{Aeq(15hour)}$	$L_{(9hour)}$	L_{Afmax}
Noise criteria greenfield/new alignment	*60*	*55*	*80*	*60*	*55*	*80*
311688—Ashlands Drive, Helidon Spa	56	**57**	**82**	57	**57**	**82**
312086—Ashlands Drive, Helidon Spa	57	**58**	**82**	58	**58**	**82**
312114—Ashlands Drive, Helidon Spa	58	**56**	**85**	58	**58**	**85**
312187—Ashlands Drive, Helidon Spa	57	**56**	80	57	**57**	80
313668—Squires Road, Lockyer	58	**57**	**84**	58	**58**	**84**
313684—Squires Road, Lockyer	57	**56**	**81**	57	**57**	**81**
313687—Squires Road, Lockyer	57	**56**	**81**	57	**57**	**81**
313704—Squires Road, Lockyer	56	**56**	**81**	56	**56**	**81**
313904—Jones Road, Ballard	56	55	**85**	56	**56**	**85**
314173—Jones Road, Ballard	55	54	**81**	55	55	**81**
314370—Howmans Road, Withcott	58	**57**	**81**	58	**58**	**81**
314490—Gittins Road, Withcott	56	55	**81**	56	**56**	**81**
314496—Gittins Road, Withcott	56	55	**83**	56	**56**	**83**
Noise criteria brownfield/redevelopment	*65*	*60*	*85*	*65*	*60*	*85*
315028—Krienke Road, Gowrie Junction	60	**61**	85	61	**61**	85
315081—Daniel Street, Gowrie Junction	59	60	85	60	**61**	85
315088—Junction Street, Gowrie Junction	60	**61**	85	61	**61**	85
315090—Junction Street, Gowrie Junction	60	**61**	**86**	61	**61**	**86**
315108—Junction Street, Gowrie Junction	60	**61**	85	61	**61**	85
315110—Morris Road, Gowrie Junction	60	**61**	**86**	62	**62**	**86**
315157—Paulsens Road, Gowrie Junction	64	**66**	**90**	65	**66**	**90**
315171—Paulsens Road, Gowrie Junction	64	**66**	**90**	**66**	**66**	**90**
315181—Paulsens Road, Gowrie Junction	65	**66**	**90**	**66**	**66**	**90**

Sensitive receptor ID	Overall day-time railway noise levels 2027, dBA			Overall night-time railway noise levels 2040, dBA		
	$L_{Aeq(15hour)}$	$L_{(9hour)}$	L_{Afmax}	$L_{Aeq(15hour)}$	$L_{(9hour)}$	L_{Afmax}
315183—Paulsens Road, Gowrie Junction	65	**66**	**90**	**66**	**66**	**90**
315185—Paulsens Road, Gowrie Junction	60	**61**	85	61	**61**	85
315191—Paulsens Road, Gowrie Junction	64	**66**	**90**	65	**66**	**90**
315192—Paulsens Road, Gowrie Junction	61	**62**	**87**	62	**62**	**87**
315193—Paulsens Road, Gowrie Junction	64	**65**	**90**	65	**66**	**90**
315202—Paulsens Road, Gowrie Junction	63	**65**	**89**	64	**65**	**89**
315212—Paulsens Road, Gowrie Junction	63	**64**	**89**	64	**65**	**89**
315214—Paulsens Road, Gowrie Junction	64	**65**	**90**	65	**66**	**90**
315215—Paulsens Road, Gowrie Junction	65	**66**	**90**	**66**	**66**	**90**
315224—Paulsens Road, Gowrie Junction	59	**61**	85	61	**61**	85

Table note:

1. L_{Amax} levels presented for night time period. Predicted noise impacts would be consistent during the day-time period (with an airborne railway noise assessment criteria of 85 dB)

The location of potential triggers, based on existing modelled sensitive receptors for year 2040 operations, are provided on Figure 15.4. Other sensitive locations (educational facilities) and residential structures expected to be acquired by the Constructing Authority are also shown.

FIGURE 15.4A-G: SENSITIVE RECEPTORS TRIGGERING THE INVESTIGATION OF NOISE MITIGATION (2040)

Figure 15.4B Sensitive Receptors Triggering the investigation of Noise Mitigation

H:\Projects-SLR\620-BNE\620-BNE\620.12209 Inland Rail\06 SLR Data\06 CADGIS\ArcGIS\G2H\G2H Detailed and Overview Mapsheets\SLR62012209_G2H_Exceedances_Summary.mxd
Service Layer Credits: ESRI Basemap

Figure 15.4c

GOWRIE TO HELIDON
Sensitive Receptors Triggering the Investigation of Noise Mitigation
FIGURE 15.4C
Proposal Extent
Existing Railway
Crossing Loops
Rail Alignment/Centreline
Bridges and Viaducts
Toowoomba Range Tunnel
Noise Assessment Area – Upgrading Existing Railway
Study Area
Sensitive Receptors in 2040
Properties to be Acquired by the Project
Other Sensitive Receptors in 2040 (Education Institution)
500m
Noise contours are based on a set distance above the local terrain level of 2.4m.
Coordinate System: GDA 1994 MGA Zone 56
Paper: A3
Date: 31-May-2021
Author: JG
Scale: 1:18,000
TOOWOOMBA TUNNEL
East Portal Loop
Main Line
Western Line
TOOWOOMBA SECOND RANGE CROSSING
The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation, in partnership with the private sector.

Figure 15.4d


GOWRIE TO HELIDON
Sensitive Receptors Triggering the Investigation of Noise Mitigation
FIGURE 15.4D
Proposal Extent
Existing Railway
Crossing Loops
Rail Alignment/Centreline
Bridges and Viaducts
Toowoomba Range Tunnel
Noise Assessment Area – Upgrading Existing Railway
Study Area
Sensitive Receptors in 2040
Properties to be Acquired by the Project
Other Sensitive Receptors in 2040 (Education Institution)
TOOWOOMBA TUNNEL
East Portal Loop
320-BR04 OAKY CREEK RAIL VIADUCT
320-BR05 WITHCOTT VIADUCT 1
320-BR06 WITHCOTT VIADUCT 2
320-BR07 WITHCOTT VIADUCT 3
320-BR08 WITHCOTT VIADUCT 4
320-BR10 SIX MILE CREEK VIADUCT
TOOWOOMBA SECOND RANGE CROSSING
MORLEYS ROAD
WALLENS ROAD
Main Line
JONES ROAD
AMOS ROAD
LITTLE OAKEY CREEK ROAD
Little Oakey Creek
Rocky Creek
500m
GOWRIE
TOOWOOMBA
HELIDON
Noise contours are based on a set distance above the local terrain level of 2.4m.
Coordinate System: GDA 1994 MGA Zone 56
Paper: A3
Date: 31-May-2021
Author: JG
Scale: 1:18,000
ARTC
InlandRail
The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation, in partnership with the private sector.

Figure 15.4e

H:\Projects-SLR\620-BNE\620-BNE\620.12209 Inland Rail\06 SLR Data\06 CADGIS\ArcGIS\G2H\G2H Detailed and Overview Mapsheets\SLR62012209_G2H_Exceedances_Summary.mxd
Service Layer Credits: ESRI Basemap

Figure 15.4f


GOWRIE TO HELIDON
Sensitive Receptors Triggering the Investigation of Noise Mitigation
FIGURE 15.4F
Proposal Extent
Existing Railway
Crossing Loops
Rail Alignment/Centreline
Bridges and Viaducts
Toowoomba Range Tunnel
Noise Assessment Area – Upgrading Existing Railway
Study Area
Sensitive Receptors in 2040
Properties to be Acquired by the Project
Other Sensitive Receptors in 2040 (Education Institution)
500m
GOWRIE
TOOWOOMBA
HELIDON
Noise contours are based on a set distance above the local terrain level of 2.4m.
Coordinate System: GDA 1994 MGA Zone 56
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ARTC will not be responsible for any loss or damage suffered as a result of any person whatsoever placing reliance upon the information contained within this GIS map.
Paper: A3
Scale: 1:18,000
Date: 31-May-2021
Author: JG
ARTC
InlandRail
The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation, in partnership with the private sector.
320-BR11 POSTMANS RIDGE VIADUCT
Postman Ridge Loop
320-BR12 MURPHYS CREEK ROAD VIADUCT
320-BR13 WITHCOTT SEEDLINGS VIADUCT
320-BR14 LOCKYER CREEK VIADUCT
TOOWOOMBA SECOND RANGE CROSSING
HOWMANS ROAD
ROSSITERS ROAD
LOCKYER SIDING ROAD
POSTMANS RIDGE ROAD
MURPHYS CREEK ROAD
SIX MILE CREEK ROAD
Six Mile Creek
Lockyer Creek
Rocky Creek
Main Line
313684
313704
313687
313668
312187
312114
312086
311888

Figure 15.4

H:\Projects-SLR\620-BNE\620-BNE\620.12209 Inland Rail\06 SLR Data\06 CADGIS\ArcGIS\G2H\G2H Detailed and Overview Mapsheets\SLR62012209_G2H_Exceedances_Summary.mxd
Service Layer Credits: ESRI Basemap

15.8.9.2 Trains accessing the crossing loops

A review of the predicted noise levels at the sensitive receptors relevant to the three crossing loops were up to $L_{Aeq(15hour)}$ 46 dBA daytime, $L_{Aeq(9hour)}$ 46 dBA night-time and L_{AFmax} 58 dBA for both the daytime and night-time periods.

The predicted noise levels from the crossing loops were below the noise management criteria and are substantially lower than the railway noise levels from the daily train passby events on the mainline. Because the crossing loops are within 4.5 m of the mainline, they are not expected to be the primary influence on the overall daytime and night-time predicted noise levels at the sensitive receptors.

15.8.9.3 Railway noise characteristics

The potential impacts of noise from railway operations can be influenced by the characteristics of rollingstock noise. An overview of the potential noise characteristics from freight rail operations is summarised below:

- There can be a prominent contribution of noise in the low frequency range, between 80 Hz and 250 Hz, in close proximity to rail corridors (at 15 m from the rail line). The diesel-electric locomotive engines and exhaust systems are the primary source of the low frequency noise during the train passby events.
- While the noise emissions of the locomotives have a low frequency noise content in close proximity to the rail line it does not mean that low frequency noise characteristics will necessarily be experienced at sensitive receptors
- The ability to detect features, such as low frequency noise, will also depend on the contribution of the other sources of noise in the local environment, which may influence an individual's perception of the loudness and character of the rollingstock noise. Other sources of noise may include road traffic and the operation of the tunnel infrastructure.
- Analysis of locomotive noise emissions did not identify prominent tones at specific frequencies and the noise emission from the rollingstock operations is not expected to include tonal noise characteristics.

Other general characteristics of railway noise are summarised below and are usually specific to individual items of rollingstock and track features:

- Bunching or stretching can occur when the couplings on a train are subject to sudden changes in force during acceleration and deceleration, which may cause short-lived squeaks and bangs. Events of this nature may have subjective impulsive noise emission characteristics, although not necessarily quantified as impulsive noise, at nearby sensitive receptors. Noise events of this nature have been assessed at the three crossing loops proposed on the Project.
- A short-lived booming noise, with potential low frequency characteristics, can be caused by empty containers and wagons resonating
- Curving noise can result in prominent tonal noise emissions. The Project includes relatively short sections of tight-radius curves at the tie-ins to the existing West Moreton System (between Toowoomba and Helidon) and the potential noise emissions from curving noise were included in the noise predictions
- When trains depart from the crossing loops, the locomotives may be required to initially operate under a high notch setting to accelerate from a standing position. This can cause increased noise emissions from the locomotives, which may result in a perceptible increase in railway noise for a short time interval nearby to the crossing loops. Given the short duration and train passbys on the adjacent main line track, the event would not be expected to influence the noise levels over the 15-hour daytime and 9-hour night-time assessment periods.
- The Project will be newly constructed rail that will be specifically designed for freight rail operations and subject to periodic maintenance. This can reduce potential for features, such as corrugation (deformation of the track), to increase noise emissions.
- The track for Inland Rail will be continuously welded rail, which reduces the likelihood of 'clickety-clack' sounds from the wheel–rail interface.

A more detailed discussion is provided in Appendix P: Operational Railway Noise and Vibration.

15.8.9.4 Potential for sleep disturbance from railway operations

The adopted L_{Amax} noise trigger accounts for the highest level of noise during train passbys and the number of passby events in the night-time. The assessment of railway noise determined that L_{Amax} noise assessment criteria were met at the majority of sensitive receptors on the Project. There were up to 23 sensitive receptors where the predicted noise levels, at the external worst-case building façade, were above the adopted L_{Amax} noise trigger by up to 6 dBA in the night-time period.

The noise predictions identified the received L_{Amax} noise levels were well below the adopted railway noise management levels at sensitive receptors that are further than 500 m from the rail corridor. Nonetheless, railway noise has the potential to be audible at sensitive land uses, both externally and internally, even where the adopted railway noise management levels are achieved.

To further inform future approaches for the management of noise and mitigation of noise-related impacts on Inland Rail, the assessment has considered guidance on sleep disturbance from the World Health Organisation (WHO). The WHO guideline *Night Noise Guidelines for Europe* (WHO, 2009) recommends that internal (indoor) noise levels are not above L_{Amax} 42 dBA to preserve sleep quality.

The WHO guideline advises the L_{Amax} 42 dBA noise level is considered a 'best estimate' of the minimum threshold for potential awakening reactions by transport noise. It was informed from transport noise studies in Europe, including non-railway sources such as aircraft and road traffic. Further advice from the WHO also acknowledges the establishment of relationships between single event noise indicators, such as L_{Amax}, and long-term health outcomes remain tentative.

Accordingly, the WHO guideline noise level is not applied as a noise limit or criterion for the prevention of sleep disturbance and awakening reactions. In practice, the response to noise, and aspects such as sleep disturbance, is personal and responses vary between individuals. A range of factors influence tolerance to noise, not just an absolute level of noise.

The internal L_{Amax} 42 dBA guideline level corresponds to a conservative external (outdoor) level of L_{Amax} 49 dBA, allowing for a conservative 7 dBA difference between indoor and outdoor noise levels where windows at rural residential properties are open for ventilation. Noise level reductions of at least 10 dB to 15 dB can be achieved with windows open, depending on the building construction and the source of noise.

Noise modelling indicates that predicted noise levels from rollingstock could be above L_{Amax} 49 dBA within approximately 1 km of the rail corridor. The 1 km distance is a guide to where night-time noise levels may have the potential to result in sleep reactions in habitable rooms of residential properties. Just because railway noise can be audible does not mean it will cause disturbance or annoyance impacts.

It would be expected that residential property, complying to Australian building codes and standards, would achieve façade noise reductions greater than the conservative 7 dBA assumption applied in this assessment. In such circumstances, the building construction would assist in managing noise intrusion and the guideline values for internal noise amenity would be more readily achieved.

15.8.9.5 Operational ground-borne vibration assessment

Previous measurement and assessment of ground-borne vibration from existing rail freight corridors with similar geotechnical considerations indicates that tactile vibration impacts would be limited to sensitive receptors located within 100 m of the proposed rail alignment.

Vibration levels at properties beyond this distance are routinely expected to be within recommended assessment criteria for comfort and, where the comfort goals are met, criteria relating to the integrity of building structures are also considered to be achieved, given they are typically an order of magnitude higher.

Bridge and viaduct structures are expected to be constructed from reinforced concrete and a ballasted track system. These structures are considered to have resilient matting for ballast retention (at least in the vicinity of residents) and this also provides benefits in terms of vibration isolation.

Based on the location of the nearest sensitive receptors, expected source vibration spectra and typical losses through the structure, the ground-borne vibration criteria are expected to be met at ground level assessment positions near bridges and viaducts. On this basis, the following sections consider properties within 100 m of the alignment, excluding bridges and viaducts.

The ground-borne vibration levels have been assessed as a dose vibration level (VDV), which considers both the level of vibration during a train passby event and the number of passby events in each daytime and night-time period. The VDV vibration levels were calculated based on the daily train movements for the 2027 opening year and 2040 design year rail operations.

The vibration levels were applied to determine the minimum offset distance from the outer rail where the ground-borne vibration criteria would be expected to be achieved. Suggested offset distances for the daytime and night-time rail operations are shown in Table 15.43 to allow for variation in rail condition and local factors, noting that subjective annoyance is possible at larger distances.

There are no sensitive receptors currently identified to be within this offset distance; however, this will be confirmed during detailed design, particularly as VDV levels within the assessment criteria do not eliminate the potential for perceptible vibration during train passby events. The assessment also identified that ground-borne vibration is not anticipated to impact non-Indigenous cultural heritage sites adjacent to the Project alignment.

TABLE 15.43: PREDICTED NOISE LEVEL AT THE CLOSEST NOISE SENSITIVE RECEPTOR

Year of operation	Estimated off-set to meeting vibration criteria[1,2]		Receptors within the offset distance
	Daytime	Night time	
2027 Project opening	11 m (22 trains)	15 m (18 trains)	None
2040 design year	12 m (28 trains)	16 m (21 trains)	None

Table notes:

1. The estimated offset distances are based on the VDV reference—actual vibration levels at individual receptors can vary from the calculated levels due to the rail infrastructure and geological conditions
2. VDV levels calculated applying the Wb weighted vibration levels as per the 2008 version of British Standard BS6472 (British Standards, 2008).

The assessment determined that potential ground-borne vibration levels at sites identified as possessing historical cultural values was unlikely to trigger guideline vibration levels for the management of potential vibration impacts (refer Table 15.25). Refer to Appendix P: Operational Railway Noise and Vibration for further details.

15.8.9.6 Weather

The potential for railway noise at individual sensitive receptors to be influenced by the local weather conditions is based on the interaction between the moving noise source (train pass-by), the content of the received noise and local/regional weather conditions.

While there may be periods when the weather conditions influence the propagation of noise from train pass-by events over long distances, the railway operation is forecast to be 1 to 2 train movements per hour, with audible pass-by events likely to be 2 to 5 minutes in duration. The combination of the duration and intermittency of the train passbys diminish the influence of weather conditions on the railway noise levels assessed over the 15-hour daytime and 9-hour night-time periods.

15.8.9.7 Operational ground-borne noise assessment

At a distance of greater than 50 m from the track, the most stringent internal ground-borne noise criterion of L_{ASmax} 35 dBA is expected to be achieved. Based on a 50 m offset distance, one sensitive receptor was within 50 m of the outer rail. The receptor (134754), a residential dwelling near the western tunnel portal, is within the disturbance footprint of the Project and will be acquired under the land acquisition process for the Project.

At the 50 m distance from the rail line, the local environment would be dominated by the airborne noise from train passby events, which would be expected to mask the potential ground-borne noise content. Refer to Appendix P: Operational Railway Noise and Vibration for further details.

As the building construction of the sensitive receptors is not known, it is not possible to forecast with certainty the indoor ground-borne noise levels that could eventuate during railway operations. Ground-borne noise levels are expected to be reviewed through further investigation during the detailed design of the Project.

While ground-borne noise levels calculated at sensitive receptors were principally within the assessment criteria, and do not trigger investigation or mitigation, there can still be a risk of minor perceptible ground-borne noise at sensitive receptors. Furthermore, ground-borne noise can be perceptible even where the ground-borne vibration assessment criteria are comfortably achieved.

15.8.9.8 Ground-borne noise and vibration—Toowoomba Range Tunnel

The movement of the trains through the Toowoomba Range Tunnel will induce vibration of the track system and the tunnel structure. The vibration can then propagate into the surrounding soil, and this ground-borne vibration can potentially be experienced at sensitive receptors sufficient to impact the amenity of the sensitive receptors through perceptible vibration and the generation of noise in properties (ground-borne noise).

The calculation of ground-borne noise followed development of a screening assessment model that was developed based on guidance from International Standard *ISO 148327-1 2005 Mechanical vibration—Ground-borne noise and vibration arising from rail systems—Part 1 General guidance* (ISO, 2005). Refer to Appendix P: Operational Railway Noise and Vibration for further details.

The ground vibration and ground-borne noise model accounted for the key parameters of the track design, ground conditions and proposed rail operations to calculate the required off-set distance where forecast ground-borne vibration and ground-borne noise levels would achieve the assessment criteria.

In summary, the assessment concluded that predicted ground-borne noise and ground-borne vibration from railway operations in the Toowoomba Range Tunnel would not trigger the ground-borne noise and vibration assessment criteria at the nearest sensitive receptors (e.g. residential dwellings at Mount Kynoch).

Based on the assessment, specific measures to control ground-borne vibration from railway operations in the Toowoomba Range Tunnel are not anticipated, at this time.

While ground-borne noise levels calculated at sensitive receptors were within the assessment criteria, and do not trigger investigation of mitigation measures, there can still be a risk of minor perceptible ground-borne noise at sensitive receptors. Furthermore, ground-borne noise can be perceptible even where the ground-borne vibration assessment criteria are comfortably achieved.

15.8.9.9 Operational fixed infrastructure noise

Fan specifications have been provided as part of the Project design, and fan SWL have been empirically derived (American Society of Heating, Refrigerating and Air-Conditioning Engine, 2019). It has been assumed that ventilation fans will be selected to operate within the tunnel design specifications such that noise emissions are steady-state and free of tonality. These SWLs are provided in Table 15.44.

TABLE 15.44: SOUND POWER LEVELS OF INDICATIVE FANS

Fan	Octave band centre frequency, Hz sound power level, dB								Total SWL dBA
	63	125	250	500	1,000	2,000	4,000	8,000	
Purge fans	125	130	127	123	122	120	117	117	**128**
Smoke fans	122	122	126	123	119	117	114	114	**125**
LEP (west/east ventilation stations)	111	111	115	112	108	106	103	103	**115**
LEP (intermediate ventilation station)	94	94	98	95	91	89	86	86	**97**

Indicative mitigation (attenuators) to achieve compliance with the noise criteria has been determined and provided to the tunnel engineers. This mitigation has been included in the design. The minimum insertion loss of attenuators to mitigate fan noise is presented in Table 15.45.

TABLE 15.45: MINIMUM INSERTION LOSS OF ATTENUATORS

Fan	Attenuator location in reference to fan	Location of fan	Octave band centre frequency, Hz insertion loss, dB							
			63	125	250	500	1k	2k	4k	8k
Purge	Ambient-side	Intermediate ventilation shaft	14	25	47	55	56	45	30	22
	Tunnel-side		22	37	72	79	76	76	60	40
Smoke	Ambient-side	Intermediate ventilation shaft	12	19	36	43	47	28	18	16
	Tunnel-side		23	39	77	84	80	81	64	43
LEP	Ambient-side	Intermediate ventilation shaft	12	19	36	43	47	28	18	16
	Tunnel-side		19	31	57	64	64	61	48	33
	Ambient-side	Tunnel portals	12	19	36	43	47	28	18	16
	Tunnel-side		24	41	82	89	84	86	68	45

Table notes:

1. Silencers are to be sized so that regenerated noise is negligible compared to the actual noise level
2. Ambient-side refers to attenuators located between the fan and the ventilation station emission point
3. Tunnel-side refers to attenuators located between the fan and the tunnel. This is to control noise in the tunnel and, thus, noise emission from the portal.
4. In the absence of custom-built attenuator data, attenuator octave band insertion loss is based on extrapolation of readily available attenuator data.

A 3D computational model was created in SoundPLAN version 8.0 for each operational scenario. This includes portal dimensions and ventilation building heights, and elevation contours associated with the Project's groundworks. Noise was then predicted with the above mitigation measures, in Table 15.45, and is presented in Table 15.46.

TABLE 15.46: PREDICTED NOISE LEVEL AT THE CLOSEST NOISE SENSITIVE RECEPTOR WITH MITIGATION (SILENCERS) INCLUDED

Scenario	Receptor location with respect to the tunnel		External noise criterion	Predicted noise level	External noise criterion	Predicted noise level
			$L_{Aeq,1hr}$, dB		$L_{A10,1hr}$, dB	
Purging	Eastern tunnel portal	Residential	37	19	47	24
		Commercial	52	16	No L_{A10} criteria applicable to commercial buildings	
	Intermediate ventilation shaft	Residential	37	36	47	42
		Commercial	52	39	No L_{A10} criteria applicable to commercial buildings	
		Medical	37	31	No L_{A10} criteria applicable to hospitals	
	Western tunnel portal	Residential	37	21	47	24
Maintenance	Eastern tunnel portal	Residential	37	16	47	16
		Commercial	52	13	No L_{A10} criteria applicable to commercial buildings	
	Intermediate ventilation shaft	Residential	37	33	47	33
		Commercial	52	35	No L_{A10} criteria applicable to commercial buildings	
		Medical	37	27	No L_{A10} criteria applicable to hospitals	
	Western tunnel portal	Residential	37	19	47	19

Scenario	Receptor location with respect to the tunnel		External noise criterion	Predicted noise level	External noise criterion	Predicted noise level
			$L_{Aeq,1hr}$, dB		$L_{A10,1hr}$, dB	
Emergency	Eastern tunnel portal	Residential	37	24	47	24
		Commercial	52	27	No L_{A10} criteria applicable to commercial buildings	
	Intermediate ventilation shaft	Residential	37	27	47	27
		Commercial	52	31	No L_{A10} criteria applicable to commercial buildings	
		Medical	37	21	No L_{A10} criteria applicable to hospitals	
	Western tunnel portal	Residential	37	32	47	32

With the mitigation proposed, it is predicted that the EPP (Noise) acoustic quality objectives will be met at all noise sensitive receptors.

Once fans are selected, if the sound power levels differ from those in Table 15.44, then mitigation will be reassessed. Selected fans will be free of tonality and, if not, a tonality penalty would be applied and mitigation revised.

Ancillary fixed infrastructure noise sources other than tunnel ventilation fans, such as pumps and transformers, will be located at the eastern and western tunnel portals. While noise from these sources is not yet known, nominal mitigation strategies (e.g. attenuators, solid barriers, enclosures) are expected to be implemented as part of the final design and will be designed such that operational fixed infrastructure noise impacts meet the EPP (Noise) acoustic quality objectives at noise sensitive receptors.

15.8.9.10 Operational road traffic noise

A desktop assessment has been implemented to assess the road traffic noise impacts from the operation of roads changed as part of the Project. The required setback distance in metres from the road to comply with the relevant CoP Vol 1 criterion has been calculated for each road. The quantity of sensitive receptors that are within this setback distance and predicted to exceed the criteria are included in Table 15.47. The assessment year used for these predictions is 10 years after opening (i.e. 2037).

The new roads, Morris Road and Gowrie Junction Road will result in exceedance of the 60 $L_{A10\,(18hr)}$ road traffic noise criteria for new roads. These two roads will need to be assessed during detailed design to confirm exceedances. Measures to mitigate operational road traffic noise impacts are discussed in Section 15.11.

TABLE 15.47: PREDICTED OPERATIONAL ROAD TRAFFIC NOISE

Road name	Posted speed (km/h)	CoP Vol 1 Category	Criterion $L_{A10\ (18h)}$ (dBA)	Surface	AADT[1] 2037[2]	Predicted L_{A10} at nearest receptor in 2037 (dBA)	Approximate chainage (km)	Minimum setback distance (m)[3]	Number of sensitive receptors within setback distance
Ganzer Road	80	New road	60	Unsealed	331	56	1.8	22	0
Morris Road	60	New road	60	Unsealed	787	62	1.8	54	3
Gowrie Junction Road	60	New road	60	Sealed	5,934	69	2.0	158	18
Old Homebush Road	60	New road	60	Sealed	1,120	57	2.2	50	0
East Paulsens Road	60	Existing road	68	Unsealed	1,143	59	2.4	9	0

Road name	Posted speed (km/h)	CoP Vol 1 Category	Criterion $L_{A10\ (18h)}$ (dBA)	Surface	AADT[1] 2037[2]	Predicted L_{A10} at nearest receptor in 2037 (dBA)	Approximate chainage (km)	Minimum setback distance (m)[3]	Number of sensitive receptors within setback distance
Jones Road	60	New road	60	Unsealed	408	49	11.2	41	0
McNamaras Road	40	New road	60	Sealed	1,143	48	15.4	43	0
Cattos Road	50	Existing road	68	Unsealed	836	57	24.8	6	0

Table notes:
km/hr = kilometres per hour
1. Annual Average Daily Traffic
2. 2037 Annual Average Daily Traffic estimated based on annual growth factor of 2% from 2017 traffic volumes
3. Minimum setback distance is based on distance to achieve the criteria for road traffic noise levels for proposed new roads of 60 L_{A10} (18h)

15.9 Construction cumulative impacts

Table 15.48 details other projects that may be constructed simultaneously with the Project and close enough to contribute to cumulative noise levels at sensitive receptors potentially affected by the Project. Other coordinated projects under the SDPWO Act are identified and assessed in Chapter 22: Cumulative Impacts have not been considered for noise and vibration due to their distances from the Project.

TABLE 15.48: SUMMARY OF CONSTRUCTION CUMULATIVE IMPACTS TO BE ADDRESSED

Project and Proponent	Location	Description	EIS status	Relationship to G2H
NSW/QLD Border to Gowrie (B2G)—Inland Rail (ARTC)	Rail alignment from NSW/QLD Border to Gowrie	216.2 km single-track freight railway as part of the ARTC Inland Rail Program	Draft EIS being prepared by proponent	Potential overlap of construction of B2G and construction of the Project in the Gowrie, Charlton and Kingsthorpe areas
Helidon to Calvert (H2C)—Inland Rail (ARTC)	Rail alignment from Helidon to Calvert	47 km single-track dual-gauge freight railway as part of the ARTC Inland Rail Program	Draft EIS being prepared by proponent	Potential overlap of construction of the Project and construction of H2C in the Helidon Spa and Helidon areas
InterLinkSQ	13 km west of Toowoomba	200 hectares (ha) of new transport, logistics and business hubs. Located on the narrow-gauge regional rail network and interstate network. Located at the junction of the Gore, Warrego and New England Highways.	Currently in development phase	Potential overlap of construction of the Project and construction of InterLinkSQ in the Gowrie, Charlton and Kingsthorpe areas
Asterion Medicinal Cannabis Facility	Wellcamp, Queensland Adjoins the Project disturbance footprint 1 km south of Toowoomba-Cecil Plains Road	A high-tech medicinal cannabis cultivation, research and manufacturing facility. The project involves construction of a 40-ha glasshouse to produce 20,000 plants per day at full capacity. Medicinal-grade cannabis grown at the facility will be manufactured into a range of medicinal products, including single patient packs, cannabis oils, gels, salts and related products, destined solely for the medicinal market. This facility is anticipated to be the largest facility of its kind in the world.	Under construction	There may be a brief overlap in 2021 between the conclusion of construction for the Asterion Medicinal Cannabis Facility and the commencement of early works activities for the Project

Simultaneous noise from construction works of B2G or H2C sections of the Inland Rail Program has the potential to increase noise levels at nearby noise sensitive receptors also impacted by construction noise associated with the Project. The likelihood of cumulative impacts from other sections of the Inland Rail Project are reduced by the linear progression of construction along the alignment. The current modelling methodology, however, already simulates simultaneous construction works by assuming that, as a worst-case, all activities could occur at any time within a defined area, including up to the Project boundary with B2G and H2C. In reality, construction crews for both projects would not be able to work as close as what was modelled if both projects were constructed at the same time and in close proximity to each other. As a result, the noise levels due to cumulative impacts are not expected to significantly increase the predicted levels at sensitive receptors.

Simultaneous noise from construction works of InterLinkSQ has the potential to increase noise levels at a limited number of sensitive receptors. InterLinkSQ is located south of, and adjacent to, the Project at the tie-in to B2G. It is anticipated that the Project and InterLinkSQ will use similar construction equipment and produce construction noise emissions of similar intensity. In the case of simultaneous works, the worst-case construction noise impacts at sensitive receptors to the south of InterLinkSQ are expected to be dominated by InterLinkSQ noise emissions. Noise impacts of Project construction at these receptors is predicted to be low. If simultaneous construction works occur, residential sensitive receptors to the west of Gowrie have the potential to be impacted by construction noise from both projects. In this instance, the maximum increase in worst-case construction noise impacts, above those predicted in Section 15.8, is 3 dBA. Such an increase is not expected to significantly increase the number or magnitude of exceedances of the CoP Vol 2 criteria. It should be noted that the predicted construction noise impacts at most of these residential receptors is below the CoP Vol 2 criteria. It is proposed that these cumulative impacts will be managed through:

- Informing nearby receptors of potential construction noise impacts
- Minimising the construction works that occur outside CoP Vol 2 standard hours (refer Table 15.11)
- Consultation with InterLinkSQ, to minimise the overlap of construction works and to maximise separation distances between cumulative construction works.

Concurrent construction of the Asterion Medicinal Cannabis Facility and the Project is expected to be brief and is unlikely to result in construction noise impacts at sensitive receptors significantly greater than those predicted to result from either project in isolation. Project construction noise impacts during earthworks are predicted to be up to 7 dBA greater than those during earlier Project works such as site setup. The scenario in which cumulative impacts increase early works noise impacts by, at worst, 3 dBA results in noise levels 4 dBA less than those predicted during earthworks of the Project alone.

The cumulative impact of noise would be managed as far as possible through the construction noise and vibration management plan (CNVMP) to ensure that the potential for adverse impacts at sensitive receptors is minimised. In addition, any overlap of construction works is likely to be for a limited period due to the linear nature of rail project construction.

15.10 Operational cumulative impacts

The subjective response to the different noise levels and noise characteristics of the intermittent sources of road traffic and railway noise are such that individuals are less likely to perceive or determine impacts based on a cumulative exposure of the combined transport noise. Consequently, the ToR requires road traffic and noise and railway noise to be assessed and, if necessary, mitigated separately.

The assessment of road traffic noise and railway are discussed in this chapter with the detailed noise assessments provided in Appendix O: Construction Noise and Vibration and Appendix P: Operational Railway Noise and Vibration, respectively.

15.10.1.1 Rail freight operations

On Inland Rail, the Project directly links to the west with the adjoining Border to Gowrie project section and links directly to the Helidon to Calvert project section to the east. At the sensitive receptors within the Project area, the primary source of rail noise will be the trains as they travel on the Project alignment.

Rail noise from the arrival and departure of the trains from the adjacent Border to Gowrie and Helidon to Calvert project sections will occur further from the Project infrastructure. The adjacent rail operations are not expected to result in a cumulative increase in daily railway noise levels at the sensitive receptors relevant to the projects.

While Inland Rail is being delivered as separate project sections, once in operation the source of railway noise and vibration would be unlikely to be defined by sensitive receptors as being within the extent of a specific project section. In this regard, subjective cumulative noise or vibration impacts from trains operating within individual project sections on Inland Rail is not anticipated to occur.

On the Project, the Inland Rail trains and existing rail operations at each project extent will be collocated within the same rail corridor. The overall railway noise levels from all train operations within the new and upgraded rail corridors have been assessed in this report.

Where required by the noise criteria and assessment methodologies, the potential cumulative noise from the existing rail traffic and the future additional rail traffic introduced with the Project was included in the noise and vibration modelling predictions, and the assessment of noise and vibration levels and associated related impacts.

Further consultation with Queensland Rail (QR) and DTMR may be warranted, regarding cumulative impacts as a result of the simultaneous operation of the railway lines should simultaneous operations occur – this includes the future timing and likely train services present. At draft EIS stage, consistent with the ARTC Inland Rail Programme Business Case (2015a), the Project design and all ARTC coordinated project assessment works have assumed all existing movements will move over to the Inland Rail alignment. Road and railway operations

While the policies and guidelines referenced by the ToR do not specify criteria or management objectives for combined road and railway transport noise, an overview assessment of potential cumulative transport noise has been undertaken to inform the EIS.

Based on the assessed road traffic and railway noise with the Project, the overview assessment determined:

- In general terms, cumulative transport noise levels would be expected only where road traffic or railway noise is within 10 dBA of each other (where the same noise metric is applied to quantify both sources of transport noise)
- At sensitive receptors adjacent to both the railway alignment and local roads (such as Ganzer Road, Morris Road, Old Homebush Road, East Paulsens Road, Jones Road, McNamaras Road and Cattos Road), the railway noise levels during train passby events are expected to be at least 10 dBA above the road traffic noise levels. The railway noise is likely to be the dominant source of noise and an increase in transport noise from the cumulative road traffic and railway noise is not expected at the sensitive receptors.
- The road traffic movements on the realigned section of Gowrie Junction Road may contribute noise levels within 10 dBA of the predicted railway noise levels, depending on the noise metrics used to evaluate transport noise. Road traffic noise levels within 152 m of Gowrie Junction Road have been identified to potentially require a review of road traffic noise mitigation at 18 sensitive receptors. The railway noise predictions identified five sensitive receptors in the area of the upgraded road network where railway noise mitigation will need to be reviewed. A review of aerial imagery identified that some property façades facing the rail corridor will likely be more exposed to railway noise than road traffic noise; whereas, the property façades facing Gowrie Junction Road may experience higher road traffic noise levels and be less exposed to railway noise. Nonetheless, any increase in daily transport noise at these receptors, from the combined road traffic and railway noise, would likely be a marginal perceptible increase of less than 3 dBA. Measures implemented by the Project to mitigate road traffic and/or railway noise would assist in addressing both the daily exposure to total transport noise as well as the shorter-term noise in the event that trains and road vehicles pass sensitive receptors at the same time.
- At the majority of sensitive receptors close enough to both the road network and railway alignment to potentially experience cumulative transport noise, the intermittent railway noise levels during train passby events are expected to be the dominant noise contribution.

The assessment has identified the potential for noise-related impacts as a result of cumulative noise to be minimal. The Project is investigating specific measures to control road traffic and railway noise consistent with the ToR and assessment criteria applied on the Project. Consequently, further measures to manage or mitigate cumulative transport noise are not likely to be required in areas where the Project's rail alignment crosses, or is adjacent to, the future local road network.

15.11 Mitigation

The noise and vibration assessments identified the construction and operation of the Project have the potential to trigger the assessment criteria. This section considers the approach to mitigation and management of noise during construction and operation.

This section outlines noise and vibration mitigation measures included as part of the Project design and the mitigation measures proposed for the Project as part of this assessment.

15.11.1 Initial mitigation

The mitigation measures and controls presented in Table 15.49 have been factored into the design for the Project. These design considerations are proposed to minimise the environmental impacts of the Project.

TABLE 15.49: INITIAL MITIGATION MEASURES OF RELEVANCE TO NOISE AND VIBRATION

Aspect	Initial mitigation
Project design	The Project has been designed with the aim of achieving construction noise and vibration criteria adapted from the CoP Vol 2 and summarised in Section 15.7.1
	The design of the Lockyer Creek viaduct has been undertaken to ensure there are no supporting structures or piers within the Roma Brisbane Gas Pipeline easement
	The bridges and viaducts are reinforced concrete structures with ballasted trackform. Potential vibration would be constrained to the immediate structure, which would be within the proposed rail corridor area. Regenerated noise issues beyond the rail corridor, identified an offset of 50 m from the outer rail, are not expected to result in a cumulative increase to the dominant airborne noise component.
Construction noise and vibration assessment	Where it is found that proposed mitigation measures are not sufficient to reduce adverse noise and vibration impacts to acceptable levels, additional mitigation measures will be investigated and implemented.
Operational noise and vibration	The Project will be designed and constructed with the aim of achieving the operational noise criteria adopted from ARTC's railway noise management criteria, the CoP Vol. 1, in the case of operational road traffic noise, and environmental noise objectives adopted from the EPP (Noise) for mechanical plant (fixed sources of noise). These criteria may be superseded by specific environmental performance requirements detailed in relevant Project approvals and environmental permits. Where it is found that standard mitigation measures are not sufficient to reduce operational noise impacts to acceptable levels, additional reasonable and practicable mitigation measures will be investigated and implemented.
Communication	Local residents/stakeholders will be provided with sufficient information to enable them to understand the likely nature, extent and duration of noise and vibration impacts during construction
	A community liaison phone number will be provided to the community so that noise-related complaints or inquiries can be received and addressed in a timely manner

15.11.2 Proposed mitigation measures

As detailed in Section 15.8, construction noise and vibration impacts are expected to exceed the limits established in Section 15.7.1. To mitigate the predicted construction noise and vibration impacts, the additional construction mitigation measures in Table 15.50 are proposed. Specific construction noise and vibration mitigation measures, and associated residual impacts, are to be determined during detailed design.

These proposed mitigation measures incorporate ARTC's standard practices, as well as industry best practice and legislative requirements such as CoP Vol. 2 and the Interim Guideline.

The operational road traffic assessment in Section 15.8.9.10 reveals that the following two roads near Gowrie are expected to exceed the operational road traffic criteria for roads specified by the CoP Vol 1 and listed in Section 15.7.8.4:

- Gowrie Junction Road
- Morris Road.

These segments are not close to built-up areas with many noise sensitive receptors. Mitigation measures in Table 15.50 are proposed to mitigate noise impacts from these roads.

TABLE 15.50: NOISE AND VIBRATION MITIGATION MEASURES

Delivery phase	Potential impacts	Mitigation and management measures
Detailed design	Construction noise and vibration impacts on sensitive receptors	Ongoing communication and consultation with nearby residents to create awareness and understanding of Project impacts prior to works occurring Prepare and implement a communications plan to liaise with potentially affected community stakeholders and landholders regarding potential noise and vibration impacts. Update the construction noise and vibration assessment to reflect the final location of construction sites, construction activities and construction scheduling to inform the development of a Construction Noise and Vibration Management Plan to ensure that the performance criteria are met. Consultation with APA to confirm design and construction methodology across the Roma Brisbane Gas Pipeline and the required interaction treatment options. This includes additional ground-borne vibration modelling for the Toowoomba Range Tunnel and the TBM operations to confirm whether vibratory monitoring or a coating survey is required, workshopping the design and construction methodology across the pipeline east of the eastern tunnel portal, external spanning of the gas pipeline easement east of Lockyer Creek sufficiently mitigates the possibility of pipeline external loading (e.g. bored or cast insitu piles) and use of protection slabs and road crossings as per relevant standards. Similar works may also be undertaken for other public utility providers, including TRC rising sewer main and the Wetalla Water Pipeline. Consultation with sensitive receptors identified from the construction noise modelling for the tunnelling operations, to determine on a case by case the preferred mitigation measures (e.g. temporary relocation of residents, respite periods as acoustic treatment are not an effective mitigation for ground-borne noise) and process to implement the measures (e.g. reconfirm the mitigation at specific points of time (e.g. 300 days, 100 days, 30 days and 10 days prior or within a specific distances). Noting that the tunnel's construction is expected to be approximately 24 months once the TBM is provisioned and as such impacts in the Mount Kynoch area may not be until 2025 three years after construction commences.
	Operational railway noise and vibration impacts on sensitive receptors	Review and, if necessary, update the operational noise and vibration assessment to reflect/inform the detailed design, including incorporation of potential noise or vibration treatments. The vibration assessment will include consideration of: ▸ Buildings/structures that will remain near to the Project works ▸ Other vibration-sensitive receptors (including buildings/structures of heritage value). The vibration assessment will identify building condition survey requirements at vibration-sensitive receptors that are expected to exceed the structural damage vibration limits given by DIN 4150-3 and recommended by the CoP Vol 2.
	Operational railway noise and vibration impacts on sensitive receptors (continued)	The following treatments are to be undertaken as part of detailed design: ▸ Source controls—mitigation measures applied to the railway infrastructure to control the emission of noise and vibration at its source. Such measures include: rail dampers; track lubrication (for control of curving noise); identification of rollingstock, causing discrete high noise events; or lower noise emission alarm bells. ▸ Pathway controls—measures to impede and limit the propagation of railway noise to the sensitive receptors and typically constructed within the rail corridor. Measures can include: railway noise barriers, low height noise barriers or earth mounding. ▸ Receptor controls—measures to mitigate noise and vibration levels or manage potential noise and vibration impacts at the sensitive receptor properties and land uses. Measures can include: architectural acoustic treatment of property; property construction/relocation; upgrades to existing property fencing; or negotiated agreement with property owners.

Delivery phase	Potential impacts	Mitigation and management measures
Detailed design [continued]	Operational road traffic noise impacts on sensitive receptors	Update the operational road traffic noise and vibration assessment to reflect the detailed design, including incorporation of potential noise treatments. The following mitigation measures are to be considered as part of detailed design, where operational road traffic noise impacts are predicted to exceed the adopted road traffic noise limit: - Realignment of road segments impacting nearby sensitive receptors - Pavement surface treatment - Provision of acoustic façade treatments to affected sensitive receptors - Noise barriers in the form of a landscaped earth mound and/or a noise fence A combination of mitigation measures may be appropriate.
	Operational fixed infrastructure noise impacts on sensitive receptors	Safety systems, such as door alarms, have not been assessed as operational fixed infrastructure but should be fit for purpose and meet safety system requirements. Where possible, the contractor will select systems with the aim of achieving the EPP (Noise) 35 dBA $L_{Aeq,\,1\,hr}$ acoustic quality objective at all sensitive receptors.
Pre-construction	Noise and vibration impacts on sensitive receptors	- Ongoing communication and consultation with nearby residents to create awareness and understanding of Project impacts prior to works occurring - Acoustic specialist to reassess the model based on the approved construction methodology to verify sensitive receptors likely to be impacts, where the impacts may occurred and the likely duration. The specialist will also recommend acoustic treatments to mitigate the impacts with all this to be conveyed to the community and the affected landholders in accordance with the relevant communications plan - Develop and implement the Construction Noise and Vibration Management Plan. The plan will include: - Location of sensitive receptors in proximity to the disturbance footprint - Requirements for pre-construction dilapidation surveys and/or vibration monitoring at vibration sensitive receptors, including heritage receptors and near underground infrastructure, during construction - Specific management measures for activities that could exceed the construction noise and vibration criteria at a sensitive receptor (e.g. squawkers for reversing vehicles, acoustic sheds, noise curtains/barriers) - Measures to monitor ground-borne noise during construction and the process to update the models - Noise and vibration criteria, trigger or alarm levels and distances for above and underground infrastructure - Notification process within the community engagement plan (including who to contact in the event of a complaint) to advise of significant works with potential for noise nuisance or vibration at sensitive receptors - Noise management measures, including controlling noise and vibration at the source, controlling noise and vibration on the source to receptor transmission path, and controlling noise and vibration at the sensitive receptor. - Practicable and reasonable measures to minimise the noise and vibration impacts of construction activities on sensitive receptors - Any other measures necessary to comply with the stated conditions imposed under Coordinator General's EIS evaluation report and legislative requirements. Where it is found that existing mitigation measures are not sufficient to reduce noise and vibration impacts to acceptable levels, additional mitigation measures will be investigated and implemented. Where construction noise and vibration impacts are unavoidable and predicted to exceed relevant criteria, after all reasonable and practicable mitigation measures are implemented, residual impact mitigation should be considered in consultation with the community and affected residents. Residual impact mitigation measures, such as construction respite periods, temporary relocation of affected occupants, and provision of architectural treatments are discussed in Section 15.11.4.1.

Delivery phase	Potential impacts	Mitigation and management measures

Pre-construction [continued]	Noise and vibration impacts on sensitive receptors from tunnelling	▶ Prior to commencement of tunnelling, site tests are proposed to determine a more representative model of the ground surrounding the tunnel. This includes:
		  ▶ Conducting transfer mobility tests along the alignment, during bore-holing or other deep ground-intrusive activities, to determine site propagation
		  ▶ Conducting vibration monitoring during the TBM launch and during preliminary TBM operations to confirm TBM source vibration levels and propagation characteristics specific to the TBM
		▶ Vibration monitoring and transfer mobility test locations are to be nominated in the construction noise and vibration management sub-plan, as part of the CEMP
		▶ Results of vibration monitoring and transfer mobility test locations are to be used to refine ground-borne noise impact predictions and inform where mitigation measures are to be applied
		▶ Residents within at least 390 m of the Toowoomba Range Tunnel section of the Project alignment to be consulted regarding ground-borne noise impacts of the TBM
		▶ Residual impacts of tunnelling, expected at sensitive receptors within a 390 m diagonal distance of the tunnel, are most likely to be managed through temporary relocation of affected residents, as detailed in Section 15.11.3
		▶ For the small industrial areas in proximity to the alignment (including receptors RET0002, IND0009 and RET0004, as per Appendix O: Construction Noise and Vibration) the owners/tenants to be engaged to identify if office spaces are on the site. If so, a mitigation plan is to be in place to minimise disruption.

Construction and commissioning	Noise and vibration impacts on sensitive receptors	▶ Sensitive receptors identified in the noise and vibration sub-plan, as well as residents within 2 km of the Project disturbance footprint and other relevant stakeholders, to be provided with sufficient information to enable them to understand the likely nature, extent and duration of noise and vibration impacts during construction ▶ Sensitive receptors with the potential to be affected by noise will be notified prior to the commencement of relevant works ▶ Construction progress and upcoming activities will be regularly communicated to local residents/stakeholders, particularly when noisy or vibration-generating activities are planned, such as vibratory compaction and piling ▶ Implementation of the Social Impact Management Plan (refer Chapter 16: Social) ▶ Additional vibration modelling to assess vibration impacts on Roma Brisbane Gas Pipeline
	Damage to buildings and structures	▶ Building condition/dilapidation surveys will be undertaken for buildings/structure in close proximity to the activities and at vibration sensitive receptors, including buildings of heritage value identified as potentially impacted by the Project during the detailed design phase modelling and assessment. Building surveys will also be undertaken at vibration sensitive receptors that are expected to exceed the structural damage vibration limits given by DIN 4150.3 and recommended by the CoP Vol 2. Surveys are to take place prior to commencement and on completion of vibration generating works (such as pile-driving). Following such surveys, more accurate data may be used to assess the impacts to vibration sensitive receptors.

Delivery phase	Potential impacts	Mitigation and management measures

Construction and commissioning [continued]	Damage to buildings and structures [continued]	‣ If, during detailed design and construction methodology assessments, vibration impacts are predicted to exceed the criteria at a heritage sensitive receptor, the following mitigation will be undertaken:
		  ‣ Consultation with the owner of the structure to determine the sensitivity of the structure to construction vibration. More appropriate criteria to be applied at the location may be agreed on as a result.
		‣ Baseline vibration monitoring to be undertaken prior to the activity commencing and monitored throughout the activity to assess compliance with vibration limits set as part of the Noise and Vibration Sub-Plan for the relevant receptor. Vibration monitoring results to be assessed and used to refine vibration predictions and management measures, as applicable, such as developing and enforcing exclusion zones around the sensitive structure.
		‣ Where reasonable and practicable, modify the construction methodology to reduce the predicted vibration impacts. This may include:
		  ‣ Using smaller equipment, such as a handheld jackhammer instead of a rockbreaker
		  ‣ Changing the construction methodology.
		‣ Construction vibration predictions will be revised following detailed geotechnical investigations and the development of a detailed construction methodology. Predictions will identify sensitive receptors and underground infrastructure with the potential to be exposed to vibration levels exceeding the relevant criteria identified in Section 15.7.6, and any criteria specific to particular infrastructure adopted through consultation with stakeholders.
		Vibration monitoring will be undertaken at locations where the potential for building/structural damage risk to sensitive receptors or underground infrastructure has been identified during the detailed design. This includes vibration sensitive receptors at which vibration impacts are expected to exceed the structural damage criteria recommended by DIN 4150.3 and recommended by the CoP Vol 2. Vibration monitoring will be undertaken by a suitably qualified professional, in accordance with the CoP Vol 2.

	Noise impacts on sensitive receptors	‣ Where practicable, noise monitoring will be undertaken at noise sensitive receptors in the event that it has previously been identified that there is potential for noise impacts to exceed relevant criteria ‣ Noise and/or vibration monitoring will also be undertaken in response to noise or vibration complaints
	Noise impacts on sensitive receptors—hours of work	‣ Construction works will be undertaken in accordance with the nominated hours of work in the CEMP. Out-of-hours activities are expected to be confirmed following consultation with the relevant councils, the local community and sensitive receptors. Where feasible, construction works will be undertaken during CoP Vol 2 standard hours, to minimise impacts to nearby sensitive receptors.

	Noise impacts on sensitive receptors—staff	‣ Staff training to be undertaken so that unnecessary sources of noise are avoided. Training will enforce that:
		  ‣ Unnecessary shouting or loud stereos/radios onsite are not tolerated
		  ‣ Materials are not to be dropped from height
		  ‣ Metal items are not thrown
		  ‣ Doors/gates are not slammed
		  ‣ Vehicle radios and engines are to be turned off or volume lowered wherever possible.

Delivery phase	Potential impacts	Mitigation and management measures
Construction and Commissioning [continued]	Noise and vibration impacts on sensitive receptors—selection of construction equipment near sensitive receptors	▸ Quieter and non-vibratory construction equipment will be selected for use near sensitive receptors, where feasible and reasonable. This is particularly important for any non-standard/out-of-hours construction activities where sensitive receptors are nearby. This is also particularly important for loud and/or vibration-intensive plant, such as mulchers and piling rigs. Appropriately sized equipment to be selected for the task, such as vibratory compactors and rock excavation equipment. For example, a 22-tonne excavator is expected to operate 8 dBA quieter than a 40-tonne excavator, based on equipment noise emissions given by BS5228.1.
	Noise and vibration impacts on sensitive receptors—selection of construction methods near sensitive receptors	Where reasonable and practicable, alternative construction methods will be adopted to reduce the noise and vibration impacts, such as: ▸ Using damped tips on rockbreakers, where appropriate ▸ Using rock saws instead of blasting ▸ During clearing, using excavators with grabs and rake attachments instead of chainsaws; and mulching cleared material at locations away from sensitive receptors ▸ Avoiding onsite fabrication work where possible ▸ Using alternatives to impact pile driving, where possible, such as continuous flight auger injected piles, pressed-in preformed piles, auger bored piles, impact bored piles or vibratory piles ▸ When piling, avoiding dynamic compaction using large tamping weights near sensitive and critical receptors, where possible. Reducing energy per blow when piling (consider first whether this may result in prolonged exposure with no realised reduction in community disturbance).
	Noise and vibration impacts on sensitive receptors—blasting	Where blasting impacts are expected to exceed the vibration limits adopted from the CoP Vol 2, the following measures will be undertaken, where practicable: ▸ Reducing the charge size by use of delays and reduced charge masses ▸ Ensuring adequate blast confinement to minimise the amount of overpressure ▸ Avoiding secondary blasting where possible; the use of rockbreakers or drop hammers may be an acceptable alternative ▸ Avoiding blasting during heavy cloud cover or during strong winds blowing towards sensitive receptors ▸ Establishing a blasting timetable through community consultation for example, blasts times negotiated with surrounding sensitive receptors.
	Noise and vibration impacts on sensitive receptors—during hours of construction	▸ Equipment will be operated in the correct manner and correctly maintained, including replacement of engine covers, repair of defective silencing equipment, tightening of rattling components and repair of leakages in compressed air lines. Construction plant, vehicles and machinery will be maintained and operated in accordance with manufacturer's instructions to minimise noise and vibration emissions. ▸ When piling, the pile and rig are to be carefully aligned, and cable slap and chain clink minimised.

Delivery phase	Potential impacts	Mitigation and management measures
Construction and Commissioning [continued]	Noise and vibration impacts on sensitive receptors—mechanical plant management	▸ All mechanical plant near sensitive receptors will be modified to reduce noise by best practical means, such as: ▸ Internal combustion engines fitted with a suitable muffler in good repair, operating as per the manufacturer's specifications, as a minimum ▸ Pneumatic tools fitted with an effective silencer on their air exhaust port, where feasible and practicable ▸ Aggregate bins and chutes lined with a rubber material, to dampen the vibration of the structure ▸ When piling, acoustic damping provided to sheet steel piles to reduce vibration and resonance ▸ When piling, resilient pads used between pile and hammerhead. Care to be taken when selecting a resilient pad as energy is transferred to the pad in the form of heat. ▸ Based on manufacturer data, between 4 and 11 dBA of attenuation can be achieved by engine mufflers. Various other equipment treatments, such as dozer track plate dampers, can provide between 6 and 10 dBA of attenuation, based on manufacturer data.
	Noise impacts on sensitive receptors—stationary noise sources	▸ Stationary noise sources near noise sensitive receptors will be shielded or enclosed. Acoustic shielding will also be considered where works are expected to occur close to sensitive receptors for lengthy periods. Temporary noise barriers or enclosures can provide between 5 and 10 dBA of attenuation, based on preliminary calculations.
	Noise and vibration impacts on sensitive receptors—shielding of noise emitting plant	▸ Where feasible, structures and noise-emitting plant will be located such that the structures provide some shielding to any nearby receptors. Structures include: ▸ Temporary site buildings, such as sheds ▸ Materials stockpiles, including the spoil stockpile at the western tunnel portal ▸ Fencing ▸ Storage/shipping containers. ▸ Attenuation by a single row of standard shipping containers of between 5 and 10 dBA is achievable based on preliminary calculations, provided that: ▸ Four containers are located side-by-side between the noise source and the sensitive receptor, and 5 m from the noise source ▸ Gaps are overlaid with mass loaded vinyl. ▸ Where vibration impacts at sensitive receptors are expected to exceed the structural damage limits adopted from the CoP Vol 2 and summarised in Section 15.8.3, and where reasonable and safe to do so, cut-off trenches to interrupt the direct transmission path of vibrations between source and receptors will be provided.
	Noise impacts on sensitive receptors	▸ Non-tonal reversing beepers (or an equivalent mechanism) to be fitted and used on all construction vehicles and mobile plant regularly used onsite and for any out-of-hours work.

Delivery phase	Potential impacts	Mitigation and management measures
Construction and Commissioning [continued]	Noise impacts on sensitive receptors—delivery of materials	▸ Site access points and roads will be sited as far as is practicable from sensitive receptors ▸ Acoustic shielding will be considered if loading/unloading areas are close to sensitive receptors ▸ Delivery vehicles will be fitted with straps rather than chains, where feasible ▸ Offsite truck parking areas, if required, will be located away from residences and will be nominated, where practicable ▸ The drop height of materials will be minimised, e.g. while loading and unloading vehicles or in storage areas ▸ Reversing movements of vehicles will be minimised to reduce the use of reversing alarms. Where practicable, sites to be designed such that delivery vehicles are able to drive through the site and not be required to reverse. ▸ Unsealed areas to be regularly graded and potholes filled in sealed access roads and hardstand areas to reduce noise from construction vehicles.
	Noise impacts on sensitive receptors—construction traffic	▸ Construction traffic to be kept to a minimum, e.g. trucks to be fully loaded so that the volume of each delivery is maximised. Where practicable, night-time construction traffic will be redirected away from noise sensitive receptors. ▸ The speed of construction traffic to be minimised near noise sensitive receptors ▸ Selection of construction traffic routes to consider noise impacts to sensitive receptors.
	Noise and vibration impacts on sensitive receptors	▸ Notify residents when the TBM is within 500 m and confirmed whether the agreed mitigation measure is still applicable ▸ Implement the agreed mitigation with the relevant landholder ▸ Undertaken ground-borne noise and vibration monitoring, where applicable.
Operation	Noise and vibration impacts on sensitive receptors—operation	▸ The operational railway noise and vibration levels will be verified through a program of noise and vibration monitoring once the Project is operational. The monitoring program would be undertaken within the initial 6 months post commencement of railway operations (train movements) on the Project. ▸ ARTC will investigate feasible and reasonable mitigation measures where monitored operational noise and/or vibration levels at sensitive receptors are confirmed to be above the railway noise and vibration criteria Mitigation options for airborne noise from train movements (refer Section 15 of Appendix P: Operational Railway Noise and Vibration): ▸ Rail noise barriers can be an effective noise mitigation option to control noise from both the wheel–rail interface and from locomotives. Appropriately designed noise walls and barriers can typically reduce noise levels by 5 to 15 dBA. ▸ In situations where the primary noise source is from the wheel–rail noise, low height barriers can be constructed close to the outer rail. The key considerations with rail noise walls or barriers, include: ▸ Proximity of key infrastructure, such as local roads, waterways and drainage culverts ▸ Limitations to the noise reduction performance where noise barriers are not able to be high enough to screen the line of sight between receptors and the trains ▸ Availability of land between the rail line and sensitive receptors ▸ Achieve minimum design performance requirements for: noise reduction, control of reflected noise, earthworks, flooding, surface water run-off, stabilisation, wind loading and erosion

Delivery phase	Potential impacts	Mitigation and management measures
Operation [continued]	Noise and vibration impacts on sensitive receptors—operation [continued]	▶ Social and environmental factors, including loss of open aspects and breezes, potential for vandalism, landscape impacts and loss of vegetation ▶ Earth mounds at the rail corridor boundary can be used as an alternative to rail noise walls or barriers ▶ Rail dampers applied to the rails to control rolling noise ▶ Maintain defective rollingstock to target maintenance for wheel flats or misaligned axles/bogies ▶ Track lubrication systems for track with a radius <500 m to control potential curving noise Exhaust mufflers for locomotive exhausts. Mitigation measures to control ground-borne noise and vibration to consider: ▶ An effective high vibration attenuation class trackform, such as Vossloh 300 NG with the 17 MN/m static stiffness 'Cellentic' pad, for the trackform in the Toowoomba Range Tunnel. Where at-source noise controls are not reasonable and practicable or do not fully attenuate noise levels to achieve the noise criteria, ARTC will consider the following at-property treatments in consultation with the landholder: ▶ Architectural treatment for habitable rooms within residences; such measures can include: upgrading acoustic glazing; acoustic window and door seals; acoustic insulation for the roof; and provision of upgrades to ventilation to allow fresh air where windows are closed, to limit noise intrusion ▶ Property treatment measures would be designed specifically for each individual receptor based on the received noise levels and building construction ▶ The application of architectural treatments will need to consider the control of low frequency noise and potential annoyance characteristics ▶ Upgrades to existing property fencing ▶ Landholder relocation may be considered on a case-by-case basis.

With the application of the silencers described in Section 15.8.9.9, no operational fixed infrastructure noise impacts are expected to exceed the EPP (Noise) acoustic quality objectives. These silencers are indicative mitigation measures and other mitigation options can be explored, such as:

- Installation of acoustic louvres on the ventilation station façade
- Internal acoustic lining in the tunnel and/or ventilation system
- Use of quieter plant equipment.

Selection of mitigation measures will be confirmed during detailed design, once fan selection decisions have been made.

15.11.3 Operational railway noise and vibration mitigation

ARTC is applying the following strategy for the Project, as the basis for selecting reasonable and practicable noise mitigation:

- Noise barriers are generally only considered where groups of triggered sensitive receptors are apparent. For isolated receptors, such as single dwellings in rural areas, noise barriers are not considered.
- The noise mitigation for isolated receptors is expected to include:
  - At-property architectural treatments to the building (such as increased glazing or façade constructions) to control rail noise inside the building
  - Upgrades to the receptor property boundary fencing to improve screening of rail noise levels.
- For two receptors on the same side of the track, the potential for a noise barrier or architectural treatment of the building will be considered on a case-by-case basis
- For three or more receptors in close proximity on the same side of the track, noise barriers will be considered as a primary noise mitigation option.

At the time of the EIS, based on the results of the railway noise assessment, and with consideration to ARTCs noise strategy, railway noise barriers within the rail corridor are anticipated by ARTC to not be considered either reasonable or practical for the Project. A review of potential reasonable and practicable mitigation options, to reduce and control noise levels and noise-related impacts at sensitive land uses, is discussed in Table 15.51.

A comprehensive review of reasonable and practicable railway noise and vibration mitigation measures, including railway noise barriers, is discussed further in Appendix P: Operational Railway Noise and Vibration.

The final decision on noise mitigation will be determined during the detailed design and construction of the Project. Property mitigations will be site-specific and based on conditions present.

TABLE 15.51: NOISE MITIGATION OPTIONS FOR ROLLING STOCK NOISE

Action required	Safeguard details
At property treatments	
Architectural treatment of property	Where external rail noise levels are validated, through measurement, to exceed the assessment criteria, a potential option is to mitigate the intrusion of rail noise in the affected property. The provision of architectural treatment would depend on a number of factors and is expected to only apply to habitable rooms or acoustically significant rooms/uses of sensitive buildings. Typically, measures such as upgraded acoustic glazing; acoustic window and door seals; and acoustic insulation for the roof are considered to mitigate noise intrusion. The provision of upgrades to ventilation, such as fresh air ventilation (acoustic ducting), allow windows to be kept closed as a mitigation option while maintaining air flow.
	Appropriately designed measures, where windows are closed, can mitigate the intrusion of noise by more than 10 dBA; however, these measures can be more effective to control the intrusion of rolling noise, as it is more broadband in nature and often does not have prominent tonal or low-frequency components. All consideration of architectural property treatment would be subject to the individual property. Suitability will be confirmed prior to the implementation of at-property noise control treatments.
	In rural locations, the age and construction of residential properties can influence the practical implementation of modern architectural treatments. The review of architectural treatments will require a further review of the eligible properties and advice from suitably qualified professionals.
Consideration of low-frequency noise content	Where the control of locomotive exhaust noise is required, the architectural acoustic treatments would need to consider the control of low-frequency noise intrusion to achieve an overall improvement to the internal rail noise levels and potential characteristics that could cause annoyance. The control of low-frequency noise in a property is challenging and care needs to be taken to manage residual impacts, such as the architectural treatments controlling the mid and high frequencies, which may cause the low-frequency noise to become more perceptible.
Upgrades to existing property fencing	Existing fencing at the boundary of individual receptors can be upgraded by replacing part or all of the existing fencing with an 'acoustic' fence design. Compared to standard residential property fencing, an acoustic fence, such as aerated concrete (solid masonry), has an improved acoustic transmission loss performance. While the noise reduction performance will be specific to individual properties, upgrades to existing property fencing are likely to be suitable only where noise reductions of less than 10 dBA are required. The potential for upgrading existing property fencing can be limited by the line of sight between the railway and the receptor, the available land and the requirements of local councils and regulatory authorities with respect to the height and materials permitted for property boundary fencing. Agreement between the landholder and ARTC would be required for ARTC to undertake works on private property.
Property relocation	In rural locations, individual residential property can be located on large land holdings. It may be possible to relocate the residential property within the same land so that it is further from the rail corridor and noise levels would be lower. The relocation of property would be assessed on a case-by-case basis to ensure there would be a notable improvement to the noise environment at the relocation site.
Negotiated agreements	The implementation of architectural treatments, and other measures to private property, would likely be subject to the agreement of commercial and legal terms and conditions between ARTC and the property owner.

Action required	Safeguard details
Source controls	
Managing curving noise	Track lubrication systems: ▸ Diagnosis and control of curving noise can require detailed investigation of the track systems and rollingstock. Track lubrication systems are an effective control measure to reduce, and even eliminate, curving noise. Wayside lubrication systems include gauge-face lubrication and top of rail friction modifiers. The Project alignment includes a section of curved track with a radius <500 m where the Project connects with the West Moreton System east of Gowrie. On this basis, track lubrication systems should be considered for the rail spur to control potential curving noise. Other measures: ▸ Depending on the specific source of the rail noise, other measures can include wheel dampers to control aspects such as curving noise (wheel squeal). Because such measures require specifications for the rollingstock they will not be readily implementable by ARTC without appropriate commitments from rail operators.
Rail dampers	Rail dampers may provide localised benefit for the control of rolling noise where the contribution from the rail is a primary factor. International experience suggests a reduction in rolling noise of 3 dBA could be achieved and there is limited evidence that suggests rail dampers can provide some benefit in controlling curving noise. The effectiveness of rail dampers may be limited by the stiffness of the ballasted track and concrete sleepers, the forces exerted by the heavy rail freight and the long-term durability and maintenance of such measures. Sections of generally straight alignments that are not highly susceptible to prominent or regular wear. These sections would be most suited for consideration of rail dampers.
Identification of the causes of rollingstock noise	Defects with the wagons, such as wheel flats or misaligned axles/bogies can cause discrete and potentially annoying high noise events. ARTC currently implements Wayside Monitoring Systems across the rail network. A range of monitoring systems are in place to identify individual rollingstock and the specific sources of noise for the targeted management and mitigation of railway noise. The Wayside Monitoring Systems include: ▸ Wheel impact and load detector, bearing acoustic monitoring (RailBAM) and Squeal acoustic detector (RailSQAD) ▸ Angle of attack, hunting detector and wheel profile monitoring. A similar monitoring program could be implemented to identify sources of high noise events. Once identified, defective rollingstock can be temporarily removed from service and defects repaired to address factors contributing to higher noise levels or discrete annoying noise characteristics. This measure is not readily implementable by ARTC without appropriate commitments from rail operators. It is likely the overall reduction to L_{Aeq} and average L_{AMax} noise levels would be minor but would assist in managing noise events that could cause disturbance.
Exhausts and engine shrouds	The exhaust outlets of the locomotives can be a primary source of low-frequency and overall noise emissions from the train passbys. The exhaust systems of new and existing locomotives can be modified with exhaust mufflers to improve attenuation of noise emissions, including low-frequency noise. Because such measures require specifications for the rollingstock, they will not be readily implementable by ARTC without appropriate commitments from freight operators.
Operations	
Operational verification	The operational railway noise and vibration levels will be verified through a program of noise and vibration monitoring once the Project is operational. The monitoring program would be undertaken within six months of commencement of Project railway operations (post commissioning train movements). ARTC will investigate reasonable and practicable mitigation measures where monitored noise and or vibration levels at sensitive receptors are confirmed to be above the railway noise and vibration criteria.

15.11.4 Residual impact mitigation

15.11.4.1 Construction noise impacts

Across all construction activities, 64 per cent of exceedances of the upper standard hours noise limit under the CoP Vol 2 are within 10 dBA of the limit, as are 68 per cent of exceedances of the evening non-standard hours noise limit. Of the construction noise mitigation measures proposed in Section 15.11.2, those which can be quantified can be expected to provide between 4 and 11 dBA attenuation. The remaining approximate 46 per cent of exceedances are not expected to be feasibly mitigated to below the appropriate limit by physical attenuation alone. Where further mitigation is not practicable, residual exceedances will need to be managed. As with the implementation of mitigation measures, management of residual impacts are to be undertaken in consultation with the community and affected residents.

Specific management of residual impacts will be determined during detailed design, and included in the construction noise and vibration management sub-plan. As with the implementation of mitigation measures, management of residual impacts are to be considered in consultation with affected occupants.

Construction works by nature can be inherently noisy and, even with the implementation of reasonable and practicable mitigation measures, construction noise can be audible in the local environment. There remains potential that where noise levels are managed to achieve the noise criteria from the CoP Vol 2 noise-related impacts, such as disturbance or annoyance, could occur.

Residual exceedances can be expected where noise and vibration impacts are unavoidable and above relevant criteria after all reasonable and practicable mitigation measures are implemented. Currently, these residual impacts would be addressed through respite, temporary relocation of affected occupants and the provision of architectural treatments.

Respite periods involve scheduling work periods when people are least affected, such as by:

- Scheduling work for when premises are not in operation or occupied
- Restricting the works to occur within standard hours as defined by CoP Vol 2
- Restricting the number of nights per week that works are undertaken near sensitive receptors.

Temporary relocation involves the voluntary relocation of impacted occupants for short periods of time where all reasonable and practicable measures and respite periods has been implemented and further mitigation is impractical. Examples of temporary relocation may involve the offer of an alternative activity or accommodation. This is likely the main solution for the tunneling impacts as acoustics treatments are not suitable for ground-borne noise.

For the 72 sensitive receptors where ground-borne noise is predicted to exceed the relevant ground-borne noise criteria consultation will be ongoing as the impacts may not be experienced until three years after construction has commented (i.e. the tunnel excavation rate may be 10.5 m/day, with most of the sensitive receptors located at Mount Kynoch approximately 4.5 km). ARTC will continue to engage with the directly affected landholders and will seek to engaged with the other identified sensitive receptors too:

- Outline the impacts, including how the impact were predicted, how the impact may be experienced at the location and the duration of the impact. Noting that the duration and the timing of the impact will only be determined once the construction methodology is confirmed.
- Describe likely treatments to manage the impacts, with the main option being for the resident to remain at the property or for the temporary relocation of residents. Noting that acoustic treatment are not an effective mitigation for ground-borne noise
- Confirm the notification process to implement the mitigation measures. That is, reconfirm the mitigation at specific points of time (e.g. 300 days, 100 days, 30 days and 10 days prior) or within at specific distances with the relevant landholder.
- Changes to the level of impacts based on updated modelling, changes to construction and actual monitoring data will also be conveyed to the receptors.

This engagement process will be ongoing throughout the Project, with the process to be formalised through a communication plan.

Architectural treatments may involve the provision of alternative ventilation where the windows are to remain closed. The existing architecture of the building may not adequately mitigate the impacts due the design constraints of specific elements (e.g. windows and doors) and architectural treatments should primarily focus on those elements.

15.11.4.2 Operational noise

Residual impacts for construction activities will be temporary and will cease once nearby construction is complete.

Residual operational noise impacts will require the implementation of mitigation measures in accordance with relevant legislation and policy to meet the relevant criteria. The residual operational noise levels may result in minor, and not unreasonable, increases in background noise levels for a limited number of sensitive receptors.

Given the sparse nature of the sensitive receptors, along with the Project design (i.e. there is over six km of viaducts in Lockyer Valley where exceedances are predicted) the reasonable and practicable noise mitigation for the Project is expected to primarily be at-property treatments, such as upgrading existing glazing or the provision of air conditioning, to manage the intrusion of rail noise and maintain internal (indoor) noise amenity in habitable rooms. These treatments do not address the source emission of rollingstock noise or the external (outdoor) rail noise levels in the environment surrounding the rail corridor.

Consultation with the affected sensitive receptors has commenced, including discussion around mitigation measures with some residents indicating a preference for soil bunds rather than noise barriers. This consultation will be ongoing, including in response to the outcomes of further assessment of the operational railway noise modelling during detailed design.

Consultation with QR is to be undertaken as the majority of the exceedances are in the brownfield section where the existing rail corridor also constrains solutions at track.

The intent at this stage is to mitigate the noise from the operation of the Inland Rail Project, noting that it has been assumed that the existing rail traffic will move over to the Inland Rail alignment in preference to the existing rail alignment. As noted in Section 15.8.9, the noise levels from the existing rail operations were modelled and the predicted noise levels at all sensitive receptors were below the criteria outlined in the Interim Guideline (e.g. LAmax 87dBA). Rail movement on the existing shared corridor have been modelled as part of the Project. ARTC as such are not mitigating impacts associated with existing brownfield movements.

The operation of the existing alignment and triggers for appropriate mitigation measures will need to be confirmed with QR as part of bilateral mechanisms.

15.12 Conclusions

15.12.1 Construction noise

A construction noise impact assessment has been carried out in accordance with the CoP Vol 2 and the ToR. Reasonable worst-case construction scenarios have been assessed for each of the main construction activities.

The assessment of noise associated with the construction of the Project indicates exceedances of both the lower and upper external noise limits in the noise and vibration study area. The number of exceedances varies with the time of day and the construction activity. The greatest construction noise impact is that of earthworks occurring during non-standard hours, which is predicted to result in construction noise impacts at 2,131 (refer Table 15.29) sensitive receptors to exceed the relevant construction noise criterion. During standard hours, earthworks noise impacts are predicted to exceed the relevant criterion at 192 sensitive receptors, of which 70 are predicted to exceed the criterion by more than 10 dBA. The magnitude and number of exceedances are detailed in Appendix O: Construction Noise and Vibration.

Noise generated during 'earthworks' and 'rail civil works' construction activity is predicted at the highest number of sensitive receptors; however, other construction activity may have greater overall impact depending on actual timing and duration of each construction stage.

Prior to relevant works commencing, a Noise and Vibration Sub-plan would be developed as part of the CEMP, developed in response to detailed construction planning and detailed design. Where it is predicted that noise or vibration impacts will exceed the criteria, reasonable and practicable mitigation measures will be developed in consultation with adversely affected sensitive receptors.

15.12.2 Tunnel construction

The construction of the Toowoomba Range Tunnel will be the longest continuous construction activity for the Project. The tunnel does not directly underly any residential and commercial buildings; however, it is predicted that the operation of the TBM will exceed the relevant criteria at 22 sensitive receptors during standard hours (i.e. within a 390 m diagonal distance of the tunnel) and 72 residential receptors during non-standard hours noise criterion (i.e. within a 390 m diagonal distance of the tunnel).

The duration of the impact will be dependent on the type of TBM being operated, the depth of the tunnel and the local geology. Based on an estimated excavation rate of 10.5 m/day, the duration of the impacts could be up to 75 days.

Consultation with the potentially affected receptors will be ongoing through the detailed design and construction phases, including the potential to relocate occupants when works are located within the abovementioned distances.

15.12.2.1 Construction road traffic noise

The CoP Vol 2 specifies that construction traffic should not increase the pre-construction traffic noise level by more than 3 dB. The maximum predicted increase in noise level from five roads is greater than this criterion.

These roads are primarily in rural locations and the existing base traffic volumes quantities are low. As such, the initial airborne road traffic noise levels are low, before the addition of construction traffic. Relevant mitigation measures outlined in Section 15.11.2 will be applied to these five roads expected to exceed the criteria.

15.12.3 Construction vibration

Minimum working distances for vibration intensive construction work have been predicted for human comfort and structural damage limits in Section 15.8.3. Exceedances of the construction vibration criteria adopted from CoP Vol 2 have been predicted at up to 175 sensitive receptors. Specific measures to mitigate vibration have been outlined in Section 15.11.2.

15.12.4 Blasting

Maximum blasting charge masses based on indicative setback distances of sensitive structures and heritage buildings are presented in Section 15.8.4, including heritage structures. This type of assessment has been completed in the absence of detailed information surrounding the blasting works required as part of the Project. Additional assessments incorporating site conditions will need to be completed during future stages of the Project to ensure safe charge mass amounts are used. Measures to mitigate these impacts of blasting are proposed in Section 15.11.2.

15.12.5 Operational rail noise and vibration

Based on the prediction and assessment of potential noise levels from the daily train movements on the Project, the noise criteria for the daytime and night-time periods are achieved at the majority of the identified sensitive receptors. There are up to 33 sensitive receptors (32 properties assumed to be residential and the Gowrie State School) where noise levels trigger a review of mitigation.

The majority (19) of the exceedances are residential buildings, including multiple dwellings on the same land parcel, within the brownfield section (e.g. Paulsens Road). Within the greenfield section of the Project, 13 exceedances are predicted, which generally reflects the settlement pattern along this section of the Project alignment.

The locations of the 33 sensitive receptors, the predicted noise levels at each receptor and potential mitigations measures were reviewed to identify the appropriate noise mitigation options. In addition to source noise controls implemented in the design and construction of the Project, reasonable and practicable noise mitigation is expected involve at-property treatment for the sensitive receptors.

The specifics of at-property treatments will be determined by ARTC on a case-by-case basis that will consider a range of factors, including received railway noise levels, pre-existing condition of the buildings and habitable rooms, construction and design of the property, engineering feasibility, cost, and consultation with the affected landholders.

The assessment of vibration from railway operations, including within the Toowoomba Range Tunnel, determined that predicted levels would achieve the criteria for ground-borne noise and ground-borne vibration at the identified sensitive receptors. On this basis, the assessment did not identify a need for specific vibration treatments beyond the highly resilient trackform proposed for slab track and resilient matting for retention of ballast on bridge and such elevated track sections.

It is important to note that where the Project achieves the noise and vibration criteria there can still be potential for noise and vibration from railway operations to be audible/perceptible within the environment. It is not unreasonable for outdoor noise from railway operations to be audible and perceptible at least 1 km from the Project alignment depending on weather conditions at the time. For some sensitive receptors the relocation of existing railway services on to the new Project infrastructure and the removal of the existing level crossing is likely to reduce railway noise levels.

Noise and vibration from railway operations will continue to be assessed during the future phases of the Project to verify the outcomes of this assessment. During the initial commencement of railway operations on the Project to confirm noise and vibration levels at sensitive receptors and the requirements for reasonable and practicable mitigation measures.

15.12.6 Operational road traffic noise

A desktop assessment of road traffic noise impacts from road segments changed by the Project was undertaken to predict the potential noise impacts associated with each road alteration. These roads were assessed against relevant criteria from the CoP Vol 1. The desktop assessment considered the increase in traffic flows and relative distance to the nearest sensitive receptors for each road. Influence from other dominant noise sources has not been considered.

Two roads near Gowrie Junction that are categorised under the CoP Vol 1 as new roads are predicted to exceed the appropriate operational road traffic noise criterion. Specific measures to mitigate operational road traffic noise have been outlined in Section 15.11.3.

15.12.7 Operational tunnel infrastructure noise

An assessment of the noise impacts of operational fixed infrastructure such as the tunnel ventilation system has been carried out. Impacts were assessed against the EPP (Noise) acoustic quality objectives at nearby sensitive receptors.

Attenuation of the tunnel ventilation plant has been included in the design of the tunnel to meet the acoustic quality objectives at all noise sensitive receptors during all ventilation operational scenarios. Nominal mitigation strategies (such as attenuators, solid barriers, enclosures) would be implemented, and designed to meet appropriate noise level emissions.

15.12.8 Noise and vibration management

Overall, the assessments have identified that noise and vibration during the construction and operation has the potential to influence the noise environment along the Project alignment.

The application of industry standard best practice measures to reduce and control noise and vibration emission and mitigate associated impacts have been considered. It is expected the proposed approach to noise and vibration management will to achieve the objectives of the relevant policy and guidelines referenced in the ToR for the majority of sensitive receptors.

Due to the nature of the proposed construction works and railway operations and the proximity of nearby sensitive receptors, it is expected the Project will change the local noise environment for some sensitive receptors.

ARTC will develop and implement mitigation measures to manage both temporary (construction) and permanent (operational) noise and vibration emissions generated by the Project. The objective will be to reduce and control noise and vibration in a feasible manner. The intent will be to reduce in a reasonable and practical manner (based on engineering, environmental, social and commercial considerations).

The noise and vibration levels will continue to be assessed, and the mitigation requirements verified, during the detail design and construction of the Project.

A program of noise and vibration monitoring will be conducted both during construction and when Project railway commence.