APPENDIX

O

Air Quality Technical Report

Part 1 of 3

INLAND RAIL—BORDER TO GOWRIE ENVIRONMENTAL IMPACT STATEMENT

IR_1534

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

Inland Rail Border to Gowrie EIS

Appendix O – Air Quality

Australian Rail Track Corporation

Reference: 3100

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Abbreviations

Abbreviation	Explanation
µm	micrometre
AOI	area of influence
AQIA	air quality impact assessment
AQIA area	the air environment and footprint of identified sensitive receptor locations adjacent to the Project alignment running from the NSW/QLD border to Gowrie
ARTC	Australian Rail Track Corporation Ltd
ATMS	Advanced Train Management Systems
B2G	Border to Gowrie Project
BoM	Bureau of Meteorology
CIA	cumulative impact assessment
CO	carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DES (QLD)	Department of Environment and Science
ENSO	El Niño-Southern Oscillation
NSW EPA	NSW Environment Protection Authority
EPA Victoria	Environment Protection Authority Victoria
Inland Rail	Melbourne to Brisbane Inland Rail
km	kilometres
m	metre
MEI	Multivariate ENSO Index
NO	nitrogen oxide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
NSW	New South Wales
O_3	ozone
ONI	Oceanic Niño Index
PAHs	polycyclic aromatic hydrocarbons
PM_{10}	particulate matter less than 10 micrometres
$PM_{2.5}$	particulate matter less than 2.5 micrometres
QLD	Queensland
SOI	Southern Oscillation Index
the proponent	Australian Rail Track Corporation Ltd
THC	total hydrocarbons
US EPA	US Environmental Protection Agency
VOCs	volatile organic compounds

Executive summary

The proponent proposes to construct and operate the Border to Gowrie section of Inland Rail (the Project), which consists of approximately 216.2 kilometres of single-track railway with five crossing loops to accommodate double stack freight trains.

Key elements of the air quality impact assessment included:

- Desktop review, including review of other studies in the area, relevant legislation, historical meteorological data and ambient air quality monitoring data
- Generation of air quality impact assessment (AQIA) area specific meteorology
- Qualitative discussion of potential air quality impacts during construction activities
- Air quality dispersion modelling of the operation of the Project
- Impact assessment and identification of mitigation strategies
- Assessment of the residual impact with the inclusion of the identified mitigation measures.

In order to quantify the emissions for diesel locomotives, an emissions inventory was developed. The key pollutants of interest included in the emissions inventory for diesel locomotives were oxides of nitrogen, particulates less than 10 micrometres (PM_{10}), particulates less than 2.5 micrometres ($PM_{2.5}$), and total suspended particulates.

An air quality dispersion modelling assessment was completed based upon methodologies and guidance presented in the following:

- *Application requirements for activities with impacts to air*, a guideline document under the *Environmental Protection Act 1994* (QLD) to support applications for activities with impacts to air (DES, 2019)
- *Approved methods for the modelling and assessment of air pollutants in New South Wales*, which provides statutory methods for modelling and assessing emissions of air pollutants in NSW (NSW EPA, 2017) but is considered robust and applicable for QLD
- *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, Australia"* (Barclay & Scire, 2011) which provides detailed guidance on selection of CALPUFF modelling variables
- *Guidance on the assessment of dust from demolition and construction*, UK Institute of Air Quality Management (UK IAQM, 2014). This document provides a qualitative risk assessment process for the assessment of the potential impact of dust generated from demolition, earthmoving, and construction activities.

Meteorological data utilised in the assessment was derived in accordance with the aforementioned guidance from The Air Pollution Model developed by CSIRO (CSIRO, 2008). Dispersion modelling of pollutants was then completed utilising CALPUFF with meteorology refined using CALMET.

A conservative approach has been adopted for this assessment, which has guided the nature of the assumptions that have been made in establishing the input parameters for the assessment. The key assumptions included in the assessment are:

- The diesel locomotive particulate emission rates for $PM_{2.5}$ are taken from the National Pollution Inventory and are 96 per cent of PM_{10}
- Nitrogen dioxide concentrations were derived from modelled results utilising the ozone limiting method as per *Approved methods for the modelling and assessment of air pollutants in New South Wales* (NSW EPA, 2017).

A survey of sensitive receptors in the AQIA area has been undertaken via desktop review of aerial imagery from QLD Globe. The identified sensitive receptors within the AQIA area were included in the dispersion model developed for the Project. Potential worst case pollutant concentrations were also predicted across the AQIA area through the inclusion of a grid of receptors covering the entire Project domain.

The predicted air quality concentrations and deposition rates were compared to Project specific air quality objectives that were developed considering the *Environmental Protection Act 1994* (EP Act), the *Environmental Protection (Air) Policy 2019* (EPP (Air)), *National Environment Protection (Ambient Air Quality) Measure* (Air Quality NEPM) and guideline values commonly recommended by the Queensland Department of Environment and Science. The Project objectives are based on protecting health and wellbeing, health and biodiversity of ecosystems and protecting agriculture environmental values of the atmospheric environment at nominated sensitive receptors.

Dispersion modelling carried out for the Project predicted that cumulative pollutant concentrations and deposition levels would be below the relevant air quality objectives at all identified sensitive receptors for all pollutants of concern with the exception of 24-hour PM_{10}. The air quality goal for 24-hour PM_{10} is predicted to be exceeded by 0.1 $\mu g/m^3$ at a single receptor located approximately 1.1 km to the north of the existing Commodore Mine. The dominant source of PM_{10} at the exceeding receptor is Commodore Mine.

There is uncertainty regarding emissions from the Commodore Mine due to the uncertainty in the emission estimation method used, and the absence of ambient monitoring data for the area local to the mine. To improve the understanding of background air quality at receptors near the mine, an air quality monitoring station has been installed at a residential dwelling on Millmerran Inglewood Road, Millmerran, approximately 1.4 km to the north of Commodore Mine. Monitoring data from this location will be used to guide the detailed design phase of the Project.

For the construction of the Project, dust sources will be variable in nature and proximity to sensitive receptors. Proposed construction mitigation measures need to address this variability. A Dust Management Sub-plan (the Sub-plan), as a component of the Construction Environmental Management Plan will be prepared prior to the commencement of construction. The objective of the Sub-plan will be to specify controls and procedures for the avoidance or minimisation of impacts relating to dust and emissions during construction of the Project. The Sub-plan will also specify monitoring requirements and complaint response procedures.

1 Introduction

This air quality impact assessment (AQIA) provide an assessment of the impacts of the Border to Gowrie Project (the Project) on the environmental values of air, and subsequent impacts on sensitive receptors.

This report has been prepared to support the Border to Gowrie Project Environmental Impact Statement (EIS).

The Project is one of 13 projects making up the 1,700 kilometre (km) Inland Rail Program as presented in Figure 1.1. The Project comprises approximately 145.0 km of new (greenfield) rail corridor and utilisation of approximately 71.2 km of existing (brownfield) rail corridor. The 216.2 km of new rail track will consist of seven kilometres of single-gauge track and 209.2 km of dual-gauge track.

The Project ties-in to adjoining Inland Rail projects at either end; specifically, the North Star to NSW/QLD Border project at the southern end and the Gowrie to Helidon project at the northern end.

The location of the Project is shown in Figure 1.2.

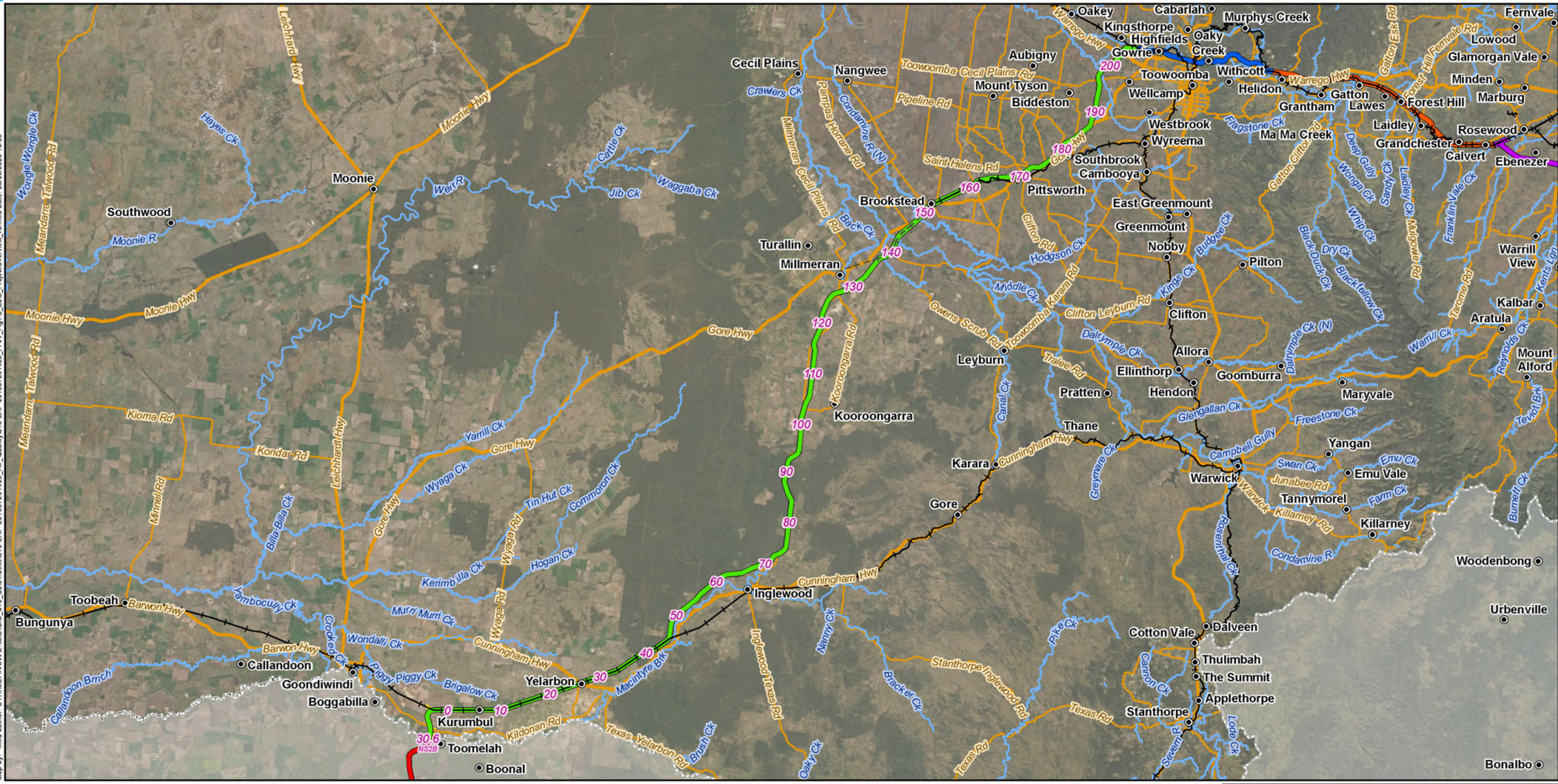
1.1 Assessment scope

The AQIA has been developed through the following steps:

- Identification of typical and peak operation train movements for the year 2040
- An analysis of the expected construction and operation activities from an air quality perspective
- Identification of the relevant ambient air quality objectives that protect or enhance the environmental values of the air environment
- Discussion of existing air quality and local meteorology
- Identification of potential sources of air emissions associated with the Project
- Identification of nearby sensitive receptors
- Identification of potential air quality impacts, through:
  - A qualitative risk assessment of particulate emissions from construction works
  - A quantitative dispersion modelling assessment of operational emissions associated with freight rail movements for peak train operations, including prediction of pollutant water concentrations in rainwater water tanks
- Identification of mitigation and management measures to minimise potential air quality impacts, and assessment of the residual impact with the implementation of these measures.

Figure 1.1 **Melbourne to Brisbane Inland Rail location map**

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



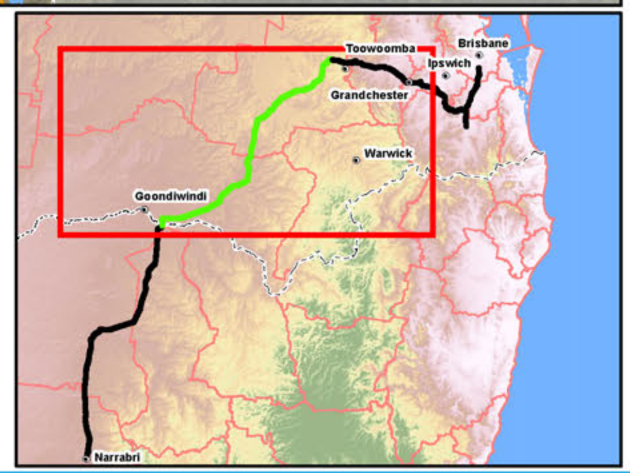
Map by: <mxd author>DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig1.2_B2G_ProjectOverview_v3.mxd Date: 28/05/2020 13:05

Legend

- 5 Chainage (km)
- Localities
- North Star to NSW/QLD border alignment
- Border to Gowrie alignment
- Gowrie to Helidon alignment
- Helidon to Calvert alignment
- Calvert to Kagaru alignment
- Existing rail (operational)
- Existing rail (non-operational)
- Major roads
- Minor roads
- Watercourses
- NSW/QLD border

A3 scale: 1:800,000

0 6 12 18 24 30 km



Future Freight
Integrating Community, Environment and Engineering

Issue date: 27/05/2020 Version: 1
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 1.2: Project overview

1.2 Terms of reference requirements

The purpose of this report is to address sections 11.127 to 11.138 of the Terms of reference (ToR) that were issued for the Project in November 2018. Locations where each relevant ToR requirement is addressed in this technical report is presented in Table 1.1.

Table 1.1 Compliance against relevant sections of the terms of reference

Air quality terms of reference requirements		Addressed in technical report
Existing environment		
11.127	Describe the existing air quality that may be affected by the Project in the context of environmental values	Section 2.4, Section 3 and Section 4
11.128	Discuss the existing local and regional air shed environment.	Section 4.2
11.129	Provide baseline data on local meteorology and ambient levels of pollutants for later 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 4.1 and Appendix A
11.130	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 DES monitoring stations cannot be reliably extrapolated.	Section 4.2, Section 4.3, Section 4.5 and Appendix B
Impact assessment		
11.131	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 during construction, commissioning and operations are to be listed.	Section 2.4
11.132	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.	Section 3.6
11.133	The assessment of impacts on air will be in accordance with the EP Act, EP Regulation and EPP (Air) 2008 and reference to appropriate to Australian Standards.	Section 3 and Section 5
11.134	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 (in accordance with the EPP (Air) Policy 2008) 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 where public information is available (c) include modelling of dust deposition rates and air pollutant concentrations on surfaces that lead to potable water tanks in the vicinity of the Project. This modelling is to be in accordance with the Australian Drinking Water Guidelines (Australian Government 2011, updated October 2017) (d) predict the human health risk, including impacts from possible air pollutant concentrations on surfaces that may lead to potable water tanks, 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).	Section 4.2.7, Section 5 and Section 8 a) Section 6 and Section 7 b) Section 4.3, Section 5.3.1.2, Section 5.6, Section 7.1, Section 7.3 and Section 10 c) Section 4.5, Section 5.4 and Section 7.2 d) Section 5.4, Section 5.5, Section 7.2 and Section 7.3
Mitigation measures		
11.135	Describe the proposed mitigation measures to manage impacts to air quality, including potential impacts from coal trains, and the predicted level of effectiveness	Section 8

Air quality terms of reference requirements		Addressed in technical report
11.136	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 8
11.137	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 6 Section 7 Section 8 Section 9
11.138	Describe how the achievement of the objectives would be monitored, audited and reported, and how corrective actions would be managed	Section 8

Table note:

The ToR for the AQIA refer to the Environment Protection (Air) Policy 2008, however, the assessment has been undertaken against the current version of the policy, which was released in 2019.

1.3 Impact assessment area

For the purposes of the AQIA, the impact assessment area ("AQIA area") refers to the air environment and footprint of identified sensitive receptor locations within one kilometre of the Project alignment, extending from the NSW/QLD border to Gowrie. The location of the Project is shown in Figure 1.2.

2 Proposal description

2.1 Overview

A detailed description of the Project is provided in Chapter 5 of the EIS. The Project consists of the key permanent and temporary features listed in Table 2.1.

Table 2.1 Key features of the Project

Aspect	Description
Permanent features	
New track	▪ Approximately 216.2 km of new single track railway, consisting of: – 7.0 km of standard gauge rail (1,435 millimetres (mm)) – 209.2 km of dual gauge rail (standard (1,435 mm) and narrow (1,067 mm) gauge). ▪ Railway infrastructure and the corridor will initially be constructed for 1,800 m long trains, and future- proofed for operation of 3,600 m trains.
Rail corridor	▪ Establishment of approximately 145.0 km of new rail corridor and use of approximately 71.2 km of existing rail corridor. ▪ The rail corridor is generally a minimum width of 40 m. There is one exception to this where the Project utilises the existing rail corridor for the South Western Line parallel to Yelarbon-Kurumbul Road from Ch 7.5 km to Ch 10.0 km. The rail corridor may be as narrow as 25 m through that section to minimise impacts to Yelarbon-Kurumbul Road, adjoining land uses and their access arrangements. ▪ The rail corridor would extend out to a maximum of 230 m. Wider sections of corridor are required to accommodate earthworks, drainage structures, rail infrastructure, access tracks and fencing. ▪ The rail corridor will be of sufficient width to accommodate all proposed railway infrastructure, including the crossing loops, as well as future expansion to accommodate the potential for 3,600 m long trains.
Crossing loops and turnouts	▪ Crossing loops are places on a single-line track where trains in opposing directions can pass each other. Five crossing loops will be constructed as part of the Project, at a minimum of 2,200 m in length for each loop. ▪ Turnouts allow the train to be guided from one section of track to another. Turnouts that connect in to crossing loops and QR's existing South Western Line, Millmerran Branch Line and sidings have been incorporated into the reference design.
Bridges	▪ Bridges to accommodate topographical variation, crossings of waterways or other infrastructure.
Drainage	▪ Cross-drainage is provided by reinforced concrete pipe culverts and reinforced concrete-box culverts. ▪ Scour protection measures will be installed around culverts and abutments to prevent erosion.
Rail crossings	▪ Rail crossings, including level crossings, grade separated crossings (rail or road overbridges) and occupational/private crossings.
Ancillary works	▪ The construction of associated railway infrastructure, including maintenance sidings and signalling infrastructure to support Advanced Train Management Systems (ATMS). ▪ Ancillary works, including works to level crossings, signalling and communications, signage and fencing, drainage works, and installation or modification of services and utilities within the rail corridor.
Construction features (temporary)	
Land	▪ Temporary access tracks will be used to access construction sites. Where possible, access tracks will be retained to serve as RMAR during the operation of the Project. ▪ Land requirements for construction will include temporary workspaces, site offices and laydown facilities. These requirements are encompassed within the nominated temporary construction footprint for the Project. ▪ Laydown areas will be located approximately every 5 km (avoiding one per cent annual exceedance probability (AEP) floodplains, where possible). Larger sites will be located approximately every 2 km.
Embankments and cuttings	▪ Embankments and cuttings will be required along the length of the rail alignment.

Aspect	Description
Borrow pits	▪ Identification, establishment and lawful use of borrow pits for the sourcing of construction materials for the Project. This does not include existing borrow pits owned by third parties. Borrow pits are not included in the Project footprint as approval to establish and use borrow pits will be sought separately to the EIS approval process.
Non-resident workforce accommodation	▪ Construction, use and decommissioning of up to three temporary non-resident workforce accommodation facilities. These facilities are not included in the Project footprint as approval to establish and operate non-resident workforce accommodation will be sought separately to the EIS approval process.

2.2 Construction

For the purposes of the AQIA, it has been assumed that the following activities will occur during the construction of the Project:

- Enabling works for:
  - Utilities and services
  - Clearance and demolitions
  - Road works
  - Access tracks and haul routes
  - Diesel storage
  - Site offices
  - Construction of non-resident workforce accommodation
  - Concrete batch plants and precast facilities
  - Flash butt welding facilities
- Rail corridor works:
  - Modification of existing and installation of new drainage structures
  - Signalling system adjustments
- Structures construction:
  - Drainage structures
  - Bridges and viaducts
- Earthworks:
  - Clearing and grubbing
  - Erosion and sediment control
  - Bulk earthworks:
    - Cuttings, including drilling and blasting
    - Embankments
  - Mass haul
- Track works:
  - Laying of ballast
  - Laying of sleepers
  - Laying of rail
  - Tamping
  - Welding and stressing
- Testing and commissioning.

2.3 Operation

The locomotive types that have been assessed in this AQIA are provided in Table 2.2, with the specifications of each presented in Table 2.3. The train and wagon specifications and operational data presented in this section has been used as the basis for the impact assessment.

Table 2.2 Locomotive data

Train description	Locomotives[1]	Maximum wagons length (m)	Maximum rail speed (km/hr)	Modelled average rail speed (km/hr)[2]	Locomotive height (m)	Wagon height (m)
Express freight	NR Class (3)[5]	1,750	115	86	4.24	6.8
Super freighter	SCT/LDP Class (2)[6]	1,750	115	86	4.24	5.925
Grain, cotton, and livestock	Class 82 & 2300 Class (2, 3)[3,7]	1,750	80	60	-[4]	-[4]

Table notes:

1. Number in brackets indicates the number of locomotives per train.
2. Calculated assuming 75 per cent of journey time at maximum speed, 25 per cent of journey time is idling.
3. Locomotive configuration dependant on wagon payload.
4. No information was available for this item for this locomotive.
5. UGL National Rail Class locomotive.
6. Downer EDI SCT/LDP Class locomotive.
7. Downer EDI 82 Class locomotive.

Table 2.3 Locomotive specifications

	NR Class	SCT/LDP	Class 82
Manufacturer	UGL/GE	Downer EDI	Downer EDI/EMD
Prime Mover	7FDL16	GTA46C-ACe	12-710G3AJWC
US EPA Emissions Standard	Tier 0	Tier 1	Tier 0
Rated Max Power (kW)	2917	3350	2425

The forecast typical and peak volume of trains anticipated to be using the Project by 2040 are presented in Table 2.4, which shows that the forecast for typical train movements (136 trains per week) is significantly fewer than the forecast for peak train movements (174 trains per week). Air emissions as a result of the operation of the Project are directly related to the volume of trains, therefore a lower number of trains will result in a lower rate of pollutant emissions to air.

Emission rates for both typical and peak train movement scenarios have been calculated. However, dispersion modelling has only been undertaken for peak trains movements as this operational scenario has the greater potential to cause significant impact.

Table 2.4 Weekly typical and peak train movements by service in 2040

Train type/description	Number of trains per week – typical movements			Number of trains per week – peak movements		
	NR Class[1]	SCT/LDP Class[2]	Class 82[3]	NR Class[1]	SCT/LDP Class[2]	Class 82[3]
MB Express (Bromelton)	12	-	-	14	-	-
MB Express (Acacia Ridge)	12	-	-	14	-	-
MB Superfreighter (Bromelton)	-	32	-	-	40	-
MB Superfreighter (Acacia Ridge)	-	6	-	-	8	-
GB Superfreighter (Bromelton)	-	16	-	-	22	-
GB Superfreighter (Acacia Ridge)	-	8	-	-	10	-

Train type/description	Number of trains per week – typical movements			Number of trains per week – peak movements		
	NR Class[1]	SCT/LDP Class[2]	Class 82[3]	NR Class[1]	SCT/LDP Class[2]	Class 82[3]
Narrabri – PoB Grain	-	-	18	-	-	24
Yelarbon – PoB Grain	-	-	18	-	-	24
Narrabri – PoB Export Continuation	-	-	10	-	-	12
Yelarbon – PoB Cotton	-	-	4	-	-	6
Total	**136**			**174**		

Table notes:

1 UGL National Rail Class locomotive
2 Downer EDI SCT/LDP Class locomotive
3 Downer EDI 82 Class locomotive
PoB – Port of Brisbane

Five new crossing loops are proposed for the Project. The loops are to be constructed as new sections of track parallel to the existing track to enable the passing of trains moving in opposite directions. Each crossing loop is 2,200 m in length, initially constructed for 1,800 m long trains. However, they have been positioned to enable future extension to accommodate trains up to 3,600 m long if required. Table 2.5 presents the crossing loop start and end chainage locations.

Table 2.5 Crossing loop chainage locations

Closest location	Phase	Start chainage (km)	End chainage (km)
Yelarbon	Initial (day 1 operation)	16.3	18.5
Inglewood	Initial (day 1 operation)	50.2	52.4
Kooroongarra	Initial (day 1 operation)	89.2	91.4
Yandilla	Initial (day 1 operation)	129.8	132.0
Broxburn	Initial (day 1 operation)	174.9	177.1

2.4 Project air emissions

Pollutants of potential concern to the Project have been identified through a review of expected activities, applicable National Pollutant Inventory (NPI) emission estimation manuals, international emissions estimation guidelines and EIS literature for similar rail projects.

During the construction phase, particulate matter deposited as total suspended particulates (TSP) and airborne concentrations of particulate matter less than 10 micrometres 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). 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. Point source emissions of combustion gases and $PM_{2.5}$ are considered unlikely to result in exceedance of air quality objectives or cause nuisance to sensitive receptors and therefore have not been assessed for the construction phase.

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

The primary source of air pollution during the operation of the Project will be 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).

A brief discussion regarding these pollutants and their potential effects on health and the environmental values follows. Note that in addition to the pollutants considered in this AQIA, discussion of other pollutants not considered in detail (due to their low expected emissions) have also been provided in this section. The information presented in this section has been acquired from the NPI website (Department of Agriculture, Water and the Environment, 2019) and the NSW Department of Planning, Industry and Environment website (NSW Department of Planning, Industry and Environment, 2020).

2.4.1 Particulate matter

Airborne particles are commonly differentiated according to size based on their equivalent aerodynamic diameter. TSP refer to airborne particles, generally up to 100 micrometres (µm) in diameter. TSP is primarily associated with aesthetic impacts associated with coarse particles settling on surfaces, which also causes soiling and discolouration. These large particles can, however, cause some irritation of mucosal membranes, which pose a greater risk to health when ingested if they are contaminated. Particles with diameters less than or equal to 10 µm (known as PM_{10}) can be created through crushing and grinding of rocks and soil, and typically comprise soot, dirt, mould and pollen. These particles tend to remain suspended in the air for longer periods than larger particles (minutes or hours) and can penetrate into human lungs.

Fine particulates (those with diameters less than or equal to 2.5 µm, known as $PM_{2.5}$) are typically generated from vehicle exhaust, bushfires, and some industrial activities and can remain suspended in the air for days or weeks. As these fine particulates can travel further into human lungs than the larger particulates and are often made up of heavy metals and carcinogens, fine particulates are considered to pose a greater risk to health.

Exposure to particulate matter has been linked to a variety of adverse health effects, with epidemiological research suggesting that there is no threshold at which health effects do not occur. Factors that influence the health effects related to exposure include the mass concentration, the size of the particles and the duration of exposure (e.g. short or long term). Short-term or acute health effects include respiratory problems such as coughing, aggravated asthma and acute bronchitis, with long term or chronic effects including lung damage and non-fatal heart attacks. Furthermore, if the particles contain toxic materials (such as lead, cadmium, zinc) or live organisms (such as bacteria or fungi), toxic effects or infection can occur from inhalation of the dust.

In addition to the respiratory health impacts from fine particulate matter suspended in air, dust can cause nuisance impacts by settling on surfaces and possessions. Dust deposition is the result of suspended particles settling out of suspension. Dust deposition is a common cause of complaints, particularly due to staining of clothes (hanging on washing lines) and deposition on vehicles and window sills. Deposition on surfaces that feed into water storage can also result in contamination of potable water supplies.

2.4.2 Nitrogen oxides

Nitrogen dioxide (NO_2) is a brownish gas with a pungent odour. It exists in the atmosphere in equilibrium with nitric oxide (NO). The mixture of these two gases (and some other minor nitrogen and oxygen gas mixtures) is commonly referred to as nitrogen oxides, or NO_x. Nitrogen oxides are a product of combustion processes. In urban areas, motor vehicles and industrial combustion processes are the major sources of ambient nitrogen oxides.

Short term exposure to low levels of NO_2 can irritate the eyes, nose, throat and lungs, possibly leading to coughing, shortness of breath, tiredness and nausea. Short term exposure to high levels of NO_2 can cause rapid burning, spasms and swelling of tissues in the throat and upper respiratory tract, reduced oxygenation of tissues, and build-up of fluid in the lungs. Long-term exposure to high levels of NO_2 can cause chronic health effects including lung disease.

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. Long term exposure to NO_2 can also cause damage to plants, especially in the presence of other pollutants such as ozone (O_3) and SO_2. Nitrogen oxides are also primary ingredients in the reactions that lead to photochemical smog formation.

2.4.3 Carbon monoxide

CO is a colourless, odourless gas produced by the incomplete combustion of fuels containing carbon (e.g. oil, gas, coal and wood). CO is absorbed through the lungs of humans, where it reacts to reduce the blood's oxygen-carrying capacity. In urban areas, motor vehicles account for up to 90 per cent of all CO emissions.

Short term inhalation of relatively low levels of CO (200 ppm for 2 to 3 hours) can cause headaches, dizziness, light-headedness and fatigue. Short term exposure to higher concentrations (400 ppm) of carbon monoxide can cause sleepiness, hallucinations, convulsions, collapse, loss of consciousness and death. Long term exposure to low levels of CO can result in heart disease and damage to the nervous system, whilst long term exposure of pregnant women to CO may result in low birth weights and other birth defects.

Concentrations of CO normally present in the atmosphere are unlikely to cause ill effects and therefore have not been considered in the assessment.

2.4.4 Sulphur dioxide

SO_2 is a colourless gas with a sharp, irritating odour. It is formed in combustion processes through burning fossil fuels containing sulphur. SO_2 may be oxidised in the atmosphere to form sulfuric acid, which contributes to acid rain.

SO_2 is also an irritant gas that can cause respiratory tract infections. People with pre-existing respiratory conditions such as asthma are most sensitive to SO_2 exposure and the simultaneous presence of airborne particulate matter can compound these effects. SO_2 and its aerosols can also damage vegetation and some materials.

SO_2 in low concentrations is a common pollutant in cities and some industrial environments. Higher exposure to SO_2 is typically limited to workplace environments where it is produced as a by-product. Short term exposure (5 to 15 minutes) to concentrations of 10 to 50 ppm causes irritation of the eyes, nose and throat, choking and coughing.

The study assumes low sulphur content fuel as per the requirements of the *Fuel Quality Standards Act 2000* (Cth) and *Fuel Standard (Automotive Diesel) Determination 2001* (Cth). The regulation of low sulphur content fuel in Australia has significantly decreased the generation and concentrations of SO_2 near transport sources and concentrations are typically well below the relevant air quality objectives. Due to the low likelihood of significant impact, SO_2 has not been considered in this assessment.

2.4.5 Volatile organic compounds

Organic compounds with a vapour pressure at 20°C exceeding 0.13 kilopascals are referred to as VOCs. VOCs can be a major precursor in the production of photochemical smog, which causes atmospheric haze, eye irritation, and respiratory problems. VOCs are commonly emitted from vehicle exhausts. Three primary VOCs (benzene, toluene and xylenes) are components of petroleum and diesel fuel and are typically the focus for assessments of engine combustion emissions.

2.4.5.1 Benzene

Benzene is an airborne substance that is a precursor to photochemical smog. Benzene exposure commonly occurs through inhalation of air containing the substance. It can also enter the body through the skin, although it is poorly absorbed this way. Low levels of benzene exposure result from car exhausts. Benzene is a toxic health hazard and a known carcinogen. It has high acute toxic effects on aquatic life and long-term effects on marine life. It can cause death in plants and roots and damage to the leaves of many agricultural crops, however normal environmental concentrations of benzene are unlikely to damage plants (Scottish Environment Protection Agency, 2016). Human exposure to very high levels for even brief periods of time can potentially result in death, while lower level exposure can cause skin and eye irritation, drowsiness, dizziness, headaches and vomiting, damage to the immune system, leukaemia and birth defects.

2.4.5.2 Toluene

Toluene (methylbenzene) is a highly volatile chemical that quickly evaporates to a gas if released as a liquid. Due to relatively fast degradation, toluene emissions are usually confined to the local area in which it is emitted. Human exposure typically occurs through breathing contaminated air, but toluene can also be ingested or absorbed through the skin (in liquid form). Toluene usually leaves the body within twelve hours.

Short-term exposure to high levels of toluene can cause dizziness, sleepiness, unconsciousness and sometimes death. Long-term exposure can cause kidney damage and permanent brain damage that can lead to speech, vision and hearing problems, as well as loss of muscle and memory functions. The substance can cause membrane damage in plant leaves and is moderately toxic to aquatic life with long-term exposure.

2.4.5.3 Xylenes

Xylenes are flammable liquids that are moderately soluble in water. They are quickly degraded by sunlight when released to air, and rapidly evaporate when released to soil or water. They are used as solvents and in petrol and chemical manufacturing.

Xylenes can enter the body through inhalation or skin absorption (liquid form), and can cause irritation of the eyes and nose, stomach problems, memory and concentration problems, nausea and dizziness. High-level exposure can cause death. The substances have high acute and chronic toxicity to aquatic life and can adversely affect crops.

2.4.6 Polycyclic aromatic hydrocarbons

PAHs are a group of over 100 chemicals, which are formed through the incomplete combustion of organic materials, such as petrol. Exposure to these chemicals can cause a range of adverse reactions, including irritation of the eyes, nose and throat and skin. Exposure to very high levels can result in symptoms such as headaches, nausea, damage to the liver and kidneys, and damage to red blood cells. Some PAHs are declared to be probable or possible carcinogens to humans by the International Agency for Research on Cancer (IARC).

PAHs can vaporise or attach to dust particles and be transported through the air. The compounds commonly break down over days or weeks through chemical reactions in the atmosphere, others can persist for longer periods.

PAHs are moderately or highly acutely toxic to birds and aquatic organisms and moderately/highly chronic toxicity to aquatic life. Some of these compounds are known to cause damage and death to crops. PAHs can bioaccumulate and are moderately persistent in the environment.

2.4.7 Dioxins

Dioxins form part of a group of chemicals known as persistent organic compounds, which are of concern due to their highly toxic potential. Exposure in the long terms can cause cancer, and impairment of the endocrine, immune, and reproductive systems. Dioxins can bioaccumulate within animals in the environment and tends to accumulate in fat.

Emissions of dioxins will occur as a result of fuel combustion in trains, motor vehicles and mobile plant. An inventory of dioxin emission sources in Australia in 2002 was prepared by the Department of the Environment and Heritage (DEH, 2004). The inventory determined that transport was a minor source of dioxins, contributing less than 2 per cent of total emissions.

Based on the rural location of the Project it is expected that existing background concentrations of dioxins will be low, and therefore a background concentration of zero has been assumed for the assessment. It is considered unlikely that emissions from the Project have the potential to result in significant impacts or exceedance of the relevant air quality objectives for dioxins.

2.4.8 Trace metals

Heavy metals such as cadmium, lead, and mercury are common air pollutants that are typically emitted from industrial activities and fuel combustion. 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.

Long-term exposures to cadmium can cause anaemia, fatigue and loss of the sense of smell. Short term high exposures to cadmium can cause rapid lung damage, shortness of breath, chest pain, and a build-up of fluid in the lungs. Cadmium is a 'probable carcinogen'.

Lead can affect a wide variety of organs in the body, but mostly affects the nervous system. Exposure to lead may also cause paralysis in fingers, wrists or ankles and can cause small increases in blood pressure and may cause anaemia, malnutrition, abdominal pain and colic. High levels of lead can severely damage the brain and kidneys in adults and may cause death.

Exposure to high levels of any types of mercury can permanently damage the brain, kidneys, and developing foetus. Effects on brain functions may result in irritability, shyness, tremors, changes in vision or hearing and memory problems. High exposures of mercury vapour may cause chest pain, shortness of breath, and a build-up of fluids in the lungs that can be fatal.

Very minor emissions of trace metals will occur as a result of fuel combustion in trains, motor vehicles and mobile plant. As such, cumulative concentrations of trace metals at sensitive locations are expected to be well below relevant air quality objectives and are not expected to cause a significant impact, but have been considered in the assessment.

2.4.9 Ozone

O_3 is not emitted directly from fuel combustion, but rather is a secondary pollutant formed via chemical reaction of other pollutant species (primarily NO_X and VOCs) in the local atmosphere.

O_3 is a short-term lung irritant, affects lung function and can worsen asthma. Short term exposure to O_3 can cause difficulty in breathing, coughing, and throat irritation if exercising outdoors when O_3 levels are high.

Assessment of the formation of O_3 and other secondary pollutants has not been considered in this assessment.

2.4.10 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. Potential sources of odour from the Project include agricultural freight trains, fuel storage and wastewater odour from small scale sewage treatment.

2.4.10.1 Agriculture freight trains

Odour emissions may arise from agriculture freight trains (e.g. livestock) travelling along the alignment, including while stopped at crossing loops. Specifically, for livestock trains where many animals are transported in confined spaces an accumulation of odours can occur, which are generally associated with the decomposition of animal waste and/or feedstuffs. Odour can become an issue if pens and feeding areas are not cleaned regularly and if waste is allowed to accumulate.

2.4.10.2 Fuel storage

Fuel storage has the potential to impact nearby sensitive receptors due to the emission of VOCs and odour. Potential impacts from fuel storage have been considered in this assessment.

2.4.10.3 Sewage treatment

Portable toilet facilities will be located along the alignment during construction for workers. A suitably qualified contractor will be engaged for the removal and transport of the sewage to an approved off-site treatment facility.

Wastewater treatment and collection facilities will be included as component of non-resident workforce accommodation for the construction workforce. Sewage treatment plants with a capacity of 300 EP (equivalent population) will be required to service each non-resident workforce accommodation facility. An assessment of odour from sewage treatment plants of this size has been undertaken in this assessment.

3 Legislation, policies and guidelines

The relevant legislation and policy instruments considered in the assessment of air quality are:

- *Environmental Protection Act 1994* (QLD) (EP Act)
- *Environmental Protection Regulation 2019* (QLD) (EP Regulation)
- *Environmental Protection (Air) Policy 2019* (QLD) (EPP (Air))
- *National Environment Protection (Ambient Air Quality) Measure* (Cth) (Air Quality NEPM)
- *National Environment Protection (Air Toxics) Measure* (Cth) (Air Toxics NEPM).

3.1 Environmental Protection Act 1994 and Environment Protection Regulation 2019

The EP Act is intended to protect Queensland's environment while allowing for development that improves total quality of life, now and in the future, by encouraging ecologically sustainable development. There are several policies under the EP Act that govern the requirement for management of some environmental issues such as noise, air and water. The EP Act regulates environmentally relevant activities (ERA) under the EP Regulation, with some of these activities requiring an environmental authority to operate. The EP Act also outlines primary duties which are applicable to everyone in Queensland, including general environmental duty, which states that "*a person must not carry out any activity that causes or is likely to cause environmental harm, unless measures to prevent or minimise the harm have been taken*".

There are several policies under the EP Act that govern the requirement for management of environmental issues such as noise, air and water. These policies determine objectives to be achieved in various environments with reference to sensitive receptors. One of these, the EPP (Air) must be considered for the air quality impact assessment.

3.2 Environmental Protection (Air) Policy 2019

On 1 September 2019 the EPP (Air) was updated to the Environmental Protection (Air) Policy 2019. The AQIA has been undertaken in accordance with the 2019 version of the policy.

The EPP (Air) was prepared by the Queensland Government to enhance or protect the atmospheric environment in Queensland by providing air quality objectives. It does not apply to workplaces and the air quality objectives set out in the EPP (Air) are intended to be progressively achieved over the long term.

The EPP (Air) recommends different strategies to control emissions for different types of activities, including:

- 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**; and
- The qualities of the air environment that are conducive to **human health and wellbeing**; and
- 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; and
- The qualities of the air environment that are conducive to **protecting agricultural use** of the environment.

The air quality objectives from the EPP (Air) relevant to the Project have been adopted as air quality objectives for the AQIA and are provided in Table 3.1.

3.3 National Environment Protection (Ambient Air Quality) Measure and National Environment Protection (Air Toxics) Measure

The NEPM are broad framework-setting statutory instruments that outline agreed national objectives for protecting or managing particular aspects of the environment. The air quality of an environment is protected in by the Air Quality NEPM as amended (2015). The Air Quality NEPM provides guidance relating to air in the external environment and does not include air inside buildings or structures.

The Air Quality NEPM outlines monitoring, assessment and reporting procedures for the following pollutants:

- PM_{10}
- $PM_{2.5}$
- Nitrogen dioxide
- Carbon monoxide
- Ozone
- Sulphur dioxide.

In addition to the Air Quality NEPM, the Air Toxics NEPM provides a framework for monitoring, assessing and reporting on ambient levels of air toxics. The purpose of this NEPM is to collect information to facilitate the development of standards for ambient air toxics.

The Air Toxics NEPM includes monitoring investigation levels for use in assessing the significance of monitored levels of air toxics with respect to human health. The monitoring investigation levels are levels of air pollution below which lifetime exposure, or exposure for a given averaging time, does not constitute a significant health risk. If these limits are exceeded in the short term, it does not mean that adverse health effects automatically occur; rather some form of further investigation by the relevant jurisdiction of the cause of the exceedance is required.

The Air Quality NEPM and Air Toxics NEPM standards are intended to be applied to air quality experienced by the general population in a region and not to air quality in areas in the region affected by localised air emissions, such as individual industrial sources or projects.

The goal of the Air Quality NEPM and Air Toxics NEPM is to achieve the recommended standards with the allowable exceedances, as assessed in accordance with the associated monitoring protocol. The standards were set at a level intended to adequately protect human health and wellbeing. The standards in the Air Quality NEPM and Air Toxics NEPM relevant to the Project correspond to the EPP (Air) objectives protecting the health and wellbeing environmental values. The Air Quality NEPM standards relevant to the Project are consequently addressed in the air quality objectives in the EPP (Air).

3.4 Nuisance dust guideline

The deposition of larger dust particles can commonly cause nuisance in residential areas. Although no dust deposition objectives are prescribed in the EPP (Air), DES commonly set a guidance deposition rate of 120 milligrams per square metre per day ($mg/m^2/day$) averaged over 1 month for environmental authorities, which is 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, 2019) and is considered to be an appropriate criterion. For the purposes of the AQIA this recommended dust deposition goal has been adopted.

3.5 Other guidelines

Not all compounds of interest are detailed in the aforementioned legislation or guidelines. Other sources have been utilised to provide air quality objectives, which include the following:

- Brisbane City Council (BCC) *Air Quality Planning Scheme Policy* (AQPSP) (BCC, 2014)
- NSW Environment Protection Authority (NSW EPA) *Approved methods for the modelling and assessment of air pollutants in New South Wales* (NSW EPA, 2017), and
- Environment Protection Authority Victoria (EPA Victoria) *Guideline for recommended separation distances for industrial residual air emissions* (EPA Victoria, 2013).

The BCC, NSW EPA and EPA Victoria documents are considered to be robust guidance policies and are considered appropriate for application in the assessment.

In addition, the AQIA has been prepared with consideration given to the following:

- *Application requirements for activities with impacts to air*, guideline document under the *Environmental Protection Act 1994* to support applications for activities with impacts to air (DES, 2019)
- *Approved methods for the modelling and assessment of air pollutants in New South Wales*, which provides statutory methods for modelling and assessing emissions of air pollutants in NSW (NSW EPA, 2017) but is considered robust and applicable for QLD
- *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, Australia*" (Barclay & Scire, 2011)
- *Guidance on the assessment of dust from demolition and construction*, UK Institute of Air Quality Management (UK IAQM, 2014). This document provides a qualitative risk assessment process for the potential impact of dust generated from demolition, earthmoving, and construction activities.

3.6 Air quality objectives

The air quality objectives and guidelines values shown in Table 3.1 have been applied as the air quality objectives for the Project. Where air quality objectives for identified pollutants are not listed within the EPP (Air) and NEPM legislation, air quality objectives have been sourced from the NSW EPA *Approved methods for modelling and assessment of air pollutants in New South Wales* (EPA, 2016) and the BCC AQPSP (BCC, 2014).

The air quality objectives in Table 3.1 have designated averaging periods. Some pollutants have objectives expressed as annual average concentrations due to the chronic way in which they affect health or the natural environment (i.e. effects occur (long-term) after a prolonged period of exposure to elevated concentrations) and others have objectives expressed as 24 hour, 1 hour or 30 minute average concentrations (short-term) due to the acute way in which they affect health or the natural environment (i.e. after a relatively short period of exposure). Some pollutants have standards expressed in terms of both long-term and short-term concentrations.

The dust deposition goal shown in Table 3.1 is a daily deposition average (120 mg/m^2/day), calculated using the deposition level predicted at a modelled receptor over an averaging period of one month.

The air quality objectives presented in Table 3.1 are ambient air quality objectives and require consideration of existing background air quality in addition to contributions from the Project.

The environmental values listed in Section 3.2, that are being protected by each air quality goal are listed from the EPP (Air) and NEPM legislation. The environmental values protected through meeting these air quality objectives include the following:

- Health and wellbeing, and
- Protecting the aesthetics of the environment.

The EPP (Air) also includes air quality objectives to protect the environmental values of the health and biodiversity of ecosystems and to protect agriculture. Pollutants which have objectives to protect the health and biodiversity of ecosystems include fluoride, NO_2, O_3 and SO_2. Fluoride, O_3 and SO_2 also have objectives to protect agriculture.

Fluoride, O_3 and SO_2 are not pollutants of concern for the Project (refer Section 2.4) and therefore the impact of these pollutants on the health and biodiversity of ecosystems and on agriculture does not require consideration.

The EPP (Air) does have a NO_2 air quality objective for the health and biodiversity of ecosystems. As discussed in Section 4.5, there are no World Heritage Areas or areas protected under the *Nature Conservation Act 1992* (QLD) or the *Marine Parks Act 2004* (QLD) located within one kilometre of the alignment, and therefore the impact of NO_2 on the health and biodiversity of ecosystems has not been considered.

Further discussion of background air quality for the Project is provided in Section 4.2.

Table 3.1 Proposed air quality objectives

Pollutant	Air quality goal (µg/m³, unless stated)	Averaging period	Environmental value	Source
NO_2	250	1-hour[1]	Health and wellbeing	EPP (Air)
	62	Annual	Health and wellbeing	EPP (Air)
TSP	90	Annual	Health and wellbeing	EPP (Air)
PM_{10}	50	24 hours	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/m³	Annual	Health and wellbeing	EPP (Air)
Cadmium and compounds (measured as the total metal content in PM_{10})	5 ng/m³	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/m³	Annual	Health and wellbeing	EPP (Air)
Chromium (III) compounds (as PM_{10})	9	1 hour	-	NSW EPA
Chromium (VI) compounds (as PM_{10})	0.1	1 hour	Screening health risk assessment	BCC AQPSP
	0.01	Annual	Screening health risk assessment	BCC AQPSP
1,3-butadiene	2.4	Annual	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)
Benzo(a)pyrene (as a marker for polycyclic aromatic hydrocarbons)	0.3 ng/m³	Annual	Health and wellbeing	EPP (Air)

Pollutant	Air quality goal (µg/m³, unless stated)	Averaging period	Environmental value	Source
Polychlorinated dioxins and furans	3.0×10^{-08}	Annual	Screening health risk assessment	BCC AQPSP
Dust deposition	120 mg/m²/day	Monthly	Nuisance	DES Recommended[2]

Table notes:

µg/m³ micrograms per cubic metre
ng/m³ nanogram per cubic metre
mg/m²/day milligram per square metre per day
1 Not to be exceeded more than one day per year
2 Not legislative but adopted for the Project, see Section 3.4

4 Existing environment

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

- Meteorological conditions and climate
- Existing air quality due to regional and local sources of air pollution (natural and anthropogenic) that emit similar air pollutants as those being assessed
- 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 used in assessing the impact of the Project on the air environment.

The following sections describe the existing environment of the AQIA area.

4.1 Climate and meteorology

The Project is located in the Darling Downs and spans across the Toowoomba Regional Council (TRC) and Goondiwindi Regional Council (GRC) local government areas. The Darling Downs generally experiences a sub-tropical climate with distinct wet and dry seasons.

The Bureau of Meteorology (BoM) operates a network of monitoring stations around Australia that have long-term climatic data available for analysis. Two BoM monitoring stations have been considered in this AQIA, specifically the Oakey Aero and Inglewood Forest stations.

Several air quality stations operated in South East Queensland by DES also record meteorological data. However, the are no operational DES monitoring stations located in areas that allow for the collection of data that would be representative of the Project. The nearest DES monitoring station is more than 150 km to the west of the Project. All monitoring stations to the east of the Project are near the coast of Queensland or below the Great Dividing Range, and are therefore not representative of the climate in the AQIA area.

Locations of BoM and DES meteorological monitoring stations nearest the Project are shown in Figure 4.1.

The Project spans 216.2 km and local meteorological conditions are expected to vary across this distance, especially at areas further inland and/or away from notable terrain features. The two BoM-operated Oakey Aero and Inglewood Forest stations are considered to provide an appropriate regional coverage of climatic conditions. Another BoM-operated station located at the Toowoomba Wellcamp Airport is located nearer to the Project than the Oakey Aero and Inglewood Forest stations, however, the data is not publicly available at the time of this AQIA. Climate data from the Oakey Aero station is expected to be similar to that obtained at the Toowoomba Wellcamp Airport station and is deemed to provide a good alternative.

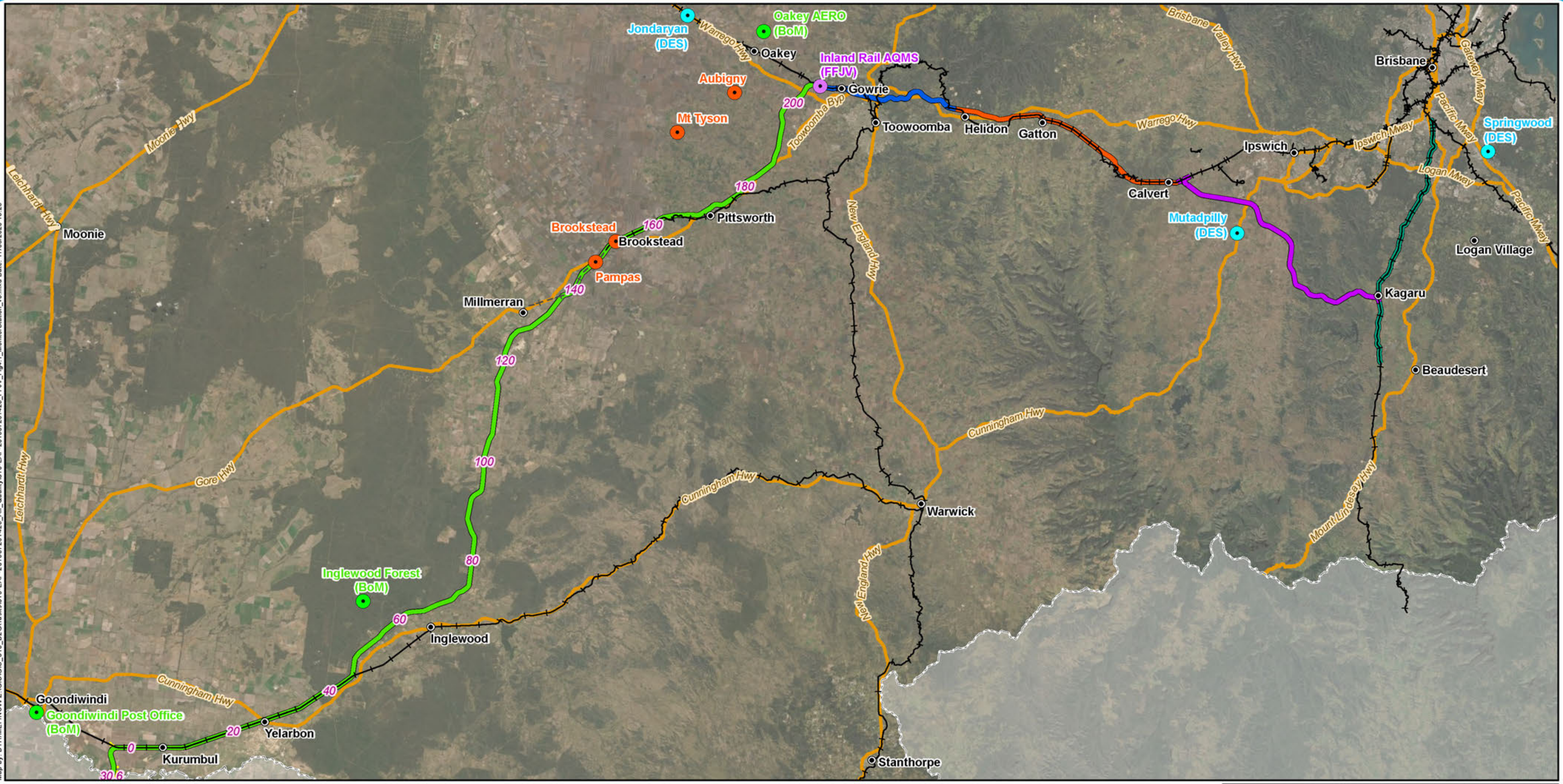
Details of the meteorological monitoring stations selected for use in the AQIA are provided in Table 4.1.

Table 4.1 Location of meteorological monitoring stations

Operator	Name	Coordinates	Distance from Project (closest point, km)	Direction from Project	Period operational	Elevation (m)
BoM	Oakey AERO	-27.40, 151.74	13.1	NW	1973 - Present	406
BoM	Inglewood Forest	-28.37, 150.95	7.0	NW	2000 - 2014	379

In addition to meteorological data from the BoM stations, output data from CALMET (refer Section 5.3.2) has also been analysed and presented in this section to describe atmospheric stability and mixing height.

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



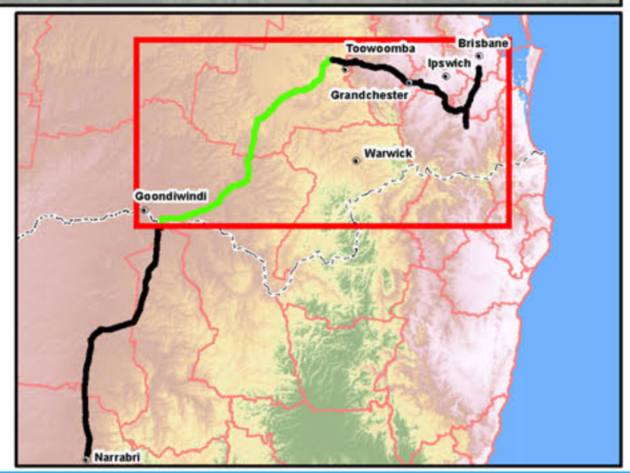
Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.1_MonitorStation_v5.mxd Date: 17/06/2020 15:29

Legend

- 5 Chainage (km)
- Localities
- North Star to NSW/QLD border alignment
- Border to Gowrie alignment
- Gowrie to Helidon alignment
- Helidon to Calvert alignment
- Calvert to Kagaru alignment
- Kagaru to Acacia Ridge/Bromelton alignment
- Major roads
- Existing rail (operational)
- Existing rail (non-operational)
- NSW/QLD border

Monitoring locations

- BoM monitoring station
- DES monitoring station
- FFJV monitoring station
- Dust deposition monitoring locations



A3 scale: 1:800,000

0 10 20 30 km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 17/06/2020 Version: 5
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.1:
Locations of meteorological and air quality monitoring stations

4.1.1 Temperature

Mean minimum and maximum temperatures have been collected from the two selected BoM stations, and are displayed in Table 4.2. Temperatures recorded at the two stations are similar: the annual mean minimum and mean maximum temperatures are higher at Inglewood Forest by 1.6°C and 1.1°C respectively.

In winter (June, July and August), mean minimum temperatures are slightly lower at Oakey Aero (4.2°C, 2.9°C and 3.6°C respectively) than at Inglewood Forest (6.7°C, 5.6°C and 6.9°C). Mean maximum temperatures for winter very similar between the two sites.

In summer (December, January and February) mean minimum temperatures are higher at Inglewood (17.7°C to 18.7°C) than at Oakey Aero (16.7°C to 17.9°C). The mean maximum temperatures are also higher at Inglewood Forest (31.5°C to 33.2°C) than at Oakey Aero (30.3°C to 31.0°C).

Overall, temperatures measured at the two stations and those expected across the AQIA area are consistent with a warm sub-tropical climate.

Table 4.2 Mean minimum (blue) and maximum (red) monthly temperatures for selected BoM monitoring stations

Station	Mean minimum and maximum temperature (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Oakey Aero[1]	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
	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
Inglewood Forest[2]	33.2	32.2	30.4	27.3	22.4	19.0	18.6	21.0	25.3	28.0	30.1	31.5	26.6
	18.7	18.0	16.2	13.1	8.8	6.7	5.6	6.9	10.6	13.1	15.9	17.7	12.6

Table notes:

1 Mean maximum and minimum temperature values have been calculated based on data from 1973 – 2019.
2 Mean maximum and minimum temperature values have been calculated based on data from 2000 – 2013.

4.1.2 Rainfall

Mean rainfall values have been collected from the two selected BoM stations and are presented in Table 4.3. A wet (summer) and dry (winter) season is shown to be experienced by the region annually.

Table 4.3 shows that for both monitoring stations, approximately 40 per cent of average annual rainfall occurs during the three months of summer, with significantly less rainfall recorded during winter months.

Table 4.3 Mean monthly and annual rainfall for selected BoM monitoring stations

Station	Mean rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Oakey Aero[1]	77.7	78.2	51.1	29.9	39.5	30.0	28.8	25.7	31.0	57.7	75.2	91.8	618.2
Inglewood Forest[2]	72.3	54.5	63.5	27.4	28.6	33.3	28.7	24.3	34.0	49.7	79.9	97.3	620.0

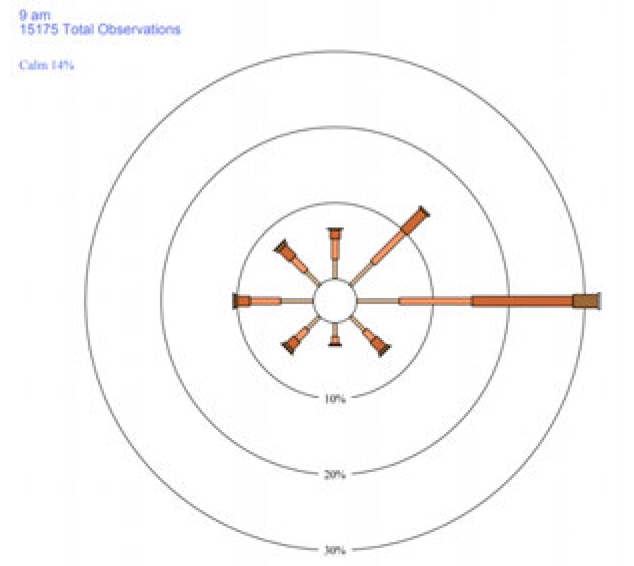
Table notes:

1 Mean rainfall values have been calculated based on data from 1970 to 2019.
2 Mean rainfall values have been calculated based on data from 2000 to 2013.

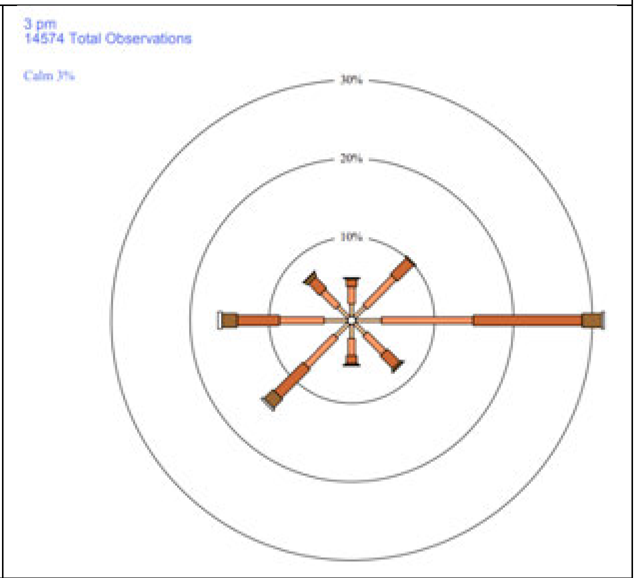
4.1.3 Wind speed and direction

Long-term annual wind roses for morning and afternoon conditions at the Oakey Aero and Inglewood Forest stations are published by BoM. The 9.00 am and 3.00 pm annual wind roses for the Oakey Aero and Inglewood Forest stations are presented in Figure 4.2.

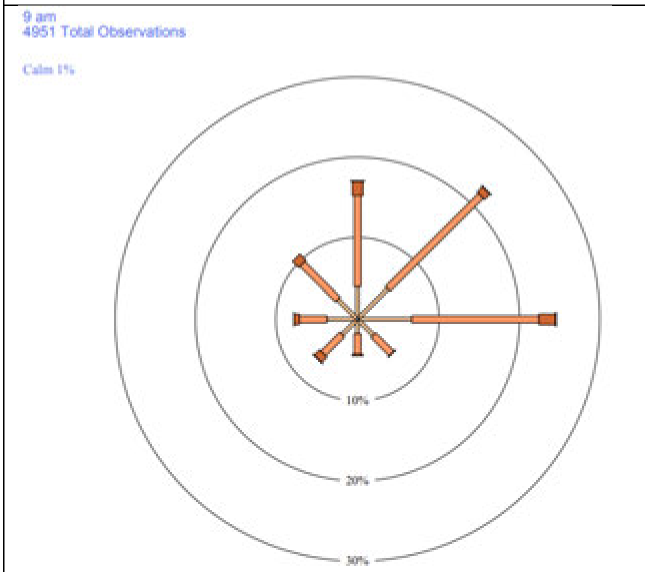
Morning winds at the Oakey Aero location blow predominantly from the east and northeast and are low to moderate strength when not calm. Calm conditions represent 14 per cent of 9.00 am wind observations.



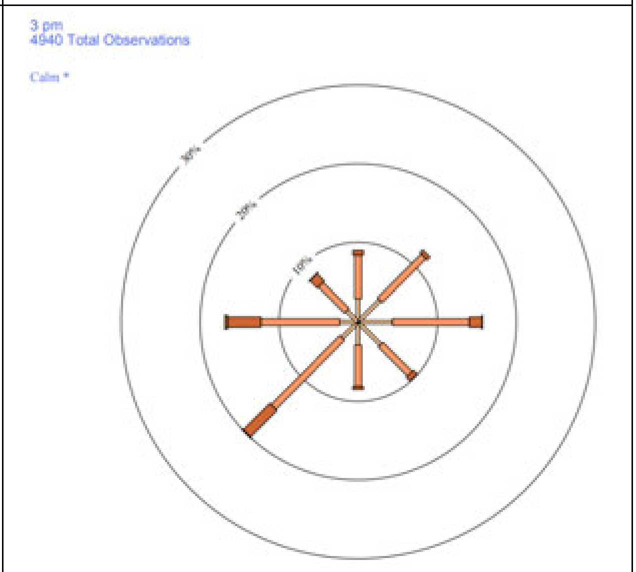
Annual 9.00 am wind rose at Oakey Aero[1]



Annual 3.00 pm wind rose at Oakey Aero[1]



Annual 9.00 am wind rose at Inglewood Forest[2]



Annual 3.00 pm wind rose at Inglewood Forest[2]

Figure 4.2 Wind roses for BoM monitoring stations Oakey Aero and Inglewood Forest

Figure notes:

1 Annual wind rose of wind direction versus wind speed based on observations from 1973 to 2018.
2 Annual wind rose of wind direction versus wind speed based on observations from 2000 to 2014.

Wind speeds at the Inglewood Forest station location are overall lower than those observed at the Oakey Aero station. Morning winds are most frequently from the north, north-east and east, and generally of low speed, with minimal calm conditions at 9.00 am (1%). Afternoon winds have a comparatively higher speed and blow predominantly from the south-west and west.

Overall, analysis of the annual wind roses for the two stations indicates that wind speed and direction is influenced on the local scale by terrain and land use. Terrain and land use are discussed further in Section 4.4.

4.1.4 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 Class 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 three extracted CALMET files has been analysed. The three CALMET files represent the northern, central, and southern modelling domains, which cover the entire Project alignment.

Figure 4.3 to Figure 4.5 show stability classes for the three domains by time of day. As expected, the stability classes indicate stable conditions during the night hours and neutral and unstable conditions during the day.

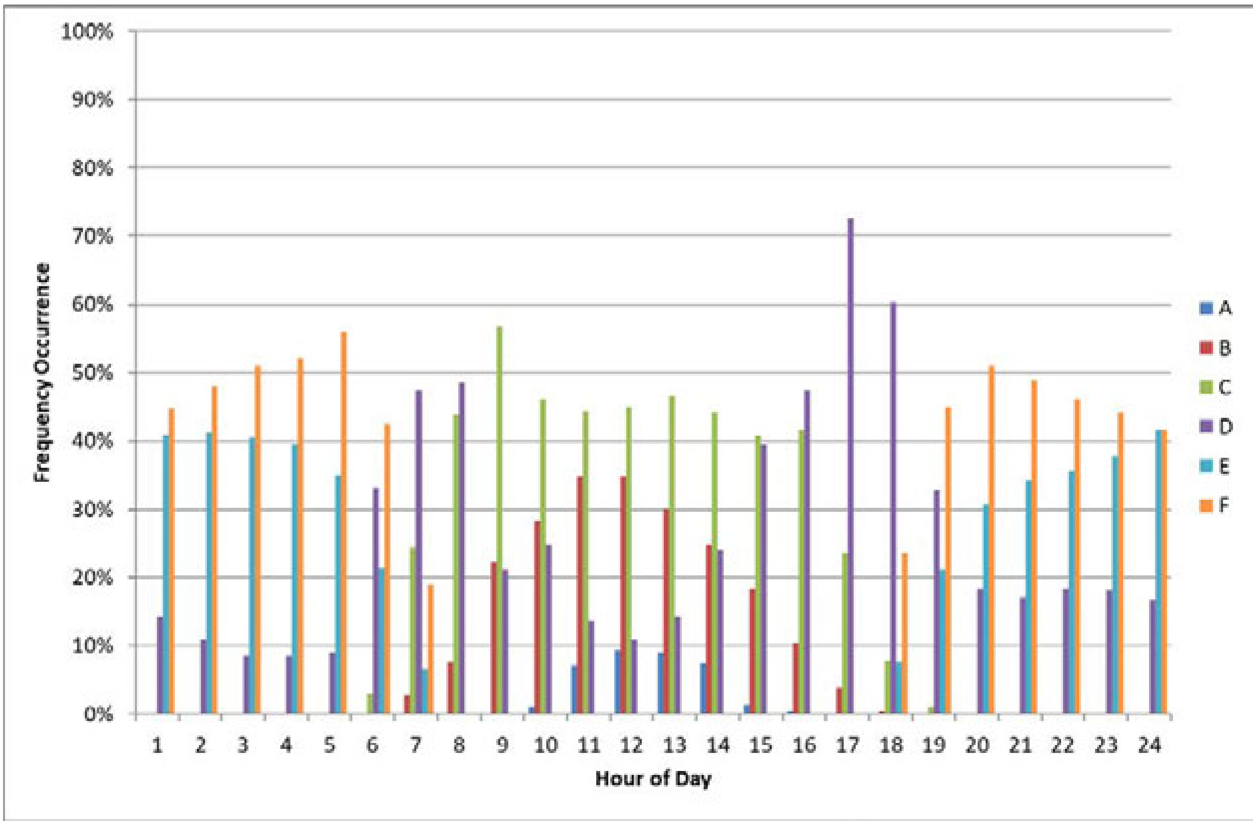


Figure 4.3 CALMET hourly stability class frequency for northern modelling domain

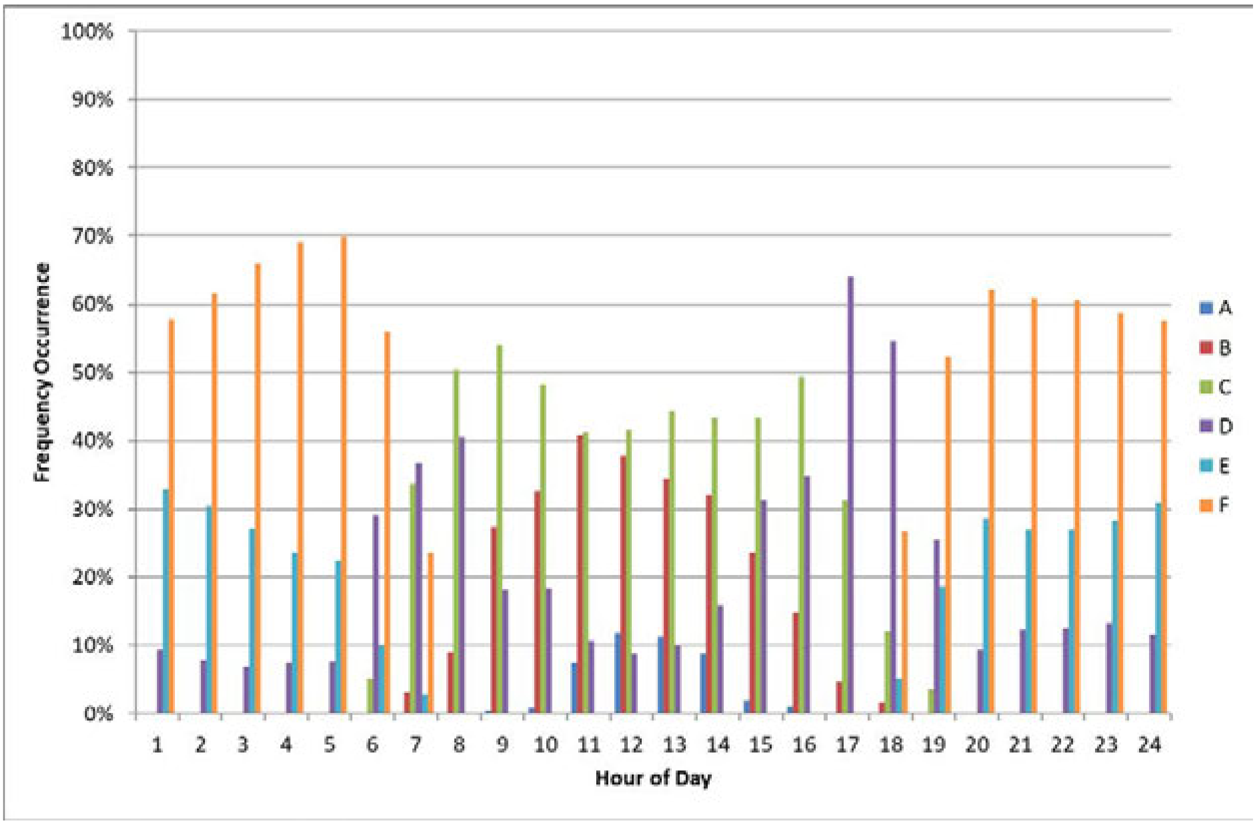


Figure 4.4 **CALMET hourly stability class frequency for central modelling domain**

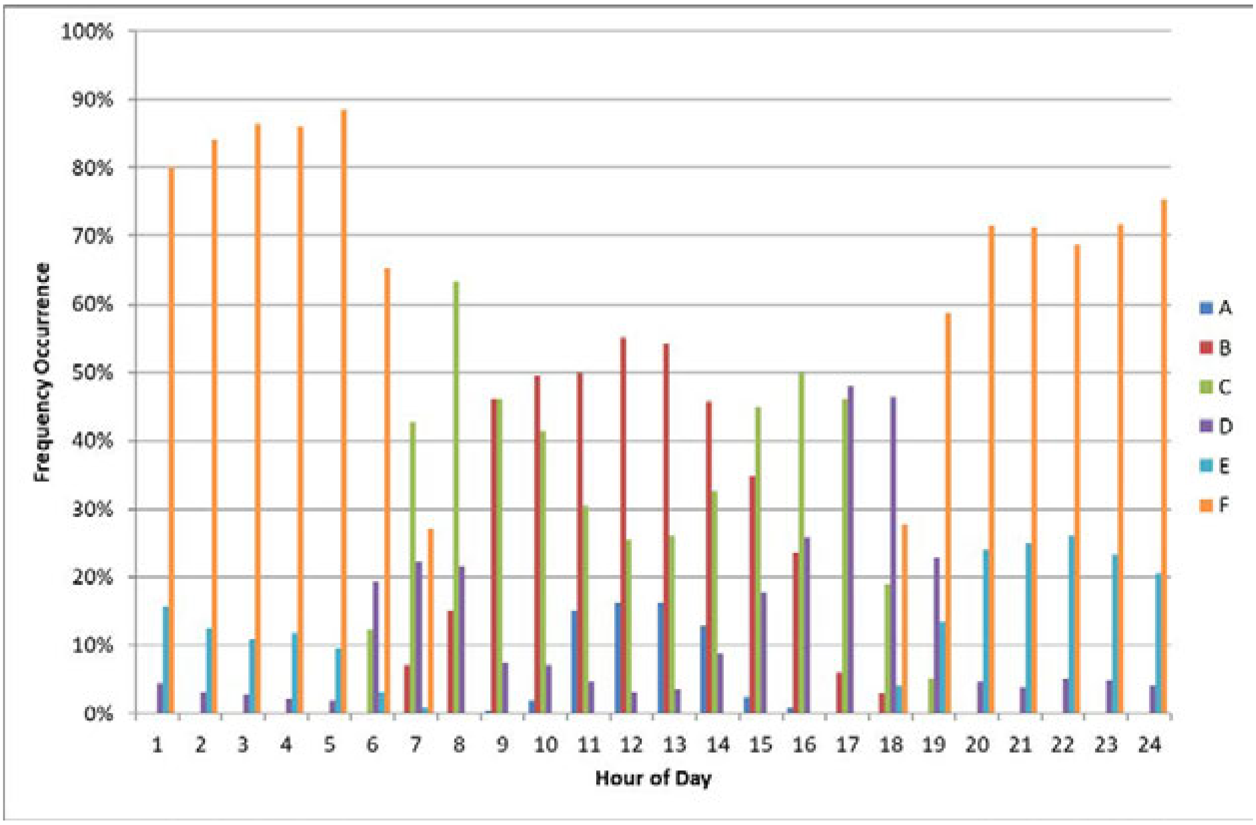


Figure 4.5 **CALMET hourly stability class frequency for southern modelling domain**

Figure 4.6 to Figure 4.8 show stability classes in relation to wind speed. As expected, stable conditions are more prevalent with lower wind speeds.

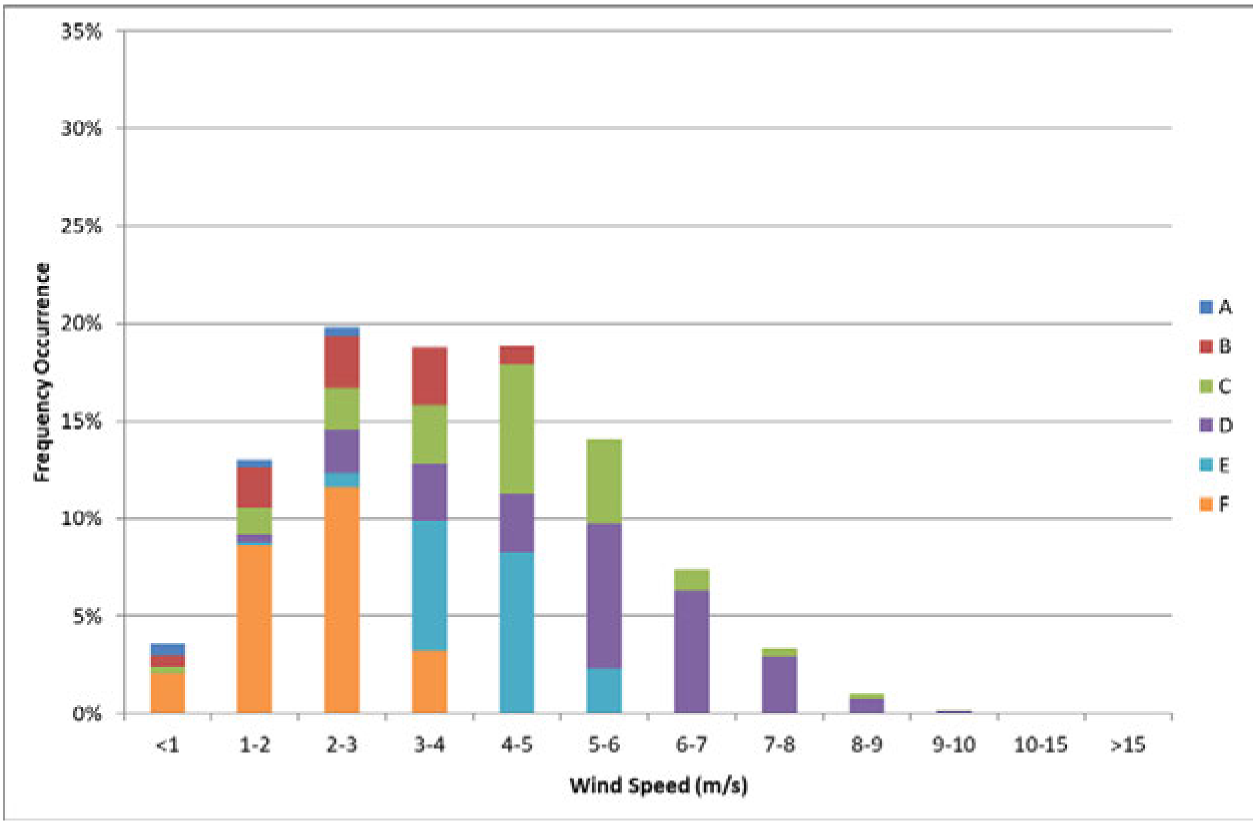


Figure 4.6 CALMET stability class frequency by wind speed for northern modelling domain

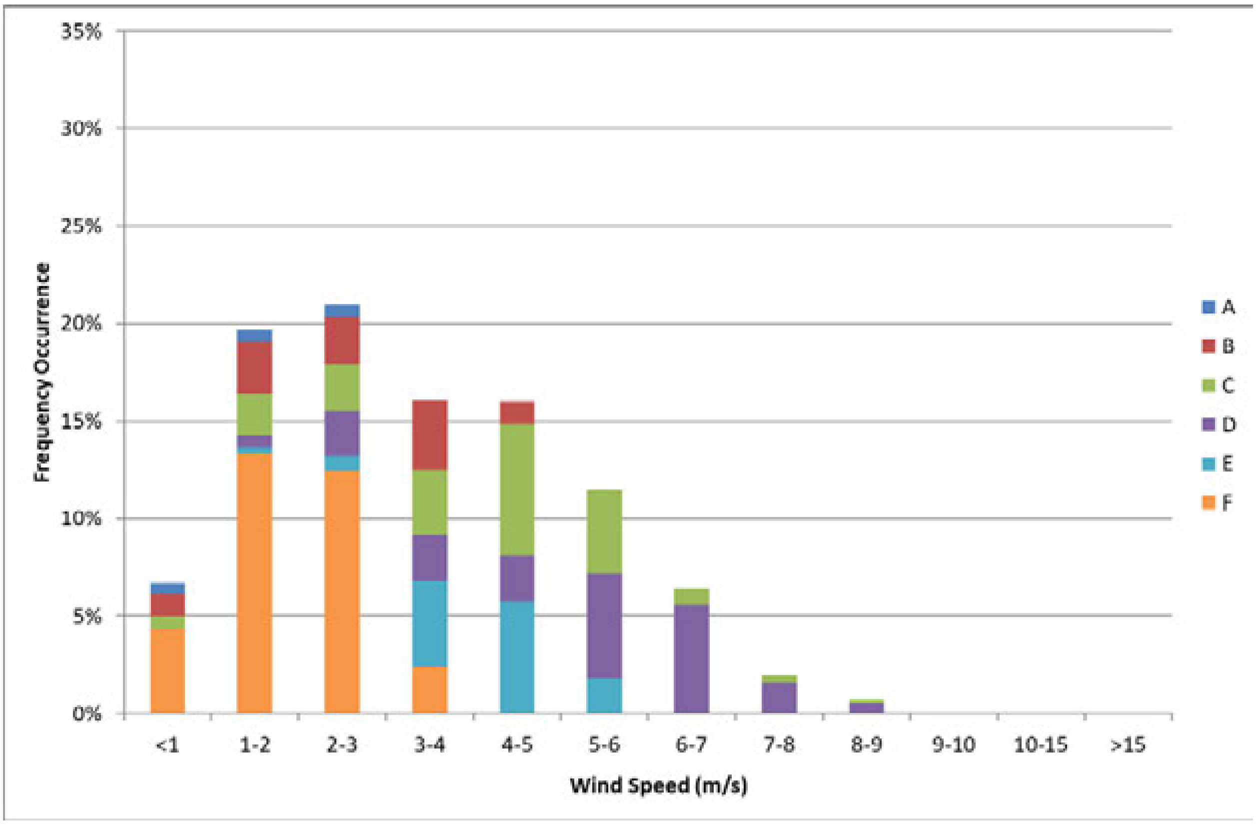


Figure 4.7 CALMET stability class frequency by wind speed for central modelling domain

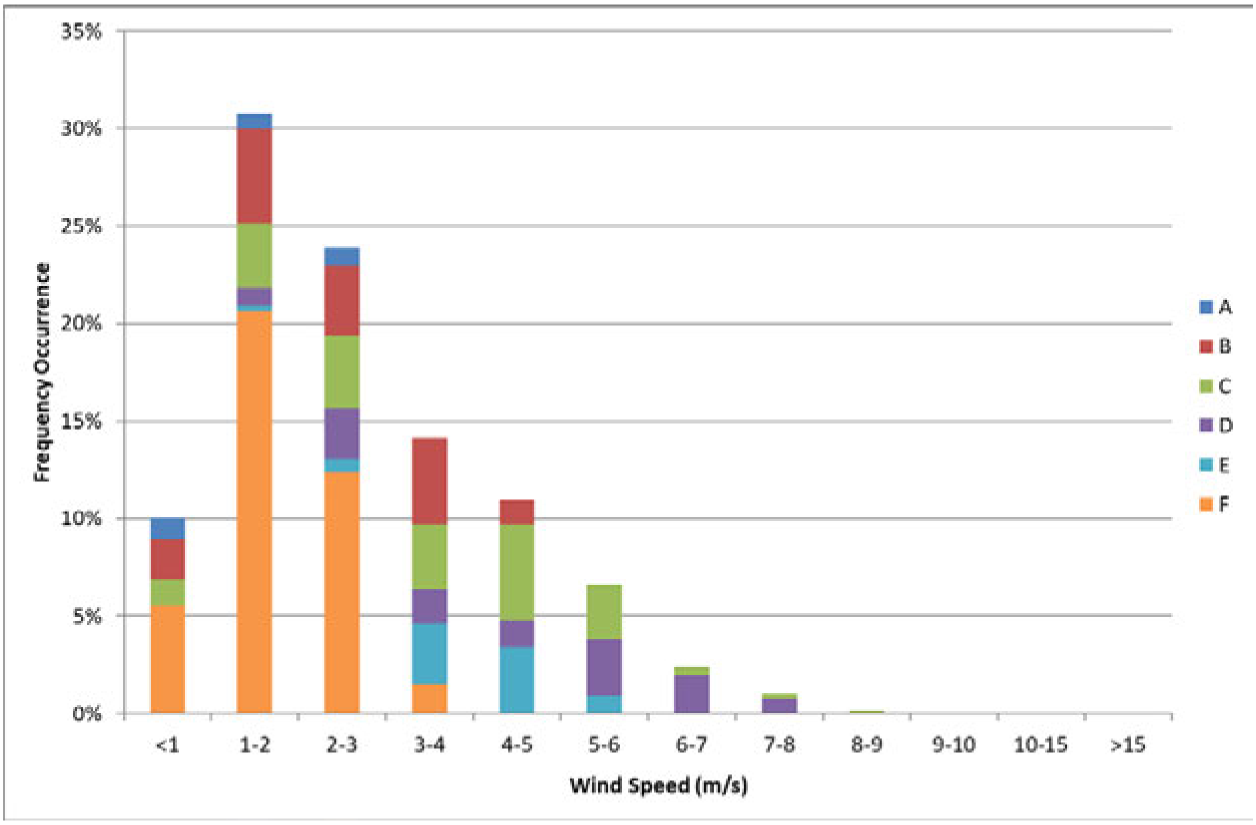


Figure 4.8 **CALMET stability class frequency by wind speed for southern modelling domain**

4.1.5 Mixing height

The planetary boundary layer is the lowest part of the atmosphere and is directly influenced by the Earth's surface. This layer can extend up to 2,000 m above ground level. The height of this layer above ground level is referred to as the mixing height.

Mixing height is estimated within CALMET for stable and convective conditions (respectively), with a minimum mixing height of 50 m. Figure 4.9 to Figure 4.11 present average mixing height by hour of day across the meteorological dataset, as generated by CALMET. These results are consistent with general atmospheric processes that show increased vertical mixing with the progression of the day, as well as lower mixing heights during night-time. Peak mixing heights are consistent with typical ranges.

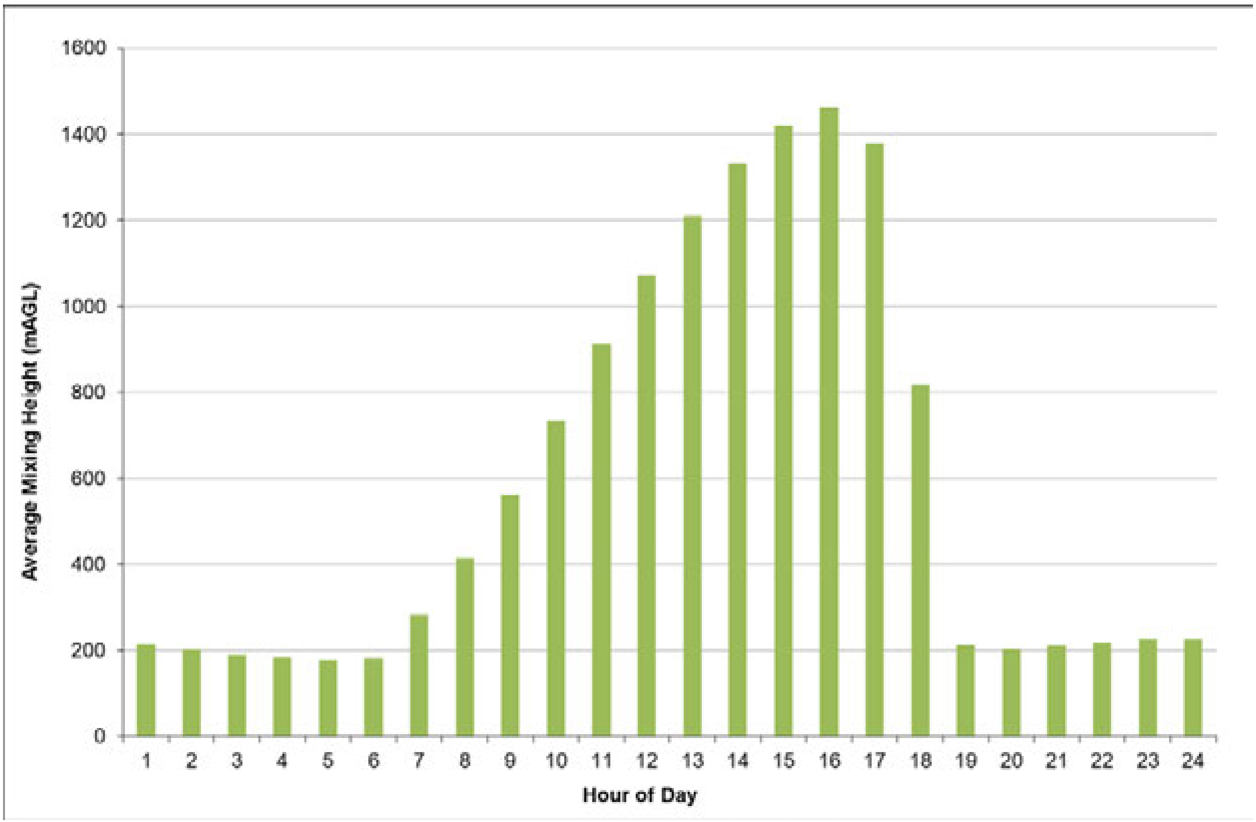


Figure 4.9 **CALMET average mixing height by hour of day for northern modelling domain**

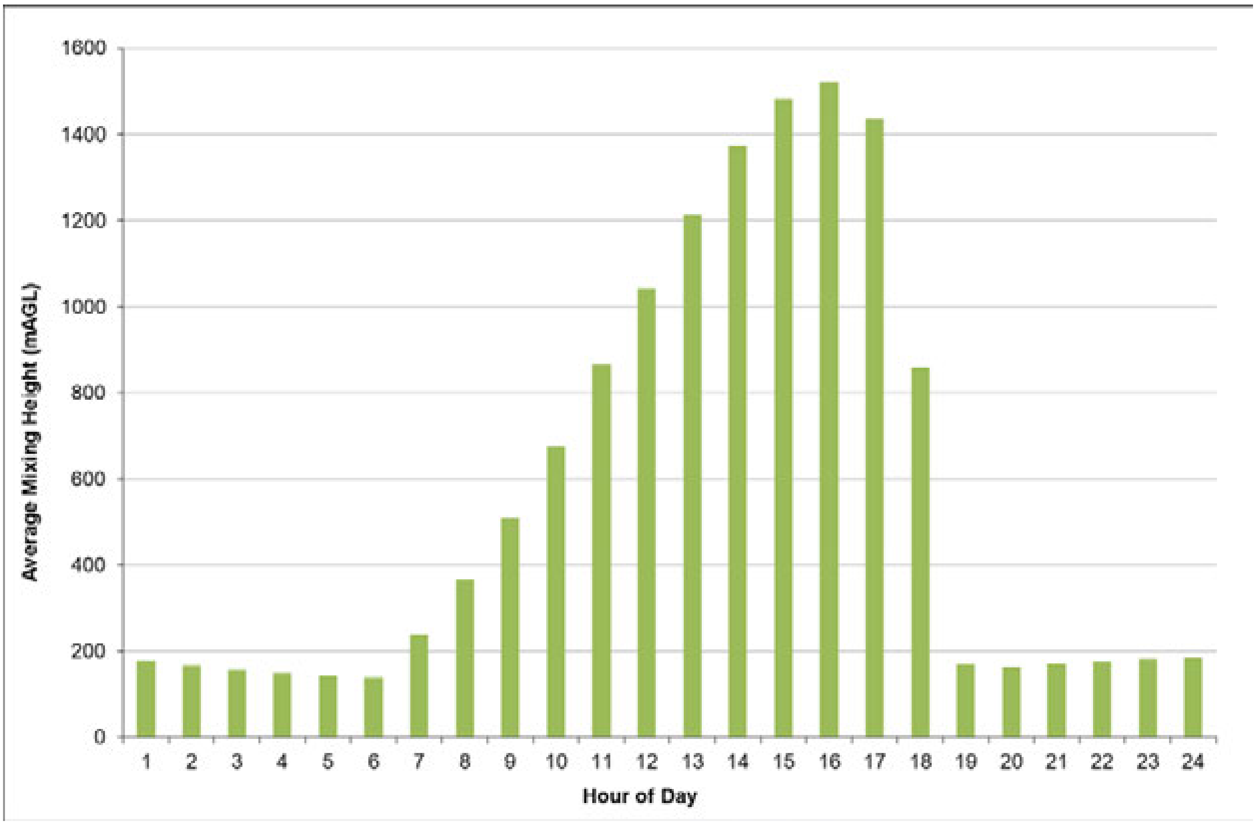


Figure 4.10 **CALMET average mixing height by hour of day for central modelling domain**

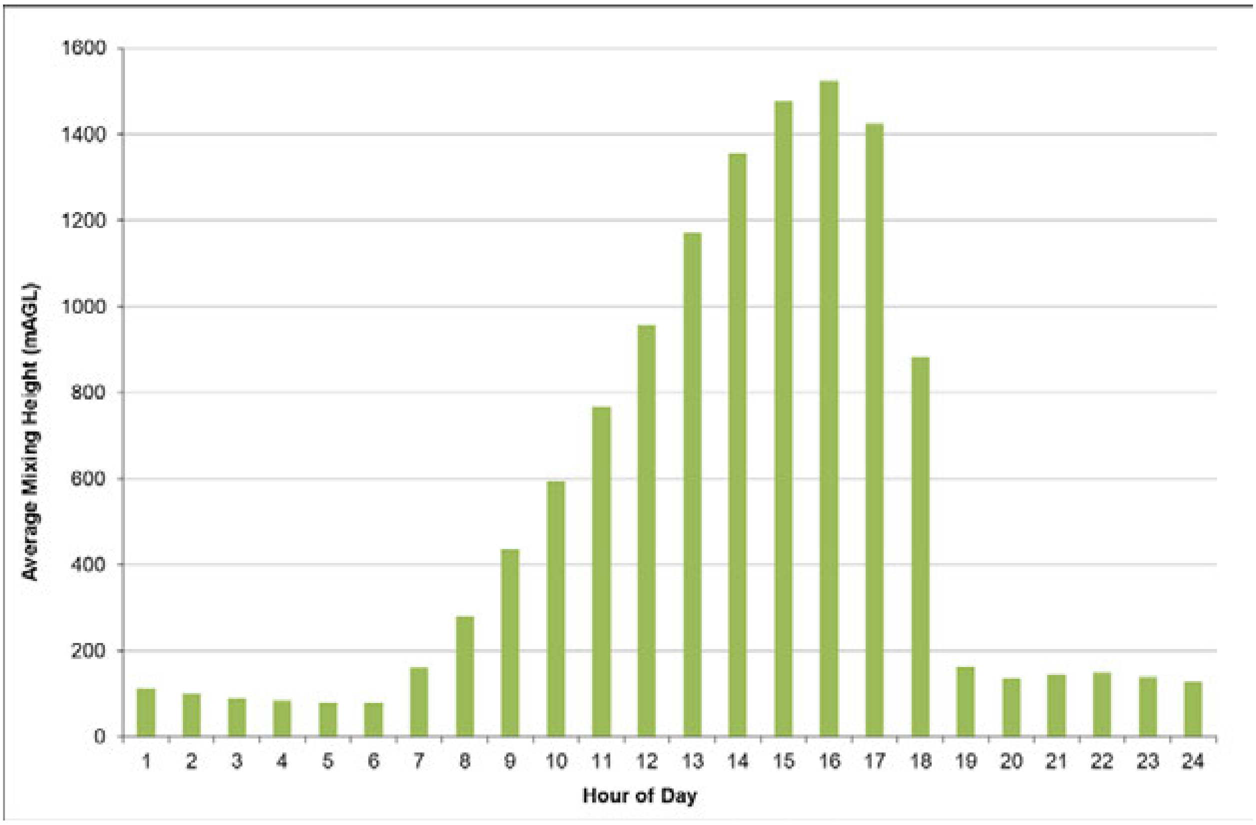


Figure 4.11 CALMET average mixing height by hour of day for southern modelling domain

4.1.6 El Niño–Southern Oscillation

For Australia, the El Niño-Southern Oscillation (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 (SOI), Oceanic Niño Index (ONI), and Multivariate ENSO Index (MEI) 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, utilising the SEI, ONI, and MEI 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 and has been selected as the year of assessment. Appendix A includes further detail on the analysis of the ENSO measurement indices and justification of selecting 2013 as the year of assessment.

4.2 Background air quality

An air quality monitoring program was conducted for the AQIA for the Project which included monitoring of PM_{10} and $PM_{2.5}$. For this purpose, an air quality monitoring station (Inland Rail AQMS) was established at a residential dwelling located off Draper Road, Charlton (Lot 29, SP294200), immediately adjacent to the northern end of the Project (refer Figure 4.1). Concentrations of PM_{10} and $PM_{2.5}$ measured at the Inland Rail AQMS have been used to define existing background concentrations for these pollutants for the AQIA.

Background concentrations for other pollutants of interest not monitored at the Inland Rail AQMS have been estimated using monitoring data available from air quality monitoring stations operated by DES. DES has an ambient monitoring network across Queensland that monitors for controlled pollutants in areas with large population bases or heavy industry adjacent to residential areas. To determine appropriate baseline levels of each pollutant, recent data from the operational stations closest to the alignment was reviewed.

The nearest historic DES monitoring station to the Project was located at Jondaryan, 40 km north-west of Toowoomba. This station operated between March 2014 to April 2015. When operational, its purpose was to serve as a peak monitoring station and it was positioned in a location near a significant local pollution source. This station is not considered suitable to provide representative background concentrations for the AQIA area and therefore has not been considered further.

A further four monitoring stations are present in South West Queensland at Hopeland, Miles Airport, Burncluith, and Condamine. Although no exceedances of ambient air quality objectives were found at these monitoring sites, it was concluded in the CSIRO's Gas Industry Social and Environmental Research Alliance investigation by Lawson et al (2018) that coal seam gas (CSG) activities are a likely contributor to the local air shed in this region. As the area surrounding the Project has no CSG activity, monitoring data from these stations is not considered an accurate representation of the background air environment for the Project and has not been used in this assessment.

A DES monitoring station was previously located in North Toowoomba, however, this station ceased operation in 2010 and its data is not considered representative of current conditions in the AQIA area.

The next nearest operational DES monitoring station to the Project is located at Mutdapilly, approximately 90 km to the east. Not all pollutants of interest are measured at the Mutdapilly station, therefore, data from the Springwood DES station was also reviewed. Springwood is the only DES station in South East Queensland that provides measurements of air toxics such as benzene and toluene. The details of the stations considered for review including pollutants monitored are presented in Table 4.4, with the location of these stations shown in Figure 4.1.

Table 4.4 Monitoring stations considered in the AQIA

Station Name	Location	Location relative to the Project alignment	Pollutants monitored
Mutdapilly	27.7528° S, 152.6509° E	90 km to east	NO_x, O_3
Springwood	27.6125° S, 153.1356° E	135 km to east-north-east, in the grounds of a high school	NO_x, O_3, SO_2, PM_{10}, $PM_{2.5}$ and air toxics (organic pollutants, e.g. benzene, toluene)
Inland Rail AQMS	27.4932° S, 151.8481° E	<0.1 km to the north, at a residential dwelling located off Draper Road, Charlton (Lot 29, SP294200)	PM_{10}, $PM_{2.5}$

In addition to monitoring data from the Inland Rail AQMS and DES monitoring stations, dust deposition monitoring data from a three-month deposited dust monitoring program conducted for the Inland Rail Project in 2016 has also been reviewed. This monitoring is discussed in Section 4.2.3.

4.2.1 Data analysis and availability

Data from the Inland Rail AQMS monitoring station has been validated using the methodology outlined in the NEPM technical paper *Data Collection and Handling* (NEPM, 2001), which details basic data validation methodologies, methods for calculation of average data, and reporting requirements for data. Periods of data were invalidated for several reasons such as data recorded immediately after power failures, persistent negative data, and data measured during routine maintenance. Monitoring data from the Inland Rail AQMS is available from July 2018. However, for the assessment, the most recent 12 months of monitoring data (at the time of assessment) has been considered, being the period from 1 September 2018 to 31 August 2019. For this period, the capture rate (availability) of 1 hour data is 90 per cent for $PM_{2.5}$ and 97 per cent for PM_{10}. The data presented in the following sections is considered representative of actual concentrations present at the time of monitoring.

The DES monitoring station datasets were sourced as validated datasets; however, the data do contain gaps that are either missing monitoring data or invalidated by DES. Data is considered to be representative of actual pollutant concentrations in the air at the time of monitoring. The datasets consist of hourly averages that have been summarised and analysed for the required averaging periods. Where there was less than 75 per cent available valid data for an averaging period, then that averaging period was not calculated. Annual averages were considered valid when at least three of the year's quarterly periods had a data availability threshold of at least 75 per cent, as per guidance from NEPM technical paper *Data Collection and Handling* (NEPM, 2001).

4.2.2 Particulate matter

Particulate matter (PM_{10} and $PM_{2.5}$) was measured at the Inland Rail AQMS using Beta Attenuation Monitors (BAMs) in accordance with Australian Standards AS/NZS 3580.9.11:2016 (PM_{10}) and AS/NZS 3580.9.12:2013 ($PM_{2.5}$). The monitoring site was located in accordance with requirements listed in Australian Standard AS/NZS 3580.1.1:2016.

4.2.2.1 PM_{10}

Available PM_{10} concentration data from the Inland Rail AQMS from 1 September 2018 to 31 August 2019 has been analysed to provide an estimate of existing PM_{10} concentrations in proximity to the Project. Measured 24 hour PM_{10} averages are presented in Figure 4.12.

Several dust storms and bush fires occurred during the monitoring period in Central and SEQ, which represent all measured exceedances of the 24 hour PM_{10} air quality goal of 50 µg/m³.

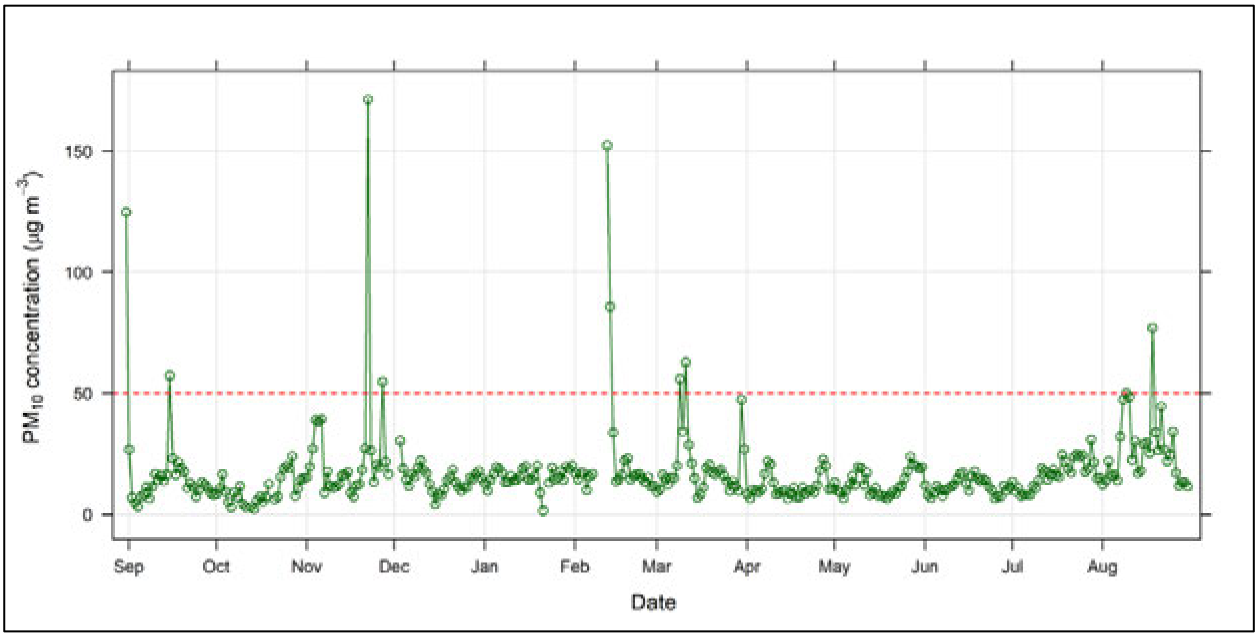


Figure 4.12 24 hour average PM_{10} concentrations measured at the Inland Rail Air Quality Monitoring Station

Average annual and 24 hour PM_{10} concentrations and statistics are presented in Table 4.5.

Table 4.5 24 hour and annual average PM_{10} concentration statistics (µg/m³) for the Inland Rail Air Quality Monitoring Station

Statistic	Monitoring period (µg/m³)	Annual average (µg/m³)	24-hour maximum (µg/m³)	24-Hour 70th percentile (µg/m³)	Number of exceedances of 24-hour goal
PM_{10}	1 September 2018 – 31 August 2019	17.1	171.4	17.4	9
Air quality objectives	50 µg/m³ (24-hour) 25 µg/m³ (Annual)				

4.2.2.2 $PM_{2.5}$

Available $PM_{2.5}$ concentration data from the Inland Rail AQMS from 1 September 2018 to 31 August 2019 have been analysed to provide an estimate of existing $PM_{2.5}$ concentrations for the Project. Measured 24 hour $PM_{2.5}$ averages are presented in Figure 4.13.

The measured 24 hour average $PM_{2.5}$ concentrations (refer Figure 4.13) show a similar trend to the measured 24 hour average PM_{10} concentrations (refer Figure 4.12). Similarly to PM_{10}, dust storms and bush fires are the cause of the elevated $PM_{2.5}$ concentrations and the measured exceedances of the 24 hour $PM_{2.5}$ air quality goal of 25 µg/m³.

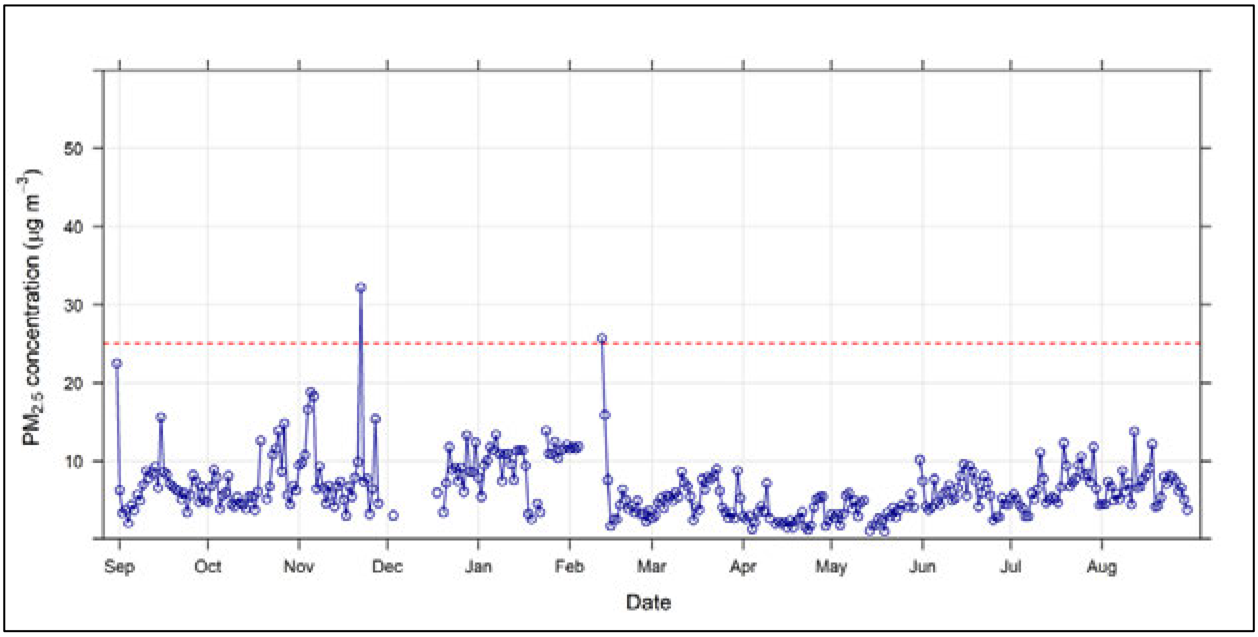


Figure 4.13 24 hour average $PM_{2.5}$ concentrations measured at the Inland Rail Air Quality Monitoring Station

Average annual and 24 hour $PM_{2.5}$ concentrations and statistics are presented in Table 4.6.

Table 4.6 24 hour and annual average $PM_{2.5}$ concentration statistics (µg/m³) for the Inland Rail Air Quality Monitoring Station

Statistic	Monitoring period	Annual average (µg/m³)	24-hour maximum (µg/m³)	24-hour 70th percentile (µg/m³)	Number of exceedances of 24-hour goal
$PM_{2.5}$	1 September 2018 – 31 August 2019	6.5	32.2	7.6	2
Air quality objectives	25 µg/m³ (24-hour) 8 µg/m³ (Annual)				

4.2.2.3 Total suspended particulates

There are no measured values that were sampled using compliant methodologies for TSP in the DES datasets and TSP is not measured at the Inland Rail AQMS. For the purpose of the assessment, annual average TSP concentrations were estimated from the measured annual average PM_{10} concentrations at the Inland Rail AQMS. TSP concentration were estimated 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), which is a ratio commonly applied for air quality assessments in Queensland. This is considered a conservative estimate and is likely an over estimation of the actual TSP present. However, this is a common ratio for dust and is considered appropriate in the absence of recently monitored data.

4.2.3 Deposited dust

A three-month deposited dust monitoring program was conducted for the Inland Rail Project in 2016, as part of the Yelarbon to Gowrie (Y2G) Preliminary Environmental Assessment (PEA) Report (AECOM, 2017). The Y2G section was a previous alignment option which has now been replaced by the Project. The monitoring was conducted at four sites in accordance with Australian Standard AS/NZS 3580.10.1:2003. The locations of each site are shown in Figure 4.1. The measured dust deposition rates (reported as total insoluble solids) are presented in Table 4.7.

Table 4.7 shows that there were no measured exceedances of the adopted goal of 120 mg/m^2/day. The highest measured rate of 50 mg/m^2/day (measured at Site 3 during May/June 2016) has been adopted as the background concentration for the AQIA area.

Table 4.7 Measured deposited dust levels (mg/m^2/day)

Site	Coordinates	Dust deposition Rate (mg/m^2/day)		
Monitoring period		03/05/2016 - 02/06/2016	02/06/2016 - 30/06/2016	30/06/2016 - 28/07/2016
Site 2 (Brookstead)	27.7583, 151.4499	27	<u>33</u>	27
Site 3 (Pampas)	27.7936, 151.4102	<u>50</u>	33	23
Site 4 (Mt Tyson)	27.5721, 151.5709	20	<u>23</u>	17
Site 5 (Aubigny)	27.5046, 151.6825	<u>40</u>	33	17
Air quality goal		120		

Table notes:

Highest monitored concentrations at each site are underlined.

4.2.4 Nitrogen dioxide

The DES Mutdapilly monitoring station is located approximately 90 km east of the Project, but is the nearest air quality monitoring station that measures NO_2. The Mutdapilly site has no local emission sources and therefore provides an ideal source of background data for NO_2.

Maximum 1 hour and annual average NO_2 concentrations for Mutdapilly from the period of 2010 to 2017 are presented in Table 4.8 and Table 4.9 respectively.

It is noted that the USEPA's Ozone Limiting Method (OLM) has been used to predict ground level concentrations of NO_2 as discussed in Section 5.3.5. The OLM considers the ambient concentrations of ozone (O_3) and NO_2 to determine the resulting cumulative NO_2 concentration with contribution (emissions) from the source under assessment (the Project). To facilitate the use of the OLM, hourly sequential O_3 and NO_2 monitoring data for the year 2013 from the Mutdapilly monitoring station has been used as this is the same year as has been used for the meteorological modelling.

Table 4.8 1 hour NO_2 maximum concentrations (µg/m^3) for Mutdapilly

Monitoring station	2010	2011	2012	2013	2014	2015	2016	2017
<u>Maximum 1 hour concentration</u>								
Mutdapilly	<u>69.8</u>	55.4	51.3	57.5	59.6	53.4	<u>69.8</u>	<u>69.8</u>
Air quality goal	250							

Table notes:

Highest monitored concentrations are underlined

Table 4.9 Annual NO2 average concentrations (µg/m^3) for Mutdapilly

Monitoring station	2010	2011	2012	2013	2014	2015	2016	2017
Mutdapilly	6.5	<u>8.3</u>	7.2	7.8	6.9	6.5	7.6	7.6
Air quality goal	62							

Table notes:

Highest monitored concentrations are underlined

4.2.5 Volatile organic compounds

The nearest monitoring station which measures toluene, xylenes, and benzene is located at Springwood. The Springwood station is located 135 km to the east of the Project in a built-up residential area close to a major traffic corridor. Measured concentrations from the Springwood station have been adopted as background concentrations for the assessment of toluene, xylenes, and benzene. However, due to the differing nature of the station's location (in contrast to the AQIA area), the adopted concentrations are considered conservative. Table 4.10, Table 4.11, and Table 4.12 present the measured concentrations for toluene, xylenes, and benzene at the Springwood station for the period of 2010 to 2017.

No exceedances of the air quality objectives for toluene, xylenes or benzene have been recorded in the period between 2010 to 2017. The species closest to its objective is annual average benzene, with a measured concentration of 5.2 µg/m³ in 2017.

Table 4.10 1 hour toluene concentrations (µg/m³) for Springwood

Pollutant	2010	2011	2012	2013	2014	2015	2016	2017
Maximum 1 hour concentration								
Toluene	71.5	207	182	299	535	497	164	678
70th Percentile 1 hour average concentration								
Toluene	6.6	7.8	16.4	19.3	20.1	21.8	23.0	8.6
Air quality goal	1,100[a.]							

Table notes:

a 30-minute average as per the EPP (Air)
b Highest monitored concentrations are underlined.

Table 4.11 24 hour average toluene and xylenes concentrations (µg/m³) for Springwood

Pollutant	2010	2011	2012	2013	2014	2015	2016	2017
Maximum 24 hour concentration								
Toluene	15.6	18.4	37.3	37.3	88.6	52.9	46.6	107
Xylenes	25.3	31.1	30.3	18.2	19.1	18.9	28.5	43.8
70th Percentile 24 hour average concentration								
Toluene	6.6	7.6	15.6	18.9	19.0	19.4	21.7	8.9
Xylenes	13.3	19.5	15.5	13.3	12.6	15.4	16.2	31.5
Air quality objectives	4,100 – Toluene 1,200 – Xylenes							

Table notes:

Highest monitored concentrations are underlined.

Table 4.12 Annual average concentrations (µg/m³) for Springwood

Pollutant	2010	2011	2012	2013	2014	2015	2016	2017
Benzene	2.5	3.9	3.1	2.5	2.4	3.0	3.3	5.2
Toluene	5.9	6.9	14.0	16.2	17.5	18.5	17.8	8.1
Xylenes	11.9	18.3	14.6	12.0	11.4	14.2	15.8	26.0
Air quality objectives	5.4 – Benzene 400 – Toluene 950 – Xylenes							

Table notes:

Highest monitored concentrations are underlined.

4.2.6 Summary of adopted pollutant concentrations

Table 4.13 summarises the background concentrations and deposition levels which have been adopted for the AQIA and the monitoring locations which are the source of the background concentrations. In accordance with the BCC AQPSP (2014) the 70th percentile concentration was selected as the adopted background concentration for assessment of the 24-hour average objectives for PM_{10}, $PM_{2.5}$, toluene and xylene. Measured annual average concentrations were used as the background concentration for the assessment of pollutants with annual average objectives.

Table 4.13 Summary of adopted existing pollutant concentration and dust deposition levels

Pollutant	Averaging time and statistic	Air quality goal (µg/m³)	Adopted background (µg/m³)	Monitoring location
Deposited Dust	30 days, maximum	-	50 mg/m²/day	4 x locations along Project Alignment (Y2G PEA)
NO_2	1 hour, maximum	250	57.5	Mutdapilly
	Annual average	62	7.8	
TSP	Annual average	90	42.8[a]	Inland Rail AQMS
PM_{10}	24 hours, 70th percentile	50	17.4	
	Annual average	25	17.1	
$PM_{2.5}$	24 hours, 70th percentile	25	7.6	
	Annual average	8	6.5	
Benzene	Annual average	5.4	5.2	Springwood[b]
Toluene	1 hour, 70th percentile	1100	23	
	24 hours, 70th percentile	4100	21.7	
	Annual average	400	18.5	
Xylenes	24 hours, 70th percentile	1200	31.5	
	Annual average	950	26	

Table notes:

a Calculated from PM_{10} concentrations measured at 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).

b. Due to the differing nature of the Springwood station's location, the adopted concentrations from the Springwood station are considered a conservative estimate of background concentrations for toluene, xylenes and benzene..

4.2.7 Assimilative capacity of the receiving environment

The assimilative capacity of the receiving air environment can be quantified through the difference between the adopted background concentrations and the air quality objectives defined in Table 3.1. For most pollutants and averaging times, the background concentrations represent less than half of the air quality goal, indicating a moderate assimilative capacity of the receiving environment. Pollutants that show lower levels of assimilative capacity include the following:

- PM_{10} 17.1 µg/m³ annual average, representing 68 per cent of the 25 µg/m³ air quality goal
- $PM_{2.5}$ 6.5 µg/m³ annual average, representing 81 per cent of the 8 µg/m³ air quality goal
- Benzene 5.2 µg/m³ annual average, representing 96 per cent of the 5.4 µg/m³ air quality goal.

4.2.8 Consideration of climate change influence on background air quality

Changing climatic conditions due to climate change also 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 which 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 air quality assessment.

4.3 Existing emission sources

The NPI (DAWE, 2020) 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 which may affect them locally.

Facilities which 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 like mines, power stations and factories, as well as other sources. NPI data tends to be a conservative estimate of industry emissions for sites like quarries and mines due to the broad and generalised assumptions made during the emission estimations.

An NPI search conducted for the AQIA area shows eight facilities are required to report emissions annually. The locations of these facilities are shown in Figure 4.14. A description of each existing emission source and its approximate distance from the Project alignment is presented in Table 4.14.

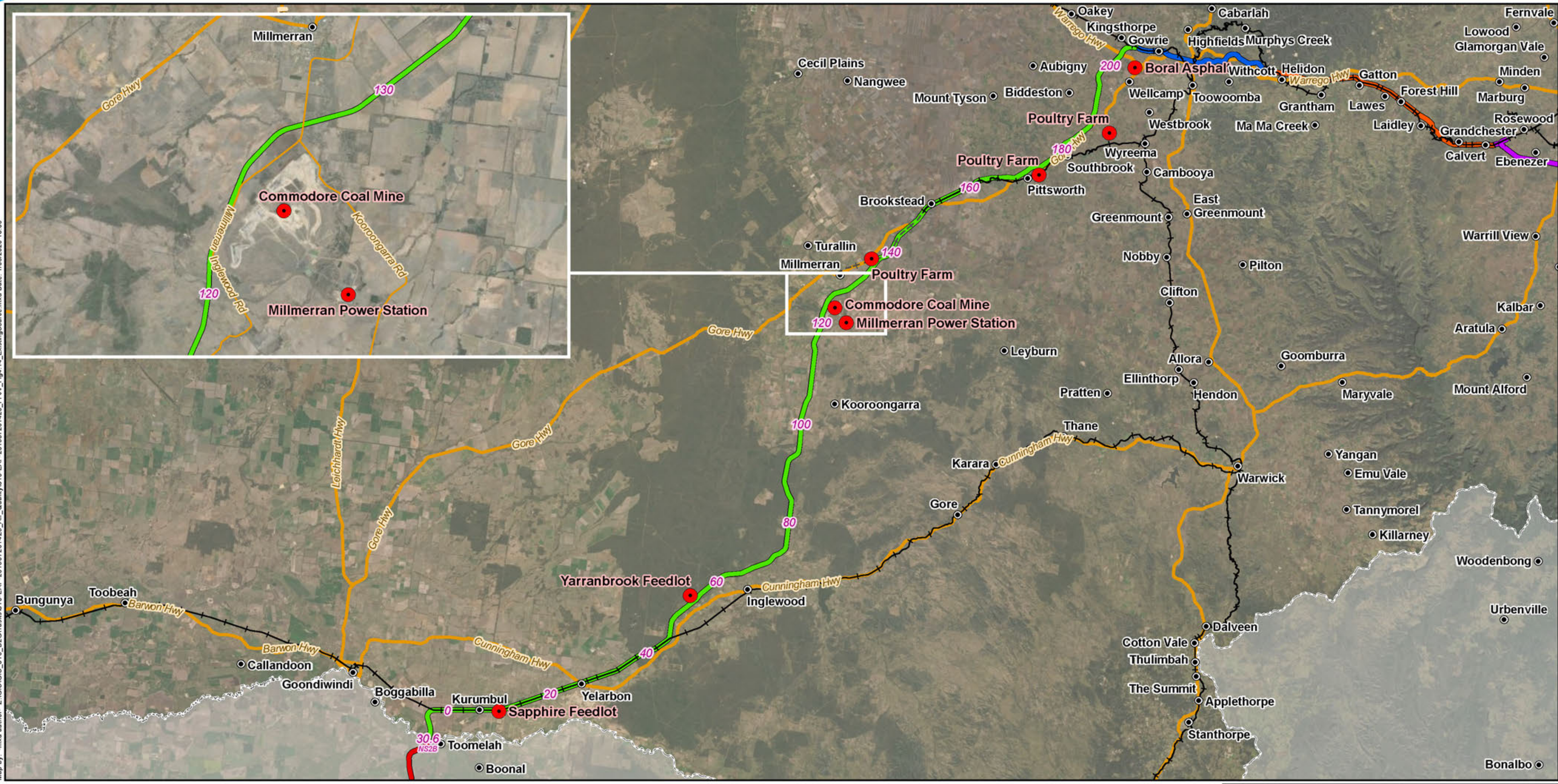
Table 4.14 National Pollutant Inventory listed facilities in the AQIA area

Facility Name	Industry	Coordinates	Distance from the Project alignment (km)	Direction from the Project alignment
Commodore Mine	Coal mining	-27.938,151.260	<1	East
Millmerran Power Station	Power generation	-27.963,151.278	4.5	South-east
Sapphire Feedlot	Sheep, beef cattle and grain farming	-28.619, 150.594	<1	South
Yarranbrook Feedlot	Sheep, beef cattle and grain farming	-28.426, 150.967	<1	North-west
Doug Hall Enterprises	Poultry farming	-27.852, 151.330	1.0	West
Pittsworth	Poultry farming	-27.714, 151.652	1.6	South
Inghams TF3 Breeder Farm Toowoomba	Poultry farming	-27.637, 151.793	4.0	East
Boral Asphalt Charlton	Hot mix asphalt manufacturing	-27.527, 151.842	3.6	South-east

Pollutant emissions of concern for the Commodore Mine and Millmerran Power Station include particulate matter, NO_x, CO and SO_2. Due to the distance from air quality monitoring stations considered, it is unlikely that emissions from the Commodore Mine and Millmerran Power Station are represented in the background concentrations adopted. Based on this, NPI reported emissions for pollutants of interest for the mine and power station were included in the dispersion model developed for the assessment.

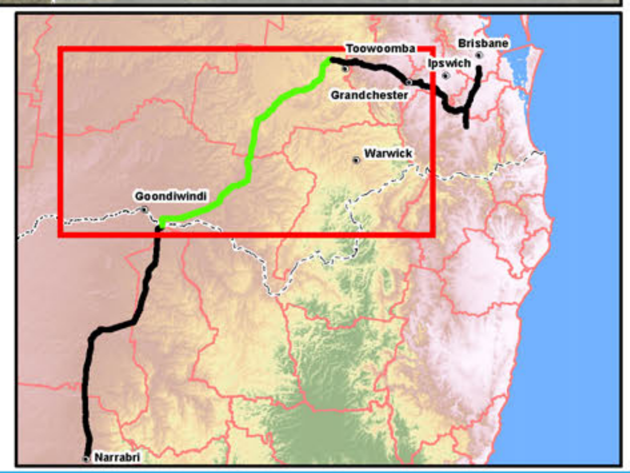
The primary pollutant of concern for the feedlots and poultry farms listed in Table 4.14 is ammonia, which is the only pollutant reported to the NPI by these facilities. Ammonia is not a pollutant of concern for the Project and emissions from these four facilities were not included in the cumulative model.

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



Legend

- 5 Chainage (km)
- Localities
- Existing emission source
- North Star to NSW/QLD border alignment
- Border to Gowrie alignment
- Gowrie to Helidon alignment
- Helidon to Calvert alignment
- Calvert to Kagaru alignment
- Major roads
- Minor roads
- Existing rail (operational)
- Existing rail (non-operational)
- NSW/QLD border



A3 scale: 1:800,000

0 6 12 18 24 30 km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 26/05/2020 Version: 1

Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.14: Existing emission sources

Boral Asphalt Charlton is 3.6 km southeast of the Project alignment and reports emissions of particulate matter, total VOCs, CO, NO_x, and SO_2 to the NPI. Emissions of all pollutants other than total VOCs are relatively minor and are not considered likely to contribute to a cumulative impact at sensitive receptors near the Project. There is the possibility of minor concentrations of VOCs from the asphalt plant reaching sensitive receptors near the Project; however, these concentrations are likely to be well below those measured at the DES Springwood monitoring station, which is influenced by large volumes of traffic emissions. Inclusion of the Springwood background values is considered conservative and the Boral emissions were not included in the model on this basis.

In addition to these operational cumulative NPI regulated sources, the following emission sources have been included in the dispersion model for the assessment due to their potential to contribute to cumulative air quality impacts at receptors in the AQIA area:

- North Star to NSW/QLD Border Project (Inland Rail)
- Gowrie to Helidon Project (Inland Rail)
- West Moreton System (existing rail line west of the junction between the Project and the Gowrie to Helidon section of Inland Rail).

Emissions from other local anthropogenic and non-anthropogenic sources such as local traffic, wind-blown dust, etc, have not been modelled individually as they are assumed to be adequately represented by the assumed background concentrations presented in Section 4.2.6.

4.4 Terrain and land use

Terrain features and land use can influence meteorological conditions on both a local and regional scale. There are five distinctive regions within the impact assessment area:

- Low-lying alluvial floodplains of the Macintyre River (typically 200.0 m Australian height datum (AHD) to 250.0 mAHD)
- Forested sandstone hills of the Macintyre Brook catchment (typically 250.0 mAHD to 350.0 mAHD)
- Undulating grazing lands and peaks near Millmerran (typically 300.0 mAHD to 650.0 mAHD)
- Broad cultivated alluvial plains of the Condamine River (typically 300.0 mAHD to 350.0 mAHD)
- Basaltic uplands and isolated peaks of the Toowoomba plateau (typically 325.0 mAHD to 700.0 mAHD).

The landscape between Kurumbul near the NSW border and Gowrie Junction is typically a sparsely settled rural landscape characterised by generally flat irrigated and non-irrigated croplands and undulating pastures, interspersed by a network of vegetated watercourses associated with the Dumaresq, Macintyre and Condamine Rivers and set against a backdrop of forested low hills and isolated volcanic peaks. It is, for the most part, a highly modified landscape as a result of historical clearing practices for agriculture and grazing, the establishment of linear infrastructure (railways, highways and powerlines) and other development activity (e.g. Commodore Mine, Toowoomba Wellcamp Airport and surrounds). Several small townships exist within 5 km of the Project alignment, these include Yelarbon, Inglewood, Millmerran, Brookstead, Pittsworth, Southbrook, Kingsthorpe and Gowrie.

The influence of terrain on wind flows and dispersion has been considered in the meteorological modelling undertaken for the assessment as discussed in Section 5.3. The effect of land use on surface roughness and dispersion has also been included in the meteorological model developed for the assessment. The height of the train emission source included in the model was based on the proposed design elevations for the alignment.

4.5 Sensitive receptors

Sensitive air quality receptors in the AQIA area were identified as per the DES *Guideline Application requirements for activities with impacts to air* (DES, 2019). As per the DES 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.

There are no World Heritage Areas or areas protected under the NC Act or the *Marine Parks Act 2004* located within one kilometre of the Project alignment.

The primary sensitive receptor type for the Project of interest for air quality assessment are rural and semi-rural dwellings, a large number of which are sparsely distributed within the AQIA area. As per the ToR, surfaces that lead to potable water tanks in the vicinity of the Project are also considered sensitive receptors.

Figure 4.15 shows the location of sensitive receptors considered for the AQIA. The sensitive receptors were identified via a desktop review of aerial imagery and no site verification was undertaken. Only sensitive receptors within one kilometre of the Project alignment centreline were included in the modelling for the operational phase impact assessment. Appendix B provides further detailed figures presenting receptor locations.

In addition to existing sensitive receptors, the Project includes allowance for three non-resident workforce accommodation facilities to accommodate the construction workforce. These non-resident workforce accommodation facilities will be occupied during the construction of the Project and therefore have been included as sensitive receptors for the construction phase impact assessment. Non-resident workforce accommodation will not be occupied during the operation of the Project and therefore are not considered in the operational phase impact assessment.

The number of sensitive receptors included in this assessment is based on the Project footprint established to accommodate the reference design and the land required to safely and efficiently construct and maintain the Project. As a consequence, the number and location of sensitive receptors of relevance for air quality impacts may change during the detail design phase of the Project and as the construction approach is finalised.

Due to the large-scale nature of the Project, it has been assumed that receptors within the temporary footprint will not be occupied during construction works and have therefore not been considered further. The extent of sensitive receptor impacts will be re-assessed through the detail design process once the Project footprint and construction methodology has been confirmed. The location and classification of sensitive receptors in proximity to the finalised Project footprint will be confirmed as part of the re-assessment process.

Discrete receptors points have been included for sensitive receptors and have been modelled at ground level (0 m above ground) as per the requirements of the DES guideline *Application requirements for activities with impacts to air* (DES, 2019). In addition to the discrete receptors, grids of receptors have been included in the modelling (at a height of 0 m above ground) to facilitate the generation of concentration contours.

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- North Star to NSW/QLD border alignment
- Border to Gowrie alignment
- Existing rail (operational)
- Minor roads
- NSW/QLD border

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
Integrating Community, Environment and Engineering

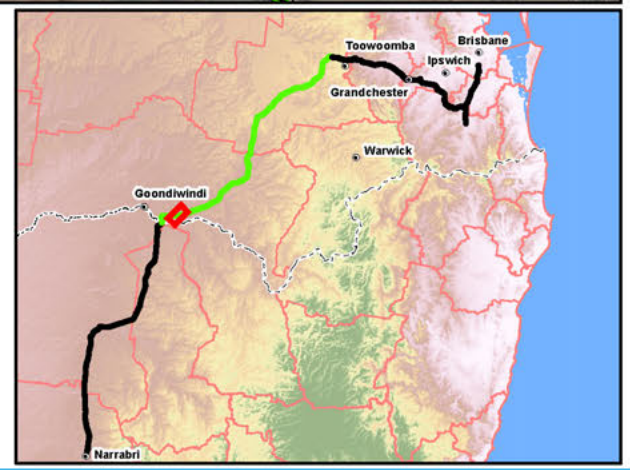
Issue date: 26/05/2020 Version: 1
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15a:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16



Legend

- Sensitive receptors
- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (operational)
- Minor roads
- NSW/QLD border

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
Integrating Community, Environment and Engineering

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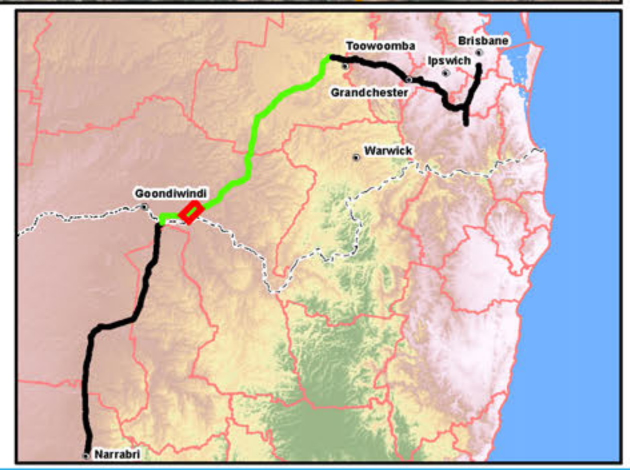
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15b:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16



Legend

- Sensitive receptors
- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads
- NSW/QLD border

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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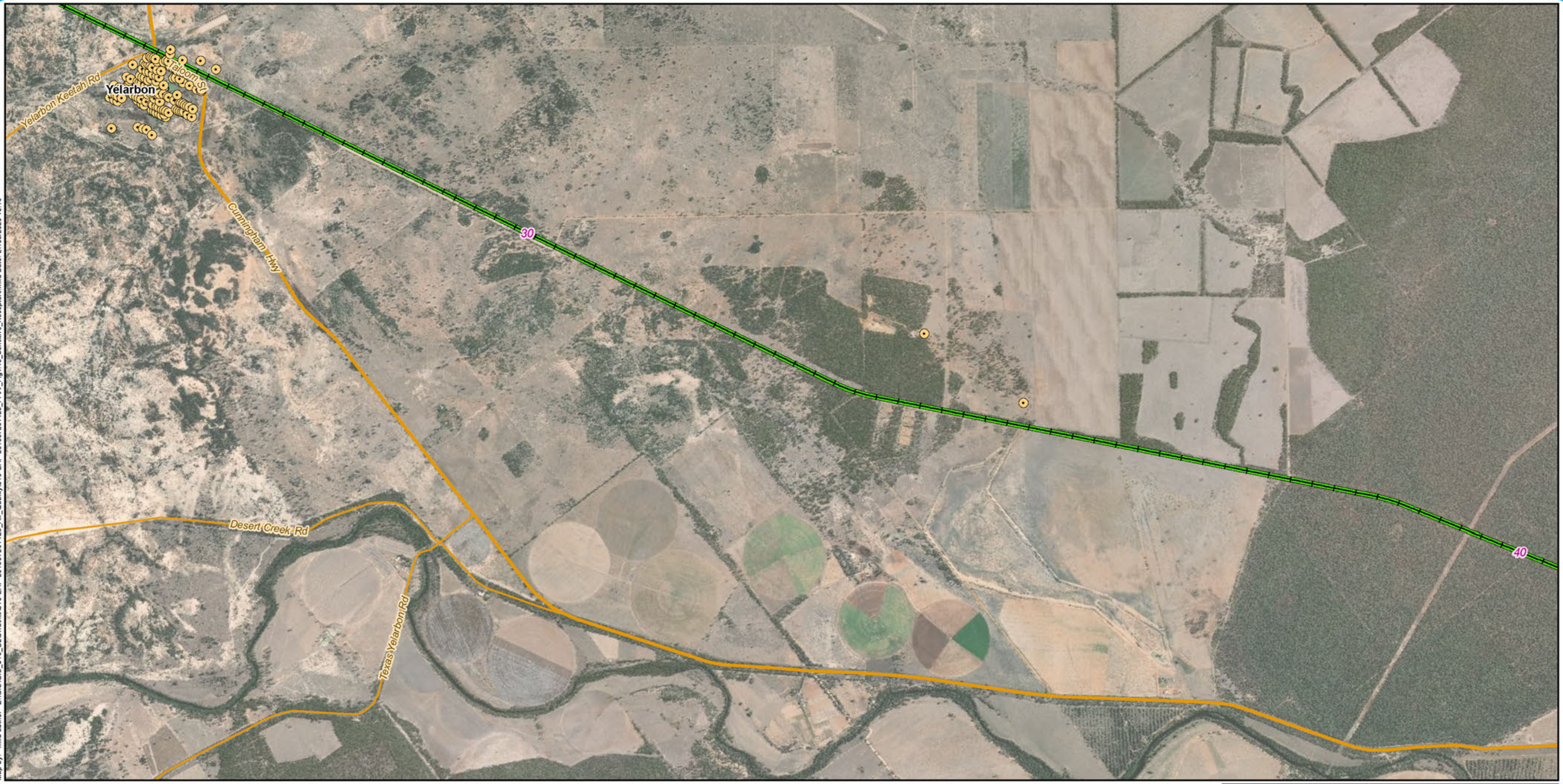
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15c:
Identified sensitive receptor locations

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



Legend

- Sensitive receptors
- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15d: Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
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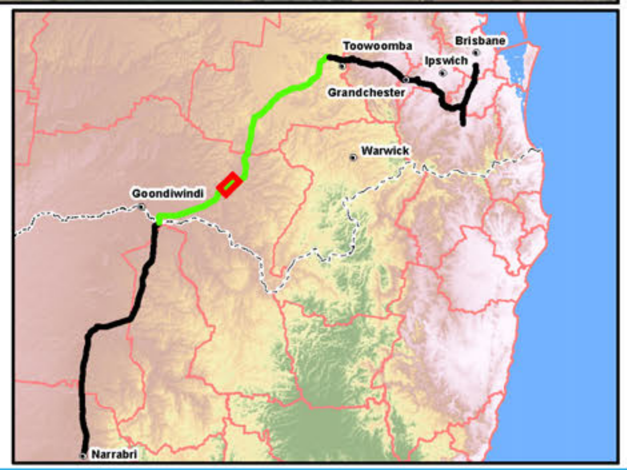
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15e:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16



Legend

- Sensitive receptors
- 5 Chainage (km)
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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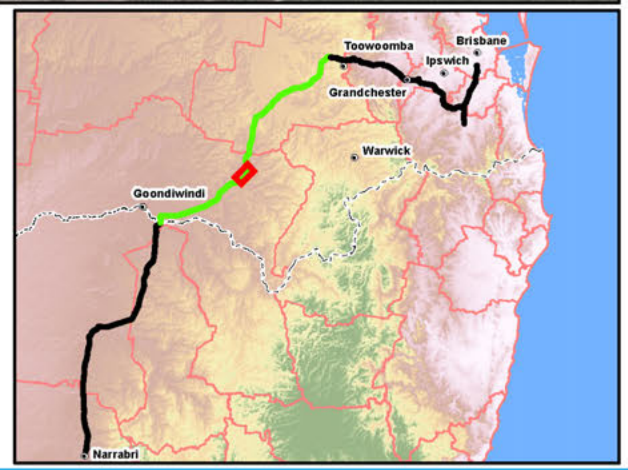
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15f:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16



Legend

- Sensitive receptors
- 5 Chainage (km)
- Border to Gowrie alignment
- Minor roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5km

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Integrating Community, Environment and Engineering

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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

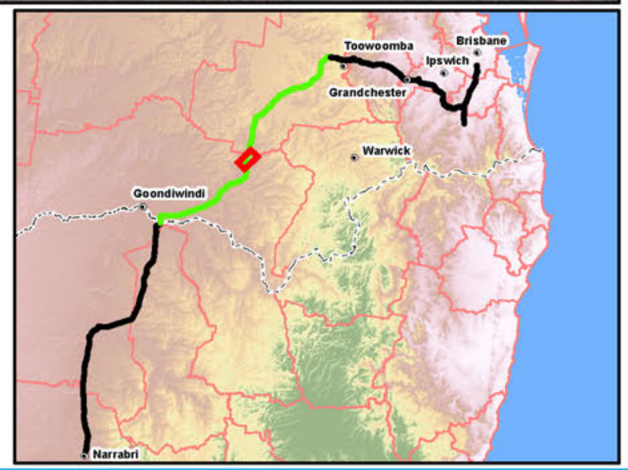
Figure 4.15g:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- Border to Gowrie alignment
- Minor roads



A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 26/05/2020 Version: 1

Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15h:

Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- Border to Gowrie alignment
- Minor roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5km

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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15i:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- Minor roads
- 5 Chainage (km)
- Border to Gowrie alignment

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
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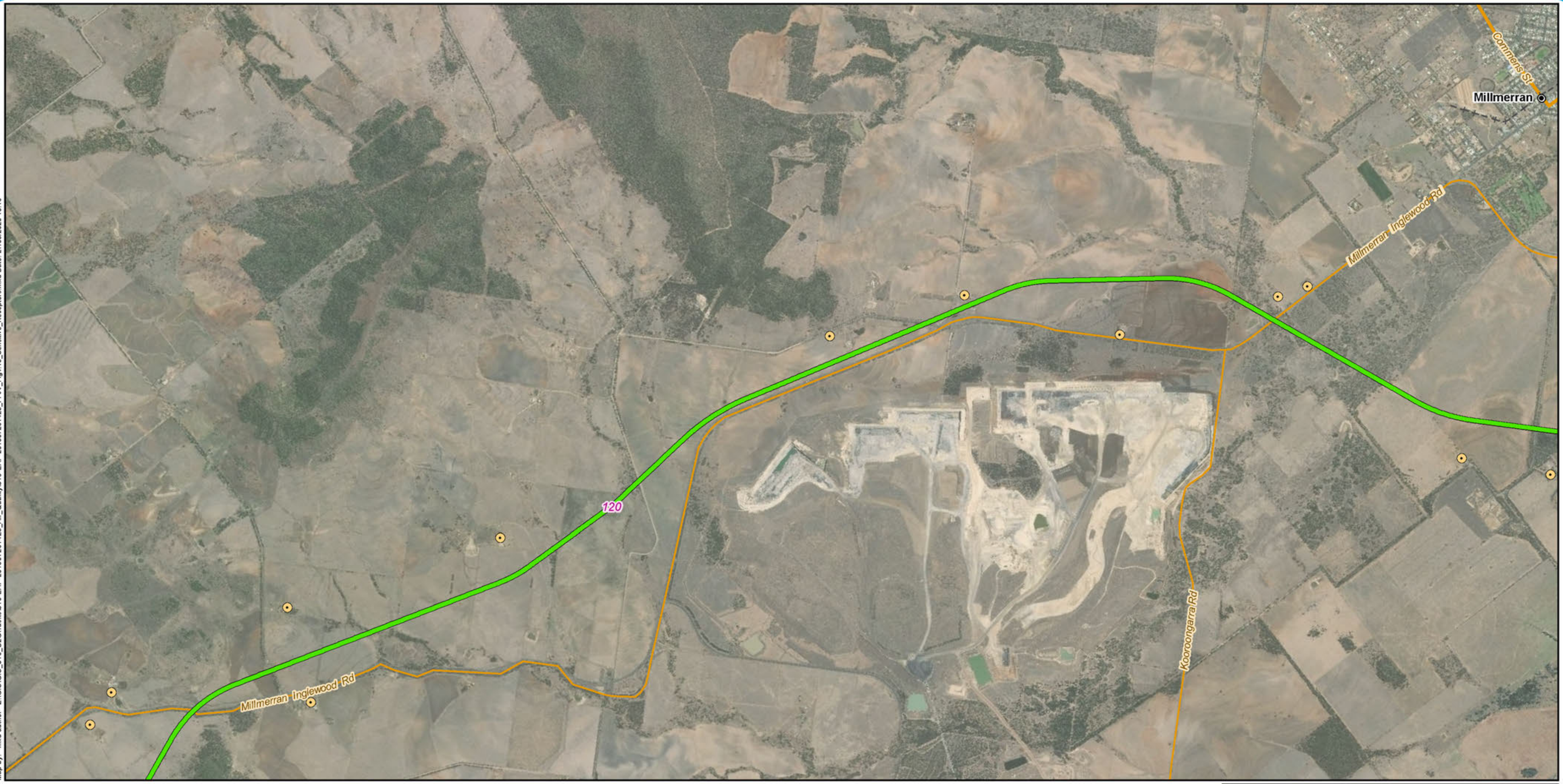
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie
Figure 4.15j:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16



Legend

- Sensitive receptors
- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (non-operational)
- Major roads
- Minor roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie
Figure 4.15k:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (non-operational)
- Major roads
- Minor roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

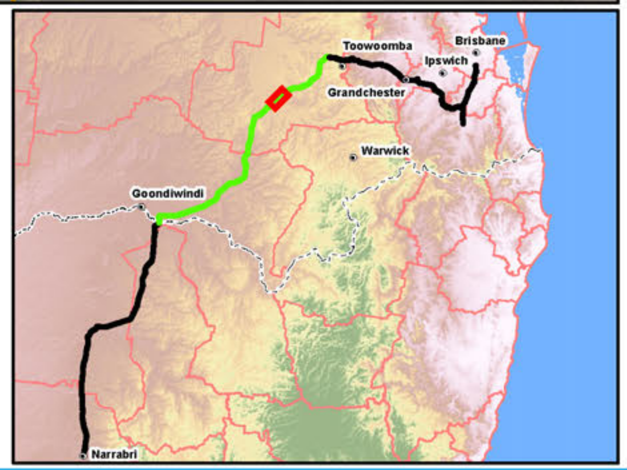
Figure 4.15l:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (operational)
- Existing rail (non-operational)
- Major roads
- Minor roads



A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
Integrating Community, Environment and Engineering

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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie
Figure 4.15m:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
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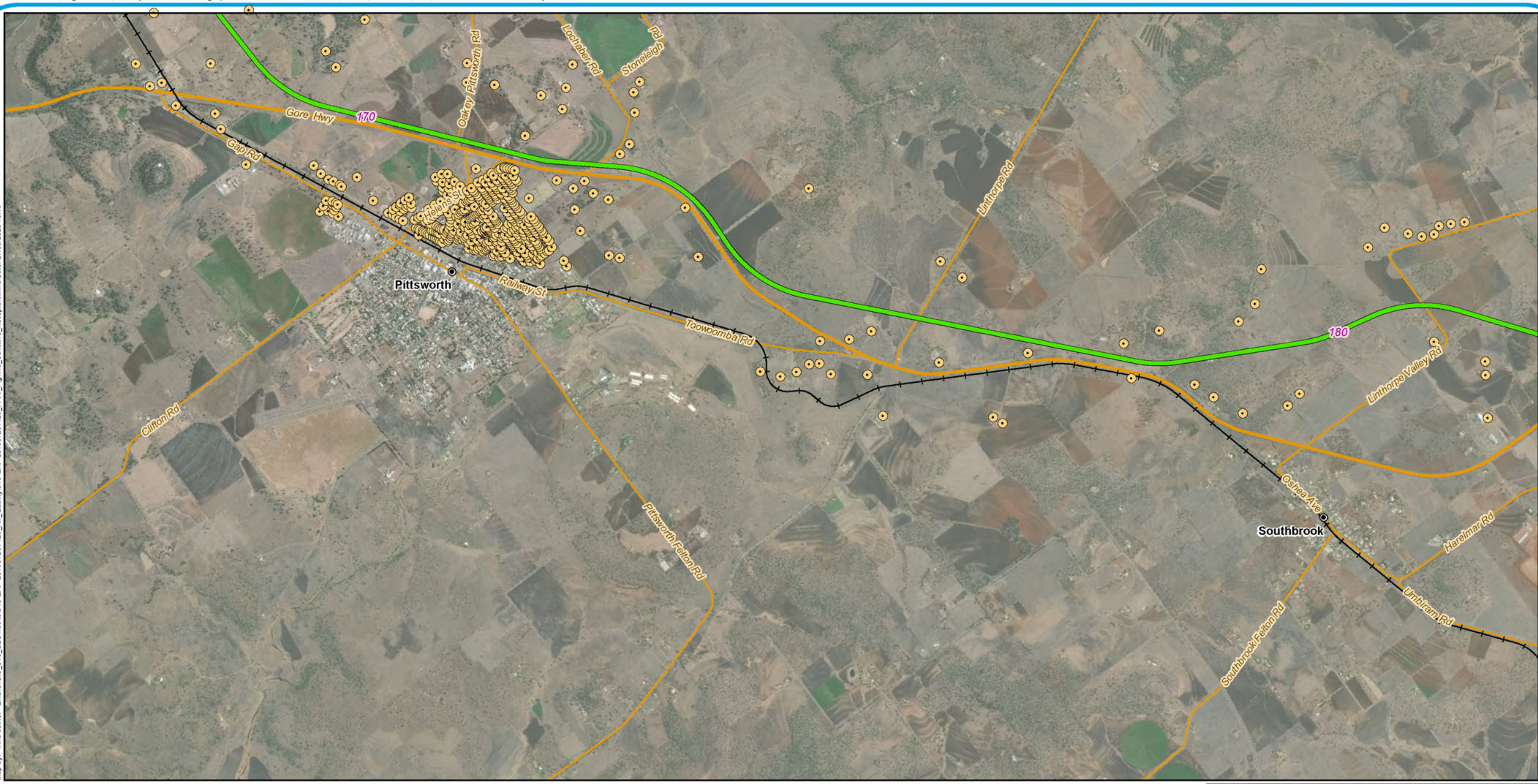
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie
Figure 4.15n:
Identified sensitive receptor locations

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



Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5km

Future Freight
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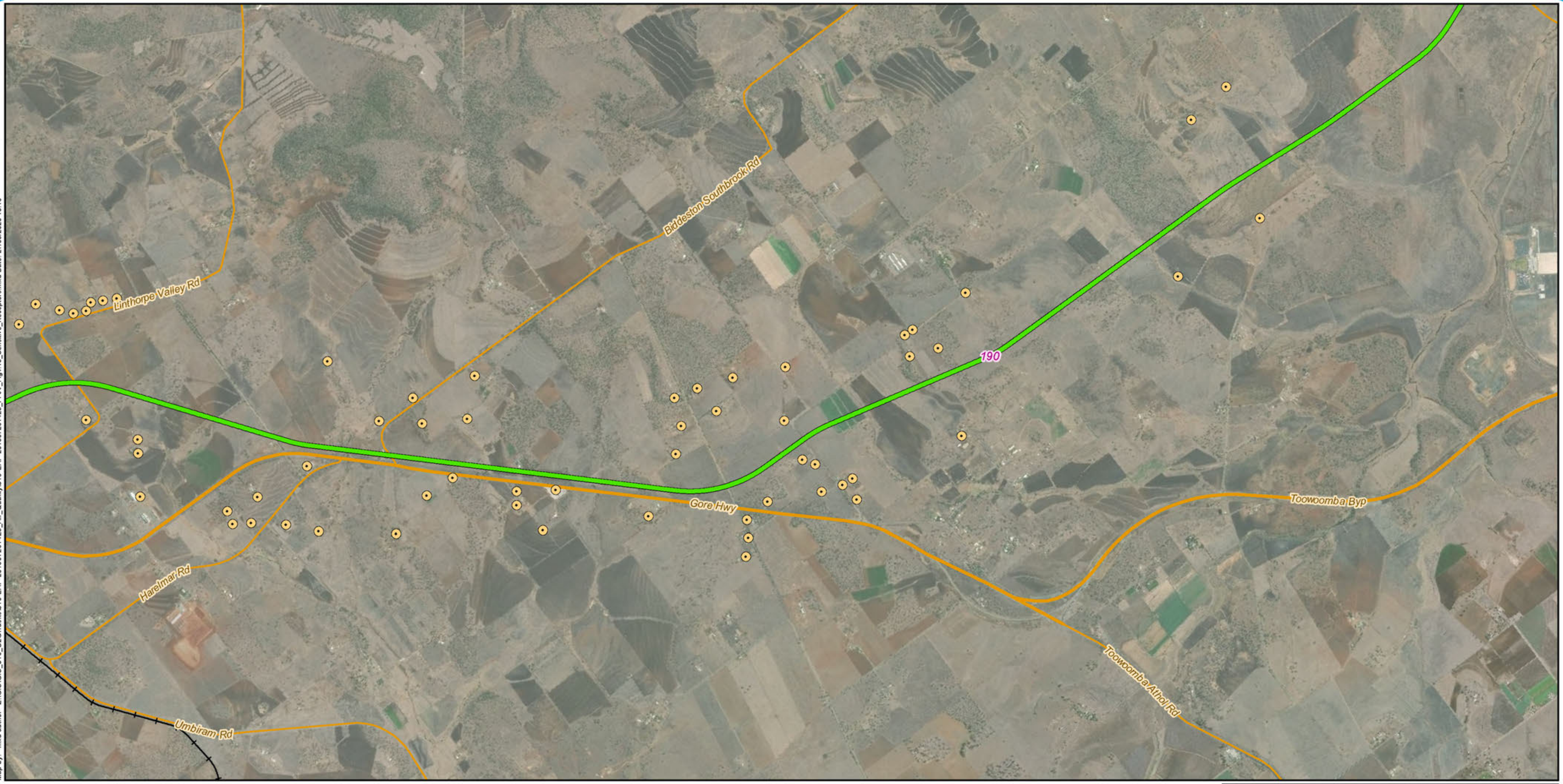
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15o: Identified sensitive receptor locations

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



Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
Integrating Community, Environment and Engineering

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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 4.15p:
Identified sensitive receptor locations

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

Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig4.15_Sensitive_Receptors.mxd Date: 27/05/2020 10:16

Legend

- Sensitive receptors
- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Gowrie to Helidon alignment
- Existing rail (operational)
- Major roads
- Minor roads

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

Future Freight
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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie
Figure 4.15q:
Identified sensitive receptor locations

5 Assessment methodology

The AQIA methodology for the construction and operation of the Project has included the following key elements:

- Qualitative impact assessment of the construction phase
- Primarily quantitative impact assessment of the operation phase, with minor emissions sources assessed qualitatively
- Identification of potential mitigation measures
- Assessment of the residual impact with the inclusion of the identified mitigation measures.

Details of the methodology used to assess air quality impacts during each phase of the Project are described in this section.

5.1 Construction air quality 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, and the transitory nature of many individual construction activities at particular locations. The potential construction air quality impacts associated with the Project were therefore assessed by describing the nature of proposed works, plant and equipment, potential emissions sources and levels. Potential dust impacts on surrounding sensitive receptors were determined through a qualitative risk assessment. Sensitive receptors located within 1km of the alignment were considered in the assessment; this includes the three temporary non-resident workforce accommodation facilities for the Project.

The highest proportion of construction emissions results from 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.

Particulate matter less than 2.5 micrometres in diameter ($PM_{2.5}$) is typically emitted in minor quantities from material movement 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, mobile plant and generators 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 objectives or cause nuisance to sensitive receptors and therefore have not been assessed in detail. However, mitigation measures for these sources have been identified to minimise the potential for impacts on sensitive receptors.

The assessment methodology to be used for the construction air quality impact assessment is the 2014 UK IAQM *Guidance on the assessment of dust from demolition and construction, Version 1.1* (UK IAQM, 2014). The IAQM process is a four-step risk-based assessment of dust emissions associated with demolition, including land clearing and earth moving, and construction activities. The construction assessment steps are 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, and
- Step 4 – reassessment: review the potential for residual impacts post mitigation.

The methodology of the IAQM risk assessment procedure is tailored specifically to the assessment of emissions to air from construction activities. The IAQM risk assessment method considers the sensitivity of the AQIA area to air quality impacts based on separation distance and existing air quality, and the potential risk of adverse impacts based on the emissions magnitude of the construction activities. The IAQM method is considered the most appropriate risk assessment method for the assessment of construction impacts for the Project.

A breakdown of each step and the associated findings of the dust impact assessment are detailed in Section 6.

In addition to construction dust, odour will be emitted from the sewage treatment plants required for non-resident workforce accommodation. The assessment of odour from these facilities has been undertaken following the EPA Victoria guideline *Recommended separation distances for industrial residual air emissions* (EPA Victoria, 2013) which is referenced in the EP Act *Guideline: Application requirements for activities with impacts to air* (DES, 2019) as being applicable for assessments in Queensland. Assessment of sewage treatment plants for non-resident workforce accommodation is presented in Section 6.2.

Odour and VOCs will also be emitted as fugitive emissions from fuel tanks located at laydown areas. Impacts from fuel storage have also been assessed following the EPA Victoria guideline *Recommended separation distances for industrial residual air emissions* (EPA Victoria, 2013), with the assessment presented in Section 6.3.

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

Detailed dispersion modelling of construction is not typically undertaken as construction activities are difficult to forecast accurately and emissions are typically well controlled by standard construction practices. 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.

5.2 Commissioning phase air quality 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 Principal 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 locomotive movements along the railway, 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 Projects air quality objectives and therefore have not been assessed.

5.3 Operation air quality assessment

This section outlines the approach taken for the modelling and assessment of the operational phase of the Project, including:

- Emissions inventory and assessment assumptions, including potential cumulative emission sources
- The dispersion modelling methodology, including:
  - Software packages
  - Meteorological data used

- – Scenarios assessed and model inputs
- – The method applied for the conversion of NOx to NO_2
- – Limitations of the modelling approach
- The method for the assessment of impacts to water tank quality
- The method assessment of agricultural freight odour.

5.3.1 Emissions inventory

An emissions inventory has been developed to quantify the emissions for diesel locomotives that may operate on the Border to Gowrie section of Inland Rail, based on the engine types, rail traffic quantities and locomotive speeds. The key pollutants of interest included in the emissions inventory for diesel locomotives are TSP, PM_{10}, $PM_{2.5}$ and NOx.

5.3.1.1 Diesel locomotive emissions

Emissions factors have been sourced from emissions testing completed on locomotives by the NSW EPA (ABMARC, 2016), as well as rated emission standards published by the US Environmental Protection Agency (US EPA) (US EPA, 2009). The US EPA emission factors are the most accurate source of available emissions data for the locomotives and are considered appropriate for use in the assessment. Table 5.1 presents the referenced emissions factors on a gram's per kilowatt hour basis (g/kWhr).

Table 5.1 Locomotive emissions factors for NOx, total particulates and VOCs (as total hydrocarbons)

Locomotive	NR Class[2]		SCT/LDP[3]	82 Class[4]
	Cycle weighted	Idling		
Locomotive Max Power in kilowatts (kW)	2,917		3,350	2,425
Rated Emission Standard	US EPA – Tier 0	-	US EPA – Tier 1	US EPA – Tier 0
Total Particulates (g/kWhr)	0.101	1.09	0.60	0.8
NO_x (g/kWhr)	16.6	43.7	9.92	12.74
Total Hydrocarbons (THC)[1] (g/kWhr)	0.519	4.66	0.74	1.34
Source	US EPA Emissions Factors for Locomotives (US EPA, 2009)	NSW EPA's Diesel Locomotive Fuel Efficiency & Emissions Testing (ABMARC, 2016) (applicable for NR121 and 93 Class)	US EPA Emissions Factors for Locomotives (US EPA, 2009)	

Table notes:

1 VOCs are a subset of THC. For this assessment 100% of THC emissions are assumed to be VOCs
2 UGL National Rail Class locomotive
3 Downer EDI SCT/LDP Class locomotive
4 Downer EDI 82 Class locomotive

In diesel locomotive operation, engine power is determined by the notch setting, which ranges from notches one through eight (Spiryagin M. , et al., 2016). During normal operation a diesel locomotive will progress through the notch settings to accelerate to the required rail line speeds. The locomotive would then operate at a certain notch setting that is dependent on the power output required to maintain the required rail speed.

The engine power at each notch setting differs greatly, for example, the power rating at notch eight is equivalent to 100 per cent of the maximum locomotive engine power. Whereas, at notch four the engine power would be closer to 35 per cent of maximum locomotive engine power (Spiryagin M. , Wolfs, Szanto, & Cole, 2015). Therefore, it is important to know the power ratings and time speed at each notch setting to provide an accurate estimate of diesel locomotive emissions.

Power ratings for each notch setting for the proposed diesel locomotive engines were not available at the time of the assessment; therefore, a review of literature was completed. The notch setting and percentage of engine power for each setting as obtained via literature review is summarised in Table 5.2.

Table 5.2 Power ratings for locomotive notch settings or operating mode from various sources

Notch setting or operating mode	**Maximum engine power**					
Source	Spiryagin et al. (2016)[1]	Spiryagin et al. (2015)	StarCrest Consulting Group (2008)	Therma-Dynamics Rail LLC (2014)	Kim et al. (2017)	Casadei & Maggioni (2016)
Idle	0.0 per cent	0.0 per cent (0 kW)	0.8 per cent (14 hp)	2.2 per cent (69 hp)	9.1 per cent (216 kW)	**2.3 per cent (74.6 bhp)**
Dynamic Braking	-	-	**3.6 per cent (67 hp)**	0.5 per cent (17 hp)	-	-
Notch 1	1.6 per cent	**4.8 per cent (133 kW)**	4.5 per cent (83 hp)	3.3 per cent (105 hp)	15.7 per cent (370 kW)	-
Notch 2	6.3 per cent	**10.7 per cent (294 kW)**	13.5 per cent (249 hp)	12.5 per cent (395 hp)	24.4 per cent (576 kW)	11.2 per cent (359 bhp)
Notch 3	14.1 per cent	**24.1 per cent (665 kW)**	26.4 per cent (487 hp)	21.7 per cent (686 hp)	34.3 per cent (810 kW)	-
Notch 4	25.0 per cent	**34.3 per cent (945 kW)**	39.9 per cent (735 hp)	32.7 per cent (1034 hp)	46.0 per cent (1086 kw)	33.0 per cent (1057 bhp)
Notch 5	39.1 per cent	**45.4 per cent (1253 kW)**	54.4 per cent (1002 hp)	46.2 per cent (1461 hp)	55.7 per cent (1316 kW)	-
Notch 6	56.3 per cent	**66.0 per cent (1820 kW)**	68.8 per cent (1268 hp)	62.4 per cent (1971 hp)	67.2 per cent (1589 kW)	59.1 per cent (1895 bhp)
Notch 7	76.6 per cent	**87.1 per cent (2400 kW)**	85.2 per cent (1570 hp)	84.2 per cent (2661 hp)	83.9 per cent (1983 kW)	-
Notch 8	100 per cent	**100 per cent (2757 kW)**	100 per cent (1843 hp)	100 per cent (3159 hp)	100 per cent (2363 kW)	100 per cent (3206 bhp)

Table notes:

1 Based upon the calculation method in Maksym et al. (2016) for notch power for diesel engine heavy haul operations - $P_n = (n^2/64) * P_{rated}$; Where P_n is the notch power; P_{rated} is the rated power in notch 8; and n is the discrete notch numbers, which takes a range from zero to eight.

Bold values represent adopted notch setting and operating mode percentages

Spiryagin et al. (2016) provides a calculation method which follows a square-law relationship to estimate engine power at the eight engine notch settings. As an example, the Spiryagin et al. (2016) study uses engine power capabilities referenced from earlier work (Spiryagin et al., 2015) to estimate engine power. The Spiryagin et al. (2016) calculation method provides a procedure to estimate notch engine power in lieu of actual measured data. However, the calculated notch engine power is lower than all other referenced sources as shown Table 5.2

Notch power ratings cited by Kim et al. (2017) are greater than all other sources, especially for idling which is 9.1 per cent of maximum rated power, 3.9 times higher than the next highest idling power usage. However, the Kim et al. (2017) study investigated locomotives specific to Korea, and in combination with the relative high-power rating locomotives assessed, the results of this study were not considered suitable for the calculation of duty cycle power ratings for the Project.

Power ratings presented by Therma-Dynamics Rail LLC (2014) were lower than most sources at almost all notch settings.

The notch engine power values from Spiryagin et al. (2015) are higher than all other sources at notch seven and comparable at all other notches. The notch power ratings presented were for a line haul diesel locomotive with a total maximum power of 2,757 kW, which is similar to the engine power of the locomotives proposed for the Project. Due to the similarity in locomotive engine power, notch settings from Spiryagin et al. (2015) were used in calculating duty cycle power ratings for the Project for train travel.

For the literature reviewed, engine idling power ranged from zero per cent (Spiryagin M. , Wolfs, Szanto, & Cole, 2015) to 9.1 per cent (Kim, Lee, Rhee, & Chun, 2017). Cassadei and Maggioni (2016) presented the second highest idling power usage at 2.3 per cent of maximum engine power which was considered appropriate for adoption for the assessment as it was based on engine testing of diesel locomotives.

Limited information was available from literature with respect to engine power during dynamic braking. From the information available, the higher engine power percentage of 3.6 per cent (StarCrest Consulting Group, 2008) was adopted for duty cycle calculations.

Table 5.3 summarises the adopted notch setting, and operating mode percentages of maximum engine power utilised to calculate average duty cycle power ratings.

Table 5.3 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	

In terms of time spent at each engine notch setting or operating mode data from US rail operation was used to provide a basis for average duty cycle power ratings. Table 5.4 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 is representative of analysis from 63 line-haul trains and 2,475 operational hours.

Table 5.4 Duty-cycles for line haul locomotives in the US (percentage time in notch)

Notch Setting/Operating Mode	Percentage of time for 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 Setting/Operating Mode	Percentage of time for line haul (per cent)
Notch 5	3.8
Notch 6	3.9
Notch 7	3.0
Notch 8	16.2

Average hourly (duty cycle) power consumption rates have been calculated for each locomotive type using the adopted notch power ratings and duty cycle information presented in Table 5.3 and Table 5.4. The calculated average hourly power consumption rates in addition to the maximum and idling power consumption rates for each locomotive are presented in Table 5.5.

Table 5.5 Locomotive power usage

Power	NR Class[1]	SCT/LDP[2]	Class 82[3]
Maximum power (kWhr)	2,917	3,350	2,425
Calculated average duty cycle (kWhr)	823	945	684
Idle (kWhr)	68	78	56

Table notes:

1 UGL National Rail Class locomotive
2 Downer EDI SCT/LDP Class locomotive
3 Downer EDI 82 Class locomotive

Pollutant diesel combustion emission rates were then calculated utilising the following parameters:

- A peak weekly total of 174 trains (as per Table 2.4)
- Locomotive type and configuration (as per Table 2.4)
- Total locomotive journey time consists of:
  - Moving 75 per cent of the time
  - Stationary and idling in crossing loops 25 per cent of the time (an assumption utilised for the operational modelling for the full length of the Inland Rail Program).

Table 5.6 presents the maximum anticipated travel speeds along the Project. Average line speeds were estimated to be 75 per cent of the maximum line speeds for the Project.

Table 5.6 Locomotive travel speeds

Power	Direction of travel	NR Class	SCT/LDP	Class 82
Maximum line speed (km/hr)	North	115	115	80
	South	115	115	80
Average line speed (km/hr)	North	86	86	60
	South	86	86	60

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

$$P_{total} = \sum^{loco} (P_{loco} \times d \times v_{loco} \times n_{loco})$$

Where:

- P_{total} is the total locomotive calculated power per hour for entire alignment (kWhr)
- P_{loco} is the calculated average duty cycle power for each locomotive type (kWhr)
- d is the rail track length of the Project alignment (km)
- v_{loco} is the average line speed of each locomotive type (km/hr)

- n_{loco} is the total number of locomotives of each train type.

The following equation calculates the pollutant emissions from locomotive traffic along the entire Project alignment.

$$ER_{pollutant} = \frac{EF_{pollutant} \times P_{total}}{d}$$

Where:

- $ER_{pollutant}$ is the calculated pollutant emission rate for NO_x, TSP, PM_{10}, $PM_{2.5}$ and Total VOC's (as THC) (g/m/s)
- $EF_{pollutant}$ is the pollutant emission factor as per Table 5.1 (g/kWhr)
- P_{total} is the total locomotive calculated power per hour for entire alignment (kWhr)
- d is the rail track length of the Project alignment (m).

The following equation represents the calculation method to determine 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 NO_x, TSP, PM_{10}, $PM_{2.5}$ and total VOC's (as THC) (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 calculated power per hour for the entire Project alignment from idling (kWhr)
- $EF_{pollutant}$ is the pollutant emission factor as per Table 5.1 (g/kWhr).

To determine continuous idling emissions, it was assumed that NR class locomotives would idle for periods up to or greater than one hour depending on the scenario modelled. The idling emission rates were therefore derived from the hourly idling locomotive power usage presented in Table 5.5, and the locomotive emission factors presented in Table 5.1. The methodology for the assessment of crossing loops is described further in Section 5.3.2.4.

The derived pollutant locomotive diesel emission rates for typical and peak train movements are presented in Table 5.7. Air emissions as a result of the operation of the Project are directly related to the number of trains, therefore a lower number of trains will result in a lower rate of pollutant emissions to air. Table 5.7 shows that total Project emissions for typical train movements are lower than the total Project emissions for peak train movements. This AQIA has assessed emissions for peak train movements only, as emission rates for peak train movements are higher and therefore the risk of impacts is also higher for this scenario.

Table 5.7 also presents the emission rates for locomotives idling at crossing loops, with the presented emission rates representing the cumulative emissions from the five proposed crossing loops. The methodology for the assessment of emissions from the crossing loops is explained in Section 5.3.2.4. Differences in train movements (e.g. typical or peak) do not influence the methodology used to assess emissions from the crossing loops.

Table 5.7 Derived pollutant diesel combustion emission rates

Pollutant	Total Project emissions for typical movements (g/m/s)	Total Project emissions for peak movements (g/m/s)	Short term average idling emissions (g/s) (per locomotive)[1]	Long term average idling emissions (g/s) (per locomotive)[2]
NO_x	6.91×10^{-5}	8.88×10^{-5}	0.824	0.2060
TSP	4.30×10^{-6}	5.52×10^{-6}	0.021	0.0051
PM_{10}	4.19×10^{-6}	5.38×10^{-6}	0.020	0.0050
$PM_{2.5}$	4.03×10^{-6}	5.17×10^{-6}	0.019	0.0048
Total VOCs	6.68×10^{-6}	1.01×10^{-5}	0.088	0.0220

Table notes:

1 Short-term (1 hour average): continuous idling of NR Class locomotives assumed throughout the year (refer Section 5.3.2.4)

2 Long-term (24 hour and annual averages): idling assumed to occur 25 per cent of the travel time, e.g. 15 minutes per hour or 6 hours per day (refer Section 5.3.2.4)

Table 5.8 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	(DEWHA, 2008)
$PM_{2.5}$	3.39	Kg/kL	93.7	(DEWHA, 2008)
Cadmium	0.01	g/tonne of fuel	0.0007	(EMEP/EEA, 2016a)
Chromium	0.05	g/tonne of fuel	0.0033	(EMEP/EEA, 2016a)
Copper	1.7	g/tonne of fuel	0.1118	(EMEP/EEA, 2016a)
Nickel	0.07	g/tonne of fuel	0.0046	(EMEP/EEA, 2016a)
Selenium	0.01	g/tonne of fuel	0.0007	(EMEP/EEA, 2016a)
Zinc	0.03	g/tonne of fuel	0.0658	(EMEP/EEA, 2016a)
Lead	0.0005	mg/kg of fuel	0.00003	(EMEP/EEA, 2016b)
Arsenic	0.0001	mg/kg of fuel	0.00001	(EMEP/EEA, 2016b)
SO_2	0.0167	kg/kL	0.046	(DEWHA, 2008)
Total hydrocarbons				
Non-methane VOCs	4.65	kg/tonne of fuel	100	(EMEP/EEA 2016a)
Benzo(a)pyrene	0.03	g/tonne of fuel	0.0006	(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)
Polychlorinated dioxins and furans (TEQ)	8.35×10^{-11}	kg/kL	-	(DEWHA, 2008)

5.3.1.2 Cumulative impacts and modelled cumulative sources

The AQIA of the Project requires assessment of the background air quality in addition to the cumulative impact of emissions from the Project in combination with emissions from existing and future sources (which will be operational at the same time as the Project).

The Commodore Mine and Millmerran Power Station are existing emission sources in the AQIA area (refer Section 4.3) and have been included in the modelling as emissions from these facilities are unlikely to be adequately represented in background air quality monitoring. To include these emissions in the dispersion modelling, NPI emissions data for each of the sources has been reviewed.

Table 5.9 provides a summary of the reported emissions for the Commodore Mine and Millmerran Power Station for the reporting years of 2012/2013 to 2018/2019, which are the most recent available years.

It is widely understood that the emissions estimation techniques for mining activities presented in the NPI guidance documents have significant uncertainty when compared with actual dust emissions. Several studies have sought to reduce the uncertainty in emissions estimates of PM_{10} and $PM_{2.5}$ by developing new emissions factors for mining activities in Australia (Roddis *et al* 2015; Laing *et al* 2015; Roddis *et al* 2013; Richardson, Putland & Verran 2015; Richardson 2013). However, these developed emissions factors have not been adopted by the NPI, and instead reference estimation techniques developed by the US EPA for US coal mines (US EPA, 1998), which generally yield over estimations of emissions from Australian coal mines.

Table 5.9 shows that there is significant variation in reported emissions for both the Commodore Mine and Millmerran Power Station. There is limited information available from the NPI website to explain the variations in reported yearly emissions for each source. Furthermore, it is noted that the Commodore Mine is the sole source of thermal coal for the Millmerran Power Station, and therefore it could be expected that emission values between the sources would correlate.

Table 5.9 Reported NPI emissions for Commodore Mine and Millmerran Power Station

Facility	Reporting Year	PM_{10} (kg)	$PM_{2.5}$ (kg)	NO_x (kg)
Commodore Mine	2018/2019	880,000	71,000	1,100,000
	2017/2018	720,000	59,000	910,000
	2016/2017	**605,023**	**53,656**	**820,240**
	2015/2016	668,215	21,709	309,773
	2014/2015	668,389	21,812	313,853
	2013/2014	337,005	1,228	242,784
	2012/2013	277,999	1,101	241,433
Millmerran Power Station	2018/2019	170,000	42,000	9,400,000
	2017/2018	100,000	25,000	9,000,000
	2016/2017	**91,520**[1]	**11,441**[2]	**8,891,295**
	2015/2016	183,830	91,570	9,491,277
	2014/2015	54,159	50	12,614,517
	2013/2014	80,200	37,900	14,500,000
	2012/2013	90,566	33,000	18,130,000

Table notes:

1 Originally reported as 91,520 kg when first published, but altered on the NPI website to 55,000 kg in March 2020. The original reported value of 91,520 kg was used in the assessment.

2 Originally reported as 11,441 kg when first published, but altered on the NPI website to 15,000 kg in March 2020. The original reported value of 11,441 kg was used in the assessment.

As an initial investigation into emissions from the Commodore Mine and Millmerran Power Station, preliminary modelling was undertaken using the reported 2016/2017 emission values. Modelled emission rates were calculated by averaging total emissions evenly across the year. Table 5.10 presents the modelled emission rates for Commodore Mine and Millmerran Power Station based upon the 2016/2017 reported NPI emissions for each pollutant.

Table 5.10 NPI emissions for Commodore Mine and Millmerran Power Station

Cumulative Source	Emissions	PM_{10}	$PM_{2.5}$	NO_x
Commodore Mine	NPI reported emissions (kg/annum)	605,023	53,656	820,240
	Total model emission rate (g/s)	19.2	1.7	26.0
Millmerran Power Station	NPI reported emissions (kg/annum)	91,520	11,441	8,891,295
	Total model emission rate (g/s)	2.9	0.4	281.9

With the emission rates presented in Table 5.10 and considering the adopted background concentrations (refer Table 4.13), exceedances of the 24-hour PM_{10} air quality goal were predicted at the nearest neighbouring receptor of the Commodore Mine, sensitive receptor 186, which is located approximately 1.1 km to the north of the mine on Millmerran Inglewood Road. At sensitive receptor 186, the predicted maximum PM_{10} 24-hour concentration was in excess of 70 µg/m^3.

Reviewing the results of the modelling it was determined that the predominant contributor at receptor 186 was the Commodore Mine, with minimal contribution from the Millmerran Power Station. This result is expected due to the emission release height of the respective sources, with emissions from the mine released at or close to ground level, and emissions from the power station released from 200 m high exhaust stacks.

Commodore Mine and Millmerran Power Station operate under EA permits, which state that they must take all reasonable and feasible avoidance measures so that particulate matter emissions generated do not exceed the following levels:

- Deposited dust: 120 mg/m^2/day averaged over one month (no allowable exceedances per year)
- PM_{10}: 50 µg/m^3 over a 24 hour averaging time (no allowable exceedances per year).

As it is part of their continual operating commitments, it is reasonable to assume that these sites are not exceeding these limits and that the modelled exceedance for PM_{10} is a result of the uncertainties in the NPI emissions estimation techniques.

Therefore, to provide a more accurate estimation of the current local air quality adjacent to the Commodore Mine, modelled particulate emissions from the mine (PM_{10} and $PM_{2.5}$ only) have been scaled so that compliance is predicted at its closest and most affected neighbouring sensitive receptor (sensitive receptor 186). The scaled PM_{10} and $PM_{2.5}$ particulate emission rates for the mine have been used when assessing the cumulative impact of the Project. Emissions of NO_x from the mine and emissions from the Millmerran Power Station have not been scaled.

NPI reported emissions of NO_x (refer Table 5.9) for Commodore Mine for 2016/2017 are higher than average for the most recent seven years of reporting and therefore have not been scaled down for the assessment.

As the operation of the mine and power station are related, reported emissions for the 2016/2017 reporting period (consistent with the year used for Commodore Mine) have been used to assess the contribution from the Millmerran Power Station. Due to the release height of the emission source modelled (200 m tall stacks), emissions from the power station have limited impact at ground level and emissions have not been scaled from those presented in Table 5.9.

In addition to the Commodore Mine and Millmerran Power Station the following proposed cumulative sources have been included in the dispersion modelling:

- North Star to NSW/QLD Border Project (Inland Rail)
- Gowrie to Helidon Project (Inland Rail)
- West Moreton System (existing rail line west of the junction between this Project and the Gowrie to Helidon section of Inland Rail).

One kilometre of the North Star to NSW/QLD Border Project and Gowrie to Helidon Project rail sources, and 3.5 km for the West Moreton System have been included in the dispersion modelling at their respective ends of the Project to ensure that their cumulative air quality impacts are assessed. The emission rates utilised for modelling were calculated based on predicted train numbers, locomotive type and freight type for each section. Modelled emission rates are presented in Table 5.11. Emission calculation details for these background rail sources are provided in Appendix C.

Table 5.11 Modelled emission rates for background rail sources

Pollutant	Modelled Emission Rate (g/m/s)		
	Gowrie to Helidon Project	West Moreton System	North Star to NSW/QLD Border Project
NO_x	1.84×10^{-4}	7.78×10^{-5}	8.88×10^{-5}
TSP	5.83×10^{-5}	5.17×10^{-5}	5.52×10^{-6}
PM_{10}	3.37×10^{-5}	2.72×10^{-5}	5.38×10^{-6}
$PM_{2.5}$	1.26×10^{-5}	6.38×10^{-6}	5.17×10^{-6}
TVOC	2.81×10^{-5}	1.62×10^{-5}	1.01×10^{-5}

In addition to the NPI sources (Commodore Mine and Millmerran Power Station) and the adjoining rail lines, other local emission sources will include ERAs, local commercial and industrial uses and vehicle traffic. Local commercial uses near the Project will include the InterLinkSQ and Asterion Medicinal Cannabis Facility projects, which are approved but not currently operational. The operations of the InterLinkSQ and Asterion Medicinal Cannabis Facility projects are not anticipated to generate significant emissions and do not require detailed assessment.

It is expected that emissions from ERAs, local commercial and industrial uses and vehicle traffic will be adequately represented by the assumed background concentrations, and these activities emit significantly lower quantities of pollutants than the major polluters that report to the NPI.

5.3.2 Modelling methodology

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 model CALPUFF.

The data that was available for this Project and a discussion of the data processing methodologies that were required in order to implement CALPUFF are discussed in the following sections. The CALPUFF model is briefly described in the following sections with further details provided in Appendix D. The modelling was undertaken in accordance with:

- Approved methods for the modelling and assessment of air pollutants in NSW (NSW EPA, 2016)
- Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for Modelling and Assessment in New South Wales (NSW OEH, 2011)
- CALPUFF View User Manual (Lakes Environmental, 2017).

Figure 5.1 presents the modelling methodology undertaken for air quality impact assessment.

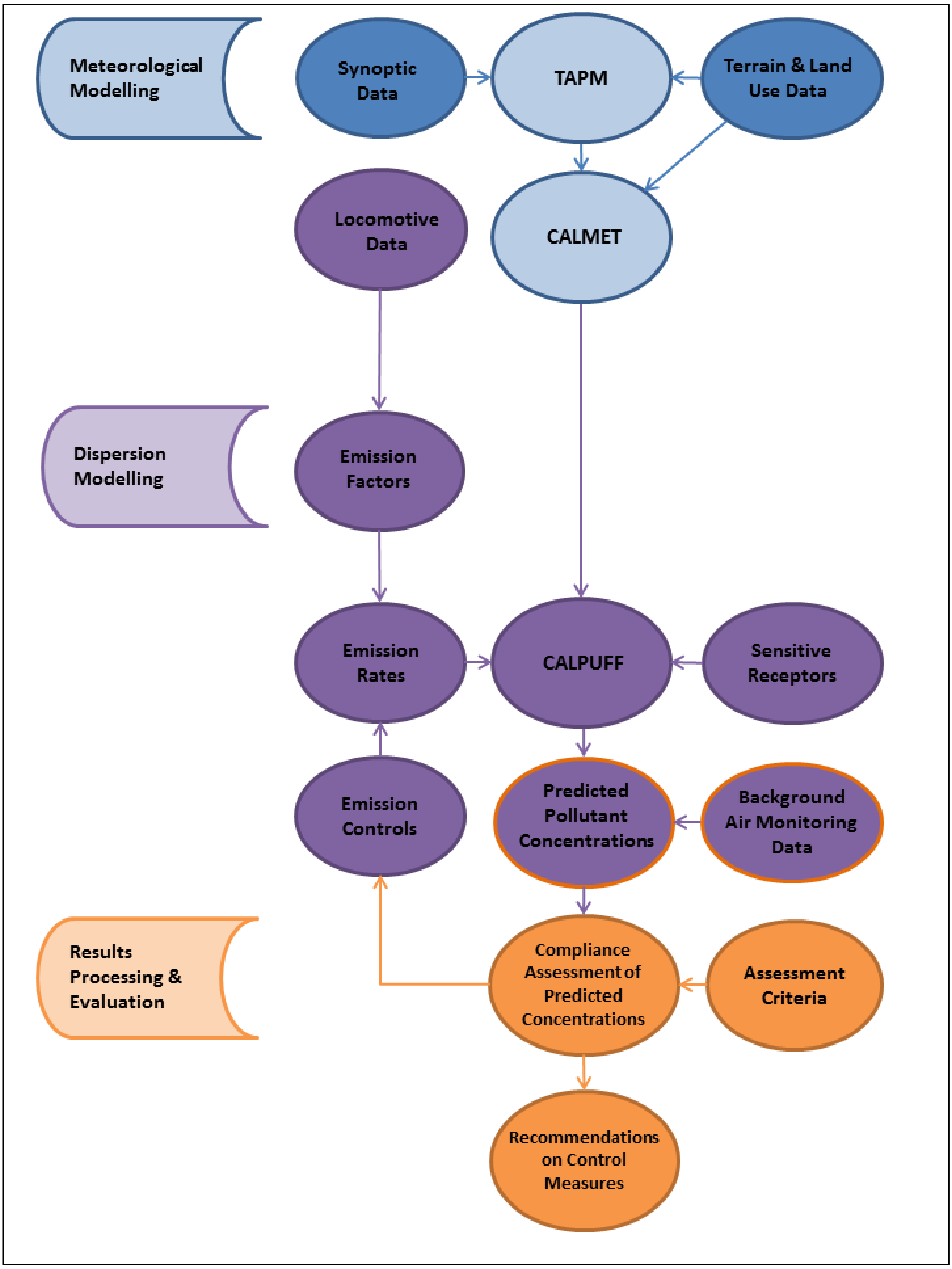


Figure 5.1 **Diagrammatic representation of the CALPUFF modelling methodology**

5.3.2.1 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, 2019f) reference is made to the guidance document *Approved methods and guidance for the modelling and assessment of air pollutants in NSW* (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 (NSW OEH, 2011). As many of these features are present in the AQIA area, the CALPUFF model is preferred over the more commonly used Gaussian models of AERMOD or AUSPLUME, which perform poorly in the aforementioned conditions.

5.3.2.2 Meteorological data

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

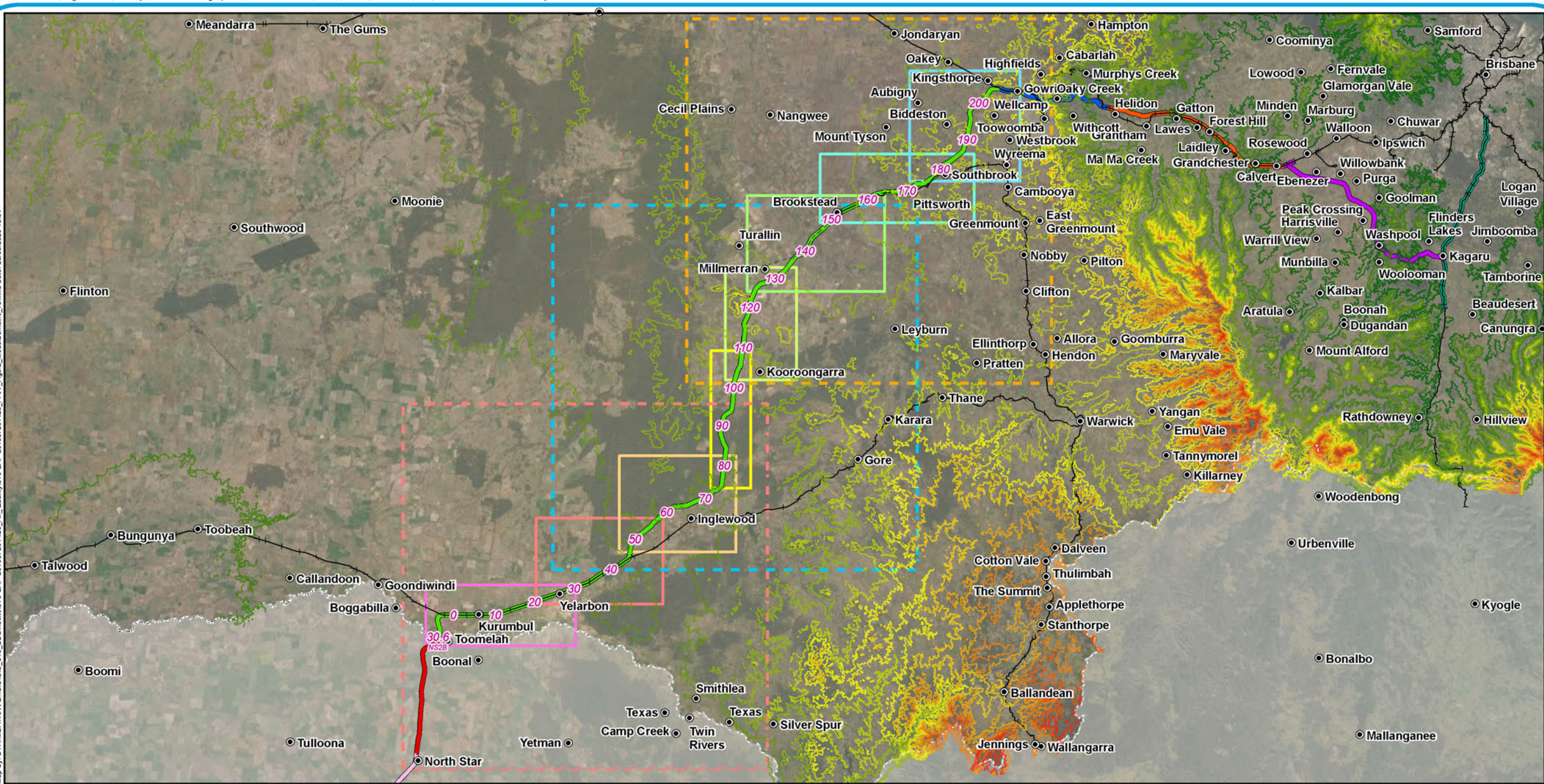
- Wind direction, which determines the initial direction of transport of pollutants from their sources.
- Wind speed, which dilutes the plume in the direction of transport and determines the travel time from source to receiver.
- Atmospheric turbulence, which indicates the dispersive ability of the atmosphere.

Prognostic meteorological data generated by TAPM for the year 2013 were used in this assessment. Further information regarding meteorological data is presented in Appendix A.

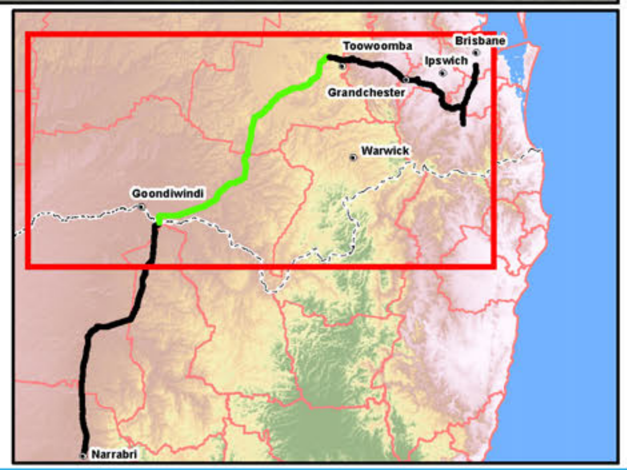
5.3.2.3 Modelling domains

Due to the length of the Project, several modelling domains were utilised as part of the assessment. Figure 5.2 presents the meteorological domains for CALMET, as well as the eight CALPUFF dispersion domains for the Project.

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



Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig5-2_ModelDomains_v3.mxd Date: 28/05/2020 13:34



Legend

- 5 Chainage (km)
- Localities
- Narrabri to North Star alignment
- North Star to NSW/QLD border alignment
- Border to Gowrie alignment
- Gowrie to Helidon alignment
- Helidon to Calvert alignment
- Calvert to Kagaru alignment
- Kagaru to Acacia Ridge/Bromelton alignment
- Existing rail (operational)
- Existing rail (non-operational)
- NSW/QLD border
- CALMET domain 1
- CALMET domain 2
- CALMET domain 3
- Computational Grid 1
- Computational Grid 2
- Computational Grid 3
- Computational Grid 4
- Computational Grid 5
- Computational Grid 6
- Computational Grid 7
- Computational Grid 8

Elevation (m)

- 100
- 200
- 300
- 400
- 500
- 600
- 700
- 800
- 900
- 1000
- 1100

A3 scale: 1:1,000,000

0 7.5 15 22.5 30 37.5 km

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Border to Gowrie

Figure 5.2:
Meteorological and dispersion model domains

5.3.2.4 Crossing loops

Crossing loops are places on a single line track where trains in opposing directions can pass each other. These are double ended and connected to the main track at both ends. Crossing loops are typically a little longer than any of the trains that might need to cross at that point. In operation, one train enters a crossing loop through one of the turnouts and idles at the other end, while the opposing train continues along the mainline track to pass the now stationary train.

The Project includes five new crossing loops. The proposed locations for the crossing loops are:

- Yelarbon – Ch 16.3 km to Ch 18.5 km (future-proofed to Ch 20.3 km to accommodate 3,600 m trains)
- Inglewood – Ch 50.2 km to Ch 52.4 km (future-proofed to Ch 54.2 km to accommodate 3,600 m trains)
- Kooroongarra – Ch 89.2 km to Ch 91.4 km (future-proofed to Ch 93.2 km to accommodate 3,600 m trains)
- Yandilla – Ch 129.8 km to Ch 132.0 km (future-proofed to Ch 129.3 km and to Ch 133.3 km to accommodate 3,600 m trains)
- Broxburn – Ch 174.9 km to Ch 177.1 km (future-proofed to Ch 178.9 km to accommodate 3,600 m trains).

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

- Emissions have been modelled from locomotives idling on the crossing loops. Travel around the crossing loops has not been modelled
- Locomotives have been modelled at each end of each crossing loop as three point sources, resulting in six emission source points per loop
- 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 (1 hour average): continuous idling of NR Class locomotives assumed throughout the year
  - Long term (24 hour and annual averages): idling assumed to occur 25 per cent of the travel time, e.g. 15 minutes per hour or 6 hours per day
- For the short-term version, the six point sources represent two Express trains with six NR Class locomotives. The long-term version represents emissions from a calculated composite emission of all trains travelling along the alignment
- No split of idling time has been assumed for each end of the loop to allow for the assessment of a worst-case idling for both the eastbound and westbound travel directions
- 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 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 5.5.

5.3.2.5 Modelling scenarios

Peak train volumes have been considered in the assessment. Modelling of emissions from train travel along the Project alignment has been undertaken assuming an even volume of train travel per day, e.g. daily train volumes and train emissions from travel along the alignment have been modelled based on the weekly train volumes divided by seven.

Two different versions (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 objectives (refer Section 3.6). The modelled scenarios and crossing loop versions assessed are summarised in Table 5.12.

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

Table 5.12 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

5.3.2.6 Consideration of climate change influence on meteorological modelling data

The meteorological modelling undertaken for the AQIA 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 AQIA 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 *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (NSW EPA, 2017) (which is the referred to guidance for air quality modelling in the EP Act – *Guideline: Application requirements for activities with impacts to air* and is therefore applicable for assessments in Queensland) the site-representative meteorological data is to be based on long term historical meteorological data (e.g. as discussed in Section 4.1) therefore the potential influence of future changing climatic conditions due to climate change has not been considered in this assessment.

5.3.2.7 Model input parameters

A summary of the data and parameters used as input parameters for dispersion modelling completed is shown in Table 5.13.

Table 5.13 Model input parameters

Parameter	Input
TAPM (v4.0.4)	
Horizontal resolution	41 x 41 grid points; outer grid spacing 30,000 m x 30,000 m with an inner grid spacing's of 10,000 and 3,000 metres.
Grid centre coordinates	286,418m E, 6,838,999m S (Domain 1) 322,403m E, 6,886,706m S (Domain 2) 354,609m E, 6,931,466m S (Domain 3)
Vertical levels	25
Land use data	Default TAPM database
Simulation length	1 January – 31 December 2013
CALMET (v6.42)	
Meteorological grid domain	87.5 km x 87.5 km
Meteorological grid resolution	500 metre resolution (175 x 175 grid cells)

Parameter	Input
Reference grid coordinate (SW corner)	242,668m E, 6,795,249m S 278,653m E, 6,842,956m S 310,8590m E, 6,887,716m S
Cell face heights in vertical grid	0, 20, 40, 80, 160, 320, 640, 1200, 2000, 3000 and 4000 m
Simulation length	1 January – 31 December 2013
Surface and upper metrological data	3D.dat from TAPM
Terrain data	SRTM Version 3.0 Global meshed with proposal design DEM (1 arc second)
Land use data	ABARES (2016)
TERRAD (Terrain radius of influence)	10.0 km
CALPUFF (v7.2.1)	
Computational grid	A unique computational grid was used for each modelled source (refer Table 5.14 for list of sources). The grid were sized to fit each source with an appropriately sized (2-4km) buffer.
Number of sensitive receptors	906
Dispersion option	Dispersion coefficient. use turbulence computed from micrometeorology
Dispersion modelling period	1 January 2013 – 31 December 2013

5.3.3 Source parameters

Table 5.14 presents the CALPUFF source parameters utilised in the dispersion modelling of the Project. Utilising guidance from US EPA (1992), the rail emission sources for diesel emissions were modelled as line sources approximated by separated volumes sources. Using this method, it is possible to emulate the effects of initial dispersion due to plume downwash (CARB, 2004).

The idling point sources represent express freight trains that consist of three stationary NR Class locomotives. The locomotive exit temperatures were sourced from locomotive emissions testing for the NSW EPA completed by (ABMARC, 2016). Other cited emission parameters for idling locomotives were sourced from CARB (2004) for a locomotive of similar type and size.

Table 5.14 presents the initial horizontal and vertical spreads used in the modelling of train travel. The spreads have been calculated using Lakes Environmental guidance (Lakes Environmental, 2017) on the calculation of dispersion from haul roads, which is based on the US EPA Haul Road Workgroup Report (US EPA, 2012). The dispersion of emissions from haul roads is very similar to dispersion from rail lines and is considered the most appropriate guidance. Initial vertical spread (sigma Z) is calculated by dividing the top of plume height (m) by 2.15. Top of plume height is equal to the vehicle (train) height (3.9 m) multiplied by 1.7 (6.63 m). Initial horizontal spread (sigma Y) is calculated by dividing the distance between the centre points of the segmented volume sources by 2.15. Plume width is calculated as the vehicle (train) width (3m) plus 6m to account for the mixing zone of a single line track.

The location of modelled sources are shown in Figure 5.3.

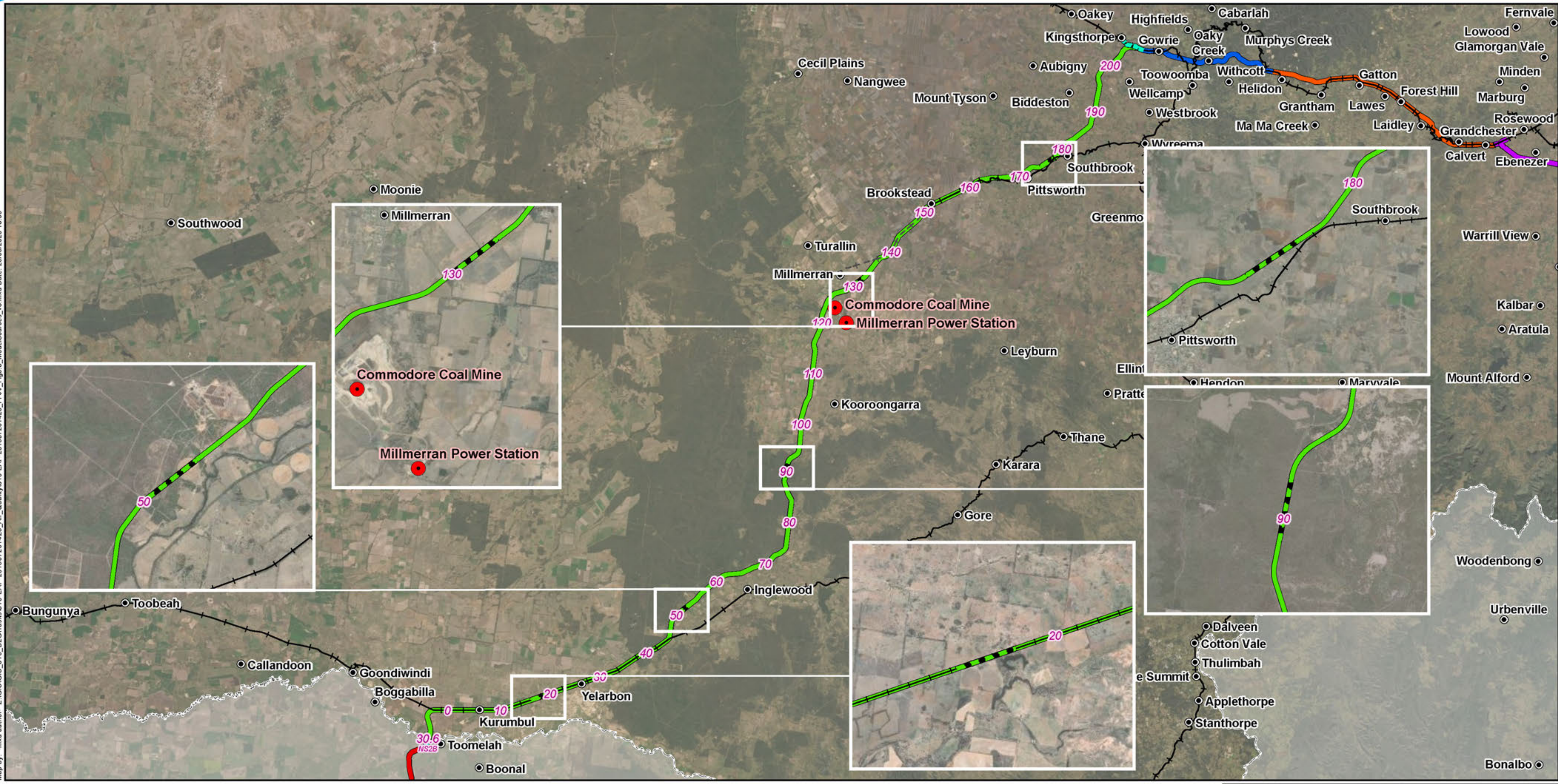
Table 5.14 CALPUFF source parameters

Source	Source type	Location (GDA 96, zone 56 J)	Release height above ground level (m)	Parameters
B2G-0	Segmented volume source (8.6 km, 216 sources)	251,061; 6,826,394 to 254,816; 6,832,169	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
B2G-1	Segmented volume source (25.0 km, 626 sources)	254,816; 6,832,169 to 279,025; 6,836,972	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
B2G-2	Segmented volume source (27.0 km, 676 sources)	279,025; 6,836,972 to 299,966; 6,851,547	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
B2G-3	Segmented volume source (26.6 km, 667 sources)	299,966;6,851,547 to 319,661;6,866,617	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
B2G-4	Segmented volume source (25.5 km, 639 sources)	319,661; 6,866,617 to 323,056; 6,890,674	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
B2G-5	Segmented e volume source (24.2 km, 606 sources)	323,056; 6,890,674 to 330,525; 6,912,065	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
B2G-6	Segmented volume source (26.5 km, 663 sources)	330,525; 6,912,065 to 349,493; 6,929,627	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
B2G-7	Segmented volume source (25.4 km, 636 sources)	349,493; 6,929,627 to 371,803;6,939,344	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
B2G-8	Segmented volume source (26.7 km, 669 sources)	371,803;6,939,344 to 386,401;6,958,278	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
G2H	Segmented volume source (1.0 km, 26 sources)	386,428; 6,958,301 to 387,354; 6,957,936	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
West Moreton System (Background)	Line volume source (3.5 km, 88 sources)	386,422; 6,958,310 to 383,406; 6,959,750	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)
NS2B	Segmented volume source (1.0 km, 26 sources)	250,695; 6,825,468 to 251,061; 6,826,394	3.3	18.6 m (initial horizontal spread) 3.1 m (initial vertical spread)

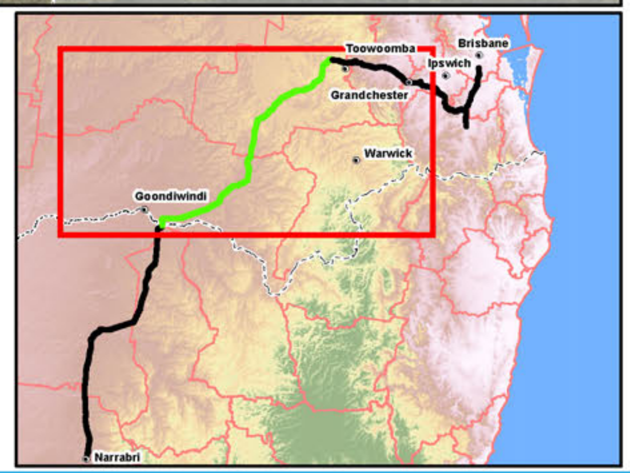
Source	Source type	Location (GDA 96, zone 56 J)	Release height above ground level (m)	Parameters
Crossing Loop 1	Point source (6 sources)	270,838; 6,834,172 270,860; 6,834,178 270,882; 6,834,184 272,867; 6,834,866 272,847; 6,834,857 272,826; 6,834,849	4.3 (0.1 m above locomotive engine)	134 ºC (exit temperature) 0.6 m (stack diameter) 2.4 m/s (exit velocity)
Crossing Loop 2	Point source (6 sources)	298619; 6850492 298637; 6850507 298656; 6850521 300198; 6851724 300180; 6851710 300163; 6851696	4.3 (0.1 m above locomotive engine)	134 ºC (exit temperature) 0.6 m (stack diameter) 2.4 m/s (exit velocity)
Crossing Loop 3	Point source (6 sources)	319171; 6876924 319177; 6876946 319181; 6876969 319575; 6878982 319572; 6878959 319569; 6878938	4.3 (0.1 m above locomotive engine)	134 ºC (exit temperature) 0.6 m (stack diameter) 2.4 m/s (exit velocity)
Crossing Loop 4	Point source (6 sources)	368035; 6935858 368054; 6935870 368073; 6935882 369706; 6936976 369687; 6936963 369669; 6936951	4.3 (0.1 m above locomotive engine)	134 ºC (exit temperature) 0.6 m (stack diameter) 2.4 m/s (exit velocity)
Crossing Loop 5	Point source (6 sources)	331855; 6912841 331873; 6912854 331892; 6912868 333512; 6914109 333495; 6914095 333478; 6914081	4.3 (0.1 m above locomotive engine)	134 ºC (exit temperature) 0.6 m (stack diameter) 2.4 m/s (exit velocity)

Source	Source type	Location (GDA 96, zone 56 J)	Release height above ground level (m)	Parameters
Commodore Mine	Combination of volume sources, volume-line sources, and areas sources	Various	Various	Various
Millmerran Power Station	Combination of 2 x point sources (stacks) and 1 x area source (stockpile)	330,732; 6,905,970 330736; 6,905,969	200 m (stacks)	140 ºC (exit temperature) 5.0 m (stack diameter) 30 m/s (exit velocity)

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



Map by: <mxd author> Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig5.3_ModelSources_v3.mxd Date: 29/05/2020 13:00



Legend

- Existing emission source
- 5 Chainage (km)
- Localities
- Cumulative rail sources
- Crossing loops
- North Star to NSW/QLD border alignment
- Border to Gowrie alignment
- Gowrie to Helidon alignment
- Helidon to Calvert alignment
- Calvert to Kagaru alignment
- Existing rail (operational)
- Existing rail (non-operational)
- NSW/QLD border

A3 scale: 1:800,000

0 6 12 18 24 30 km

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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie
Figure 5.3: Modelled sources

5.3.4 Terrain and land use data

The underlying terrain and dominant land use are important functions of plume transport modelling. Gridded terrain elevations for the modelling domain were derived from the Shuttle Radar Topography Mission (SRTM) one arc-second or around 30 metre resolution data. To reflect the final terrain formation post-construction, this data was supplemented with detailed one metre data that reflects bulk earthworks for the Project.

Land use within the AQIA area primarily consists of rural and agricultural areas, which are interspersed with occasional townships, bushland, and State forest. Land use data within the AQIA area has been derived from the Queensland Land Use Mapping Program (QLUMP) utilising the Australian Land Use and Management Classification (ABARES, 2016). The data are representative of the actual area associated with the Project, are recent and of a very fine resolution to increase the accuracy of the modelling. The land use data used in this application are different to the default land use data used in The Air Pollution Model (TAPM) and for most CALMET model applications outside of the United States, which are the USGS one kilometre land use data. Until recently, the USGS one kilometre global land use data set was the most readily available data set for air quality applications. Limitations of this data set; however, include its age (more than 20 years old), coarse resolution (between 900 metres and 1.2 kilometres), and the fact that it is categorised according to the North American land use category system, which does not correspond to all relevant Australian land use types.

As stated above, plume transport is an important function of the underlying dominant land use. The inclusion of the Australian land use data set is, therefore, an important relevant addition to this modelling application as the data are recent, relevant and of a fine resolution.

5.3.5 Conversion of NO_X to NO_2

Nitrogen oxides are produced in most combustion processes and are 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, however, all NO emitted into the atmosphere is oxidised to NO_2 and then further to other higher oxides of nitrogen.

The US EPA's Ozone Limiting Method (OLM) was used to predict ground-level concentrations of NO_2. The OLM assumes 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 NO_X 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 (NSW EPA, 2017) (Cole, 1979) (Tikvart, 1996). The OLM is a conservative approach as explained in Appendix E. Background O_3 data from the nearest air quality monitoring station to the Project which monitors O_3, the DES station at Mutdapilly, was used to convert the modelled NO_2 concentrations in accordance with the OLM methodology presented in (NSW EPA, 2017). Figure 5.4 presents the variation plots of background concentrations for NO_2 and O_3 for Mutdapilly for the year 2013.

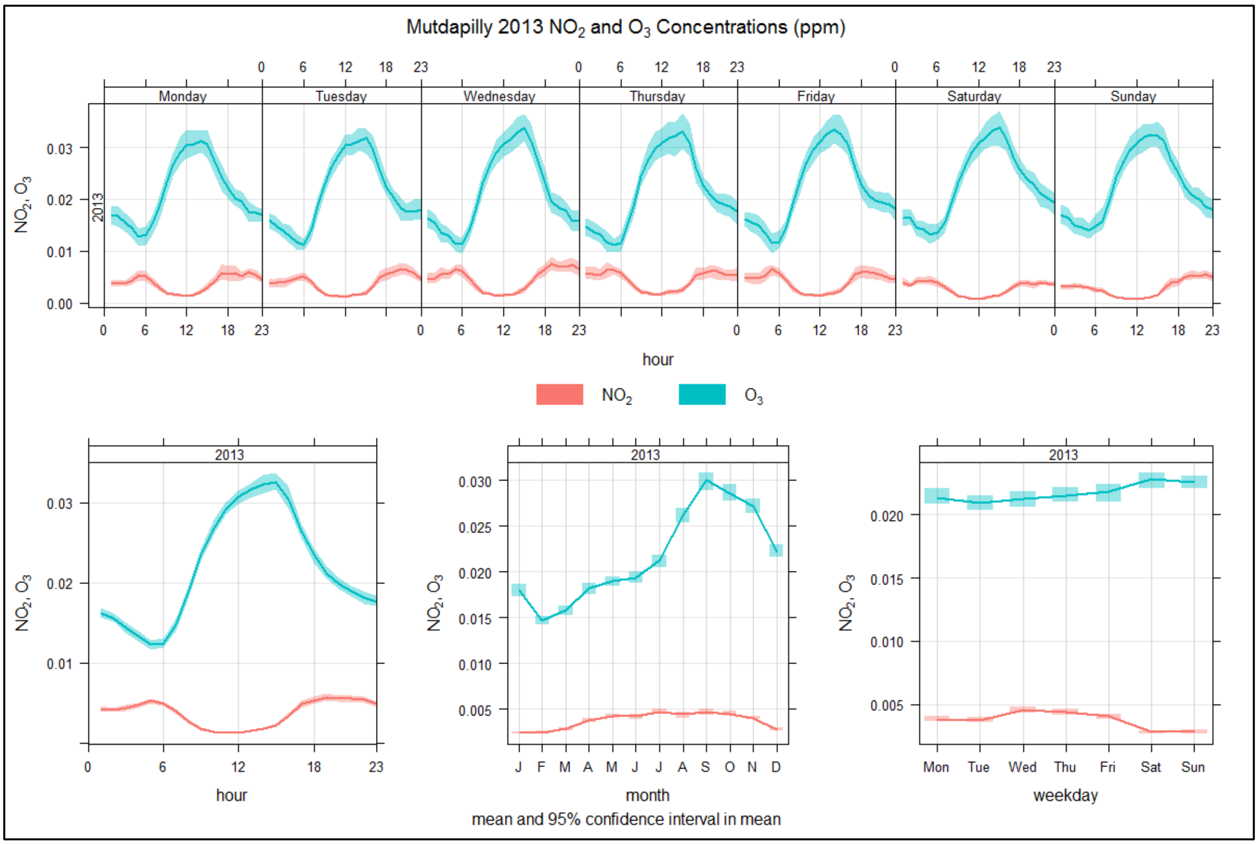

Figure 5.4 **Variation plots of concentrations for NO_2 and O_3 from the Mutdapilly DES monitoring station for 2013**

5.3.6 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. For example, the prediction of pollutant dispersion under low wind speed conditions (typically defined as those wind speeds less than one 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 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. 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 enough 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 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 receiver 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.

5.4 Water tank quality

5.4.1 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).

5.4.2 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 operational impacts to air quality, dust deposition modelling was also completed using CALPUFF to determine the impact of diesel locomotive emissions on tank water quality. Dust deposition was predicted for all modelled sensitive receptors, consistent with the assessment of impacts to air quality and as required by the ToR. The methodology for predicting the potential impact to water tank quality is summarised as follows:

- Rain water collection systems can have first flush devices which 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 sensitive receptors considered.
- Annual average dust deposition rates were predicted for every modelled sensitive receptor for peak train numbers. Every sensitive receptor was assumed to have a water tank, and the roof area (collection area) for each receptor was assumed to be 200m^2.
- It was assumed that all deposited dust at each sensitive receptor (200 m^2 roof area) was collected by a single 10,000 L rainwater tank which 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 Australian Drinking Water Guidelines (NHMRC & NRMMC 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 and multiplying it by the assumed roof area (200m^2) to determine total mass, and then speciating the predicted dust deposition level into metal concentrations using the diesel locomotive emission factors (refer Table 5.8 in Section 5.3.1.1).
- The predicted water concentrations for each pollutant species were then assessed against the objectives prescribed in the Australian Drinking Water Guidelines (NHRMC & NRMMC, 2018).

The *Australian Drinking Water Guidelines* (NHMRC &NRMMC, 2018) present guideline values on allowable contaminants within drinking water, such as from rainwater tanks. Table 5.15 presents the guideline values from the Australian Drinking Water Guidelines for the pollutants of interest for the Project. Calculated water pollutant concentrations from diesel emission deposition modelling are compared to these guideline values.

Table 5.15 Australian Drinking Water Guidelines for the pollutants of interest for the Project

Pollutant	Guideline value (mg/m³)	Environmental Value	Source
Arsenic	0.01	Health	(NHMRC &NRMMC, 2018)
Cadmium	0.002	Health	
Lead	0.01	Health	
Nickel	0.02	Health	
Chromium as Cr (VI)	0.05	Health	

5.5 Agricultural freight odour

To assess the nuisance impacts that may arise from agricultural freight trains, a qualitative assessment utilising FIDOL factors has been undertaken to determine the likelihood of odour nuisance (Department of Environment and Heritage Protection, 2018). 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.

5.6 Cumulative impact risk assessment

Section 11.134(b) of the ToR requires that the air quality assessment for the Project 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 where public information is available. In response to this requirement, the assessment of operational phase air quality impacts has incorporated the emission contributions of existing or planned developments that are or will be a source of pollutants of interest that are also relevant to the Project.

The approach used to identify and assess potential construction phase cumulative impacts of the Project is as follows:

- A review of the potential impacts identified within the assessment. The environment at the time of the ToR is the baseline, prior impacts from past land use has not be considered.
- A preliminary list of projects for consideration in the cumulative impact assessment was collated with timelines to demonstrate the temporal relationship between projects. This preliminary list of projects was compiled through consideration of the following:
  - Projects subject to assessment under the EP Act or SDPWO Act, with an Initial Advice Statement published by DES or Department of State Development, Tourism and Innovation (DSDTI)
  - Projects listed in GRC and TRC development application databases
  - Development within Priority Development Areas and State Development Areas
  - Economic Development Queensland development projects
  - Community Infrastructure Designation projects

- Projects within the public register of environmental authorities
- DTMR infrastructure projects
- Private infrastructure facilities
- Development in accordance with Regional Planning Interests
- The Inland Rail projects immediately adjacent to the Project, being the North Star to NSW/QLD Border and Gowrie to Helidon projects

- The preliminary list of projects was assessed to identify those that meet one of the following criteria:
  - Projects that have been approved but where construction has not commenced
  - Projects that have commenced construction subsequent to issuance of the ToR for the Project, but have potential for overlap in construction activities with the Border to Gowrie Project
  - Projects that have been completed subsequent to issuance of the ToR for the Project
  - Are operational developments that have future plans for expansion
- Projects that were excluded from further assessment were:
  - Existing projects, with no known plans for expansion. Such projects are typically considered part of the 'existing environment' and have been accounted for in the impact assessment of each specific matter.
  - Proposed projects that have not been developed to the point that details of their scale, size, location and core activities would be publicly available.
- Where there is a potential overlap in impacts (either spatially or temporally), a cumulative impact assessment was undertaken to determine the nature of the cumulative impact. Where possible, the assessment method was quantitative in nature however qualitative assessment has also been undertaken.
- An assessment matrix method (further detailed within Section 10 in Table 10.1 and Table 10.2) has been used to determine the significance of cumulative impacts with respect to beneficial or detrimental effects.
- Where cumulative impacts are deemed to be of medium or high significance, additional mitigation measures are proposed, beyond those already proposed by the relevant technical impact assessments.

Following the identification of each potential cumulative impact, a relevance factor score of low, medium or high has been determined in consideration of the impacts, in accordance with the assessment matrix given in Table 10.1.

6 Construction air quality impact assessment

The following sections provide an assessment of air quality impacts during the construction of the Project.

The highest proportion of construction emissions results from 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, whilst deposited dust has the potential to cause nuisance impacts but does not directly impact human health.

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 objectives or cause nuisance to sensitive receptors and therefore have not been assessed for the construction phase.

In addition to construction dust, odour will be emitted from the sewage treatment plants required for non-resident workforce accommodation. The assessment of odour from these facilities is presented in Section 6.2.

Odour and VOCs will also be emitted as fugitive emissions from fuel tanks located at laydown areas. Impacts from fuel storage have been assessed in Section 6.3.

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

6.1 Dust

The dust impact assessment was based on the methodology described in the UK IAQM document, *Guidance on the assessment of dust from demolition and construction* (UK IAQM, 2014). The risk of dust soiling and human health impacts due to particulate matter (PM_{10}) on surrounding areas were determined based on the scale of activities and proximity to sensitive receptors. The IAQM method uses a four-step process to assess dust impacts:

- Step 1: Screening based on distance to nearest sensitive receptors
- Step 2: Assess risk of dust impacts from activities based on:
  - Scale and nature of the works, which determines the potential dust emission magnitude
  - Sensitivity of the area
- Step 3: Determination of site-specific mitigation for dust-emitting activities
- Step 4: Reassess risk of dust impacts after mitigation has been considered.

Figure 6.1 presents the locations of the permanent and temporary disturbance areas within the temporary construction footprint including laydown areas and haul routes.

The IAQM assessment process is described in the following sections.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- North Star to NSW/QLD border alignment
- Border to Gowrie alignment
- Existing rail (operational)
- Minor roads
- NSW/QLD border
- Laydown access tracks
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5km

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Border to Gowrie

Figure 6.1a: Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (operational)
- Minor roads
- NSW/QLD border
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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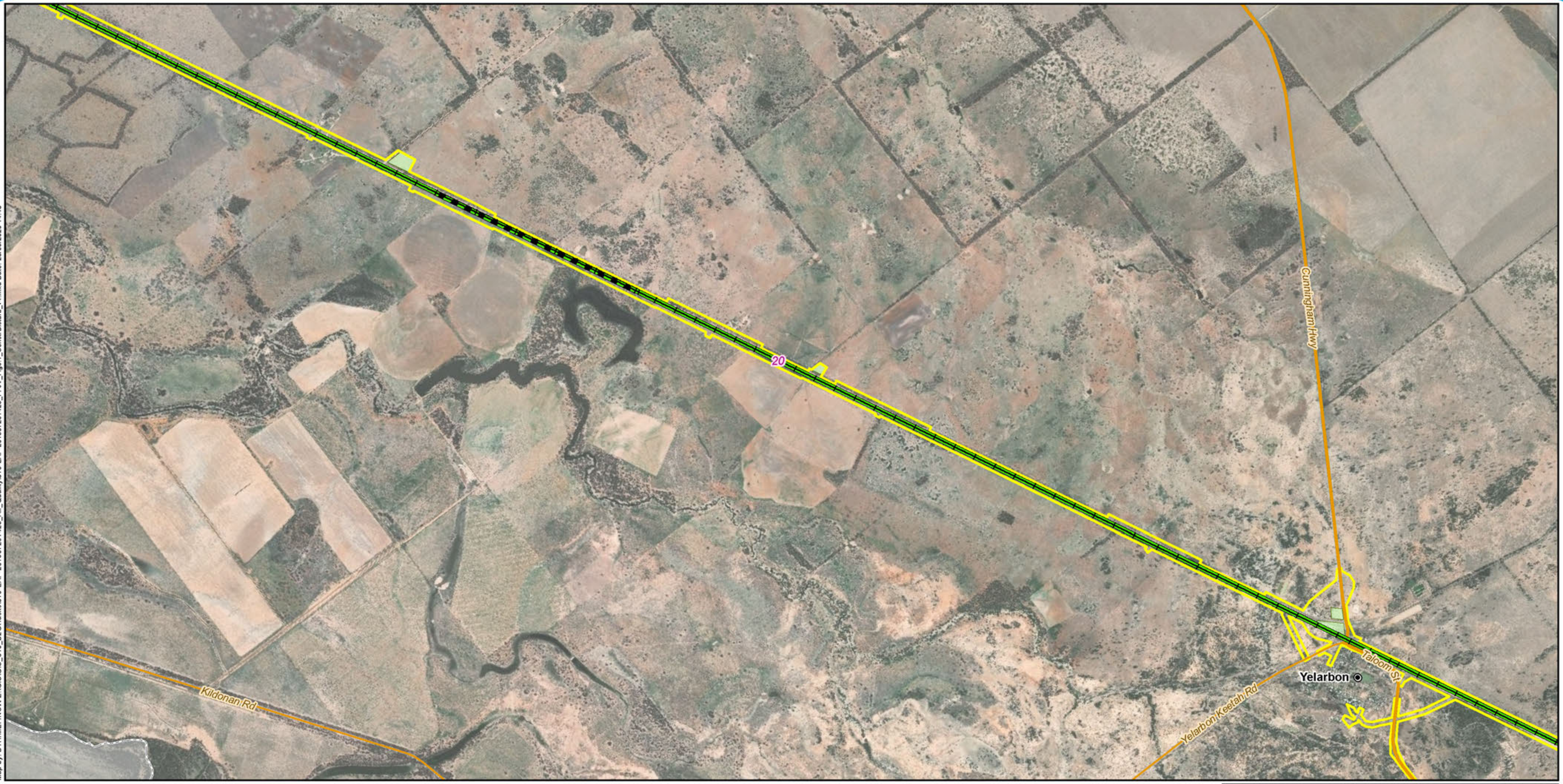
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 6.1b: Construction disturbance areas



Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Localities
- Crossing loops
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads
- NSW/QLD border
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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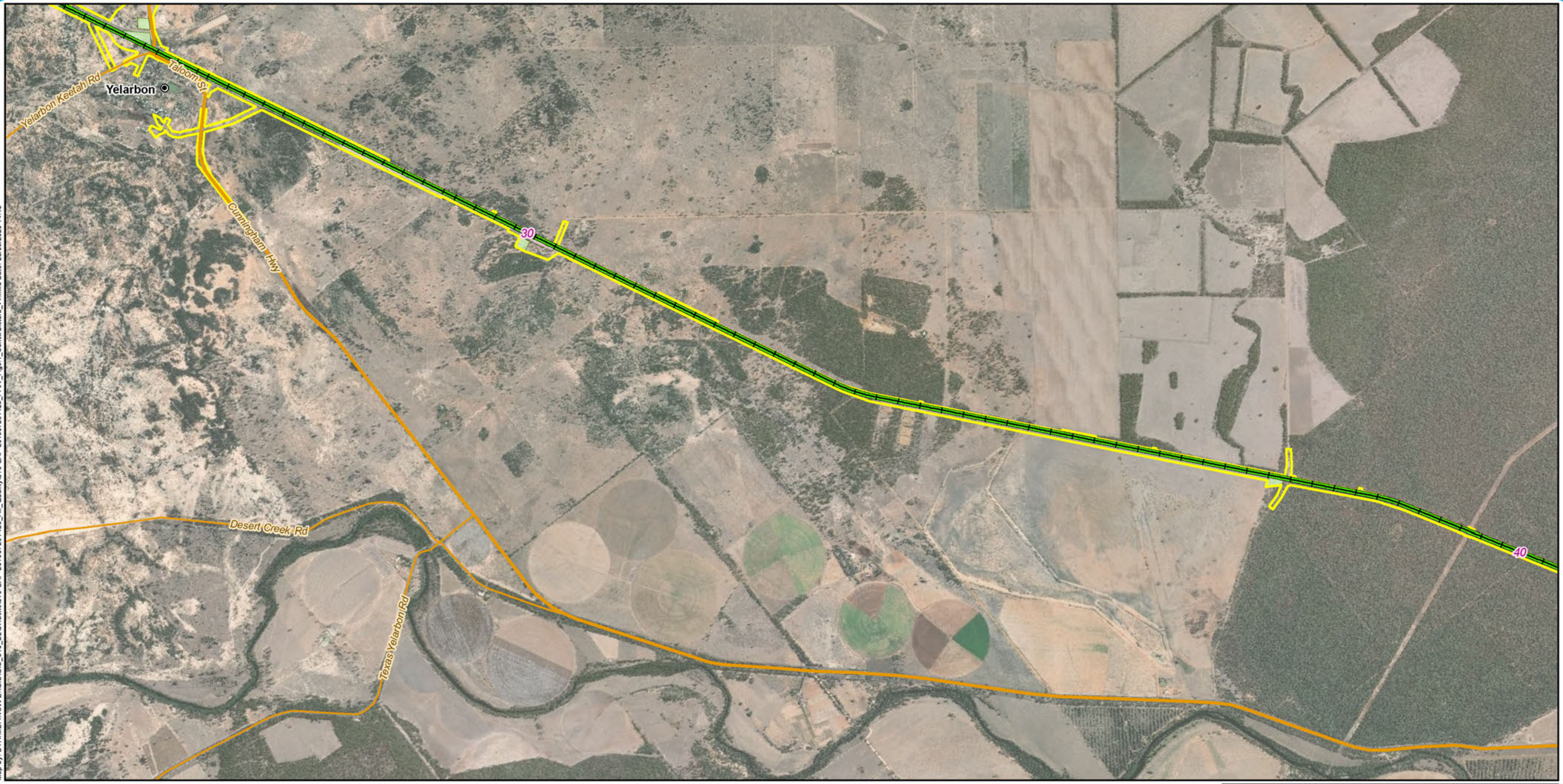
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 6.1c: Construction disturbance areas

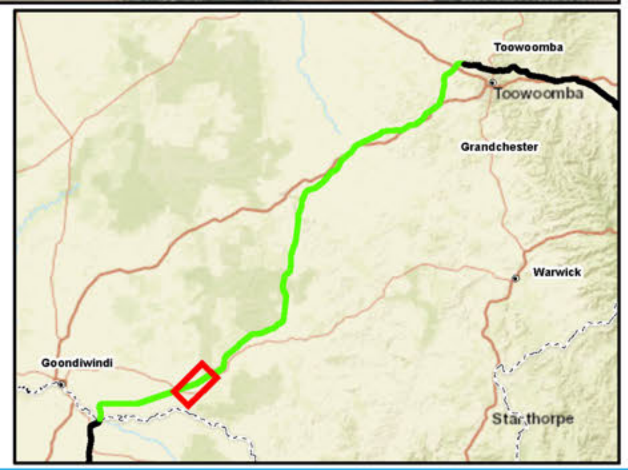
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads
- Laydown
- Project footprint



A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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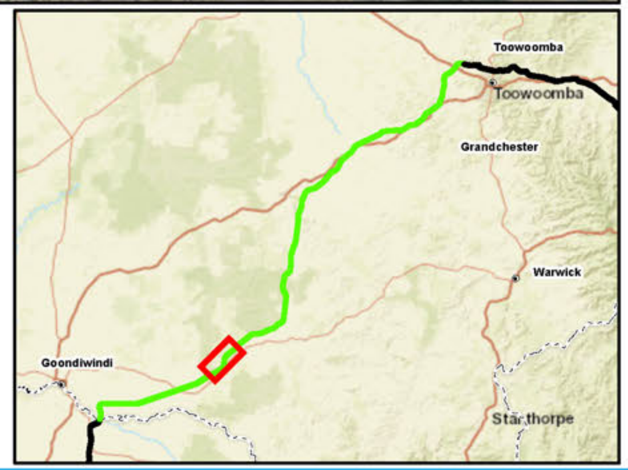
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie
Figure 6.1d:
Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43



Legend

- 5 Chainage (km)
- Crossing loops
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Laydown access tracks
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5km

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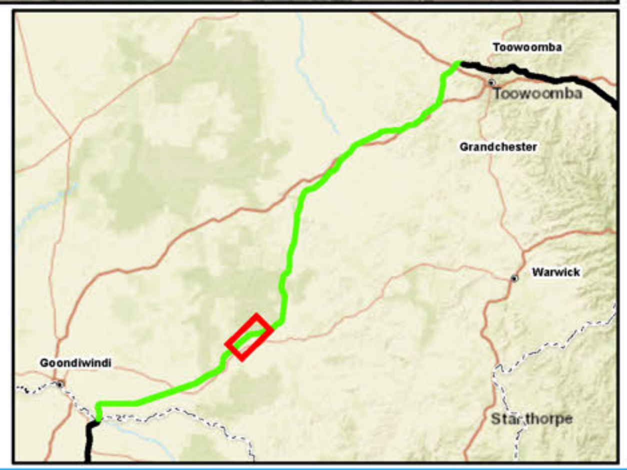
Border to Gowrie
Figure 6.1e:
Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- 5 Chainage (km)
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Laydown access tracks
- Laydown
- Project footprint



A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 6.1f: Construction disturbance areas

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Border to Gowrie alignment
- Minor roads
- Laydown access tracks
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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Border to Gowrie

Figure 6.1g: Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Crossing loops
- Border to Gowrie alignment
- Minor roads
- Laydown access tracks
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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Border to Gowrie

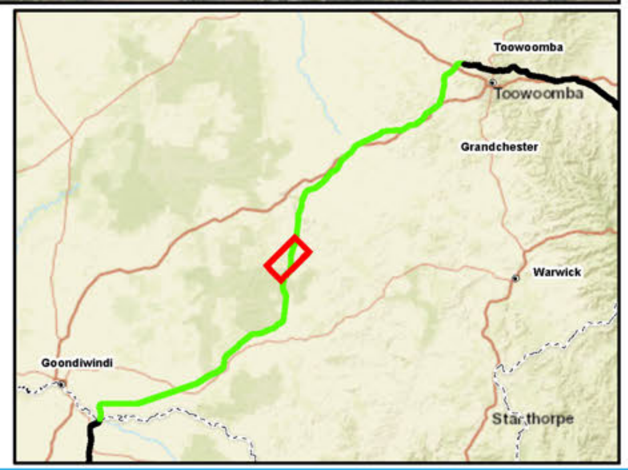
Figure 6.1h: Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Border to Gowrie alignment
- Minor roads
- Laydown access tracks
- Laydown
- Project footprint



A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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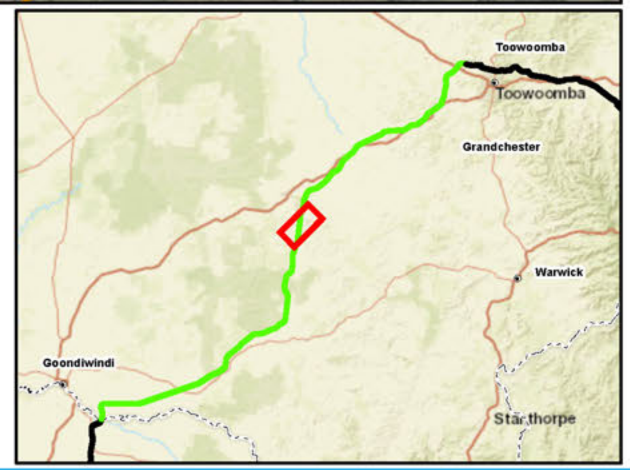
Border to Gowrie
Figure 6.1i:
Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43



Legend

- 5 Chainage (km)
- Border to Gowrie alignment
- Minor roads
- Laydown access tracks
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5km

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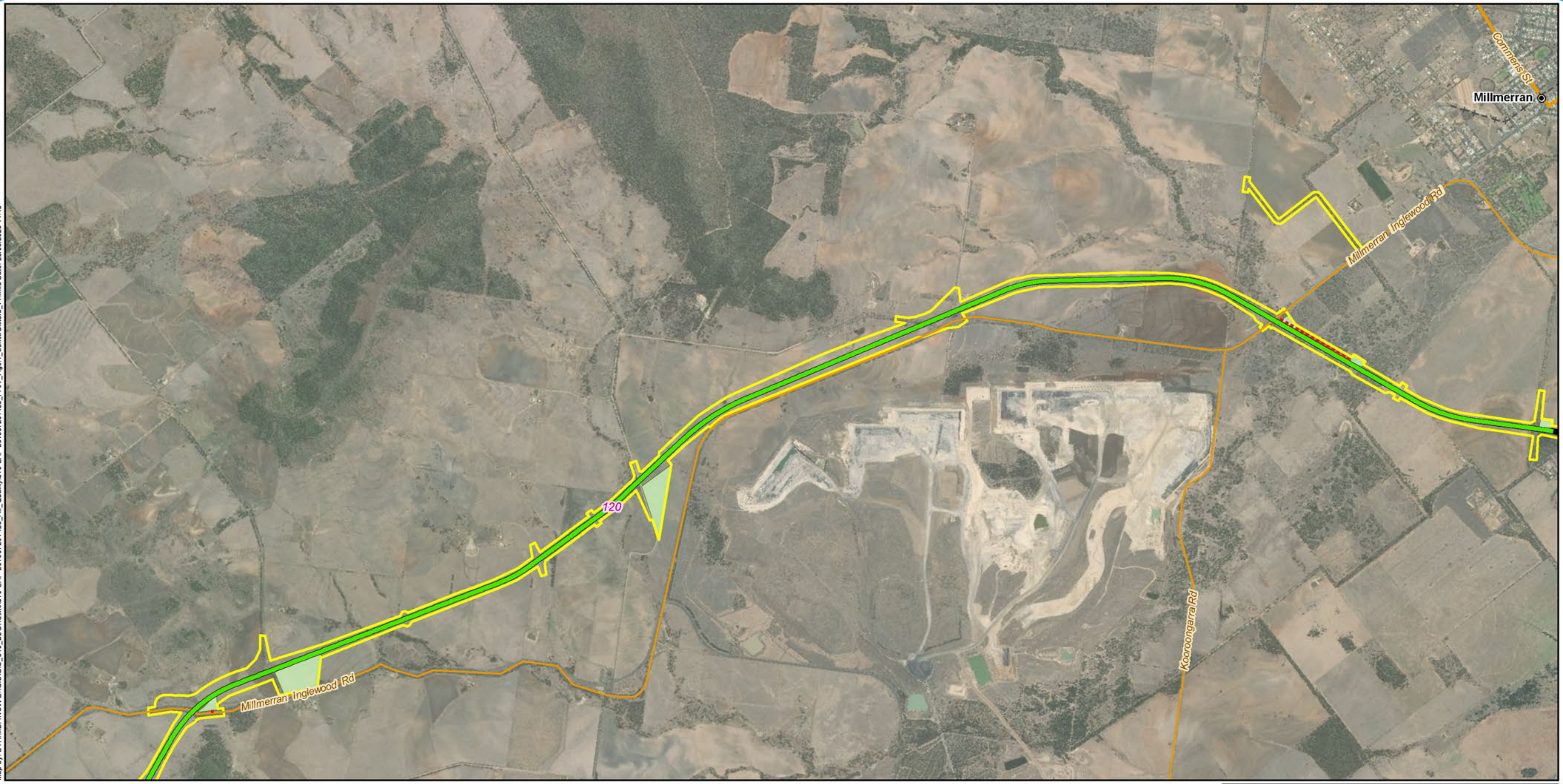
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 6.1j: Construction disturbance areas

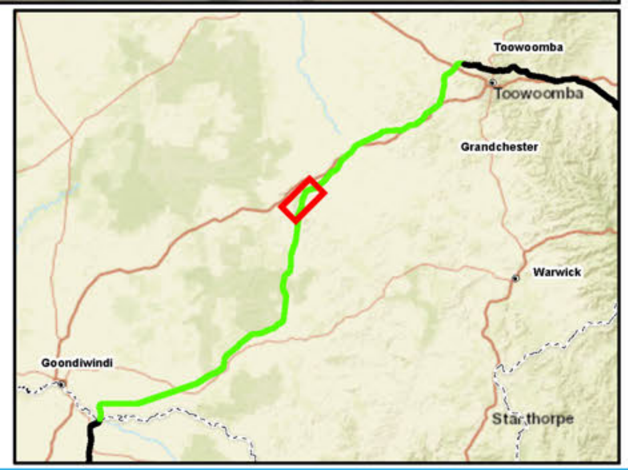
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43



Legend

- 5 Chainage (km)
- Localities
- Crossing loops
- Border to Gowrie alignment
- Existing rail (non-operational)
- Major roads
- Minor roads
- Laydown access tracks
- Laydown
- Project footprint



A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

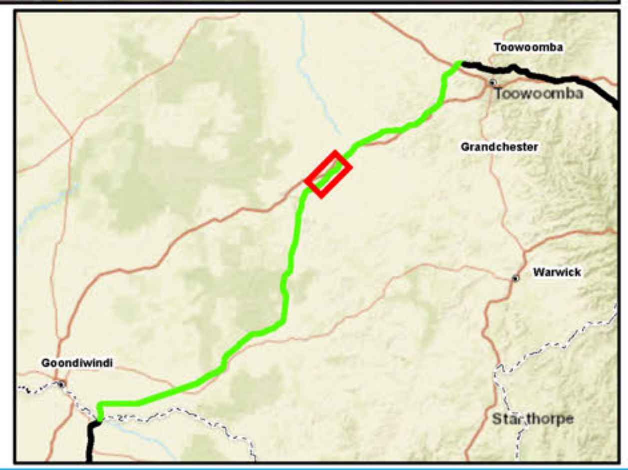
Figure 6.1k: Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Localities
- Crossing loops
- Border to Gowrie alignment
- Existing rail (non-operational)
- Major roads
- Minor roads
- Laydown access tracks
- Laydown
- Project footprint



A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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Border to Gowrie
Figure 6.1l:
Construction disturbance areas

Legend

- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Existing rail (operational)
- Existing rail (non-operational)
- Major roads
- Minor roads
- Laydown access tracks
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5km

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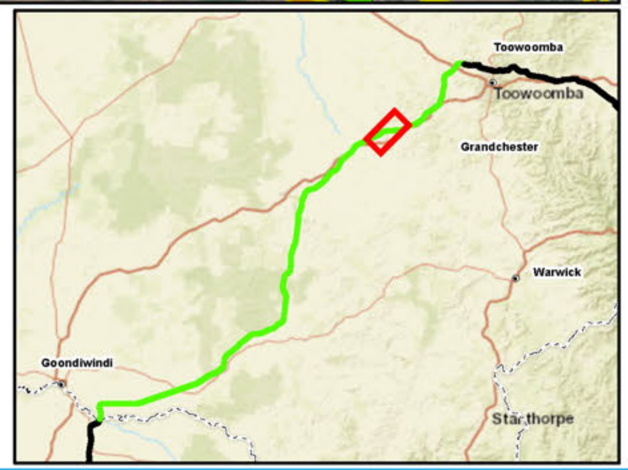
Border to Gowrie
Figure 6.1m:
Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43



Legend

- 5 Chainage (km)
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5km

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Border to Gowrie

Figure 6.1n: Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Localities
- Crossing loops
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5km

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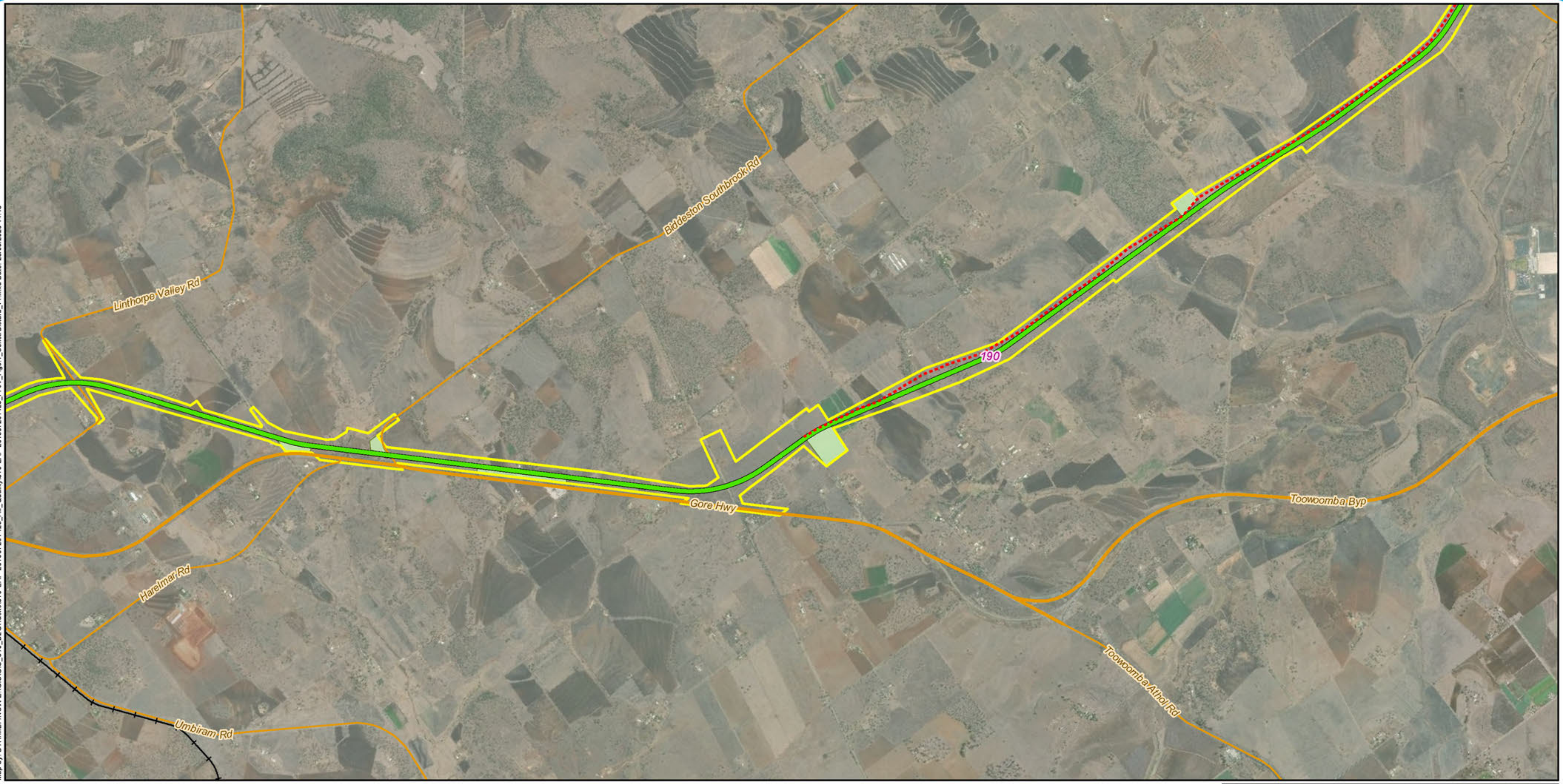
Coordinate System: GDA 1994 MGA Zone 56

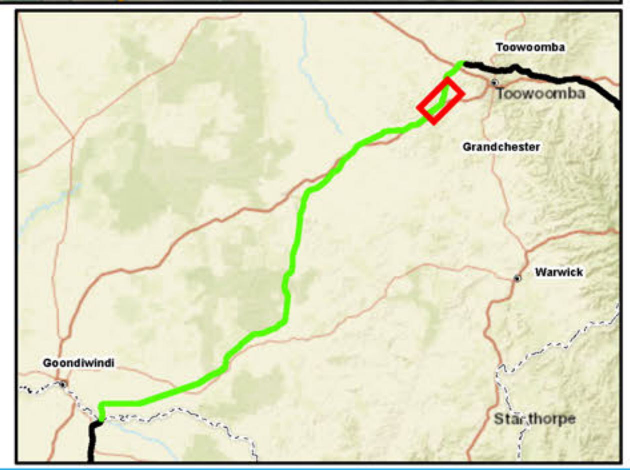
Border to Gowrie
Figure 6.1o:
Construction disturbance areas



Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Border to Gowrie alignment
- Existing rail (operational)
- Major roads
- Minor roads
- Laydown access tracks
- Laydown
- Project footprint



A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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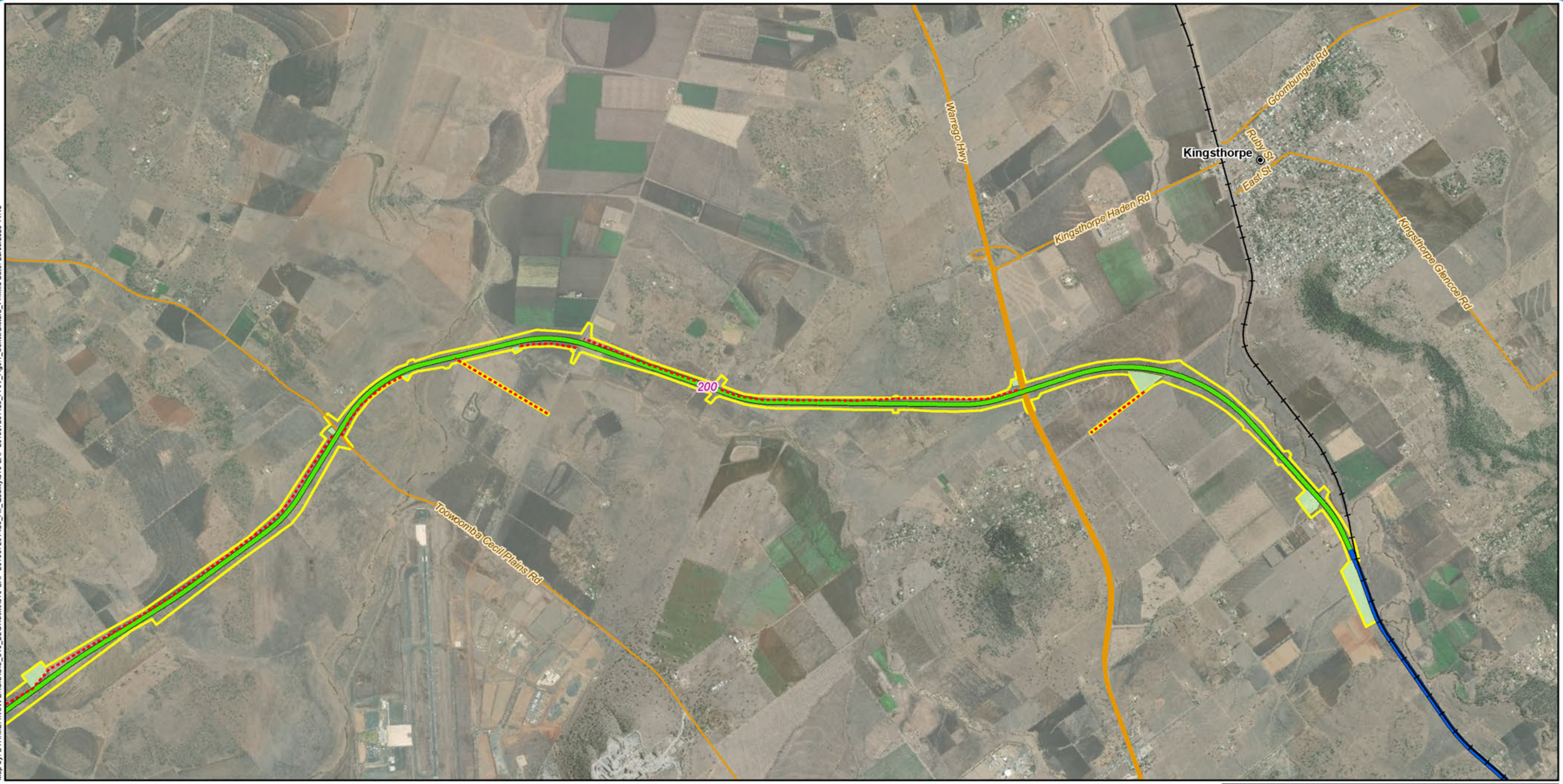
Coordinate System: GDA 1994 MGA Zone 56

Border to Gowrie

Figure 6.1p: Construction disturbance areas

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DTH/MEF/NCW Z:\GIS\GIS_310_B2G\Tasks\310-EAP-201907261425_Air_Quality\310-EAP-201907261425_FFJV_Fig6.1_ConstrDisturb_v4.mxd Date: 28/05/2020 14:43

Legend

- 5 Chainage (km)
- Localities
- Border to Gowrie alignment
- Gowrie to Helidon alignment
- Existing rail (operational)
- Major roads
- Minor roads
- Laydown access tracks
- Laydown
- Project footprint

A3 scale: 1:40,000

0 0.3 0.6 0.9 1.2 1.5 km

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Border to Gowrie
Figure 6.1q:
Construction disturbance areas

6.1.1 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 site
- 50 m from the route used by construction vehicles on public roads up to 500 m from the site entrance.

The number of sensitive receptors identified within the AQIA area is 909. Their respective distances from the Project are summarised in Table 6.1. The three temporary non-resident workforce accommodation facilities for the Project are considered in Table 6.1.

Table 6.1 Summary of sensitive receptors

Distance from construction element (m)	Number of receptors		
	Access tracks	Laydown areas	Construction footprint[1.]
0	0	1	8
<20	0	10 (11)[2.]	24 (32)[2.]
21 to 50	1	10	38
51 to 100	0	34	53
101 to 350	15	184	221
>350	893	671	573
Total	**909**		

Table notes:

1. Temporary and permanent disturbance areas
2. It is assumed that the eight receptors that fall within the construction corridors and the one receptor that falls within the laydown areas will not be occupied at the time of construction and thus no longer be sensitive receptors

As there are receptors located within 350 m of the Project footprint, further assessment of construction impacts is required.

The number of sensitive receptors estimated in this assessment are current at the time of assessment and minor variations to the number of sensitive receptors may occur as the Project progresses. Due to the large-scale nature of the Project, it has been assumed that receptors identified within the permanent footprint and the one receptor that falls within the temporary footprint (laydown area) will not be occupied once construction works have commenced and have therefore not been considered further. The extent of property impacts should be confirmed prior to the detail design, in consultation with property owners.

6.1.2 Step 2 – Dust risk assessment

Step 2 in the IAQM method 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.

6.1.3 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:*

Demolition: Any activity involved with the removal of an existing structure (or structures). This may also be referred to as de-construction, specifically when a building is to be removed a small part at a time. Example definitions for demolition are:

- *Large: Total building volume >50,000m^3, potentially dusty construction material (e.g. concrete), on-site crushing and screening, demolition activities >20 m above ground level*
- *Medium: Total building volume 20,000m^3 to 50,000m^3, potentially dusty construction material, demolition activities 10 to 20 m above ground level*
- *Small: Total building volume <20,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber), demolition activities <10 m above ground, demolition during wetter months.*

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 to10,000 m^2, moderately dusty soil type (e.g. silt), 5 to10 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.*

Construction: The key issues when determining the potential dust emission magnitude during the construction phase include the size of the building(s)/infrastructure, method of construction, construction materials, and duration of build. Example definitions for construction are:

- *Large: Total building volume >100,000 m^3, on site concrete batching, sandblasting*
- *Medium: Total building volume 25,000 m^3 to 100,000 m^3, potentially dusty construction material (e.g. concrete), on site concrete batching*
- *Small: Total building volume <25,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber).*

Track-out: Factors which determine the dust emission magnitude are vehicle size, vehicle speed, vehicle numbers, geology and duration. As with all other potential sources, professional judgement must be applied when classifying track-out into one of the dust emission magnitude categories. Example definitions for track-out are:

- *Large: >50 truck (>3.5 t) outward movements in any one day, potentially dusty surface material (e.g. high clay content), unpaved road length 50 m to 100 m*
- *Medium: 10 to 50 truck (>3.5 t) outward movements in any one day, moderately dusty surface material (e.g. high clay content), unpaved road length 50 m to 100 m*
- *Small: <10 truck (>3.5 t) outward movements in any one day, surface material with low potential for dust release, unpaved road length <50 m.*

Dust emission magnitudes for Project construction activities were estimated based on the IAQM examples listed above. Justification and the factors used in determining the magnitudes are presented in Table 6.2. Construction for the Project is expected to occur Monday to Saturday, with work days no longer than 12 hours. Where required, track possessions may occur continuously (24 hours and 7 days). Due to time constraints multiple work fronts will be present at any one time along the alignment.

Table 6.2 **Construction activities and dust emission magnitude justification**

Activity	Potential dust emission magnitude	Justification
Demolition	Small	▪ Existing buildings likely to be demolished, all assumed to be small homesteads. ▪ Buildings assumed to be primarily of low dust potential material (wood/cladding). Materials to be confirmed prior to demolition. ▪ Total building volume presently unknown although assumed to be <10,000 m^3. ▪ Possible demolition and realignment of existing roads - to be confirmed in detail design phase of the Project.
Earthworks	Large	▪ Multiple work fronts at any one time along the alignment. ▪ Vegetation clearing along the proposed alignment corridor for new access tracks and laydown areas will occur where necessary. Clearing is staged to limit size of disturbance area at any one time. ▪ Topsoil along entire alignment (216.2 km) will be stripped (approximate depth of 0.3 m) and stockpiled. Wherever possible and appropriate material will be reused within Project area. ▪ 75 laydown areas along the alignment, with the ability to provide locations for excavation stockpiling. Stockpiles to be located as close as possible to the excavation source. ▪ Total cut of 12,525,038 m^3 and total fill of 13,347,369 m^3. ▪ Utility relocations. ▪ Earthworks material likely to be dusty especially during dry season. Soil types along corridor location to be confirmed.
Construction	Large	▪ Construction period of approximately four years, with multiple work fronts at any one time along the alignment. ▪ Installation of approximately 216.2 km of railway utilising steel rail, sleepers, ballast and concrete. Concrete and ballast present high dust risk. ▪ Construction of 34 new bridge structures – steel material low dust risk but concrete high dust risk. ▪ Temporary site offices and parking facilities likely to be constructed at each LADP. ▪ Construction of 13 fuel storage facilities: two approximately <20,000 litres, and 11 approximately <10,000 litres. ▪ Laydown areas to also include temporary parking facilities for construction workers. ▪ Construction of flash butt welding facility ▪ Construction of temporary and permanent fencing – total lengths to be determined during detail design phase.
Track-out	Large	▪ Multiple work fronts at any one time along alignment. ▪ High amount of daily vehicle movements expected per work site (both light and heavy vehicles). ▪ Movement of ballast from sources, and between LADPs and ballast handling facility via 18 t dump trucks. ▪ After construction, access tracks are expected to only be used for maintenance activities. ▪ Total length of unpaved road/access tracks unknown until design is finalised but will be >100 m due to the size of the Project.

6.1.4 Step 2B – Sensitivity of surrounding area

The IAQM methodology allows the sensitivity of an area to dust soiling and human health impacts due to particulate matter 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 soiling and human health impacts are provided. 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. For example, 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. For example, 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 6.3 details the IAQM guidance sensitivity levels for dust soiling effects on people and property. As detailed in Section 6.1.1 the total number of receptors identified in the impact assessment area is 909. All 909 receptors are classified as high sensitivity as they are residential uses. Of the 909 receptors:

- 349 are located within 350 m of a construction dust source
- 121 of the 349 are located less than 100 m away
- 66 of the 349 receptors are located less than 50 m away; and
- 27 of the 349 receptors are located less than 20 m away.

Assessing the sensitivity level to dust soiling 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 216.2 km 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 impact assessment area a rating of 'High' for sensitivity to dust soiling 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 soiling impacts.

Table 6.3 IAQM surrounding area sensitivity to dust soiling impacts

Receptor sensitivity	Number of receptors	Distance from the source			
		<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 6.4. 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. The IAQM method effectively considers the assimilative capacity of the environment through consideration of background concentrations.

As the UK air quality objectives for PM_{10} differ from the ambient air quality objectives adopted for use in this assessment (EPP (Air) objectives and other Australian air quality objectives) the annual mean concentration categories used in the assessment (refer Table 6.4) 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 6.4 Surrounding area 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 - 100	High	High	Medium	Low	Low
		1 - 10	High	Medium	Low	Low	Low
	21 – 25 µg/m³	> 100	High	High	Medium	Low	Low
		10 - 100	High	Medium	Low	Low	Low
		1 - 10	High	Medium	Low	Low	Low
	17 – 21 µg/m³	> 100	High	Medium	Low	Low	Low
		10 - 100	High	Medium	Low	Low	Low
		1 - 10	Medium	Low	Low	Low	Low
	< 17 µg/m³	> 100	Medium	Low	Low	Low	Low
		10 - 100	Low	Low	Low	Low	Low
		1 - 10	Low	Low	Low	Low	Low
Medium	> 25 µg/m³	> 10	High	Medium	Low	Low	Low
		1 - 10	Medium	Low	Low	Low	Low
	21 – 25 µg/m³	> 10	Medium	Low	Low	Low	Low
		1 - 10	Low	Low	Low	Low	Low
	17 – 21 µg/m³	> 10	Low	Low	Low	Low	Low
		1 - 10	Low	Low	Low	Low	Low
	< 17 µg/m³	> 10	Low	Low	Low	Low	Low
		1 - 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 4.2, the background annual average PM_{10} concentration at the Inland Rail AQMS monitoring station for the period of September 2018 to August 2019 was 17.1 µg/m³.

Table 6.4 provides the modified IAQM guidance sensitivity levels for human health impacts for four annual mean PM_{10} background categories, including below 17 µg/m³ and between 17 to 21 µg/m³. Although the measured concentration at the Inland Rail AQMS was 17.1 µg/m³, the risk matrix for the lowest concentration category (below 17 µg/m³) has been adopted due to the marginal exceedance of the 17 ug/m³ cut-off.

There are greater than 10 high sensitivity receptors within 20 m of the Project's temporary disturbance footprint, and therefore based on the IAQM risk matrix the sensitivity of the AIA area to human health impacts is considered to be 'Low'.

6.1.5 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 AQIA area (in Table 6.3 and Table 6.4) 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 for each activity which is presented in Table 6.5. The 'without mitigation' dust risk impacts for each activity are summarised in Table 6.6.

Table 6.5 IAQM risk matrix

Activity	Surrounding area sensitivity	Dust emission magnitude		
		Large	Medium	Small
Demolition	High	High risk	Medium risk	Medium risk
	Medium	High risk	Medium risk	Low risk
	Low	Medium risk	Low risk	Negligible
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
Track-out	High	High risk	Medium risk	Low risk
	Medium	Medium risk	Low risk	Negligible
	Low	Low risk	Low risk	Negligible

Table 6.6 Without mitigation dust risk impacts for Project construction activities

Activity	Demolition	Earthworks	Construction	Track-out
Scale of Activity	**Small**	**Large**	**Large**	**Large**
Dust soiling	Low	Medium	Medium	Medium
Human health	Negligible	Low	Low	Low

The result of the qualitative air quality risk assessment shows that the unmitigated air emissions from the construction of the Project poses a 'Low' risk of human health impacts but a 'Medium' risk of dust soiling.

6.1.6 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. The IAQM guidance states that a high or medium-level risk rating means that suitable management measures will need to be implemented during construction to reduce the risk of significant impacts.

A Construction Environmental Management Plan (CEMP) will be developed to mitigate and manage potential impacts during the construction. The implementation of approved site-specific and in-principle management measures, as listed in Section 8, is expected to result in minimal risk of dust impacts on surrounding receptors.

6.1.7 Step 4 – Reassessment

The final step of the IAQM methodology is to determine whether there are likely to be significant residual impacts, post mitigation, arising from a proposed development.

A CEMP will be developed to mitigate and manage potential impacts during the construction phase. Mitigation measures proposed to mitigate construction impacts are presented in Table 8.2 in Section 8.2. An assessment of the residual risk of impact from construction with the implementation of the proposed mitigation measures is presented in Table 9.1 in Section 9.

6.2 Non-resident workforce accommodation

Construction personnel who do not live within a safe commutable distance to the Project will be housed in temporary non-resident workforce accommodation. Each accommodation facility will be required to hold 300 staff during the peak between weeks 50 and 70. The average occupancy of the non-resident workforce accommodation outside of the peak period will be approximately 150 people per facility. There are currently three non-resident workforce accommodation facilities proposed for the Project. Locations for the non-resident workforce accommodation have been identified in the vicinity of the townships of Yelarbon, Inglewood and Millmerran (Turallin).

It is anticipated that each non-resident workforce accommodation facility will be self-contained, including the provision of on-site temporary package sewage treatment plants. Sewage treatment plants with a capacity of 300 equivalent persons (EP) will be required to service each non-resident workforce accommodation facility. Odour impacts are possible even from small scale sewage treatment plants, such as those proposed.

The EPA Victoria guideline *Recommended separation distances for industrial residual air emissions* (EPA Victoria, 2013) provides guidance on suitable separation distances between wastewater treatment facilities and neighbouring sensitive receptors. Table 6.7 presents the calculation methods and derived separation distances for a 300 EP sewage treatment plant.

Table 6.7 Separation distances for sewage

Type of installation	EPA Victoria separation distance equation	Separation distance required for 300 EP sewage treatment plant (m)
Mechanical/biological wastewater plants	$10\ n^{1/3}$	67
Aerobic pondage systems	$5\ n^{1/2}$	87
Facultative ponds	$10\ n^{1/2}$	173

Table note:

n = equivalent population

Mechanical or biological wastewater treatment systems are likely to be used and therefore a minimum separation distance of 67 m should be maintained from neighbouring sensitive receptors to minimise odour impacts for neighbouring sensitive receptors.

6.3 Tank fuel storage

Fuel tank storage locations are proposed at 11 locations along the Project site during the construction of the Project. Table 6.8 presents the proposed construction areas that will include diesel fuel storage areas, the storage volumes proposed, and distances to the closest identified sensitive receptors.

Table 6.8 Fuel tank storage locations

Construction area ID	Chainage (km)	Location	Fuel storage proposed (L)	Distance from boundary of construction footprint to closest sensitive receptor
B2G-LDN006.3	6.3	Yelarbon-Kurumbul Road	10,000	15 m
B2G-LDN025.9	25.9	Yelarbon-Kurumbul Road (South)	10,000	95 m
B2G-LDN054.2	54.2	Cremascos Road	10,000	160 m
B2G-LDN074.0	74.0	Millmerran-Inglewood Road	10,000	680 m
B2G-LDN081.0	81.0	Millmerran-Inglewood Road	10,000	3.45 km
B2G-LDN116.5	116.0	Millmerran-Inglewood Road	20,000	120 m
B2G-LDN161.0	161.0	Pittsworth-Tummaville Road	20,000	250 m
B2G-LDN175.5	175.5	Linthorpe Road Bridge	10,000	95 m
B2G-LDN188.2	188.2	Athol School Road	10,000	80 m
B2G-LDN192.3	192.3	Athol School Road & Toowoomba Cecil Plains Road	10,000	575 m
B2G-LDN206.3	206.3	Leesons Road	10,000	70 m

For the largest fuel storage tanks of 20,000 L, the distance to the closest receptor is approximately 120 m, whilst for the smaller tanks of 10,000 L the distance to the closest receptor is 15 m.

EPA Victoria (EPA Victoria, 2013) provides guidance on separation distances for the storage of petroleum products (100 m for floating roof tanks, and 250 m for fixed roof tanks), but this guidance is for tanks exceeding 2000 tonnes, which is far greater than the size of the tanks proposed for the Project.

The BCC Service Station Code provides performance outcomes 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 an annual fuel throughput of less than 1.2 megalitres (ML) the acceptable separation distance is 10 m, whilst 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), whilst the 10,000 L tanks would need to be refilled more than twice per day (900 times per year). It is considered improbable that this volume of diesel will be consumed, and it is expected that annual fuel throughput will be considerably less than 9 ML.

All construction areas with the exception of B2G-LDN006.3 have a separation distance from the nearest boundary to the closest receptor of greater than 50 m. However, the dimensions of B2G-LDN006.3 are approximately 300 m x 27 m, and therefore the tank in this construction area is able to be located at a position that is further than 50 m from the nearest receptor and therefore, be located an acceptable distance away from the closest neighbouring sensitive receptor.

It is recommended that at minimum fuel tanks should be located at least 50 m from the nearest sensitive receptor, but separation distances should 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* is expected to result in negligible impacts to sensitive receptors based on the recommendations of the BCC Service Station Code.

7 Operational air quality impact assessment

7.1 Air quality

The results of the dispersion modelling for the operational phase assessment are presented in this section according to the increments presented in Table 7.1.

Table 7.1 Modelling increment descriptions

Increments	Description
Project only contribution	Represents the predicted concentrations from modelled Project locomotive emissions for peak train movements. Different versions of the model have been run to accurately assess emissions from the crossing loops as discussed in Section 5.3.2.4.
Background concentration	Adopted background concentrations as per Section 4.2.
Project only contribution + background concentration	The summation the Project only contribution and background concentration
Non-Project contribution	The modelled non-Project cumulative emission sources adjacent to the alignment, which include the Commodore Mine and Millmerran Power Station
Non-Project contribution + background concentration	The summation of the non-Project contribution and background concentration
Total cumulative concentration	The cumulative concentration from Project only contribution, non-Project contribution, and background concentration

Table 7.2 presents the highest total cumulative ground level concentrations at the worst impacted sensitive receptor for each pollutant for peak operation train numbers (2040). The predicted ground level concentrations have been compared against the relevant air quality objectives (refer Section 3). The air quality objectives adopted for the assessment are prescribed to protect the environmental values of health and wellbeing and protecting the aesthetic environment, which includes avoiding nuisance.

The results in Table 7.2 show that compliance has been predicted at all modelled sensitive receptors for all pollutants and all averaging periods for peak operational train numbers, with the exception of 24-hour average PM_{10}.

Exceedance of the 24-hour average PM_{10} air quality goal is predicted at sensitive receptor 186, located approximately 1.1 km to the north of the existing Commodore Mine and to the north of the Project alignment. Table 7.2 shows that the predicted PM_{10} 24-hour cumulative concentration at sensitive receptor 186 is 50.1 µg/m^3, which represents a 0.1 µg/m^3 exceedance of the air quality goal of 50 µg/m^3.

As discussed in Section 5.3.1.2, emission rates for the Commodore Mine were estimated using NPI emission data and scaled down for PM_{10} and $PM_{2.5}$ based on achieving compliance with their EA permit at existing sensitive receptors, specifically compliance with the PM_{10} 24-hour goal of 50 µg/m^3 at sensitive receptor 186. Therefore, based on the assessment methodology applied, the contribution of the Project to the exceedance at this receptor is considered to be minor.

There is uncertainty regarding emissions from the Commodore Mine due to the uncertainty in the NPI emission estimation methods and the absence of ambient monitoring data for the area local to the mine and Millmerran Power Station. Therefore there is also uncertainty regarding the accuracy of the predicted cumulative concentrations at receptors near the mine, including at sensitive receptor 186.

To improve the understanding of background air quality in the area local to the mine, an air quality monitoring station has been installed at a residential dwelling on Millmerran-Inglewood Road, Millmerran (sensitive receptor 188), which is located approximately 1.4 km to the north of Commodore Mine and approximately 300 m north of sensitive receptor 186. This location is considered representative of receptors near the mine and power station. Monitoring data from this location will improve understanding of ambient air quality and emissions from the mine, and will be used to guide the detail design and finalisation of the construction approach for the Project. Further discussion of the monitoring at this location is provided in Section 8.4.

Based on the results of the modelling, the operation of the Project is not expected to significantly adversely impact environmental values of the air environment. The assessment has considered background air quality in the prediction of cumulative concentration and deposition levels at sensitive receptors and has therefore considered the assimilative capacity of the air environment in determining the impact of the Project.

The assessment of operation phase impacts has considered peak train numbers, in the year 2040 (refer Table 2.4). As typical train numbers will be lower than peak volumes, predicted concentrations and dust deposition levels and the impact to sensitive receptors would be reduced for the typical number of train movements.

Predicted pollutant concentration contours are presented in Figure 7.1 to Figure 7.5. Figure 7.1 to Figure 7.3 present the cumulative concentration contours for PM_{10} (24 hour), $PM_{2.5}$ (annual) and NO_2 (1 hour) including all non-Project sources. To demonstrate the influence of the Commodore Mine and Millmerran Power Station on particulate matter concentrations, Figure 7.4 and Figure 7.5 present the concentration contours for PM_{10} (24 hour) and $PM_{2.5}$ (annual) excluding the mine and power station (e.g. the only non-Project sources included being the West Moreton System and the adjoining Inland Rail projects). The concentration contours presented include the adopted background concentrations and can be compared directly against the adopted air quality objectives (refer Section 3.6).

Table 7.2 Highest predicted ground level concentrations for identified sensitive receptors for peak operational train numbers in 2040

Pollutant	Average period	Highest predicted ground level pollutant concentration at identified sensitive receptor locations for peak operational train numbers in 2040					Highest Project contribution (A) sensitive receptor ID	Highest total cumulative concentration (A + B + C) sensitive receptor ID	Air quality goal (refer Section 3.6)	Units
		Project only contribution (A)	Background concentration (B)	Project only contribution + Background concentration (A + B)	Non-Project contribution (C)	Total cumulative concentration (A + B + C)[d]				
TSP	Annual average	0.5	42.8	43.3	14.7	57.5	R142	R183	90	µg/m^3
Deposited dust	30 day	0.1	50.0	50.1	0.1	50.2	R785	R184	120	mg/m^2/day
PM_{10}	24 hour, maximum	7.5	17.4	24.9	32.6	**50.1**	R785	R186	50	µg/m^3
	Annual average	0.5	17.1	17.6	4.9	22.1	R142	R184	25	µg/m^3
$PM_{2.5}$	24 hour, maximum	7.1	7.6	14.7	2.8	14.7	R785	R785	25	µg/m^3
	Annual average	0.5	6.5	7.0	0.4	7.0	R142	R183	8	µg/m^3
NO_2	1 hour, maximum	100.4 [a.]	57.5 [a.]	-[a]	-[a]	157.9 [a.]	R785	R785	250	µg/m^3
	Annual average	6.5 [a.]	7.8 [a.]	-[a]	-[a]	14.3 [a.]	R142	R142	62	µg/m^3
Arsenic and compounds	Annual average	4.7×10^{-5}	-[b.]	-[b.]	-[c.]	-[b.]	R142	R142	6	ng/m^3
Cadmium and compounds	Annual average	0.003	-[b.]	-[b.]	-[c.]	-[b.]	R142	R142	5	ng/m^3
Chromium III and compounds	1 hour, maximum	0.0006	-[b.]	-[b.]	-[c.]	-[b.]	R785	R785	9	µg/m^3
Chromium VI and compounds	1 hour, maximum	0.0006	-[b.]	-[b.]	-[c.]	-[b.]	R785	R785	0.1	µg/m^3
	Annual average	1.5×10^{-5}	-[b.]	-[b.]	-[c.]	-[b.]	R142	R142	0.01	µg/m^3
Lead and compounds	Annual average	1.4×10^{-5}	-[b.]	-[b.]	-[c.]	-[b.]	R142	R142	0.5	µg/m^3
Nickel and compounds	Annual average	2.2×10^{-5}	-[b.]	-[b.]	-[c.]	-[b.]	R142	R142	22	ng/m^3
Dioxins and furans	Annual average	1.8×10^{-13}	-[b.]	-[b.]	-[c.]	-[b.]	R785	R785	3×10^{-08}	µg/m^3

Pollutant	Average period	Highest predicted ground level pollutant concentration at identified sensitive receptor locations for peak operational train numbers in 2040					Highest Project contribution (A) sensitive receptor ID	Highest total cumulative concentration (A + B + C) sensitive receptor ID	Air quality goal (refer Section 3.6)	Units
		Project only contribution (A)	Background concentration (B)	Project only contribution + Background concentration (A + B)	Non-Project contribution (C)	Total cumulative concentration (A + B + C)[d]				
Polycyclic aromatic hydrocarbon (as benzo[a]pyrene)	Annual average	0.006	-[b.]	-[b.]	-[c.]	-[b.]	R785	R785	0.3	ng/m^3
1,3-butadiene	1 hour, maximum	0.07	-[b.]	-[b.]	-[c.]	-[b.]	R785	R785	2.4	µg/m^3
Benzene	Annual average	0.0007	5.2	5.2	0.0003	5.2	R785	R785	5.4	µg/m^3
Toluene	30 minute maximum[e]	0.009	23.0	23.0	0.001	23.0	R785	R785	1,100	µg/m^3
	24 hour, maximum	0.003	21.7	21.7	0.0002	21.7	R785	R785	4,100	µg/m^3
	Annual average	9.3×10^{-5}	18.5	18.5	4.5×10^{-5}	18.5	R785	R785	400	µg/m^3
Xylenes	24 hour, maximum	0.4	31.5	31.9	0.03	31.9	R785	R785	1,100	µg/m^3
	Annual average	0.01	26.0	26.0	0.006	26.0	R785	R785	950	µg/m^3

Table notes:

Cells shaded red denote exceedance of adopted air quality goal (refer Section 3.6)

a The OLM was used to determine NO_2 concentrations. The OLM method is complex as it uses modelled hourly NO_x concentrations and hourly varying background NO_2 and O_3 monitoring data from the Mutdapilly DES monitoring station for 2013. Due to the complexity of this process the emission sources included in the model, including cumulative sources, were modelled in the same model run and were not modelled individually. As a result, the individual contribution from Project and non-Project sources cannot be determined, however, based on the location of the worst affected receptors (R785 and R142) the predominant source at the worst affected receptors presented in Table 7.2 is the Project. The “Project only contribution (A)” listed in Table 7.2 has been calculated based on the predicted total cumulative concentration, minus the measured NO_2 background concentrations for Mutdapilly for 2013 (“Background concentration (B)”).

b No background monitoring data is available for this modelled pollutant.

c Compound not listed as a NPI pollutant from modelled non-Project emission sources, and therefore nil value is presented.

d The highest Project only contribution (A) and the highest non-Project contribution (C) may be predicted at different receptors and therefore the total cumulative concentrations does not necessarily equal the sum of the values A, B and C presented in this table.

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

7.2 Tank water impacts

Impacts to tank water have been assessed using the methodology described in Section 5.4.

Table 7.3 presents the highest predicted pollutant concentrations for the water tank of the sensitive receptor worst affected by the Project. Table 7.3 also presents the drinking water guideline values prescribed by the Australian Drinking Water Guidelines (NHMRC, NRMMC, 2018).

Table 7.3 shows that at the worst affected receptor for the peak train number scenario in 2040, compliance is predicted for all pollutants by a significant margin. As typical train numbers will be lower than the peak numbers applied, impacts to tank water would generally be less than that predicted.

As compliance with the drinking water guideline values is predicted by a significant margin, the residual impact to drinking water as a consequence of the Project is expected to be insignificant.

Table 7.3 Highest predicted water tank concentrations at sensitive receptors

Pollutant	Receptor	Maximum predicted annual deposition rate (µg/m²/s)	Estimated roof area (m²)	Maximum predicted total deposited mass (microgram (µg))	Tank water volume (L)	Highest predicted concentration (mg/L)	Guideline value (mg/L)
Arsenic	R785	1.4×10^{-10}	200[a.]	0.9	1000[b.]	8.7×10^{-7}	0.01
Cadmium		9.6×10^{-9}		60.7		6.1×10^{-5}	0.002
Lead		4.1×10^{-10}		2.6		2.6×10^{-6}	0.01
Nickel		6.3×10^{-8}		398.6		4.0×10^{-4}	0.02
Chromium VI		4.5×10^{-8}		285.9		2.9×10^{-4}	0.05

Table notes:

a. Based upon the average surface area of a large house.

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

7.3 Agricultural train odour impacts

The impacts from agricultural train odour have been assessed using the methodology described in Section 5.5. Odour emissions from agriculture freight train pass-bys are expected to be highly diluted due to the volume of air which 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 nuisance impact.

Table 7.4 presents an assessment of odour impacts from livestock freight trains using the FIDOL factors described in Section 5.5. Livestock trains are considered to be the agriculture freight with the highest potential to impact sensitive receptors (greater potential than grain, as an example) and therefore have been adopted for the assessment of odour.

Table 7.4 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 Project rail 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 train pass-by (2 minutes 42 seconds for a 3,600 m train travelling at 80 km/h). At crossing loops, the exposure is expected to be longer (estimated average of approximately one hour) but will still be relatively short.
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 agricultural and residential for the larger town centres of Yelarbon, Inglewood, Millmerran, Pittsworth, Southbrook, Kingsthorpe and Gowrie. Due to the land use of the receiving environment intermittent odour from agricultural activities and livestock is unlikely to be uncommon to the existing ambient air environment. People living and visiting rural areas are expected to have a higher tolerance for rural activities and their associated effects, such as odour.

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 of the nearest sensitive receptors and the sensitivity of the receptor to odour. However, impacts are expected to be infrequent and of a short duration (one hour or less), and the Project is located in a predominantly rural area where intermittent odour from agricultural uses are likely to be common to the existing ambient air environment. Based on the reasoning provided, odour emissions from agriculture freight are considered unlikely to result in significant impact to neighbouring sensitive receptors.