CHAPTER 12

Air Quality

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

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

IR_1536

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12.1 Summary

This air quality impact assessment (AQIA) has considered construction, commissioning, and operational phases of the Gowrie to Helidon Project (the Project).

A survey of sensitive receptors (e.g. residential dwellings), along with select agricultural land uses in the AQIA study area has been undertaken via desktop review of aerial imagery from Queensland Globe. A total of 2,829 sensitive receptors relevant to the Project were included in the qualitative construction assessment and in the dispersion model developed for the assessment of the operational phase of the Project. In addition to assessing impacts to residential dwellings and agricultural land uses, the assessment of the operation phase has also considered the potential for impacts to the health and biodiversity of ecosystems.

Air emissions from the construction of large, linear infrastructure projects are difficult to estimate due to the broad range and transitory nature of construction activities. Also, construction activities for the Project will be distributed across a large geographical area; as such, emissions from the Project during construction were assessed qualitatively, through a review of anticipated construction activities, plant and equipment. The results of the qualitative air quality risk assessment show that the unmitigated air emissions from the construction phase of the Project poses a high risk to human health and a medium risk to impacts from dust deposition. Mitigation measures are proposed for the construction phase, which are expected to reduce the risk of impacts to an acceptable level.

A quantitative compliance assessment has been undertaken for air quality impacts during the operational phase of the Project. The quantitative assessment included consideration of existing air quality and dispersion modelling of emissions from train travel along the Project alignment, trains idling at crossing loops, and emissions from the Toowoomba Range Tunnel portals. To assess emissions from normal operations, and potential worst-case operations, the assessment of operational impacts has considered forecast train volumes for 2040, both for a forecast typical train volume scenario (328 rains per week) and a forecast peak train volume scenario (402 trains per week).

The predicted air quality concentrations and deposition rates were compared to Project air quality goals that were adopted considering the *Environmental Protection Act 1994* (Qld) (EP Act), the Environmental Protection (Air) Policy 2019 (Qld), *National Environment Protection (Ambient Air Quality) Measure* (Ambient Air Quality NEPM) (National Environmental Protection Council (NEPC), 1998a) and guidelines commonly recommended by the Queensland Department of Environment and Science (DES). The environmental values that are protected by the air quality goals considered protecting health and wellbeing, protecting the health and biodiversity of ecosystems, protecting agriculture uses, and protecting the aesthetics of the environment.

The assessment of the operational phase of the Project has determined that compliance is predicted for all air quality goals at all sensitive receptors for the peak and typical scenarios, with the exclusion of a single receptor, which is a residential dwelling located in the permanent disturbance footprint of the Project, near the western tunnel portal of the Toowoomba Range Tunnel. It is expected that this property will be acquired and, on this basis, the operation of the Project is expected to comply with the adopted air quality goals at all sensitive receptors.

The assessment of the operational phase of the Project for residual impacts to water quality in water tanks has predicted compliance with the drinking water guideline values prescribed by the *Australian Drinking Water Guidelines* (National Health and Medical Research Council (NHMRC), 2018). For the pollutant species of interest, pollutant concentrations in water tanks were predicted to be less than 1 per cent of the guideline values at all sensitive receptors. The methodology applied for the assessment of impacts to water tanks is also applicable for assessment of impacts to water quality for dams, and compliance with the drinking water guideline values would also be expected for dams. This is relevant where the Project alignment traverses between two dams associated with the Withcott Seedlings operations, while no other dams are present within 100 m of the Project alignment.

Tunnel ventilation design and the assessment of in-tunnel air quality has been undertaken as part of the design work for the Project. One of the primary objectives of the tunnel ventilation system design was maintenance of acceptable air quality inside the tunnel and at the tunnel portals. The ventilation system has been designed such that the tunnel will undergo a purge cycle following train passages, to ventilate the tunnels of any residual pollutants and heat, and ensure a suitable environment prior to the next train entering the tunnel. The purging methodology for the tunnel has been incorporated in the dispersion modelling of emissions from the tunnel portals.

Tunnel ventilation design focused on maintaining acceptable air quality inside the tunnel considering human exposure and locomotive manufacturer requirements for air intake quality. The key pollutants considered were carbon monoxide (CO), nitrogen dioxide (NO_2) and nitric oxide (NO). The adopted in-tunnel air quality criteria are consistent with in-tunnel air quality guideline values adopted elsewhere in Australia and internationally.

Odour emissions from the operation of the Project are considered minor and have been assessed qualitatively. It is expected that odour impacts on sensitive receptors will not be significant based on the nature of the sources associated with the Project and the receiving environment.

Overall, the operation of the Project is not expected to significantly adversely impact environmental values, including human health and wellbeing; the aesthetic environment; health and biodiversity of ecosystems; and agricultural uses.

A number of mitigation and management measures have been proposed in order to minimise potential impacts. During the detailed phase of construction planning, a Construction Environment Management Plan (CEMP) will be developed that will include an Air Quality Sub-plan. Mitigation measures proposed for the construction phase of the Project are included in the draft Outline Environmental Management Plan (draft Outline EMP).

12.2 Scope of chapter

The objective of this chapter is to outline how the Project will be planned, designed, constructed and operated in a manner protective of the environment, and, in particular, the airshed relevant to the Project. In this chapter, the potential impacts arising from the Project on air quality are described and mitigation measures are proposed. A qualitative assessment of the construction phase impacts has also been undertaken through a risk assessment of the emission sources associated with construction activity. The assessment of operational phase impacts has been undertaken quantitatively via dispersion modelling of emissions. The assessment of construction and operational phase impacts has been undertaken considering relevant legislation, historical meteorological data and ambient air quality monitoring data and the requirements of the Terms of Reference (ToR) for the Project.

A detailed description of the Project can be found in Chapter 6: Project Description. The technical report detailing the AQIA that underpins this chapter is provided in Appendix K: Air Quality Technical Report. The AQIA was completed based on methodologies and guidance presented in the following documents:

- Application requirements for activities with impacts to air (EP Act Air Guideline) (DES, 2017a), a guideline document under the *Environmental Protection Act 1994* (Qld) (EP Act) to support applications for activities with impacts to air
- Approved methods for the modelling and assessment of air pollutants in New South Wales, (New South Wales Environmental Protection Authority (NSW EPA), 2016), which provides statutory methods for modelling and assessing emissions of air pollutants in NSW but is relevant and applicable for assessments in Queensland
- *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved methods for the modelling and assessments of air pollutants in NSW* (Barclay & Scire, 2011), which provides detailed guidance on selection of CALPUFF modelling variables. This guidance is written for NSW but is relevant and applicable for Queensland
- Guidance on the assessment of dust from demolition and construction, authored by the United Kingdom (UK) Institute of Air Quality Management (IAQM) (UK IAQM, 2014). This document provides a qualitative risk assessment process for the potential impact of dust generated from demolition, earthmoving and construction activities. In the absence of Australian-specific guidance, this methodology is considered the most appropriate for the assessment of construction impacts.

12.3 Terms of Reference requirements

The ToR relevant to the AQIA and where in the chapter each of the ToR requirements has been addressed has been provided in Table 12.1. The ToR states that the assessment should follow the *Queensland Environmental Protection (Air) Policy 2008*; however, this document was updated in 2019 to the *Environmental Protection (Air) Policy 2019*. The 2019 version includes amendments to air quality objectives and thus has been used for the AQIA.

TABLE 12.1 COMPLIANCE WITH TERMS OF REFERENCE REQUIREMENTS

Air Quality Terms of Reference requirements		Where addressed in the EIS
Existing environment		
11.124	Describe the existing air quality that may be affected by the Project in the context of environmental values.	Sections 12.4.3 and 12.4.4 Appendix K: Air Quality Technical Report, Sections 2, 3 and 4
11.125	Discuss the existing local and regional air shed environment.	Section 12.4.4 Appendix K: Air Quality Technical Report, Section 4
11.126	Provide baseline data on local meteorology and ambient levels of pollutants for modelling of air quality. Parameters should include air temperature, wind speed and directions, atmospheric stability, mixing depth and other parameters necessary for input to the model.	Section 12.4.4 Appendix K: Air Quality Technical Report, Section 5
11.127	The assessment of environmental values must describe and map at a suitable scale the location of all sensitive air receptors adjacent to all Project components. An estimate of typical background air quality levels should be based on surveys at representative sites where data from existing DEHP monitoring stations cannot be reliably extrapolated.	Section 12.4.4 Figure 12.3 Appendix K: Air Quality Technical Report, Section 4
Existing Environment		
11.128	Describe the characteristics of any contaminants or materials that may be released as a result of the construction or operations of the Project, including point source and fugitive emissions. Emissions (point source and fugitive) during construction, commissioning and operations are to be listed.	Sections 12.4.2, 12.6.1, 12.6.2 and 12.6.3 Appendix K: Air Quality Technical Report, Sections 2, 5 and 6
11.129	The relevant air quality goals or objectives that will be adopted for the assessment should be clearly outlined as a basis of the assessment of impacts on air.	Sections 12.4 and 12.4.3[a] Appendix K: Air Quality Technical Report, Section 3.6
11.130	The assessment of impacts on air will be in accordance with the EP Act, EP Regulation and Environmental Protection (Air) Policy 2008 (EPP (Air)) and reference to appropriate to Australian Standards.	Sections 12.4 and 12.4.3[a] Appendix K: Air Quality Technical Report, Sections 3 and 5

Air Quality Terms of Reference requirements		Where addressed in the EIS
11.131	Predict the impacts of the releases from the activity on environmental values of the receiving environment using recognised quality assured methods. The description of impacts should take into consideration the assimilative capacity of the receiving environment and the practices and procedures that would be used to avoid or minimise impacts. The impact prediction must: a) address residual impacts on the environmental values (including appropriate indicators and air quality objectives) of the air receiving environment, with reference to the air environment at sensitive receptors. This should include all relevant values potentially impacted by the activity, under the EP Act, EP Regulation and EPP (Air) b) address the cumulative impact of the release with other known releases of contaminants, materials or wastes associated with existing major Projects and/or developments and those which are progressing through planning and approval processes and public information is available c) quantify the human health risk and amenity impacts associated with emissions from the Project for all contaminants covered by the National Environmental Protection (Ambient Air Quality) Measure or the EPP (Air).	Sections 12.4, 12.4.3, 12.6 and 12.7 Appendix K: Air Quality Technical Report, Sections 6 to 8
Mitigation Measures		
11.132	Describe the proposed mitigation measures to manage impacts to air quality, including potential impacts from coal trains, and the predicted level of effectiveness of the mitigation measures.	Sections 12.6 and 12.8 Appendix K: Air Quality Technical Report, Sections 5 and 9
11.133	Describe how the proposed activity will be consistent with best practice environmental management. Where a government plan is relevant to the activity or site where the activity is proposed, describe the activity's consistency with that plan.	Section 12.8 Appendix K: Air Quality Technical Report, Section 9
11.134	Describe any expected exceedances of air quality goals or criteria following the provision and/or application of mitigation measures, and how any residual impacts would be addressed.	Section 12.9 Appendix K: Air Quality Technical Report, Sections 7, 8 and 9
11.135	Describe how the achievement of the objectives would be monitored, audited and reported, and how corrective actions would be managed.	Section 12.8.4 Appendix K: Air Quality Technical Report, Section 9.4
Climate		
11.162	Describe the climate patterns with particular regard to discharges to water and air and the propagation of noise related to the project.	Sections 12.5.3.4 and 12.6.3.3 Appendix K: Air Quality Technical Report, Sections 4.4.8 and 5.3.2.8

Table note:

a. The assessment has been undertaken in accordance with the EPP (Air) 2019 (refer Section 12.4).

12.4 Legislation, policies, standards and guidelines

12.4.1 Regulatory context

The legislation, policies, standards and guidelines relevant to the Project, or used in the AQIA, are described in Table 12.2. Further information on the legislative framework relevant to the Project is provided in Chapter 3: Project Approvals.

TABLE 12.2: REGULATORY CONTEXT

Legislation, policy or guideline	Relevance to the Project
National Environment Protection (Ambient Air Quality) Measure (NEPM) (NEPC, 1998a)	Federal measure that sets standards for six major air pollutants in Australia. The standards for these pollutants have been considered in this AQIA.
National Environment Protection (National Pollutant Inventory) Measure (NEPC, 1998b)	The National Pollutant Inventory (NPI), regulated by the Australian Government, tracks pollution across Australia, to ensure that the community has access to information about the emission and transfer of toxic substances that may affect them locally. All major polluters are required by the Australian Government to submit annual reports of their emissions to air. Information available from the NPI regarding emission sources near the Project has been considered in this AQIA.
Environmental Protection Act 1994 (EP Act) Environment Protection Regulation 2019	State legislation and regulation that governs protection of environmental values in Queensland. This regulation has been considered in the AQIA for the Project.
Environmental Protection (Air) Policy 2019 (EPP (Air))	Subordinate legislation under the EP Act to protect the environmental values of the air environment. The air quality objectives in the EP Act for the pollutants of concern have been adopted as Project air quality goals.
Environmental Protection Act 1994— Guideline: Application requirements for activities with impacts to air (EP Act Air Guideline) (DES, 2017a)	Guideline on information requirements for applications for activities with impacts to air. This guideline has been used to guide the methodology of this AQIA.
Approved methods for the modelling and assessment of air pollutants in New South Wales (NSW EPA, 2016)	Statutory methods for modelling and assessing air quality in NSW. Developed for NSW but adopted as technical guidance for the development of dispersion models Australia-wide and is referred to by the EP Act Air Guideline as the guiding document for the modelling of air pollutants. This document has been used to guide the methodology of this AQIA.
National Health and Medical Research Council (NHMRC), *Australian Drinking Water Guidelines 2011* (NHMRC, 2018)	Provides guidance and criteria to water regulators and suppliers on monitoring and managing drinking water quality. The criteria from this document have been used for the assessment of impacts to drinking water.
NSW Environment Protection Agency (NSW EPA), *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved methods for modelling and assessment of air pollutants in New South Wales* (Barclay & Scire, 2011)	Document that provides detailed guidance on selection of CALPUFF modelling variables. Developed for NSW but adopted as technical guidance for the development of dispersion models Australia-wide. This document has been used to guide the methodology for the dispersion modelling undertaken for this AQIA.
United Kingdom Institute of Air Quality Management (IAQM), *Guidance on the assessment of dust from demolition and construction* (UK IAQM, 2014)	This document provides a qualitative risk assessment process for the potential impact of dust generated from demolition, earthmoving, and construction activities.
Brisbane City Council (BCC), *Air Quality Planning Scheme Policy* (AQPSP) (City Plan 2014) (BCC, 2014)	This document provides guidance on assessment methodologies and air quality objectives for AQIAs undertaken for projects in the BCC local government area. Air quality objectives from this policy have been used in this assessment for pollutants not included in the EPP (Air).

Legislation, policy or guideline	Relevance to the Project
Government of Victoria Environment Protection Authority (EPA Victoria), *Recommended separation distances for industrial residual air emissions* (EPA Victoria, 2013)	The guideline provides recommended separation distances for activities with emissions to air. The guideline is written by EPA Victoria but is referenced in the EP Act Air Guideline and is applicable to assessments in Queensland.
Government of South Australia Environment Protection Authority (SA EPA), *Evaluation distances for effective air quality and noise management* (SA EPA, 2016)	The guideline provides recommended separation distances for activities with emissions to air and provides reference information appropriate for assessments in Queensland.
Government of Western Australia Environment Protection Authority (WA EPA), *Guidance for the assessment of environmental factors: separation distances between industrial and sensitive land uses* (WA EPA, 2005)	The guideline provides recommended separation distances for activities with emissions to air and provides reference information appropriate for assessments in Queensland.

12.4.2 Project air emissions

Based on the review of expected Project activities, applicable NPI emission estimation manuals, and EIS literature for similar rail projects, the air pollutants expected to be generated during the construction and operational phases of the Project are listed in Table 12.3, with a detailed description provided in Appendix K: Air Quality. Table 12.3 also notes the pollutants that were considered in the design of the Toowoomba Range Tunnel ventilation system (NO, NO_2 and CO).

During the construction phase, particulate matter deposited as total suspended particulates (TSP) and airborne concentrations of particulate matter less than 10 micrometres (μm) in diameter (PM_{10}) will be of primary concern. These pollutants have the potential for nuisance impacts if not correctly managed (UK IAQM, 2014). For construction activities, particulate matter less than 2.5 micrometres in diameter ($PM_{2.5}$) is typically emitted in minor quantities from mechanical sources and is more predominant from combustion point sources (i.e. combustion engines, such as those in vehicles or generators). Point source emissions of combustion gases (e.g. oxides of nitrogen (NO_x) and CO) and $PM_{2.5}$ from diesel construction vehicles and mobile plant will be significantly lower than particulate emissions from construction activities. Emissions of combustion gases and $PM_{2.5}$ are considered unlikely to result in exceedance of air quality goals or cause nuisance to sensitive receptors, and, therefore, have not been assessed in any further detail for the construction phase; however, mitigation measures are proposed for these sources.

In addition to construction dust, odour and volatile organic compounds (VOCs) will be emitted as fugitive emissions from fuel tanks located at laydown areas.

Air emissions during the commissioning phase of the Project are anticipated to be minor and are expected to be limited to point source combustion engine emissions from transport vehicles and train locomotives, and limited fugitive dust emissions from vehicle travel on unsealed roads.

The primary source of air pollution during the operation of the Project will be point source locomotive engine exhaust. The gaseous pollutants contained in the exhaust are produced as a product of diesel combustion and include NO_x, PM_{10}, $PM_{2.5}$, VOCs, and polycyclic aromatic hydrocarbons (PAHs). In addition to diesel combustion, fugitive coal dust emissions (TSP, PM_{10}, $PM_{2.5}$ and dust deposition) are also considered to have the potential to impact sensitive receptors, and have been assessed for the operational phase.

Given the uncertainty associated with the timeframe for decommissioning, this phase has not been considered in this AQIA.

TABLE 12.3: POLLUTANTS CONSIDERED IN THE AQIA

Pollutant	Description[a]
Total suspended particulates (TSP)	TSP refers to airborne particles ranging from 0.1 micrometres (μm) to 100 μm in diameter. TSP is primarily associated with aesthetic impacts, including impacts resulting from dust deposition; however, if the particles contain toxic materials (such as lead, cadmium, zinc), toxic effects (health impacts) can occur from inhalation of the dust.
PM_{10}	Particulate matter less than 10 μm in diameter (PM_{10}). Exposure to particulate matter has been linked to a variety of adverse health effects, such as respiratory problems.

Pollutant	Description[a]
$PM_{2.5}$	Particulate matter less than 2.5 µm in diameter ($PM_{2.5}$). Exposure to particulate matter has been linked to a variety of adverse health effects such as respiratory problems. Fine particles ($PM_{2.5}$) can travel further into the human respiratory system than coarser particle sizes.
Oxides of nitrogen (NO_x)	NO_x describes a mixture of NO and NO_2. NO_x is colourless at low concentrations but has an odour. NO_2 is a brownish gas with a pungent odour. There is no air quality criteria for NO for the protection of human health and, therefore, NO has not been considered in the AQIA for impacts to environmental values; however, NO has been considered in the design of the Toowoomba Range Tunnel ventilation system.
Nitrogen dioxide (NO_2)	NO_2 is a brownish gas with a pungent odour. Nitrogen dioxide can cause damage to the human respiratory tract, increasing a person's susceptibility to respiratory infections and asthma. Sensitive populations, such as the elderly, children, and people with pre-existing health conditions are most susceptible to the adverse effects of NO_2 exposure. In addition to consideration in the AQIA, NO_2 has also been considered in the design of the Toowoomba Range Tunnel ventilation system.
Carbon monoxide (CO)	CO is a colourless, odourless gas formed when substances containing carbon (such as petrol, gas, coal and wood) are burned with an insufficient supply of air. Concentrations of CO normally present in the atmosphere are unlikely to cause ill effects and, therefore, have not been considered in the AQIA for assessment of impacts to environmental values. The design of the Toowoomba Range Tunnel ventilation system has ensured that in-tunnel CO concentrations will be below occupational health and safety levels.
Volatile organic compounds (VOCs)	VOCs are carbon-based chemicals that readily evaporate at room temperature, including xylene, toluene and benzene. VOC species are harmful to human health, with the health impacts specific to the individual compound and nature of exposure.
Polycyclic aromatic hydrocarbons (PAHs)	PAHs are a group of over 100 chemicals that are formed through the incomplete combustion of organic materials, such as petrol or diesel. Exposure to these chemicals can cause a range of adverse reactions, including irritation of the eyes, nose, throat and skin.
Trace metals including arsenic, cadmium, lead, nickel and chromium VI	Heavy metals, such as cadmium, lead and mercury are common air pollutants that are typically emitted from industrial activities and fuel combustion. Fugitive coal dust emissions from rail transport along the Project alignment have potential to be deposited on surfaces, including surfaces that lead to rainwater tanks. Coal may contain traces of these elements. Exposure to heavy metals can result in a range of health impacts, including kidney and bone damage, developmental and neurobehavioral disorders, elevated blood pressure and potentially even lung cancer.
Odour	Odour emissions can be either a single compound or a mixture of compounds that have the potential to affect environmental amenity and cause nuisance.
Sulfur dioxide (SO_2)	SO_2 is a colourless gas with a sharp, irritating odour. The AQIA assumes low sulfur content fuel as per the requirements of the *Fuel Quality Standards Act 2000* (Cth) and the Fuel Standard (Automotive Diesel) Determination 2001 administered by DAWE. The regulation of low sulfur content fuel in Australia has significantly decreased the generation and concentrations of SO_2 near transport sources. Due to the low likelihood of significant impact, SO_2 has not been considered in this assessment.
Ozone (O_3)	O_3 is not emitted directly from fuel combustion, but rather is a secondary pollutant formed via a chemical reaction of other pollutant species in the local atmosphere. Assessment of the formation of ozone and other secondary pollutants has not been considered in this assessment.
Fluoride	Emissions of fluoride primarily originate from industrial processes, such as the manufacture of glass or bricks, and not through the combustion of fuel (e.g. diesel locomotives). Significant emissions of fluoride are not anticipated for the Project.

Table note:

a. The descriptions provided have been derived from the information provided on the Department of the Environment, Water, Heritage and the Arts National Pollutant Inventory website and the NSW Department of Planning, Industry and Environment website (**environment.nsw.gov.au**).

12.4.3 Environmental values and air quality objectives

The EPP (Air) was prepared by the Queensland Government to achieve the object of the EP Act in relation to the air environment. Air quality objectives are provided in the EPP (Air) as indicators for identifying environmental values of the air environment that are required to be enhanced or protected. The air quality objectives in the EPP (Air) are intended to be progressively achieved over the long term. A summary of the air quality objectives relevant to the Project is provided in Table 12.4.

The air quality objectives provided in the EPP (Air) are assessable at the location of sensitive receptors. Sensitive receptors are defined in the EP Act Air Guideline, with the definition including residential dwellings, short-term accommodation, educational facilities and health facilities. The Air EIS Information Guideline (DES, 2020) also includes 'remnant and regrowth ecosystems of all types' as key priority areas, which 'may be affected by the dispersal of contaminants' that require consideration. Detailed discussion of sensitive receptors and the types of land uses that are required to be considered is provided in Section 12.5.6.

The EPP (Air) achieves the purpose of the EP Act by:

- Identifying environmental values to be enhanced or protected
- Stating indicators and air quality objectives for enhancing or protecting the environmental values
- Providing a framework for making consistent, equitable and informed decisions about the air environment.

The environmental values to be enhanced or protected under the EPP (Air) are:

- The qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems
- The qualities of the air environment that are conducive to human health and wellbeing
- The qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property
- The qualities of the air environment that are conducive to protecting agricultural use of the environment.

Where air quality objectives for identified pollutants are not listed within the EPP (Air) or NEPM legislation, objectives have been sourced from the NSW EPA *Approved methods for the modelling and assessment of air pollutants in NSW* (NSW EPA, 2016) and the BCC AQPSP (BCC, 2014). Both of these documents are considered to be robust guidance policies for AQIAs and are considered appropriate for application in the assessment for the Project.

No dust deposition objectives are prescribed in the EPP (Air); however, the DES commonly set a guidance deposition rate of 120.0 milligrams per square metre per day (mg/m^2/day), averaged over 1 month, for environmental authorities based on research into community complaints for coal-related projects. Although this deposition limit is not a legislative requirement, it is frequently used in Queensland (DES, 2017a) and is considered to be an appropriate criterion.

The air quality objectives and guidelines values shown in Table 12.4 have been applied as the air quality goals for the Project, and are referred to as goals hereafter.

The environmental values presented that are being protected by each air quality goal (as defined by the EPP (Air) and other adopted legislation and guidelines) are shown in Table 12.4. The environmental values protected through meeting these air quality objectives include:

- Health and wellbeing
- Protection of the aesthetic environment
- Health and biodiversity of ecosystems.

With respect to the environmental value of the health and biodiversity of ecosystems, the only pollutant species of concern for the Project for which the EPP (Air) prescribes an air quality objective is NO_2 (refer Table 12.4).

In addition to the environmental values listed above, the EPP (Air) also includes air quality objectives to protect agriculture. The pollutant species of concern for agriculture as per the EPP (Air) are fluoride, SO_2 and O_3. As discussed in Section 12.4.2, fluoride, SO_2 and O_3 are not pollutants of concern for the Project and have not been included in the assessment.

Based on the requirements of the EPP (Air), the impact of Project air emissions on agriculture does not require consideration; however, due to the potential for NO_2 to impact plants, roots and agricultural crops (refer Section 12.4.2), the potential for impacts to agriculture has been considered based on compliance with the NO_2 annual average objective for the protection of the health and biodiversity of ecosystems (refer Table 12.4).

In addition to NO_2, deposited dust is also considered to have the potential to impact on agricultural crops and livestock, through the inhibition of plant growth or impairment of livestock development.

Research on vegetation response to dust deposition impact (Doley, 2003) has shown that, for sunny conditions, a dust deposition rate of up to 15 grams per square metre per month (g/m^2/month) (or 500 milligrams per square metre per day (mg/m^2/day)) is unlikely to have a detectable effect on crop growth, and it is not until a deposition rate of up to 30 g/m^2/month (or 1,000 mg/m^2/day) that there is a measurable reduction in crop growth under overcast conditions. Livestock research on dairy cows (Andrews & Skriskandarajah, 1992) has shown that a dust deposition rate of up to 120 g/m^2/month (or 4,000 mg/m^2/day) does not influence the amount of feed cattle eat or the amount of milk produced. These dust deposition levels have been considered in the assessment of the operational phase of the Project to assess the potential for impact to agriculture.

The potential impacts from dust on native vegetation are also identified and discussed in Appendix I: Terrestrial and Aquatic Ecology and Appendix J: Matters of National Environmental Significance.

A cumulative impact assessment, considering Project emissions, non-Project emissions and background air quality, has been undertaken to assess the potential for the Project to impact the environmental values of the air environment. Discussion of background air quality for the Project is provided in Section 12.5.3.

TABLE 12.4: PROJECT AIR QUALITY GOALS

Pollutant	Air quality goal (µg/m^3)	Averaging period	Environmental value	Source
NO_2	250	1-hour[a]	Health and wellbeing	EPP (Air)
	62	Annual	Health and wellbeing	EPP (Air)
	33	Annual	Health and biodiversity of ecosystems	EPP (Air)
TSP	90	Annual	Health and wellbeing	EPP (Air)
PM_{10}	50	24 hours[b]	Health and wellbeing	EPP (Air)
	25	Annual	Health and wellbeing	EPP (Air)
$PM_{2.5}$	25	24 hours	Health and wellbeing	EPP (Air)
	8	Annual	Health and wellbeing	EPP (Air)
Arsenic and compounds (measured as the total metal content in PM_{10})	6 ng/m^3	Annual	Health and wellbeing	EPP (Air)
Cadmium and compounds (measured as the total metal content in PM_{10})	5 ng/m^3	Annual	Health and wellbeing	EPP (Air)
Lead and compounds (measured as the total metal content in TSP)	0.5	Annual	Health and wellbeing	EPP (Air)
Nickel and compounds (measured as the total metal content in PM_{10})	22 ng/m^3	Annual	Health and wellbeing	EPP (Air)
Chromium (III) compounds (as PM_{10})	9	1 hour	Health and wellbeing	NSW EPA
Chromium (VI) compounds (as PM_{10})	0.1	1 hour	Screening health risk assessment	BCC AQ Planning Scheme Policy
	0.01	Annual	Screening health risk assessment	BCC AQ Planning Scheme Policy
1,3-butadiene	2.4	1 hour	Health and wellbeing	EPP (Air)
Benzene	5.4	Annual	Health and wellbeing	EPP (Air)
Toluene	1,100	30 minutes	Protecting aesthetic environment	EPP (Air)
	4,100	24 hours	Health and wellbeing	EPP (Air)
	400	Annual	Health and wellbeing	EPP (Air)
Xylenes	1,200	24 hours	Health and wellbeing	EPP (Air)
	950	Annual	Health and wellbeing	EPP (Air)

Pollutant	Air quality goal (µg/m³)	Averaging period	Environmental value	Source
Benzo(a)pyrene (as a marker for polycyclic aromatic hydrocarbons)	0.3 ng/m^3	Annual	Health and wellbeing	EPP (Air)
Polychlorinated dioxins and furans	3.0 x 10^{-08}	Annual	Screening health risk assessment	BCC AQ Planning Scheme Policy
Dust deposition	120 mg/m^2/day	Monthly	Nuisance	DES Recommended[c]

Table notes:
µg/m³ = micrograms per cubic metre
ng/m^3 = nanogram per cubic metre
mg/m^2/day = milligram per square metre per day
a. Not to be exceeded more than one day per year
b. The 2019 version of the EPP (Air) does not allow for any exceedances of the 24 hour goal for PM_{10}. The 2008 version of the EPP (Air) allowed for exceedances for five days per year and therefore air quality assessments previously considered the 6th highest PM_{10} 24-hour average. As there are no exceedances allowed in the 2019 version of the EPP (Air), the maximum predicted PM_{10} 24-hour concentration has been considered in the assessment rather than the 6th highest.
c. Not legislative, recommended Project goal to reduce likelihood of complaints

The in-tunnel air quality criteria adopted for tunnel ventilation design for the Toowoomba Range Tunnel are discussed in Section 12.7.3.6. The in-tunnel air quality criteria was adopted considering short-term human exposure (including workplace exposure) and locomotive manufacturer requirements for air intake quality. The air quality goals presented in Table 12.4 are relevant for the assessment of air quality impacts to environmental values and are not strictly applicable to in-tunnel scenarios.

12.4.4 Drinking water quality objectives

In addition to assessment of potential impacts to the air environment, the AQIA has also assessed potential impacts to drinking water quality as a result of the operation of the Project. The assessment has specifically considered the impact to rainwater tank water quality.

The *Australian Drinking Water Guidelines* (ADWG) (NHMRC, 2018) present guideline values on allowable contaminants within drinking water and are relevant for drinking water from rainwater tanks. Table 12.5 presents the drinking water criteria for the pollutants of interest, which have been adopted for the assessment.

TABLE 12.5: DRINKING WATER QUALITY GUIDELINES

Pollutant	Guideline value (mg/L)	Environmental value	Source
Arsenic	0.01	Health	(NHMRC, 2018)
Cadmium	0.002	Health	
Lead	0.01	Health	
Nickel	0.02	Health	
Chromium as Cr(VI)	0.05	Health	

Table notes:
mg/L = milligram per litre

12.5 Existing environment

The existing environmental values of the air environment that may be affected by the Project are described in this section. Aspects of the existing environment relevant to this assessment include:

- Meteorological conditions and climate
- Existing air quality, including regional and local sources of air pollution (natural and anthropogenic) that emit similar air pollutants to those being assessed. Existing concentrations of pollutants of concern for the Project have been adopted as background concentrations to ensure a cumulative assessment of air quality impacts.
- Terrain and land use.

In addition to discussion of existing air quality and meteorological conditions, this section also introduces and presents the locations of sensitive receptors, which have been considered in assessing the impacts of the Project on the environmental values of the air environment.

12.5.1 Air quality impact assessment study area and assessment domain

The AQIA study area is defined as the area approximately 2 kilometres (km) either side of the Project alignment, which is the proposed rail centreline.

The assessment domain is defined as the regional area surrounding and including the AQIA study area and has been adopted as the area within approximately 100 km of the Project alignment. Air quality and meteorological monitoring data from locations outside the AQIA study area but within the assessment domain have been considered in this assessment.

The Project disturbance footprint includes the permanent disturbance footprint and the extended temporary footprint required for the construction of the Project.

Figure 12.1 presents the locations of relevant meteorological and air quality monitoring stations referenced in the AQIA.

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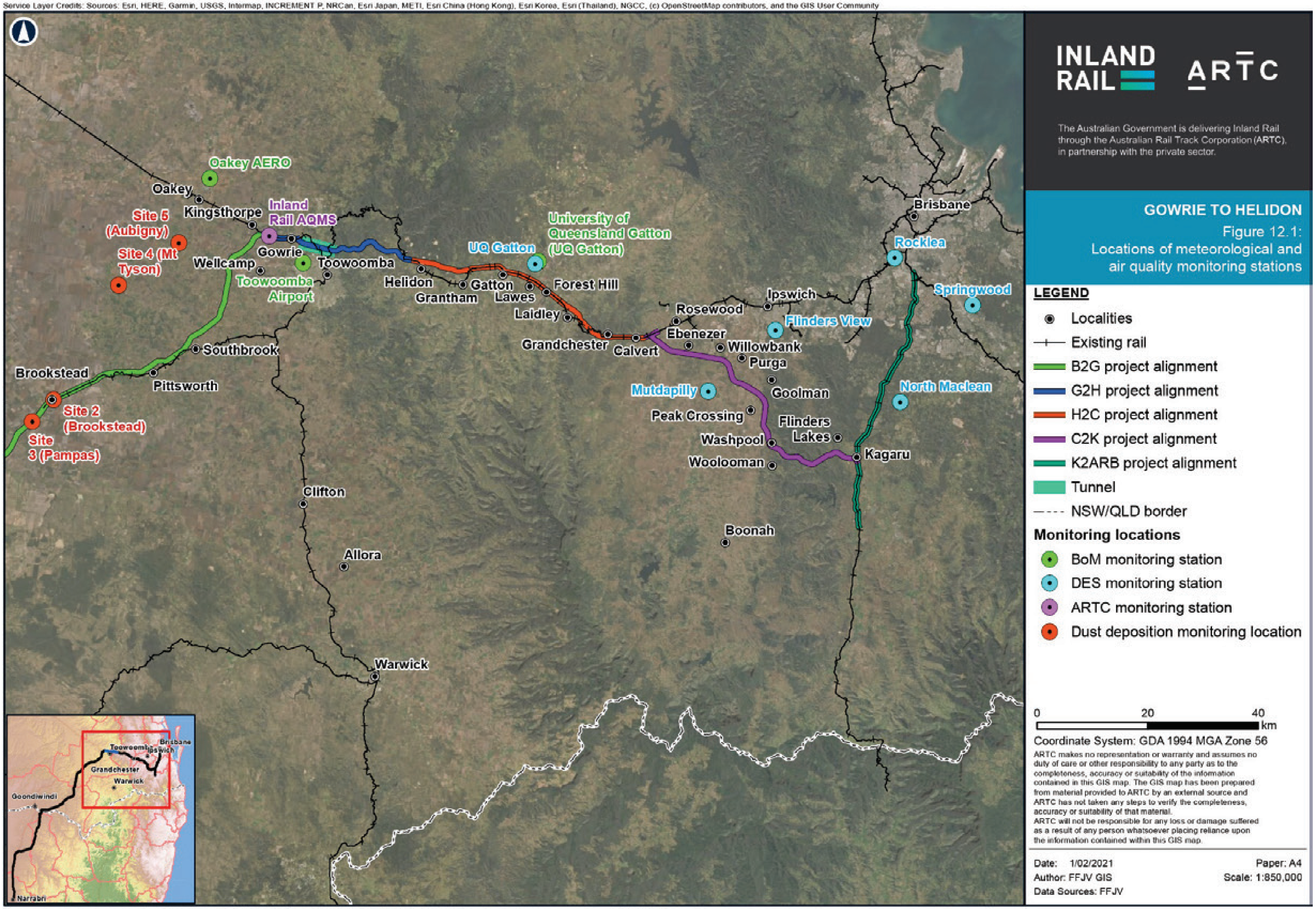

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12.5.2 Meteorology and climate

The Bureau of Meteorology (BoM) operates a network of meteorological stations around Australia that have long-term climatic data available for analysis. Three BoM monitoring stations have been considered to provide a greater regional coverage of climatic conditions within the assessment domain. The BoM stations considered in the assessment were the Oakey Aero (Oakey Army Aviation Centre), Toowoomba Airport and The University of Queensland (UQ) Gatton stations.

The locations of the meteorological monitoring stations are shown in Figure 12.1, with details for each station provided in Table 12.6.

TABLE 12.6: DETAILS OF BOM METEOROLOGICAL STATIONS CONSIDERED IN THE ASSESSMENT

Station name	Coordinates	Location relative to Project	Period operational	Elevation (metres (m))
Toowoomba Airport	-27.5425, 151.9134	3.7 km S	1996–present	641 m
Oakey Aero	-27.4034, 151.7413	14.7 km NW	1973–present	406 m
UQ Gatton	-27.5436, 152.3375	22.3 km E	1897–present	89 m

The monitoring stations are all considered to provide data representative of the AQIA study area; however, the most representative stations are Toowoomba Airport, located approximately 4 km to the south of the western tunnel portal, and UQ Gatton, which is located approximately 22.3 km to the east of the Project. Meteorological monitoring data from both the UQ Gatton station and the Toowoomba Airport station has been used to develop the meteorological and dispersion models for the assessment.

In addition to the measured meteorological data from the BoM stations, output data from CALMET (refer Section 12.6.2) has also been analysed and presented in this section to describe atmospheric stability and mixing height. Dispersion modelling for the assessment of the operational phase requires selection of a meteorological year. Selection of the meteorological year for the assessment was undertaken primarily considering the El Niño-Southern Oscillation (ENSO), which has the strongest effect on year-to-year climate variability in Australia. Considering the ENSO, the selected meteorological year for the assessment was 2013 and, therefore, the analysis of atmospheric stability and mixing height is undertaken for this year. The selection of the assessment year for meteorological modelling is discussed further in Section 12.6.3.3.

12.5.2.1 Temperature

Mean minimum and maximum temperatures have been collected from the Oakey Aero, Toowoomba Airport and UQ Gatton BoM stations and are displayed in Table 12.7.

Table 12.7 shows that the average maximum temperatures for the UQ Gatton and Oakey Aero BoM stations are similar, with the Toowoomba Airport BoM monitoring station recording slightly lower maximum temperatures. The annual average minimum temperatures are similar across all three stations, with slightly lower minimum temperatures recorded at Oakey Aero and Toowoomba Airport when compared with UQ Gatton. This difference in temperatures between the BoM stations is likely attributable to the difference in elevation, with the Toowoomba Airport BoM station located at 691 m above sea level, the Oakey Aero BoM station located at 406 m above sea level, and the UQ Gatton BoM station located at 89 m above sea level. Also, the distance of the BoM stations to the eastern coastline is likely to be an attributing factor in the cooler temperatures experienced further inland.

TABLE 12.7: MEAN MINIMUM (BLUE) AND MAXIMUM (RED) MONTHLY TEMPERATURES AT BOM STATIONS RELEVANT TO THE PROJECT

BoM station	Mean minimum and mean maximum temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
UQ Gatton[1]	19.1	19.0	17.3	13.7	10.2	7.6	6.2	6.7	9.5	13.2	16.0	18.1	13.0
	31.6	30.8	29.6	27.2	23.8	21.1	20.8	22.5	25.6	28.2	30.2	31.3	26.9
Oakey Aero[2]	17.9	17.7	15.8	11.8	7.8	4.2	2.9	3.6	7.3	11.4	14.5	16.7	11.0
	31.0	30.1	28.7	25.9	22.3	19.1	18.7	20.5	24.0	26.7	28.8	30.3	25.5
Toowoomba Airport[3]	17.6	17.6	16.5	13.4	10.0	7.6	6.6	7.5	10.6	12.8	14.8	16.6	12.6
	28.4	27.6	26.2	23.3	19.9	17.0	16.8	18.7	22.3	24.5	26.2	27.6	23.2

Table notes:
1. Mean maximum and minimum temperature values have been calculated based on 106 years of data (1913 to 2019)
2. Mean maximum and minimum temperature values have been calculated based on 46 years of data (1973 to 2019)
3. Mean maximum and minimum temperature values have been calculated based on 24 years of data (1996 to 2019)

12.5.2.2 Rainfall

Mean rainfall values have been collected from the Oakey Aero, Toowoomba Airport and UQ Gatton BoM stations and are presented in Table 12.8. The data shows that distinct wet (summer) and dry (winter) seasons are experienced at the monitoring locations annually. Of the three BoM stations, UQ Gatton receives the highest amount of rainfall annually (770.2 millimetres (mm)), followed by Toowoomba Airport (718.1 mm) and Oakey AERO (614.3 mm). Over 39 per cent of average annual rainfall occurs during summer for each of the BoM stations.

TABLE 12.8: MEAN MONTHLY AND ANNUAL RAINFALL AT THE BOM STATIONS RELEVANT TO THE PROJECT

BoM station	Mean rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
UQ Gatton[1]	110.1	99.4	79.3	48.6	45.4	41.7	36.4	26.7	34.8	65.0	78.5	99.2	770.2
Oakey AERO[2]	77.7	78.2	51.4	29.3	38.8	29.6	28.2	25.4	31.0	57.7	75.2	91.8	614.3
Toowoomba Airport[3]	90.6	102.2	86.4	26.2	36.5	36.1	26.6	29.8	35.6	65.1	75.8	104.0	718.1

Table notes:
1. Mean rainfall values have been calculated based on 122 years of data (1897 to 2019)
2. Mean rainfall values have been calculated based on 50 years of data (1970 to 2019)
3. Mean rainfall values have been calculated based on 24 years of data (1996 to 2019)

12.5.2.3 Wind speed and direction

Long-term annual wind speed and direction data was requested from BoM for the Oakey Aero, Toowoomba Airport and UQ Gatton stations. Wind roses for each of these stations for the most recent years with available data have been analysed and are presented in Appendix K: Air Quality Technical Report.

The wind conditions for each of the stations are summarised as follows:

- The wind rose for the UQ Gatton BoM station shows that the predominant wind direction at this station is westerly; however, easterly winds are more prevalent during warmer seasons. The proportion of calm conditions is 6 per cent.
- The wind rose for the Oakey Aero BoM station shows that the predominant wind directions are easterly and east north easterly. The proportion of calm conditions is 0.4 per cent.
- The wind rose for the Toowoomba Airport BoM station shows that the predominant wind direction is easterly, with little variation recorded. The proportion of calm conditions is 0.5 per cent.

Overall, analysis of the annual wind roses shows that the wind speed and directions at each BoM station varies significantly. This variation is due to the influence of terrain, elevation, and land use on local scale winds, which is discussed further in Section 12.5.5.

12.5.2.4 Atmospheric stability

Stability is a measure of the convective properties of a parcel of air. Stable conditions occur when convective processes are low, while unstable conditions are associated with stronger convective processes, which are associated with potentially rapid changes in temperature. Stable atmospheres occur when a parcel of air is cooler than the surrounding environment, so the parcel of air (and any pollution within it) sinks. Conversely, unstable atmospheres occur when a parcel of air is warmer than the surrounding environment, making the parcel of air buoyant and, subsequently, leading to the parcel of air rising.

Stability is commonly explained using Pasquill-Gifford A–F stability class designations. Classes A, B and C represent unstable conditions, with Class A representing very unstable conditions and C representing slightly unstable conditions. Class D stability corresponds to neutral conditions, which are typical during overcast days and nights. Classes E and F correspond to slightly stable and stable conditions respectively, which occur at night.

Stability class data extracted from the CALMET files for locations representing the Toowoomba Airport and UQ Gatton BoM stations, and the western and eastern tunnel portals of the Toowoomba Range Tunnel are presented in Appendix K: Air Quality Technical Report.

Meteorological modelling using CALMET predicts that at the UQ Gatton BoM station atmospheric conditions are predominantly stable (Class F). At the Toowoomba Airport BoM station and the western and eastern tunnel portals of the Toowoomba Range Tunnel atmospheric stability is predicted to be predominantly neutral (Class D).

12.5.2.5 Mixing height

Mixing height is estimated within CALMET for stable and convective conditions (respectively), with a minimum mixing height of 50 m above ground level. The hourly mixing height statistics, as predicted by CALMET for locations representing the BoM Toowoomba Airport and UQ Gatton BoM stations and the western and eastern tunnel portals of the Toowoomba Range Tunnel are presented in Appendix K: Air Quality Technical Report. The CALMET modelling predicts peak mixing heights mixing heights of up to 3,000 m above ground level.

12.5.3 Background air quality

12.5.3.1 Sources of available monitoring data

In order to characterise the existing air quality in the AQIA study area, a review of available air quality monitoring data was conducted considering the following sources:

- Publicly available air quality monitoring data from monitoring stations operated by DES
- Monitoring data available from the Inland Rail air quality monitoring station (AQMS), located at a residential dwelling located off Draper Road, Charlton (Lot 29 on SP294200), west of Gowrie
- Dust deposition monitoring data from monitoring undertaken for the Inland Rail Program in 2016.

The locations of the monitoring stations considered are shown in Figure 12.1, with the details for each station presented in Table 12.9.

An ambient monitoring network across Queensland, operated by DES, monitors for controlled pollutants in areas with large population bases or heavy industry adjacent to residential areas. The nearest operational DES monitoring station to the AQIA study area is located at Gatton, approximately 22 km east of the Project; however, this station measures meteorological parameters only. Several DES monitoring stations are located in the assessment domain, including: Flinders View, Mutdapilly, North Maclean, Rocklea, and Springwood; all of which are situated over 50 km the east of Project. Historic monitoring data from DES campaign monitoring, undertaken in Toowoomba in 2006 and 2007, was also reviewed but not used in the assessment due to the age of the monitoring data.

The Inland Rail AQMS is located approximately 0.2 km to the south-west of the western end of the Project alignment and undertakes monitoring of PM_{10} and $PM_{2.5}$. The Inland Rail AQMS is the closest air quality monitoring station to the Project and is located in the AQIA study area.

A three-month dust deposition monitoring campaign conducted for the Inland Rail Program in 2016 has been used for the assessment of dust deposition. This deposition monitoring was undertaken as an early environmental study for a previous alignment, identified as Yelarbon to Gowrie (Y2G). The Y2G section was a previous alignment option that has now been replaced by the Border to Gowrie (B2G) project alignment, though there is a small area of overlap. The monitoring locations represent rural areas with agricultural sources in the surrounding area, similar to the Project alignment. For the urban areas of the Project alignment, this may result in conservative estimates of dust deposition rates; however, for the purposes of this AQIA, the data collected at these monitoring locations is deemed appropriate.

The operational DES monitoring stations, the Inland Rail AQMS and the previous dust deposition monitoring are considered to provide suitable data for the determination of background air quality for the AQIA study area; therefore, other than PM_{10} and $PM_{2.5}$ monitoring at the Inland Rail AQMS, no additional study area specific monitoring has been undertaken.

To determine appropriate baseline levels of each pollutant, recent data from the nearest monitoring stations was analysed. Preference was given to the stations closest to the Project and in a similar environment (i.e. semi-rural, etc); however, not all pollutant species of interest are measured at each monitoring station as shown in Table 12.9.

Due to their proximity to the Project and local emission sources, monitoring data from the five DES monitoring stations in combination with the Inland Rail monitoring sites can be reliably extrapolated for the assessment of background air quality for the AQIA study area.

TABLE 12.9: DETAILS OF MONITORING STATIONS CONSIDERED IN THE ASSESSMENT

Station name	Operator	Coordinates	Location relative to the Project [a]	Pollutants monitored	Years of data available
Gatton	DES	-27.5434, 152.3343	22 km E	None, meteorology only	2010 to 2018
Flinders View	DES	-27.6528, 152.7741	67 km E	NO_x, O_3, SO_2, PM_{10}	2010 to 2018
Mutdapilly	DES	-27.7528, 152.6509	58 km ESE	NO_x, O_3	2010 to 2018
North Maclean	DES	-27.7708, 153.0030	94 km ESE	NO_x, O_3	2010 to 2018
Rocklea	DES	-27.5358, 152.9934	87 km E	NO_x, O_3, PM_{10}, $PM_{2.5}$ and visibility-reducing particles	2010 to 2018
Springwood	DES	-27.6125, 153.1356	102 km E	NO_x, O_3, SO_2, PM_{10}, $PM_{2.5}$ and air toxics (organic pollutants)	2010 to 2018
Inland Rail AQMS	ARTC	-27.4948, 151.8479	0.2 km SW	PM_{10} and $PM_{2.5}$	2018 to 2019
Site 2 (Brookstead)	ARTC Dust Deposition Monitoring	-27.7583, 151.4499	49 km SW	Dust deposition	May 2016 to July 2016
Site 3 (Pampas)		-27.7936, 151.4102	55 km SW		
Site 4 (Mt Tyson)		-27.5721, 151.5709	29 km W		
Site 5 (Aubigny)		-27.5046, 151.6825	17 km W		

Table note:

a. east (E), east-south-east (ESE), south-west (SW), west (W)

12.5.3.2 Adopted background air quality

Table 12.10 summarises the background concentrations that have been adopted for the AQIA. Where appropriate, the 70th percentile concentration was selected as the adopted background concentration. Further information regarding air quality monitoring data availability and validity is detailed in Appendix K: Air Quality Technical Report.

As shown in Table 12.10, background concentrations of TSP, PM_{10} and $PM_{2.5}$ adopted for the assessment have been taken from the Inland Rail AQMS. The Inland Rail AQMS is located approximately 200 m to the south of the existing Queensland Rail (QR) West Moreton System rail corridor at Charlton, and measured concentrations at the Inland Rail AQMS are influenced by emissions from existing rail traffic. The adoption of the measured concentrations from the Inland Rail AQMS is, therefore, considered to provide a conservative estimate of background concentrations.

TABLE 12.10: SUMMARY OF ADOPTED BACKGROUND POLLUTANT CONCENTRATIONS

Pollutant	Averaging time and = statistic	Adopted air quality goal (µg/m³)	Adopted background concentration (µg/m³)	Year of measurement	Monitoring location
Deposited dust	30-day, maximum	120 mg/m²/day	50 mg/m²/day	2016	Site 3 (Pampas) (located adjacent to the B2G project alignment)
NO_2	1 hour, maximum	250	57.5	2013	Mutdapilly
	Annual average	62	7.8	2013	
TSP	Annual average	90	42.8[a]	2018 and 2019	Inland Rail AQMS (near Gowrie)
PM_{10}	24 hours, 70th percentile	50	17.4	2018 and 2019	
	Annual average	25	17.1	2018 and 2019	
$PM_{2.5}$	24 hours, 70th percentile	25	7.6	2018 and 2019	
	Annual average	8	6.5	2018 and 2019	
Benzene	Annual average	5.4	5.2	2017	Springwood
Toluene	1 hour, 70th percentile	1,100	23.0	2016	
	24 hours, 70th percentile	4,100	21.7	2016	
	Annual average	400	18.5	2015	
Xylenes	24 hours, 70h percentile	1,200	37.6	2018	
	Annual average	950	33.8	2018	

Table note:

a. Calculated from PM_{10} concentrations measured at the Inland Rail AQMS using a ratio of 2.5, which is based on a PM_{10}:TSP ratio of 0.4 as reported by the Australian Coal Association Research Program (ACARP, 1999).

12.5.3.3 Assimilative capacity of the receiving environment

The assimilative capacity of the receiving air environment can be quantified by determining the difference between the adopted background concentrations (refer Table 12.10) and the air quality goals defined in Table 12.4. For most pollutants and averaging times, the background concentrations represent less than half of the criteria, indicating a moderate assimilative capacity of the receiving environment. Pollutants that show lower levels of assimilative capacity include the following:

- Annual average background for PM_{10} is 17.1 µg/m³, representing 68.4 per cent of the 25 µg/m³ goal
- Annual average background for $PM_{2.5}$ is 6.5 µg/m³, representing 81.2 per cent of the 8 µg/m³ goal
- Annual average background for benzene is 5.2 µg/m³, representing 96.3 per cent of the 5.4 µg/m³ goal.

12.5.3.4 Consideration of the influence of climate change on background air quality

Changing climatic conditions has the ability to influence ambient air quality via increased frequency of atypical events, such as bushfires and dust storms; however, it is considered difficult to confidently predict the influence of climate change on the duration, frequency and magnitude of extreme air quality events. It is also highlighted that, in comparative terms, emissions from the operation of the Project could be considered insignificant in comparison to major regional air quality events such as bushfires and dust storms. Due to the uncertainty that would be inherent in assessing the influence of changing climatic conditions due to climate change on the background air quality, climate change has not been considered beyond the bushfires and dust storms that are already present in the datasets used to establish the existing environment background concentrations adopted for the AQIA.

12.5.4 Existing emission sources

12.5.4.1 National Pollutant Inventory emission sources

The NPI (DAWE, 2019) is regulated by the Australian Government. The purpose of the NPI is to track pollution sources across Australia and ensure that the community has access to information about the emission and transfer of toxic substances that may affect them locally.

Facilities that exceed NPI reporting thresholds are required by the Australian Government to submit annual reports of their emissions to air. The NPI has emission estimates for 93 toxic substances and the source and location of these emissions. These substances have been identified as important due to their possible effect on human health and the environment. The data comes from facilities such as mines, power stations and factories, as well as other sources. NPI data tends to be a conservative estimate of industry emissions for sites such as quarries and mines due to the broad and generalised assumptions made during the emission estimations.

A search of the NPI database for the area in the assessment domain shows that there are five facilities in the AQIA study area that are required to report emissions annually. In addition, there are a further four facilities within 2 km of the boundary of the AQIA study area. These facilities and their reported emissions are described in Table 12.11, with their locations shown in Figure 12.2.

TABLE 12.11: NPI-LISTED FACILITIES CONSIDERED IN AQIA

Facility name	Industry	Pollutants emitted	Coordinates	Approximate distance/ location relative to the Project
Toowoomba Waste Management Centre	Landfill	Benzene (36 kg/yr), CO (79 kg/yr), toluene (590 kg/yr), total VOCs (5,200 kg/yr), xylenes (110 kg/yr)	-27.509063, 151.927316	Project passes beneath the facility (at a depth of approximately 95 m)
Wetalla Wastewater Treatment Plant (WTP) Stage 4/5	WTP	NH_3 (700 kg/yr)	-27.505986, 151.930013	0.6 km north of Toowoomba Range Tunnel
Mount Kynoch WTP	WTP	Cl (<1 kg/yr)	-27.509325, 151.955169	0.9 km north of Toowoomba Range Tunnel
Harlaxton Quarry	Gravel and sand quarrying	Trace metals (<35 kg/yr)	-27.530157, 151.962578	0.9 km south of eastern tunnel portal
Baillie Henderson Hospital	Back up electricity supply and steam generation	Benzene (<1 kg/yr), CO (1,400 kg/yr), toluene (<1 kg/yr), total VOCs (160 kg/yr), xylenes (<1 kg/yr), NO_x (4,200 kg/yr), PM_{10} (110 kg/yr), $PM_{2.5}$ (110 kg/yr)	-27.524058, 151.935935	1.1 km south of the Toowoomba Range Tunnel
Toowoomba Willowburn (Aurizon Operations limited)	Rollingstock maintenance	Total VOCs (7.6 kg/yr)	-27.539523, 151.947555	2.5 km south of the Toowoomba Range Tunnel
Boral Asphalt Charlton	Asphalt plant	CO (4,400 kg/yr), NO_x (9,600 kg/yr), PM_{10} (4,300 kg/yr), $PM_{2.5}$ (230 kg/yr), PAH (43 kg/yr), SO_2 (800 kg/yr), total VOCs (4,500 kg/yr)	-27.527520, 151.842788	3.6 km south of the alignment
Toowoomba Asphalt Plant	Asphalt plant	CO (2,700 kg/yr), NO_x (6,700 kg/yr), PM_{10} (2,300 kg/yr), $PM_{2.5}$ (48 kg/yr), PAH (8.1 kg/yr), SO_2 (8,800 kg/yr), total VOCs (1,600 kg/yr)	-27.540691, 151.905449	3.6 km south of the Toowoomba Range Tunnel
AIR BP Toowoomba	Petroleum product wholesaling	Total VOCs (9.5 kg/yr)	-27.544125, 151.917275	3.8 km south of the Toowoomba Range Tunnel

Table note:
kg/yr = kilograms per year

There are no sensitive receptors located in close proximity (within 500 m) to the Toowoomba Waste Management Centre. It is expected that emissions from the landfill will be accurately represented by assumed background concentrations.

The Wetalla and Mount Kynoch WTPs are located within 1 km of the Project and emit ammonia (NH_3) and chlorine (Cl), respectively. These pollutants are not emitted by Project sources and, therefore, are not required to be considered in further detail as part of the AQIA for the Project.

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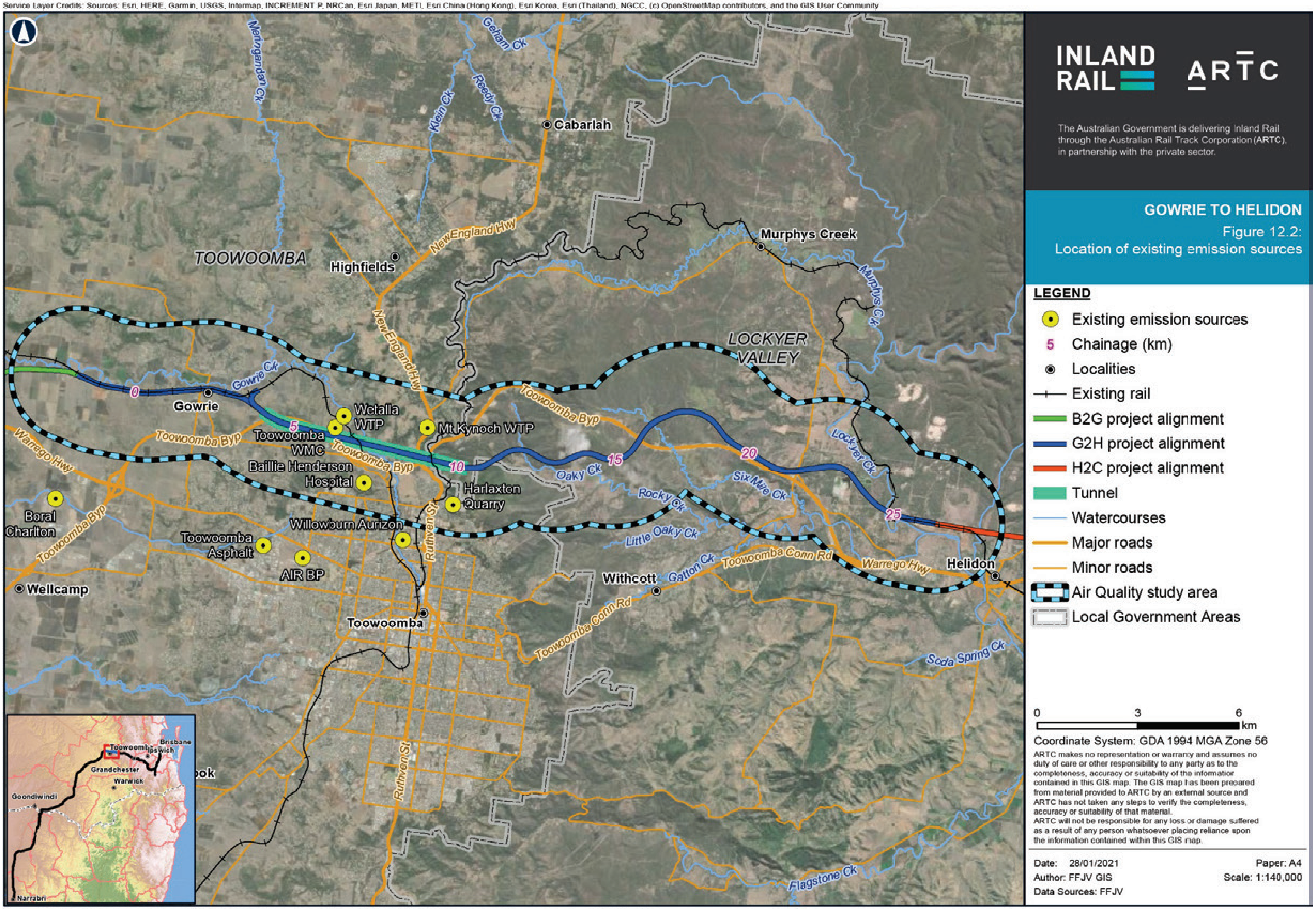

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The Harlaxton Quarry is located approximately 900 m to the south of the eastern tunnel portal, at the north-eastern edge of Toowoomba. The quarry is listed as emitting low levels (<35 kg/yr) of trace metals, which will not be emitted in significant quantity by the Project. It is expected that the quarry also generates dust, though this is not included on the NPI website. The nearest sensitive receptor to the eastern tunnel portal is approximately 730m to the southwest, with this receptor located approximately 350m from the nearest active area of the quarry. It is expected that the Project's contribution to pollutant concentrations and deposition levels at the nearest receptors will be minimal and, therefore, emissions from the quarry have been considered qualitatively for both the construction and operational phases.

The Harlaxton Quarry is located approximately 900 m to the south of the eastern tunnel portal, at the north-eastern edge of Toowoomba. The quarry is listed as emitting low levels (<35 kg/yr) of trace metals, which will not be emitted in significant quantity by the Project. It is expected that the quarry also generates dust, though this is not included on the NPI website. The nearest sensitive receptor to the eastern tunnel portal is approximately 730m to the southwest, with this receptor located approximately 350m from the nearest active area of the quarry. It is expected that the Project's contribution to pollutant concentrations and deposition levels at the nearest receptors will be minimal and, therefore, emissions from the quarry have been considered qualitatively for both the construction and operational phases.

The Baillie Henderson Hospital is located 1.1 km to the south of the Toowoomba Range Tunnel and is listed as a moderate source of NO_x emissions. Based on the source of emissions (backup electricity supply and steam generation) it is expected that emissions will not occur on a regular basis and will be released at height via an exhaust stack. It is expected that with an elevated release height of emissions from the hospital, it can be accurately represented by assumed background concentrations and, therefore, emissions from the hospital have not been considered in any further detail.

The AIR BP and Toowoomba Willowburn facilities are located 3.8 km and 2.5 km from the Project, respectively, and emit a low quantity of total VOCs (<10 kg/yr). Based on the distance to the Project and the low level of emissions, these sources are not considered in any further detail.

The asphalt plants located in Toowoomba and Charlton are significant pollution sources, and emit NO_x, PM_{10}, $PM_{2.5}$ and VOCs, which are common to emissions from the Project; however, both asphalt plants are located at significant distance from the Project (3.6 km for each plant, respectively) and emissions from the plants are unlikely to impact the receptors that have the potential to be impacted by the Project. It is expected that emissions from the asphalt plants will be accurately represented by assumed background concentrations and, therefore, have not been considered in any further detail as part of the AQIA for the Project.

12.5.4.2 Other local emission sources

In addition to the NPI sources listed in Table 12.11, other local emission sources will include environmentally relevant activities (ERAs), vehicle traffic and existing rail traffic on the QR West Moreton System rail corridor.

Sites with ERAs that do not report to the NPI, emit lower quantities of pollutants than the major polluters that are required to report to the NPI; as such, it is expected that emissions from ERAs will be adequately represented by the assumed background concentrations.

Based on the nature of the roads in the AQIA study area, emissions from local vehicle traffic are not expected to be significant, with the exception of the Toowoomba Bypass, which is assessed in Section 12.6.3.2.

The Project alignment is co-located with the existing QR West Moreton System rail corridor for approximately 4.8 km in the Gowrie area and 800 m in the Helidon area. There is also an existing crossing loop on the West Moreton System rail corridor at Gowrie. Emissions from trains operating on the existing QR network will currently be influencing the background air quality in the AQIA study area and air quality at the location of the Inland Rail AQMS as discussed in Section 12.5.3. For the assessment of the operational phase of the Project (refer Section 12.6.2), it has been assumed that all trains, including those existing services that currently use the QR West Moreton System rail corridor, will travel along the Project and, therefore, the existing train movements have been considered in the assessment.

12.5.5 Terrain and land use

The AQIA study area traverses through the rugged topography of the Toowoomba Range. The Project alignment straddles the hills, valleys, and escarpments of the Great Dividing Range (GDR), which includes the peaks of Mt Kynoch and Mt Lofty. The landscape, from Gowrie, approaching the GDR consists of a gentle incline before reaching peak elevation of approximately 644.5 m Australian Height Datum (AHD), as the Project alignment traverses under (depth of ~200 m) the New England Highway and Toowoomba Bypass at Mount Kynoch.

A steep drop in elevation occurs after the Project alignment passes the GDR to the east, with periodic and isolated peaks featuring with reducing elevation towards Helidon. The lowest elevation for the Project alignment occurs at Lockyer Creek, 1 km to the west of Helidon, with an approximate elevation of 148.5 m AHD.

Several small townships and suburbs of Toowoomba exist within 5 km of the Project alignment—these include Helidon Spa, Postmans Ridge, Lockyer, Blue Mountain Heights, Mount Kynoch, Cranley, and Gowrie.

The Project passes through rural and grazing lands and is in tunnel under the Toowoomba Plateau, passing under the localities of Cranley, Mount Kynoch and Ballard, and emerging on the eastern side of the Toowoomba Range near Mt Kynoch, before continuing through areas of native vegetation and grazing properties of the Lockyer Valley.

The influence of terrain on wind flows and dispersion, and the influence of land use on surface roughness has been considered in the meteorological modelling undertaken for the assessment. The height of the train emission sources included in the modelling is based on the proposed design elevations for the Project alignment and includes proposed bridges and viaducts.

Chapter 8: Land Use and Tenure and Chapter 9: Land Resources discuss land use surrounding the Project.

12.5.6 Sensitive receptors

Sensitive receptors in the AQIA study area were identified as per the EP Act Air Guideline. As per the EP Act Air Guideline, a sensitive receptor can include the following:

- A dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises
- A motel, hotel or hostel
- A kindergarten, school, university or other educational institution
- A medical centre or hospital
- A protected area under the *Nature Conservation Act 1992* (Qld), the *Marine Parks Act 2004* (Qld) or a World Heritage Area
- A public park or garden
- A place used as a workplace including an office for business or commercial purposes.

The Project is primarily situated in a rural setting but traverses in close proximity to urban areas of the Toowoomba including Gowrie and residential areas in the Lockyer Valley. The predominant sensitive receptor type in the AQIA study area are residential dwellings. In addition to assessing air quality impacts at residential dwellings, the potential impact of Project air emissions on potable water tanks and drinking water quality at residential dwellings has also been considered.

The *EP Act Air Guideline* definition for sensitive receptors includes areas protected under the *Nature Conservation Act 1992* (Qld) or the *Marine Parks Act 2004* (Qld), or World Heritage Areas. The *Nature Conservation Act 1992* (Qld) defines protected areas as national parks, conservation parks, resource reserves, special wildlife reserves, nature refuges or coordinated conservation areas. In addition to the *EP Act Air Guideline* definition, the *Air EIS Information Guideline* (DES, 2020) states that 'remnant and regrowth ecosystems of all types' may be affected by the dispersal of air contaminants and should be considered.

There are no World Heritage Areas or areas protected under the *Nature Conservation Act 1992* (Qld) or the *Marine Parks Act 2004* (Qld) located in the AQIA study area. The nearest protected area is the Lockyer Resource Reserve, with the southern-most section of the reserve located approximately 2.6 km north of the eastern extent of the Project alignment. As there are no World Heritage Areas or protected areas in the AQIA study area, significant impacts to these areas are considered unlikely and impacts to these areas have not been considered in the assessment.

Based on the broad inclusion of 'remnant and regrowth ecosystems of all types' in the *Air EIS Information Guideline* (DES, 2020), the impact of NO_2 on these ecosystems has been investigated through the assessment of predicted annual average NO_2 concentrations against the EPP (Air) annual average goal NO_2 for the protection of the health and biodiversity of ecosystems (33 $\mu g/m^3$) (refer Table 12.4).

With respect to agricultural land uses, the AQIA has considered Withcott Seedlings, which is a commercial agricultural business that produces vegetable seedlings. Withcott Seedlings is located on Postmans Ridge Road at Withcott and is a certified organic supplier of seedlings. The Project traverses the facility, on viaduct, between two large water storage dams. Impacts on Withcott Seedlings from air emissions associated with the Project are discussed in Section 12.6.3.5.

Discrete receptor points have been included for residential sensitive receptors and Withcott Seedlings, with discrete receptor points modelled at ground level (0 m above ground) as per the requirements of the EP Act Air Guideline. A total of 2,829 discrete receptor points have been included in the model at a height of 0 m above ground. In addition to these discrete receptor points, grids of receptor points (grid receptors) have been included in the modelling (also at 0 m above ground) to understand the spatial impact of Project air emissions and to facilitate the generation of concentration contours. Due to the spatial distribution of remnant and regrowth ecosystems, impacts to these ecological receptors have been assessed considering modelled results for grid receptors and analysis of concentration contour plots. Figure 12.3 shows the location of identified sensitive receptors (discrete receptors) considered in the AQIA.

The number of sensitive receptors considered in the AQIA is different to the number of receptors considered in noise impact assessments for the Project. The study area for the noise impact assessments is larger than the AQIA study area, and extends further into the urban areas of Toowoomba, resulting in additional sensitive receptors being considered. The mechanics of noise propagation and the dispersion of air emissions are significantly different, and, therefore, it is appropriate for the study areas and number of receptors for these assessments to be different.

The number of sensitive receptors in the AQIA study area may have minor variations as the Project progresses.

There are eight receptors (receptors R_386, R_447, R_888, R_898, R_923, R_931, R_2296 and R_2323) located in the Project disturbance footprint. Of these eight receptors, seven have been considered in the assessment of the construction phase (e.g. it has been assumed for assessment purposes that these receptors are inhabited during construction of the Project). There is one receptor (receptor R_2323) that represents a potential site office for a laydown area that will be used by the Project during construction, and this receptor has not been considered in the assessment of the construction phase.

There are six receptors located in the permanent disturbance footprint (receptors R_386, R_447, R_888, R_898, R_923 and R_931). These six receptors have been considered in the assessment of the operation phase.

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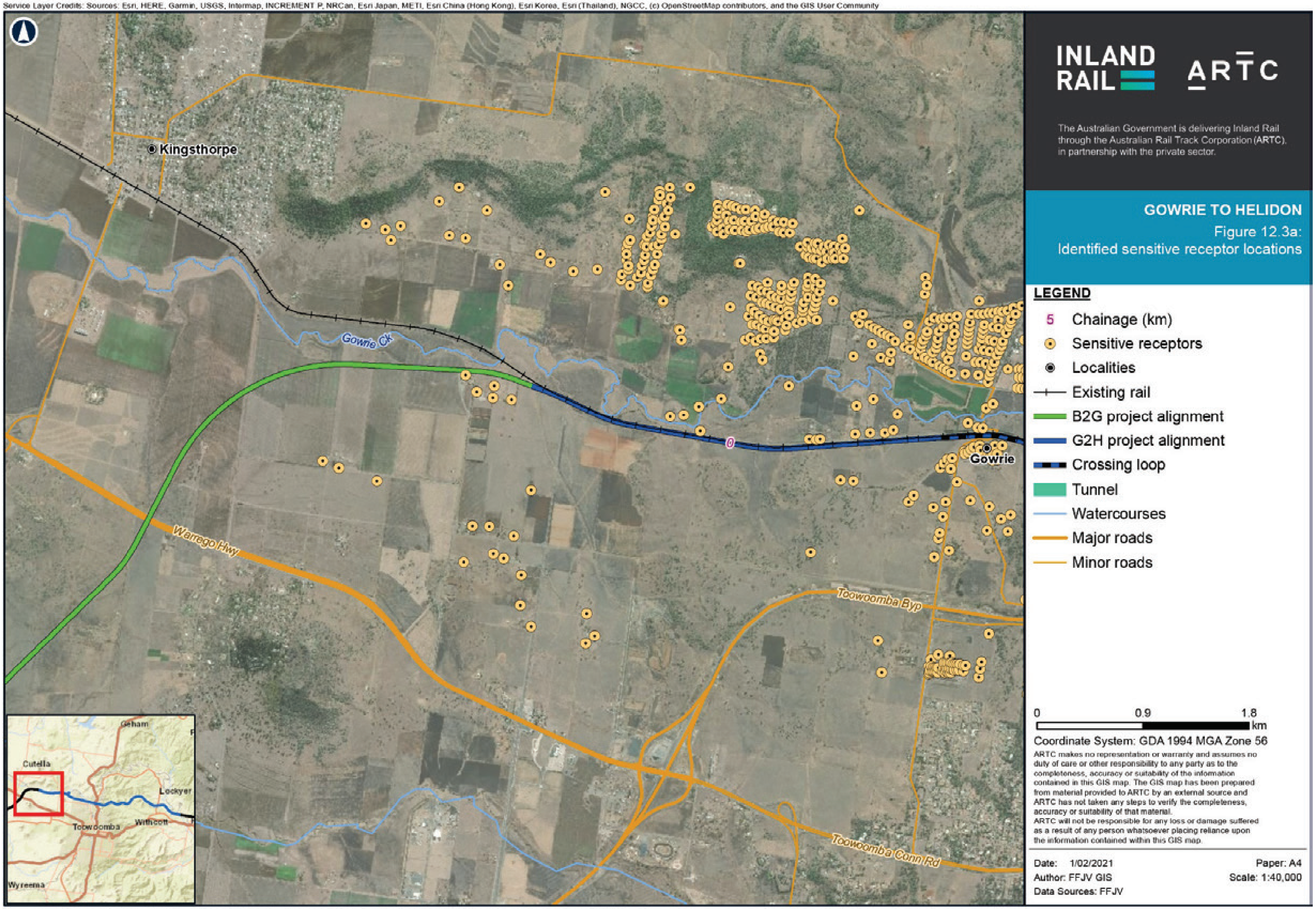

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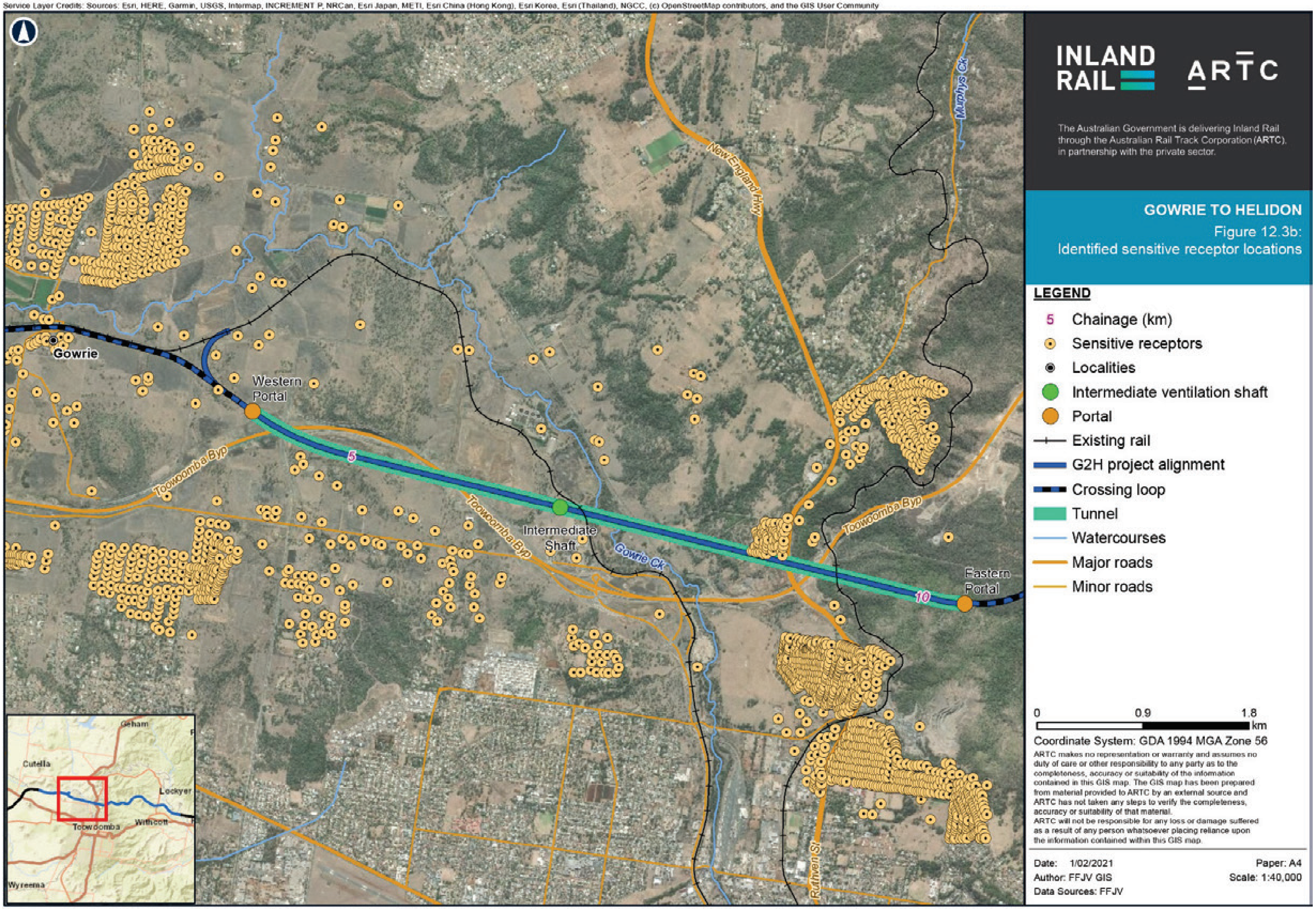

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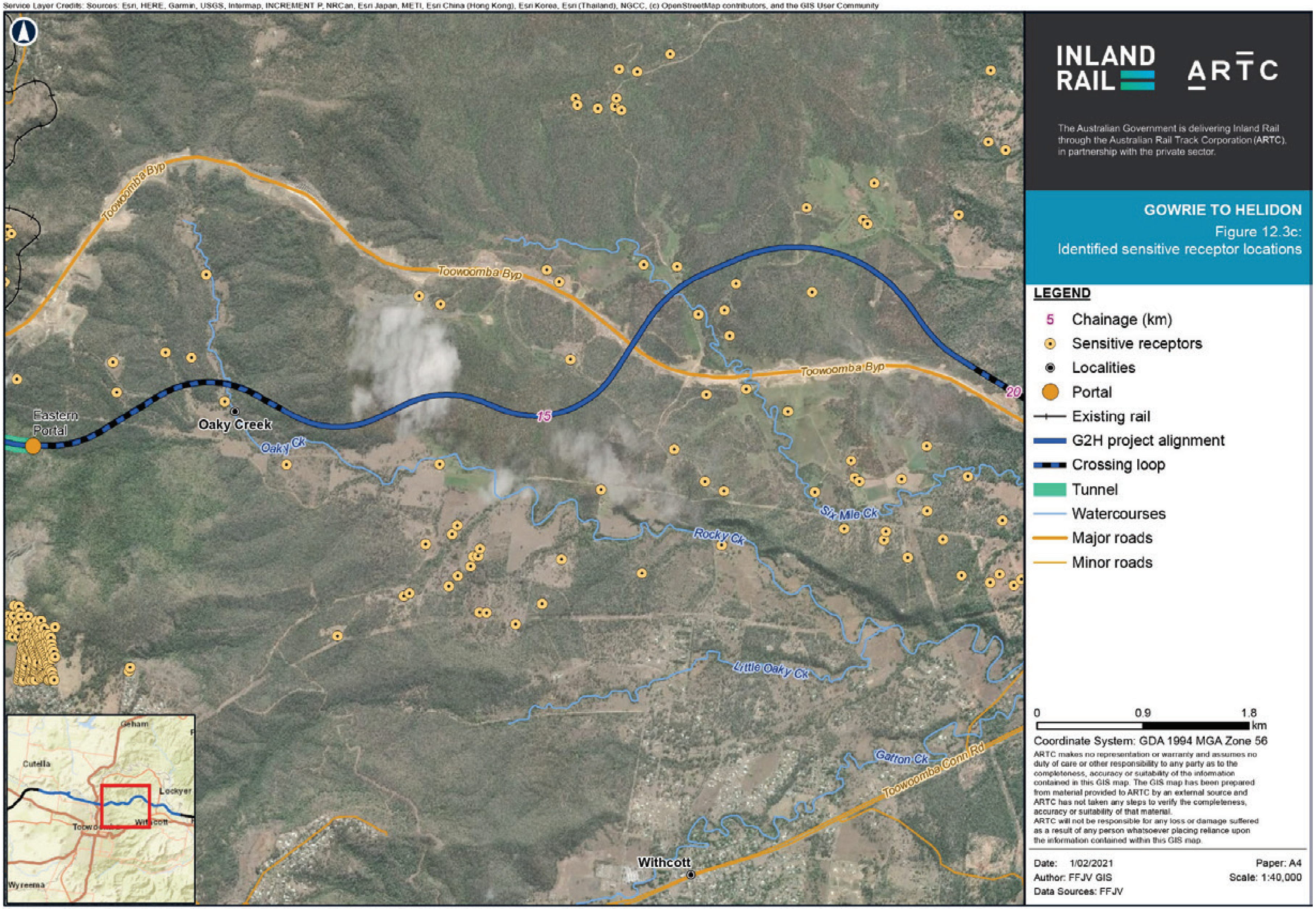

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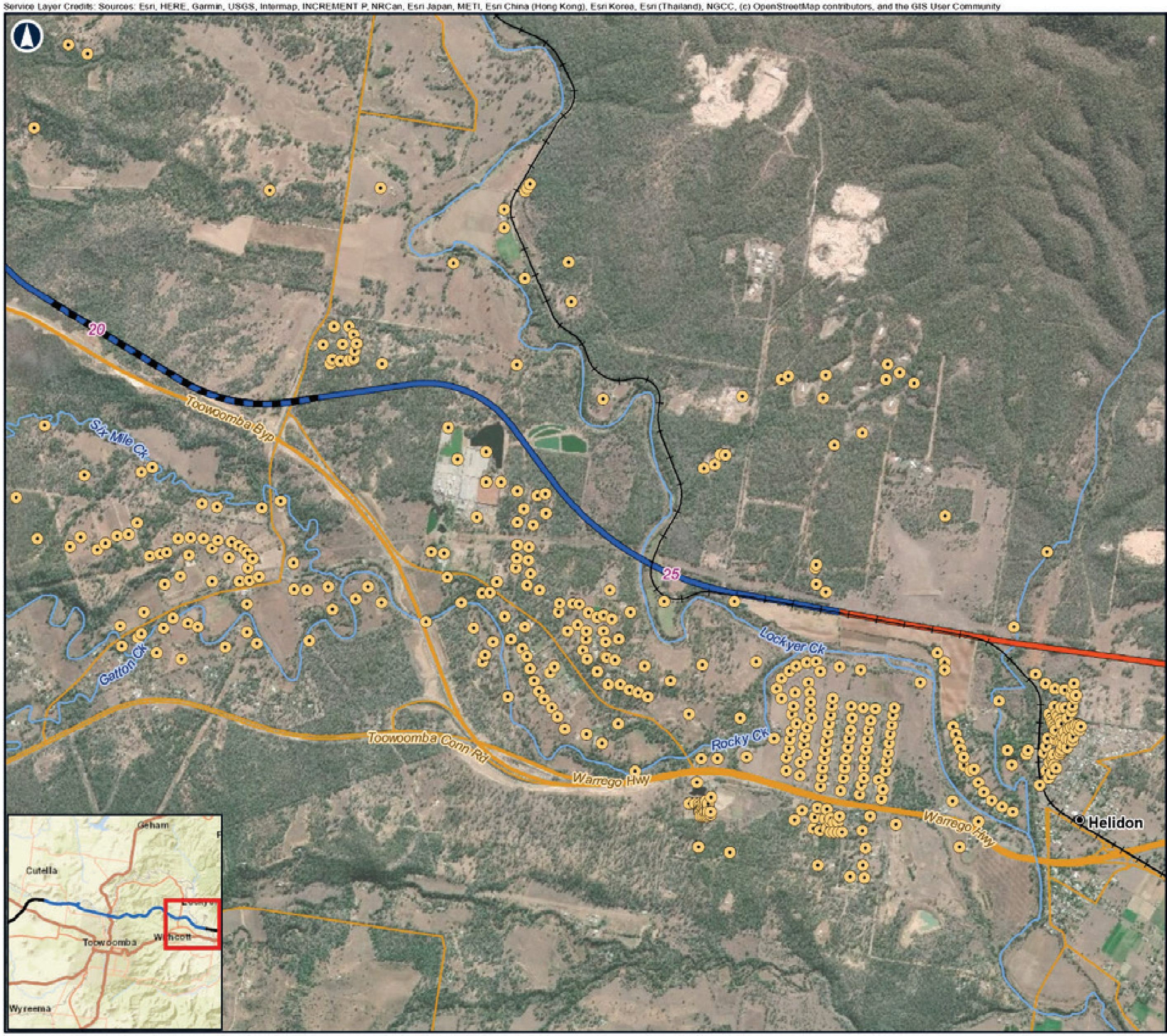

INLAND RAIL

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 12.3d: Identified sensitive receptor locations

LEGEND

- 5 Chainage (km)
- Sensitive receptors
- Localities
- Existing rail
- G2H project alignment
- H2C project alignment
- Crossing loop
- Tunnel
- Watercourses
- Major roads
- Minor roads

0 0.9 1.8 km

Coordinate System: GDA 1994 MGA Zone 56

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12.6 Methodology

The AQIA methodology for the Project includes the following key elements:

- Qualitative impact assessment for the construction phase to estimate potential air quality impacts
- The potential for commissioning phase impacts is discussed in Section 12.6.2
- Primarily quantitative impact assessment for the operational phase to estimate potential air quality impacts, including cumulative air quality impacts. Some minor emissions sources are assessed qualitatively.
- Identification of mitigation measures
- Assessment of the residual impact with the inclusion of the identified mitigation measures.

Early community and stakeholder engagement on the draft ToR resulted in the EIS including assessment of potential pollutants in water tanks against drinking water guidelines. Dust generation during construction and operation have also been key matters raised by stakeholders and the community, which has helped to inform the development of mitigation measures for both construction and operation. This includes consideration of both onsite construction activities, and the movement of construction vehicles and equipment to and within the Project disturbance footprint, along with air emissions from the Toowoomba Range Tunnel portals during operation and the potential impact to nearby residential areas located near the portals.

Further information about the AQIA methodology is provided in Appendix K: Air Quality Technical Report.

12.6.1 Construction phase impact assessment

Construction emissions for large linear infrastructure projects are complex due to the number of construction activities, the distribution of sites across a large geographical area, the transitory nature of many individual construction activities at particular locations and the averaging periods for air quality goals. As such, air quality impacts from the construction phase of the Project have been assessed via a qualitative risk assessment.

As discussed in Section 12.4.2, the highest proportion of construction emissions is generated by mechanical activity, e.g. material movement or mobile equipment travel, which typically generate coarser particulate emissions (PM_{10} and TSP). Airborne PM_{10} and deposited dust (TSP) are the main pollutants of concern for construction activities and these pollutant species are the focus of the assessment for construction dust. Point-source gaseous emissions from diesel construction vehicles will be significantly lower than particulate emissions from construction activities, and are unlikely to result in exceedance of air quality goals and have not been assessed in any further detail; however, mitigation measures for these sources are proposed.

The assessment methodology used for the construction phase is based on the methodology provided in the IAQM Guidance on the assessment of dust from demolition and construction (UK IAQM, 2014). The IAQM process is a four-step risk-based assessment, summarised as follows:

- Step 1—screening assessment: assess distance from receptors to active construction areas
- Step 2—dust risk assessment: assess the dust emission magnitude (scale of activity) of the identified sources, determine the sensitivity of the surrounding area, and determine the risk of impacts if no mitigation is implemented
- Step 3—management strategies: identify the mitigation measures required to minimise the risk of impacts to sensitive receptors
- Step 4—reassessment: review the potential for residual impacts post mitigation.

The emission sources considered include demolition, earthworks, construction and trackout, which are defined as follows:

- Demolition: any activity involved with the removal of an existing structure (or structures)
- Earthworks: the processes of soil stripping, ground levelling, excavation and landscaping
- Construction: any activity involved with the provision of a new structure (or structures), its modification or refurbishment
- Trackout: the incidental transport of dust and dirt from the construction/demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network. For the purpose of this assessment, dust generated by vehicles on unsealed roads has also been included in trackout.

The assessment of construction dust impacts is presented in Section 12.7.1. Tunnel construction would include aspects of each of these emissions sources.

In addition to construction dust, odour and VOCs will be emitted from fuel tanks located at laydown areas. Impacts from fuel storage have been assessed in Section 12.7.1.2. This assessment of fuel storage tanks has followed guidance from the *BCC AQPSP Service Station Code* (BCC, 2014) and the Victorian EPA *Recommended separation distances for industrial residual air emissions* (EPA Victoria, 2013), which is referenced in the *EP Act Air Guideline* as being applicable for assessments in Queensland.

Assessment of crushing plant and blasting, which may be required to facilitate construction, is provided in Sections 12.7.1.3 and 12.7.1.4. Odour emissions from welding and sewage treatment facilities are considered to present negligible risk of significant impacts and, therefore, these emission sources have not been considered.

Detailed dispersion modelling of construction is not typically undertaken as construction activity is difficult to forecast accurately and emissions are typically well controlled by industry standard best-practice mitigation measures. The qualitative assessment method applied for the assessment of construction-phase impacts is considered appropriate for the Project and is consistent with industry standard methodology.

A breakdown of each step and the associated findings of the dust impact assessment are detailed in Appendix K: Air Quality Technical Report.

12.6.2 Commissioning phase impact assessment

The commissioning phase of the Project will involve 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. All rail system commissioning activities will be undertaken in accordance with an approved Test and Commissioning Plan developed by the construction contractor and approved by ARTC.

Air emissions during the commissioning phase of the Project are anticipated to be minor and are expected to be limited to combustion engine emissions from transport vehicles and train locomotives, and limited dust emissions from vehicle travel on unsealed roads.

In regard to train travel on the line, emissions from the commissioning phase of the Project will be significantly lower than emissions during the operational phase.

Air emissions from the commissioning phase of the Project are expected to be insignificant and are considered unlikely to generate nuisance or risk exceedance of the Project's air quality goals and, therefore, have not been assessed.

12.6.3 Operational phase impact assessment

12.6.3.1 Overview

Dispersion modelling addressing line source emissions (i.e. emissions from freight trains travelling along the track and through the Toowoomba Range Tunnel) was undertaken to determine if the operation of the Project will comply with the adopted air quality goals at sensitive receptor locations.

The air dispersion modelling was undertaken using the CALPUFF and GRAL modelling suites. The GRAL model was developed at the Institute for Internal Combustion Engines and Thermodynamics, Technical University Graz, Austria, specifically to assess the dispersion of pollutants from roadways and tunnel portals, and has been used to model emissions from the Toowoomba Range Tunnel. The CALPUFF model was used to model all other open-air sections of the Project alignment (e.g. outside the tunnel).

Meteorological data was prepared using The Air Pollution Model (TAPM) and data from nearby monitoring stations. The data available for this Project and a discussion of the methodologies required to implement dispersion modelling are detailed in this section and in Appendix K: Air Quality Technical Report.

An emissions inventory was compiled and used to inform the dispersion modelling. The emissions inventory links activities during the operational phase to the potential emission sources. Information used in the emissions inventory included the proposed method of operation of the Project, frequency and speed of trains, and emissions factors for diesel engines. Modelling of emissions from the tunnel considered the length and cross-sectional area of the tunnel, the emissions that would occur inside the tunnel and the ventilation design (i.e. air will be drawn down from the intermediate ventilation shaft and will purge the tunnel via the eastern and western tunnel portals). Locomotive emissions that occur within the tunnel will not be emitted from the intermediate ventilation shaft and, therefore, the shaft is not an emissions source.

In addition to emissions from overland rail travel, stopped trains were also modelled for the crossing loops planned to be situated east and west of the Toowoomba Range Tunnel and at Postmans Ridge. Concentrations at sensitive receptors located close to crossing loops, are likely to be higher than for train travel due to the potential extended amount of residence time at the crossing loop and the potential for two trains operating in close proximity to each other. Emissions from crossing loops have been modelled specifically to address this scenario and the potential impacts that may result.

Estimated emissions included fugitive dust from rail transport of coal along the Project alignment. The potential for contamination of water tanks from deposition of pollutants from the operation of the Project has also been investigated.

Cumulative assessment of air quality impacts from the Project was undertaken by considering the following:

- Existing background air quality
- NPI-listed facilities
- Other projects of local, regional or State significance relevant to the AQIA
- Existing emission sources, including the QR West Moreton System Rail Corridor and the Toowoomba Bypass
- The adjoining B2G and Helidon to Calvert (H2C) sections of the Inland Rail Program.

The contribution from other local sources is represented by the assumed background concentrations for the pollutants assessed (refer Section 12.5.3.2).

12.6.3.2 Emissions inventory

To quantify emissions from the operation of the Project, an emissions inventory was developed. The key pollutants of interest for the operational phase are TSP, PM_{10}, $PM_{2.5}$, and NO_x; however, emissions have been calculated for all pollutant species that have air quality goals (refer Table 12.4).

Train volumes

It is estimated that in the opening year of the Project (2027), typical operations will involve approximately 226 trains per week (approximately 33 trains per day) with volumes increasing in future operational years. In 2027, the majority of the rail traffic on the Project will be existing trains that currently use the QR network. In future years, additional rail traffic will be generated as a result of the Inland Rail Program and the ARTC network.

To assess emissions from normal operations and potential worst-case operations, the assessment of operational impacts has considered both typical and peak train volumes for 2040, as shown in Table 12.12. The forecast peak train volume for 2040 is 402 trains per week. The forecast typical train volume for 2040 is anticipated to 81.6 per cent of the peak volume, with an equal reduction (18.4 per cent reduction) across each train type, resulting in approximately 328 trains per week for the typical scenario. Train volumes for the commencement in 2027 are forecast to be lower than in 2040 and, therefore, assessment using 2040 train volumes provides a worst-case assessment of impacts to air quality.

Existing rail traffic on the West Moreton System rail corridor is predominantly comprised of coal trains, with a smaller number of agricultural freight services. The Project alignment caters for larger train load tonnages, larger train sizes and alternate configurations (e.g. more locomotives), which reduces the required number of coal services per day, while allowing for additional agricultural rail movements. The train types and configurations that will use the Project alignment have been considered in the AQIA.

TABLE 12.12: WEEKLY TRAIN MOVEMENTS BY SERVICE

	Volume of trains/week		Locomotive type			
Train type/description	Typical[a]	Peak	NR Class[b]	SCT Class[c]	Class 82[d]	PR22L[e]
MB Express (Bromelton)	11	14	x	-	-	-
MB Express (Acacia Ridge)	11	14	x	-	-	-
MB Superfreighter (Bromelton)	33	40	-	x	-	-
MB Superfreighter (Acacia Ridge)	6	8	-	x	-	-
GB Superfreighter (Bromelton)	18	22	-	x	-	-
GB Superfreighter (Acacia Ridge)	8	10	-	x	-	-
New Acland Coal[f]	46	56	-	-	-	x

Train type/description	Volume of trains/week		Locomotive type			
	Typical[a]	Peak	NR Class[b]	SCT Class[c]	Class 82[d]	PR22L[e]
Camby Downs/Rywung Coal[f]	46	56	-	-	-	x
Kogan Creek Coal[f]	34	42	-	-	-	x
Wilkie Creek Coal[f]	23	28	-	-	-	x
Narrabri—PoB Grain	20	24	-	-	x	-
Yelarbon—PoB Grain	20	24	-	-	x	-
Oakey—PoB Grain[f]	19	24	-	-	x	-
Narrabri—PoB Export Cont	10	12	-	-	x	-
Yelarbon—PoB Cotton	5	6	-	-	x	-
Toowoomba Export Containers[f]	10	12	-	-	-	x
Westlander[f]	3	4	-	-	-	x
Oakey—Rosewood Livestock[f]	5	6	-	-	x	-
Total	**328**	**402**				

Table notes:

a. The typical volumes are approximate and have been rounded to the nearest whole number based on typical train volumes being expected to be 81.6 per cent of the peak volume for 2040

b UGL National Rail Class locomotive

c. Downer EDI SCT/LDP Class locomotive

d. Downer EDI 82 Class locomotive

e. Progress Rail EMD22L locomotive

f. Indicates that this train service is an existing service which currently uses the QR rail line.

MB = Melbourne to Brisbane

GB = Broken Hill to Brisbane

POB = Port of Brisbane

"**X**" Indicates that this locomotive operates the listed train type, "-"indicates that this locomotive is not on this train type.

The Project alignment is located adjacent to the existing QR West Moreton System rail corridor for approximately 5.6 km of the total length. For the purpose of the assessment it has been assumed that all trains, including those existing services that currently use the QR West Moreton System rail corridor, will travel along the Project. This can be considered a conservative assumption, assuming that all trains travelling along the Project alignment concentrate the emission source.

Diesel locomotive emissions

Emission factors have been sourced from emissions testing completed on locomotives by the NSW EPA (2016) and rated emission standards published by the US Environmental Protection Agency (US EPA) and European Union. The US EPA and European Environment Agency (EEA) emission factors are the most accurate source of available emissions data for the locomotives and are considered appropriate for use in the assessment. Table 12.13 presents the referenced emissions factors on a grams per kilowatt hour (g/kWh) basis.

TABLE 12.13: LOCOMOTIVE EMISSIONS FACTORS

Locomotive	NR Class[b] Cycle weighted	NR Class[b] Idling	SCT/LDP[c]	82 Class[d]	PR22L[e]
Locomotive Max Power (kW)	2,917		3,350	2,425	1,640
Rated Emission Standard	US EPA—Tier 0	-	US EPA—Tier 1	US EPA—Tier 0	EURO IIIA
Total Particulates (g/kWh)	0.8	1.09	0.60	0.8	0.20
NO_x (g/kWh)	12.74	43.7	9.92	12.74	6.00
Total Hydrocarbons (THC)[a] (g/kWh)	1.34	4.66	0.74	1.34	0.50
Source	US EPA Emissions Limits—Line Haul Locomotives	Diesel Locomotive Fuel Efficiency & Emission Testing Report Nov 2016 by ABMARC for NSW EPA (NR121 & 93 Class)	US EPA Emissions Limits—Line Haul Locomotives		EU Emissions Standards—Nonroad Engines

Table notes:
kWh = kilowatt hour; g/kWh = grams per kilowatt hour
a. VOCs are a subset of THC. For this assessment 100 per cent of THC emissions are assumed to be VOCs.
b. UGL National Rail Class locomotive
c. Downer EDI SCT/LDP Class locomotive
d. Downer EDI 82 Class locomotive
e. Downer EDI/Progress Rail Services PR22L locomotive

Table 12.14 summarises the operating mode percentages of maximum engine power used for each engine notch setting to calculate average duty cycle power ratings.

To determine the time spent at each engine notch setting, data from US rail operations was used to provide a basis for average duty cycle power ratings. Table 12.15 presents US EPA data from Ireson, Germer, and Schmid (2005), which represents duty cycle data for line haul diesel locomotives in the US. The line haul data presented is the result of analysis of 63 line-haul trains and 2,475 operational hours.

TABLE 12.14: ADOPTED NOTCH SETTING AND OPERATING MODE POWER RATING PERCENTAGES

Notch setting or operating mode	Adopted percentage of maximum engine power (per cent)	Source
Idle	2.3	Casadei & Maggioni (2016)
Dynamic Braking	3.6	StarCrest Consulting Group (2008)
Notch 1	4.8	Spiryagin et al. (2015)
Notch 2	10.7	
Notch 3	24.1	
Notch 4	34.3	
Notch 5	45.4	
Notch 6	66.0	
Notch 7	87.1	
Notch 8	100.0	

TABLE 12.15: DUTY-CYCLES FOR LINE HAUL LOCOMOTIVES IN THE US (PERCENTAGE TIME IN NOTCH)

Notch setting/operating mode	Line haul (per cent)
Idle	38.0
Dynamic Braking	12.5
Notch 1	6.5
Notch 2	6.5
Notch 3	5.2
Notch 4	4.4
Notch 5	3.8
Notch 6	3.9
Notch 7	3.0
Notch 8	16.2

Average hourly power consumption rates have been calculated for each locomotive type using the adopted notch power ratings and duty cycle information presented in Table 12.14 and Table 12.15. The calculated average hourly power consumption rates in addition to the maximum and idling power consumption rates for each locomotive are presented in Table 12.16.

TABLE 12.16: LOCOMOTIVE POWER USAGE

Power	NR Class[a]	SCT/LDP[b]	Class 82[c]	PR22L[d]
Maximum power (kWh)	2,917	3,350	2,425	1,640
Calculated duty cycle (kWh)	823	945	684	463
Idle (kWh)	68	78	56	38

Table notes:

a. UGL National Rail Class locomotive
b. Downer EDI SCT/LDP Class locomotive
c. Downer EDI 82 Class locomotive
d. Downer EDI/Progress Rail Services PR22L locomotive

kWh = Kilowatt hours

Table 12.17 presents the maximum design line speed for the Project alignment and the estimated average line speed, which has been used to estimate train travel emissions. The average line speed has been estimated assuming that the average travel speed is 75 per cent of the maximum design speed. Assessment of train travel emissions has also assumed that trains idle for 25 per cent of total journey time (based on the Project alignment length and average line speed). Changes in grade along the Project alignment have not been considered when estimating emissions from locomotives, with engine load determined based on the power consumption for each locomotive as presented in Table 12.16.

TABLE 12.17: LOCOMOTIVE TRAVEL SPEEDS

Power	Direction of travel	NR Class[a]	SCT/LDP[b]	Class 82[c]	PR22L[d]
Maximum design line speed (km/h)	Eastbound	115	115	80	80
	Westbound	115	115	80	100
Average line speed (km/h)	Eastbound	86	86	60	60
	Westbound	86	86	60	75

Table notes:

km/hr = kilometres per hour

a. UGL National Rail Class locomotive
b. Downer EDI SCT/LDP Class locomotive
c. Downer EDI 82 Class locomotive
d. Downer EDI/Progress Rail Services PR22L locomotive

The following equation represents the calculation method used to determine the total locomotive power per hour for the entire Project alignment.

$$P_{loco} = t_{loco} \times n_{loco} \times c_{loco}$$

Where:

- P_{loco} is the total calculated power per hour for the Project alignment for a specific locomotive type (kWh)
- t_{loco} is the average time taken for the locomotive to travel the Project alignment, derived from the average line speed of each locomotive type (km/h) and the Project alignment length (km)
- n_{loco} is the total number of locomotives of each train type per hour
- c_{loco} is the calculated average duty cycle power for each locomotive type (kWh).

The total number of locomotives for each train type has been assigned based on train specification data provided by ARTC for rail traffic forecasts for 2040. The number of locomotives per train type as adopted in this assessment are as follows:

- Express freight trains: three NR Class locomotives per train
- Super freighter trains: two SCT Class locomotives per train
- Grain, cotton and livestock: two Class 82 locomotives per train
- Coal trains: three PR22L locomotives per train
- Westlander: one PR22L locomotive per train.

The locomotive numbers above have been adopted for all trains (dependent on type) modelled in the assessment, including for existing services that currently use the QR West Moreton System rail corridor, which are assumed to travel along the Project alignment for the purpose of this assessment.

Pollutant diesel combustion emission rates were then calculated using the following:

- For the typical scenario emissions have been calculated based on a total of 328 trains per week (approximately 47 trains per day) (refer Table 12.12)
- For the peak scenario emissions have been calculated based on a total of 402 trains per week (approximately 57 trains per day) (refer Table 12.12)
- Locomotive power usage has been adopted as presented in Table 12.16
- 75 per cent of journey time was assumed to consist of travel time, with 25 per cent of journey time assumed to consist of trains being stationary and idling in crossing loops (based on operational rail modelling).

The following equation was used to calculate the pollutant emissions from locomotive traffic along the entire Project alignment.

$$ER_{pollutant} = \frac{\left[\sum^{loco}\left(P_{loco} \times EF_{pollutant}\right)\right]}{3600 \times d}$$

Where:

- $ER_{pollutant}$ is the calculated pollutant emission rate for each pollutant (e.g. NO_x, TSP, PM_{10}, $PM_{2.5}$, and total VOC's) (grams per metre per second, g/m/s)
- P_{loco} is the total locomotive calculated power per hour for entire Project alignment (kWh)
- $EF_{pollutant}$ is the pollutant emission factor as per Table 12.13 (g/kWh)
- d is the rail track length of the Project alignment (m).

The following equation was used to calculate emissions from idling locomotives during normal assumed operation.

$$ER_{idle} = \left[\sum^{loco}\left(\frac{t_{loco}}{3} \times n_{loco} \times P_{loco}\right)\right] \times EF_{pollutant}$$

Where:

- ER_{idle} is the calculated pollutant emission rate for each pollutant (e.g. NO_x, TSP, PM_{10}, $PM_{2.5}$, CO, and total VOCs) (grams per second, g/s)
- t_{loco} is the locomotive travel time along the Project alignment without stopping. Idling time is assumed to be 25 per cent of the total travel time along the Project alignment, i.e. 1/3 of the non-stopping travel time of a locomotive to travel the Project alignment
- n_{loco} is the total number of locomotives of each train type
- P_{loco} is the total locomotive idling engine power per hour per train(kWh)
- $EF_{pollutant}$ is the pollutant emission factor as per Table 12.13 (g/kWh).

To determine continuous idling emissions from crossing loops, it was assumed that three NR class locomotives would idle for periods up to, or greater than, 1 hour. The idling emission rates were therefore derived from the hourly idling locomotive power usage presented in Table 12.16, and the locomotive emission factors presented in Table 12.13. The methodology for the assessment of emissions from crossing loops is discussed in Section 12.6.3.3.

The derived pollutant locomotive diesel emission rates for the main pollutants of concern are presented in Table 12.18. The locomotive idling emissions rates for each crossing loop are also presented. The methodology for the assessment of emissions from the crossing loops is explained in Section 12.6.3.3.

TABLE 12.18: DERIVED POLLUTANT DIESEL COMBUSTION EMISSION RATES

Pollutant	Total Project emissions (g/m/s)	Long-term average idling emissions (g/s) (per crossing loop)	Short-term average idling emissions (g/s) (per crossing loop)
NO_x	1.46×10^{-04}	0.134	4.944
TSP	5.78×10^{-05}	0.003	0.123
PM_{10}	3.27×10^{-05}	0.003	0.120
$PM_{2.5}$	1.12×10^{-05}	0.003	0.116
Total VOCs	2.06×10^{-05}	0.014	0.527

Table note:

a. Explanation of the scenarios modelled (long term and short term) for the assessment of emissions from the crossing loops is provided in Section 12.6.3.3.

Where emissions factors for specific pollutants of concern were not available, emission factors from the *NPI Emissions estimation technique manual for Railway Yard Operations* (NPI, 2008) and the European Monitoring and Evaluation Program/European Environmental Authority (EMEP/EEA) Air pollutant emission inventory guidebook 2016 (EMEP/EEA 2016a and 2016b) were used. The referenced and speciated locomotive emissions factors are presented in Table 12.19.

TABLE 12.19: LOCOMOTIVE EMISSION FACTORS AND SPECIATION

Pollutant	Emission factor	Units	Speciation percentage (per cent)	Source
Total suspended particulates				
PM_{10}	3.53	kg/kL	97.6	(NPI, 2008)
$PM_{2.5}$	3.39	kg/kL	93.7	(NPI, 2008)
Cadmium	0.01	g/tonne of fuel	0.00066	(EMEP/EEA, 2016a)
Chromium	0.05	g/tonne of fuel	0.0033	(EMEP/EEA, 2016a)
Copper	1.7	g/tonne of fuel	0.11	(EMEP/EEA, 2016a)
Nickel	0.07	g/tonne of fuel	0.0046	(EMEP/EEA, 2016a)
Selenium	0.01	g/tonne of fuel	0.00066	(EMEP/EEA, 2016a)

Pollutant	Emission factor	Units	Speciation percentage (per cent)	Source
Zinc	0.03	g/tonne of fuel	0.066	(EMEP/EEA, 2016a)
Lead	0.0005	mg/kg of fuel	0.000033	(EMEP/EEA, 2016b)
Arsenic	0.0001	mg/kg of fuel	0.0000066	(EMEP/EEA, 2016b)
Total hydrocarbons				
Non-methane VOCs	4.65	kg/tonne of fuel	100	(EMEP/EEA, 2016a)
Benzo(a)pyrene	0.03	g/tonne of fuel	0.00065	(EMEP/EEA, 2016a)
Toluene	-	-	0.01	(EMEP/EEA, 2016b)
m,p-xylenes	-	-	0.98	(EMEP/EEA, 2016b)
o-xylenes	-	-	0.40	(EMEP/EEA, 2016b)
Benzene	-	-	0.07	(EMEP/EEA, 2016b)
1,3-Butadiene	0.31	kg/kL	7.3	(NPI, 2008)
Polychlorinated dioxins and furans (TEQ)	8.35×10^{-11}	kg/kL	0.0000000020	(NPI, 2008)

Table note:
kg/kL—kilograms per kilolitre
g/tonne of fuel—grams per tonne of fuel
mg/kg of fuel—milligrams per kilogram of fuel

Fugitive coal dust

The nature of dust emissions from the coal wagons (laden and unladen) is fugitive, i.e. the emissions are not released through an easily quantifiable source, such as a vent or stack. The primary mechanism for coal dust lift-off from coal wagons is the movement of air over uncovered laden wagons; therefore, the surface area open to the wind plays a pivotal role in the amount of fugitive coal dust emitted.

Veneering is a best-practice management measure for coal trains, currently applied to coal wagons used on the Bowen Basin coal rail lines and on the West Moreton System rail corridor. It is expected that all coal trains operating on Inland Rail will use veneering to control coal dust emissions; however, this AQIA has also undertaken modelling of emissions from coal trains without the inclusion of veneering, to investigate the potential for air quality impacts without this mitigation measure.

A detailed study into the surface wind speed across loaded wagons and their associated dust emissions has been carried out in *Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains* (Connell Hatch, 2008). The study also presents an equation to calculate the mass emission rate of coal dust from a moving laden wagon at a particular site, using the average wind speed at each modelling location, together with the train speed data for that site:

$$m = k_1 * v^2 + k_2 * v + k_3$$

Where:

- m is the mass emission rate of coal dust (as TSP) from the wagon surface in g/km/tonne of coal transported
- k_1 is a constant with a value of 0.0000378
- k_2 is a constant with a value of -0.000126
- k_3 is a constant with a value of 0.000063
- v is the air velocity over the surface of the train in km/h.

This veneer acts as a binding agent to reduce the amount of surface lift-off of particulates from the laden wagons. *Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains* (Connell Hatch, 2008) suggested that a reduction in surface lift-off of up to 85 per cent was achievable through its application. Trials completed by the BNSF Railway Company and Union Pacific Railroad Company investigated the effectiveness of coal dust suppressants in the Powder River Basin in the US. The trials looked at seven different chemical agents in suppressing coal dust emissions from 1,633 loaded trains. The trials found, '… coal dust reductions ranged from 75 per cent to 93 per cent depending on the topical treatment used in the test' (BNSF & Union Pacific railroad company (BNSF & UP), 2010); therefore, a conservative assumption of 75 per cent reduction in the coal dust emission rates has been taken into account in this study for the laden coal trains, with the inclusion of veneering as a mitigation measure.

DES (when formerly operating as the Department of Science, Information Technology and Innovation, DSITI) has previously undertaken air quality monitoring to investigate coal dust emissions from the Western Metropolitan Rail System, with reports published in 2013 (DSITI, 2013b) and 2016 (DSITI, 2016b). The Queensland Resources Council engaged the then DSITI to conduct a dust monitoring program, with a focus on coal dust, along the Western Metropolitan Rail System, on behalf of the users and operators of the network. The monitoring was undertaken in two phases; Phase 1 (from March to June 2013) (reported in 2013) and Phase 2 (from February 2014 and ongoing) (reported in 2016). The purpose of the monitoring was to assess background particulate levels along the rail corridor and to assess the effectiveness of the fully implemented South West Supply Chain Coal Dust Management Plan, which includes veneering.

The 2016 DSITI report concludes that the implementation of the South West Supply Chain Coal Dust Management Plan had been 'highly effective in reducing the loss of coal dust from loaded rail wagons during transport'; however, the DSITI reports do not nominate an emission reduction rate (reduction percentage) for veneering to coal wagons which can be used in dispersion modelling and therefore the findings for emission reduction from the Connell Hatch (2008) evaluation have been used for dispersion modelling.

The 2013 and 2016 DSITI reports note that emissions from coal haulage trains represent a minor contribution to overall ambient particulate concentrations, with regional particulate emission sources determined to have greater impact on the ambient particulate levels measured. Due to the minor contribution attributed to coal train emissions, the adopted coal train emission rates used in this assessment have not been validated against the DSITI monitoring data from the Western Metropolitan Rail System.

Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains (Connell Hatch, 2008) also detailed that following unloading of the coal at the port or terminals, a small amount of residual coal typically remained in the wagon (approximately 0.13 tonnes (t) per wagon), which was transported back to the mine/s. In addition, parasitic loads were found to be located on the wagon sills, shear plates and bogies, which resulted in further fugitive emissions.

Although wagon washing is undertaken at some coal handling facilities (such as at the Jondaryan Load Out Facility), wagon washing is not undertaken at the Port of Brisbane and, therefore, it is expected that residual coal will remain in the wagons following unloading at the port. Therefore, an additional 0.13 tonnes (t) of coal per wagon was added to the proposed coal train payload of 85.9 t per wagon when developing the modelled particulate emission rates to account for residual coal in the wagons on return trips.

Coal dust emission rates for the rail were calculated using the following input parameters:

- A travel speed of 80 kilometres per hour (km/hr) for a laden coal train travelling along the Project alignment (maximum coal train speed). The travel speed was used as the wind speed when calculating the mass emission rate of coal dust
- Application of veneer to coal wagons is expected to reduce emissions from between 75-85 per cent. It has been conservatively assumed that fugitive coal dust emissions will be reduced by 75 per cent based on field trials (Connell Hatch, 2008)
- An average coal payload per train of 5,592 t (inclusive of 0.13 t residual coal per wagon)
- A conversion factor of 0.5 from TSP to PM_{10} (US EPA, 1998)
- A conversion factor of 0.15 from PM_{10} to $PM_{2.5}$ (US EPA, 1998) based on the particle size distributions for mechanically generated emissions from aggregate and unprocessed ores published in the US EPA AP42 Compilation of Air Pollutant Emission Factors (US EPA, 1998). Particle size distribution data is not provided for coal but size distributions for aggregate and unprocessed ores (15 per cent for $PM_{2.5}$) is considered acceptable in lieu of specific data for coal.

Modelling of coal dust emissions assumes that all coal trains travel at speed (80 km/hr) along the Project alignment and do not slow down to access the crossing loops. Fugitive emissions of coal dust from trains at the crossing loops has not been modelled specifically; however, at lower wind speeds across the coal wagons, emissions are estimated to be considerably lower than the modelled travel speed of 80 km/hr. For example, fugitive emissions from a stationary coal train with an average 10 km/hr cross wind, the fugitive coal dust emissions represent 1.1 per cent of emissions from a coal train travelling at 80 km/hr; coupled with the assumption that the coal trains travel at 80 km/hr for the entire Project alignment results in a conservative estimate of coal dust emissions, which is expected to adequately represent fugitive coal dust emissions from the crossing loops proposed in the Project.

The calculated fugitive coal dust emission rates are presented in Table 12.20.

TABLE 12.20: DERIVED COAL DUST EMISSION RATES

Pollutant[a]	Uncontrolled coal dust emissions (g/m/s) per train	Controlled coal dust emissions (g/m/s) per train	Total Project alignment-controlled coal dust emissions (g/m/s)
TSP	2.14×10^{-6}	5.36×10^{-7}	4.99×10^{-05}
PM_{10}	1.07×10^{-6}	2.68×10^{-7}	2.49×10^{-05}
$PM_{2.5}$	1.61×10^{-7}	4.02×10^{-8}	3.74×10^{-06}

Table note:

a. PM_{10} has been assumed to represent 50 per cent of TSP emissions, with $PM_{2.5}$ assumed to represent 15 per cent of PM_{10} emissions.

Fugitive dust from freight and livestock trains

Grain and cotton freight are containerised and the freight of enclosed containers is considered to have minimal potential for fugitive dust emissions.

There is potential for emissions from livestock freight trains due to earth and soil being transported into the wagons by cattle; however, it is expected that this material would be removed from the wagons early during train travel and would not be transported along the Project alignment. The forecast volume of livestock trains (six trains per week for peak volumes in 2040, refer Table 12.12) is also low and overall fugitive dust emissions from livestock trains are not considered a significant source requiring modelling.

Fugitive dust emissions from freight and livestock trains would therefore be minimal and have been excluded from further assessment and modelling.

Toowoomba Range Tunnel portal emissions

The ventilation system for the Toowoomba Range Tunnel has been designed such that locomotive emissions that occur within the tunnel are exhausted via the tunnel portals rather than via the intermediate ventilation shaft. The intermediate ventilation shaft and aboveground purging systems and equipment will be used to deliver fresh air from the surface to the tunnel below at the intermediate ventilation shaft, with this intake air purging air within the tunnel (which has been polluted by locomotives) outward from the tunnel in each direction to the portals.

There are three doors proposed for the tunnel (east portal door, west portal door and intermediate door) that may open and close at differing points during a locomotives' transit through the tunnel. For trains travelling uphill (westbound), the portal doors at the western portal will be closed prior to entry. This allows the train and tunnels to be ventilated by airflow induced by the piston action of moving trains into the tunnel. Once the train travels past the intermediate ventilation shaft, the western portal door opens and the intermediate door closes. Fresh air then flushes the tunnel airspace from the intermediate ventilation shaft outwards to each of the portal doors. Effectively, this splits the uphill locomotive emissions between the two tunnel portals. It has been assumed for the assessment, that the tunnel is purged after each train travelling the tunnel and that no air pollutants accumulate within the tunnel airspace.

Emissions from the Toowoomba Range Tunnel portals were calculated using specific parameters relevant to the tunnel and are summarised as follows:

- Total tunnel length of 6,350 m (including ventilation buildings at each portal)
- Intermediate ventilation shaft located 2,700 m from the western tunnel portal
- Portal door of 60 m^2 at each end

- Emissions from trains in the tunnel have been calculated following the emissions inventory methodology described for locomotives and fugitive coal dust. Emissions have been calculated for travel in each direction, considering the travel speed and duration uphill (westbound) and downhill (eastbound)
- Fugitive coal dust emissions have been calculated for coal trains travelling only in the eastbound direction, as coal trains will not be laden with coal when they are travelling westbound.

A key aspect of pollutant dispersion from tunnels is the portal area, as this influences the volume of air leaving the tunnel. As there are portal doors at each end of the Toowoomba Range Tunnel, the area with the tunnel doors open (60 square metres (m^2)) has been used in the assessment.

Table 12.21 presents the average train speeds for each group of expected locomotive type, which is a result of the locomotive number and type per train, weight of trailing wagons, and gradient of the tunnel rail track. A weighted average was calculated based on the percentage of rail traffic expected to travel through the tunnel. Also, the average speeds are broken into 'stopping' and 'non-stopping' speeds, based on operational modelling of rail traffic travelling directly through the tunnel without stopping and for stopping at the crossing loops at each end of the tunnel.

TABLE 12.21: TOOWOOMBA RANGE TUNNEL AVERAGE LOCOMOTIVE SPEEDS (KM/HR)

	Non-stopping		Stopping	
Train type	**Eastbound**	**Westbound**	**Eastbound**	**Westbound**
Superfreighter	55.0	25.5	50.7	25.0
Express	55.0	32.7	51.2	32.3
Coal	53.7	45.0	52.1	44.2
Agriculture-Steel-Containers	55.0	50.2	53.9	48.5
Weighted average	**54.4**	**41.9**	**52.3**	**40.9**

Table note:
The weighted average speed has been calculated by multiplying the speed for each train by the ratio of that train type over the total number of trains travelling in that direction. For example, for non-stopping eastbound travel there are a total of 402 trains, comprised of: 80 Superfreighter trains (ratio of 0.19); 28 Express trains (ratio of 0.07); 196 Coal trains (ratio of 0.47); and 114 Agriculture trains (ratio of 0.27). The formula is, therefore, 55.0 km/hr x 0.20 + 55.0 km/hr x 0.07 + 53.7 km/hr x 0.47 + 55.0 km/hr x 0.27 = 54.4 km/hr.

The power required per train for the modelling of tunnel travel in each direction for each train type is presented in Table 12.34. The power required has been calculated using maximum rated locomotive power (as specified by ARTC) for each train travelling in the westbound direction (uphill) and 10 per cent of the maximum power is required for each train travelling in the eastbound direction (downhill). This 10 per cent power rating estimate was used to represent the downhill idling and dynamic braking emissions of the trains for the design of tunnel ventilation systems and the AQIA.

TABLE 12.22: TOOWOOMBA RANGE TUNNEL POWER (KW) PER TRAIN

Train type	Eastbound	Westbound
Superfreighter	670	6,700
Express	875	8,751
Coal	492	4,920
Agriculture-Steel-Containers	728	7,275

Table 12.23 summarises the tunnel portal emissions used in the dispersion modelling, which include the cumulative sources of locomotive diesel combustion emissions and fugitive dust emissions from coal train wagons.

As the train power required has been assumed to be constant based on direction of travel (refer Table 12.22), tunnel portal emissions have been calculated using the 'stopping' speeds presented in Table 12.20. The 'stopping' speeds are lower than the 'non-stopping' speeds and, therefore, adopting the lower travel speeds results in a longer travel duration and higher total emissions within the tunnel.

The intermediate ventilation shaft of the tunnel is located approximately 2,700 m from the western tunnel portal, and 3,650 m from the eastern tunnel portal. Emissions from the tunnel portals have been calculated assuming that emissions from train travel between the western tunnel portal and the intermediate ventilation shaft will be emitted via the western tunnel portal, and emissions from train travel between the intermediate ventilation shaft and the eastern tunnel portal will be emitted via the eastern tunnel portal. Locomotive emissions that occur within the tunnel will not be emitted from the intermediate ventilation shaft.

Emissions from the tunnel portals have been modelled as occurring continuously based on the weekly train volumes for the peak, and typical volume scenarios assessed.

TABLE 12.23: DERIVED TOOWOOMBA RANGE TUNNEL PORTAL EMISSIONS

Pollutant	Western tunnel portal emission rate (g/s)	Eastern tunnel portal emission rate (g/s)
NO_x	1.17	1.58
TSP	0.10	0.14
PM_{10}	0.08	0.11
$PM_{2.5}$	0.06	0.09
Total VOCs	0.16	0.22

Table note:
Tunnel portal emissions have been calculated using the 'stopping"' speeds presented in Table 12.20. The stopping speeds are lower than the 'non-stopping' speeds and, as the train power required has been assumed to be constant based on direction of travel (refer Table 12.22), adopting the lower travel speeds results in a longer travel duration and higher emission rates.

Adjoining Inland Rail projects

To assess the cumulative impact of the Inland Rail Program, the adjoining sections of the Inland Rail Program adjacent to the Project, namely the B2G and H2C sections, have been included in the dispersion modelling undertaken for the assessment of operational-phase impacts.

A 1-km section of the H2C project has been modelled at the eastern end of the Project alignment, with 1 km of the B2G project section modelled at the western end. The emission rates used for the modelling of these sections were calculated based on the rail traffic forecast for these projects for 2040. For H2C, the volume of trains for a 1-km section of rail line, modelled, is the same as for the Project. For B2G, traffic volumes are lower due to the loss of trains that travel along the QR West Moreton System rail corridor.

Existing QR network rail traffic

West Moreton System

Due to the travel efficiency presented by the Project alignment, all future train traffic travelling between Gowrie and Helidon will use the Project alignment, rather than the existing West Moreton System Western Line and Main Line. This assumption has been incorporated into the modelling for the AQIA.

The assessment has considered potential impact of emissions from trains travelling along the Western Line prior to joining or leaving the Project alignment. The AQIA has modelled emissions from train traffic on the 1 km section of the Western Line closest to the connection to the Project alignment.

The Project alignment also includes a turnout to join to the Western Line, connecting into Toowoomba. This spur will allow the Westlander passenger trains to travel into and out of Toowoomba using the Project alignment to travel through the Toowoomba Range.

West Moreton System Gowrie to Toowoomba

The operation of the Inland Rail Program will increase Westlander train travel on the section of the Western Line between the Project (from the turnout) and Toowoomba from four trains per week to eight trains per week.

Four additional train movements per week is not significant, however, and emissions from eight trains per week do not present a risk for exceedance of the adopted air quality goals. On this basis, emissions from Westlander trains between the Project alignment and Toowoomba have not been assessed. No other train services have been considered along this section of the Western Line or the spur line.

Toowoomba Bypass

The Toowoomba Bypass is a 41 km stretch of highway travelling from Helidon Spa at its eastern end to Athol at its western end. The Toowoomba Bypass consists of the Warrego Highway (A2) from the Warrego east interchange (Helidon Spa) to the Warrego west interchange (Charlton), and the Gore Highway (A39) from the Warrego west interchange (Charlton) to the Gore Highway interchange (Athol). The Toowoomba Bypass was officially opened to traffic in September 2019.

The span of the Toowoomba Bypass east to west is longer than the Project and the Toowoomba Bypass intersects the Project at a number of locations, most notably for AQIA purposes, near the western tunnel portal of the Toowoomba Range Tunnel. The Project also runs parallel and in close proximity to the Toowoomba Bypass for approximately 15 km in the Lockyer Valley.

Pollutant species emitted from road traffic on the Toowoomba Bypass include NO_x, PM_{10} and $PM_{2.5}$, which are pollutants of concern for the Project. The purpose of the bypass is to provide an alternative route for heavy vehicle transport trucks, and therefore the bypass is anticipated to support a higher than typical proportion of heavy vehicles that generate more emissions than a standard light passenger vehicle.

Due to the location of the Toowoomba Bypass in relation to the Project, emissions from road traffic using the bypass have been modelled in the assessment to allow for cumulative assessment of impacts during the operational phase.

The methodology adopted for modelling emissions from the Toowoomba Bypass is outlined in detail in Appendix K: Air Quality Technical Report. The methodology adopted is considered to be conservative and is likely to over-estimate emissions from traffic on this road.

The length of the Toowoomba Bypass that has been modelled is the section between O'Mara Road (Gore Highway overpass) at the western end to Helidon Spa (where the bypass reconnects with the existing Warrego Highway) at the eastern end.

12.6.3.3 Dispersion modelling

The air dispersion modelling conducted for this assessment was based on a modelling approach using TAPM as a meteorological pre-processor to the air dispersion models CALPUFF and GRAL. The CALPUFF model was used primarily for the modelling assessment; however, for assessment of pollutant impacts from the Toowoomba Range Tunnel, portal sources the GRAL model were used.

The data that was available for this Project, and a discussion of the data processing methodologies that were required in order to implement both CALPUFF and GRAL, are discussed in the following sections. The models are briefly described in the following sections, with further details provided in Appendix K: Air Quality Technical Report. The modelling was undertaken in accordance with relevant guidance documents and appropriate literature (NSW EPA, 2016; Barclay & Scire, 2011).

Selection of meteorological year

For Australia, the ENSO has the strongest effect on year-to-year climate variability in Australia, mostly affecting rainfall and temperature. El Niño incidences represent periods of unusually warm Pacific Ocean conditions along the western coast of South America, which frequently presents as high rainfall events in South America and drought conditions for Australia. Conversely, La Niña periods represent cooler ocean surface temperatures along the western coast of South America and increase the likelihood of drought conditions locally, and high rainfall periods in Australia.

The Southern Oscillation Index, Oceanic Niño Index, and Multivariate ENSO Index are measures that can indicate episodes of El Niño and La Niña. Due to differences in methodology, each of these aforementioned indices can have slightly differing results; however, using the Southern Oscillation Index, Oceanic Niño Index, and Multivariate ENSO Index measures for ENSO, agreeance can be seen on which years represent periods of El Niño or La Niña. The three indices show that the year 2013 was relatively neutral in terms of ENSO. The year 2013 represents an ideal candidate for selection of a meteorological period that is relatively unaffected by variances in weather due to ENSO and, therefore, data from this year has been used for the assessment.

Further discussion regarding the selection of the meteorological year is provided in Appendix K: Air Quality Technical Report.

Consideration of the influence of climate change on meteorological modelling data

The meteorological modelling undertaken for the air quality study area has been undertaken using prognostic meteorological data generated by TAPM and observational data from BoM stations for the year 2013. The purpose of meteorological modelling is to develop meteorological input for dispersion modelling, which is representative of typical meteorological conditions for the study area based on long-term historical meteorological data.

Changing climatic conditions due to climate change has the potential to influence wind conditions, atmospheric stability, mixing height and other meteorological factors important to the dispersion of ground-released pollution; however, as described in NSW EPA *Approved methods for the modelling and assessment of air pollutants in New South Wales* (NSW EPA, 2016) (a guidance document referred to for air quality modelling in the EP Act Air Guideline and applicable for assessments in Queensland), site-representative meteorological data is to be used and meteorological modelling outputs validated against long-term historical meteorological data. Therefore, the potential influence of changing climatic conditions in the future due to climate change has not been considered further in this assessment.

TAPM and meteorological data

The meteorological data used in the dispersion model are of fundamental importance, as these data drive the predictions of the transport and dispersion of the air pollutants in the atmosphere. The most critical parameters are:

- Wind direction, which determines the initial direction of transport of pollutants from their sources
- Wind speed, which dilutes the plume in the direction of transport and determines the travel time from source to receiver
- Atmospheric turbulence, which indicates the dispersive ability of the atmosphere.

Meteorological data from three BoM stations relevant to the Project, in addition to prognostic meteorological data generated by TAPM, has been used in the assessment. Pseudo upper air (UA) stations were generated from TAPM model runs for the AQIA study area. The use of pseudo UA stations allows the CALMET modelling to be driven primarily by surface observations, while providing the required upper air meteorology data.

A total of four pseudo UA stations were generated from TAPM, with individual runs undertaken for each station. The model setup for TAPM for each of the runs undertaken is presented in Table 12.24. The pseudo UA stations were located in areas of mostly flat terrain and uniform land use types.

TABLE 12.24: TAPM INPUT PARAMETERS

Parameter	Input
TAPM Version	4.0.4
Number of grids (spacing)	5 (30 km, 10 km, 3 km, 1 km, 0.3 km)
Number of grid points	41
Number of vertical levels	25
Terrain height database	9 second DEM
Year of analysis	January to December 2013
Grid centre point	See Table 12.25 for UA1, UA2, UA3 and UA4.

Meteorological data was sourced from the UQ Gatton, Oakey Aero and Toowoomba Airport BoM stations. A summary of the meteorological stations considered, including the prognostic stations, is presented in Table 12.25.

TABLE 12.25: METEOROLOGICAL STATIONS INCLUDED IN MODELLING

Station	Coordinates (GDA zone 56)	Variables	Source
UQ Gatton	434,567 m E; 6,953,179 m S	Wind direction; wind speed; temperature; rainfall; pressure; relative humidity	BoM
Toowoomba Airport	393,126 m E; 6,952,754 m S	Wind direction; wind speed; temperature; rainfall; pressure; relative humidity	
Oakey Aero	375,561 m E; 6,968,254 m S	Wind direction; wind speed; temperature; rainfall; pressure; relative humidity	

Station	Coordinates (GDA zone 56)	Variables	Source
UA1	379,852 m E; 6,952,368 m S	Upper air	TAPM
UA2	390,894 m E; 6,963,208 m S	Upper air	
UA3	394,946 m E; 6,949,227 m S	Upper air	
UA4	410,294 m E; 6,955,458 m S	Upper air	

Table note:
The coordinates presented are in the coordinate system required by TAPM.

CALPUFF

The CALPUFF suite of programs, including meteorological (CALMET), dispersion (CALPUFF) and post-processing modules (CALPOST), is an advanced non-steady state modelling system designed for meteorological and air quality modelling. DES does not require the use of any particular dispersion model (e.g. CALPUFF or AERMOD models); however, within the DES guideline, *Application requirements for activities with impacts to air* (DES, 2017a) reference is made to the NSW EPA guidance document, *Approved methods and guidance for the modelling and assessment of air pollutants in New South Wales* (NSW EPA, 2016), which recommends CALPUFF. CALPUFF is appropriate in applications involving complex terrain, non-steady-state conditions, in areas where coastal effects may occur and/or when there are high frequencies of stable or calm meteorological conditions (Barclay & Scire, 2011). As many of these features are present in the AQIA study area, the CALPUFF model is preferred over the more commonly used Gaussian models of AERMOD or AUSPLUME, which perform poorly in the aforementioned conditions.

GRAL

In order to investigate the air quality impacts from the railway tunnel portal emissions, the GRAL dispersion model has been used. GRAL is a Lagrangian Particle model developed at the Institute for Internal Combustion Engines and Thermodynamics, Technical University Graz, Austria, specifically to assess the dispersion of pollutants from roadways and tunnel portals (Oettl et al., 2002; Oettl et al., 2003; Oettl et al., 2005). GRAL has been extensively evaluated against experimental data from five different road tunnel portals, both in flat and complex terrain, with high and low traffic volumes—namely the Enrei, Hitachi and Ninomiya tunnels in Japan (Oettl et al., 2003), and the Kaisermuehlen (Oettl et al., 2005) and Enrentalerberg tunnels in Austria (Oettl et al., 2002). The GRAL model was specifically used to assess emissions from the Toowoomba Range Tunnel portals.

The results from the GRAL modelling have been combined with the results from the CALPUFF modelling to determine the total concentrations at modelled receptors.

Crossing loops

Locomotive diesel emissions from crossing loops have been modelled based on the following:

- Locomotives have been modelled at each end of each crossing loop as three-point sources, resulting in six emission source points per loop. This modelling is conservative as it assumes locomotives are idling at each end of the crossing loop simultaneously.
- Emissions have been modelled from locomotives idling on the crossing loops only. Travel around the crossing loops has not been modelled, as emissions during this short length of travel are not considered significant due to the brief transit time, and as this travel is considered to be modelled by the travel of trains along the Project alignment, which is adjacent to the loops. Overall, the assessment of the loops is considered conservative due to the assumption of idling locomotives at each end.
- Two different approaches (hereafter referred to as versions) have been assessed for crossing loops to accurately consider emissions and allow for assessment against both short- and long-term averaging periods:
  - Short term (assessment against 1-hour, 24-hour and monthly dust deposition air quality goals): continuous idling of NR Class locomotives every hour throughout the year
  - Long term (assessment against annual average air quality goals): idling assumed to occur 25 per cent of the travel time, e.g. 15 minutes per hour or 6 hours per day.

- For both the short- and long-term versions, emissions from the six-point sources have been modelled conservatively, assuming the locomotives to be NR Class locomotives, which have the highest emission rates of all the locomotives considered (refer Table 12.13).
- The locomotive point sources have been located on the top and in the centre of 'buildings' included in the model to account for the influence of downwash caused by the structure of the locomotives.

Fugitive emissions of coal dust from trains stopped at the crossing loops have not been modelled specifically, as emissions from the wagons at the crossing loops will be much lower than emissions from the wagons during train travel, due to the reduced wind speed over the wagon while stationary. Using the emission formulas presented in Section 12.6.3.2, and assuming a loaded coal train was stationary on a crossing loop for one hour with an average wind speed of 10 km/h, it is estimated that TSP emissions from the stationary train would be equivalent to approximately 5 per cent of the TSP emissions generated from a train travelling along the length of the Project adjacent the crossing loop (2.2 km). This not considered to be significant considering the conservative assumptions included in the assessment.

Fugitive odour from agricultural freight trains stopped at the crossing loops has been assessed qualitatively. The methodology for the qualitative assessment of fugitive odour is described in Section 12.6.3.6.

Modelling scenarios

Two train volume scenarios (peak and typical train volumes) have been included in the assessment, as discussed in Section 12.6.3.2. In addition to the two train volume scenarios, two different versions of each scenario (short term and long term) have been run to enable accurate assessment of emissions from the crossing loops against both short-term and long-term air quality goals. The modelled scenarios and crossing loop versions assessed are summarised in Table 12.26.

The model predictions from the short-term version have been used to assess compliance against the short-term air quality goals (1 hour, 24 hour, etc.), with the model predictions from the long-term version used to assess compliance against annual average air quality goals.

Modelling of emissions from train travel along the Project is consistent for all scenarios and crossing loop versions; the only exception being differing emission rates due to the change in train volumes between the peak and typical scenarios.

TABLE 12.26: DISPERSION MODELLING SCENARIOS

Scenario	Crossing loop version	Crossing loop idling description	Air quality goal averaging periods assessed
Peak train volumes 2040	Short term	Continuous idling emissions from crossing loops	30-minute, 1-hour, 24-hour and monthly dust deposition
	Long term	Idling at loops assumed to occur 25 per cent of the travel time	Annual
Typical train volumes 2040	Short term	Continuous idling emissions from crossing loops	30-minute, 1-hour, 24-hour and monthly dust deposition
	Long term	Idling at loops assumed to occur 25 per cent of the travel time	Annual

A summary of the data and parameters used as input parameters for the dispersion modelling is provided in Appendix K: Air Quality Technical Report.

Limitations

The atmosphere is a complex, physical system and the movement of air in a given location is dependent on multiple variables, including temperature, topography and land use, as well as larger-scale synoptic processes. Dispersion modelling is a method of simulating the movement of air pollutants in the atmosphere using mathematical equations. The model equations necessarily involve some level of simplification of these very complex processes based on our understanding of the processes involved and their interactions, available input data, and processing time and data storage limitations.

These simplifications come at the expense of accuracy, which particularly affects model predictions during certain meteorological conditions and source emission types, e.g. the prediction of pollutant dispersion under low wind-speed conditions (typically defined as those wind speeds less than 1 metre per second (m/s)) or for low-level, non-buoyant sources, is problematic for most dispersion models. To accommodate these known deficiencies, the model outputs tend to provide conservative estimates of pollutant concentrations at particular locations.

While the models contain a large number of variables that can be modified to increase the accuracy of the predictions under any given circumstances, the constraints of model use in a commercial setting, as well as the lack of data against which to compare the results in most instances, typically precludes extensive testing of the impacts of modification of these variables. With this in mind, model developers typically specify a range of default values for model variables that are applicable under most modelling circumstances. These default values are recommended for use unless there is sufficient evidence to support their modification.

As a result, the results of dispersion modelling provide an indication of the likely level of pollutants within the modelling domain. While the models, when used appropriately and with high-quality input data, can provide very good indications of the scale of pollutant concentrations and the likely locations of the maximum concentrations occurring, their outputs should not be considered to be representative of exact pollutant concentrations at any given location or point in time. As stated above, however, the model predictions are typically conservative, and tend to over predict maximum pollutant concentrations at receptor locations.

This assessment was undertaken with the data available at the time of the assessment. Should changes to the Project be made, further assessment may be required to determine if the findings of this assessment are still applicable.

12.6.3.4 Conversion of NO_x to NO_2

NO_x is produced in most combustion processes and is formed during the oxidation of nitrogen in fuel and nitrogen in the air. During high-temperature processes, a variety of oxides are formed, including NO and NO_2. NO will generally comprise 95 per cent of the volume of NO_X at the point of emission. The remaining NO_X will primarily consist of NO_2. The conversion of NO to NO_2 requires O_3 to be present in the air, as O_3 is the catalyst for the conversion. Ultimately, all NO emitted into the atmosphere is oxidised to NO_2 and then further to other higher NO_x.

The US EPA's Ozone Limiting Method (OLM) was used to predict ground-level concentrations of NO_2. The OLM is based on the assumption that approximately 10 per cent of the initial NO_X emissions are emitted as NO_2. If the O_3 concentration is greater than 90 per cent of the predicted NOx concentrations, all the NO_X is assumed to be converted to NO_2; otherwise, NO_2 concentrations are predicted using the equation:

$$NO_2 = 46/48 \times O_3 + 0.1 \times NO_x$$

This method assumes instant conversion of NO to NO_2 in the plume, which can lead to overestimation of concentrations close to the source, since conversion would usually occur over a period of hours. This method is described in detail in *Approved methods for the modelling and assessment of air pollutants in New South Wales* (NSW EPA, 2016). The OLM is a conservative approach, as explained in Appendix K: Air Quality Technical Report (Appendix D). Due to its proximity to the Project, background O_3 data from the Mutdapilly monitoring station were used to convert the modelled NO_2 concentrations in accordance with the OLM methodology presented in *Approved methods for the modelling and assessment of air pollutants in New South Wales* (NSW EPA, 2016).

12.6.3.5 Water tank quality

Potential impacts

In rural and remote Australia, where reticulated water supply is not always available, the use of domestic rainwater tanks is common practice. Rainfall is collected from roof run-off and, where installed, is most commonly used as the primary source of household drinking water (enHealth, 2010). Rainwater stored in tanks has the potential to be contaminated by chemical, physical and microbial sources, and become a hazard to human health. Industrial and traffic emissions have the potential to be a source of chemical contamination through their atmospheric deposition onto rooves where water is collected (Gunawardena, 2012).

Fugitive coal dust deposition

Fugitive coal dust emissions from rail transport along the Project rail corridor have potential to be deposited on surfaces that lead to rainwater tanks. Coal may contain many trace elements, some of which include the followings: sulfur (S), chlorine (Cl), arsenic (As), boron (B), cadmium (Cd), lead (Pb), mercury (Hg), molybdenum (Mo), selenium (Se), chromium (Cr), copper (Cu), fluorine (F), nickel (Ni), vanadium (V), and zinc (Zn). Several of these compounds can have toxic and chronic health effects, which is dependent on exposure length, concentration and path of ingestion. A leaching test study completed by Lucas et al. (2009) showed through experimentation that even though these compounds exist within coal and coal dust, they leach negligible amounts into receiving water, and measured concentrations were well below the 2011 ADWG (NHMRC, 2018). Therefore, it is expected that coal dust will not pose a significant risk to drinking water and has not been included in the assessment of water quality impacts.

Assessing impacts to water tank quality

The potential for the operation of the Project to impact tank water quality collected via roof catchments has been investigated. Using the emissions inventory developed for assessment of impacts to air quality, dust deposition modelling was also completed using CALPUFF to determine the impact of diesel combustion emissions on tank water quality. As per the assessment of impacts to air quality, and as required by the ToR, dust deposition was predicted for all receptors within the AQIA study area. The methodology for predicting the potential impact to water tank quality is summarised as follows:

- Rainwater collection systems can have first-flush devices that take the first water captured by rooves and divert it for disposal rather than collection in a water tank. First flush systems were not assumed to be installed for any of the receptors considered.
- Annual average dust deposition rates were predicted for every receptor in the AQIA study area for peak and typical train operations. Every receptor was assumed to have a water tank and the roof area (collection area) for each receptor was assumed to be 200 m^2.
- It was assumed that all deposited dust at each receptor (200 m^2 roof area) was collected by a 10,000 litre (L) rainwater tank that was 10 per cent full, resulting in a receiving water volume of 1,000 L. This conservative assumption allows for periods where there may be prolonged periods of drought and short rainfall events that wash deposited pollutants into rainwater tanks.
- The objectives used for the assessment of impacts to water quality were taken from the ADWG (NHMRC, 2018), which provides guideline water concentrations for arsenic, cadmium, lead, nickel and chromium VI, which are all metals.
- The concentration of metals in water tanks was determined by taking the predicted annual average dust deposition level (e.g. 2 milligrams per square metre, mg/m^2), multiplying it by the assumed roof area (200 m^2) to determine total mass (e.g. 400 mg), and then speciating the predicted dust deposition level into metal concentrations using the diesel locomotive emission factors (refer Section 12.6.3.2).
- The predicted water concentrations for each species were then assessed against the objectives prescribed by NHMRC (refer Section 12.4.4).

The methodology applied is described for water tanks; however, it is also applicable for assessment of impacts to water quality for dams assuming that the surface area (roof area) and receiving water volumes (1,000 L) are comparable.

It is highlighted that Withcott Seedlings at Withcott is located in the AQIA study area and the Project alignment travels between water storage dams at this land use. There is uncertainty with respect to the volume of the storage dams at Withcott Seedlings and the catchment surface area for each dam; however, the water volume and catchment area assumed (1,000 L and 200 m^2) and the deposition period (annual deposition) are all expected to be conservative estimates for water dams at Withcott Seedlings.

Detailed dispersion modelling is not typically undertaken for construction activity and has not been undertaken for the construction phase assessment for the Project. Construction dust has, therefore, not been considered for the assessment of tank water quality.

Similarly, fugitive emissions from fuel storage tanks required for the construction phase have not been considered for the assessment of tank water quality. Fugitive emissions from fuel storage tanks will be gaseous and will not be a significant issue with respect to deposition and tank water quality.

12.6.3.6 Agricultural freight odour

To assess the nuisance impacts that may arise from agricultural freight trains, a qualitative assessment using FIDOL factors has been undertaken to determine the likelihood of odour nuisance. The following factors, described using the acronym FIDOL, are widely accepted as being important dimensions of odour nuisance:

- Frequency (F)—How often an individual is exposed to the odour
- Intensity (I)—The strength of the odour
- Duration (D)—The length of exposure
- Offensiveness (O)—The offensiveness or intrinsic character, known as the hedonic tone of the odour, may be pleasant, neutral, or unpleasant
- Location (L)—The type of land use and nature of human activities in the vicinity of an odour source.

In addition to the above, sensitivity of the receiving community and 'offensiveness' of the odours likely to be emitted was considered in the qualitative odour analysis.

12.6.4 Cumulative impact assessment

As part of the EIS process for the Project, and as typically required for AQIAs, a cumulative impact assessment is required. AQIAs are inherently cumulative assessments as they are required to consider background air quality when assessing against air quality goals.

In addition to consideration of background air quality (refer Section 12.5.3), this assessment has also considered cumulative impacts to sensitive receptors in the operational phase of the Project by assessing emissions from the adjoining Inland Rail projects (B2G and H2C), train traffic on the QR West Moreton System and road traffic on the Toowoomba Bypass. No other projects were identified that required inclusion in the assessment of cumulative operational phase impacts. The results of the operational phase assessment are discussed in Section 12.7.3.

As cumulative impacts for the operation phase of the Project have been considered in detail in this assessment via dispersion modelling, further assessment of cumulative impacts is only required for the construction phase of the Project.

A qualitative cumulative impact assessment (CIA) has been undertaken for the construction phase of the Project. This CIA has considered B2G, H2C, Harlaxton Quarry and the Toowoomba Bypass in addition to other projects of relevance to the AQIA (refer Section 12.7.4).

The assessment has been undertaken using a risk matrix, following the same approach as provided in Chapter 22: Cumulative Impacts, but adapted to consider individual projects. Discussion of the assessment method and results is provided in Section 12.7.4, with a detailed assessment provided in Appendix K: Air Quality Technical Report.

12.7 Potential air quality impacts

The following sections summarise the potential air quality impacts that may arise as a result of construction and operation of the Project.

12.7.1 Construction

The highest proportion of construction emissions are generated by mechanical activity, e.g. material movement or mobile equipment activity, which typically generate coarser particulate emissions (PM_{10} and TSP). Airborne PM_{10} and deposited dust (TSP) are the main pollutants of concern for construction activities and these pollutant species are the focus of the assessment for construction dust. Airborne PM_{10} has the potential to impact human health due to inhalation of particulate matter, while deposited dust has the potential to cause nuisance impacts.

Particulate matter less than 2.5 micrometres in diameter ($PM_{2.5}$) is typically emitted in minor quantities from mechanical sources and is more predominant from combustion point sources (i.e. combustion engines). Point source emissions of combustion gases (e.g. oxides of nitrogen (NO_x) and carbon monoxide (CO)) and $PM_{2.5}$ from diesel construction vehicles and mobile plant will be significantly lower than particulate emissions from construction activities. Emissions of combustion gases and $PM_{2.5}$ are considered unlikely to result in exceedance of air quality goals or cause nuisance to sensitive receptors and, therefore, have not been assessed for the construction phase; however, mitigation measures for these sources have been identified to minimise the potential for impacts on sensitive receptors.

In addition to construction dust, odour and VOCs will be emitted as fugitive emissions from fuel tanks located at laydown areas. Impacts from fuel storage have been assessed in Section 12.7.1.2.

Assessment of crushing plant and blasting, which may be required to facilitate construction, is provided in Sections 12.7.1.3 and 12.7.1.4.

No other significant pollutant emissions (excluding dust, odour and VOCs) are anticipated from the construction phase of the Project.

The assessment of construction phase impacts considers construction traffic haul routes; however, the assessment does not include consideration of the use of private roads. The use of any private roads during construction would require a specific agreement between the construction contractor and the private road owner.

12.7.1.1 Construction dust

A qualitative impact assessment of the construction of the Project was completed using the UK IAQM methodology for the assessment of dust from demolition and construction (UK IAQM, 2014). The construction disturbance areas for the Project are shown in Figure 12.4.

The IAQM methodology determines the scale of activity for each construction source (demolition, earthworks, construction and trackout) based on the work required for the Project without mitigation. The method then determines the sensitivity of the AQIA study area to air quality impacts for both amenity (dust deposition, TSP) and human health (airborne concentrations of PM_{10}) based on the separation distance from the construction area (Project disturbance footprint) to receptors and the existing ambient air quality in the AQIA study area. A risk rating (using the IAQM risk matrix) is then determined for each construction source based on the defined scale of activity and receptor sensitivity to quantify the risk of human health and amenity impacts.

The IAQM methodology was developed for construction sites in urban areas but has been applied for the assessment of the Project as it is a recognised construction risk assessment method. The outcomes of the construction dust impact assessment are presented in this section.

Potential impacts from dust deposition on aquatic and terrestrial ecosystems is discussed in Chapter 11: Flora and Fauna and in Appendix I: Terrestrial and Aquatic Ecology.

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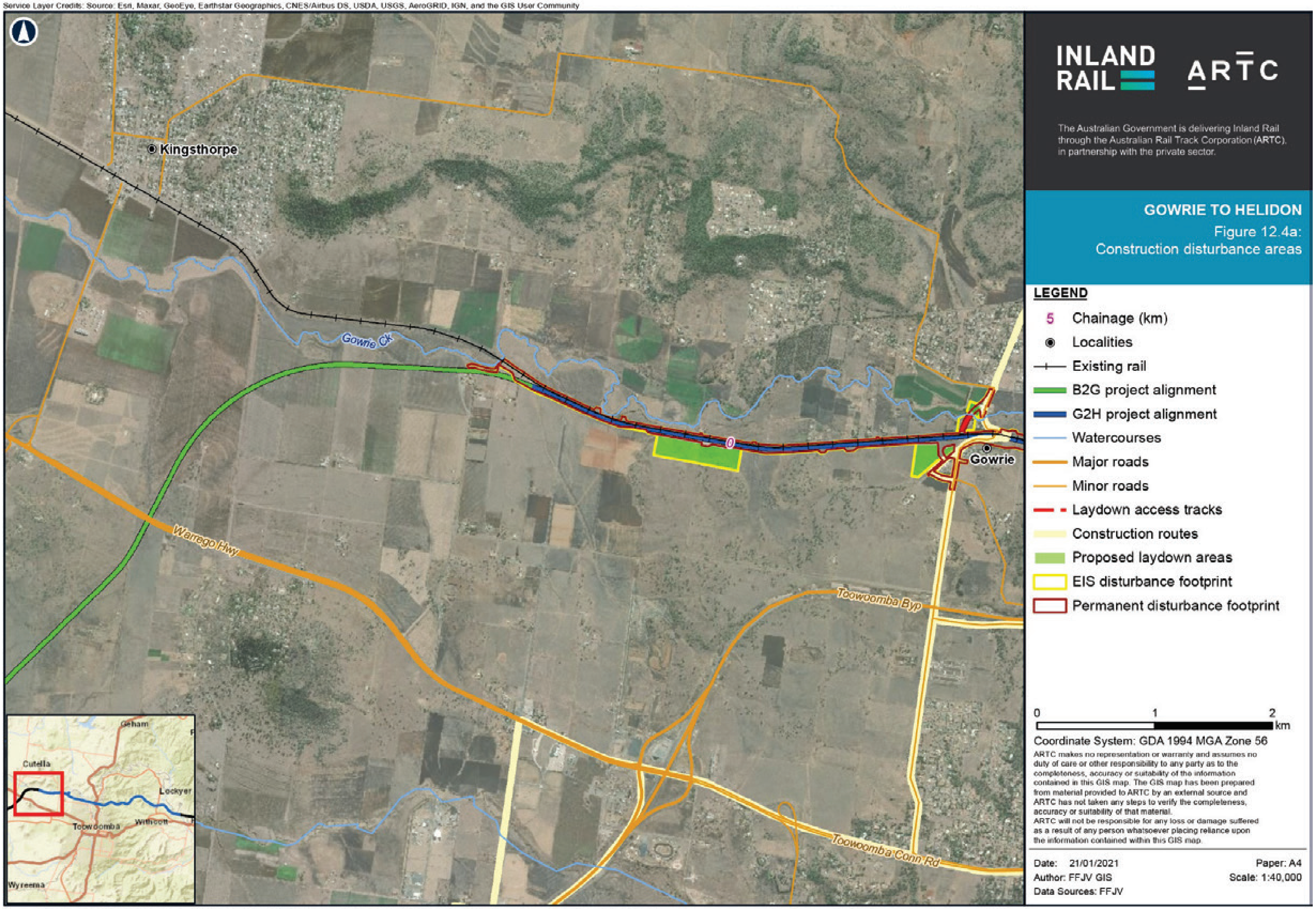

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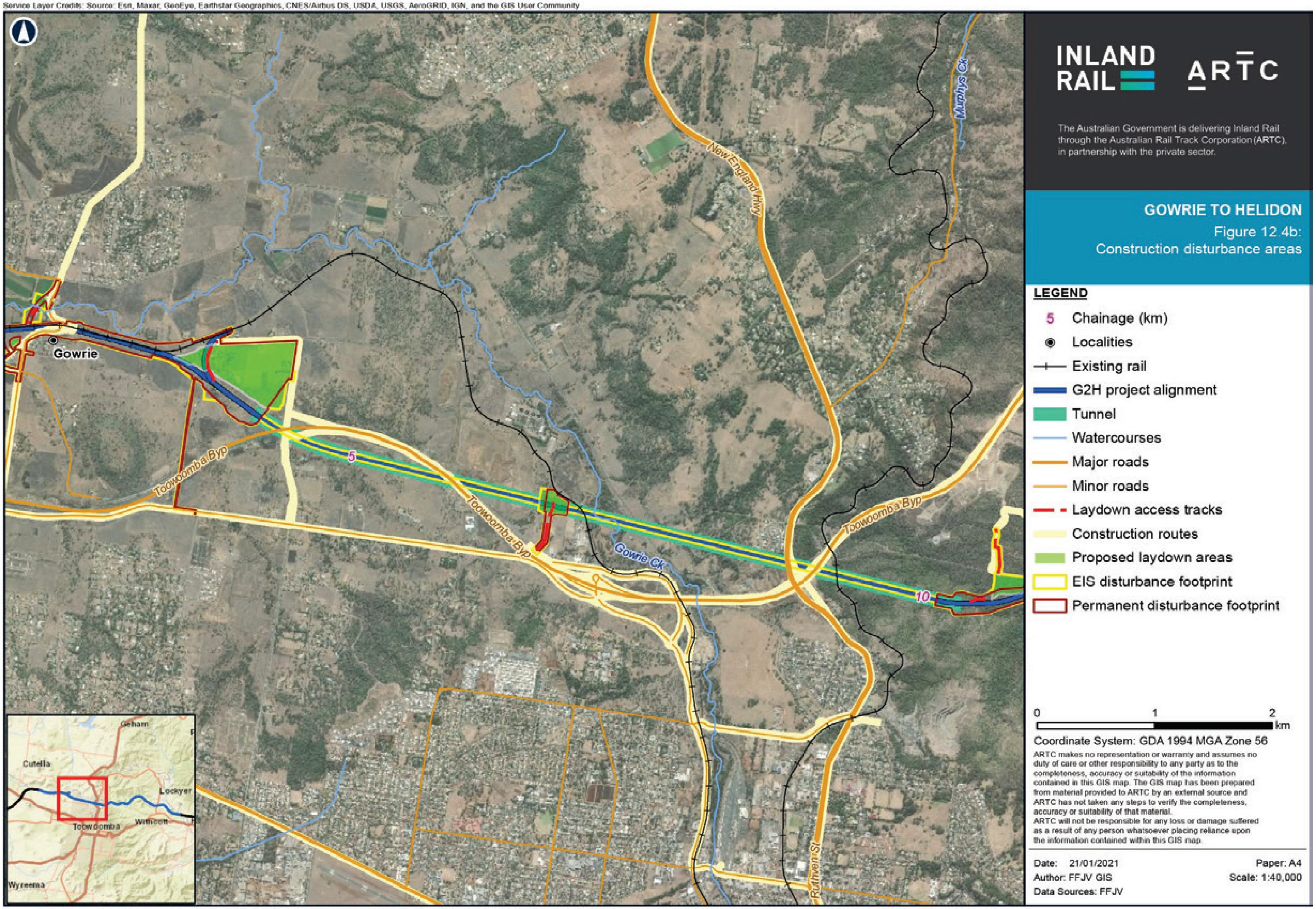

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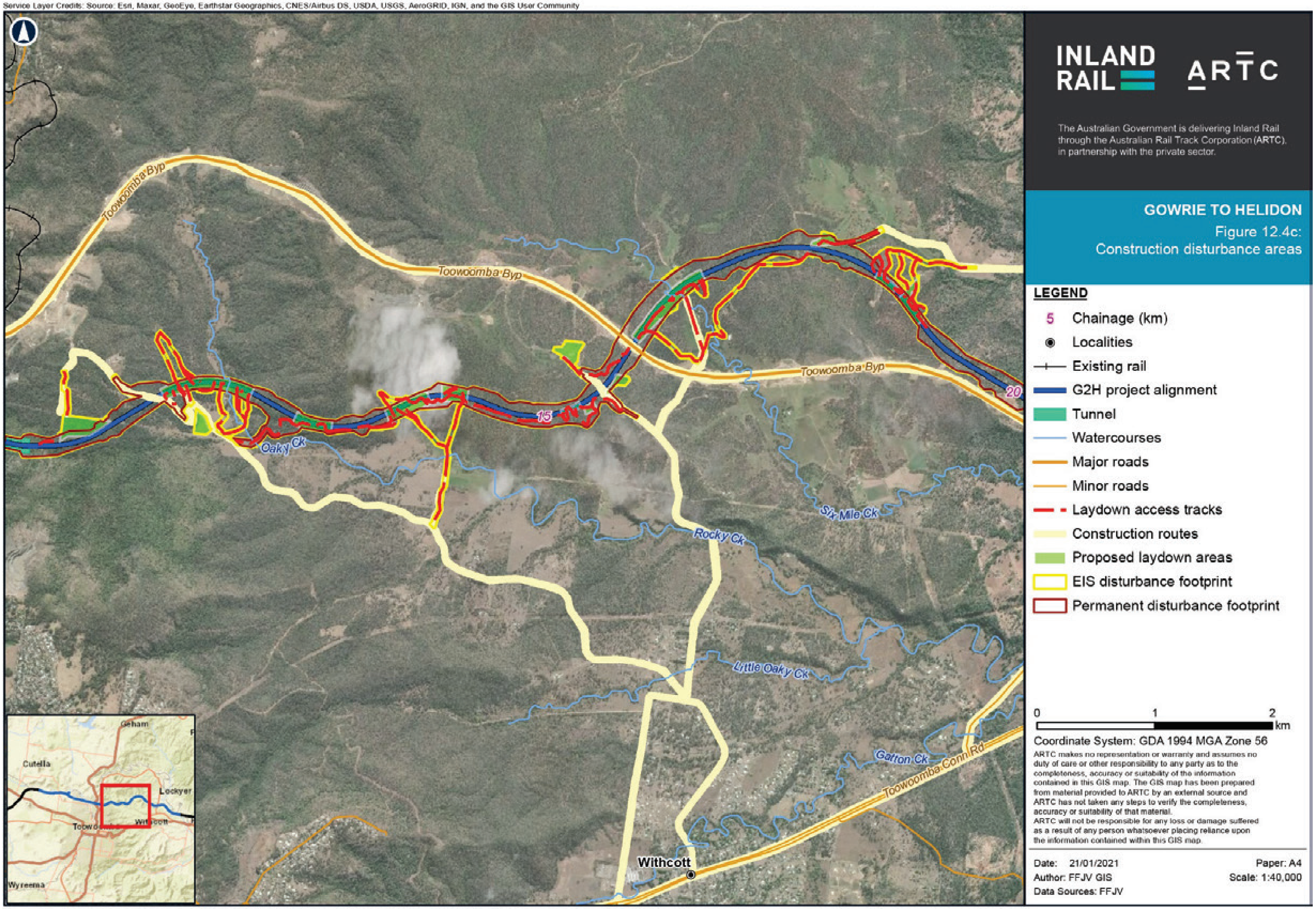

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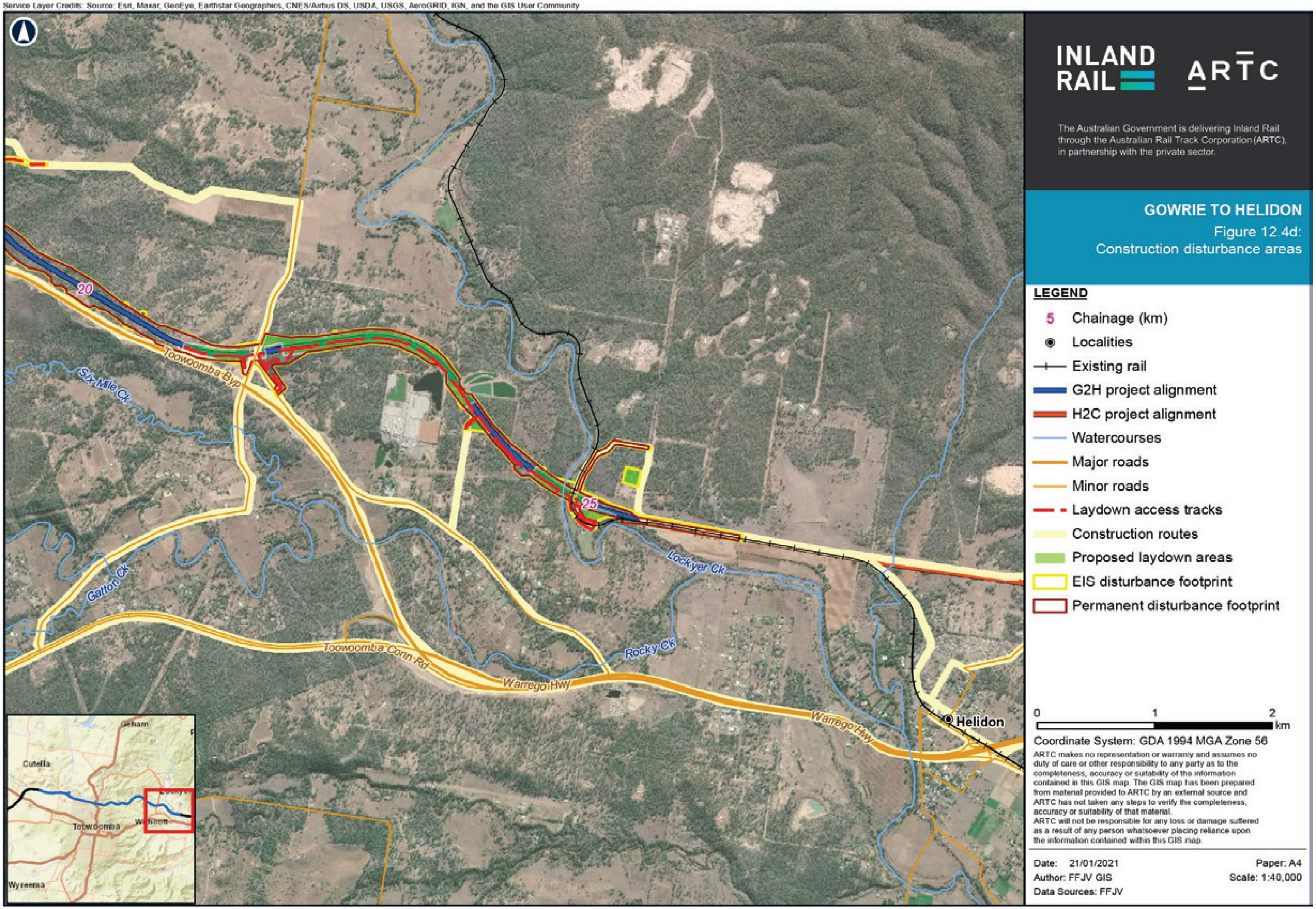

GOWRIE TO HELIDON

Figure 12.4d: Construction disturbance areas

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Step 1—Screening assessment

The IAQM method recommends further assessment of dust impacts for construction activities where sensitive receptors are located closer than:

- 350 m from the boundary of the Project activity
- 50 m from the route used by all construction vehicles (including heavy vehicles) on public roads more than 500 m from the site entrance.

The number of identified sensitive receptors within the AQIA study area is 2,829, with 2,828 of these receptors considered to be sensitive during the construction phase of the Project (receptor R_2323 represents a site office within a laydown area for the Project and has not been considered). Their respective distances from the Project disturbance footprint are shown in Table 12.27.

For the purposes of the assessment, only construction traffic routes within the AQIA study area have been considered. It is considered unlikely that impacts to sensitive receptors located near construction traffic routes outside of the AQIA study area will be significant and, therefore, construction traffic routes outside the AQIA study area have not been assessed.

The sensitivity of the AQIA study area to construction dust impacts is determined considering the number of sensitive receptors and the separation distance to active construction areas. For the purpose of the construction assessment, the separation distance categories (as presented in Table 12.27) have been determined across the entire length of the Project, as opposed to breaking construction areas into smaller segments. In reality, construction air quality impacts will be localised to specific construction areas (e.g. laydown areas) and areas with a higher density of sensitive receptors (e.g. townships) will be more sensitive than sparsely populated rural areas.

TABLE 12.27: SUMMARY OF SENSITIVE RECEPTOR DISTANCES TO THE PROJECT CONSTRUCTION AREAS

	Number of receptors			
Separation distance (m)	Access tracks	Laydown areas	Construction corridor	Overall distance[b]
0 [a]	0	4	7	7
<20	20	6	29	42
21 to 50	186	4	28	196
51 to 100	263	17	29	266
101 to 350	935	85	184	931
>350	1,425	2,716	2,560	1,393
Total[c]	**2,828**			

Table notes:

a. Sensitive receptors located within the Project disturbance footprint are assumed to be present during the construction phase for the assessment with the exception of receptor R_2323

b. Total number of sensitive receptors that are located within the distance category from the Project disturbance footprint

c. The total number of identified sensitive receptors within the AQIA study area is 2,829; however, only 2,828 of these receptors are considered to be sensitive during the construction phase of the Project as receptor R_2323 represents a site office within a laydown area for the Project.

Each sensitive receptor within the AQIA study area was identified using a combination of Queensland land property information and aerial imagery. The number of sensitive receptors in the AQIA study area may have minor variations as the Project progresses.

Step 2—Dust risk assessment

Step 2 in the IAQM is a risk assessment tool designed to appraise the potential for dust impacts due to unmitigated dust emissions from a construction project. The key components of the risk assessment are defining the dust emission magnitudes (Step 2A), the surrounding area sensitivity (Step 2B), and then combining these in a risk matrix (Step 2C) to determine an overall risk of dust impacts.

Step 2A—Dust emission magnitude

Dust emission magnitudes are estimated according to the scale of works being undertaken and other considerations, such as meteorology, types of material being used, or general demolition methodology. The IAQM guidance provides examples to aid classification, as presented in the following excerpt from IAQM:

The dust emission magnitude is based on the scale of the anticipated works and should be classified as Small, Medium, or Large. The following are examples of how the potential dust emission magnitude for different activities can be defined. Note that, in each case, not all the criteria need to be met, and that other criteria may be used if justified in the assessment:

…

Earthworks: Earthworks will primarily involve excavating material, haulage, tipping and stockpiling. This may also involve levelling the site and landscaping. Example definitions for earthworks are:

- *Large: Total site area >10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), >10 heavy earth moving vehicles active at any one time, formation of bunds >8 m in height, total material moved >100,000 tonnes.*
- *Medium: Total site area 2,500 m^2 to 10,000 m^2, moderately dusty soil type (e.g. silt), 5 to 10 heavy earth moving vehicles active at any one time, formation of bunds 4 m to 8 m in height, total material moved 20,000 tonnes to 100,000 tonnes.*
- *Small: Total site area <2,000 m^2 – soil type with large grain size, e.g. sand, <5 heavy earth moving vehicles at one time, formation of bunds <4 m in height, total material moved <20,000 tonnes, earthworks during wetter months.* (UK IAQM, 2014)

Potential dust emission magnitudes for the Project were estimated based on the IAQM examples listed. Justification and the factors used in determining the magnitudes are presented in Table 12.28.

It is highlighted that a significant volume of material is required to be excavated as part of the construction of the Project, including excavation required for the Toowoomba Range Tunnel. A permanent stockpile is also proposed to be located at the western tunnel portal. Excavation activities, including those for the tunnel, are considered to be a significant potential dust source.

TABLE 12.28: CONSTRUCTION ACTIVITIES AND DUST EMISSION MAGNITUDE JUSTIFICATION

Activity	Potential dust emission magnitude	Justification
Demolition	Insignificant	▸ Some demolition of homes near the western tunnel portal may be required; however, the extent of the demolition is not confirmed and is not expected to be a significant source of emissions and, therefore, the impact of demolition on sensitive receptors has not been assessed.
Earthworks	Large	▸ Crushing and screening for the processing of structural fill is proposed to be undertaken at the laydown area at the western tunnel portal (G2H-LDN003.7) and the existing Toowoomba Bypass project laydown area at the bottom of the range (G2H-LDN015.6) as shown in Figure 6.5 in Chapter 6: Project Description. The potential for impacts from crushing is discussed separately in Section 12.7.1.3 ▸ Multiple work fronts at any one time within the Project disturbance footprint ▸ Vegetation clearing will be required within the Project disturbance footprint ▸ Clearing will be staged to limit the size of the cleared area at any one time where practical ▸ Topsoil along parts of the Project disturbance footprint will be stripped and stockpiled. Wherever possible and appropriate, material will be reused along the Project alignment ▸ Twenty four laydown areas within the Project disturbance footprint, primarily to act as locations for excavation stockpiling. Stockpiles to be located as close as possible to the excavation source

Activity	Potential dust emission magnitude	Justification
Earthworks [continued]	Large [continued]	▶ The total cut across the AQIA study area, excluding the tunnel, has been estimated to be 2,380,000 cubic metres (m^3). Thirteen cuts along the AQIA study area are required to maintain the required track elevations for the proposed rail line. The total length of cut for the Project will be in the range of 6.65 km with a maximum cut depth of 45.7 m ▶ The volume of material required to be excavated for the tunnel is estimated to be in the order of approximately 730,000 m^3 based on a bored diameter of approximately 12.2 m ▶ A permanent earthworks stockpile is proposed near the western portal of the Toowoomba Range Tunnel.
		▶ The Toowoomba Range Tunnel will be constructed primary using a tunnel boring machine (TBM); though a cut and cover and mined tunnel will be used at the eastern tunnel portal. The TBM will involve a bentonite slurry, which will require separation at the western tunnel portal for reuse ▶ Earthworks material will be dusty especially, with a higher potential for emissions during dry periods ▶ No borrow pits are required for the Project.
Construction	Large	▶ Construction period of five years, with multiple work fronts at any one time within the Project disturbance footprint; however, the Toowoomba Range Tunnel will likely be for the entire period, including provisioning, set-up and decommissioning of the TBM ▶ Installation of railway using steel rail, sleepers, ballast and concrete. Concrete and ballast present high dust risk. ▶ Construction of undrained railway tunnel approximately 6.24 km in length, including the tunnel control centre at the western tunnel portal. Tunnel construction will be undertaken via TBM. A mined tunnel and cut cover approach initially required at the eastern tunnel portal ▶ Intermediate ventilation shaft and associated infrastructure to be constructed at Cranley. The shaft will be constructed using a conventional shaft sink construction method. This shaft will be approximately 17 m internal diameter and 100 m deep and will be excavated prior to the tunnel construction ▶ The Project requires 13 new bridge and viaduct structures comprising 10 viaducts and three bridges, totaling approximately 6.7 km in length ▶ Four temporary site offices ▶ A concrete batching plant will be located at the western tunnel portal laydown area ▶ Construction of fuel storage areas within five laydown areas with capacities between 20,000 to 40,000 L ▶ Laydown areas will include temporary parking facilities for construction workers ▶ Construction of temporary rail handling facility ▶ Construction of temporary and permanent fencing ▶ Approximately 2,120,000 m^3 of fill material will be needed for the construction of embankments for the Project with a total length of approximately 15.4 km with a maximum embankment height of 33.3 m ▶ Construction of the bridges, viaducts and the eastern tunnel portal will require piling rigs.
Trackout	Large	▶ Multiple work fronts at any one time within the Project disturbance footprint ▶ High amount of daily vehicle movements expected per work site (both light and heavy vehicles) ▶ A ballast-handling facility will be established so that ballast can be delivered along the alignment using a train consist. Movement of ballast from sources, and between laydown areas and ballast handling facility via heavy haulage trucks ▶ Access tracks not designated as road maintenance access roads will be rehabilitated or left in-situ subject to relevant landowner agreements.

Emissions of TSP and PM_{10} from construction have been estimated for loading, unloading and haulage of cut-and-fill material (hereafter material) to provide an indication of the quantity of emissions from these sources. Emissions have been estimated using the emission factors presented in the NPI *Emissions estimation technique manual for Mining* (NPI, 2012), which are also referenced by the Queensland Government Department of Transport and Main Roads (DTMR) *Traffic Air Quality Management Manual* (DTMR, 2009). Although the emission formulas in this NPI manual are prescribed for mining, they are considered appropriate to estimate emissions from loading, unloading and haulage due to the similarity of these activities between mining and construction.

Construction dust will be generated by numerous activities (as described in Table 12.28) and will not be limited to loading, unloading and haulage; however, these activities have been considered to provide an indication of potential emissions as they will occur along the Project alignment.

Emissions have been estimated assuming that the majority of earthworks for the Project are undertaken over a period of two years, and that the volume of cut and fill required to be loaded and unloaded is 2,380,000 m^3 (as per Table 12.28). Assuming a density of 2,000 kilograms per cubic metre (kg/m^3), this equates to 4,760,000 tonnes of material that will require handling. The estimated indicative construction dust emissions are summarised as follows:

- Dust from loading material has been estimated to generate emissions at a rate of 0.16 kilograms per tonne (kg/t) for TSP and 0.08 kg/t for PM_{10}. The total volume of material estimated to be loaded per day across the entire Project (assuming two-year earthworks duration) is approximately 4,330 m^3, or 8,660 tonnes based on the assumed density of 2,000 kg/m^3. This results in estimated total emissions of approximately 1,386 kg/day of TSP and 693 kg/day of PM_{10} across the entire Project. Chapter 13.2.3 of *Compilation of Air Pollutant Emission Factors* (US EPA, 1998) states that wet suppression and reduction of wind speed (e.g. via wind breaks) are the recommended control measures for cut-and-fill material handling, which have estimated control efficiencies of 50 per cent and 30 per cent, respectively (NPI, 2012).
- Dust from uncontrolled (no mitigation) unloading of material has been estimated to generate emissions at a rate of 0.012 kg/t for TSP and 0.004 kg/t for PM_{10}. Assuming the total volume of material that is unloaded is 8,660 t/day, this results in an estimated emission rate of approximately 104 kg/day of TSP and 35 kg/day of PM_{10} across the entire Project. Assuming that the material is dumped at 12 of the 24 laydown areas for the Project, the unmitigated emission rate per laydown area would be approximately 9 kg/day for TSP and 3 kg/day for PM_{10}. Further assuming that a 70 per cent reduction in emissions could be achieved through the use of water sprays at the point of unloading, the mitigated emission rate per laydown area would be reduced to 2.7 kg/day for TSP and 0.9 kg/day for PM_{10}.
- Uncontrolled emissions of dust from the movement of vehicles on unsealed roads has been estimated to generate emissions at a rate of 2.6 kg/vehicle kilometres travelled for TSP and 0.72 kg/vehicle kilometres travelled for PM_{10}. Assuming that the transport capacity of the haul trucks used is 50 t/truck, the total weight of material generated is 8,660 t, and the total haul distance per truck is 2,400 km, the total vehicle kilometres travelled is estimated to be approximately 208 km/day. This results in an estimated emission rate of approximately 541 kg/day for TSP and 150 kg/day for PM_{10} across the entire Project. Assuming a 75 per cent reduction in emissions could be achieved through the application of water to the haul roads, the emission rates would be reduced to approximately 135.3 kg/day for TSP and 37.5 kg/day for PM_{10} across the entire Project.
- Emissions will also be generated via wind erosion of exposed areas and stockpiles. Emission quantities for wind erosion cannot be accurately estimated at this time due to uncertainty regarding the total area of stockpiles and exposed earth; however, there are numerous mitigation measures available including wind breaks (30 per cent emission reduction), water sprays (50 per cent emission reduction) and enclosure (e.g. stockpile covers) (99 per cent emission reduction) to effectively control this source.

The impact of construction activity on sensitive receptors will be influenced by the source characteristics (e.g. emission rate, emission height, etc.) the proximity of the receptor to construction dust sources, and local weather conditions at the time of the activity. The estimated emissions, therefore, cannot be used with any confidence to determine compliance at sensitive receptors; however, it is evident from the emission estimates that construction dust emissions can be significantly reduced through the implementation of mitigation measures.

The following sections outline the sensitivity of the AQIA study area to unmitigated construction dust impacts. The proposed mitigation measures and the assessed residual impacts with the implementation of the mitigation measures are discussed in Section 12.8.

Step 2B—Sensitivity of surrounding area

The IAQM methodology allows the sensitivity of an area to dust deposition, human health impacts due to PM_{10}, and ecological effects to be classified as high, medium, or low. The classifications are determined according to matrix tables provided in the IAQM guidance document. Individual matrix tables for dust deposition and human health impacts are provided in Table 12.29 and Table 12.30, respectively. Factors used in the matrix tables to determine the sensitivity of the surrounding area are described as follows:

- Receptor sensitivity (for individual receptors in the area):
  - High sensitivity—locations where members of the public are likely to be exposed for eight hours or more in a day, e.g. private residences, hospitals, schools, or aged care homes
  - Medium sensitivity—places of work where exposure is likely to be eight hours or more in a day
  - Low sensitivity—locations where exposure is transient (i.e. one or two hours maximum), e.g. parks, footpaths, shopping streets, playing fields.
- Ambient annual mean PM_{10} concentrations (only applicable to the human health impact matrix)
- Number of receptors in the area
- Proximity of receptors to dust sources.

Table 12.34 details the IAQM guidance sensitivity levels from dust deposition effects on people and property. As detailed in Section 12.5.6, the total number of sensitive receptors within the AQIA study area considered for the construction phase is 2,828. Of these, 2,094 receptors are classified as high sensitivity as they are private places of residence, with the remaining receptors predominantly medium sensitivity. Of the 2,828 receptors, 1,435 are located within 350 m of a construction dust source; and 42 of the receptors are located less than 20 m away, with seven of these receptors located within the Project disturbance footprint.

Assessing the sensitivity level to dust deposition effects from the Project using the IAQM guidance, the sensitivity is determined to be high as there are more than 10 receptors located within 20 m of active construction areas; however, the length of the Project is 28 km, including approximately 6 km in tunnel, and the density of receptors near active construction areas is much less than a standard construction site in an urban area. Based on the land use of the AQIA study area, a rating of high for sensitivity to dust deposition is considered overly conservative, and a rating of medium is considered more appropriate. A rating of medium has been used for the sensitivity of receptors to dust deposition impacts.

TABLE 12.29: IAQM ASSESSMENT MATRIX FOR THE DETERMINATION OF SENSITIVITY TO DUST DEPOSITION IMPACTS

Surrounding area sensitivity to dust deposition impacts

		Distance from the source (m)			
Receptor sensitivity	Number of receptors	<20	<50	<100	<350
High	>100	High	High	Medium	Low
	10–100	High	Medium	Low	Low
	1–10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

A modified version of the IAQM guidance for assessing the sensitivity of an area to human health impacts is shown in Table 12.30. For high and medium sensitivity receptors, the IAQM methods takes the existing background concentrations of PM_{10} (as an annual average) experienced in the area of interest (e.g. AQIA study area). As the UK objectives for PM_{10} objectives differ from the ambient air quality goals adopted for use in this assessment (Queensland air quality objectives), the annual mean concentration categories used in the assessment have been modified from those presented in the IAQM method. This approach is consistent with the IAQM guidance, which notes that in using the tables to define the sensitivity of an area, professional judgement may be used to determine alternative sensitivity categories.

TABLE 12.30: IAQM ASSESSMENT MATRIX FOR THE DETERMINATION OF SENSITIVITY TO HUMAN HEALTH IMPACTS

Receptor sensitivity	Annual mean PM_{10} concentration[a]	Number of receptors	Distance from the source				
			<20	<50	<100	<250	<350
High	> 25 µg/m³	> 100	High	High	High	Medium	Low
		10 to 100	High	High	Medium	Low	Low
		1 to 10	High	Medium	Low	Low	Low
	21 to 25 µg/m³	> 100	High	High	Medium	Low	Low
		10 to 100	High	Medium	Low	Low	Low
		1 to 10	High	Medium	Low	Low	Low
	17 to 21 µg/m³	> 100	High	Medium	Low	Low	Low
		10 to 100	High	Medium	Low	Low	Low
		1 to 10	Medium	Low	Low	Low	Low
	< 17 µg/m³	> 100	Medium	Low	Low	Low	Low
		10 to 100	Low	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low	Low
Medium	> 25 µg/m³	> 10	High	Medium	Low	Low	Low
		1 to 10	Medium	Low	Low	Low	Low
	21 to 25 µg/m³	> 10	Medium	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low	Low
	17 to 21 µg/m³	> 10	Low	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low	Low
	< 17 µg/m³	> 10	Low	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low	Low
Low	Any	>1	Low	Low	Low	Low	Low

Table note:

a. The annual mean PM_{10} concentration categories have been modified from the IAQM guidance to adjust for assessment of a site in Queensland.

As detailed in Section 12.5.3.2, the background annual average PM_{10} concentration at the Inland Rail AQMS at Gowrie was 17.1 µg/m³. Table 12.30, above, provides the modified IAQM guidance sensitivity levels for human health impacts based on the receptor sensitivity and the annual mean PM_{10} concentration.

Assessing the sensitivity level to human health impacts using the IAQM guidance, the sensitivity is determined to be high as there are between 10 to 100 receptors within 20 m of active construction areas, and the background concentration is greater than 17 µg/m³.

Similar to the classification for sensitivity to dust deposition impacts, the determined sensitivity classification of 'high' for human health impacts is considered to be conservative due to the length of the Project and the density of sensitive receptors near active construction areas; however, due to the importance of assessing human health, the sensitivity rating of high has been used for the assessment to provide a conservative assessment of impacts. The most sensitive areas to construction dust impacts will be residential areas in the several small townships or suburbs of Toowoomba located near the Project alignment, including Gowrie, Cranley, Mount Kynoch, Blue Mountain Heights, Lockyer, Postmans Ridge and Helidon Spa.

Step 2C—Unmitigated risks of impacts

The dust emission magnitudes for each activity, as determined in Step 2A, were combined with the sensitivity of the areas adjacent to the Project (in Table 12.29 and Table 12.30) to determine the risk of construction dust air quality impacts, with no mitigation applied. The risk of impacts for each activity is assessed according to the IAQM risk matrix methodology in Table 12.31. The 'without mitigation' dust risk impacts for each activity are summarised in Table 12.32. No significant demolition is required for the Project and, therefore, the impact of demolition does not require assessment.

TABLE 12.31 INSTITUTE OF AIR QUALITY MANAGEMENT RISK MATRIX

Activity	Surrounding area sensitivity	Dust emission magnitude: Large	Medium	Small
Earthworks	High	High risk	Medium risk	Low risk
	Medium	Medium risk	Medium risk	Low risk
	Low	Low risk	Low risk	Negligible
Construction	High	High risk	Medium risk	Low risk
	Medium	Medium risk	Medium risk	Low risk
	Low	Low risk	Low risk	Negligible
Trackout	High	High risk	Medium risk	Low risk
	Medium	Medium risk	Low risk	Negligible
	Low	Low risk	Low risk	Negligible

TABLE 12.32: WITHOUT MITIGATION DUST RISK IMPACTS FOR PROJECT CONSTRUCTION ACTIVITIES

Potential impact	Risk: Earthworks	Construction	Trackout
Scale of Activity (IAQM Table 4)	Large	Large	Large
Dust Soiling	Medium	Medium	Medium
Human Health	High	High	High

The result of the qualitative air quality risk assessment shows that the unmitigated air emissions from the construction of the Project poses a high risk of human health impacts but a medium risk of impact from dust deposition.

Step 3—Management strategies

The outcome of Step 2C is used to determine the level of management that is required to ensure that dust impacts on surrounding sensitive receptors are maintained at an acceptable level. A high or medium risk rating means that suitable management measures will need to be implemented during the Project.

A CEMP will be developed to mitigate and manage potential impacts during construction. The implementation of site-specific and in-principle management measures, as listed in Section 12.8 and in the Air Quality Sub-plan in the draft Outline EMP (refer Chapter 23: Draft Outline Environmental Management Plan), will result in minimal risk of dust impacts on surrounding receptors.

Step 4—Reassessment

The final step of the IAQM methodology (UK IAQM, 2014) is to determine whether there are significant residual impacts, post mitigation, arising from a proposed development. The guidance states:

> *For almost all construction activity, the aim should be to prevent significant effects on receptors through the use of effective mitigation. Experience shows that this is normally possible. Hence the residual effect will normally be "not significant.*

The dust risk assessment in Table 12.32 shows that without mitigation there is an anticipated high risk to human health, and a medium risk of impact from dust deposition as a result of earthworks, construction and trackout.

The construction dust sources associated with the Project are common emission sources. Industry standard mitigation measures to reduce dust emissions exist for all the identified sources and it is expected that emissions can be well managed through diligent implementation of these controls. In addition to mitigation at the source, visual monitoring of dust generation (visible plumes) and deposition on horizontal sources is an effective way to monitor the effectiveness of mitigation measures to ensure impacts to sensitive receptors are minimised.

It is anticipated that with effective mitigation of construction dust sources the residual impact on both dust deposition and human health will not be significant. Further discussion of mitigation measures, and assessment of the residual impact with the implementation of mitigation, is provided in Section 12.8.

12.7.1.2 Tank fuel storage

Fuel tank storage locations are proposed at five locations in the Project disturbance footprint during the construction of the Project. Fuel storage has the potential to impact nearby sensitive receptors due to the emission of VOCs and odour. Table 12.33 presents the proposed construction areas that will include diesel fuel storage, the volumes proposed to be stored and the distance from each area to the closest identified sensitive receptor.

TABLE 12.33: FUEL TANK STORAGE LOCATIONS

Construction area ID[1]	Chainage (km)	Location	Maximum fuel storage proposed (L)	Distance from boundary of construction area to closest sensitive receptor (m)
G2H-LDN003.7	3.70	Gowrie Junction Road and Boundary Street, Gowrie Junction	40,000	60
G2H-LDN010.5	10.50	Wallens Road, Ballard	40,000	250
G2H-LDN011.9	11.90	Jones Road, Withcott	20,000	430
G2H-LDN018.8	18.80	Howmans Road, Lockyer	20,000	630
G2H-LDN025.1	25.10	Cattos Road, Helidon	20,000	350

Table note:

1. Construction areas are shown in Figure 6.5 in Chapter 6: Project Description as laydown areas.

Table 12.33 shows that for the largest fuel storage tanks of 40,000 L, the distance to the closest sensitive receptor is between 60 m to 250 m, while for the smaller tanks of 20,000 L the distance to the closest sensitive receptor is between 350 m to 630 m.

The BCC AQPSP includes a Service Station Code (BCC, 2014), which provides performance and acceptable outcomes for service stations to ensure that service station developments are located at 'sufficient distance from dwellings to maintain residential amenity in adjoining, adjacent or surrounding areas'. Acceptable Outcome AO7.2 specifies acceptable separation distances based on annual fuel throughput. For service stations with annual fuel throughput of between 1.2 to 9 ML, the accepted distance is 50 m. The Service Station Code specifically excludes diesel from the definition of fuel; however, diesel is less volatile than petrol and other motor spirits and, therefore, the application of these buffers is considered conservative for diesel.

To exceed an annual throughput of 9 ML, the 20,000 L tanks would need to be refilled more than once per day (450 times per year), while the 40,000 L tanks would need to be refilled more than once every two days (225 times per year). It is considered improbable that this volume of diesel will be consumed and it is expected that annual fuel throughput at each location identified in Table 12.33 will be considerably less than 9 ML.

All construction areas have a separation distance from the nearest boundary to the closest receptor of greater than 50 m and, therefore, an acceptable separation distance can be achieved for fuel storage at each laydown area.

If the location or size of laydown areas is revised as the Project design progresses, it is proposed that, at minimum, fuel tanks will be located at least 50 m from the nearest sensitive receptor, but separation distances will be maximised as far as practical within site restrictions. A minimum separation distance of 50 m and compliance with Australian Standard AS 1940:2017 *The storage and handling of flammable and combustible liquids* (Standards Australia, 2017) is expected to result in negligible impacts to sensitive receptors based on the recommendations of the BCC AQPSP Service Station Code.

12.7.1.3 Crushing plant

Onsite crushing and screening for the processing of structural fill is proposed to be undertaken at two laydown areas: the laydown area at Gowrie Junction Road and Boundary Street (G2H-LDN003.7); and the existing Toowoomba Bypass project laydown area at McNamaras Road (G2H-LDN015.6), as shown in Figure 6.5 in Chapter 6: Project Description.

Crushing would generate dust emissions and these emissions have the potential to impact sensitive receptors.

The EPA Victoria guideline, *Recommended separation distances for industrial residual air emissions* (EPA Victoria, 2013) provides guidance on suitable separation distances between mining and extractive activities and neighbouring sensitive receptors, including for crushing. Table 12.34 presents the recommended separation distances for crushing associated with different mining and extractive activities.

TABLE 12.34: SEPARATION DISTANCES FOR CRUSHING ASSOCIATED WITH MINING AND EXTRACTIVE INDUSTRIES

Mining or extractive operation	Type of activity	Recommended separation distance (m)
Open-cut coal mine	Harvesting, crushing, screening, stockpiling and conveying of coal	1,000
Mine for other minerals	Crushing, screening, stockpiling and conveying of other minerals	250
Quarry	Quarrying, crushing, screening, stockpiling and conveying of rock	250 (without blasting) 500 (with blasting or with respirable crystalline silica)

Source: EPA Victoria, 2013

Based on the material anticipated to require processing, the separation distance of 250 m for quarries (without blasting) is considered the most appropriate for the proposed crushing and screening activities associated with the Project.

The nearest sensitive receptor to the McNamaras Road laydown area is approximately 500 m to the north, which is further than the recommended separation distance of 250 m. The nearest sensitive receptor to the Gowrie Junction Road and Boundary Street laydown area is located approximately 60 m to the north of the laydown area boundary, which is within the recommended separation distance of 250 m.

The dimensions of the Gowrie Junction Road and Boundary Street laydown area is triangular in shape and covers an area of approximately 338,000 m^2, and, therefore, the location of crushing and screening plant could be located at a position inside the laydown area, which is further than 250 m from the nearest sensitive receptor.

It is proposed that, at minimum, crushing and screening plant would be located at least 250 m from the nearest sensitive receptor but separation distances would be maximised as far as practical within site restrictions. With a minimum separation distance of 250 m, emissions from crushing and screening are anticipated to have minimal impact on air quality at sensitive receptors in the AQIA study area.

12.7.1.4 Blasting

Cuttings in the existing ground profile will need to be made where the final design level is lower than the surrounding land. Non-rippable rock (rock that is not able to be broken down using mechanical means) will be broken via drill and blast or by hydraulic rock-breakers. Significant volumes of non-rippable rock are anticipated within some of the cuttings along the Project alignment, particularly through the Toowoomba Range. The extent to which drilling and blasting will be required is subject to further geotechnical investigation. Based on the preliminary geotechnical information, it is anticipated that blasting may be required in the more significant cuttings, e.g. near the western tunnel portal and the eastern tunnel portal.

Blasting would generate dust emissions and these emissions have the potential to impact sensitive receptors.

Recommended separation distances for industrial residual air emissions (EPA Victoria, 2013) includes a recommended separation distance of 500 m for quarries that undertake blasting.

If blasting is required to construct the Toowoomba Range Tunnel, dust emissions from blasting would not impact sensitive receptors, as they would occur underground. Blasting at other major cuttings along the alignment may also impact sensitive receptors, subject to the exact locations where blasting is required and the separation to sensitive receptors.

In order to minimise the risk of impact to sensitive receptors, it is proposed that blasting is not undertaken at locations if the prevailing wind conditions are likely to transport dust emissions toward the nearest sensitive receptors, if these receptors are= within 500 m of the blasting location.

There are two sensitive receptors within 500 m of the western tunnel portal, with a total of 11 receptors within 700 m of the portal (allowing for blasting 100m either side of the location of the tunnel portal). Of these 11 receptors near the western tunnel portal, four are within the Project disturbance footprint. At the eastern tunnel portal, there are no receptors within 500 m but one receptor is located within 700 m (570 m to the north), with this receptor located outside the Project disturbance footprint.

Where drilling and blasting is to be undertaken, the construction contractor will develop a Blasting Management Plan that will detail the adoption of appropriate and safe mitigation measures, which will be approved by DTMR prior to work commencing.

12.7.1.5 Concrete batching

A concrete batching plant may be located at the laydown area near the western tunnel portal, to facilitate construction of the Project.

Guidance on recommended separation distances between concrete batching plants and sensitive receptors is provided in the following State government guidance documents:

- *Guideline: Recommended separation distances for industrial residual air emissions* (EPA Victoria, 2013)
- *Evaluation distances for effective air quality and noise management* (EPA South Australia, 2016)
- Guidance for the assessment of environmental factors: separation distances between industrial and sensitive land uses (EPA Western Australia, 2005).

The recommended separation distances are summarised in Table 12.35.

TABLE 12.35: RECOMMENDED SEPARATION DISTANCES FOR CONCRETE BATCHING PLANTS

Industrial activity	Recommended separation distance (m)	Source
Production of concrete	100	EPA Victoria
Concrete batching works	200	EPA South Australia
Concrete batching plant or cement products (bricks) manufacturing	300-500 (depending on size)	EPA Western Australia

The nearest receptor to the western tunnel portal laydown area is located approximately 250 m to the north. The dimensions of the laydown area are approximately 150 m by 400 m and, therefore, there is significant space within the laydown area to further increase this separation distance.

Based on the recommended separation distances presented in Table 12.35, it is expected that, if required, the concrete batching plant can be located in a position that does not present significant risk of impacts to air quality at sensitive receptors.

12.7.2 Commissioning

Air emissions during the commissioning phase of the Project are anticipated to be minor and are expected to be limited to combustion engine emissions from transport vehicles and train locomotives and limited dust emissions from vehicle travel on unsealed roads.

Air emissions from the commissioning phase of the Project are expected to be insignificant and are considered unlikely to generate nuisance or risk exceedance of the Project's air quality goals; and, therefore, have not been assessed in any further detail.

12.7.3 Operation

This section presents the results of the assessment of impacts to air quality and tank water quality from the operational phase of the Project. The assessment of impacts from the operational phase has been undertaken considering forecast train movements for the year 2040.

12.7.3.1 Human receptors

Modelled results

The results of the modelling of typical and peak operational impacts are presented in this section. The results are itemised in the increments described below in Table 12.36.

TABLE 12.36: MODELLING INCREMENT DESCRIPTIONS

Increments	Description
Project-only contribution	Represents the predicted contribution from modelled Project emissions, including emissions from the Project alignment, the crossing loops and the Toowoomba Range Tunnel portals
With veneering	The predicted contribution from modelled Project emissions, with the inclusion of veneering to laden coal trains (75 per cent reduction to emissions from coal wagons) (only applicable for TSP, PM_{10}, $PM_{2.5}$ and deposited dust)
Without veneering	The predicted contribution from modelled Project emissions without veneering (no reduction to coal wagon emissions) (only applicable for TSP, PM_{10}, $PM_{2.5}$ and deposited dust). Although it is expected that all coal trains operating on Inland Rail will use veneering, modelling of emissions from coal trains without the inclusion of veneering has been undertaken to investigate the potential for air quality impacts without this mitigation measure
Background concentration	Adopted background concentrations and existing emissions sources, as per Section 12.5.3.2
Total cumulative concentration	The cumulative concentration of the Project contribution, the adopted background concentration and non-project contributions (from the B2G and H2C projects, QR West Moreton System and the Toowoomba Bypass)

The results of the dispersion modelling are shown in Table 12.37 and Table 12.38 for the peak and typical train volume scenarios, respectively, with the air quality goals for each pollutant also presented.

Modelled results are presented in Table 12.37 and Table 12.38 for the worst-affected receptor in the Projects' permanent disturbance footprint, and the worst-affected receptor outside the Project's permanent disturbance footprint.

There are seven sensitive receptors located in the permanent disturbance footprint (receptors R_386, R_437, R_447, R_888, R_898, R_923 and R_931). The worst-affected receptor in the Project's permanent disturbance footprint is receptor R_898, which is the worst-affected receptor for each pollutant and averaging period. The worst-affected receptor outside the Project's permanent disturbance footprint varies depending on the pollutant and averaging period being assessed.

Receptor R_898, a residential dwelling, is located 360 m northwest of the western tunnel portal of the Toowoomba Range Tunnel and adjacent to the crossing loop near the western tunnel portal. Receptor R_898 is located approximately 20 m from the nearest modelled crossing loop idling locomotive point source. The location of receptor R_898 is shown in the concentration contour plots, which are discussed later in this section.

The results for receptor R_898 from Table 12.37 and Table 12.38 are summarised as follows:

- Predicted cumulative 1-hour NO_2 concentrations exceed the air quality goals for both the peak and typical scenarios
- With veneering, predicted cumulative 24-hour maximum $PM_{2.5}$ and annual average $PM_{2.5}$ concentrations exceed the relevant air quality goals for both the peak and typical scenarios
- Without veneering, predicted cumulative 24-hour maximum PM_{10}, 24-hour maximum $PM_{2.5}$ and annual average $PM_{2.5}$ concentrations exceed the relevant air quality goals for both the peak and typical scenarios
- Predicted concentration and dust deposition levels at R_898 are compliant for all other pollutant species for the peak and typical scenarios.

Receptor R_898 is a residential dwelling located in the permanent disturbance footprint of the Project. It is expected that all sensitive receptors within the permanent disturbance footprint will be acquired pursuant to the land acquisition process; as such, it is expected that during operations a residential dwelling will not exist at the location represented by receptor R_898, or other receptors located within the permanent disturbance footprint. Predicted cumulative concentrations and dust deposition levels at the other six sensitive receptors located in the permanent disturbance footprint (receptors R_386, R_437, R_447, R_888, R_923 and R_931), are compliant with the relevant air quality goals for all pollutant species for both the typical and peak traffic volume scenarios (both with and without veneering).

Table 12.37 and Table 12.38 show that predicted cumulative concentrations and dust deposition levels, at the worst-affected receptor outside the permanent disturbance footprint, are compliant with the relevant air quality goals for all pollutant species (without veneering) for both the typical and peak traffic volume scenarios. It should be noted, however, that coal wagons on the alignment travelling to the Port of Brisbane will be veneered at the coal loading source.

The air quality goals adopted for the assessment are prescribed to protect the environmental values of health and wellbeing and protecting the aesthetic environment. Assessment of the Project impacts to these environmental values is discussed in the following sections.

Modelled results for PM_{10}, $PM_{2.5}$ and NO_2 for every receptor for the peak train volume scenario, with and without the inclusion of veneering, are presented in in Appendix K: Air Quality Technical Report. Appendix K: Air Quality Technical Report (Appendix B) provides additional detailed figures for the sensitive receptors included in the modelling.

TABLE 12.37: PREDICTED GROUND LEVEL CONCENTRATIONS AT THE WORST-AFFECTED SENSITIVE RECEPTORS WITHIN AND OUTSIDE THE PERMANENT DISTURBANCE FOOTPRINT FOR PEAK OPERATIONS

			Highest predicted ground level pollutant concentration at identified sensitive receptor locations (µg/m^3)				
Pollutant	**Averaging period**	**Receptor**[a]	Project only contribution (A)	Background concentration (B)	Project + Background (A + B)	Total Cumulative Concentration (A + B + Non Project Sources)	**Air quality goal (µg/m^3)**
TSP	Annual average (with veneering)	R_898	5.1	42.75	47.9	48.1	90
		R_2591	2.2		44.9	45.0	
	Annual average (*without* veneering)	R_898	9.5		52.2	52.3	
		R_2591	7.7		50.5	50.6	
PM_{10}	24-hour maximum (with veneering)	R_898	31.8	17.4	49.2	49.2	50
		R_821	5.6		23.0	23.1	
	24-hour maximum (*without* veneering)	R_898	35.3		**52.7**	**52.7**	
		R_224	13.2		30.6	30.7	
	Annual average (with veneering)	R_898	4.3	17.1	21.4	21.5	25
		R_2591	1.2		18.3	18.4	
	Annual average (*without* veneering)	R_898	6.5		23.6	23.7	
		R_2591	4.0		21.1	21.2	
$PM_{2.5}$	24-hour maximum (with veneering)	R_898	29.7	7.6	**37.3**	**37.3**	25
		R_821	5.1		12.7	12.7	
	24-hour maximum (*without* veneering)	R_898	30.2		**37.8**	**37.9**	
		R_821	5.2		12.8	12.8	
	Annual average (with veneering)	R_898	3.5	6.5	**10.0**	**10.1**	8
		R_2548	0.4		6.9	7.3	
	Annual average (*without* veneering)	R_898	3.9		**10.4**	**10.4**	
		R_2591	0.8		7.3	7.4	
Deposited dust	30 day (with veneering)	R_898	1.7	50	51.7	51.7	120 mg/m^2/day[b]
		R_2591	0.1		50.1	50.1	
	30 day (*without* veneering)	R_898	1.9		51.9	51.9	

Pollutant	Averaging period	Receptor[a]	Highest predicted ground level pollutant concentration at identified sensitive receptor locations (µg/m³)				Air quality goal (µg/m³)
			Project only contribution (A)	Background concentration (B)	Project + Background (A + B)	Total Cumulative Concentration (A + B + Non Project Sources)	
		R_2591	0.2		50.2	50.2	
NO_2	1 hour maximum	R_898	227.4	57.5[c]	**284.9**	**286.6**	250
		R_397	109.4		166.9	171.9	
	Annual average	R_898	45.0	7.8[c]	52.8	53.9	62
		R_2548	5.6		13.4	23.6	
Arsenic and compounds	Annual average	R_898	1.02×10^{-4}	- [d]	1.02×10^{-4}	1.02×10^{-4}	6 ng/m³
		R_2591	2.90×10^{-5}		2.90×10^{-5}	2.90×10^{-5}	
Cadmium and compounds	Annual average	R_898	7.13×10^{-3}	- [d]	7.13×10^{-3}	7.13×10^{-3}	5 ng/m³
		R_2591	2.03×10^{-3}		2.03×10^{-3}	2.03×10^{-3}	
Chromium III and compounds	1 hour maximum	R_898	4.64×10^{-4}	- [d]	4.64×10^{-4}	4.64×10^{-4}	9
		R_821	1.52×10^{-4}		1.52×10^{-4}	1.52×10^{-4}	
Chromium VI and compounds	1 hour maximum	R_898	4.64×10^{-4}	- [d]	4.64×10^{-4}	4.64×10^{-4}	0.1
		R_821	1.52×10^{-4}		1.52×10^{-4}	1.52×10^{-4}	
	Annual average	R_898	3.36×10^{-5}	- [d]	3.36×10^{-5}	3.36×10^{-5}	0.01
		R_2591	9.59×10^{-6}		9.59×10^{-6}	9.59×10^{-6}	
Lead and compounds	Annual average	R_898	2.12×10^{-7}	- [d]	2.12×10^{-7}	2.12×10^{-7}	0.5
		R_2591	8.94×10^{-8}		8.94×10^{-8}	8.94×10^{-8}	
Nickel and compounds	Annual average	R_898	4.69×10^{-2}	- [d]	4.69×10^{-2}	4.69×10^{-2}	22 ng/m³
		R_2591	1.34×10^{-2}		1.34×10^{-2}	1.34×10^{-2}	
Dioxins and furans	Annual average	R_898	2.99×10^{-12}	- [d]	2.99×10^{-12}	2.99×10^{-12}	3×10^{-8}
		R_2548	1.70×10^{-13}		1.70×10^{-13}	1.70×10^{-13}	
Polycyclic aromatic hydrocarbon (as benzo[a]pyrene)	Annual average	R_898	9.14×10^{-2}	- [d]	9.14×10^{-2}	9.14×10^{-2}	0.3 ng/m³
		R_2548	5.19×10^{-3}		5.19×10^{-3}	5.19 x 10-3	
1,3-butadiene	Annual average	R_898	1.14	- [d]	1.1	1.1	2.4

Pollutant	Averaging period	Receptor[a]	Highest predicted ground level pollutant concentration at identified sensitive receptor locations (µg/m³): Project only contribution (A)	Background concentration (B)	Project + Background (A + B)	Total Cumulative Concentration (A + B + Non Project Sources)	Air quality goal (µg/m³)
		R_2548	6.49×10^{-2}		0.1	0.1	
Benzene	Annual average	R_898	1.07×10^{-2}	5.2	5.2	5.2	5.4
		R_2548	6.06×10^{-4}		5.2	5.2	
Toluene	30-minute maximum[e]	R_898	2.84×10^{-2}	23.0	23.0	23.0	1100
		R_821	8.63×10^{-3}		23.0	23.0	
	24-hour maximum	R_898	1.34×10^{-2}	21.7	21.7	21.7	4100
		R_821	2.26×10^{-3}		21.7	21.7	
	Annual average	R_898	1.52×10^{-3}	18.5	18.5	18.5	400
		R_2548	8.66×10^{-5}		18.5	18.5	
Xylenes	24-hour maximum	R_898	1.85	37.6	39.4	39.4	1100
		R_821	3.11×10^{-1}		37.9	37.9	
	Annual average	R_898	2.10×10^{-1}	33.8	34.0	34.0	950
		R_2548	1.19×10^{-2}		33.8	33.8	

Table notes:
Results in **bold** exceed the relevant air quality goal

a. Results are presented for the worst-affected receptor within the permanent disturbance footprint and the worst-affected receptor outside the permanent disturbance footprint. The first row (receptor R_898) presents the modelled result for the worst-affected receptor within the permanent disturbance footprint, with the second row presenting the modelled result for the worst-affected receptor outside the permanent disturbance footprint
b. Air quality goal of 120 mg/m2/day, calculated based on the average deposition over a period of one month
c. Concentrations of NO2 have been predicted using the USEPA's OLM and the hourly background concentrations as measured at the DES Mutdapilly monitoring site in 2013. The background concentrations presented in the table have not been used specifically in the assessment but are included to provide an indication of background concentrations and the Project contribution. To provide an indication of the Project contribution, this value has been calculated by subtracting the background concentration from the predicted cumulative concentration.
d. No background monitoring data available for modelled pollutant
e. 30-minute maximum calculated from 1-hour modelling results as per (Turner, 1970)

TABLE 12.38: PREDICTED GROUND LEVEL CONCENTRATIONS AT THE WORST-AFFECTED SENSITIVE RECEPTORS WITHIN AND OUTSIDE THE PERMANENT DISTURBANCE FOOTPRINT FOR TYPICAL OPERATIONS

Pollutant	Averaging period	Receptor[a]	Highest predicted ground level pollutant concentration at identified sensitive receptor locations (µg/m³)				Air quality goal (µg/m³)
			Project only contribution (A)	Background concentration (B)	Project + Background (A + B)	Total Cumulative Concentration (A + B + Non Project Sources)	
TSP	Annual average (with veneering)	R_898	4.8	42.75	47.6	47.7	90
		R_2591	1.8		44.5	44.6	
	Annual average (*without* veneering)	R_898	8.4		51.1	51.2	
		R_2591	6.3		49.1	49.2	
PM_{10}	24-hour maximum (with veneering)	R_898	31.5	17.4	48.9	48.9	50
		R_821	5.5		22.9	23.0	
	24-hour maximum (*without* veneering)	R_898	34.3		**51.7**	**51.8**	
		R_224	10.8		28.2	28.3	
	Annual average (with veneering)	R_898	4.1	17.1	21.2	21.3	25
		R_2591	1.0		18.1	18.2	
	Annual average (*without* veneering)	R_898	5.9		23.0	23.1	
		R_2591	3.3		20.4	20.4	
$PM_{2.5}$	24-hour maximum (with veneering)	R_898	29.6	7.6	**37.2**	**37.2**	25
		R_821	5.0		12.6	12.6	
	24-hour maximum (*without* veneering)	R_898	30.0		**37.6**	**37.7**	
		R_821	5.2		12.8	12.8	
	Annual average (with veneering)	R_898	3.5	6.5	**10.0**	**10.0**	8
		R_2548	0.3		6.8	7.3	
	Annual average (*without* veneering)	R_898	3.7		**10.2**	**10.3**	
		R_2548	0.7		7.2	7.3	
Deposited dust	30 day (with veneering)	R_898	1.6	50	51.6	51.6	120 mg/m²/day[b]
		R_2591	0.1		50.1	50.1	
	30 day (*without* veneering)	R_898	1.8		51.8	51.8	

Pollutant	Averaging period	Receptor[a]	Highest predicted ground level pollutant concentration at identified sensitive receptor locations (μg/m³): Project only contribution (A)	Background concentration (B)	Project + Background (A + B)	Total Cumulative Concentration (A + B + Non Project Sources)	Air quality goal (μg/m³)
		R_2591	0.2		50.2	50.2	
NO_2	1 hour maximum	R_898	226.8	57.5[c]	284.3	286.6	250
		R_397	109.4		166.9	171.9	
	Annual average	R_898	44.8	7.8[c]	52.6	53.7	62
		R_2548	5.3		13.1	23.5	
Arsenic and compounds	Annual average	R_898	9.78×10^{-5}	-[d]	9.78×10^{-5}	9.78×10^{-5}	6 ng/m³
		R_2591	2.37×10^{-5}		2.37×10^{-5}	2.37×10^{-5}	
Cadmium and compounds	Annual average	R_898	6.84×10^{-3}	-[d]	6.84×10^{-3}	6.84×10^{-3}	5 ng/m³
		R_2591	1.66×10^{-3}		1.66×10^{-3}	1.66×10^{-3}	
Chromium III and compounds	1-hour maximum	R_898	4.58×10^{-4}	-[d]	4.58×10^{-4}	4.58×10^{-4}	9
		R_821	1.48×10^{-4}		1.48×10^{-4}	1.48×10^{-4}	
Chromium VI and compounds	1-hour maximum	R_898	4.58×10^{-4}	-[d]	4.58×10^{-4}	4.58×10^{-4}	0.1
		R_821	1.48×10^{-4}		1.48×10^{-4}	1.48×10^{-4}	
	Annual average	R_898	3.23×10^{-5}	-[d]	3.23×10^{-5}	3.23×10^{-5}	0.01
		R_2591	7.82×10^{-6}		7.82×10^{-6}	7.82×10^{-6}	
Lead and compounds	Annual average	R_898	1.99×10^{-7}	-[d]	1.99×10^{-7}	1.99×10^{-7}	0.5
		R_2591	7.29×10^{-8}		7.29×10^{-8}	7.29×10^{-8}	
Nickel and compounds	Annual average	R_898	4.50×10^{-2}	-[d]	4.50×10^{-2}	4.50×10^{-2}	22 ng/m³
		R_2591	1.09×10^{-2}		1.09×10^{-2}	1.09×10^{-2}	
Dioxins and furans	Annual average	R_898	2.96×10^{-12}	-[d]	2.96×10^{-12}	2.96×10^{-12}	3×10^{-8}
		R_2548	1.60×10^{-13}		1.60×10^{-13}	1.60×10^{-13}	
Polycyclic aromatic hydrocarbon (as benzo[a]pyrene)	Annual average	R_898	9.07×10^{-2}	-[d]	9.07×10^{-2}	9.07×10^{-2}	0.3 ng/m³
		R_2548	4.91×10^{-3}		4.91×10^{-3}	4.91×10^{-3}	
1,3-butadiene	Annual average	R_898	1.1	-[d]	1.1	1.1	

			Highest predicted ground level pollutant concentration at identified sensitive receptor locations (μg/m³)				
Pollutant	**Averaging period**	**Receptor[a]**	Project only contribution (A)	Background concentration (B)	Project + Background (A + B)	Total Cumulative Concentration (A + B + Non Project Sources)	**Air quality goal (μg/m³)**
		R_2548	6.14×10^{-2}		6.14×10^{-2}	0.1	2.4
Benzene	Annual average	R_898	1.06×10^{-2}	5.2	5.2	5.2	5.4
		R_2548	5.73×10^{-4}		5.2	5.2	
Toluene	30-minute maximum[e]	R_898	2.84×10^{-2}	23.0	23.0	23.0	1100
		R_821	8.61×10^{-3}		23.0	23.0	
	24-hour maximum	R_898	1.34×10^{-2}	21.7	21.7	21.7	4100
		R_821	2.25×10^{-3}		21.7	21.7	
	Annual average	R_898	1.51×10^{-3}	18.5	18.5	18.5	400
		R_2548	8.18×10^{-5}		18.5	18.5	
Xylenes	24-hour maximum	R_898	1.84	37.6	39.4	39.4	1100
		R_821	3.11×10^{-1}		37.9	37.9	
	Annual average	R_898	2.09×10^{-1}	33.8	34.0	34.0	950
		R_2548	1.13×10^{-2}		33.8	33.8	

Table notes:

Results in **bold** exceed the relevant air quality goal

a. Results are presented for the worst-affected receptor within the permanent disturbance footprint and the worst-affected receptor outside the permanent disturbance footprint. The first row (receptor R_898) presents the modelled result for the worst-affected receptor within the permanent disturbance footprint, with the second row presenting the modelled result for the worst-affected receptor outside the permanent disturbance footprint

b. Air quality goal of 120 mg/m^2/day, calculated based on the average deposition over a period of one month

c. Concentrations of NO_2 have been predicted using the USEPA's OLM and the hourly background concentrations as measured at the DES Mutdapilly monitoring site in 2013. The background concentrations presented in the table have not been used specifically in the assessment but are included to provide an indication of background concentrations and the Project contribution. To provide an indication of the Project contribution, this value has been calculated by subtracting the background concentration from the predicted cumulative concentration.

d. No background monitoring data available for modelled pollutant

e. 30-minute maximum calculated from 1-hour modelling results as per (Turner, 1970)

Concentration contour plots

Predicted cumulative concentration contour plots for the peak train volume scenario for PM_{10} (maximum 24-hour concentration), $PM_{2.5}$ (annual average concentration) and NO_2 (1-hour maximum concentration) are shown in the figure series Figure 12.5, Figure 12.6 and Figure 12.7. Predicted cumulative pollutant concentration contours for the same pollutant for the typical train volume scenario are presented in Figure 12.8, Figure 12.9 and Figure 12.10. The concentration contours are cumulative and, therefore, can be compared directly against the Project air quality goals, as defined in Section 12.4.3.

The concentration contour plots show the predicted cumulative ground level concentration (as contour lines) across the AQIA study area. The contour plots show that ground level concentrations decrease with increased distance from the Project alignment.

The contour plots also show the influence of the crossing loops on pollutant concentrations, with peak concentrations predicted near each of the crossing loops. The contour plots also show elevated concentrations near the eastern and western portals of the Toowoomba Range Tunnel, with elevated concentrations predicted near the tunnel portals due to emissions from the crossing loops and the tunnel portals. The crossing loops are the dominant source of emissions and have a greater impact on the concentration contours than emissions from the tunnel portals. This is due to the quantity of air that is purged from the tunnel and the dilution this provides for emissions from the tunnel portals.

The shape of the concentration contours near the portals is influenced by the averaging period presented (e.g. 1 hour, 24 hour or annual average) and the topography near the portals.

Modelling of the Project alignment and the crossing loops has included the design elevations for each element. The concentration contours presented in Figure 12. to Figure 12. are presented at ground level (0 m above ground), as per the requirements of the EP Act Air Guideline and as required to assess the impact at sensitive receptors. At locations where the design elevation for the Project is above ground level, predicted concentrations at ground level are lower due to the enhanced dispersion that occurs between the emission release point and the point at which the plume reaches the ground.

The location of the worst-affected receptor, R_898, is shown in each of the concentration contour plots. Receptor R_898 is located near the western tunnel portal and adjacent the crossing loop. Figure 12. to Figure 12. illustrate that peak concentrations occur at R_898 and the surrounding area to this receptor. As noted above, R_898, a residential dwelling, is located within the permanent disturbance footprint of the Project and it is expected that this existing residence will be acquired pursuant to the land acquisition process. As such, it is expected that, during operations, residential dwelling will not exist at the location represented by receptor R_898.

In addition to the concentration contours presented in Figure 12. to Figure 12., predicted cumulative annual average NO_2 concentration contours are presented in Section 12.7.3.3 for the assessment of impacts to ecological receptors. The concentration contours presented in Section 12.7.3.3 (refer Figure 12.11 and Figure 12.12, respectively) can be used to review predicted annual average NO_2 concentrations at all modelled discrete sensitive receptors, including ecological receptors and residential dwellings. Predicted annual average NO_2 concentrations are below the air quality goal (62 µg/m^3) for human health and wellbeing at all modelled discrete receptors for both the peak and typical train volume scenarios (refer Table 12.37 and Table 12.38, respectively).

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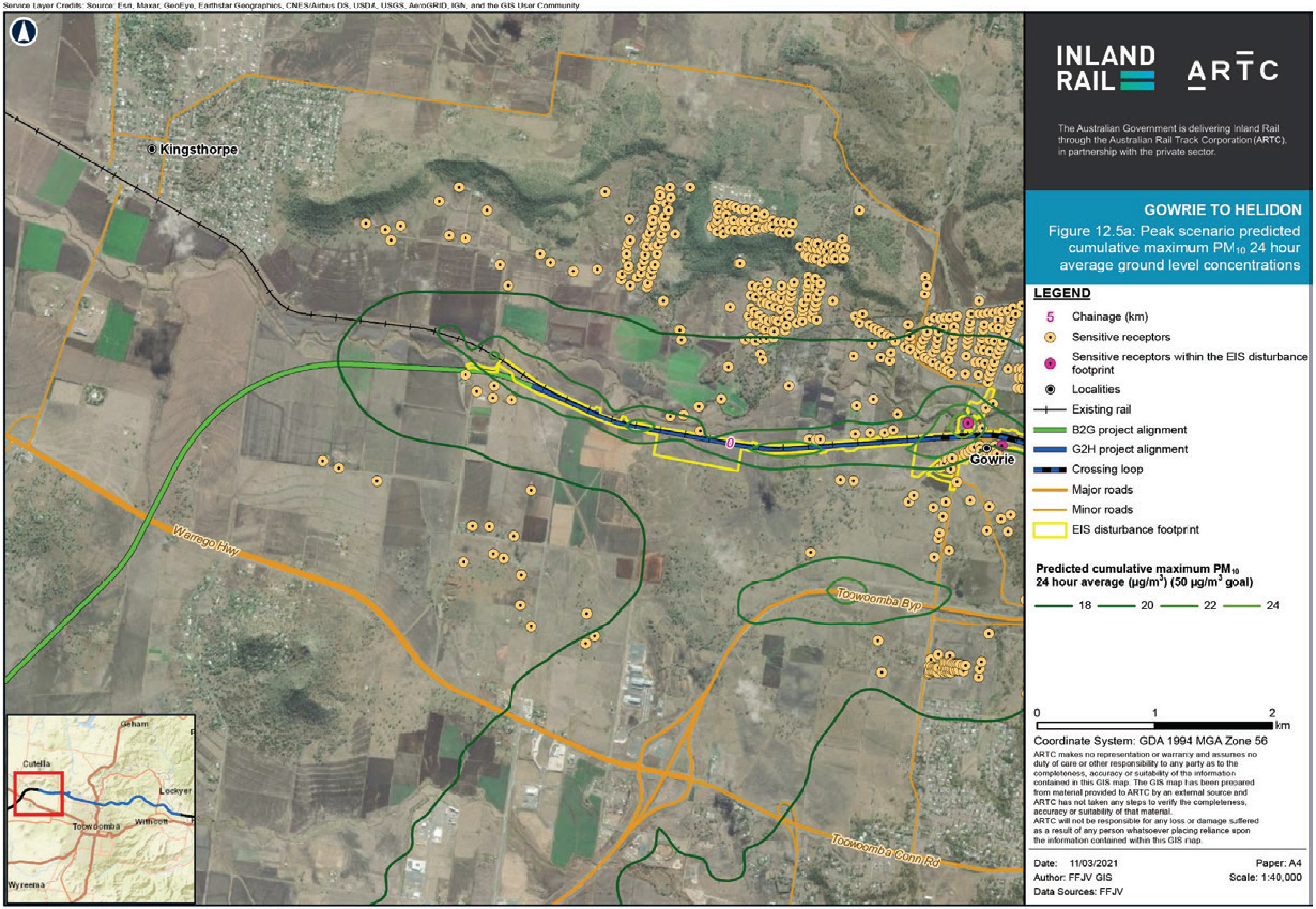

Figure 12.5a: Peak scenario predicted cumulative maximum PM_{10} 24 hour average ground level concentrations

Map by: MEF/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.5_Peak_PM10_v5.mxd Date: 11/03/2021 10:39

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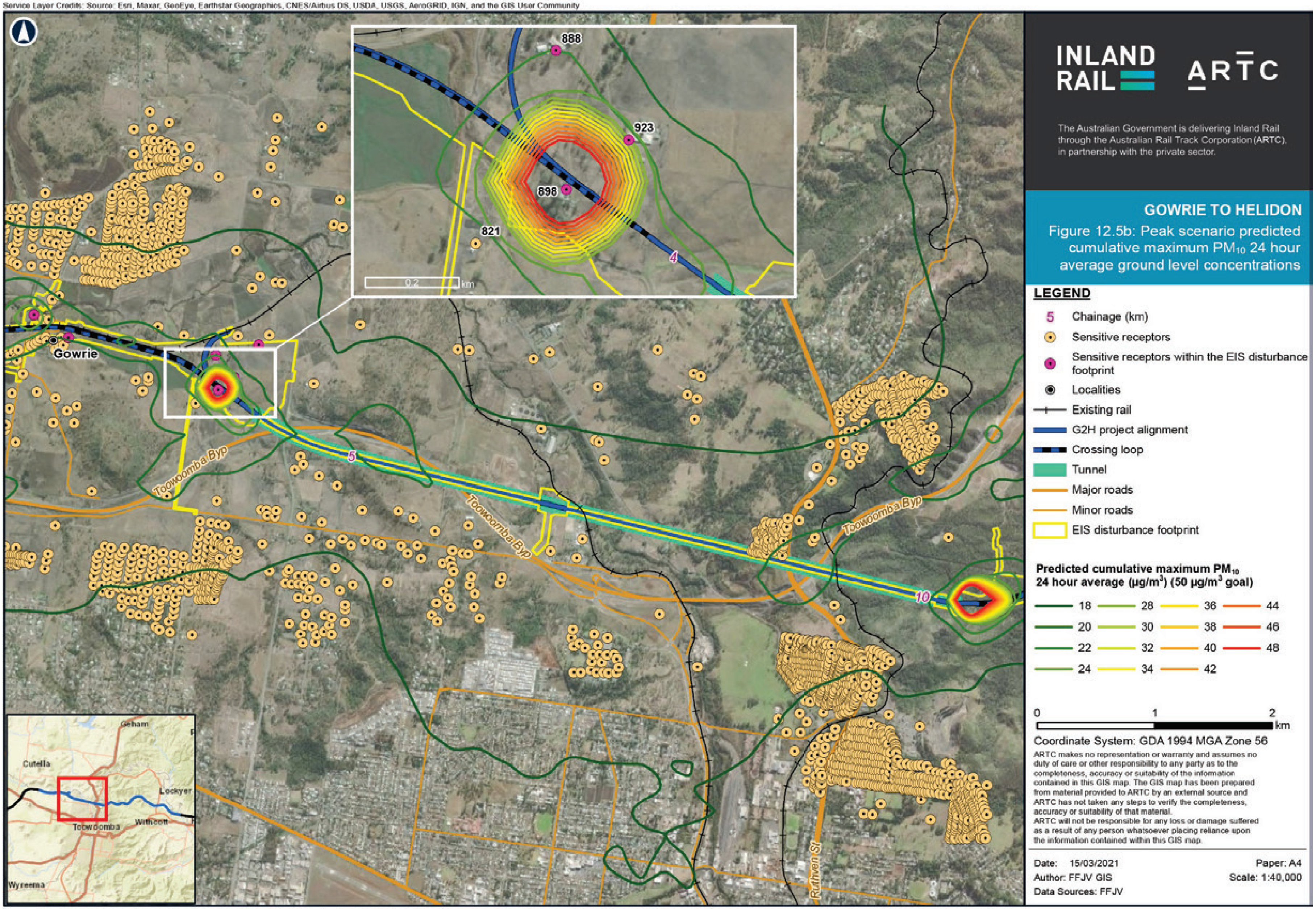

Figure 12.5b: Peak scenario predicted cumulative maximum PM_{10} 24 hour average ground level concentrations

Map by: MEF/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.5b_Peak_PM10_v5.mxd Date: 15/03/2021 11:00

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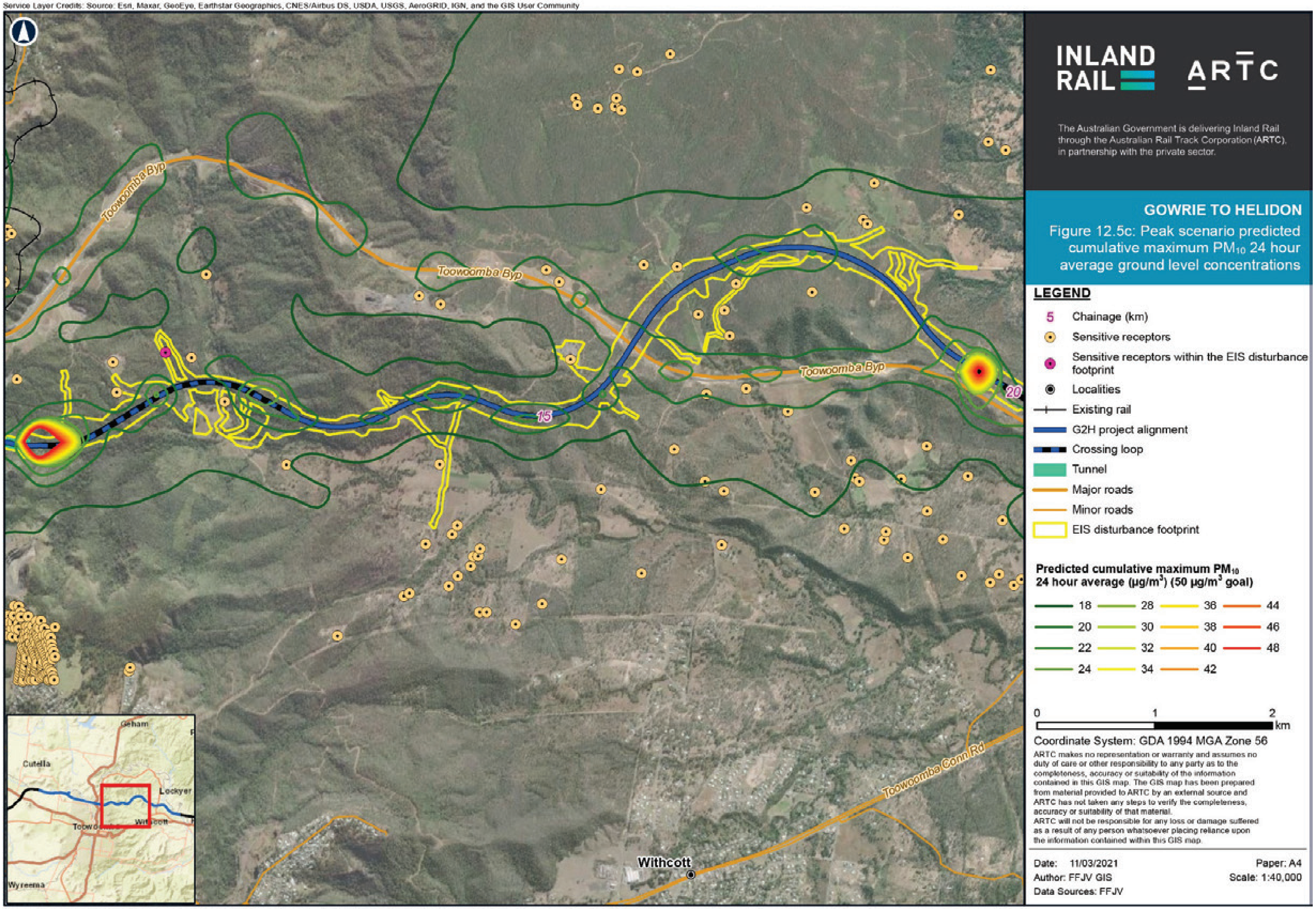

Figure 12.5c: Peak scenario predicted cumulative maximum PM_{10} 24 hour average ground level concentrations

Map by: MEF/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.5_Peak_PM10_v5.mxd Date: 11/03/2021 10:39

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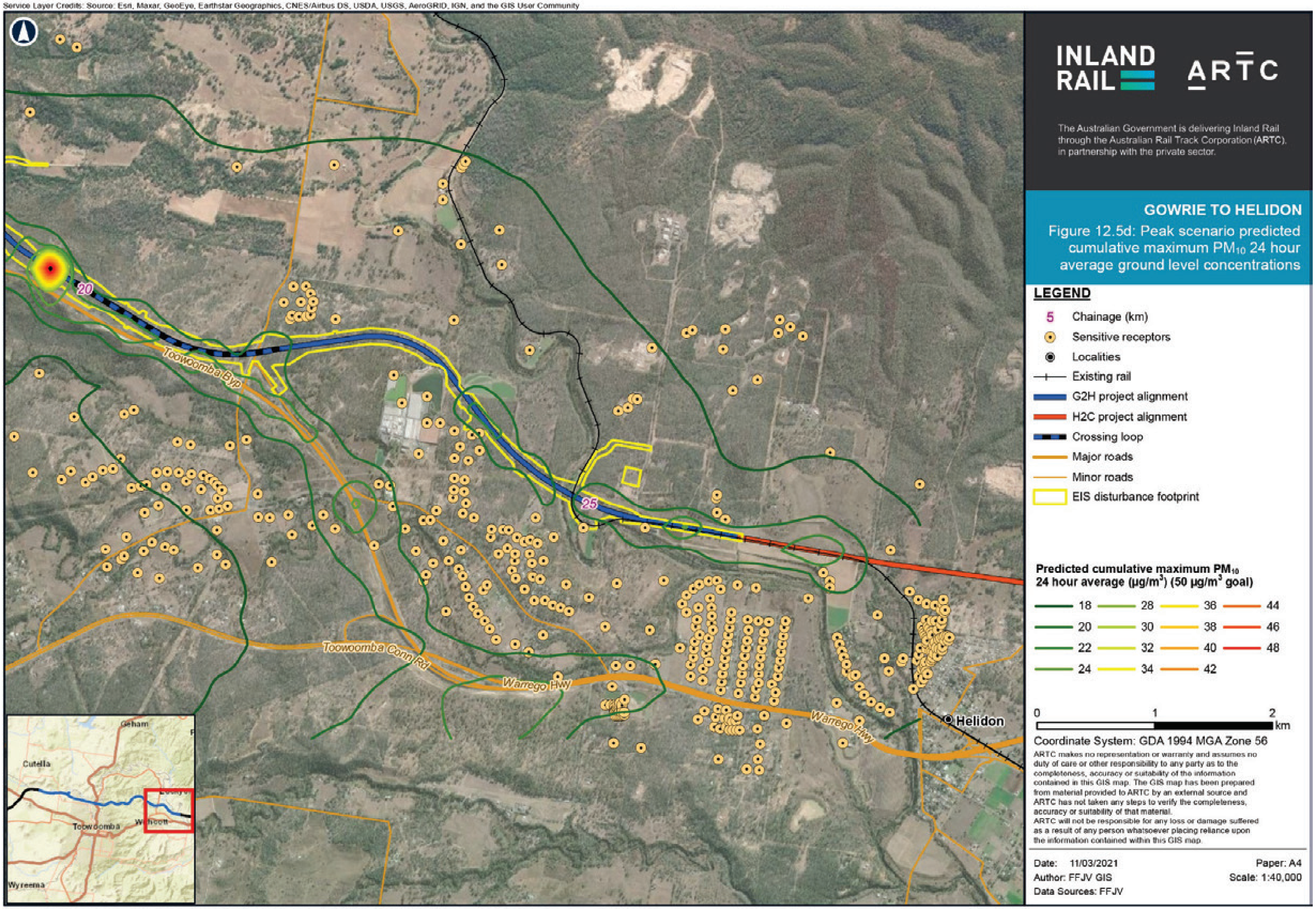

Figure 12.5d: Peak scenario predicted cumulative maximum PM_{10} 24 hour average ground level concentrations

Map by: MEF/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.5_Peak_PM10_v5.mxd Date: 11/03/2021 10:39

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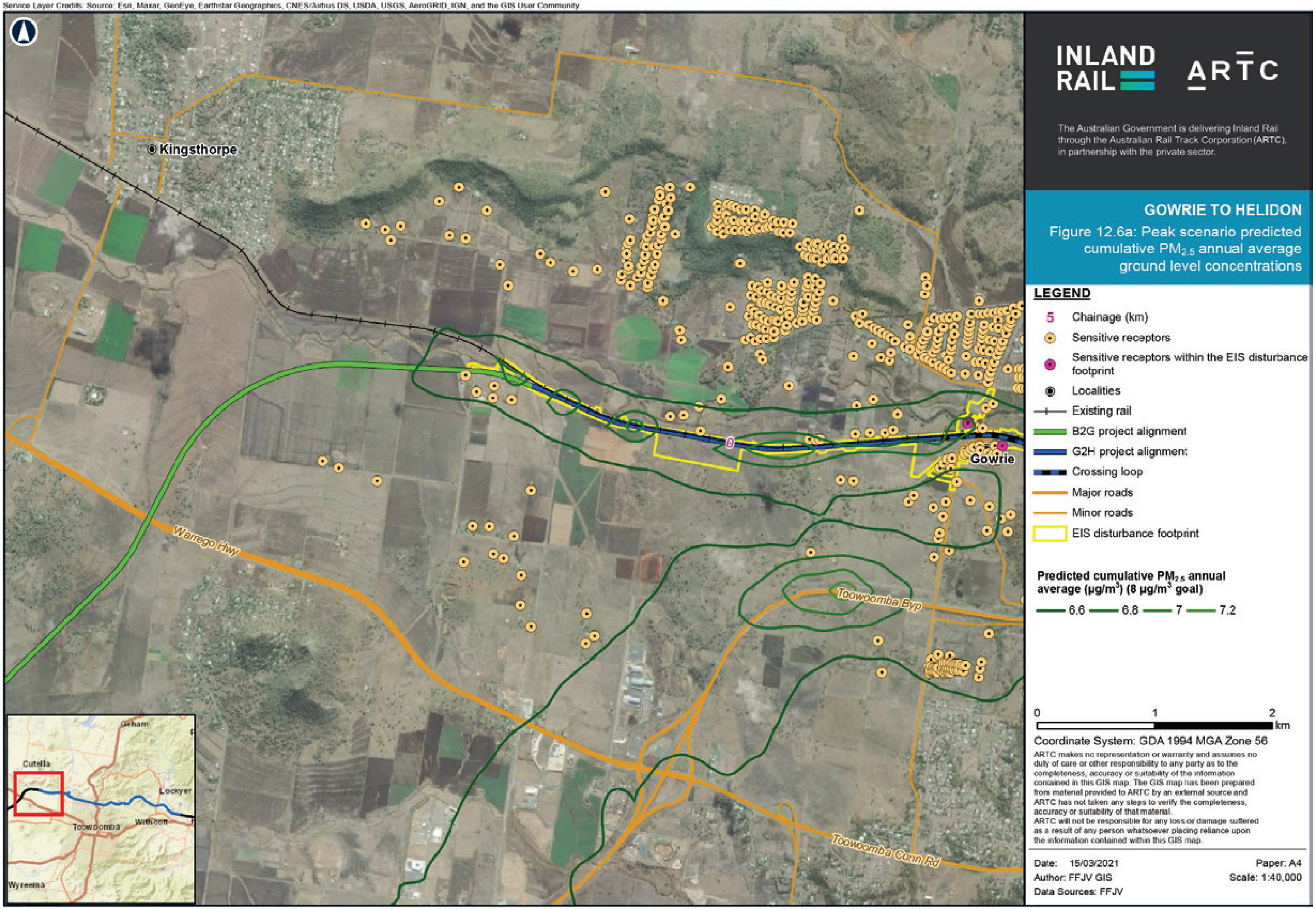

GOWRIE TO HELIDON

Figure 12.6a: Peak scenario predicted cumulative $PM_{2.5}$ annual average ground level concentrations

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.6_Peak_PM25_v5.mxd Date: 15/03/2021 10:38

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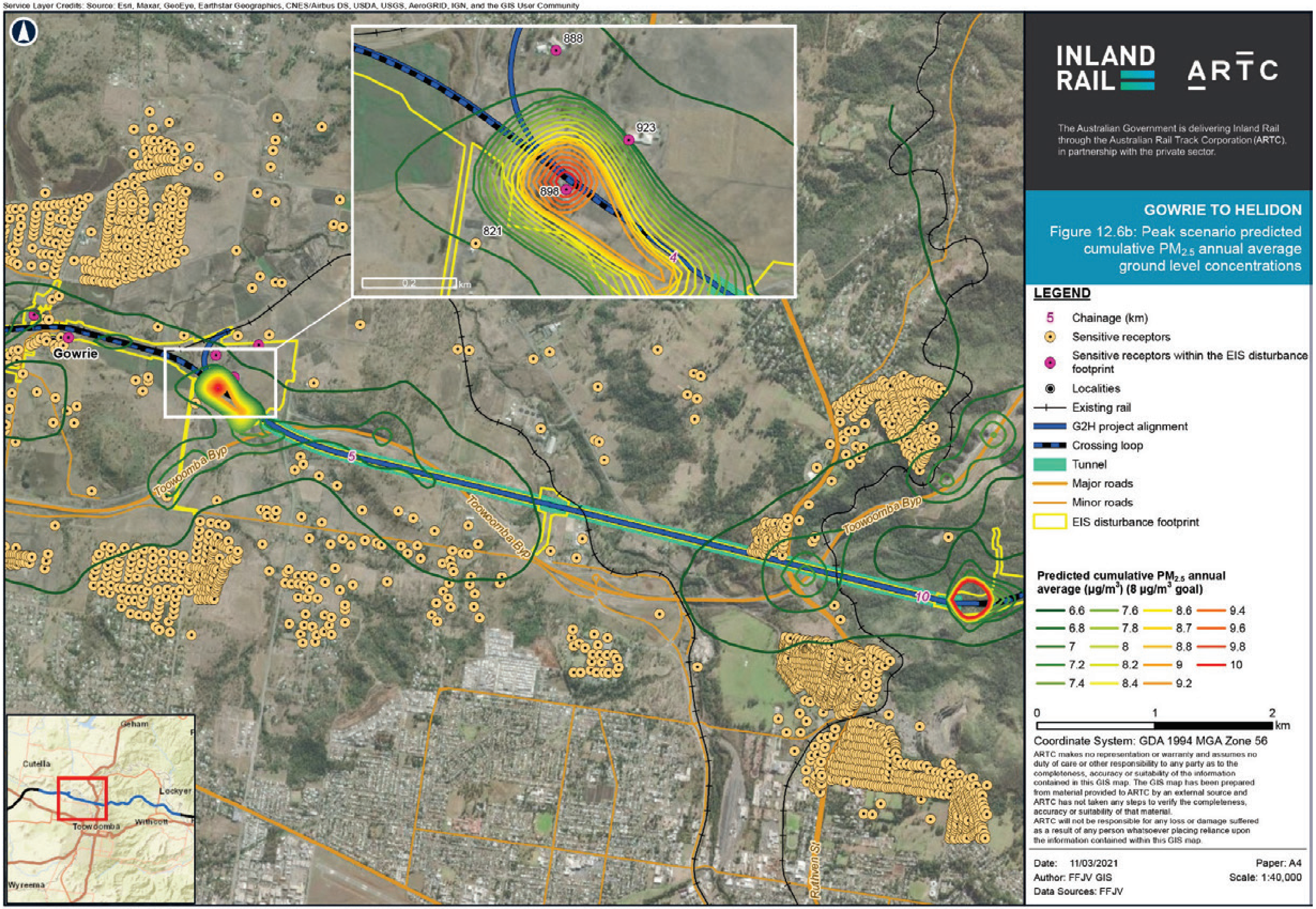

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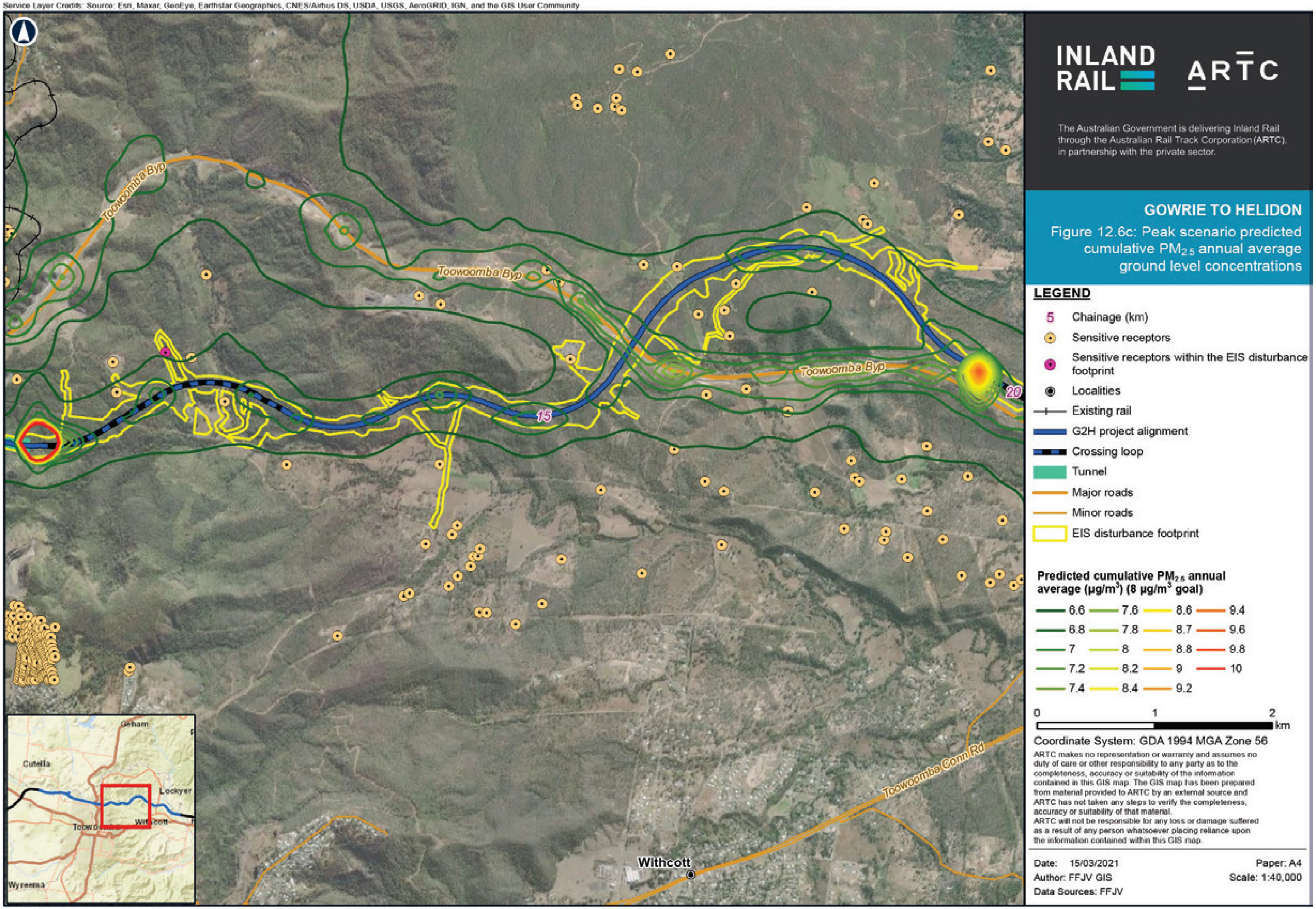

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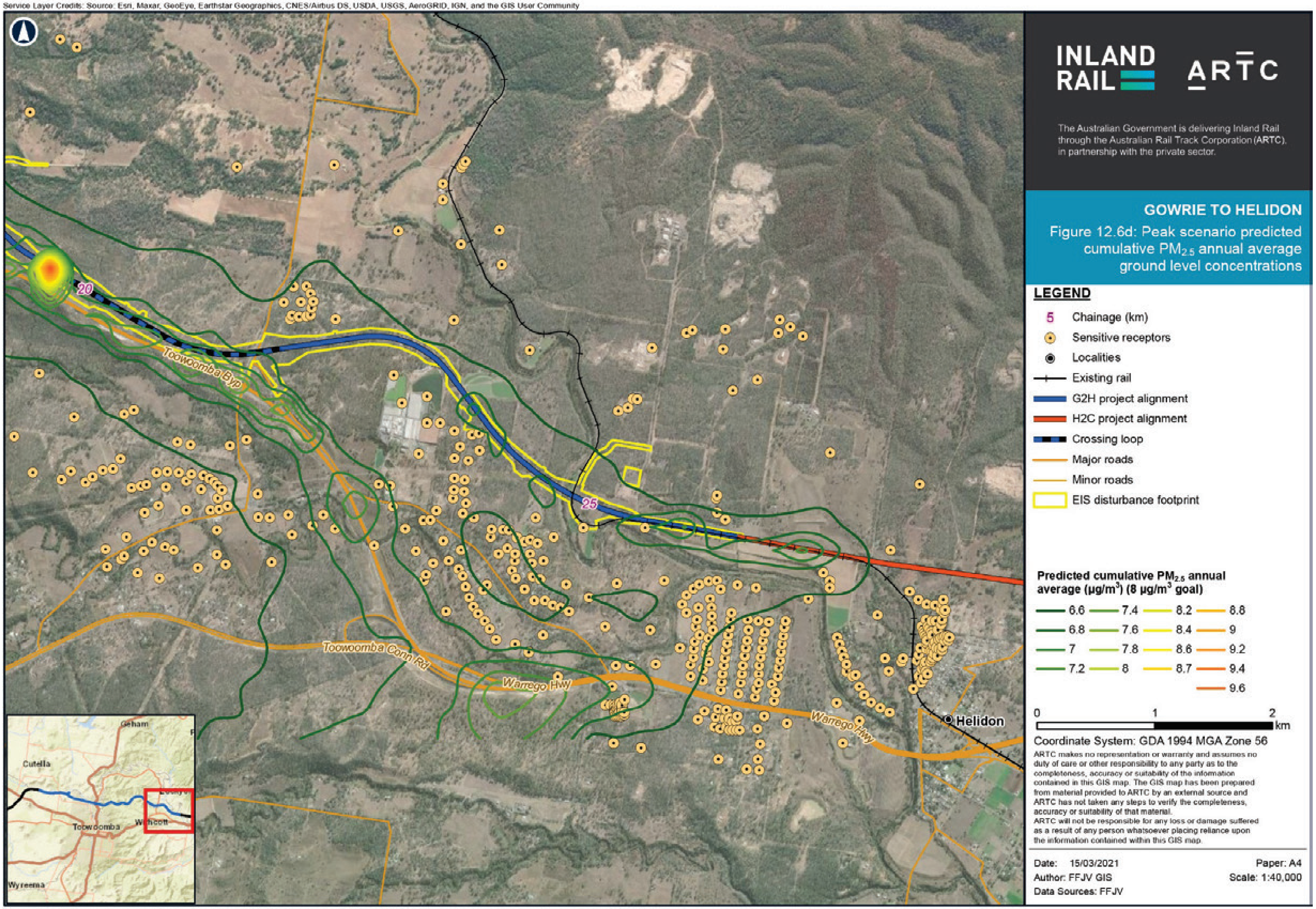

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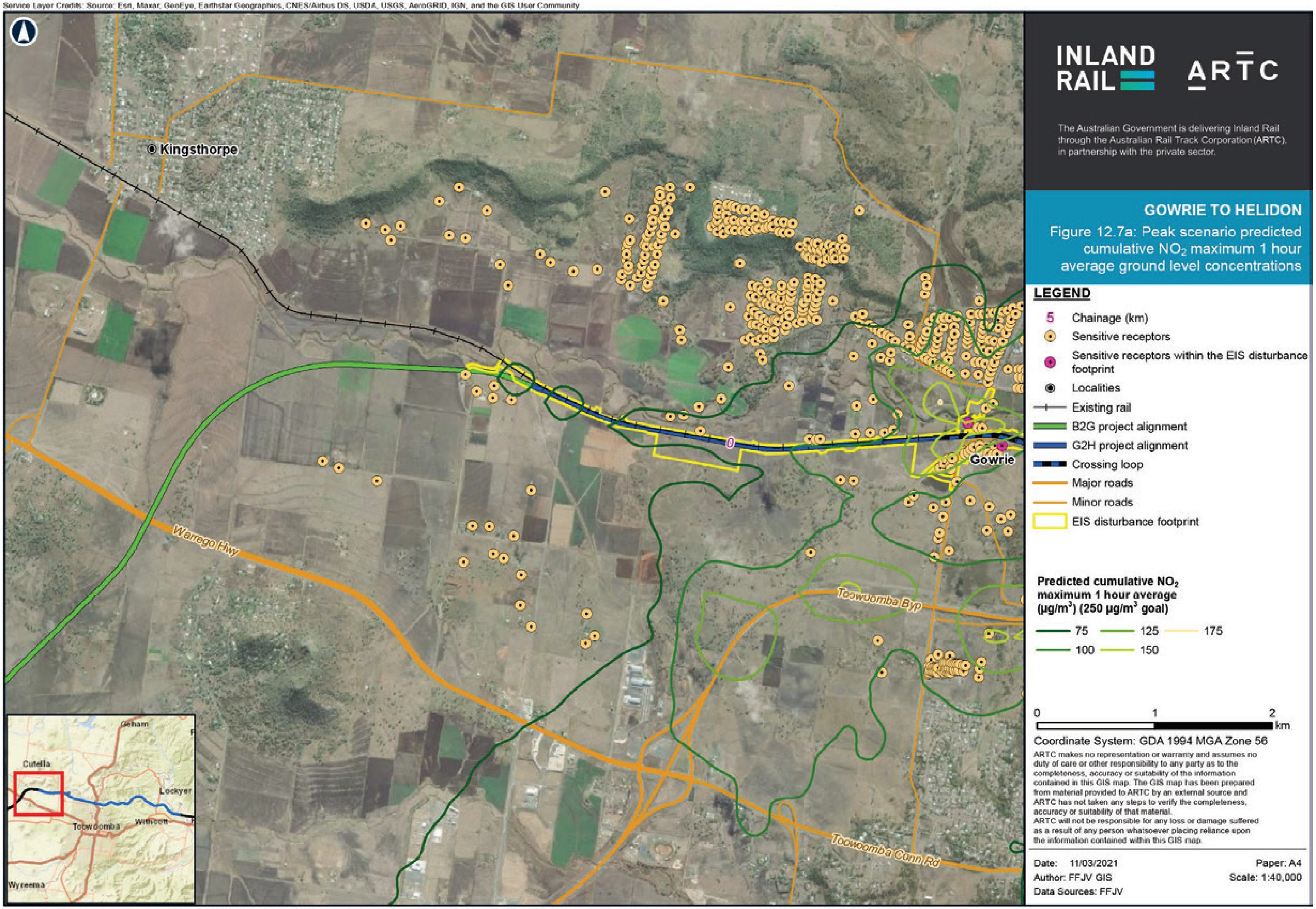

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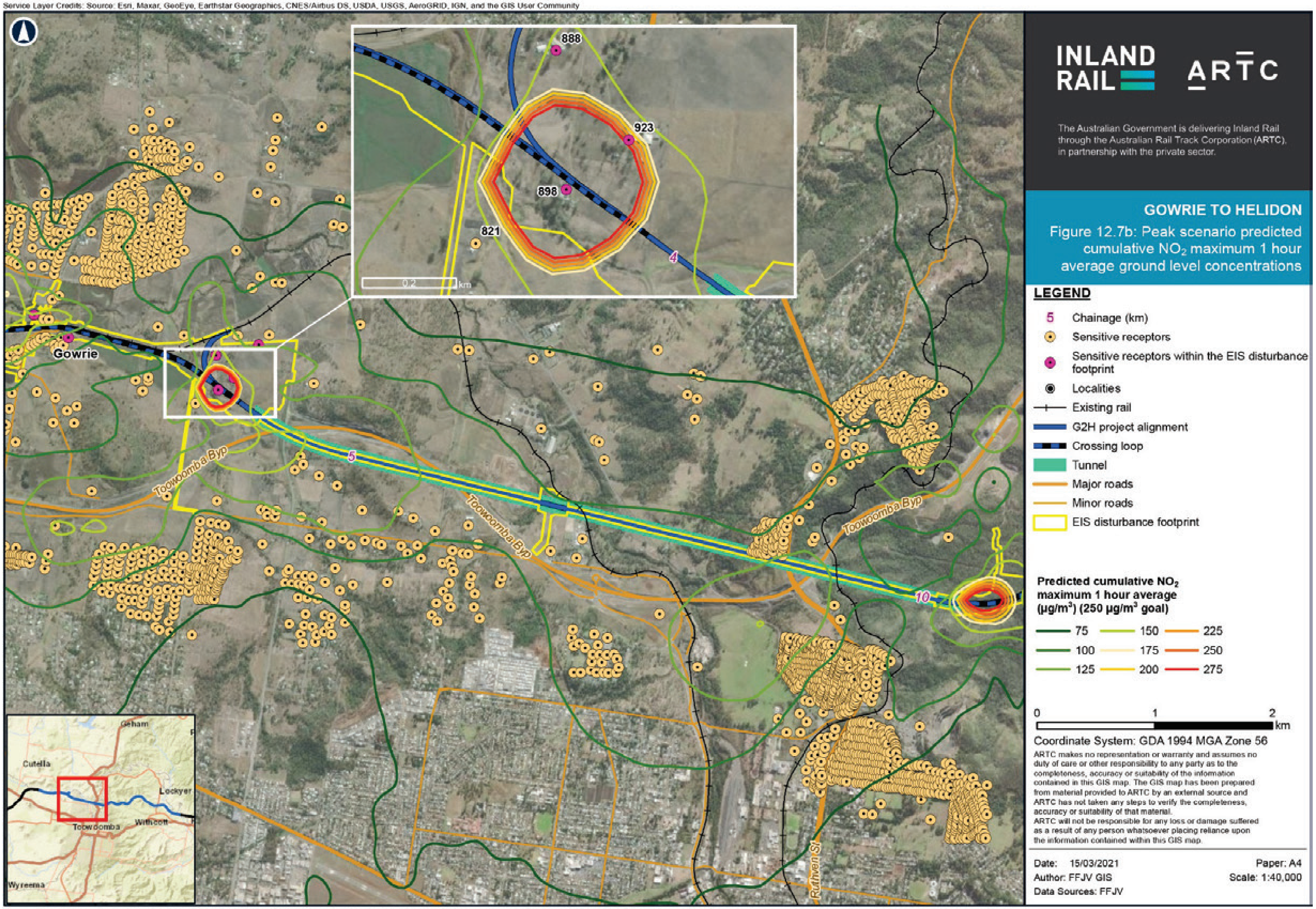

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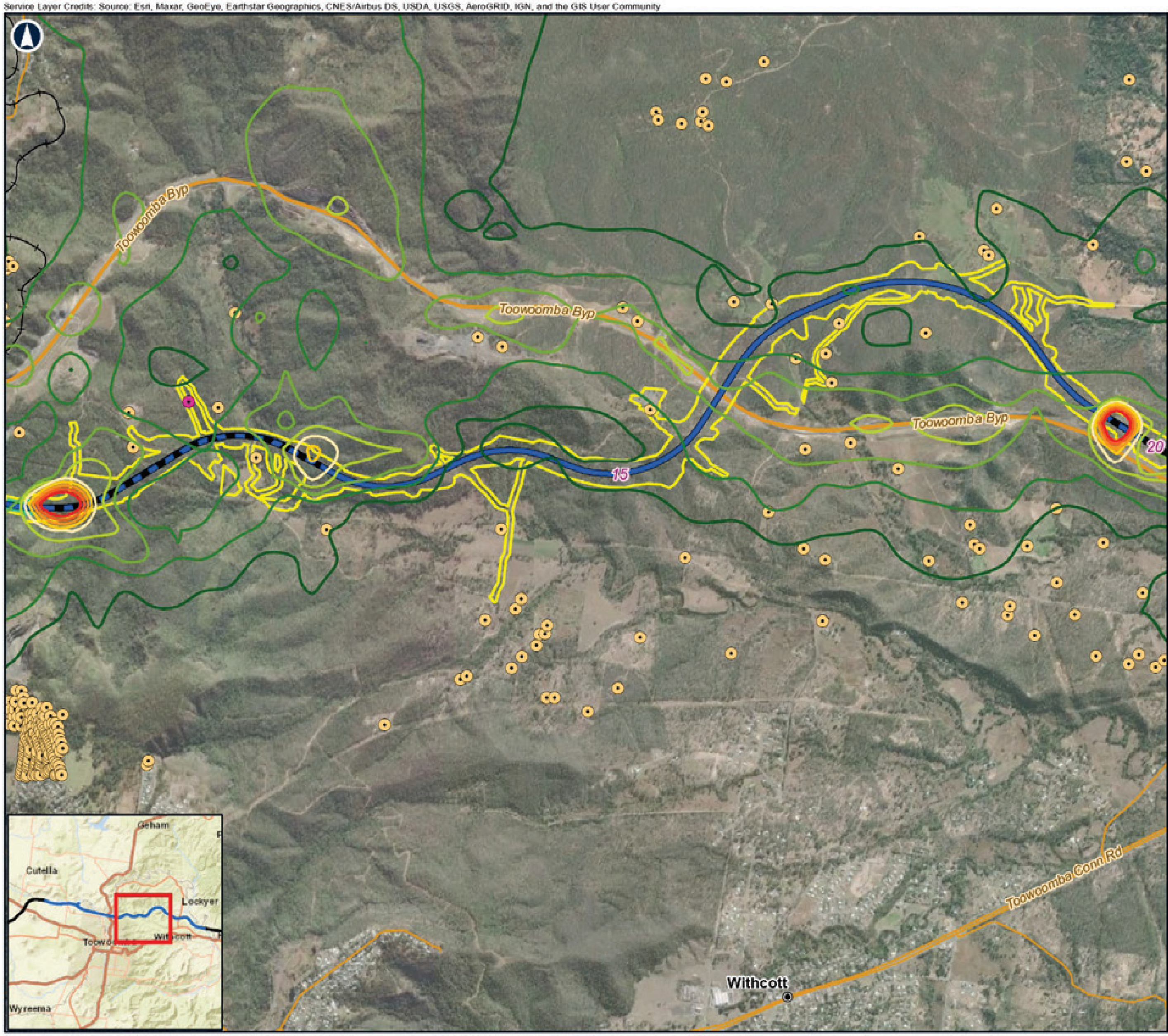

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GOWRIE TO HELIDON

Figure 12.7c: Peak scenario predicted cumulative NO_2 maximum 1 hour average ground level concentrations

LEGEND

- 5 Chainage (km)
- Sensitive receptors
- Sensitive receptors within the EIS disturbance footprint
- Localities
- Existing rail
- G2H project alignment
- Crossing loop
- Tunnel
- Major roads
- Minor roads
- EIS disturbance footprint

Predicted cumulative NO_2 maximum 1 hour average ($\mu g/m^3$) (250 $\mu g/m^3$ goal)

75, 100, 125, 150, 175, 200, 225, 250, 275

0 1 2 km

Coordinate System: GDA 1994 MGA Zone 56

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Author: FFJV GIS Scale: 1:40,000
Data Sources: FFJV

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.7_Peak_NO2_v5.mxd Date: 11/03/2021 11:30

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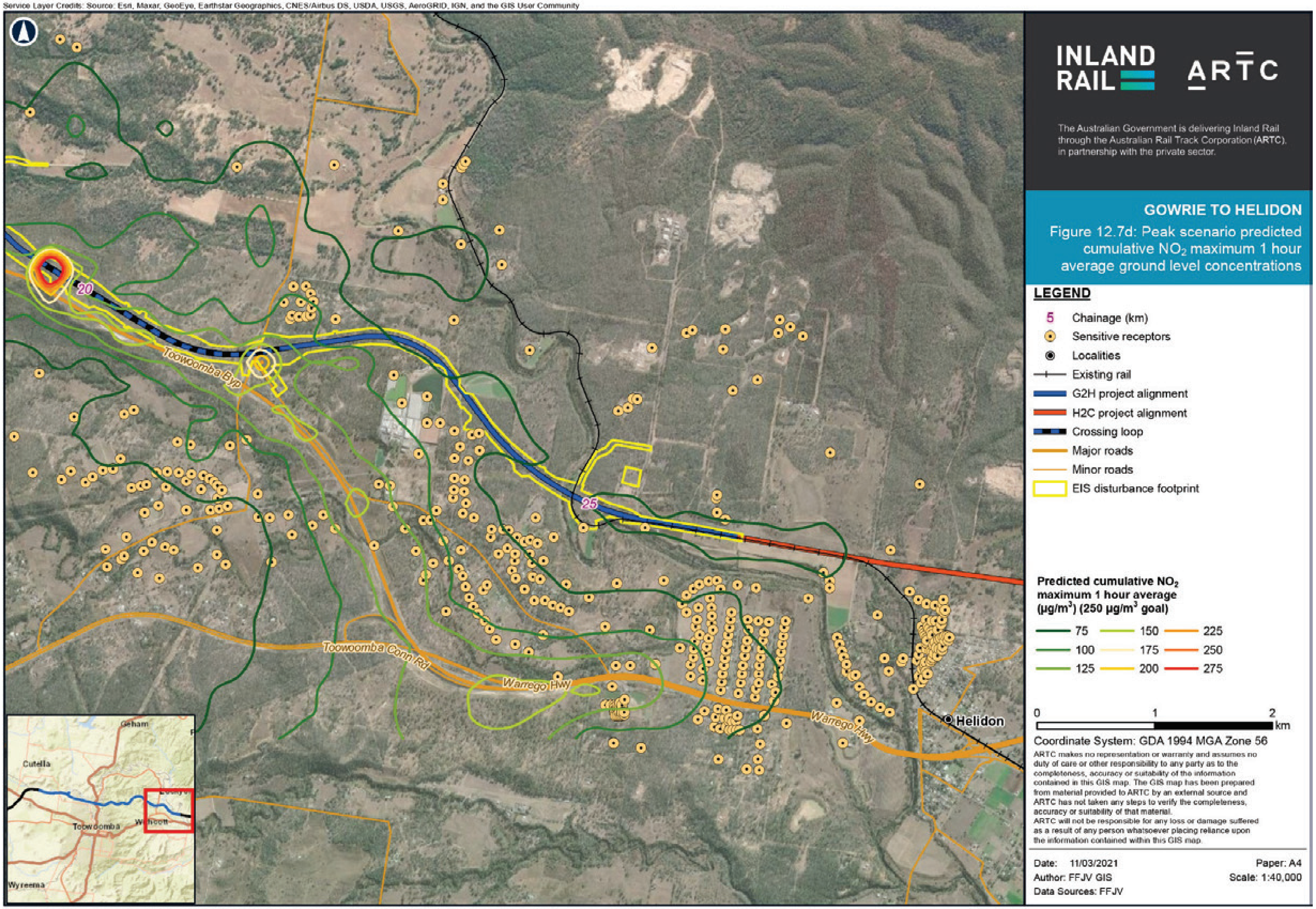
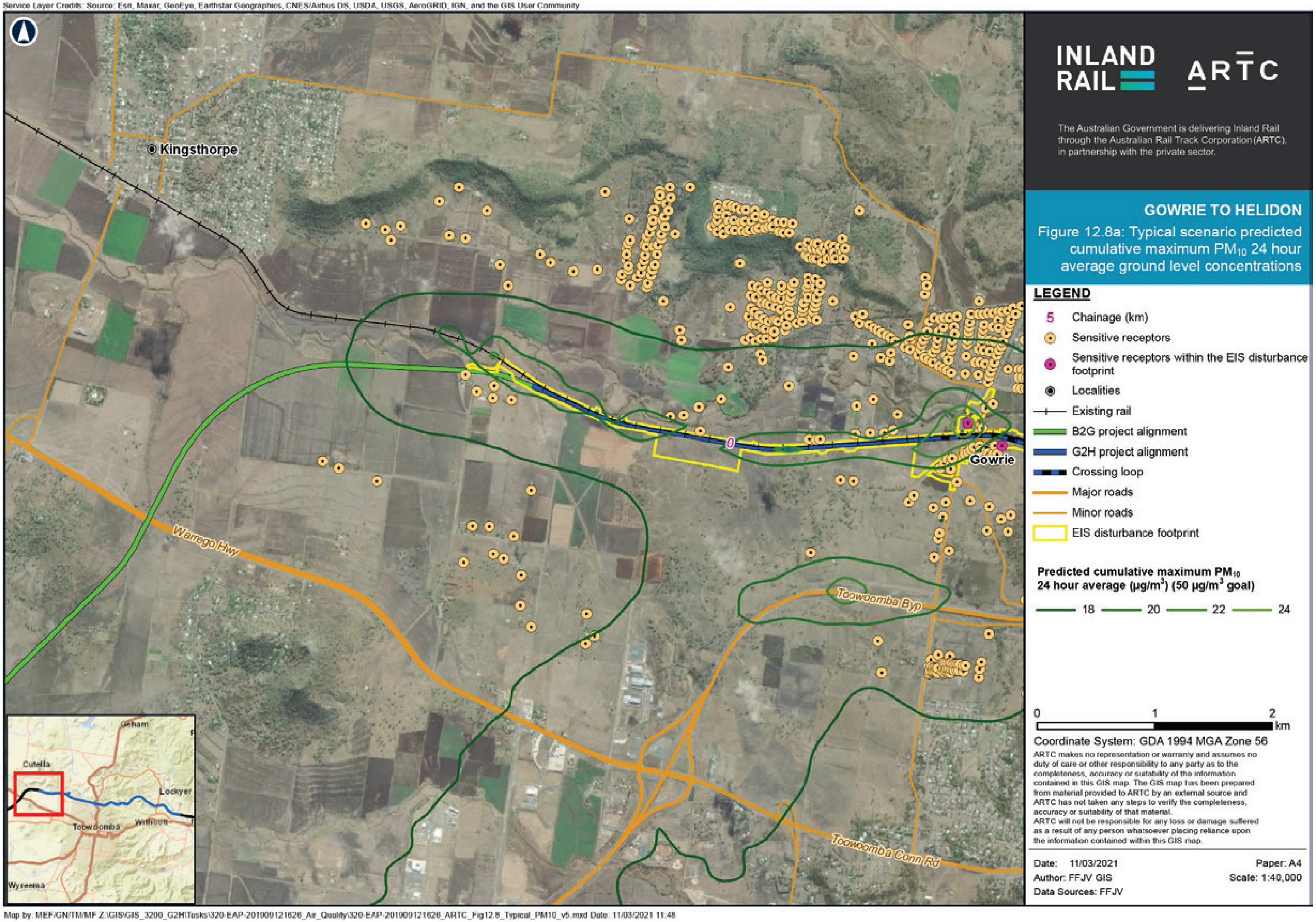


Figure 12.7d: Peak scenario predicted cumulative NO_2 maximum 1 hour average ground level concentrations

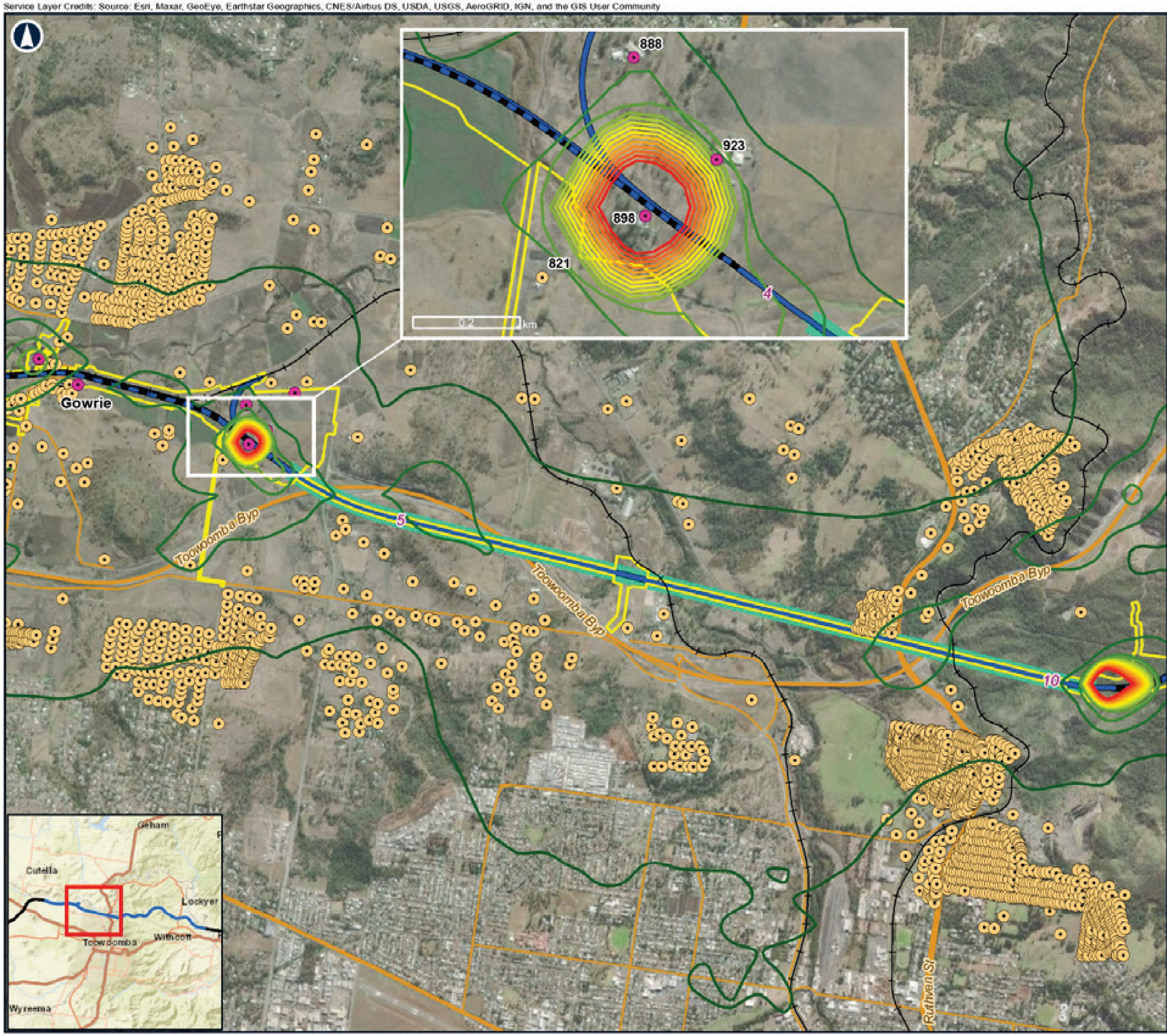
Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.7_Peak_NO2_v5.mxd Date: 11/03/2021 11:30



GOWRIE TO HELIDON

Figure 12.8a: Typical scenario predicted cumulative maximum PM_{10} 24 hour average ground level concentrations

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



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GOWRIE TO HELIDON

Figure 12.8b: Typical scenario predicted cumulative maximum PM_{10} 24 hour average ground level concentrations

LEGEND

- 5 Chainage (km)
- Sensitive receptors
- Sensitive receptors within the EIS disturbance footprint
- Localities
- Existing rail
- G2H project alignment
- Crossing loop
- Tunnel
- Major roads
- Minor roads
- EIS disturbance footprint

Predicted cumulative maximum PM_{10} 24 hour average ($\mu g/m^3$) (50 $\mu g/m^3$ goal)

18, 20, 22, 24, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48

0 1 2 km

Coordinate System: GDA 1994 MGA Zone 56

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Date: 15/03/2021
Author: FFJV GIS
Data Sources: FFJV
Paper: A4
Scale: 1:40,000

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.8b_Typical_PM10_v5.mxd Date: 15/03/2021 11:16

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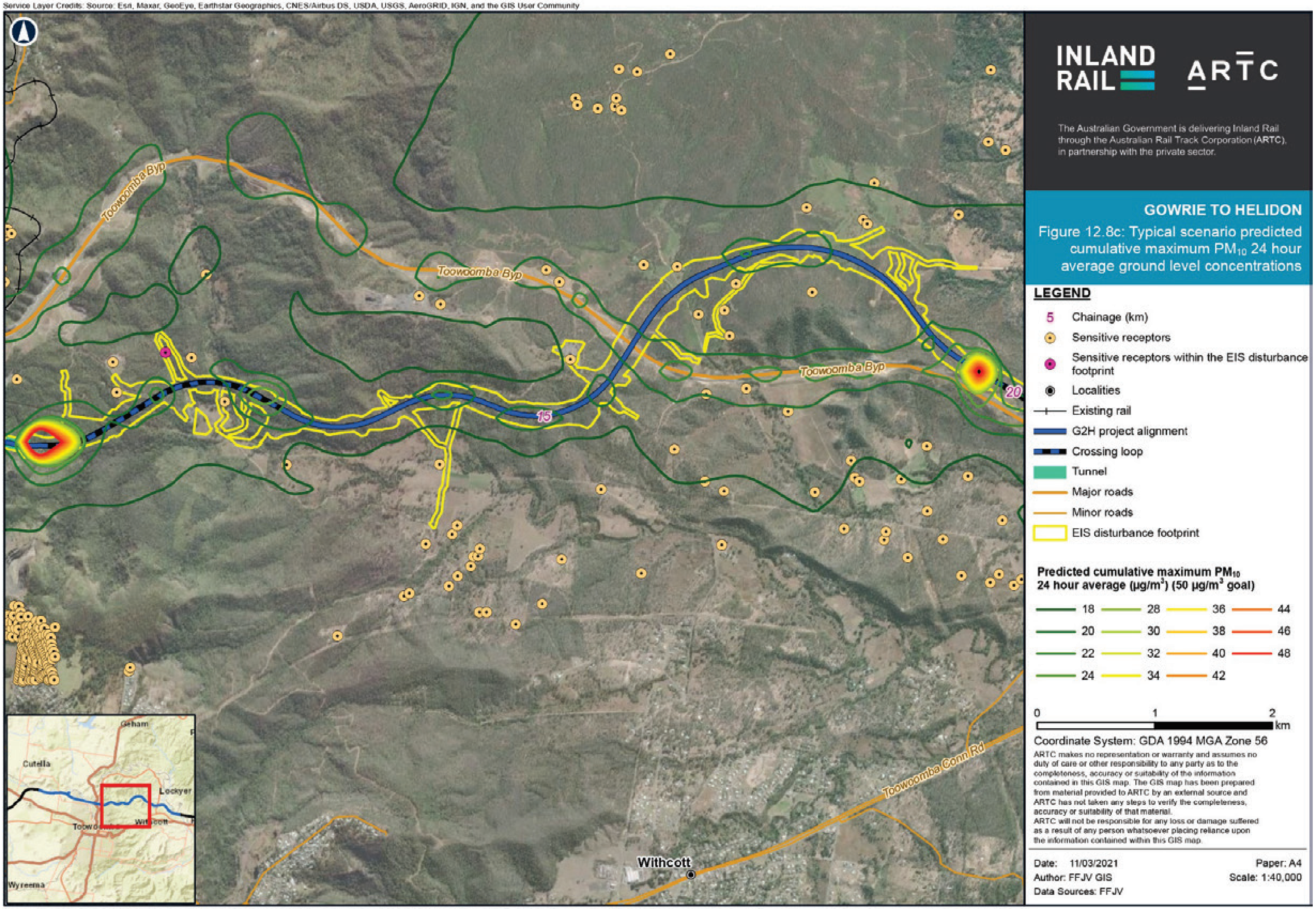

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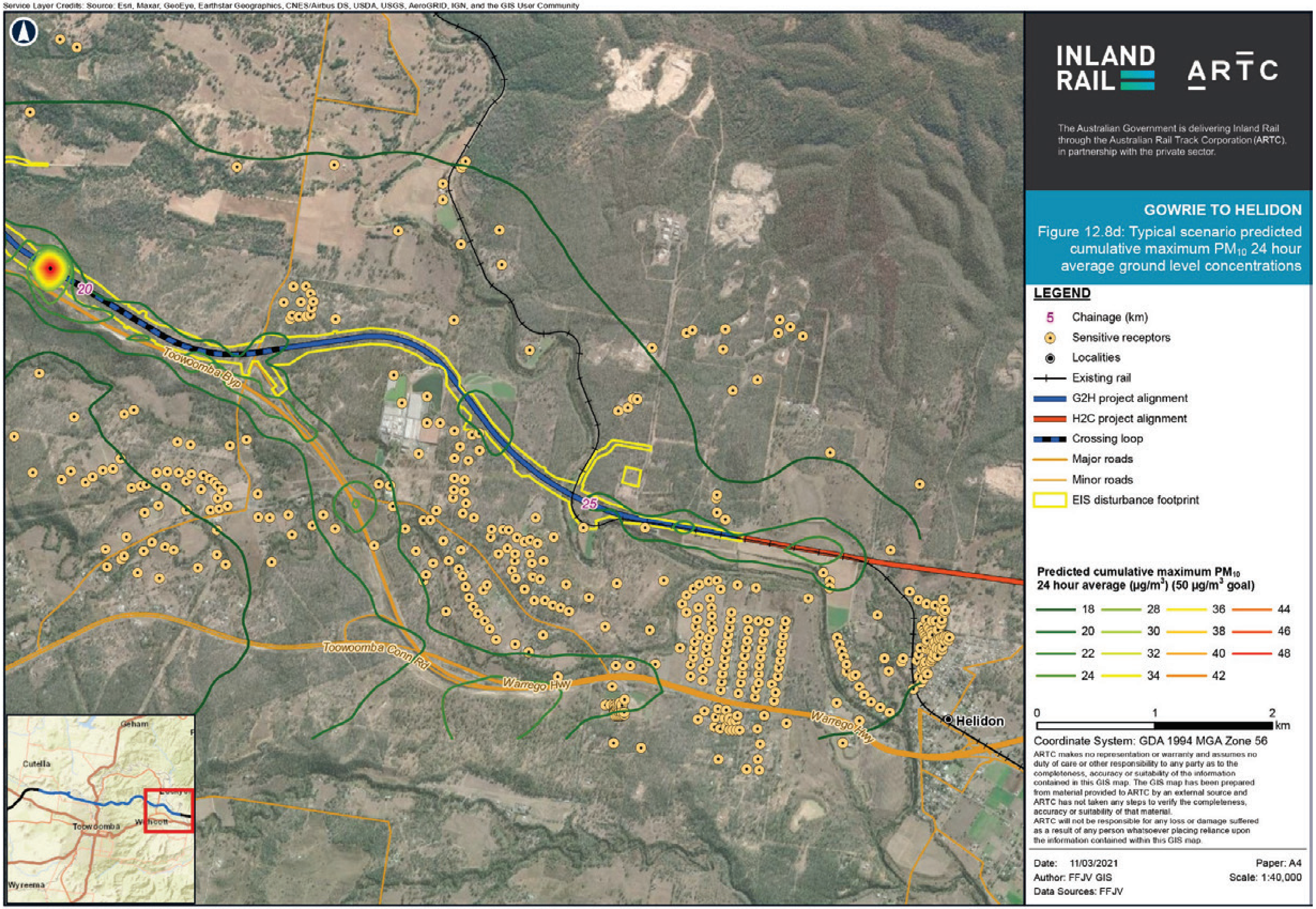
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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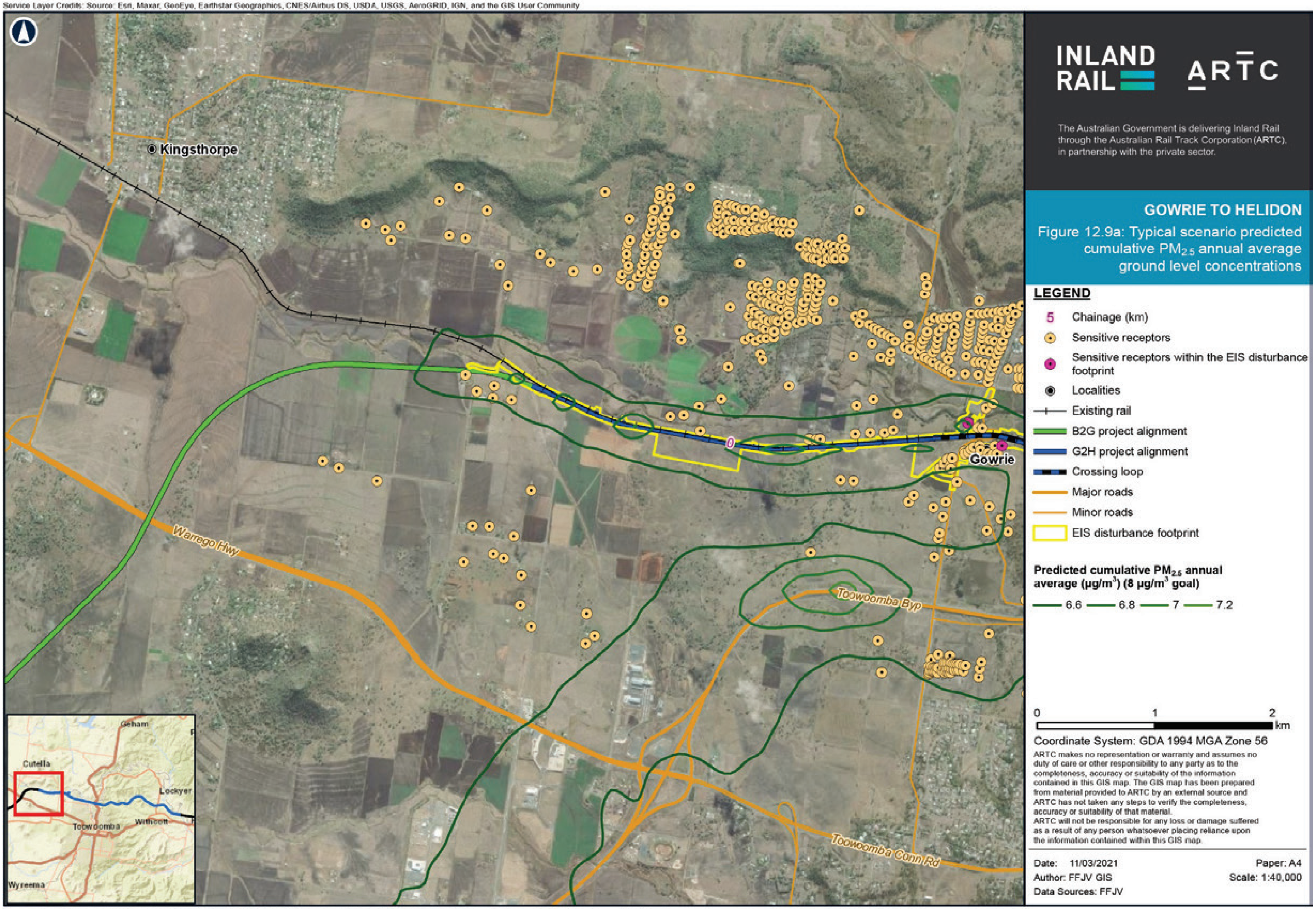

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.9_Typical_PM25_v5.mxd Date: 11/03/2021 12:21

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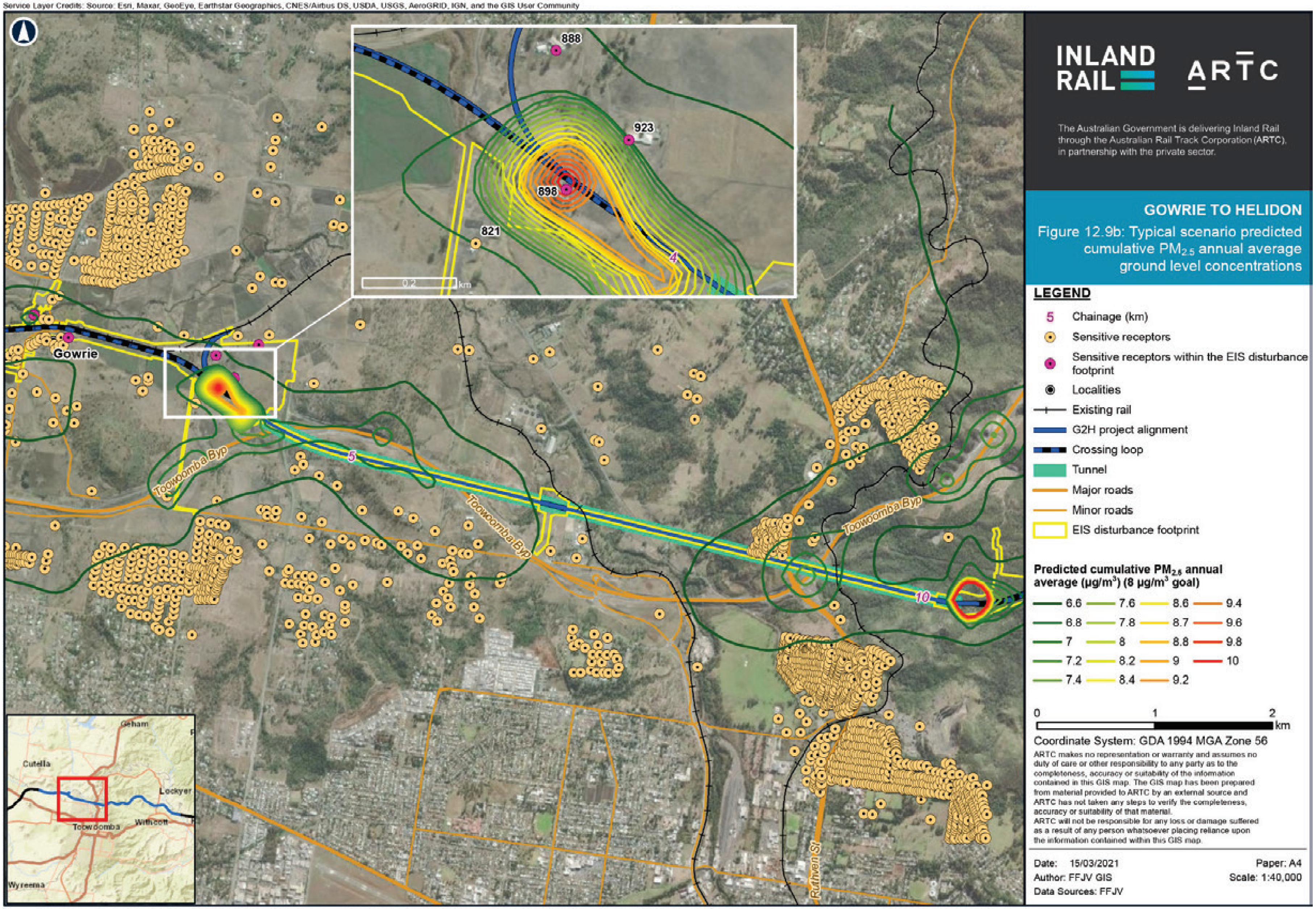

Figure 12.9b: Typical scenario predicted cumulative $PM_{2.5}$ annual average ground level concentrations

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.9b_Typical_PM25_v5.mxd Date: 15/03/2021 11:12

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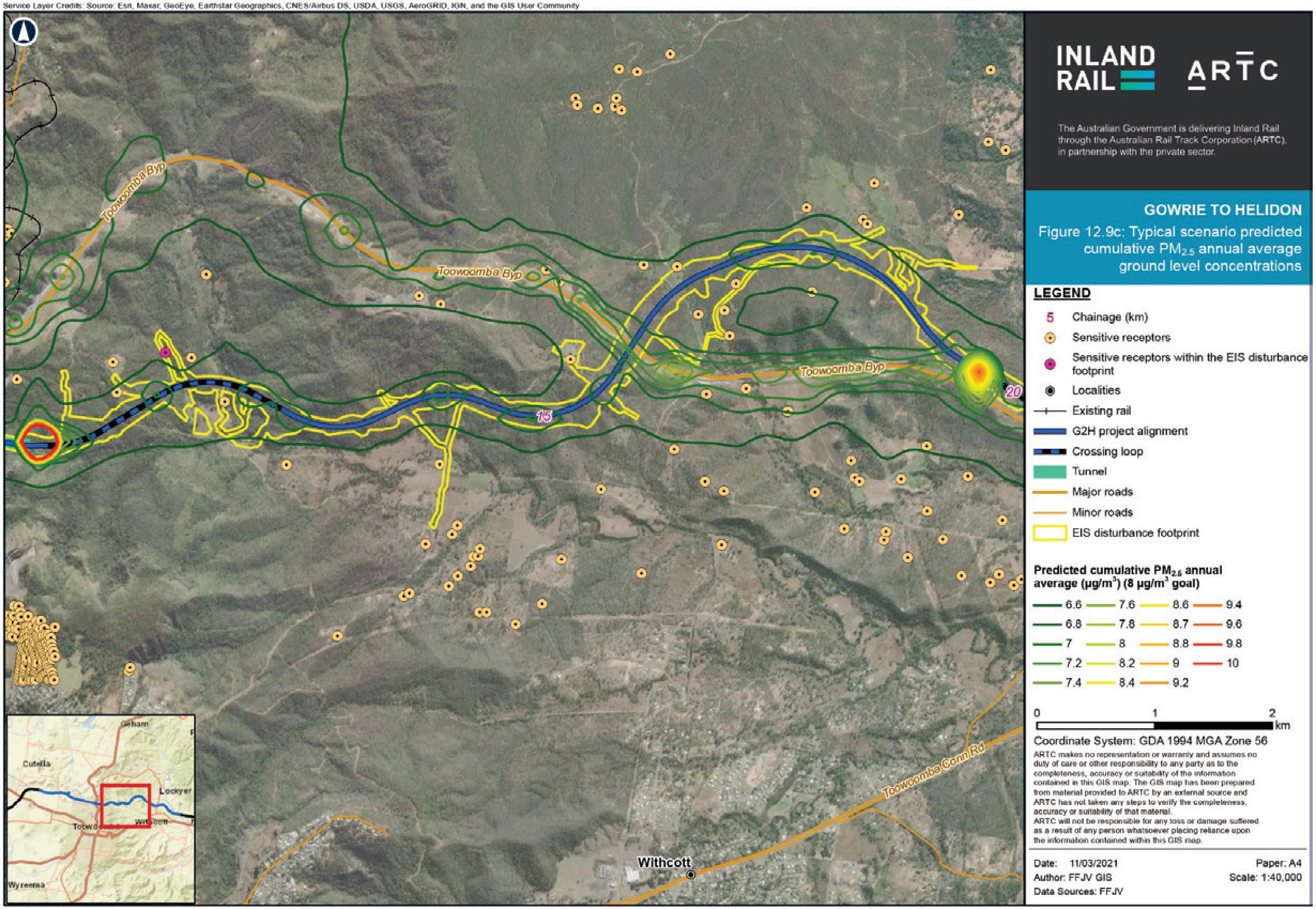

Figure 12.9c: Typical scenario predicted cumulative $PM_{2.5}$ annual average ground level concentrations

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.9_Typical_PM25_v5.mxd Date: 11/03/2021 12:21

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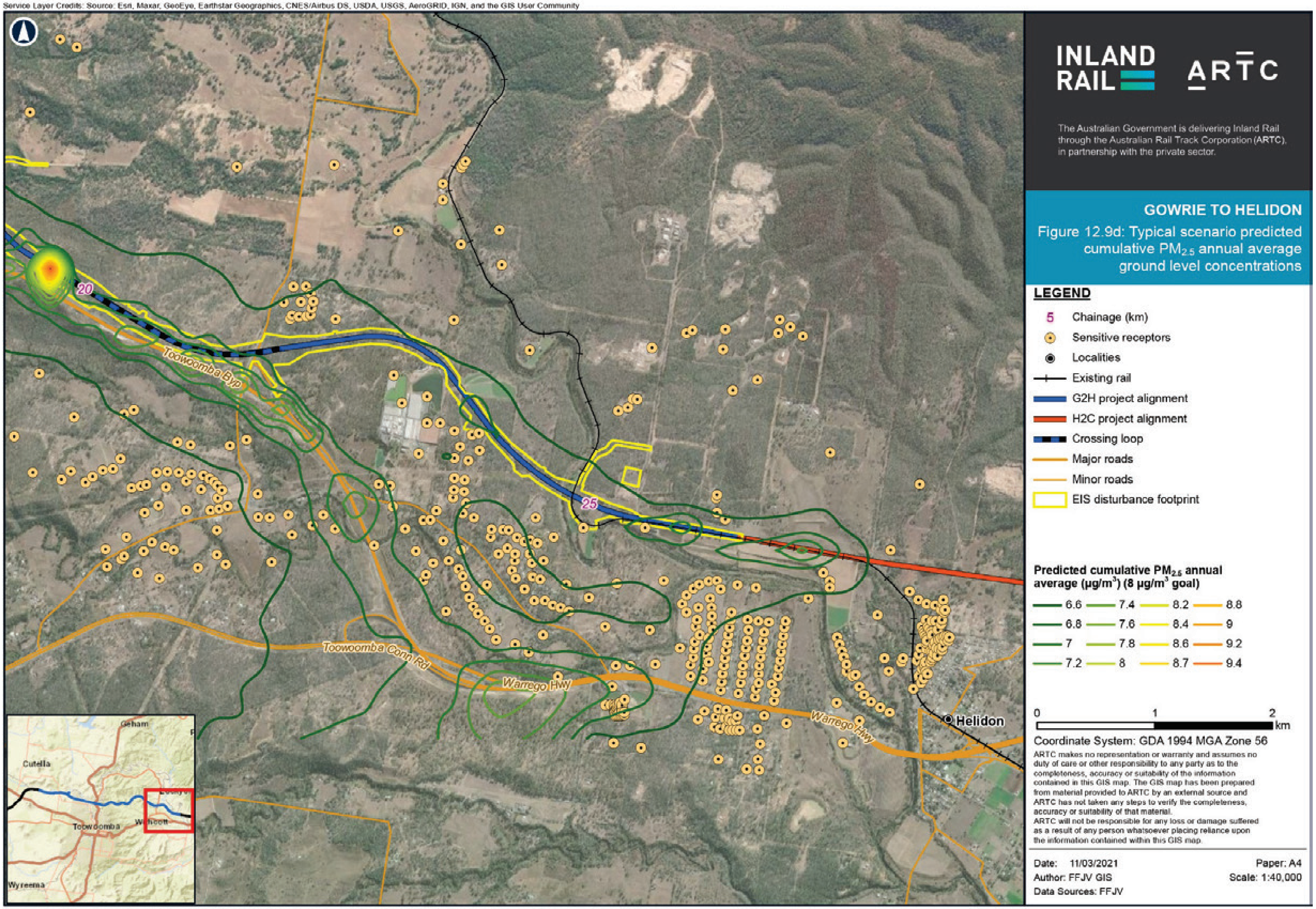

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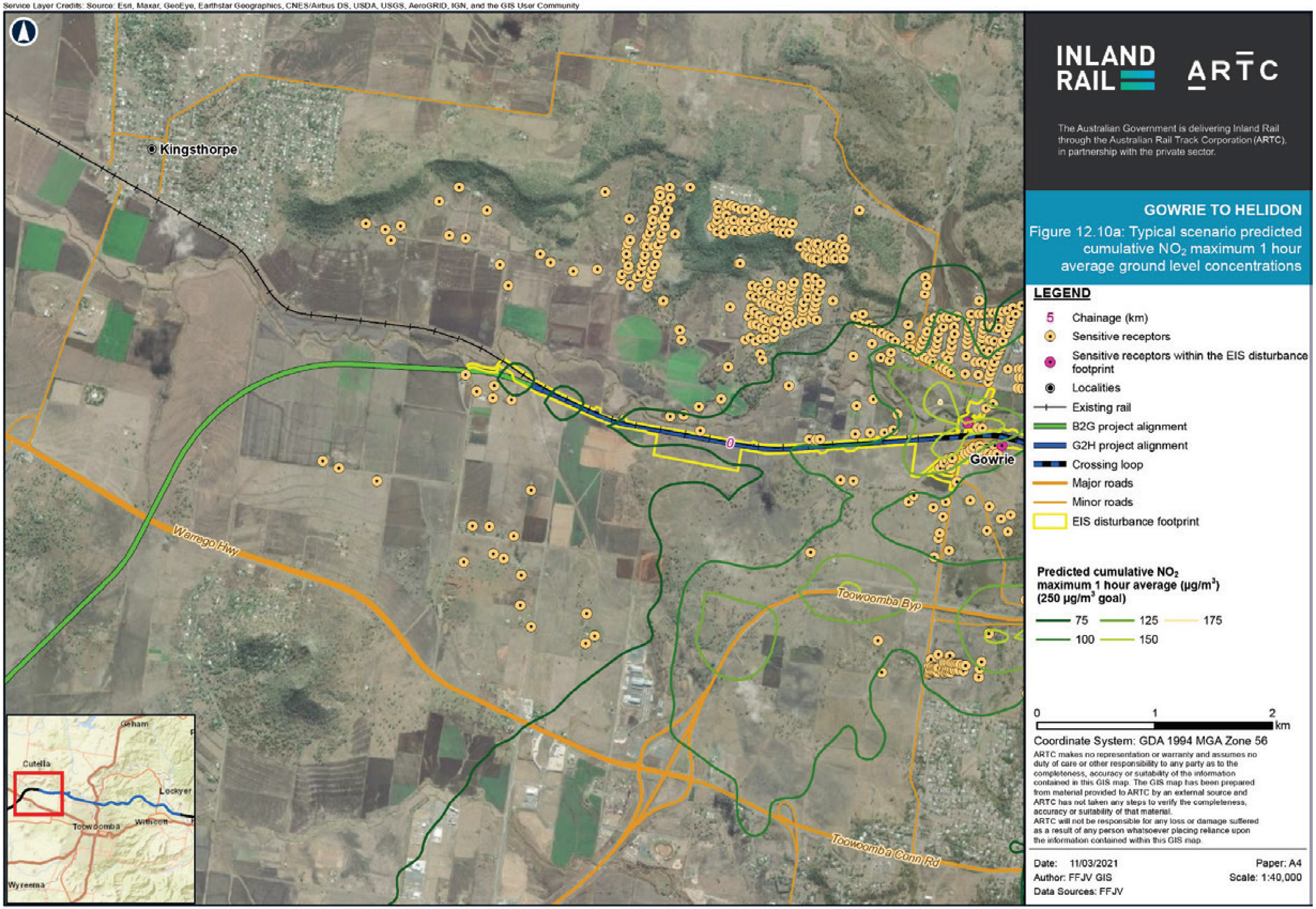

GOWRIE TO HELIDON

Figure 12.10a: Typical scenario predicted cumulative NO_2 maximum 1 hour average ground level concentrations

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.10_Typical_NO2_v5.mxd Date: 11/03/2021 12:25

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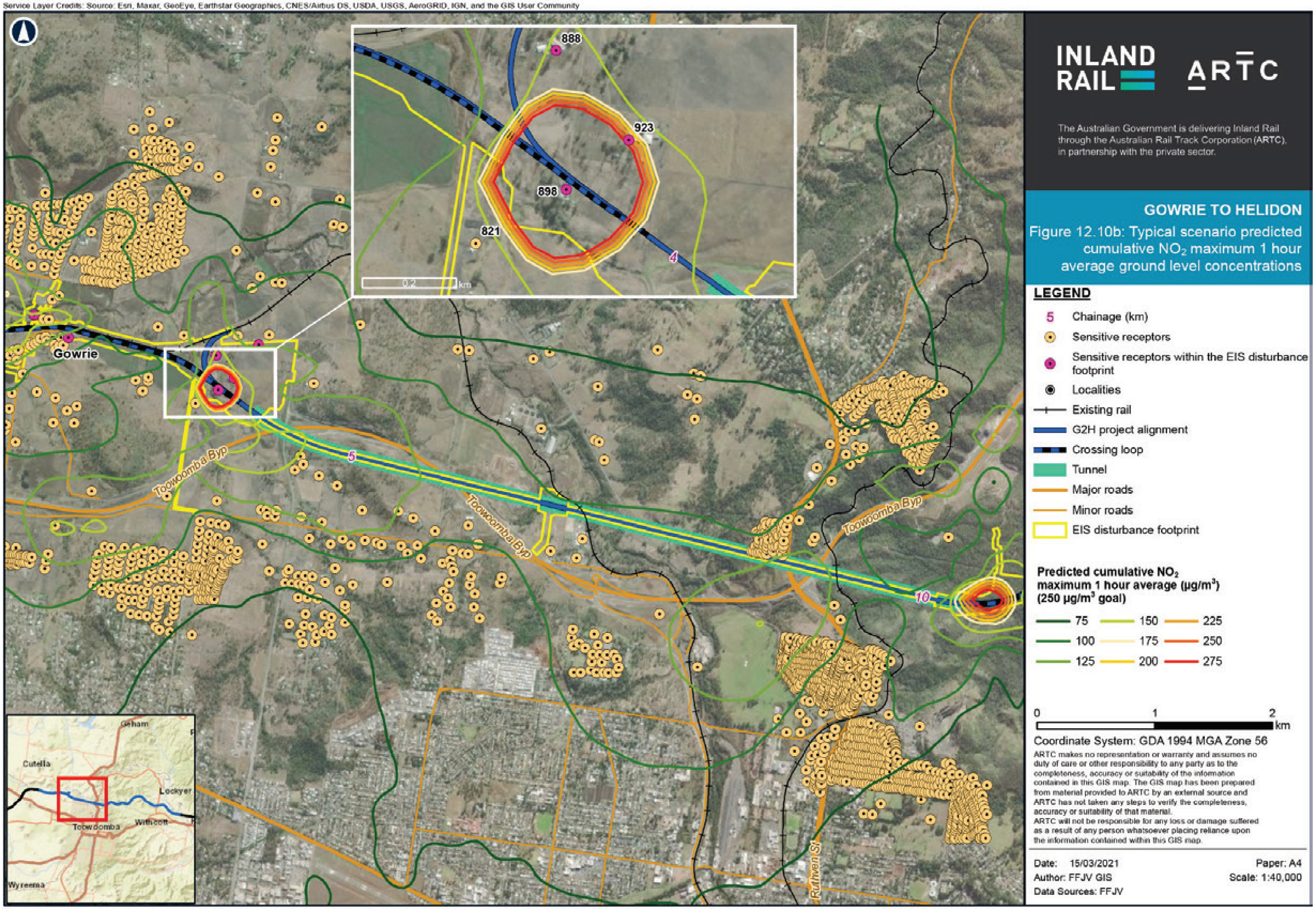

Figure 12.10b: Typical scenario predicted cumulative NO_2 maximum 1 hour average ground level concentrations

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.10b_Typical_NO2_v5.mxd Date: 11/03/2021 12:30

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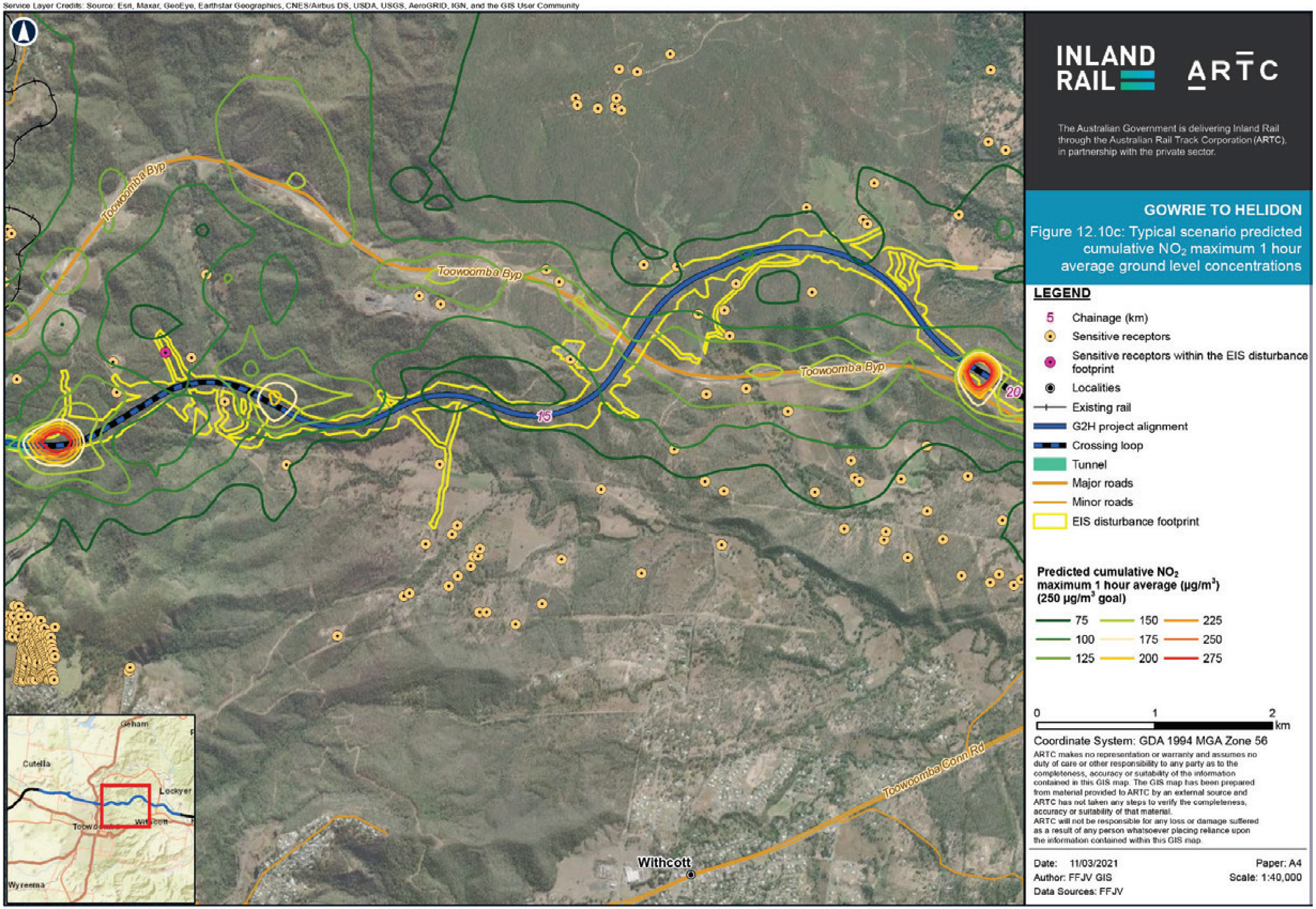

Figure 12.10c: Typical scenario predicted cumulative NO_2 maximum 1 hour average ground level concentrations

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.10_Typical_NO2_v5.mxd Date: 11/03/2021 12:25

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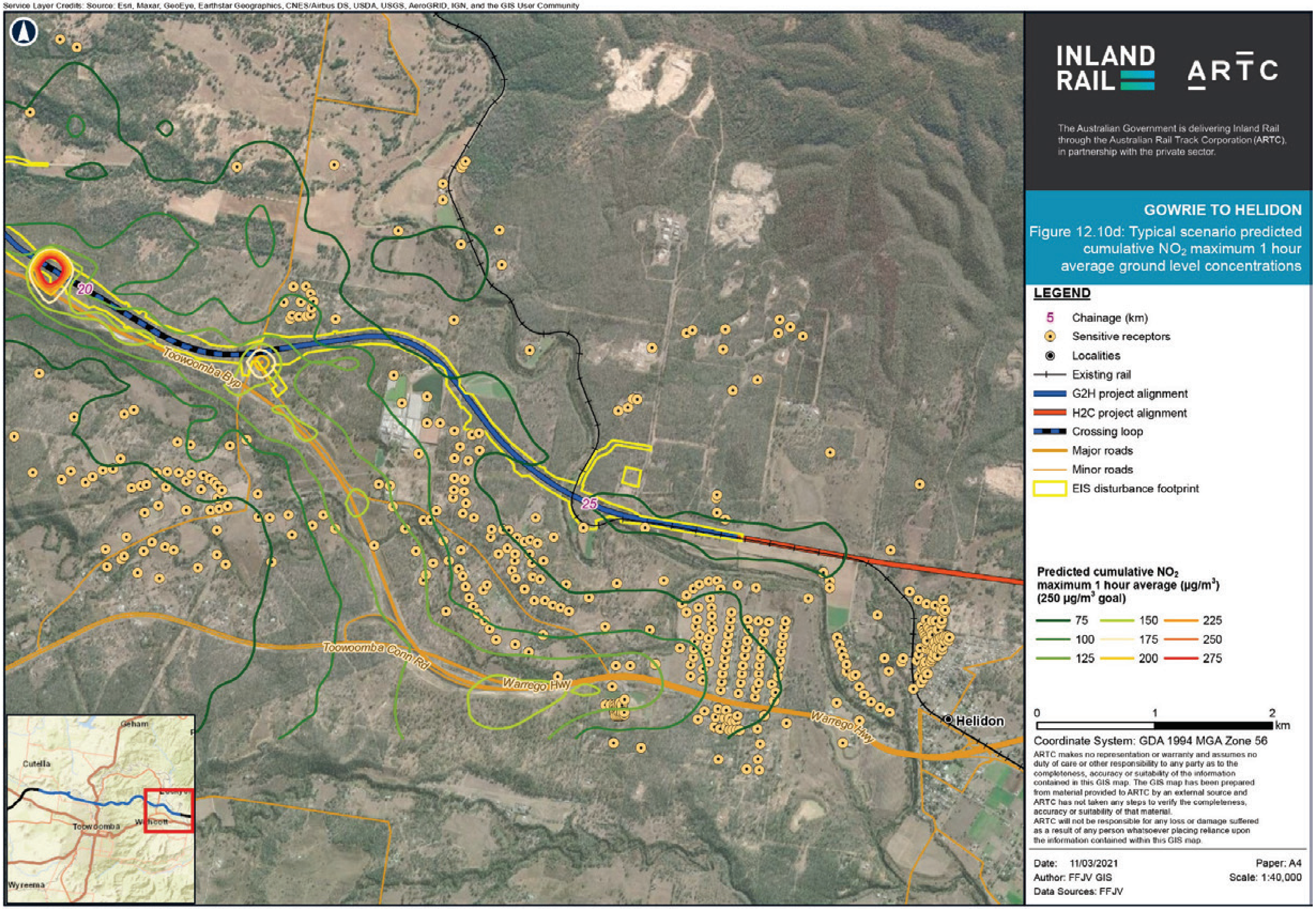

Figure 12.10d: Typical scenario predicted cumulative NO_2 maximum 1 hour average ground level concentrations

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.10_Typical_NO2_v5.mxd Date: 11/03/2021 12:25

Discussion of impacts to receptors near the Harlaxton Quarry

Figure 12.5b, Figure 12.6b, Figure 12.8b and Figure 12.9b show the predicted concentration contours for PM_{10} (24 hour) and $PM_{2.5}$ (annual) for the AQIA study area, which includes the Harlaxton Quarry. It is evident from these contour plots that predicted concentrations at the sensitive receptors located near the Harlaxton Quarry are well below the relevant air quality goals, and are close to the assumed background concentrations for each pollutant (18.4 µg/m^3 for PM_{10} 24 hour, 7.3 µg/m^3 for $PM_{2.5}$ annual) for both the peak and typical assessment scenarios.

The nearest sensitive receptor to the Project that is near the quarry is receptor R_1924, which represents a residential dwelling located on Gilmour Court, Harlaxton. Receptor R_1924 is located approximately 730m to the southwest of the eastern tunnel portal. To review the potential risk of significant cumulative impacts at this sensitive receptor and other sensitive receptors near the quarry, the predicted Project contribution to TSP, PM_{10}, $PM_{2.5}$ and dust deposition, has been reviewed for receptor R_1924. The predicted Project contributions for the peak operations scenario at receptor R_1924 are summarised as follows:

- TSP annual average: 0.15 µg/m^3 with veneering (0.2 per cent of goal), 0.39 µg/m^3 without veneering (0.4 per cent of goal)
- PM_{10} annual average: 0.11 µg/m^3 with veneering (0.4 per cent of goal), 0.23 µg/m^3 without veneering (0.9 per cent of goal)
- PM_{10} 24 hour maximum: 0.71 µg/m^3 with veneering (1.4 per cent of goal), 1.19 µg/m^3 without veneering (2.4 per cent of goal)
- $PM_{2.5}$ annual average: 0.07 µg/m^3 with veneering (0.9 per cent of goal), 0.09 µg/m^3 without veneering (1.1 per cent of goal)
- Dust deposition: 0.01 mg/m^2/day with veneering (0.01 per cent of goal), 0.03 mg/m^2/day without veneering (0.03 per cent of goal).

Based on the Project contributions and percentage proportion of the relevant air quality goals, it is considered that the Project's contribution to pollutant concentration and deposition levels at the nearest sensitive receptors to the quarry will be minimal. Therefore, the risk of significant cumulative impact at sensitive receptors as a result of the Project and the quarry is not considered to be significant.

Discussion of impacts to human health

All of the pollutant species considered in detail for the assessment of operational impacts are set for the protection of human health, with the exception of dust deposition and toluene (30-minute average). With the exception of receptor R_898, which is located within the permanent disturbance footprint and will be acquired for the Project, the predicted cumulative concentrations for all pollutants assessed are below the adopted air quality goals for both the peak and typical train volume scenarios for all sensitive receptors. The predicted cumulative concentrations for all pollutants are below the adopted air quality goals for all sensitive receptors outside the permanent disturbance footprint for the Project.

The assessment has considered background air quality in the prediction of cumulative concentrations and, therefore, the results of the assessment can be used to assess the impact on human health.

On the expectation that receptor R_898 is acquired, the operation of the Project is expected to comply with the adopted air quality goals for all sensitive receptors; therefore, the operation of the Project is not expected to significantly impact the environmental value of health and wellbeing.

Discussion of impacts to amenity

The pollutant species that have air quality goals set for the protection of the aesthetic environment are toluene (30-minute average, for odour) and dust deposition.

The predicted maximum Project contribution to deposited dust for the peak scenario at the worst-affected receptor (R_898) is 1.66 mg/m^2/day with veneering and 1.88 mg/m^2/day without veneering, and 0.06 mg/m^2/day with veneering and 0.18 mg/m^2/day without veneering at the second worst-affected receptors (R_923 with veneering, and R_2591 without veneering). Each of these predicted contributions represent less than 2 per cent of the adopted air quality goal of 120 mg/m^2/day.

Odour concentrations have not been modelled specifically, as emissions from combustion engines, such as locomotives do not typically require odour assessment; however, toluene and xylenes are pollutant species, which commonly require odour assessment (BCC AQPSP, 2014) and, therefore, predicted concentrations of these species have been reviewed to screen the potential for odour impacts.

For toluene and xylene, the predicted Project contributions at the worst-affected receptors within and outside the permanent disturbance footprint for the peak scenario were less than 0.1 per cent (toluene) and 0.2 per cent (xylene) of the adopted air quality goals for all relevant averaging periods. Detailed analysis of the modelling results for toluene and xylene is presented in Appendix K: Air Quality Technical Report.

Based on the magnitude of the predicted Project contributions and, as Table 12.37 and Table 12.38 show that the predicted cumulative concentration and deposition levels are well below the air quality goals for toluene, xylenes and deposited dust, the operation of the Project is not expected to adversely impact the environmental values of aesthetic environment. Therefore, the risk of amenity impacts as a result of the operation of the Project is considered to be low. The assessment has considered emissions from the Project alignment, crossing loops and the tunnel, and, therefore, all of these emission sources are considered to provide low risk of impacts to amenity.

Discussion of impacts to the assimilative capacity of the air environment

The assessment has considered background air quality in the prediction of cumulative concentrations and deposition levels at sensitive receptors and has, therefore, considered the assimilative capacity of the air environment in determining compliance with the adopted air quality goals.

The remaining assimilative capacity of the receiving environment with the operation of the Project has been calculated for TSP, PM_{10}, $PM_{2.5}$ and NO_2, which are the pollutants emitted in the highest quantities by the operation of the Project. The remaining assimilative capacity for the peak and typical train volume scenarios have been calculated for the worst-affected receptors in and outside the permanent disturbance footprint for the Project, with the results presented in Table 12.39 and Table 12.40. It is highlighted that this is a conservative assessment of the assimilative capacity of the receiving environment, as predicted concentrations vary significantly at different sensitive receptors.

Table 12.39 and Table 12.40 show that for receptor R_898, due to the predicted exceedances at this receptor, there is no remaining assimilative capacity for 1 hour concentrations of NO_2, 24-hour concentrations of $PM_{2.5}$ (with and without veneering) and PM_{10} (without veneering) and annual average concentrations of $PM_{2.5}$ (with and without veneering) for both the peak and typical scenarios. As outlined above, the receptor R_898 land parcel will be acquired as part of the land acquisition process for the Project.

Table 12.39 and Table 12.40 show that for the worst-affected sensitive receptor outside the permanent disturbance footprint, the pollutant with the highest predicted change to the assimilative capacity of the air environment is NO_2, which is predicted to change by 41 per cent for 1 hour predictions and 25 per cent for annual average predictions for both the peak and typical scenarios; however, for this receptor, the remaining assimilative capacity is 31 per cent for 1-hour concentrations and 62 per cent for annual average concentrations.

For particulates at all sensitive receptors outside the permanent disturbance footprint, Table 12.39 and Table 12.40 show that with veneering included the maximum change to the assimilative capacity of the receiving environment is 20 per cent for 24-hour $PM_{2.5}$, which is the predicted change for both the peak and typical scenarios. Without veneering, the maximum change to the assimilative capacity of the receiving environment is 21 per cent for 24-hour PM_{10} for both the peak and typical scenarios.

TABLE 12.39: REMAINING ASSIMILATIVE CAPACITY FOR WORST-AFFECTED SENSITIVE RECEPTORS WITHIN AND OUTSIDE THE PERMANENT DISTURBANCE FOOTPRINT FOR PEAK OPERATION

Pollutant	Averaging period	Receptor[a]	Project-only contribution (μg/m^3)	Total cumulative concentration (μg/m^3)	Air quality goal (μg/m^3)	Remaining assimilative capacity at worst-affected receptor (per cent)[b, c]	Change to assimilative capacity at worst-affected receptor (per cent)
TSP	Annual average (with veneering)	R_898	5.1	48.1	90	47	6
		R_2591	2.2	45.0		50	3
	Annual average (*without* veneering)	R_898	9.5	52.3		42	11
		R_2591	7.7	50.6		44	9
PM_{10}	24-hour maximum (with veneering)	R_898	31.8	49.2	50	2	64
		R_821	5.6	23.1		54	11
	24-hour maximum (*without* veneering)	R_898	35.3	**52.7**		-5	71
		R_224	13.2	30.7		39	27
	Annual average (with veneering)	R_898	4.3	21.5	25	14	18
		R_2591	1.2	18.4		26	5
	Annual average (*without* veneering)	R_898	6.5	23.7		5	26
		R_2591	4.0	21.2		15	16
$PM_{2.5}$	24-hour maximum (with veneering)	R_898	29.7	**37.3**	25	-49	119
		R_821	5.1	12.7		49	20
	24-hour maximum (*without* veneering)	R_898	30.2	**37.9**		-51	121
		R_821	5.2	12.8		49	21
	Annual average (with veneering)	R_898	3.5	**10.1**	8	-26	45
		R_2548	0.4	7.3		9	10
	Annual average (*without* veneering)	R_898	3.9	**10.4**		-31	49
		R_2591	0.8	7.4		8	11
NO_2	1 hour maximum	R_898	215.1	**286.6**	250	-15	87
		R_397	97.1	171.9		31	41
	Annual average	R_898	44.5	53.9	62	13	74
		R_2548	5.1	23.6		62	25

Table notes:

Results in bold exceed the relevant air quality goal

a. Results are presented for the worst-affected receptor in the permanent disturbance footprint and the worst-affected receptor outside the permanent disturbance footprint. The first row (receptor R_898) presents the modelled result for the worst-affected receptor within the permanent disturbance footprint, with the second row presenting the modelled result for the worst-affected receptor outside the permanent disturbance footprint

b. The remaining assimilative capacity of the receiving environment at the worst-affected receptor considering contributions from the operation of the Project and non-Project sources

c. Negative percentage values occur for pollutants where the air quality goal is exceeded

TABLE 12.40: REMAINING ASSIMILATIVE CAPACITY FOR WORST-AFFECTED SENSITIVE RECEPTORS WITHIN AND OUTSIDE THE PERMANENT DISTURBANCE FOOTPRINT FOR TYPICAL OPERATION

Pollutant	Averaging period	Receptor[a]	Project-only contribution (μg/m^3)	Total cumulative concentration (μg/m^3)	Air quality goal (μg/m^3)	Remaining assimilative capacity at worst-affected receptor (per cent)[b, c]	Change to assimilative capacity at worst-affected receptor (per cent)
TSP	Annual average (with veneering)	R_898	4.8	47.7	90	47	6
		R_2591	1.8	44.6		50	2
	Annual average (*without* veneering)	R_898	8.4	51.2		43	9
		R_2591	6.3	49.2		45	7
PM_{10}	24-hour maximum (with veneering)	R_898	31.5	48.9	50	2	63
		R_821	5.5	23.0		54	11
	24-hour maximum (*without* veneering)	R_898	34.3	**51.8**		-4	69
		R_224	10.8	28.3		43	22
	Annual average (with veneering)	R_898	4.1	21.3	25	15	17
		R_2591	1.0	18.2		27	4
	Annual average (*without* veneering)	R_898	5.9	23.1		8	24
		R_2591	3.3	20.4		18	13
$PM_{2.5}$	24-hour maximum (with veneering)	R_898	29.6	**37.2**	25	-49	119
		R_821	5.0	12.6		49	20
	24-hour maximum (*without* veneering)	R_898	30.0	**37.7**		-51	120
		R_821	5.2	12.8		49	21
	Annual average (with veneering)	R_898	3.5	**10.0**	8	-26	44
		R_2548	0.3	7.3		9	10
	Annual average (*without* veneering)	R_898	3.7	**10.3**		-29	48
		R_2548	0.7	7.3		9	10
NO_2	1-hour maximum	R_898	214.5	**286.6**	250	-15	87
		R_397	97.1	171.9		31	41
	Annual average	R_898	44.3	53.7	62	13	73
		R_2548	4.8	23.5		62	25

Table notes:

Results in **bold** exceed the relevant air quality goal

a. Results are presented for the worst-affected receptor in the permanent disturbance footprint and the worst-affected receptor outside the permanent disturbance footprint. The first row (receptor R_898) presents the modelled result for the worst-affected receptor within the permanent disturbance footprint, with the second row presenting the modelled result for the worst-affected receptor outside the permanent disturbance footprint

b. The remaining assimilative capacity of the receiving environment at the worst-affected receptor considering contributions from the operation of the Project and non-Project sources

c. Negative percentage values occur for pollutants where the air quality goal is exceeded

12.7.3.2 Drinking water impacts

Table 12.41 and Table 12.42 also present the drinking water guideline values prescribed by the ADWG (NHMRC, 2018).

The worst-affected sensitive receptor in the permanent disturbance footprint is R_898, located near the western tunnel portal. The worst-affected sensitive receptor outside the permanent disturbance footprint is R_2591, which is located at the eastern end of the Project and is the closest receptor to the open air section of the Project alignment (i.e. excluding the tunnel) with the exception of R_898.

Table 12.41 and Table 12.42 show that at the worst-affected receptors compliance is predicted for all pollutants, with pollutant concentrations predicted to be less than 1 per cent of the guideline values.

As pollutant concentrations in water tanks are predicted to be well below the drinking water guideline values prescribed by the ADWG (NHMRC, 2018), the residual impact to drinking water is expected to be insignificant.

The methodology applied for the assessment of impacts to water tanks is also applicable for assessment of impacts to water quality for dams, assuming that the surface area (roof area) and receiving water volumes (1,000 L) are comparable. On this assumption, impacts to dam water quality are also anticipated to be insignificant. This is of note as the Project traverses between two dams associated with the Withcott Seedlings operations, while no other dams are present within 100 m of the Project alignment.

TABLE 12.41: HIGHEST PREDICTED WATER TANK CONCENTRATIONS AT SENSITIVE RECEPTORS FOR PEAK PROJECT OPERATIONS

Pollutant	Receptor[a]	Maximum predicted annual deposition rate (µg/m²/s)	Estimated roof area (m²)	Maximum predicted total deposited mass (µg)	Tank water volume (L)[d]	Highest predicted concentration (mg/L)	Guideline value (mg/L)[e]
Arsenic	R_898	3.41×10^{-10}	200[b.]	2.15	1,000[b.]	2.15×10^{-6}	0.01
	R_2591	4.03×10^{-11}		0.25		2.54×10^{-7}	
Cadmium	R_898	1.70×10^{-10}		1.07		1.07×10^{-6}	0.002
	R_2591	2.02×10^{-11}		0.13		1.27×10^{-7}	
Lead	R_898	1.70×10^{-9}		10.75		1.07×10^{-5}	0.01
	R_2591	2.02×10^{-10}		1.27		1.27×10^{-6}	
Nickel	R_898	6.82×10^{-10}		4.30		4.30×10^{-6}	0.02
	R_2591	8.07×10^{-11}		0.51		5.09×10^{-7}	
Chromium VI	R_898	2.90×10^{-8}		182.73		1.83×10^{-4}	0.05
	R_2591	3.43×10^{-9}		21.62		2.16×10^{-5}	

Table notes:

a. Results are presented for the worst-affected receptor in the permanent disturbance footprint and the worst-affected receptor outside the permanent disturbance footprint. The first row (receptor R_898) presents the modelled result for the worst-affected receptor in the permanent disturbance footprint, with the second row presenting the modelled result for the worst-affected receptor outside the permanent disturbance footprint (receptor R_2591).

b. Based on the average surface area of a large house

c. Assumption of a 10,000 L water tank at 10 per cent capacity, with a resultant water volume of 1000 L

d. The assessment has been undertaken for a water tank, but the result would also be the same for a dam assuming the volume of the dam is 1,000 L

e. Source: ADWG (NHMRC, 2018)

TABLE 12.42: HIGHEST PREDICTED WATER TANK CONCENTRATIONS AT SENSITIVE RECEPTORS FOR TYPICAL PROJECT OPERATIONS

Pollutant	Receptor	Maximum predicted annual deposition rate (µg/m²/s)	Estimated roof area (m²)	Maximum predicted total deposited mass (µg)	Tank water volume (L)[c]	Highest predicted concentration (mg/L)	Guideline value (mg/L)[d]
Arsenic	R_898	3.30×10^{-10}	200 [a]	2.08	1,000 [b]	2.08×10^{-6}	0.01
	R_2591	3.29×10^{-11}		0.21		2.08×10^{-7}	
Cadmium	R_898	1.65×10^{-10}		1.04		1.04×10^{-6}	0.002
	R_2591	1.65×10^{-11}		0.10		1.04×10^{-7}	

Pollutant	Receptor	Maximum predicted annual deposition rate ($\mu g/m^2/s$)	Estimated roof area (m^2)	Maximum predicted total deposited mass (µg)	Tank water volume (L)[c]	Highest predicted concentration (mg/L)	Guideline value (mg/L)[d]
Lead	R_898	1.65×10^{-9}		10.41		1.04×10^{-5}	0.01
	R_2591	1.65×10^{-10}		1.04		1.04×10^{-6}	
Nickel	R_898	6.60×10^{-10}		4.17		4.17×10^{-6}	0.02
	R_2591	6.58×10^{-11}		0.42		4.15×10^{-7}	
Chromium VI	R_898	2.81×10^{-8}		177.04		1.77×10^{-4}	0.05
	R_2591	2.80×10^{-9}		17.64		1.76×10^{-5}	

Table notes:

a. Results are presented for the worst-affected receptor in the permanent disturbance footprint and the worst-affected receptor outside the permanent disturbance footprint. The first row (receptor R_898) presents the modelled result for the worst-affected receptor in the permanent disturbance footprint, with the second row presenting the modelled result for the worst-affected receptor outside the permanent disturbance footprint (receptor R_2591).
b. Based upon the average surface area of a large house
c. Assumption of a 10,000 L water tank at 10 per cent capacity, with a resultant water volume of 1000 L
d. The assessment has been undertaken for a water tank, but the result would also be the same for a dam assuming the volume of the dam is 1,000 L
e. Source: ADWG (NHMRC, 2018).

12.7.3.3 Impacts to ecological receptors

The potential for impacts to ecological receptors has been investigated via review of predicted annual average NO_2 concentration contours. Modelling predictions for the peak and typical volume scenarios have been reviewed to determine if the annual average NO_2 air quality goal of 33 $\mu g/m^3$, set for the protection of the environmental value of the health and biodiversity of ecosystems (refer Table 12.4), is exceeded within the AQIA study area.

Predicted cumulative NO_2 annual average concentration contours for the peak train volume scenario are shown in Figure 12.11. Predicted cumulative NO_2 annual average concentration contours for the typical train volume scenario are shown in Figure 12.12.

Consistent with the concentration contours plots for PM_{10} (24 hour), $PM_{2.5}$ (annual) and NO_2 (1 hour), shown in Figure 12.11 and Figure 12.12, indicate that the highest predicted annual average NO_2 concentrations are predicted at the locations of crossing loops at the western and eastern portals of the Toowoomba Range Tunnel. The crossing loops are the dominant source of NO_2 emissions and have a greater impact on the concentration contours than emissions from the tunnel portals due to the quantity of air that is purged from the tunnel and the dilution this provides for emissions from the tunnel portals. Consistent with the concentration contour plots for other pollutant species, the shape of the concentration contours near the crossing loops and tunnel portals is influenced by the topography near these areas.

The concentration contours shown in Figure 12.11 and Figure 12.12 show that the annual average NO_2 air quality goal (33 $\mu g/m^3$) is predicted to be exceeded outside the permanent disturbance footprint of the Project at the following locations:

- The Toowoomba Range Tunnel western crossing loop, at a maximum distance outside the permanent disturbance footprint of approximately 5 m for both the peak and typical train volume scenarios. There are no remnant and regrowth ecosystems in this area (refer Appendix I: Terrestrial and Aquatic Ecology)
- The Toowoomba Range Tunnel eastern portal and crossing loop, at a maximum distance outside the permanent disturbance footprint of approximately 40 m (north of the footprint) for the peak scenario, and approximately 30 m (north of the footprint) for the typical scenario. The majority of the area to the north of the permanent disturbance footprint is mapped as non-remnant (refer Appendix I: Terrestrial and Aquatic Ecology).
- At the western end of the Postmans Ridge crossing loop, to the south of the permanent disturbance footprint of the Project within the road corridor of the Toowoomba Bypass for both the peak and typical train volume scenarios. Part of the remnant and regrowth ecosystems in this area have been cleared to accommodate the Toowoomba Bypass, with clearing also proposed for the Project disturbance footprint in this area (refer Appendix I: Terrestrial and Aquatic Ecology).

The concentration contours shown in Figure 12.11 and Figure 12.12 are cumulative predictions and include emissions from the Toowoomba Bypass. The influence of emissions from the Toowoomba Bypass is evident in Figure 12.11 and Figure 12.12, with elevated concentrations predicted along the alignment of the road, including exceedances of the annual average NO_2 air quality goal (33 µg/m^3). As discussed in Section 12.6.3.2, the methodology adopted for the modelling of emissions from the Toowoomba Bypass is expected to over-estimate emissions from traffic on this road and, therefore, over-predict concentrations of NO_2.

Based on the limited areas outside the Project permanent disturbance footprint at which the annual average NO_2 air quality goal of 33 µg/m^3 is predicted to be exceeded and the level of disturbance (current and required for the Project), it is considered unlikely that significant impacts to ecological receptors, including remnant and regrowth ecosystems, will occur as a result of the operation of the Project.

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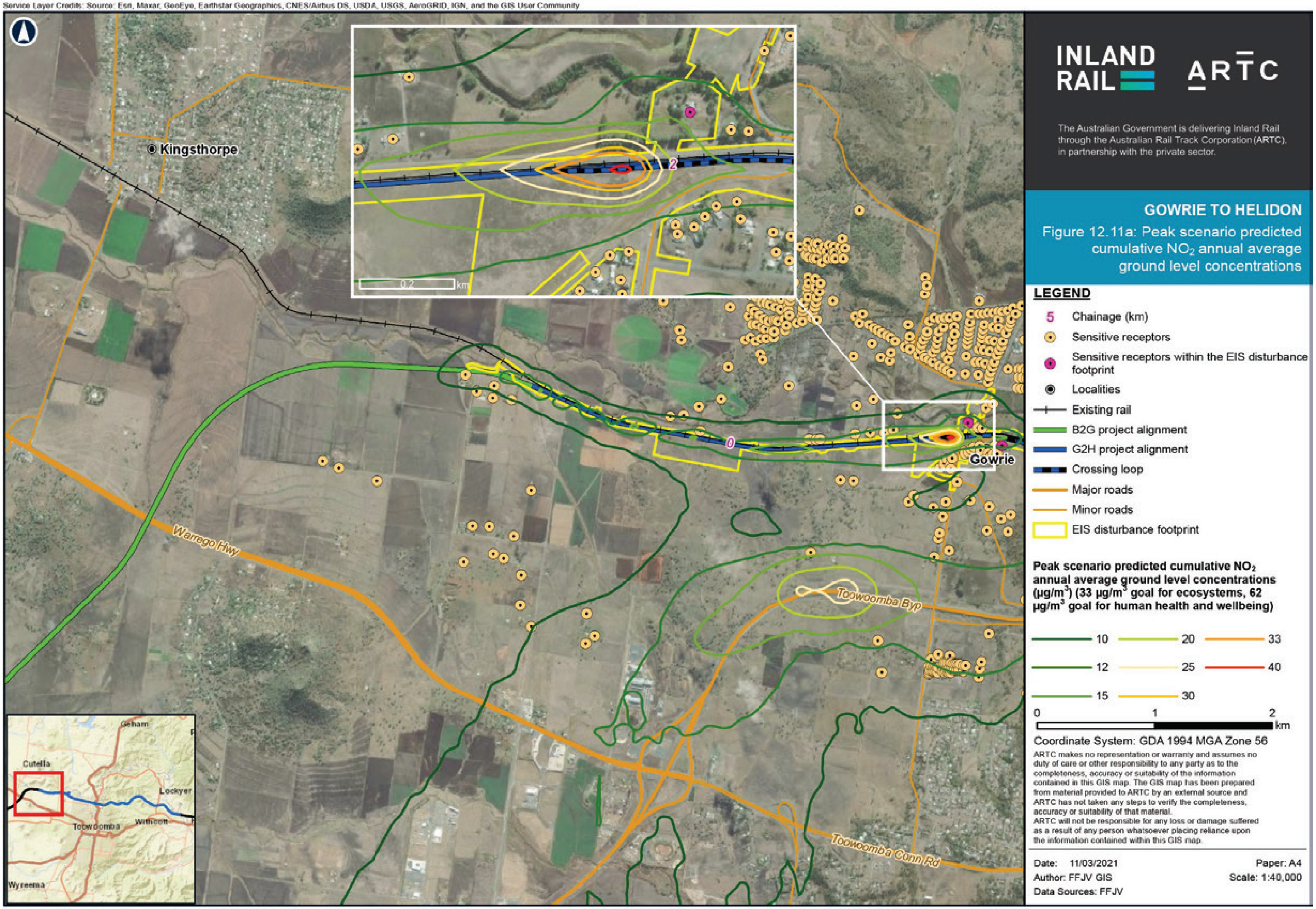

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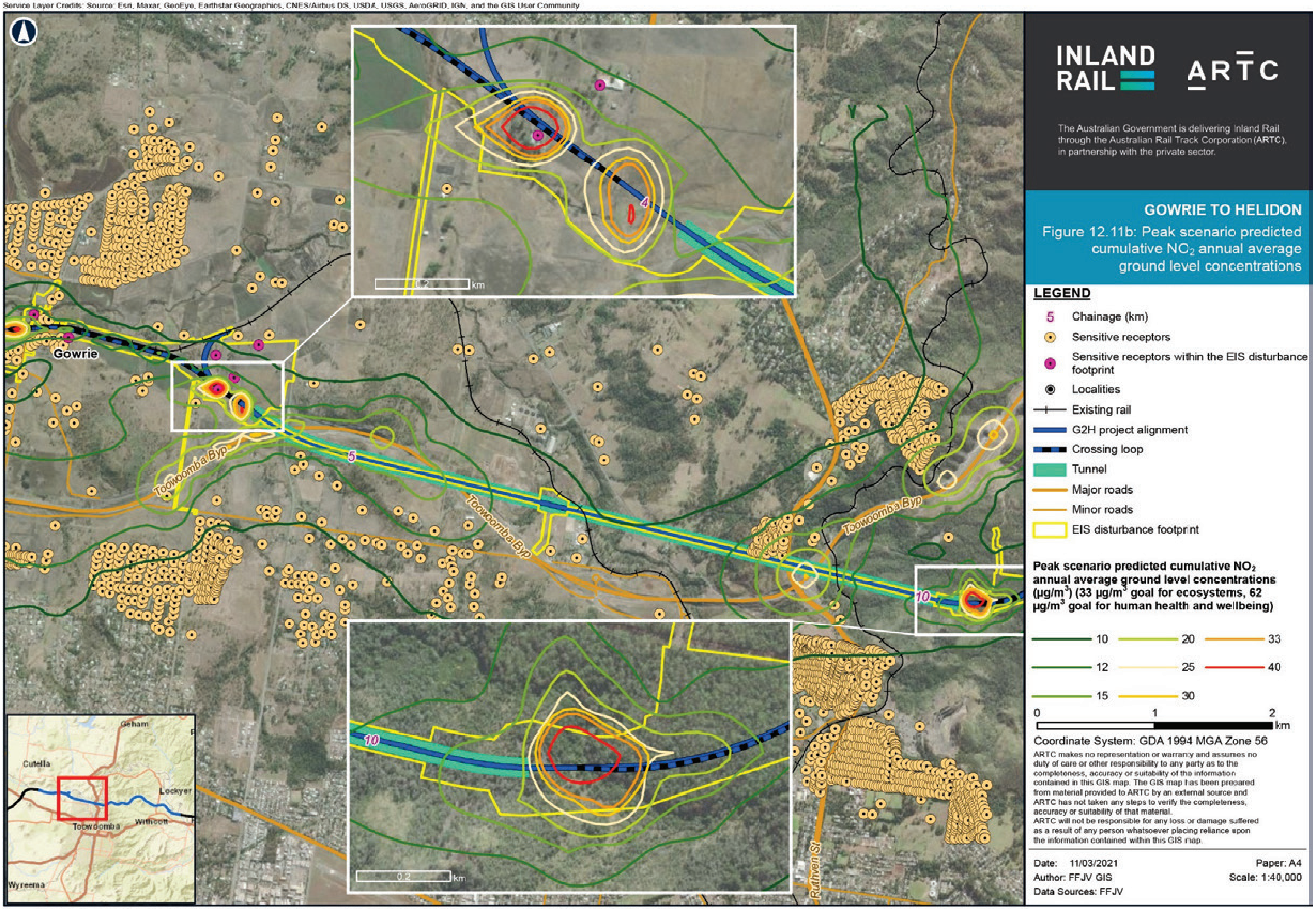

GOWRIE TO HELIDON

Figure 12.11b: Peak scenario predicted cumulative NO_2 annual average ground level concentrations

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.11b_Peak_NO2_v3.mxd Date: 11/03/2021 13:13

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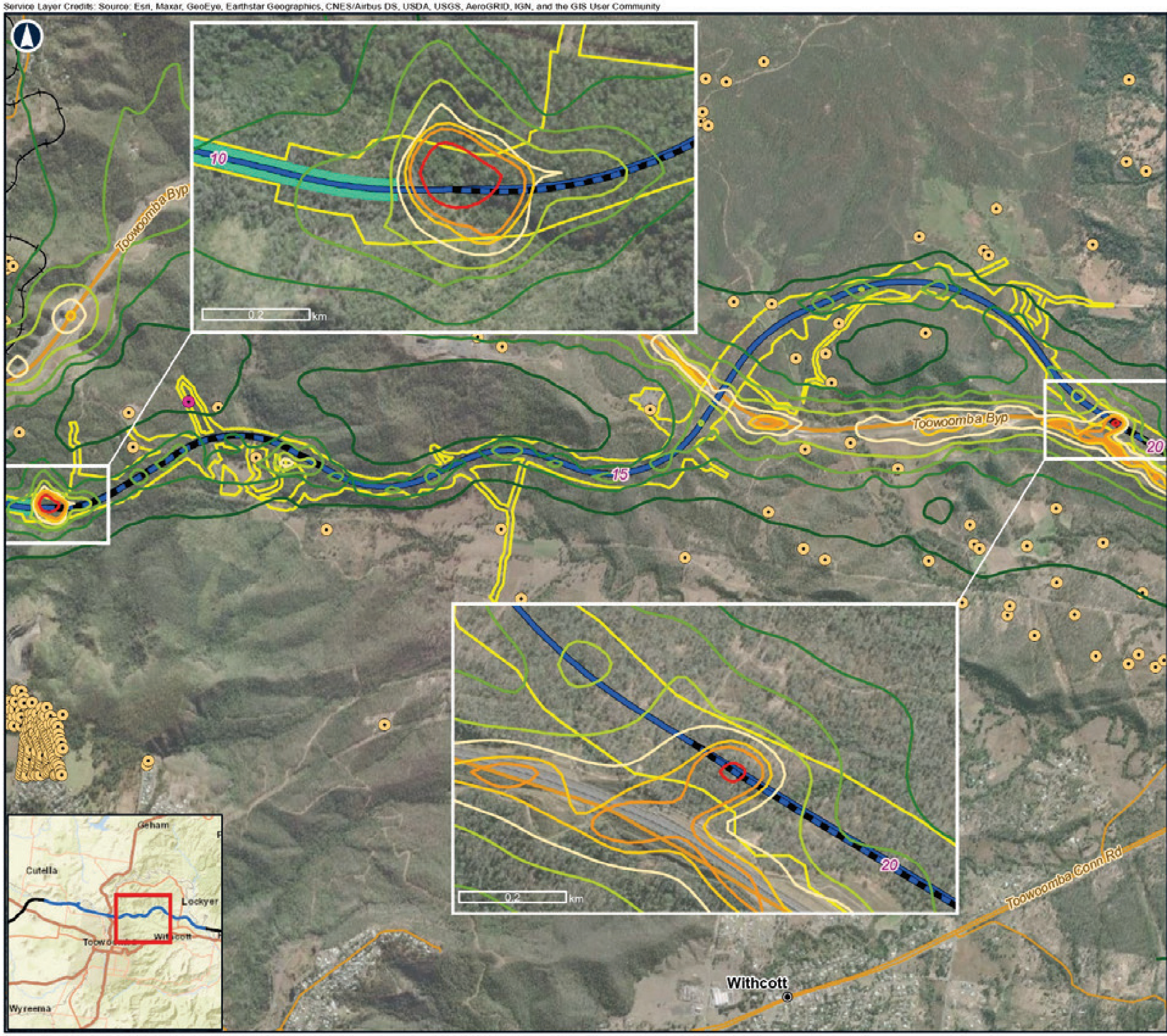

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GOWRIE TO HELIDON

Figure 12.11c: Peak scenario predicted cumulative NO_2 annual average ground level concentrations

LEGEND

- 5 Chainage (km)
- Sensitive receptors
- Sensitive receptors within the EIS disturbance footprint
- Localities
- Existing rail
- G2H project alignment
- Crossing loop
- Tunnel
- Major roads
- Minor roads
- EIS disturbance footprint

Peak scenario predicted cumulative NO_2 annual average ground level concentrations (µg/m^3) (33 µg/m^3 goal for ecosystems, 62 µg/m^3 goal for human health and wellbeing)

10, 12, 15, 20, 25, 30, 33, 40

0 1 2 km

Coordinate System: GDA 1994 MGA Zone 56

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Author: FFJV GIS
Data Sources: FFJV
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Scale: 1:40,000

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.11c_Peak_NO2_v3.mxd Date: 11/03/2021 12:38

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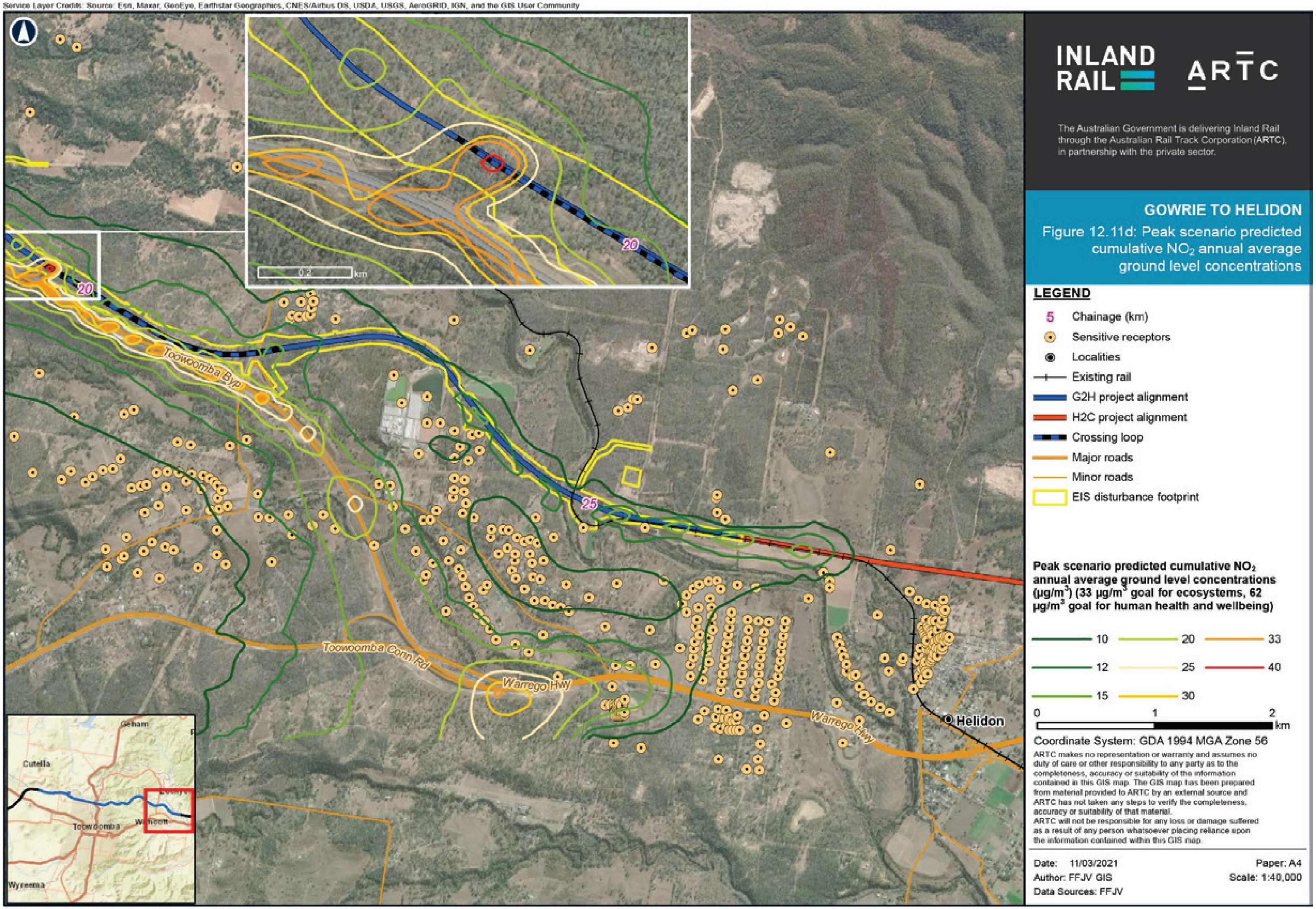

Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.11d_Peak_NO2_v3.mxd Date: 11/03/2021 13:07

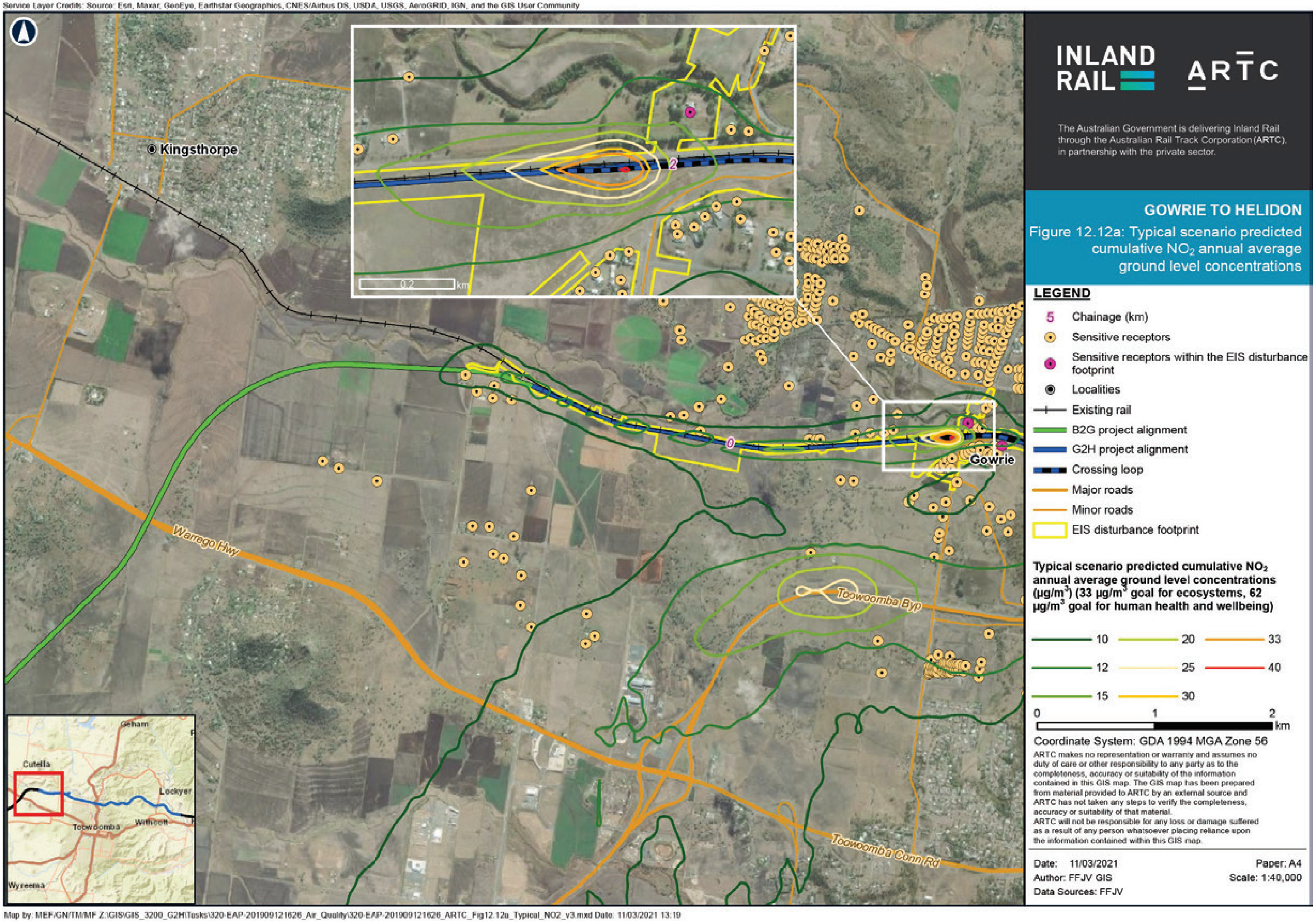

Figure 12.12a: Typical scenario predicted cumulative NO_2 annual average ground level concentrations

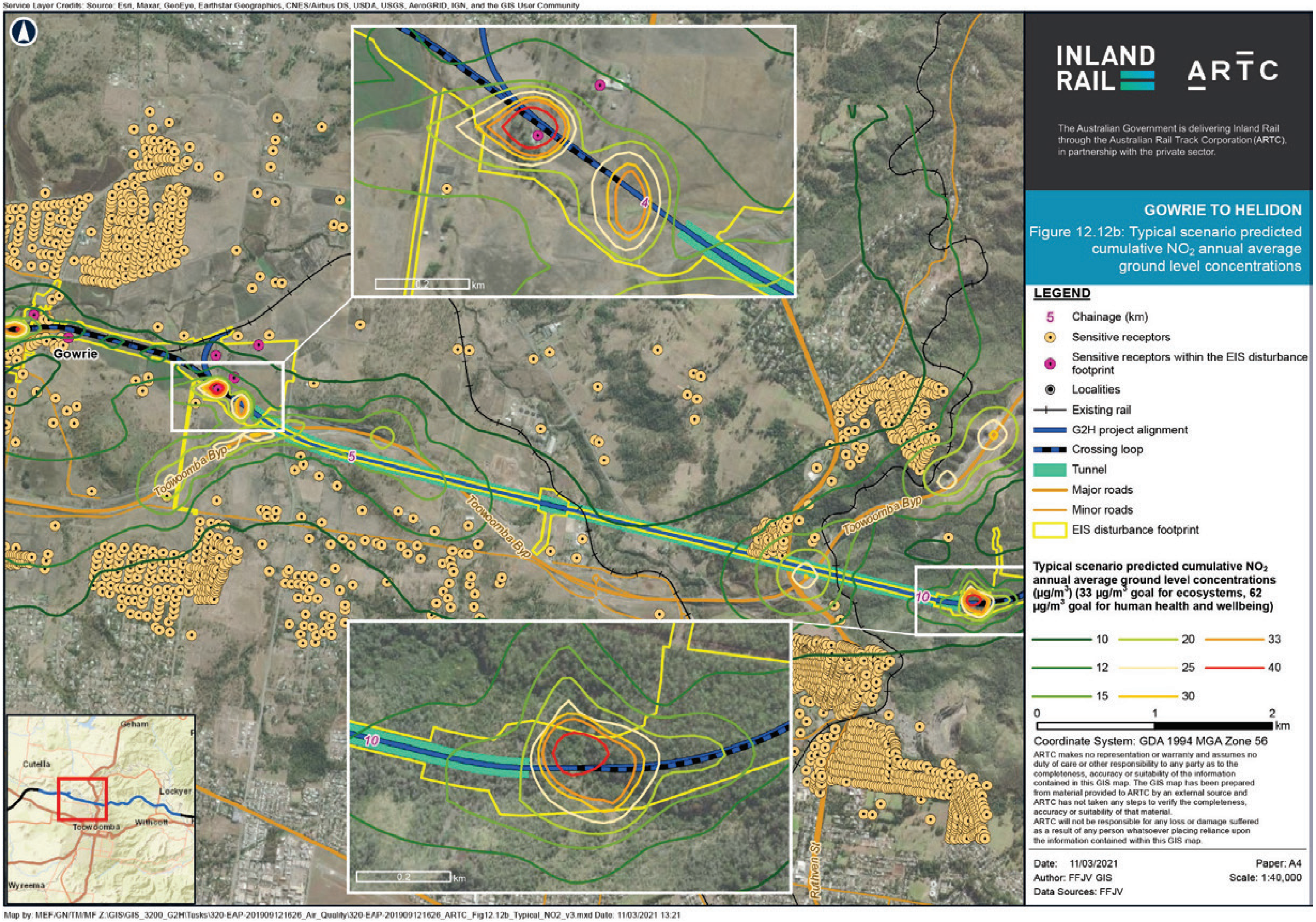
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Figure 12.12b: Typical scenario predicted cumulative NO_2 annual average ground level concentrations
LEGEND
5 Chainage (km)
Sensitive receptors
Sensitive receptors within the EIS disturbance footprint
Localities
Existing rail
G2H project alignment
Crossing loop
Tunnel
Major roads
Minor roads
EIS disturbance footprint
Typical scenario predicted cumulative NO_2 annual average ground level concentrations (µg/m³) (33 µg/m³ goal for ecosystems, 62 µg/m³ goal for human health and wellbeing)
10
20
33
12
25
40
15
30
0
1
2
km
Coordinate System: GDA 1994 MGA Zone 56
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Date: 11/03/2021
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Scale: 1:40,000
Gowrie
Toowoomba Byp
Rathven St
Geham
Cutella
Lockyer
Toowoomba
Withcott
Wyreema
4
5
10
0.2
km
Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.12b_Typical_NO2_v3.mxd Date: 11/03/2021 13:21

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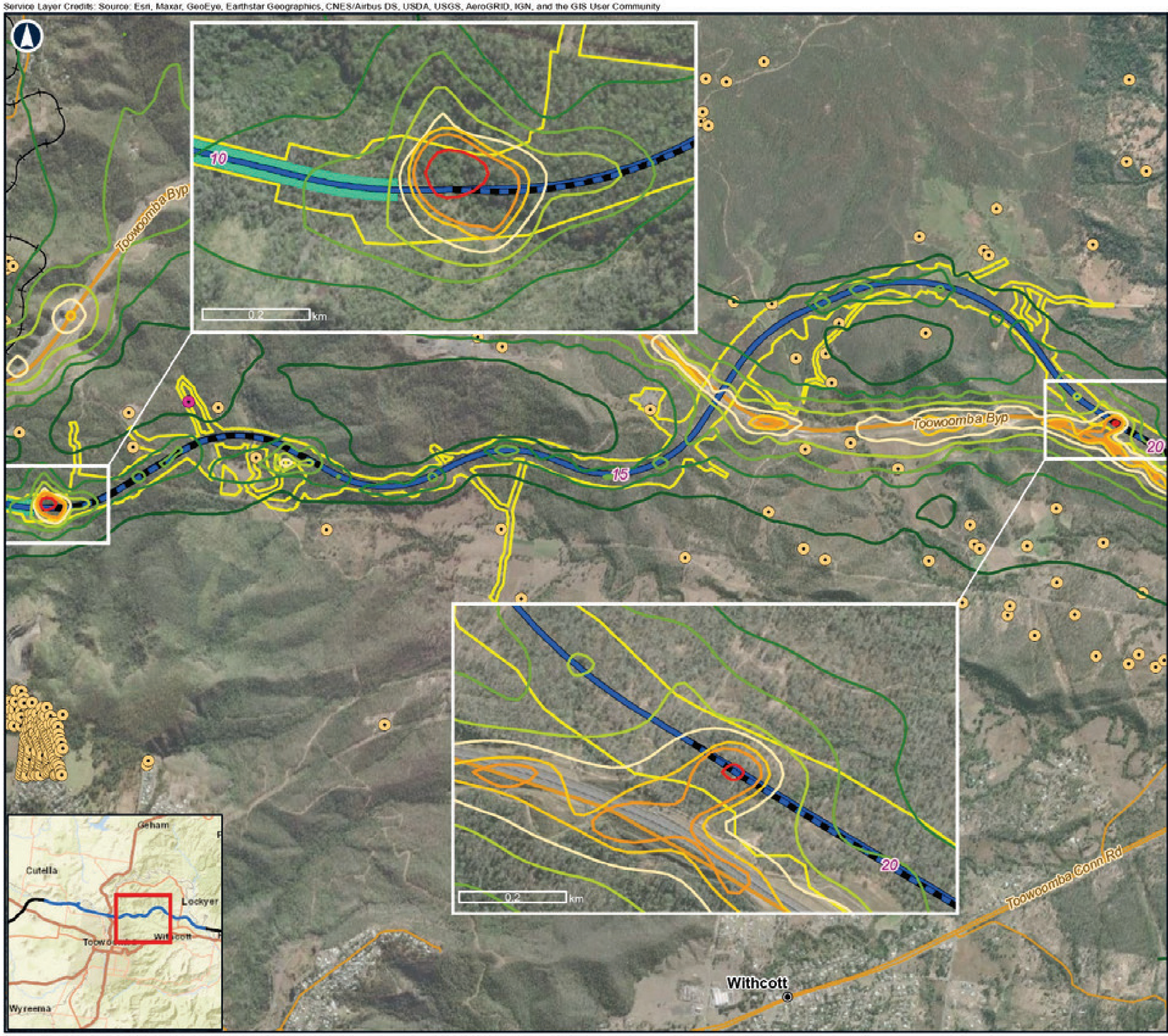

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GOWRIE TO HELIDON

Figure 12.12c: Typical scenario predicted cumulative NO_2 annual average ground level concentrations

LEGEND

- 5 Chainage (km)
- Sensitive receptors
- Sensitive receptors within the EIS disturbance footprint
- Localities
- Existing rail
- G2H project alignment
- Crossing loop
- Tunnel
- Major roads
- Minor roads
- EIS disturbance footprint

Typical scenario predicted cumulative NO_2 annual average ground level concentrations (µg/m^3) (33 µg/m^3 goal for ecosystems, 62 µg/m^3 goal for human health and wellbeing)

10, 12, 15, 20, 25, 30, 33, 40

0 1 2 km

Coordinate System: GDA 1994 MGA Zone 56

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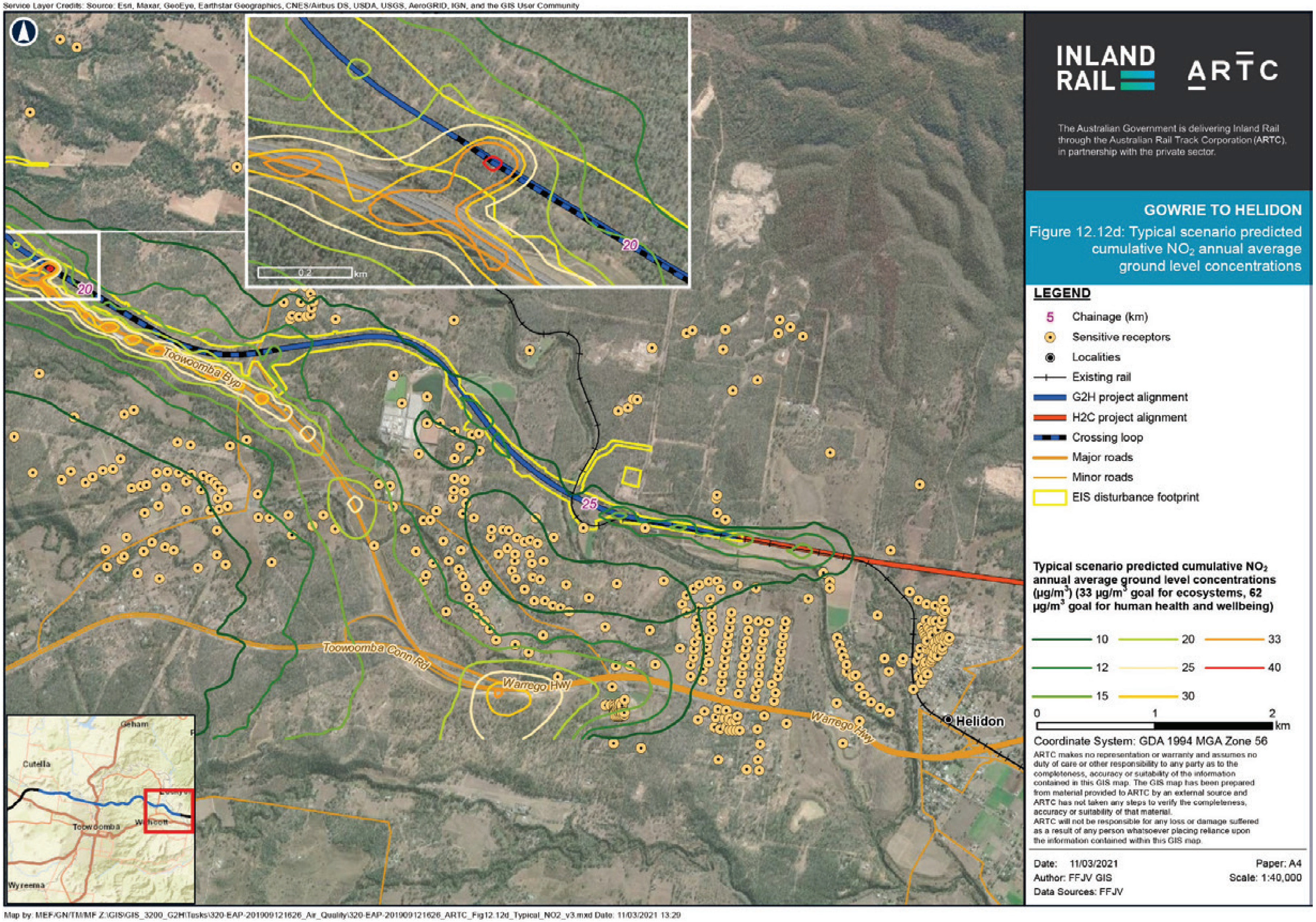

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Figure 12.12d: Typical scenario predicted cumulative NO2 annual average ground level concentrations
LEGEND
5 Chainage (km)
Sensitive receptors
Localities
Existing rail
G2H project alignment
H2C project alignment
Crossing loop
Major roads
Minor roads
EIS disturbance footprint
Typical scenario predicted cumulative NO2 annual average ground level concentrations (µg/m3) (33 µg/m3 goal for ecosystems, 62 µg/m3 goal for human health and wellbeing)
10 20 33
12 25 40
15 30
0 1 2 km
Coordinate System: GDA 1994 MGA Zone 56
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Author: FFJV GIS
Data Sources: FFJV
Paper: A4
Scale: 1:40,000
Toowoomba Byp
Toowoomba Conn Rd
Warrego Hwy
Helidon
20
25
0.2 km
Cutella
Toowoomba
Withcott
Wyreema
Map by: MEF/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.12d_Typical_NO2_v3.mxd Date: 11/03/2021 13:29

12.7.3.4 Agricultural impacts

The predicted maximum dust deposition levels for the worst-affected receptor in the AQIA study area are shown in Table 12.37 and Table 12.38 for the typical and peak train volume scenarios, with and without veneering. The worst-affected receptor outside the Project permanent disturbance footprint is receptor R_2591. The predicted maximum cumulative deposition levels at receptor R_2591 were 50.1 mg/m^2/day with veneering, and 50.2 mg/m^2/day without veneering. The predicted deposition levels were the same for the peak and typical train volume scenarios.

As discussed in Section 12.4.3, research on vegetation response to dust deposition impact has shown that a measurable reduction in crop growth is not observed below a dust deposition rate of 1,000 mg/m^2/day (Doley, 2003), and that a deposition rate of up to 4,000 mg/m^2/day does not influence the amount of feed cattle eat or the amount of milk produced (Andrews & Skriskandarajah, 1992).

For each of the scenarios assessed, the predicted maximum cumulative dust deposition level at the worst-affected receptor is well below these levels, with the highest predicted level being 50.2 mg/m^2/day for the peak train volume scenario, without veneering. Based on the predicted results, the impact of dust deposition on agricultural uses within the AQIA study area is not anticipated to be significant.

In addition to deposited dust, NO_2 has the potential to impact agricultural land uses; however, as discussed in Section 12.7.3.3, there is limited area outside the Project permanent disturbance footprint at which the annual average NO_2 air quality goal of 33 µg/m^3 (set for the protection of the health and biodiversity of ecosystems) is predicted to be exceeded. Based on the predicted annual average concentrations of NO_2 within the AQIA study area, it is considered unlikely that significant impacts to agricultural receptors will occur as a result of the operation of the Project.

12.7.3.5 Agricultural train odour impacts

Odour emissions from agriculture freight train pass-bys are expected to be highly diluted due to the volume of air that will pass through and around the train over the duration of travel and, therefore, odour emissions from moving agriculture freight trains are considered unlikely to cause significant impact or exceedance of the odour criterion.

Table 12.43 presents an assessment of odour impacts from livestock freight trains using the FIDOL factors. Livestock trains are considered to be the agriculture freight with the highest potential to impact sensitive receptors (e.g. livestock has a greater potential for odour emissions when compared to grain) and, therefore, have been assumed for the assessment of odour.

TABLE 12.43: SUMMARY OF FIDOL FACTORS FOR ODOUR GENERATED BY AGRICULTURAL TRAINS

FIDOL factor	Livestock trains
Frequency (F)	During peak operations, it is expected that a maximum of six livestock trains per week will travel the alignment. As such, the frequency of the event is low, with an average of less than one livestock train per day during peak periods.
Intensity (I)	Odour intensity is expected to range from strong to very strong for livestock trains.
Duration (D)	Duration of exposure is expected to be short, with the time of exposure limited to the length of time taken for the train to pass a point along the Project alignment. At crossing loops, the duration of exposure is expected to be longer compared to train pass-bys on the main track. The exact duration at the crossing loops will be subject to individual train operation but could be up to 60 minutes.
Offensiveness (O)	The offensiveness of the odour is expected to be unpleasant.
Location (L)	The land use of the receiving environment can be classified as mainly rural residential, rural, and residential for the small townships and suburbs of Toowoomba City located near the alignment, including Gowrie, Cranley, Mount Kynoch, Blue Mountain Heights, Lockyer, Postmans Ridge and Helidon Spa. Due to the land use of the receiving environment, odour from agricultural activities and livestock is expected to be common to the existing ambient air environment. People living and visiting rural areas often have a higher tolerance for rural activities and their associated effects; thus, having a lower sensitivity to the odours expected.

It is expected that odour produced from passing trains or trains stopped at crossing loops could be of high intensity and offensiveness, depending on the separation distance to the nearest sensitive receptors and the sensitivity of the receptor to odour. The main area of concern is the western tunnel portal crossing loop, due to its proximity to, and the number of, sensitive receptors. The closest receptor within the Project disturbance footprint is located approximately 20 m from the western tunnel portal (receptor R_898), with the closest receptor outside the footprint located approximately 60 m (receptor R_410) from the western tunnel portal crossing loop.

Impacts are expected to be infrequent and of a short duration (i.e. one hour or less), however, and the Project is located in a predominantly rural area where odour from agricultural uses is likely to be common to the existing airshed. Based on the reasoning provided, odour emissions from agriculture freight are considered unlikely to result in significant impact to neighbouring sensitive receptors.

12.7.3.6 In-tunnel air quality

One of the primary objectives of the tunnel ventilation system design was maintenance of acceptable air quality inside the tunnel and at the tunnel portals. Tunnel ventilation design and the assessment of in-tunnel air quality was undertaken, considering normal, purge, emergency and maintenance operations for express, superfreighter, coal and passenger train types travelling both uphill and downhill in the tunnel. Other train consists were not considered, as these train services have less critical design requirements for the ventilation system compared to the larger freight trains that were modelled.

The in-tunnel air quality analysis used the Subway Environmental Simulation computer program to determine the air flows, temperature and pollutant levels in varying design cases for different trains and Computational Fluid Dynamics to determine the effects of thermal stratification on tunnel air temperatures for specific train types.

The ventilation system has been designed such that the tunnel will undergo a purge cycle following train passages, to ventilate the tunnels of any residual pollutants and heat, and ensure a suitable environment prior to the next train entering the tunnel. Ventilation scenarios based on emissions rates from various locomotives travelling through the tunnel were modelled considering the purging methodology of the tunnel.

Tunnel ventilation design focused on maintaining acceptable air quality inside the tunnel, considering human exposure and locomotive manufacturer requirements for air intake quality. The key pollutants considered were CO, NO_2 and NO. The air quality criteria adopted for the design of the tunnel ventilation for systems is summarised as follows:

- CO: in-tunnel concentration criteria of 87 ppm (approximately 103,087 µg/m^3 at 15 °C)
- NO_2: in-tunnel concentration criteria of 1 particle per million (ppm) (approximately 1,947 µg/m^3 at 15 °C) for passenger services and 3 ppm (approximately 5,840 µg/m^3 at 15ºC) for freight services
- NO: in-tunnel time weighted average (TWA) concentration criteria of 25 ppm (approximately 31,750 µg/m^3 at 15 °C).

Table 12.44 compares the adopted tunnel design in-tunnel air quality criteria for NO_2 and CO to criteria adopted elsewhere in Australia and other areas around the world, as presented by Longley (2014).

Comparison of in-tunnel air quality criteria has not been undertaken for NO as this pollutant is not typically of concern in tunnels and there is no objective for NO to protect human health. The NO in-tunnel air quality criteria that was adopted for the tunnel design was sourced from SafeWork Australia workplace exposure standards.

TABLE 12.44: IN-TUNNEL AIR QUALITY GUIDELINE CONCENTRATION VALUES FOR AUSTRALIA AND OTHER COUNTRIES

Pollutant	Concentration (ppm)	Averaging period (minutes)	Notes
CO	200 ppm	3	Cross City and Lane Cove tunnels, Sydney
	100 ppm	5	Hong Kong
	50 ppm	15	CityLink tunnels, Melbourne
	70 ppm	15	PIARC from 2010, Clem7 and Airport Link tunnels, Brisbane
	87 ppm	**15**	**Adopted tunnel design in-tunnel air quality criterion for Toowoomba Range Tunnel**
	87 ppm	15	M5 East, Cross City and Lane Cove tunnels, Sydney
	100 ppm	15	PIARC
	120 ppm	15	United States
	50 ppm	30	Cross City and Lane Cove tunnels, Sydney

Pollutant	Concentration (ppm)	Averaging period (minutes)	Notes
NO_2	1 ppm	5	Hong Kong
	0.4 ppm	15	France from 2010
	0.75 ppm	15	Norway (tunnel midpoint)
	1 ppm	**15**	**Adopted tunnel design in-tunnel air quality criterion for Toowoomba Range Tunnel (for passenger trains)**
	1 ppm	15	New Zealand (design standard only)
	1.5 ppm (tunnel end)	15	Norway (tunnel end)
	0.5 ppm	20	Belgium

The adopted in-tunnel air quality criteria are consistent with in-tunnel air quality guideline values adopted elsewhere in Australia and internationally.

The CO criterion is consistent with what was implemented for Sydney tunnels (i.e. M5 East, Cross City and Lane Cove tunnels), which also adopted the 87-ppm criterion; however, it is slightly higher than the in-tunnel air quality CO criterion of 70 ppm used for the Clem7 and Airport Link tunnels in Brisbane. The NO_2 criterion is consistent with the New Zealand design standard of 1 ppm; however, it is marginally higher than most in-tunnel NO_2 criterion for Norway, Belgium and France, which range from 0.4 to 1.5 ppm.

However, these in-tunnel air quality criteria are implemented for road tunnels in major urban areas that may experience thousands of vehicles per hour. As such, they are not specifically appropriate for a rail tunnel with significantly less traffic such that which is proposed as part of the Project; however, application of this criteria for a rail tunnel would mean that air quality is kept below threshold limits that are more stringent than required; thus, lowering the inherent associated health risks from exposure to these pollutants. Overall, it is expected that the adopted in-tunnel air quality criteria for the tunnel ventilation design is appropriate to maintain acceptable air quality in the tunnel.

In addition to the above tunnel design air quality threshold, the Toowoomba Range Tunnel ventilation system will include air quality monitoring to measure in-tunnel concentrations of NO_2, NO and CO to ensure that pollutant concentrations are appropriate for train entry. If in-tunnel monitoring determines that purging is required, the purging cycle will commence after the last locomotive has cleared the tunnel portal before a new train will be allowed to enter the tunnel.

12.7.4 Cumulative impact assessment

When projects occur within proximity to each other there is potential for cumulative impacts and it is a requirement of the ToR that potential cumulative impacts are considered.

As cumulative impacts for the operation phase of the Project (which included the Toowoomba Bypass, Harlaxton Quarry, sections of the West Moreton System and the adjacent Inland Rail projects) have already been considered in detail in this assessment (refer Section 12.7.3), further assessment of cumulative impacts is only required for the construction phase of the Project.

The potential significance of cumulative impacts that may arise as a result of the construction of the Project, in combination with the construction and operation of other projects, has been assessed following the risk matrix method presented in Chapter 22: Cumulative Impacts, adapted to consider individual projects. The significance of the potential cumulative impact has been determined by using professional judgement to select the most appropriate relevance factor for each aspect (Low, Medium or High). Detail on the assessment methodology for cumulative impacts is also presented in Appendix K: Air Quality Technical Report.

A total of 10 projects located within or near the air quality study area have been assessed for cumulative air quality impacts during the construction phase of the Project. These projects are either currently operational or will be constructed, and or operational, during the construction phase of the Project. The majority of the projects that have been considered are expected to have limited potential for cumulative impacts.

The projects that have been considered in the cumulative impact assessment are listed in Table 12.45. The locations of the assessed projects are shown in Figure 12.13.

The Toowoomba Bypass has been considered in this cumulative impact assessment; however, existing rail traffic on the West Moreton System has not been considered. Background air quality for particulates, including PM_{10} and TSP, has been assessed using monitoring data available from the Inland Rail AQMS (refer Section 12.5.3). The Inland Rail AQMS is located approximately 200 m to the south of the existing West Moreton System rail corridor at Charlton and measured concentrations at the Inland Rail AQMS are influenced by emissions from existing rail traffic. As the IAQM construction dust assessment methodology considers background air quality (refer Section 12.7.1.1), the influence of the West Moreton System has already been considered in the construction phase assessment.

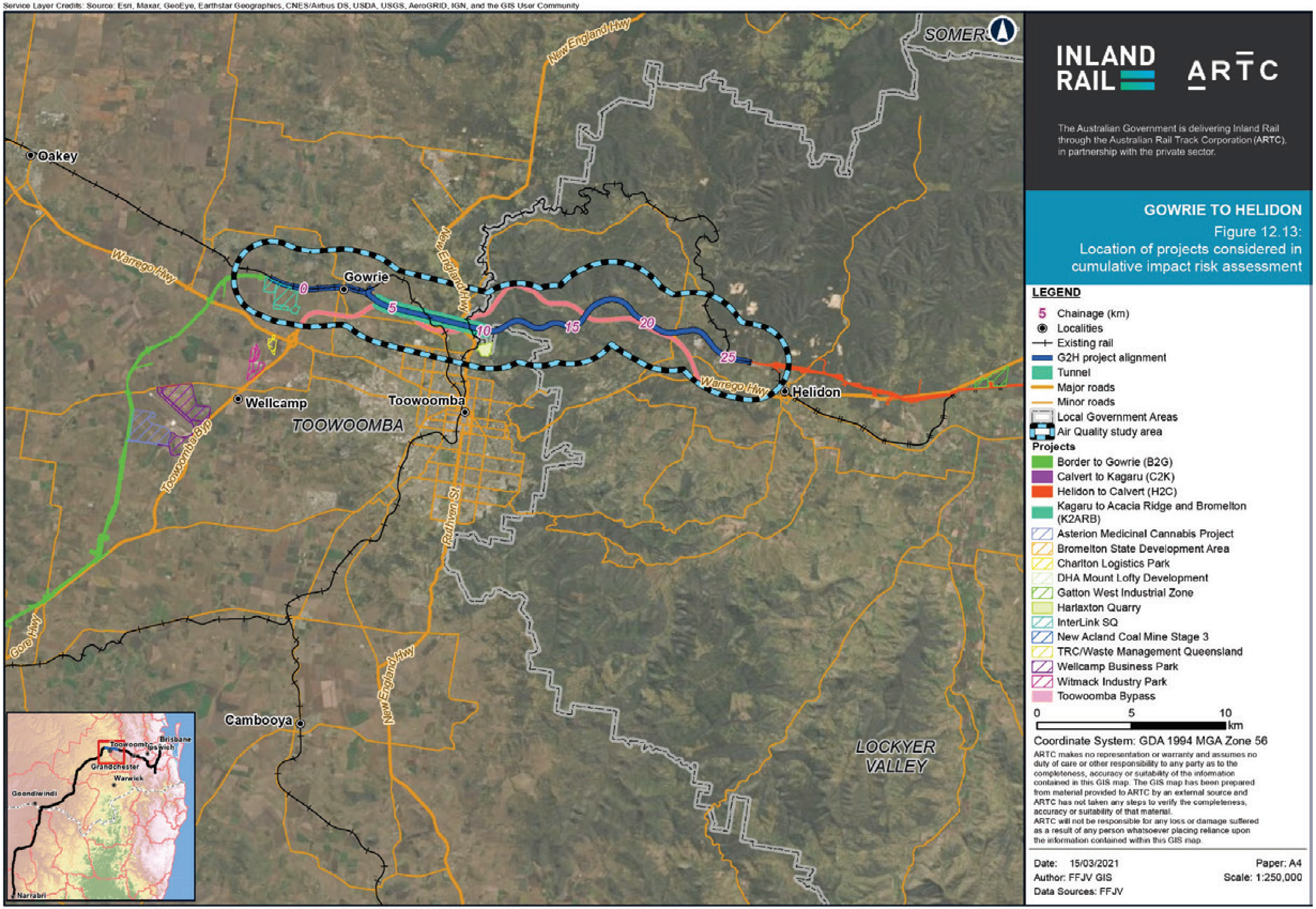
TABLE 12.45: PROJECTS CONSIDERED FOR THE CUMULATIVE IMPACT ASSESSMENT

Project and proponent	Location	Description	Construction dates
B2G (ARTC)	Immediately west of the Project, from the Queensland/New South Wales Border to Gowrie	Comprised of approximately 216.2 km single-track dual-gauge freight railway as part of the ARTC Inland Rail Program	2021 to 2026
H2C(ARTC)	Immediately east of the Project, from Helidon to Calvert	Comprised of approximately 48-km single-track dual-gauge freight railway as part of the ARTC Inland Rail Program	2021 to 2026
Toowoomba Bypass	Located between Helidon Spa at its eastern end to Athol at its western end	Toowoomba Bypass is a new 41-km stretch of highway. The Toowoomba Bypass consists of the Warrego Highway (A2) from the Warrego east interchange (Helidon Spa) to the Warrego west interchange (Charlton), and the Gore Highway (A39) from the Warrego west interchange (Charlton) to the Gore Highway interchange (Athol)	The Toowoomba Bypass was officially opened to traffic in September 2019
InterLinkSQ	Located 13 km west of Toowoomba The InterLinkSQ project is adjacent to the Project alignment (located immediately south of the alignment) at the western end	2017 to 2037 assumed to continue development until Inland Rail is operational	
Wellcamp Business Park (Wagners)	Wellcamp, Queensland Located approximately 7 km to the south-west of the western end of the Project alignment	The Wellcamp Business Park is a 500-ha industrial and commercial park that forms part of the Toowoomba Enterprise Hub. The Business Park is located in close proximity to the Toowoomba Wellcamp Airport and other major transportation infrastructure	Operational—subject to continuing construction and expansion
Witmack Industry Park	Wellcamp, Queensland. Located approximately 3.5 km to the south of the western end of the Project alignment	The Witmack Industry Park is a large industrial land development that offers large size industrial land parcels. Businesses situated within the Witmack Industrial Park include the Toowoomba Pulse Data Centre	Operational—subject to continuing construction and expansion
Charlton Logistics Park	Wellcamp, Queensland Located approximately 2.8 km to the south of the western end of the Project alignment	The Charlton Logistics Park is part of the Toowoomba Enterprise Hub and provides fully serviced 2-ha sites and is well situated for potential transport and logistics operators due to its proximity to transport infrastructure	2019 to 2024 Operational—subject to continuing construction and expansion
Gatton West Industrial Zone (GWIZ)	3 km north-west of Gatton. Located approximately 12-km east of the eastern end of the Project alignment, adjacent to the northern boundary of H2C	Industrial development including a transport and logistics hub on the Warrego Highway	Unknown

Project and proponent	Location	Description	Construction dates
Harlaxton Quarry	Harlaxton, Queensland. Located approximately 900 m to the south of the Project's eastern tunnel portal	An existing quarry specialising in the production of road base material and aggregates	Operational
Asterion Medicinal Cannabis Project	Wellcamp, Queensland. Located approximately 9 km to the south-west of the western end of the Project alignment	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. The facility will be powered by renewable energy	2020 to 2021

Table note:
Although several of the projects listed in Table 12.45 are currently under construction or are operational, emissions from these projects will not be represented by the background air quality concentrations adopted for the assessment (refer Section 12.5.3.2) due to the location of the air quality monitoring stations referenced.

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



Map by: MEF/DTH/GN/TM/MF Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-201909121626_Air_Quality\320-EAP-201909121626_ARTC_Fig12.13_Cumulative_v2.mxd Date: 15/03/2021 11:20

The results of the assessment of the significance of cumulative impacts during the construction phase of the Project are presented in Table 12.46.

The majority of the assessed projects considered in the cumulative impact assessment have the greatest potential to cause cumulative impacts during their construction phase—the only exception being the Harlaxton Quarry and Toowoomba Bypass, which are already operational and, therefore, construction is not required. With the exception of the B2G, H2C, Harlaxton Quarry and the Toowoomba Bypass projects (which have been included in the operational assessment for the Project), emissions from the operation of the assessed projects are not considered to be significant and do not have the potential to generate cumulative impacts.

The relevance factor for the sensitivity of the receiving environment in Table 12.46 has been assigned as Low for all projects. This factor has been assigned considering the number of sensitive receptors that may be affected by cumulative impacts with the assessed project, the sensitivity to the emissions that will cause the impact (e.g. sensitivity to dust), and the mostly isolated nature of construction-phase emissions from the Project.

Based on the assigned relevance factors, Table 12.46 shows that cumulative air quality impacts are expected to be of Low significance for all assessed projects.

Mitigation measures for the construction phase of the Project are discussed in Section 12.8.3. The proposed mitigation measures for the Project will reduce the potential for cumulative impacts at sensitive receptors. In addition to the proposed mitigation measures, visual and quantitative dust monitoring will be undertaken at sensitive receptor locations near the Harlaxton Quarry (refer Section 12.8.4.2) to assist in managing cumulative impacts at these receptors.

Implementation of the mitigation measures and the CEMP is expected to be sufficient to minimise the risk of significant cumulative impacts.

TABLE 12.46: CUMULATIVE IMPACT ASSESSMENT OF ASSESSABLE PROJECTS

Project	Potential cumulative impact	Aspect	Relevance factor	Sum of relevance factors	Impact significance	Comments and management measures
B2G (ARTC)	The construction of B2G will occur concurrently with the construction of the Project. Air emissions during construction could impact receptors located near both projects. B2G and the Project will operate concurrently. Air emissions from the operation of B2G have been assessed as part of the assessment of the operation phase of the Project.	Probability of the impact	Medium (2)	6	Low	▸ The significance of cumulative impacts is considered to be low. ▸ It is considered unlikely that construction for each project will occur in the same localised area simultaneously, to the extent that would cause significant impacts to existing receptors. Sensitive receptors are sparse in the area where construction for each project is likely to overlap and the majority of receptors have significant separation distance from the Project disturbance footprint. ▸ Proposed mitigation measures for the construction phase of the Project are presented in Section 12.8.3. Mitigation measures are proposed for the B2G project in the project EIS. ▸ Cumulative impacts as a result of the operation of both projects has been assessed in detail, with the results of the operational phase assessment presented in Section 12.7.3.
		Duration of the impact	Medium (2)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			

Project	Potential cumulative impact	Aspect	Relevance factor	Sum of relevance factors	Impact significance	Comments and management measures
H2C (ARTC)	The construction of H2C will occur concurrently with the construction of the Project. Air emissions during construction could impact receptors located near both projects. H2C and the Project will operate concurrently. Air emissions from the operation of H2C have been assessed as part of the assessment of the operation phase of the Project.	Probability of the impact	Medium (2)	6	Low	▸ The significance of cumulative impacts is considered to be low. ▸ It is considered unlikely that construction for each project will occur in the same localised area simultaneously, to the extent that would cause significant impacts to existing receptors. Sensitive receptors are sparse in the area where construction for each project is likely to overlap, and the majority of receptors have significant separation distance from the Project disturbance footprint. ▸ Proposed mitigation measures for the construction phase of the Project are presented in Section 12.8.3. Mitigation measures are proposed for the H2C project in the project EIS. ▸ Cumulative impacts as a result of the operation of both projects has been assessed in detail, with the results of the operational phase assessment presented in Section 12.7.3.
		Duration of the impact	Medium (2)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			

Project	Potential cumulative impact	Aspect	Relevance factor	Sum of relevance factors	Impact significance	Comments and management measures
Toowoomba Bypass	The operation of the Toowoomba Bypass will occur concurrently with the construction and operation of the Project. Pollutant species emitted from road traffic on the Toowoomba Bypass include NO_x, PM_{10} and $PM_{2.5}$. The cumulative impact of the operation of both projects has been considered in detail via dispersion modelling of emissions from the Toowoomba Bypass.	Probability of the impact	Low (1)	4	Low	▶ The significance of cumulative impacts is considered to be low. ▶ Construction dust is the concern during the construction phase of the Project. Particulate emissions from the operation of the Toowoomba Bypass will be low in comparison to potential construction dust emissions and, therefore, the potential for cumulative impacts is limited. ▶ Road traffic emissions also disperse efficiently following release and, therefore, it is unlikely that cumulative impacts could occur outside the Toowoomba Bypass corridor. ▶ No additional mitigation measures are required further to those proposed for the Project (refer Section 12.8.3). ▶ Cumulative impacts as a result of the operation of both projects has been assessed in detail, with the results of the operational-phase assessment presented in Section 12.7.3.
		Duration of the impact	Low (1)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			
InterLinkSQ	The construction of the Project will occur concurrently with the construction and operation of the InterLinkSQ project. Construction dust emissions during the construction phase of the InterLinkSQ project could be significant when activities such as earthworks are being undertaken. Air emissions during the operation of InterLinkSQ will predominantly be limited to combustion engine emissions (transport vehicles) and are not expected to be significant in magnitude.	Probability of the impact	Medium (2)	6	Low	▶ The significance of cumulative impacts is considered to be low. ▶ It is considered unlikely that construction for each project will occur in the same localised area simultaneously to the extent that would cause significant impacts to existing receptors. Sensitive receptors are sparse in the area where construction for each project is likely to overlap and the majority of receptors have significant separation distance from the Project disturbance footprint. ▶ No additional mitigation measures are required further to those proposed for the Project.
		Duration of the impact	Medium (2)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			

Project	Potential cumulative impact	Aspect	Relevance factor	Sum of relevance factors	Impact significance	Comments and management measures
Wellcamp Business Park (Wagners)	The operation and potential further development (construction) of the business park will occur concurrently with the construction of the Project. Air emissions will likely occur during further development, subject to the construction activities required. Air emissions from the operation of the business park will occur and may change subject to the type of land uses accommodated in the future. Existing land uses are not considered significant emission sources for the purpose of assessing impacts to the AQIA study area.	Probability of the impact	Low (1)	4	Low	▸ The significance of cumulative impacts is considered to be low. ▸ Due to the separation distance between the business park and the Project alignment (approximately 7 km), the risk of significant cumulative impacts as a result of construction phase emissions is low. ▸ Operational emissions from the business park are not considered significant and the risk of significant cumulative impacts for this phase is negligible. ▸ No additional mitigation measures are required further to those proposed for the Project.
		Duration of the impact	Low (1))			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			
Witmack Industry Park	The operation and potential further development (construction) of the business park will occur concurrently with the construction of the Project. Air emissions will likely occur during further development, subject to the construction activities required. Air emissions from the operation of the business park will occur and may change subject to the type of land uses accommodated in the future. Existing land uses are not considered significant emission sources for the purpose of assessing impacts to the AQIA study area.	Probability of the impact	Low (1)	4	Low	▸ The significance of cumulative impacts is considered to be low. ▸ Due to the separation distance between the business park and the Project alignment (approximately 3.5 km), the risk of significant cumulative impacts as a result of construction phase emissions is low. ▸ Operational emissions from the business park are not considered significant and the risk of significant cumulative impacts for this phase is negligible. ▸ No additional mitigation measures are required further to those proposed for the Project.
		Duration of the impact	Low (1))			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			

Project	Potential cumulative impact	Aspect	Relevance factor	Sum of relevance factors	Impact significance	Comments and management measures
Charlton Logistics Park	The operation and potential further development (construction) of the business park will occur concurrently with the construction of the Project. Air emissions will likely occur during further development, subject to the construction activities required. Air emissions from the operation of the business park will occur and may change subject to the type of land uses accommodated in the future. Existing land uses are not considered significant emission sources for the purpose of assessing impacts to the AQIA study area.	Probability of the impact	Low (1)	4	Low	▸ The significance of cumulative impacts is considered to be low. ▸ Due to the separation distance between the business park and the Project alignment (approximately 2.8 km), the risk of significant cumulative impacts as a result of construction phase emissions is low. ▸ Operational emissions from the business park are not considered significant and the risk of significant cumulative impacts for this phase is negligible. ▸ No additional mitigation measures are required further to those proposed for the Project.
		Duration of the impact	Low (1))			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			
Gatton West Industrial Zone (GWIZ)	The construction and operation phases of the GWIZ project overlap with the construction phase of the Project. Air emissions will likely occur during construction, subject to the construction activities required. The operation of the GWIZ will likely increase road traffic on surrounding roads, including the Warrego Highway.	Probability of the impact	Low (1)	4	Low	▸ The significance of cumulative impacts is considered to be low. ▸ Due to significant separation distance (12 km), the risk of cumulative impacts is considered to be low. ▸ Increases in road traffic emissions as a result of the GWIZ project are not expected to be significant. ▸ No additional mitigation measures are required.
		Duration of the impact	Low (1)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			

Project	Potential cumulative impact	Aspect	Relevance factor	Sum of relevance factors	Impact significance	Comments and management measures
Harlaxton Quarry	The quarry is currently operational and is expected to operate concurrently with the construction of the Project. The quarry specialises in the production of road base material and aggregates and it is expected that the operation of the quarry will emit particulates and minor emissions of gaseous pollutants. Air emissions from the operation of the quarry and the construction of the Project could impact sensitive receptors located near both projects. The cumulative impact of the operation of both projects has been considered in detail, via analysis of dispersion modelling results for receptors near the quarry.	Probability of the impact	Medium (2)	6	Low	▸ The significance of cumulative impacts is considered to be low. ▸ The nearest sensitive receptor to the Project, which is also located near the quarry is receptor R_1924, which represents a residential dwelling located on Gilmour Court, Harlaxton. Receptor R_1924 is located approximately 610 m south-west of the Project disturbance footprint, and approximately 350 m north-east of the nearest active area of the quarry. The projects are located at different orientations to the nearest sensitive receptors. ▸ Proposed mitigation measures for the construction phase of the Project will reduce the potential for cumulative impacts at sensitive receptors near the quarry. To further manage potential cumulative impacts, visual and quantitative dust monitoring will be undertaken at sensitive receptor locations near the quarry (refer Section 12.8.4.2). ▸ Cumulative impacts as a result of the operation of both projects has been assessed in detail in Section 12.7.3.
		Duration of the impact	Medium (2)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			

Project	Potential cumulative impact	Aspect	Relevance factor	Sum of relevance factors	Impact significance	Comments and management measures
Asterion Medicinal Cannabis Project	Construction and operation of the Asterion project will occur concurrently with the construction of the Project. Construction dust emissions during the construction phase of the Asterion project could be significant when activities such as earthworks are being undertaken; however, there is significant separation distance between the Asterion project and the Project (9 km). Emission sources during operation of the Asterion project are expected to be limited to transport vehicles. The magnitude of these emissions is considered to negligible with respect to potential cumulative impacts.	Probability of the impact	Low (1)	4	Low	▸ The significance of cumulative impacts is considered to be low. ▸ Due to significant separation distance (9 km), the risk of cumulative impacts is considered to be low. ▸ Operational emissions are not expected to be significant and the risk of significant cumulative impacts for this phase is negligible. ▸ No additional mitigation measures are required.
		Duration of the impact	Low (1)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Low (1)			

12.8 Mitigation

This section outlines the mitigation measures included in the Project design and identifies proposed mitigation measures to manage impacts to air quality in the pre-construction, and construction and operational phases of the Project.

No comprehensive guideline information is currently available for best-practice environmental management measures for the emissions of air pollutants from construction-related emissions in Queensland or Australia. Guidance on management measures is provided within the IAQM Guideline for the assessment of dust from demolition and construction (UK IAQM, 2014). Many of the IAQM Guideline measures are tailored to the UK and, therefore, are not necessarily applicable for Australia; however, where similar conditions do exist, the proposed mitigation measures for the Project align with the suggested mitigation measures from the IAQM guideline.

In addition to the IAQM guideline, the mitigation measures proposed for the construction phase of the Project are also generally consistent with construction mitigation measures prescribed by the New Zealand Ministry for the Environment (NZMfE) *Good Practice Guide for Assessing and Managing Dust* (NZMfE, 2016) and the NSW EPA Air quality guidance note for construction sites (NSW EPA, 2017), which are both recognised technical guideline documents.

Mitigation measures prescribed in the *NPI Emissions estimation manual for Mining* (NPI, 2012) are also considered applicable for the construction phase and selected mitigation measures from this document are proposed.

The mitigation measures that are proposed for the Project are considered to represent best-practice environmental management of air emissions.

12.8.1 Design measures

The initial mitigation measures presented in Table 12.47 have been incorporated into the Project design. These design measures have been identified through collaborative development of the design and consideration of environmental constraints and issues, including proximity to sensitive receptors. These design measures are relevant to both construction and operational phases of the Project.

TABLE 12.47: INITIAL MITIGATION IN DESIGN

Aspect	Initial mitigation
Emissions from refuelling activities during construction	The planning, siting and assessment of potential fuel storage locations has taken into consideration the location of sensitive receptors.
Emissions from construction vehicles	The horizontal and vertical alignment has been established to optimise the earthworks and minimise excess spoil (where possible). By minimising the material deficit for construction of the Project, the volume of material required to be handled and transported has been reduced. The Project design also accommodates the storage and management of excess material from the excavation of the Toowoomba Range Tunnel at the western tunnel portal (i.e. stockpile within the railway corridor). Less material handling reduces potential road transport truck movements and vehicular emissions. Construction-phase haulage routes that provide the shortest journey time between origin and destination have been considered. These routes restrict fuel consumption and vehicular emissions. A traffic impact assessment of these routes has been undertaken as presented in Appendix U: Traffic Impact Assessment.
Fugitive dust emissions (windborne erosion) during construction and operation	The Project disturbance footprint defined in the Project design has aimed to minimise clearing extents to that required to construct and operate the works. Railway batters and other exposed surfaces have been designed to enable stabilisation to reduce fugitive dust emissions.
Emissions from operational locomotives	The Project design through the steep terrain and topographical constraints associated with the Toowoomba Range (approximately 22 km) maintains a constant gradient of 1.55 per cent, while also maximising curve radius conducive to freight rail. This results in faster train transit time and less locomotive emissions.
In-tunnel air quality	The mechanical ventilation system for the Toowoomba Range Tunnel has been designed to maintain air quality inside the tunnel to an acceptable standard considering human exposure and locomotive manufacturer requirements for air intake quality. This includes monitoring systems to detect pollutant leaks and inform purging events.

12.8.2 Operational management measures

Dust and air quality management measures will be incorporated into the environmental risk management frameworks that will apply to third-party freight train operators as part of network access agreements. The network access agreements will require train operators to prepare suitably detailed environmental management plans for their operations, detailing how the operator will manage all risks. These plans will include clear performance requirements and traceable corrective measures and be subject to verification and auditing by ARTC as the rail network manager.

As the rail network manager, ARTC would be responsible for reviewing risks with regards to accessing and operating on the rail network, including environmental management. Where necessary, ARTC as the rail network manager will impose conditions on rail operators to implement controls for the reduction or mitigation of these risks.

The assessment of the operational phase has assessed impacts considering the inclusion of a number of the operational management measures as required by the South West Supply Chain Coal Dust Management Plan (2019), such as veneering, are applied to the Project. The mitigation measures in the Coal Dust Management Plan aim to minimise surface lift-off of materials in transit and establishes protocols to minimise spillage onto external areas of wagons to reduce emissions. In addition to veneering, measures currently implemented through the South West Supply Chain include:

- Coal washing and moisture management
- Load profiling and use of 'garden bed profile'
- Monitoring of performance.

The assessment of the operational phase has determined that veneering will minimise and reduce potential particulate matters impacts based on the assessed volume of coal trains. The implementation of veneering has been assumed to reduce coal dust emissions from coal-laden trains by 75 per cent, as discussed in Section 12.6.3.2.

Veneering is currently applied to coal trains that use the rail corridor of the West Moreton System; therefore, existing coal trains that currently use the West Moreton System, and that would use the Project in the future, will already implement veneering.

Prior to operation of the Project, engagement will be undertaken with existing stakeholders and members of the South West Supply Chain (including QR, DES, etc.) with regards to coal dust management and monitoring requirements necessary to maintain the integrity of the existing *South West Supply Chain Coal Dust Management Plan* (2019).

Maintenance activities do have a potential to generate dust- or air-quality impacts—these activities will be managed under ARTCs Environmental Management System and in accordance with the measures described in the relevant maintenance procedures and environmental management plans.

As discussed in Section 12.7.3.6, the Toowoomba Range Tunnel will include in-tunnel air quality monitoring of NO_2, NO and CO as part of the ventilation system, to ensure air quality in the tunnel is acceptable prior to train travel through the tunnel. The in-tunnel air quality monitoring system may be used to ensure tunnel design minimises potential environmental impacts of the tunnel ventilation system, subject to the design and specifications of the in-tunnel air quality monitoring system.

12.8.3 Proposed mitigation measures

In order to manage Project risks during construction, a number of mitigation measures have been proposed for implementation in future phases of Project delivery, as presented in Table 12.48. These proposed mitigation measures have been identified to address Project-specific issues and opportunities, address legislative requirements, accepted government plans, policies and practice.

Table 12.48 identifies the relevant Project phase, the aspect to be managed, and the proposed mitigation measure. For several of the mitigation measures proposed, the expected control efficiency (emission reduction percentage) has been nominated. The control efficiencies reported have been obtained from the NPI Emissions estimation manual for Mining (NPI, 2012).

In the construction phase of the Project, including pre-construction activities, dust sources will be variable and transitory in nature and the potential for impacts will vary with proximity to sensitive receptors.

During the commissioning phase of the Project, air emissions are expected to be limited to combustion engine emissions associated with transport vehicles and train locomotives, and limited dust emissions from vehicle travel on unsealed roads. Mitigation measures for transport vehicles (dust and combustion engine emissions) are the same during the construction and commissioning phases, and, therefore, the mitigation measures in Table 12.48 are combined for these phases. Air emissions from train locomotives during the commissioning phase are not expected to be significant and, therefore, no mitigation measures are required for train locomotives in this phase.

The draft Outline EMP (refer Chapter 23: Draft Outline Environmental Management Plan), provides further context and the framework for implementation of these measures.

A CEMP will be required for the construction of the Project, to manage potential impacts from dust emissions. The mitigation measures presented in Table 12.48 will be included in the CEMP for the Project.

TABLE 12.48: AIR QUALITY MITIGATION MEASURES

Delivery phase	Aspect	Proposed mitigation measures
Detailed design	Availability of water for dust suppression and stabilisation during construction	Prior to construction, quantities of water required for dust suppression, construction, landscaping and stabilisation activities will be confirmed. The availability and suitability of water supply sources will be determined and, where water supply is deemed insufficient or in high demand for other uses, other dust suppression and stabilisation methods will be implemented.
	Emissions from refuelling activities during construction	Design of fuel storage areas will ensure that fuel tanks will be located at least 50 m from the nearest sensitive receptor, with separation distances maximised as far as practical within site restrictions.
	Fugitive dust emissions (windborne erosion) during construction and operation	Detailed design will aim to avoid increasing the extent of the Project disturbance footprint. Laydown areas and other construction-phase facilities will be designed and arranged to minimise emissions and reduce the potential for impacts to air quality. Design considerations will include the locations of stockpiles, activity areas, travel routes, rumble grids and truck washdown areas, etc. The location of the permanent spoil mound at the western tunnel portal laydown area will consider proximity to sensitive receptors and allowance for mitigation measures (e.g. profiling and stabilisation of stockpile and maximising separation distance from nearest sensitive receptors (noting that the stockpile may also buffer other amenity issues)). Earthworks and landscape design of railway batters and other exposed surfaces will be designed to incorporate treatments and enable stabilisation to reduce wind erosion.
	Emissions from operation of batching plants	Design the laydown area at the eastern tunnel portal (G2H-LDN010.5) such that the concrete batching plant (if required) can be located at a position at least 500 m from the nearest sensitive receptor.
	Emissions from operation of crushing plant	Design the laydown areas at the western tunnel portal (G2H-LDN003.7) and McNamaras Road (G2H-LDN015.6) such that crushing plant (if required) can be located at a position at least 250 m from the nearest sensitive receptor.
Pre-construction and construction	Dust generation from pre-construction activities	Vehicle travel on unsealed roads will be minimised as far as practical. Sealed roads will be used where possible. Disturbed areas will be rehabilitated and stabilise as soon as practical on completion of works. Vehicles and mobile plant will minimise idling as much as practical.

Delivery phase	Aspect	Proposed mitigation measures
Construction and commissioning	Dust generation from earthworks, clearing and grubbing, mobile plant activity and wind erosion of exposed areas within the Project disturbance footprint	Limit clearing to the Project disturbance footprint, as identified during the detailed design constructability assessment and planning. Limit clearing to that required to safely construct and operate the Project. Where practical, stage clearing and grubbing, and construction activities to limit the size of exposed areas. Implement water sprays to reduce dust emissions from excavation or disturbance of soils or vegetation, or handling ballast. Implement water sprays to reduce dust emissions from trucks unloading material (anticipated emission reduction of 70 per cent). Implement water sprays to reduce dust emissions for mobile plant loading to or from material stockpiles (anticipated emission reduction of 50 per cent). To reduce wind erosion from stockpiles, the following mitigation methods are proposed subject to water availability and stockpile activity: ▸ Water sprays (anticipated emission reduction of 50 per cent) ▸ Wind breaks or earthworks profiling (anticipated emission reduction of 30 per cent) ▸ Application of rock armour/covering (anticipated emission reduction of 30 per cent) ▸ Covering of the stockpile with an impermeable covering (i.e. tarpaulin) or binding agent (anticipated emission reduction of 100 per cent). If water sprays are implemented for stockpiles, the application rate of water will be increased for stockpiles that will receive new material regularly, such as tunnel excavation stockpiles.
		Disturbed areas and exposed surfaces will be stabilised as a soon as practical. The following mitigation methods will be used subject to final purpose of the exposed area: ▸ Initial establishment of vegetation (anticipated emission reduction of 30 per cent) ▸ Maintained revegetation (anticipated emission reduction of 90 per cent) ▸ Establishment of self-sustaining rehabilitation vegetation (anticipated emission reduction of 100 per cent) ▸ Sealing of exposed surface (i.e. concrete, asphalt, etc) (anticipated emission reduction of 100 per cent). Long-term stockpiles will be avoided where possible; however, where necessary (e.g. topsoil), long-term stockpiles will be established in locations with suitable separation from sensitive receptors and not in the path of prevailing winds (which would transport dust towards sensitive receptors). During periods of inactivity, stockpiles will be covered with an impermeable covering (i.e. tarpaulin) or binding agent (anticipated emission reduction of 100 per cent). Establish and communicate the protocol for notifying relevant stakeholders when potentially dust generating activities (e.g. blasting) are planned to be carried out, with contact details for queries or complaints. Monitor air quality during construction of the Project, and report and audit monitoring results as discussed in Section 23.15.5.4 of Chapter 23: Draft Outline EMP. Monitor, record and audit complaints about dust and emissions in accordance with the Complaint Management Handling Procedure described in Section 23.13 of Chapter 23: Draft Outline EMP and the requirements of the Social Impact Management Plan.

Delivery phase	Aspect	Proposed mitigation measures
Construction and commissioning [continued]	Emission from blasting	Do not undertake blasting during wind conditions that are likely to transport dust emissions toward sensitive receptors within 500 m of the blasting location.
	Emissions from refuelling activities	Fuel storage areas will be located at least 50 m from the nearest sensitive receptor, with separation distances maximised as far as practical within site restrictions.
	Emissions from combustion engines (construction vehicles and generators)	Construction plant, vehicles and machinery will be maintained and operate in accordance with manufacturer's recommendations. Vehicles and mobile plant will minimise idling as much as practical. Diesel generators will be avoided where practical. Where required, generators will be located as far as possible from sensitive receptors.
	Use of non-potable water for dust suppression	Water used in dust suppression will be of suitable quality and not result in environmental or human health risks, or impact rehabilitation outcomes. Water additives used to improve dust suppression effectiveness (e.g. the addition of soil binders to water for dust suppression on roads or hard stand areas, which has a potential control efficiency of up to 100 per cent) will be risk assessed prior to adoption.
	Dust generated by traffic on access tracks	To reduce emissions from vehicle travel on unsealed roads, the following mitigation methods will be implemented for haul roads with receptors located within 350 m: - Level 1 road watering (2 litres per square metre per hour ($L/m^2/h$)) (anticipated emission reduction of 50 per cent) - Level 2 road watering (greater than 2 $L/m^2/h$) (anticipated emission reduction of 75 per cent) Road sealing with binding agent or asphalt (anticipated emission reduction of 100 per cent).
	Fugitive dust emissions from vehicles transporting materials to and from site	Vehicles transporting potentially dust- and/or spillage-generating material to and from the construction site will have their loads covered immediately after loading (prior to traversing public roads). Rumble grids and the operation of truck washdown areas will be maintained to reduce trackout of material onto public roads, where it may become resuspended.
	Cumulative effects of dust emissions from construction and external land uses or activities	Sensitive receptors near the existing Harlaxton Quarry may be impacted by the operation of the quarry and the construction phase of the Project. The cumulative impact of both sources on sensitive receptors and the effectiveness of the proposed mitigation measures for Project construction activity near the quarry will be monitored via visual monitoring and air quality monitoring, as discussed in Section 12.8.4. In the event of validated complaints or measured exceedances of the Project air quality goals, enhanced mitigation will be implemented. Project construction activities to be undertaken near the quarry that have the highest potential to generate air emissions include excavation works, blasting and vehicle travel on unsealed roads. Mitigation measures for these activities are presented in this table.

Delivery phase	Aspect	Proposed mitigation measures
Construction and commissioning [continued]	Dust generation and deposition as a result of adverse weather conditions	Avoid ground-disturbing activities including excavation and vegetation clearing during windy conditions (e.g. winds > 36 km/hr or 20 knots), where practical. When avoidance of ground-disturbing activities is not practical, implement enhanced management measures, such as: - Increased rate of water application to haul roads (e.g. increase to Level 2 watering, >2 L/m²/h) - Increased rate of water application to excavation and clearing areas - Implement temporary stabilisation (binding agent) to access tracks and haul roads (anticipated emission reduction of 100 per cent). Where possible, stockpiles will be covered (anticipated emission reduction of 100 per cent) prior to the onset of adverse weather.
Operations	Emissions from the operation of the Project, including train travel along the alignment and through the Toowoomba Range Tunnel	Prior to operation of the Project, engagement will be undertaken with existing stakeholders and members of the South West Supply Chain (including QR, DES, etc.) with regards to coal dust management and monitoring requirements necessary to maintain the integrity of the existing *South West Supply Chain Coal Dust Management Plan* (2019). The Toowoomba Range Tunnel will include in-tunnel air quality monitoring as part of the ventilation system, to trigger tunnel purging once in-tunnel pollution design thresholds have been reached, to ensure air quality within the tunnel is acceptable prior to train travel through the tunnel. Monitor, record and audit complaints about dust and emissions in accordance with the ARTC Complaint Management Handling Procedure and the requirements of the Social Impact Management Plan.
	Emissions from idling locomotives	Train operators will be educated on the potential impact of idling locomoties on air quality and will be encouraged to reduce idling when possible.

12.8.4 Monitoring, reporting and auditing

This section describes how the Project will monitor, report and audit compliance with the Project's air quality goals.

12.8.4.1 Construction-phase weather conditions monitoring

To aid in the avoidance of dust generation during adverse weather conditions, weather forecasts and observations for adverse weather (e.g. winds greater than 36 km/hr) will be observed during the construction phase of the Project, using existing BoM weather stations.

To assist with auditing and the analysis of air quality monitoring and complaints (if received), periods of adverse weather periods will be recorded in monthly environmental reports.

12.8.4.2 Construction-phase air quality monitoring

Visual and quantitative air quality monitoring will be undertaken for the construction phase of the Project.

Visual monitoring of dust generation (visible plumes) will be undertaken throughout construction. Daily onsite inspections of dust generation will be undertaken by construction staff to monitor dust being generated onsite, to inform mitigation measures. In addition, weekly offsite inspection will be undertaken at sensitive receptors located near high-intensity construction areas, such as heavily trafficked haul roads, excavation areas and laydown areas. Visual monitoring will include checks of dust deposition on horizontal surfaces, such as cars and window sills. Visual monitoring will be the responsibility of the construction contractor.

Quantitative air quality monitoring will be undertaken via monitoring of dust deposition. Dust deposition monitoring will be undertaken at sensitive receptor locations near the Harlaxton Quarry, which have the potential to be impacted by emissions from the construction phase of the Project and emissions from the operation of the quarry.

Selection of the locations for the installation of dust deposition gauges will be undertaken by a suitably qualified air quality professional. The monitoring locations will be demarcated and sign posted.

In the event that dust deposition monitoring determines exceedance of the Project's air quality goal (120 mg/m^2/day) at sensitive receptors, additional monitoring, including monitoring of airborne particulate concentrations (e.g. TSP or PM_{10}), may be required. If validated air quality complaints are received from locations that are not represented by the location of air monitoring stations, additional monitoring stations may be deployed.

In the event that dust deposition or airborne air quality monitoring determines exceedance of the Project air quality goals, corrective actions will be required to mitigate impacts and minimise the risk of further exceedances. Corrective actions will be the responsibility of the construction contractor; however, as a minimum, the corrective actions would include the following:

- Review of the air quality monitoring data to determine the period/s of exceedance, along with local weather conditions
- Review of Project and non-Project related emission sources that may have been responsible for, or contributed too, the measured exceedance
- Upon identification of Project-related emission source, undertake a review of the mitigation measures implemented at the time when the exceedance was recorded
- Evaluate the effectiveness of mitigation measures and standard working procedures, and adjust or enhance the application of mitigation measures to reduce construction emissions and minimise the risk of future exceedances
- Monitor the effectiveness of enhanced mitigation measures and, if required, reduce the intensity of construction works.

Air quality monitoring data and logs of visual monitoring inspections will be included in the monthly environmental monitoring reports prepared by the construction contractor.

12.8.4.3 Operational-phase air quality monitoring

Quantitative air quality monitoring will be undertaken during the operational phase at a yet to be determined location(s) along the Queensland section of the Inland Rail alignment. As the rail network manager, ARTC would be responsible for providing support and funding for air quality monitoring.

Requirements for the air quality monitoring station, including the location of any monitoring stations will be discussed with the stakeholders of the South West Supply Chain, including the DES and the DTMR. It is expected that the pollutant species monitored will include dust deposition and airborne concentrations of PM_{10} and TSP, and that the monitoring station will be generally equivalent in nature to the existing monitoring stations operating as part of the South West Supply Chain Coal Dust Management Plan.

The existing monitoring stations operating as part of the South West Supply Chain Coal Dust Management Plan currently include continuous monitoring of airborne concentrations of TSP, PM_{10} and $PM_{2.5}$ at Cannon Hill, and dust deposition monitoring at Cannon Hill, Fairfield and Toowoomba.

Air quality monitoring data will be reported monthly. The responsibility for the reporting of the monitoring data and the maintenance and ongoing operation of the monitoring station will be discussed with the stakeholders of the South West Supply Chain.

In the event of complaints being received regarding air quality, appropriate response and monitoring may occur following investigation into the complaint.

In the event that exceedances of the Project air quality goals are measured during the operational phase, corrective actions will be required to mitigate impacts and minimise the risk of further exceedances. Requirements for corrective actions will be discussed with the stakeholders of the South West Supply Chain; however, corrective actions that may be undertaken include:

- Review of the air quality monitoring data to determine the period/s of exceedance
- Review of Project and non-Project related emission sources that may have been responsible for, or contributed too, the measured exceedance
- Upon identification of Project-related emission source, undertake a review of operational activities at the time when the exceedance was recorded
- Evaluation of the effectiveness of mitigation measures and standard operational procedures with respect to the potential for future exceedances.

In addition to monitoring adjacent the rail line, in-tunnel air quality monitoring data will also be used to determine compliance with in-tunnel air quality goals.

12.8.4.4 Operational-phase emissions reporting

Emissions reporting will be undertaken where applicable. If required, emissions reporting requirements will be determined during the detailed design phase, to be consistent with the Infrastructure Sustainability Council of Australia (ISCA) and National Greenhouse and Energy Report (NGER) requirements.

12.9 Residual impact assessment

12.9.1.1 Construction

Potential air quality impacts to sensitive receptors and the environmental values of human health (PM_{10}), and the aesthetic environment (TSP as deposited dust), as a result of the construction phase of the Project, have been assessed in accordance with the qualitative impact assessment methodology described in Section 12.6.2. Assessment of the residual impact of the construction phase of the Project following the implementation of the proposed mitigation measures (refer Section 12.8.3) is presented in this section.

The assessment of residual impacts to sensitive receptors during the construction of the Project is presented in Table 12.49. The methodology for the residual impact assessment is summarised as follows:

- The receptor sensitivity, initial emission magnitude and initial significance for each construction activity category (earthworks, construction and trackout) presented in Table 12.49 is the assessed risk of impacts without mitigation as presented in Section 12.7.1.1 and summarised in Table 12.32
- The residual emission magnitude has been determined qualitatively, based on the anticipated reduction to construction dust emissions, considering the available mitigation measures and the nominated control efficiencies presented in Table 12.48

- The residual significance (residual impact) has been determined using the IAQM risk matrix for each construction activity (refer Table 12.29 and Table 12.30), considering the residual emission magnitudes assigned for each activity and receptor sensitivity
- Table 12.49 shows that, following the IAQM risk matrix, the residual significance with the proposed mitigation measures is low for all activities and impacts, with the exception of potential impacts to human health from trackout, which is categorised as medium.

A discussed in Section 12.7.1.1, the sensitivity rating of high for human health impacts for the entire AQIA study area is considered conservative and, in reality, the most sensitive areas to construction dust impacts will be residential areas in the several small townships or suburbs of Toowoomba located near the Project alignment, including Gowrie, Cranley, Mount Kynoch, Blue Mountain Heights, Lockyer, Postmans Ridge and Helidon Spa.

The IAQM construction dust assessment guidance states:

> *For almost all construction activity, the aim should be to prevent significant effects on sensitive receptors through the use of suitable and effective mitigation. Experience shows that this is normally possible. Hence the residual effect will normally be "not significant".*

Consistent with the IAQM statement, it is expected that, with implementation of the proposed mitigation measures, the impacts to air quality with respect to dust deposition and human health will not be significant; however, mitigation measures for trackout (e.g. water sprays on haul roads) will need to be implemented diligently near residential areas to ensure that emissions are minimised to reduce the risk of impacts.

TABLE 12.49 INITIAL AND RESIDUAL SIGNIFICANCE ASSESSMENT FOR POTENTIAL AIR QUALITY IMPACTS ASSOCIATED WITH CONSTRUCTION

				Initial significance[b]		Residual significance[c]	
Activity	Aspect[a]	Potential impact	Receptor sensitivity	Emission magnitude	Significance	Emission magnitude	Significance
Earthworks associated with pre-construction and construction phase	All dust generating sources associated with pre-construction and construction-phase earthworks	Dust deposition (aesthetic environment)	Medium	Large	Medium	Small	Low
		Human health	High	Large	High	Small	Low
Construction	All dust generating sources associated with construction phase for the Project	Dust deposition (aesthetic environment)	Medium	Large	Medium	Small	Low
		Human health	High	Large	High	Small	Low
Trackout associated with pre-construction and construction phase	All dust generating sources associated with pre-construction and construction-phase traffic associated with the Project	Dust deposition (aesthetic environment)	Medium	Large	Medium	Medium	Low
		Human health	High	Large	High	Medium	Medium

Table notes:

a. Refer to Table 12.48 for the proposed additional mitigation measures relevant to each aspect

b. Includes implementation of initial mitigation specified in Table 12.47

c. Assessment of residual risk once the mitigation measures identified in Table 12.48 have been applied.

12.9.1.2 Operation

A quantitative (compliance) assessment has been undertaken for potential operational impacts, as predicted concentrations at sensitive receptors have been assessed against legislative and other nominated air quality and water quality objectives. Dispersion modelling undertaken for the operational phase assessment has investigated mitigation measures (veneering to coal wagons) and predicted air quality impacts at sensitive receptors. The results of the dispersion modelling, with respect to impacts to the environmental values of human health and wellbeing, the aesthetic environment (amenity), the health and biodiversity of ecosystems, agricultural uses and the assimilative capacity of the environment are discussed in Section 12.7.3. Section 12.7.3 presents the outcomes of the residual impact assessment for the operational phase of the Project, as these results include the influence of operational mitigation measures; however, a summary is provided in this section for completeness.

The assessment of the operational phase of the Project for residual impacts to air quality (refer Section 12.7.3.1) has determined that compliance is predicted for all air quality goals at all sensitive receptors, which will be present post construction (e.g. excluding sensitive receptors acquired for the Project, such as receptor R_898).

The assessment of the operational phase of the Project for residual impacts to water quality (refer Section 12.7.3.2) has determined that compliance with the adopted water quality objectives is predicted at all receptors. The methodology applied for the assessment of impacts to water tanks is also applicable for assessment of impacts to water quality for dams, assuming that the surface area (roof area) and receiving water volumes (1,000 L) are comparable. Based on the methodology applied, the residual impact to water quality as a result of emissions to air during the operation of the Project is not anticipated to be significant.

Compliance is predicted for all air quality goals at all existing sensitive receptors that will be present during the operation of the Project and, therefore, assimilative capacity remains at each of the assessed receptors.

As discussed in Section 12.7.3.3, based on the predicted annual average NO_2 air quality concentrations outside the permanent disturbance footprint, and the existing environment associated with these areas, it is considered unlikely that significant impacts to the health and biodiversity of ecosystems will occur as a result of the operation of the Project.

Similarly, based on predicted dust deposition rates and annual average NO_2 air quality concentrations, it is considered unlikely that significant impacts to agricultural uses will occur as a result of the operation of the Project (refer Section 12.1.1.1).

12.10 Conclusions

An AQIA has been conducted to determine the potential impacts of the Project on air quality.

A qualitative construction dust risk assessment was undertaken using the UK IAQM document, *Guidance on the assessment of dust from demolition and construction*. The risk of dust deposition and human health impacts due to particulate matter (PM_{10}) on surrounding areas was determined based on the scale of activities and proximity to sensitive receptors. The outcome of the assessment showed that that the residual significance with the proposed mitigation measures is expected to be low or negligible. Consistent with statements made in the IAQM document, it is expected that, with effective implementation of the proposed mitigation measures, the impacts to air quality, with respect to dust deposition and human health, will not be significant.

A quantitative dispersion modelling assessment was undertaken for the operational phase, using the dispersion models CALPUFF and GRAL. Twelve months of meteorological input data representative for the AQIA study area was developed for use in CALPUFF. Diesel exhaust emissions from locomotives and fugitive emissions from coal trains were estimated for projected peak and typical train volumes for the Project in 2040. Ground level concentrations of particulate matter (TSP, PM_{10} and $PM_{2.5}$), NO_2, VOCs, and heavy metals were predicted using CALPUFF and GRAL at nearby sensitive receptors.

Dispersion modelling carried out for the operation of the Project determined that compliance is predicted for all pollutants at all sensitive receptors, with and without veneering for typical and peak operations. The operation of the Project is expected to comply with the adopted air quality goals at all sensitive receptors.

Investigations into the deposition of dust emissions at sensitive receptor locations showed that predicted pollutant water concentrations would be compliant with the ADWG, and significantly lower than the assessment criteria. Predicted dust deposition levels are also well below the levels that have been shown to impact crops and livestock, and, therefore, the impact of dust deposition on agricultural uses within the AQIA study area is not anticipated to be significant.

Modelling predictions for the peak and typical volume scenarios have been reviewed to determine if the annual average NO_2 air quality goal of 33 µg/m^3, set for the protection of the environmental value of the health and biodiversity of ecosystems, is exceeded within the AQIA study area. Based on the limited areas outside the Project permanent disturbance footprint at which the annual average NO_2 air quality goal is predicted to be exceeded, it is considered unlikely that significant impacts to ecological receptors will occur as a result of the operation of the Project; therefore, the operation of the Project is not expected to significantly impact the environmental value of the health and biodiversity of ecosystems.

The impact of odour from agricultural trains using the Project alignment has been assessed qualitatively using FIDOL factors. Odour emissions from agriculture freight are considered unlikely to result in significant impact to neighbouring sensitive receptors, due to the frequency and duration of the odour-generating event (train pass-by) and the predominantly rural nature of the AQIA study area.

Overall, the operation of the Project is not expected to significantly adversely impact environmental values, including human health and wellbeing, the aesthetic environment, health and biodiversity of ecosystems, and agricultural uses.

The AQIA undertaken for the Project showed that, with appropriate mitigation in place, the construction and operation of the Project can be managed in a way that air quality impacts to nearby sensitive receptors are maintained at an acceptable level, where the nominated environmental values of the air environment are protected. A CEMP will be required for the construction of the Project to manage potential impacts from dust emissions. Mitigation measures for trackout (e.g. water sprays on haul roads) will need to be implemented diligently near urban areas to ensure that emissions are minimised, to reduce the risk of impacts.

Tunnel ventilation design has been undertaken for the Toowoomba Range Tunnel, focusing on maintaining the acceptability of air quality inside the tunnel, considering human exposure and locomotive manufacturer requirements for air intake quality. The key pollutants considered were CO, NO_2 and NO. The adopted in-tunnel air quality criteria are consistent with in-tunnel air quality guideline values adopted elsewhere in Australia and internationally.