Regional Rail Fleet Project
Dubbo Maintenance Facility REF

Transport for NSW

Air Quality Impact Assessment

Final

1 August 2018

Regional Rail Fleet Project - Dubbo Maintenance Facility REF

Project No:	IA175200.400
Document Title:	Air Quality Impact Assessment
Document No.:	D0
Revision:	v3
Date:	1 August 2018
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File Name:	\\Jacobs.com\ANZ\IE\Projects\04_Eastern\IA175200\Technical\Air Quality\Regional Rail Program_Dubbo Maintenance Facility_AQIA_Final.docx

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Document history and status

Revision	Date	Description	By	Review	Approved
D0vA	02/07/2018	Initial draft for internal technical review	LS	MD	MD
D0v0	03/07/2018	First draft for client review	LS	AB	AB
D0v1	17/07/2018	Second draft following client review	LS	AB	AB
D0v2	26/07/2018	Minor edits by PM	AB	AB	AB
D0v3	31/07/2018	Fourth draft following additional minor client comments	LS	AB	AB
Final	1/8/2018	Final			AB

Contents

Executive Summary

Introduction and purpose of this report

As part of the Regional Rail Fleet Project, Transport for NSW plans to develop a maintenance facility at Dubbo (the Proposal), NSW to maintain a new train fleet that would replace XPT, XPLORER and Endeavour services. This document provides and assessment of potential air quality impacts associated with the construction and operational phases of this Proposal. The objectives of this assessment were to:

- Identify and assess potential air quality impacts associated with the construction and operational phases of the Proposal, including cumulative and regional considerations in accordance with current guidelines.
- Demonstrate the Proposal's ability to comply with the relevant regulatory framework, specifically the *Protection of the Environment Operations Act 1997* and the *Protection of the Environment Operations (Clean Air) Regulation (2010)*.

Assessment overview and key findings

To determine potential impacts to local and regional air quality during construction a qualitative, risk-based assessment was undertaken using the method described in *Guidance on the assessment of dust from demolition and construction Version 1.1* (UK IAQM, 2014). The assessment determined that there was a moderate risk of dust impacts during construction, and that safeguards would be required.

Impacts to local and regional air quality during operations were evaluated by quantitative modelling, using the CALMET/CALPUFF meteorological and dispersion model. Emission estimates from trains at the Proposal were estimated using guidance from *Emission Factors for Locomotives EPA-420-F-09-025* (United States Environmental Protection Agency, 2009). Emissions from surface preparation and coating/ graffiti removal activities planned at the site were estimated using *Emission estimation technique manual for Railway yard operations Version 2.0* (Commonwealth Department of the Environment, Water, Heritage and the Arts [DEWHA], 2008) and *Emission Estimation Technique Manual for Surface Coating* (QLD Department of Environment and Heritage, 1999) respectively. Emissions from the planned on-site diesel storage tank were estimated using the US EPA TANKS program (version 4.0.9d).

Recommendations and conclusion

To mitigate and otherwise effectively manage the potential air quality risks predicted during construction, standard and additional measures are recommended. These include appropriate work practices and scheduling, consultation, equipment selection, monitoring and preventative controls.

During operations, impacts associated with the Proposal are predicted to be minimal and would be unlikely to result in exceedances of the impact assessment criteria from the *Approved Methods for Modelling and Assessment of Air Pollutants in NSW* (Approved Methods) (NSW Environment Protection Authority, 2016) for the relevant pollutants assessed.

1. Introduction

As part of the Regional Rail Fleet Project (RRFP), Transport for NSW (TfNSW) plans to construct a maintenance facility at Dubbo (the Proposal), NSW to maintain a new train fleet that would replace XPT, XPLORER and Endeavour services. Jacobs was engaged by TfNSW to prepare a Review of Environmental Factors (REF) for the construction and operation of the Proposal. Impacts to local air quality have been identified as a potential risk during the Proposal, and are assessed in this Air Quality Impact Assessment (AQIA) report which supports the REF.

The objectives of this assessment were to:

- Provide a brief overview of the Proposal, including any aspects particularly relevant air quality (**Section 2.1**).
- Identify key construction and operational air quality risks (**Section 2.2**).
- Detail the overall method of assessment (**Section 3**).
- Determine criteria for assessing potential impacts associated with the Proposal based on guidance presented in the relevant statues and guidelines (**Section 4**).
- Characterise key features of the environment surrounding the Proposal including nearby sensitive receivers, land uses, terrain features, prevailing climate and meteorological conditions and ambient air quality (**Section 5**).
- Assess potential air quality impacts during construction (**Section 6**).
- Develop an inventory of emissions to air during operations (**Section 7**).
- Assess potential impacts during operations (**Section 8**).
- Develop suitable mitigation and monitoring measures as identified to be necessary, including an evaluation of how they would achieve any required levels of reduction (**Section 9**).

2. Proposal overview

2.1 Key features

The Proposal would comprise six tracks each capable of holding 200 metre trains, with three of these roads being partly covered by the maintenance building. The key features of the Proposal would comprise the following:

- Maintenance facility elements:
  - A maintenance building would include three tracks to undertake maintenance activities partly housed within a single covered enclosure. The size of the building would be approximately 220 metres by 30 metres.
  - Wheel lathe – a separate building allowing for train wheels to be periodically machined using an underfloor wheel lathe.
  - Train wash – an enclosed structure comprising automated wash equipment for train sets with nearby waste water treatment plant.
- Administration building – a building comprising office facilities, kitchen, dining area and amenities.
- Security building.
- Storage area, loading dock and fuel delivery area – used for the delivery and storage of plant, equipment and fuel.
- Rail infrastructure works:
  - Realignment of the Main Western Line through the site.
  - Six maintenance rail tracks (three tracks within the maintenance facility building and three external).
  - A connection to the Main Western Line on the western side of the site.
  - Decanting and provisioning infrastructure.
- Road vehicle infrastructure:
  - Access roads throughout the site.
  - Staff car park.
- Power supply including a substation, and utility adjustments.
- Relocated detention basins.
- Earthworks.

Subject to approval, construction is expected to commence in 2019 and take around 30 months to complete. Operation of the maintenance facility is scheduled to commence in 2021.

2.2 Primary air quality-related risks

2.2.1 Construction

Dust generated during demolition, excavation, materials handling and compaction activities is expected to be the primary air quality-related risk during construction. Dust is a general term used to describe particulate matter in the form of total suspended solids (TSP) or particulate matter with a smaller aerodynamic diameter (PM_{10} and $PM_{2.5}$). When not properly managed, airborne dust has the potential to cause adverse health and nuisance effects.

Other potential air quality issues during construction would be localised and are expected to include exhaust emissions associated with combustion of fossil fuels, and the potential for odours associated with some excavated materials.

2.2.2 Operations

Emission estimation technique manual for Railway yard operations Version 2.0 (Commonwealth Department of the Environment, Water, Heritage and the Arts [DEWHA], 2008) describes likely types and sources of emissions to air from typical operations at railway yard facilities:

- Combustion products (oxides of nitrogen [NO_x], carbon monoxide [CO], sulfur dioxide [SO_2], total and speciated volatile organic compounds [VOCs] and particulate matter [PM_{10} and $PM_{2.5}$]) from the operation of diesel locomotives.
- Emission of VOCs from the storage and transfer of fuels.
- Combustion products emitted from on-site vehicle operations.
- Emissions from maintenance activities (e.g. oil and grease removal, car and locomotive cleaning, rust removal, paint preparation, surface coating and finishing, and spraying and cleaning operations).

These are also expected to be the primary sources of operational emissions to air from the Proposal during operations.

3. Method of assessment

The methodology followed in assessing and evaluating potential impacts during the Proposal is outlined in the following bullet points:

- **Identify key air quality risks associated with the Proposal:** Details of the Proposal were reviewed to determine the primary air quality risks at the site. This stage of the assessment is described above in **Section 2.2**.
- **Determine assessment criteria:** Criteria for assessing potential air quality impacts associated with the Proposal were developed based on guidance presented in relevant statutes and guidelines. The criteria adopted for the assessment are presented in **Section 4**.
- **Identify surrounding receivers and land uses:** Nearby sensitive receivers in relation to the Proposal site were identified using aerial imagery. Designated land uses around the Proposal were determined from the Local Environment Plan (LEP) accessed using the Planning Portal provided by the NSW Department of Planning and Environment. Identified surrounding receivers and land uses are described in **Section 5.1**.
- **Determine local physical environment characteristics and prevailing climate and meteorological conditions:** A digital terrain model (DTM) was developed for the area around the site using 30 m resolution elevation data obtained from the NASA Shuttle Radar Tomography Mission (SRTM3). Terrain around the Proposal is described in **Section 5.2**.

  Prevailing climate and meteorological conditions around the Proposal were determined using data collected at the nearby automatic weather station (AWS) operated by the Bureau of Meteorology (BoM) at Dubbo Airport (station number 065070). Annual and seasonal wind roses were developed using meteorological data collected in 2013, 2014, 2015, 2016 and 2017. This step in the assessment is presented in **Section 5.3**.
- **Establish background air quality conditions:** Background air quality conditions around the proposal were reviewed from data collected at the nearest ambient air quality monitoring stations operated by the NSW Office of Environment and Heritage (OEH), and other publically available records from nearby private monitoring stations. These data are presented and discussed in **Section 5.4**.
- **Assessment of potential impacts:** Impacts during construction were evaluated using the method described in *Guidance on the assessment of dust from demolition and construction Version 1.1* (UK IAQM, 2014). Details and findings from this review are presented in **Section 6**.

  Emissions to air during operations were quantitatively assessed using the CALMET/CALPUFF meteorological and dispersion model. Emission estimates from trains at the Proposal were estimated using guidance presented in *Emission Factors for Locomotives EPA-420-F-09-025* (United States Environmental Protection Agency, 2009). Emissions from activities at the site were evaluated using *Emission estimation technique manual for Railway yard operations Version 2.0* (Commonwealth Department of the Environment, Water, Heritage and the Arts [DEWHA], 2008) and *Emission Estimation Technique Manual for Surface Coating* (QLD Department of Environment and Heritage, 1999) for surface preparation and coating/ graffiti removal activities respectively. Emissions from the planned on-site diesel storage tank were estimated using the US EPA TANKS program (version 4.0.9d). The emissions calculated and assessment scenarios determined are presented in **Section 7**.

  Details of the operational assessment are described in **Section 8** including specific setup details for the meteorological (TAPM and CALMET) and dispersion (CALPUFF) models; and the results of the assessment
- **Development of monitoring and management measures:** Based on the outcomes of the assessment, mitigation and monitoring measures were developed as determined to be necessary. Measures were reviewed to evaluate their ability to achieve any required levels of reduction. This is discussed in **Section 9**.

4. Policy setting and criteria

Emissions to air from activities in NSW are regulated under the *NSW Protection of the Environment Operations Act 1997 (POEO Act)*, *Protection of the Environment Operations (Clean Air) Regulation 2010 (POEO Clean Air Regulation),* and *Protection of the Environment Operations (General) Regulation 2009, Part 5.4 Air pollution*. The Clean Air Regulation 2010 provides emission concentration limits for scheduled and non-scheduled activities as identified in Schedule 1 of the POEO Act. ‘Railway systems activities’ are a scheduled activity related to the Proposal, though none of the Group 6 standards of concentration listed in Schedule 4 of the Clean Air Regulation 2010 are generally applicable. It is understood that the NSW Environment Protection Authority (EPA) are presently considering emission limits for non-road vehicles, but that these are likely to be set at United States Environmental Protection Agency Tier 4 emission performance levels which the new locomotives are already expected to meet.

The Approved Methods (NSW EPA, 2016) outlines the approach to be applied for the modelling and assessment of air pollutants in NSW. The guideline contains ‘impact assessment criteria’ for assessing potential air quality impacts associated with an activity. Criteria relevant to the pollutants related to the Proposal have been reproduced below in **Table 4-1**.

Table 4-1 Impact assessment criteria

Pollutant	Averaging time	Ground level concentration (GCL) impact assessment criteria	Criteria applies at:
Particulate matter			
Total suspended particulates (TSP)	Annual	90 µg/m³ m³ (100th percentile)	Nearest existing or likely future off-site sensitive receptors
Deposited dust	Annual	2 g/m²/month (100th percentile) increment 4 g/m²/month (100th percentile) total	
Solid particles (as PM_{10})	24 hours	50 µg/m³ (100th percentile)	
	Annual	25 µg/m³ (100th percentile)	
Solid particles (as $PM_{2.5}$)	24 hours	25 µg/m³ m³ (100th percentile)	
	Annual	8 µg/m³ m³ (100th percentile)	
Gases			
Sulfur dioxide (SO_2)	10 minute	712 µg/m³ (100th percentile)	Nearest existing or likely future off-site sensitive receptors
	1 hour	570 µg/m³ (100th percentile)	
	24 hours	228 µg/m³ (100th percentile)	
	Annual	60 µg/m³ (100th percentile)	
Nitrogen dioxide (NO_2)	1 hour	246 µg/m³ (100th percentile)	
	Annual	62 µg/m³ (100th percentile)	
Carbon monoxide (CO)	15 minutes	100 mg/m³ (100th percentile)	
	1 hour	30 mg/m³ (100th percentile)	
	8 hours	10 mg/m³ (100th percentile)	
Toxic air pollutants			
Acetone	1 hour	22,000 µg/m³ (99.9th percentile)	At and beyond the site boundary
Ammonia	1 hour	330 µg/m³ (99.9th percentile)	
Arsenic & compounds	1 hour	0.09 µg/m³ (99.9th percentile)	

Pollutant	Averaging time	Ground level concentration (GCL) impact assessment criteria	Criteria applies at:
Benzene	1 hour	29 µg/m^3 (99.9th percentile)	
1,3-Butadiene	1 hour	40 µg/m^3 (99.9th percentile)	
Cadmium & compounds	1 hour	0.018 µg/m^3 (99.9th percentile)	
Chromium III compounds	1 hour	9 µg/m^3 (99.9th percentile)	
Chromium IV compounds	1 hour	0.09 µg/m^3 (99.9th percentile)	
Copper	1 hour	18 µg/m^3 (99.9th percentile)	
Cyclohexane	1 hour	19,000 µg/m^3 (99.9th percentile)	
Dioxins and furans	1 hour	2.0E-6 µg/m^3 (99.9th percentile)	
Ethylbenzene	1 hour	8000 µg/m^3 (99.9th percentile)	
Lead & compounds	Annual	0.5 µg/m^3 (100th)	Nearest existing or likely future off-site sensitive receptors
n-Hexane	1 hour	3200 µg/m^3 (99.9th percentile)	At and beyond the site boundary
Nickel & compounds	1 hour	0.18 µg/m^3 (99.9th percentile)	
Individual odorous substances			
Cumene	1 hour	21 µg/m^3 (99.9th percentile)	Nearest existing or likely future off-site sensitive receptors
Ethyl acetate	1 hour	12,100 µg/m^3 (99.9th percentile)	
Methyl ethyl ketone	1 hour	3,200 µg/m^3 (99.9th percentile)	
Methyl isobutyl	1 hour	230 µg/m^3 (99.9th percentile)	
Toluene	1 hour	360 µg/m^3 (99.9th percentile)	
Xylenes	1 hour	190 µg/m^3 (99.9th percentile)	

The criteria for TSP, PM_{10}, $PM_{2.5}$, SO_2, NO_2, Lead and CO relate to the 100th percentile or maximum predicted concentration from the activity, plus the existing background level. Impact assessment criteria for these pollutants apply to the nearest existing or likely future sensitive receiver areas in relation to the Proposal. The criteria for the identified air toxic pollutants (except Lead) relate to the 99.9th highest 1-hour averaged ground level concentration predicted (i.e. 9th highest for a year of 1 hour records) due to Proposal related activities only, noting the use of site-specific data, and applying the ground level concentrations criteria at the boundary of the Proposal. The same 99.9th highest, 1-hour averaged ground level concentration applies for the identified individual odorous substances, though these apply at the nearest existing or likely future off-site receiver rather than the Proposal boundary.

5. Existing environment

This section of the report describes the existing environment around the Proposal location as relevant to air quality including surrounding receivers; land use; terrain; prevailing climate and meteorology; and, regional ambient air quality conditions.

5.1 Surrounding sensitive receivers

Section 5.2 of the Approved Methods considers ‘sensitive receptors’ as locations where sensitive land uses take place including ‘residences, schools and hospitals’, including locations where such uses are likely. The nearest residential receiver areas in relation to the Proposal include:

- Receivers less than 100 metres to the north of the site along Darby Close, White Street and Welchman Street.
- Receivers around 250 metres to the northeast off Hopkins Parade and Bonner Crescent.
- Receivers to the east, southeast, south and southwest along Aspen Road, Kurrajong Court, Maple Court, Cedar Court, Mulga Court, Boronia Place, Grevillea Close, Hakea Place and Wingewarra Street.
- Wingewarra Street, Hakea Place, Grevillea Close, Aspen Road, Boronia Place, Mulga Court, Cedar Court, Maple Court and Kurrajong Court.
- Receivers 200 metres or more to the west and northwest along Fitzroy Street.

The nearest non-residential sensitive receiver locations in relation to the Proposal are:

- Dubbo North Public School located 500 metres to the northwest.
- TAFE Western – Dubbo Myall Street Campus 400 metres to the north.
- TAFE Western – Dubbo Fitzroy Street Campus 700 metres to the southwest.
- Saint Mary’s Primary School 700 metres to the northeast.
- Orana Heights Public School 500 metres to the southeast.
- Dubbo Christian School 1,050 metres to the southeast.
- Central West Leadership Academy 700 metres to the southwest.
- Mian School 1,100 metres to the southwest.
- Dubbo Public School 1,000 metres to the west.
- Dubbo Base Hospital 650 metres to the north.
- Dubbo Private Hospital 1,000 metres to the north.
- Lourdes Hospital and Community Health Service 950 metres to the northeast.

Seven representative receiver locations were identified around the Proposal which is displayed below in **Figure 5-1**.

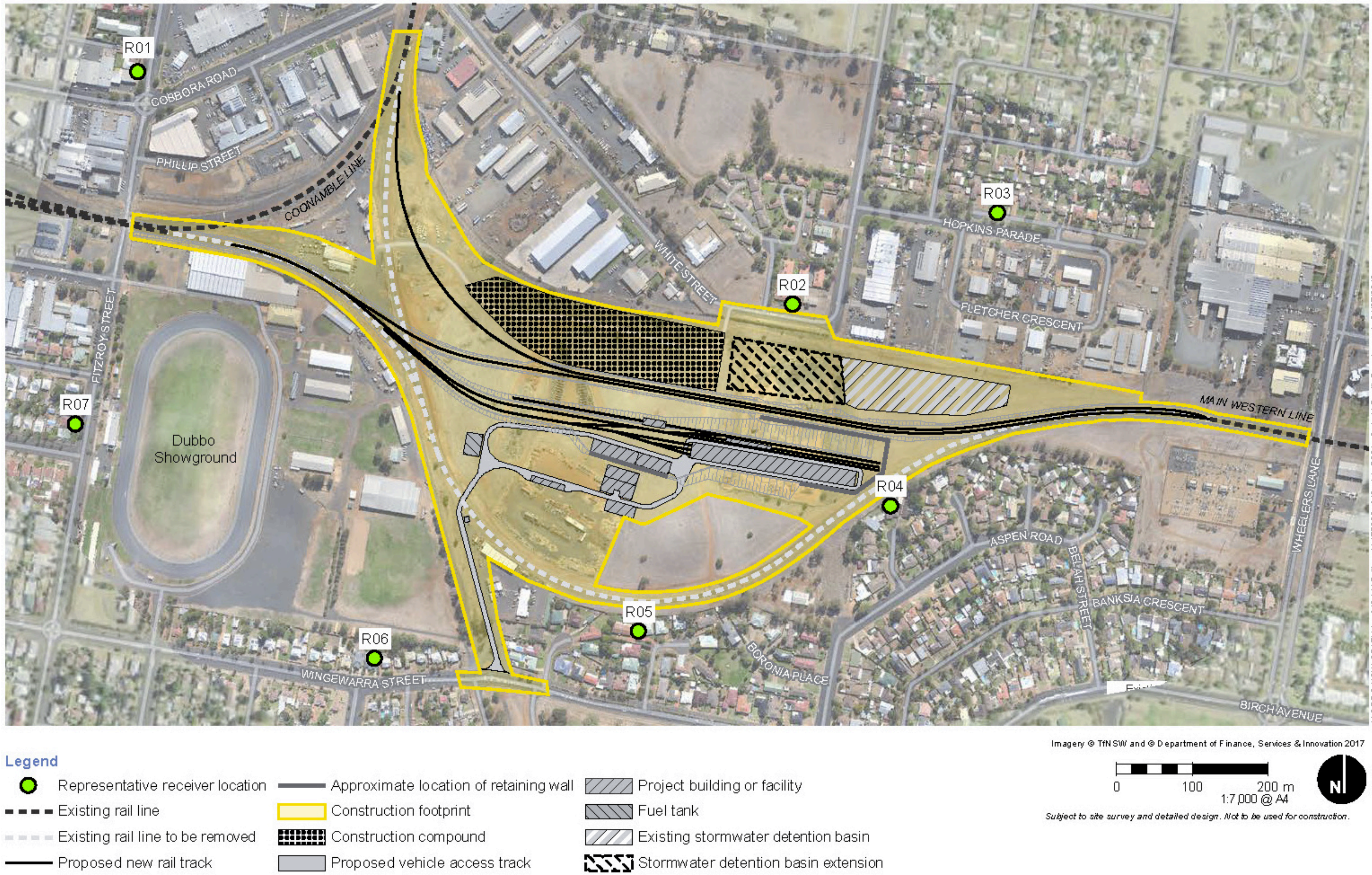


Figure 5-1 Representative air quality receiver locations

5.2 Terrain

A digital terrain model (DGM) around the Proposal was developed using 30 metre resolution ground elevation data obtained from NASA SRTM3. As displayed in the schematic shown in **Figure 5-2**, terrain around the Proposal study area is generally flat, with ground elevations ranging between approximately 250 and 350 metres above sea level.

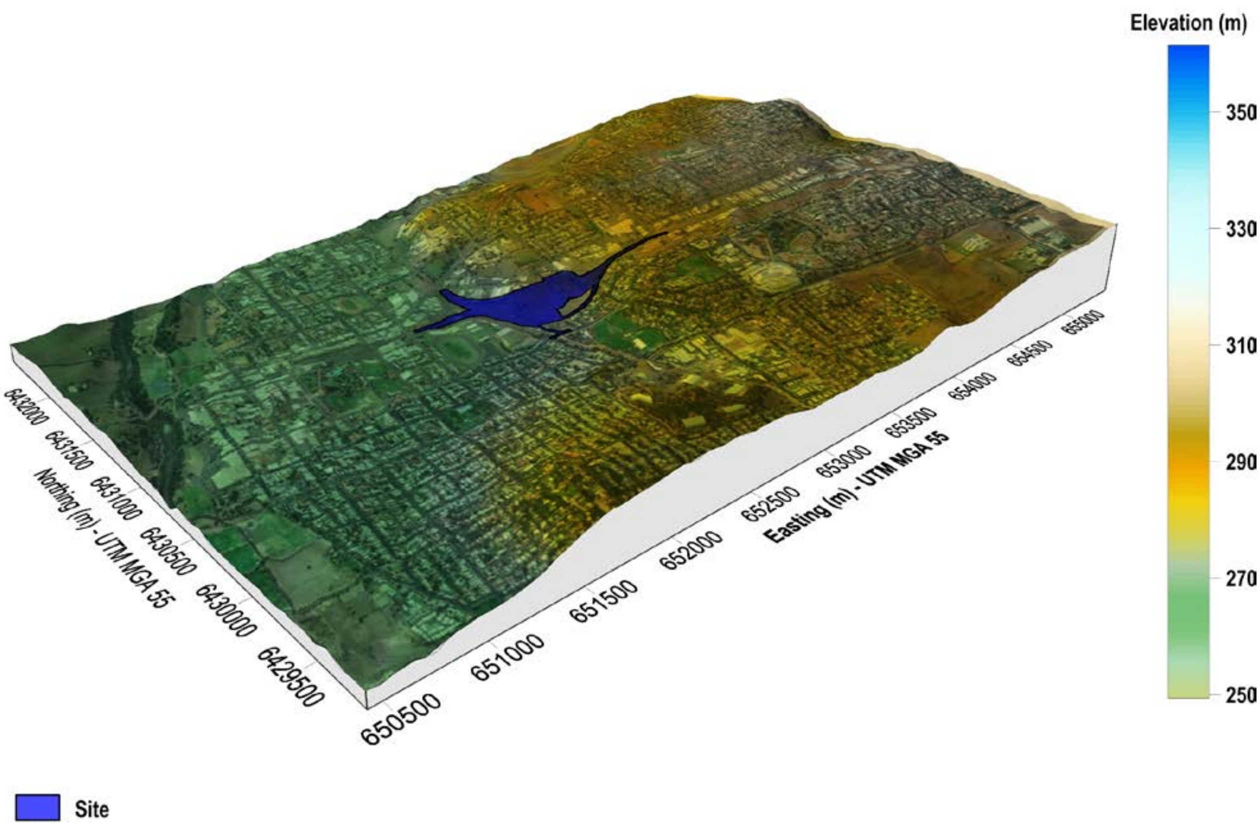


Figure 5-2 Schematic of terrain around the Proposal

5.3 Climate and meteorology

5.3.1 Climate

The nearest weather station with long-term historical climate records is the Dubbo Airport (station number 065070). This station is located approximately five and a half kilometres to the northwest of the Proposal. **Table 5-1** displays long-term temperature and rainfall averages recorded at this station from 1993 (date of commencement of measurement) to 5 December 2017.

Table 5-1 Long-term temperature and rainfall data collected at the BoM Dubbo Airport AWS from 1993 to 5 December 2017

Month	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean rainfall (mm)	Mean number of rain days (> 1 mm)
January	33.3	18.2	56.6	5
February	32	17.6	43.4	4.5
March	28.9	14.6	63.3	5
April	24.7	10.2	33.9	3.1

Month	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean rainfall (mm)	Mean number of rain days (> 1 mm)
May	20	6.5	41.2	4.1
June	16.3	4.4	51.9	5.8
July	15.5	3	43	5.2
August	17.5	3.2	35.2	3.9
September	21.2	6	44.3	4.9
October	25	9.4	45.6	5
November	28.7	13.5	60.3	5.6
December	31.4	15.9	62.4	5
Annual	**24.5**	**10.2**	**583.4**	**57.1**

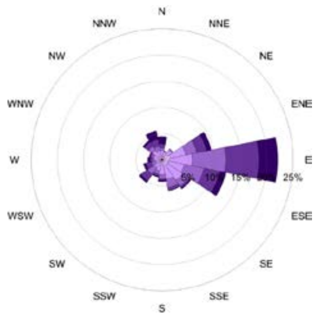
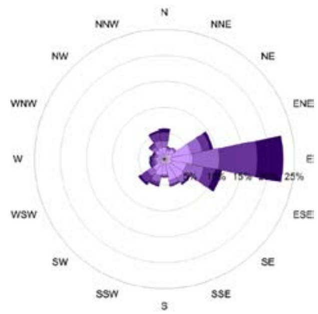
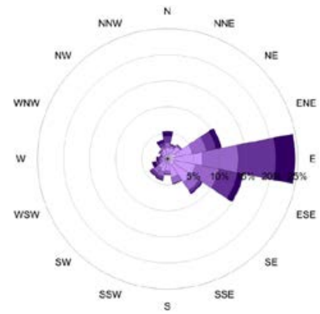
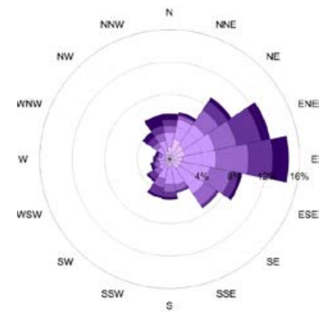
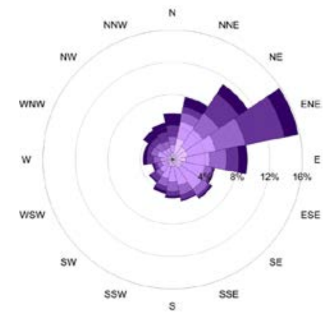
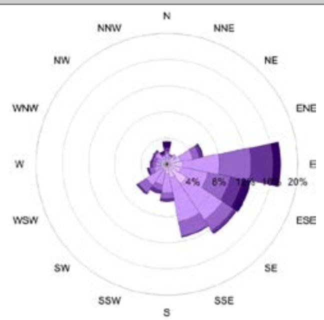
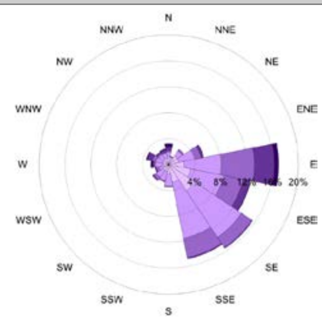
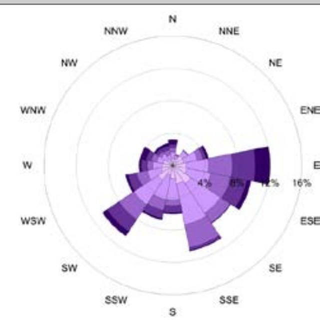
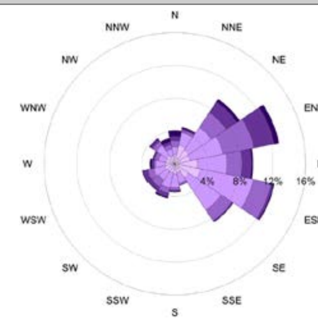
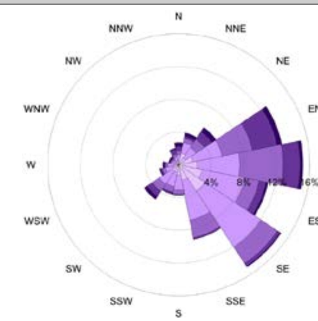
These data indicate that the locality around the Proposal experiences warm summers with mean daily maximum temperatures of around 32 degrees Celsius. Months through winter are the coldest with average mean daily maximum temperatures of approximately 16 degrees Celsius. November to March are the wettest months, where an average of 57 millimetres (mm) per month have been recorded. Rainfall is considerable lower from April to October with an average of 42 mm per month

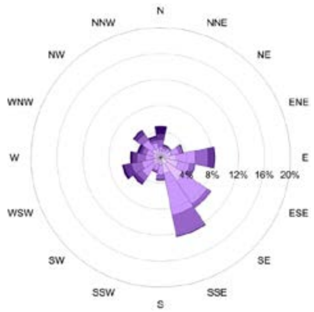
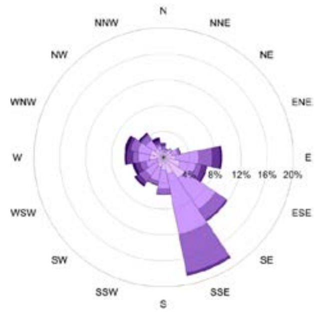
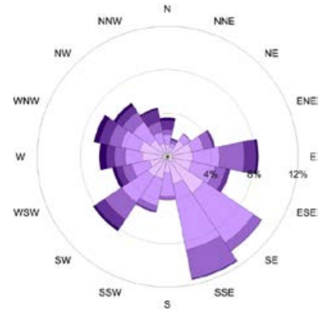
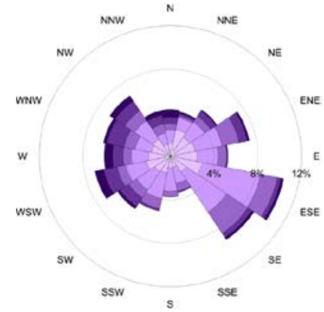
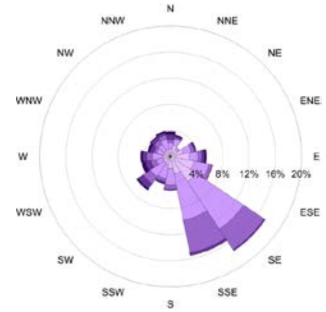
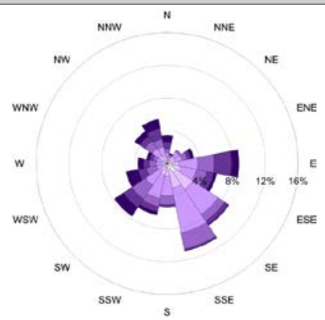
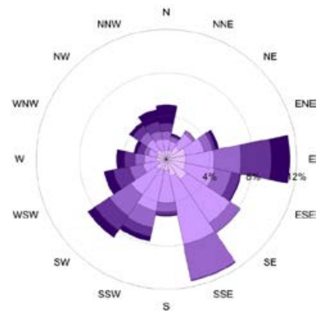
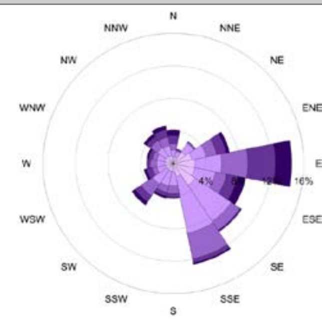
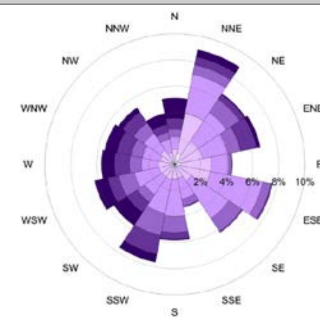
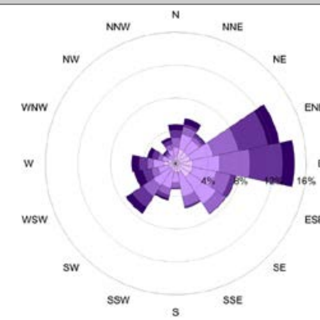
5.3.2 Meteorology

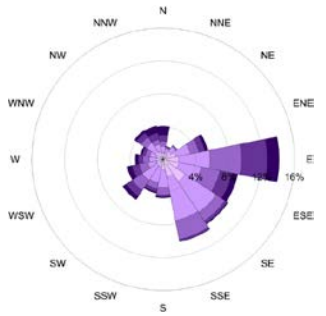
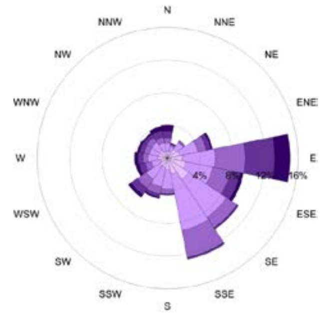
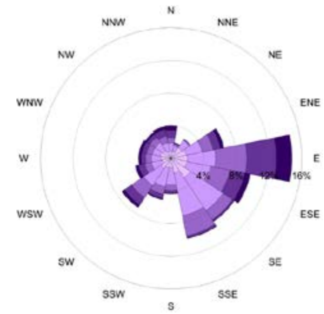
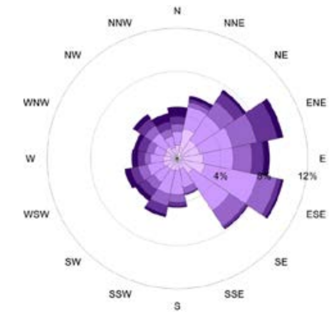
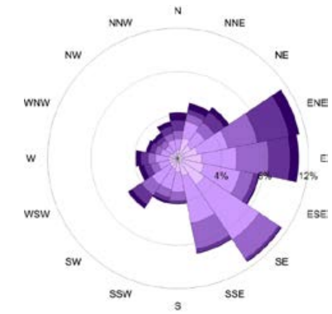
Meteorological conditions are important for determining the direction and rate at which emissions from a source would disperse. The key meteorological requirements for an air dispersion model typically include hourly records of wind speed, wind direction, temperature, atmospheric stability class and mixing layer height. For air quality assessments, a minimum one year of hourly data is usually required, which means that almost all possible meteorological conditions, including seasonal variations, are considered in the simulations.

Annual and seasonal wind roses for data recorded at Dubbo Airport AWS from 2013 to 2017 are displayed below in **Table 5-2**.

Table 5-2 Annual and seasonal wind roses for 2013, 2014, 2015, 2016 and 2017 from data measured at the Dubbo Airport AWS

2013	2014	2015	2016	2017
Summer				
				
Calms: 2.5%	Calms: 1.4%	Calms: 1.5%	Calms: 2.2%	Calms: 2.4%
Autumn				
				
Calms: 4.1%	Calms: 4.3%	Calms: 3.8%	Calms: 7.2%	Calms: 2.9%

2013	2014	2015	2016	2017
Winter				
 Calms: 17.8%	 Calms: 5.3%	 Calms: 5.1%	 Calms: 5.5%	 Calms: 5.9%
Spring				
 Calms: 13.9%	 Calms: 2.4%	 Calms: 3.3%	 Calms: 5.3%	 Calms: 2.8%

2013	2014	2015	2016	2017
Annual				
				
Calms: 9.6%	Calms: 3.4%	Calms: 3.4%	Calms: 5.1%	Calms: 3.5%
Legend				

Wind speed (m/s)

- >0.5 - 1.5
- >1.5 - 3
- >3 - 4.5
- >4.5 - 6
- >6 - 7.5
- >7.5

The annual and seasonal wind roses for these five years are generally consistent, with the following typical trends observed for each season:

- Summer – Winds blowing from the east and east northeast are most common, with calm conditions occurring around 2% of the time.
- Autumn – Winds from the east and southeast are most common, with calm conditions taking place 3 to 7% of the time.
- Winter – Prevailing winds blowing from the south southeast are most common, with calm conditions generally taking place around 5% of the time.
- Spring – Prevailing winds from the east, and southeast, with calm conditions generally occurring 3 to 5% of the time.

The frequency of different Pasquill-Gifford stability categories determined each year using the sigma-theta method are summarised below in **Table 5-3**. Class A represents the most unstable meteorological conditions, whereas Classes F and G constitute highly stable conditions; with Classes B to E reflecting the transition between these extremes and Class D considered to represent neutral conditions.

Table 5-3 Stability class statistics determined from data measured at BoM Dubbo Airport from 2013 to 2017

Stability Class	2013	2014	2015	2016	2017
A	4.0%	4.8%	4.1%	4.5%	4.3%
B	5.0%	4.7%	4.3%	4.5%	4.7%
C	9.0%	8.3%	8.4%	8.8%	9.8%
D	45.4%	45.7%	47.6%	46.9%	49.0%
E	27.8%	29.7%	28.3%	27.7%	26.7%
F and G	8.9%	6.6%	7.3%	7.6%	5.5%

Given its proximity to the Proposal, conditions at the BoM Dubbo Airport AWS are expected to be similar, and data from this location were used to select a representative year for the purpose of modelling. The 2017 dataset was selected as it was the most recent year with complete records and it displayed similar meteorological conditions to the general trends observed in the other four years reviewed.

5.4 Ambient air quality

5.4.1 Air quality index

NSW Office of Environment and Heritage (OEH) developed a metric known as the 'air quality index' (AQI) to provide an indication of the overall air quality. The metric considers pollutant data measurements for ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2) and PM_{10}, as well as visibility against criteria presented in the *Variation to the National Environment Protection (Ambient Air Quality) Measure* (National Environment Protection Council, 2015) standard for visibility. These readings are converted to a single overall value, known as the AQI using the formula:

$$AQI\ pollutant = \frac{Pollutant\ data\ reading}{Standard} \times\ 100$$

Table 5-4 provides a scale for relating AQI values to a qualitative indication of individual and relative air quality.

Table 5-4 AQI value classifications, (http://www.environment.nsw.gov.au/aqms/aqi.htm)

AQI value	Resulting classification
0 to 33	Very good
34 to 66	Good
67 to 99	Fair
100 to 149	Poor
150 to 199	Very poor
Greater than 200	Hazardous

Statistics generated from daily AQI values calculated at the nearest OEH air quality stations (Bathurst and Tamworth) for 2014 to 2017 are presented below in **Table 5-5**. These statistics indicate that daily AQI values are generally 'very good' to 'good' with occasional days of 'fair' air quality or worse, expected to be driven by particulate matter concentrations.

Table 5-5 Bathurst and Tamworth AQI value statistics (2014-2017)

Period	Bathurst AQI value statistics			Tamworth AQI value statistics		
	Annual daily average	95th percentile of daily values	Annual daily maximum	Annual daily average	95th percentile of daily values	Annual daily maximum
2014	29	58	86	32	55	133
2015	27	57	189	28	49	105
2016	29	53	68	34	59	103
2017	30	51	100	35	62	108

5.4.2 Background concentrations

The NSW OEH operates a state wide air quality monitoring network which provides information on current and historical air quality. The network includes numerous air quality stations across NSW. Data from six stations, located between approximately 200 to 470 kilometres from the Proposal, were used to characterise ambient air quality conditions for the available pollutants of potential concern relevant to the assessment around the study area. Pollutants of concern and the relevant monitoring stations where they are measured are listed below in **Table 5-6**.

Table 5-6 Summary of pollutants measured at nearby OEH monitoring stations

OEH air quality monitoring station	Location	Nitrogen dioxide (NO_2)	Sulfur dioxide (SO_2)	Carbon monoxide (CO)	Particulate matter PM_{10}	Particulate matter $PM_{2.5}$
Bathurst	Morrisset Street	-	-	-	✓	✓
Gunnedah	Kitchener Park, Osric Street	-	-	-	✓	✓
Tamworth	Hyman Park, Robert Road	-	-	-	✓	✓
Oakdale	Ridge Road	✓	-	-	✓	✓
Bargo	Silica Road	✓	✓	-	✓	✓

OEH air quality monitoring station	Location	Nitrogen dioxide (NO_2)	Sulfur dioxide (SO_2)	Carbon monoxide (CO)	Particulate matter PM_{10}	Particulate matter $PM_{2.5}$
Wyong	Wyong Racecourse	✓	✓	✓	✓	✓

The most recent (2014 - 2017) publically available results measured at each station are presented by pollutant for each relevant averaging period in **Table 5-7**. All units are presented in µg/m^3 except CO which is reported in mg/m^3. **Table 5-7** also includes the 95th percentile concentrations (typically used to characterize background levels for averaging times other than annual) and the number of times per year that the impact assessment criteria were exceeded, for 24-hour averaged PM_{10} and $PM_{2.5}$, Values exceeding the relevant criteria are displayed in **bolded text**.

These data indicate that maximum 24-hour averaged PM_{10} concentrations occasionally exceeded the 50 µg/m^3 criterion however the 95th percentile values were in the order of 60% of the criterion or less. Annually averaged PM_{10} concentrations were found to vary between the stations considered, with the highest value of 16 µg/m^3 recorded at the Tamworth station in 2014 and at the Wyong station in 2017 against the 25 µg/m^3 impact assessment criterion. Values reviewed ranged between 11 and 16 µg/m^3. Regarding $PM_{2.5}$, maximum 24-hour averaged concentrations exhibited the same trend as for PM_{10} with the 25 µg/m^3 assessment criterion occasionally being exceeded, with the 95th percentile values below this criterion. Annually averaged $PM_{2.5}$ concentrations were consistent across most stations, ranging from 5 to 8 µg/m^3. Measured results for NO_2, SO_2 and CO were well below the respective impact assessment criteria at all of the stations reviewed.

Table 5-7 Summary of OEH air quality monitoring data from various NSW locations (2014-2017)

Year	Value measured at OEH ambient air quality monitoring station						Impact assessment criterion (µg/m^3 unless stated)
	Bathurst	Gunnedah	Tamworth	Oakdale	Bargo	Wyong	
Maximum 24-hour average PM_{10} in µg/m^3							
2014	43	-	**67**	**56**	**51**	42	50
2015	**95**	-	**53**	**62**	**52**	**59**	
2016	34	-	**52**	**76**	**58**	46	
2017	50	-	**54**	47	**54**	**63**	
95th percentile of 24-hour average PM_{10} in µg/m^3							
2014	30	-	28	25	26	28	50
2015	29	-	25	22	24	27	
2016	26	-	27	24	26	28	
2017	25	-	27	22	24	29	
Number of days above with average PM_{10} concentration exceeding 50 µg/m^3							
2014	0	-	1	1	1	0	-
2015	2	-	1	1	2	1	
2016	0	-	1	5	0	0	
2017	0	-	2	0	1	1	

Year	Value measured at OEH ambient air quality monitoring station						Impact assessment criterion ($\mu g/m^3$ unless stated)
	Bathurst	Gunnedah	Tamworth	Oakdale	Bargo	Wyong	
Annual average PM_{10} in $\mu g/m^3$							
2014	15	-	16	13	15	15	25
2015	13	-	14	11	13	15	
2016	13	-	15	12	14	15	
2017	14	-	15	12	14	16	
Maximum 24-hour average $PM_{2.5}$ in $\mu g/m^3$ (*indicates data not complete for entire year)							
2014	-	-	-	-	-	20, (11), 0	25
2015	-	-	-	-	-	13, (9), 0	
2016	*15	-	*18	-	-	20	
2017	18	-	22	26	21	**27**	
95th percentile of 24-hour average $PM_{2.5}$ in $\mu g/m^3$							
2014	-	-	-	-	-	11	25
2015	-	-	-	-	-	9	
2016	*10	-	*14	-	-	11	
2017	10	-	14	11	12	11	
Number of days above with average $PM_{2.5}$ concentration exceeding 25 $\mu g/m^3$							
2014	-	-	-	-	-	0	-
2015	-	-	-	-	-	0	
2016	0	-	0	-	-	0	
2017	0	-	0	1	0	1	
Annual average $PM_{2.5}$ in $\mu g/m^3$							
2014	-	-	-	-	-	6	8
2015	-	-	-	-	-	5	
2016	-	-	-	-	-	6	
2017	6	-	8	6	6	6	
Maximum 1 hour averaged NO_2 in $\mu g/m^3$							
2014	-	-	-	53	74	70	246
2015	-	-	-	49	99	66	
2016	-	-	-	45	94	94	
2017	-	-	-	45	135	105	
Annual average NO_2 in $\mu g/m^3$							
2014	-	-	-	4	10	10	62
2015	-	-	-	4	10	10	
2016	-	-	-	4	10	10	
2017	-	-	-	2	12	10	

Year	Value measured at OEH ambient air quality monitoring station						Impact assessment criterion ($\mu g/m^3$ unless stated)
	Bathurst	Gunnedah	Tamworth	Oakdale	Bargo	Wyong	
Maximum 1 hour averaged SO_2 in $\mu g/m^3$							
2014	-	-	-	-	29	114	570
2015	-	-	-	-	26	197	
2016	-	-	-	-	29	91	
2017	-	-	-	-	29	134	
Maximum 24-hour averaged SO_2 in $\mu g/m^3$							
2014	-	-	-	-	6	11	228
2015	-	-	-	-	6	26	
2016	-	-	-	-	11	11	
2017	-	-	-	-	6	20	
Annual average SO_2 in $\mu g/m^3$							
2014	-	-	-	-	1	2	60
2015	-	-	-	-	1	1	
2016	-	-	-	-	1	1	
2017	-	-	-	-	1	2	
Maximum 1-hour averaged CO in mg/m^3							
2014	-	-	-	-	-	1	30 mg/m^3
2015	-	-	-	-	-	1	
2016	-	-	-	-	-	1	
2017	-	-	-	-	-	2	
Maximum 8-hour averaged CO in mg/m^3							
2014	-	-	-	-	-	1	10 mg/m^3
2015	-	-	-	-	-	1	
2016	-	-	-	-	-	1	
2017	-	-	-	-	-	1	

5.4.3 Adopted background concentrations

Considering the monitoring data presented above, the following background concentrations were established for the receiving environment around the Proposal. **Table 5-8** includes reasoning why each value was selected. It is noted that TSP is not measured at any of the stations considered. Section 7.3 of the report, "Dubbo Zirconia Project Air Quality and Greenhouse Gas Assessment" (Pacific Environment Limited, 2013) provides a background concentration for TSP of 19 $\mu g/m^3$ from monitoring conducted in the Dubbo region between March 2001 and February 2002. In lieu of other available information, this background concentration was also adopted as a TSP annual average for this assessment.

Table 5-8 Adopted pollutant background concentrations

Pollutant	Averaging time	Adopted background concentration* ($\mu g/m^3$ unless otherwise stated)	Justification
Total suspended particulate	Annual	19	Measured between March 2001 and February 2002 in the Dubbo Region.
Particulate matter (PM_{10})	24-hour	30	Highest 95th percentile concentration for 2014 to 2017 inclusive measured at Bathurst; the nearest OEH station in-relation to the Proposal.
	Annual	15	Highest concentration recorded at the OEH Bathurst station from 2014 to 2017 inclusive.
Particulate matter ($PM_{2.5}$)	24-hour	10	95th percentile concentration recorded in 2016 and 2017 at the OEH Bathurst station.
	Annual	6	Value recorded in 2017 at the OEH Bathurst station.
Nitrogen dioxide (NO2)	1-hour	53	Highest concentration recorded at the OEH Oakdale station from 2014 to 2017 inclusive.
	Annual	4	Highest concentration recorded at the OEH Oakdale station from 2014 to 2017 inclusive.
Sulfur dioxide (SO2)	1-hour	29	Highest concentration recorded at the OEH Bargo station from 2014 to 2017 inclusive.
	24-hour	11	Highest concentration recorded at the OEH Bargo station from 2014 to 2017 inclusive.
	Annual	1	Highest concentration recorded at the OEH Bargo station from 2014 to 2017 inclusive.
Carbon monoxide	1-hour	2 mg/m^3	Highest concentration recorded at the OEH Wyong station from 2014 to 2017 inclusive.
	8-hour	1 mg/m^3	Highest concentration recorded at the OEH Wyong station from 2014 to 2017 inclusive.

6. Assessment of impacts during construction

6.1 Construction

As identified above in **Section 2.2.1**, generation of dust is expected to be the primary air risk during construction. This risk was evaluated in this assessment using the method developed by the UK IAQM. The process and outcomes arising from each step in the assessment process is detailed in the following subsections.

6.1.1 Step 1 – Screening assessment

Step 1 of the UK IAQM assessment method involves a screening review to confirm the presence of human and ecological receptors within the vicinity of a project. The intent of this step is to identify whether there are receivers nearby which have the potential to be impacted by the intended works. The setback distances considered for this assessment are listed in **Table 6-1**.

Table 6-1 UK IAQM Step 1 - Screening assessment receiver setback distances

Receiver type	Screening level assessment distance
Human receptors	Located within 350 m of the boundary of the site; or 50 m of the route(s) used by construction vehicles on public roads or within 500 m of site egress points.
Ecological receptors	Located within 50 m of the boundary of the site; or 50 m of the route(s) used by construction vehicles on public roads or within 500 m of site egress points.

As identified in **Section 5.1**, human and/or ecological receptors are located within these stated setback distances, and a Detailed Assessment was determined to be required for the Proposal.

6.1.2 Step 2 – Risk assessment

The second step in the UK IAQM methodology involves evaluating the risk of dust impacts during construction. This step is divided into three steps which are described in the following subsections.

Step 2A – Potential for dust emissions

Step 2A involves the estimation of the magnitude of potential dust emissions associated with the Proposal construction activities. The method for evaluating the magnitude of potential emissions considers the scale and nature of the anticipated activities. The objectives used to classify the magnitude of dust emissions arising from demolition, earthworks, construction and trackout activities from the UK IAQM method have been reproduced in **Table 6-2**.

Table 6-2 UK IAQM Step 2A - Objectives for classifying the magnitude of potential dust emissions

Construction activity	Potential dust emission magnitude classification
Demolition	Large – Total building volume greater than 50,000 m^3, potentially dusty construction material (e.g. concrete), on-site crushing and screening, demolition activities greater than 20 m above ground level
	Medium – Total building volume 20,000 to 50,000 m^3, potentially dusty construction material, demolition activities 10 to 20 m above ground.
	Small – Total building volume less than 20,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber), demolition activities less than 10 m above ground, demolition during wetter months.

Construction activity	Potential dust emission magnitude classification
Earthworks (i.e. excavating materials, internal haulage, tipping and stockpiling, site levelling and landscaping)	Large – Total site area greater than 10,000 m^2, potentially dusty soil type (e.g. clay, which would be prone to suspension when dry due to small particle size), more than 10 heavy earth moving materials active at any one time, formation of bunds greater than 8 m in height, total materials moved exceeding 100,000 tonnes.
	Medium – Total site area between 2,500 and 10,000 m^2, moderately dusty soil type (e.g. silt), 5 to 10 heavy earth moving vehicles active at any one time, formation of bunds 4 to 8 m in height, total material moved between 20,000 and 100,000 tonnes.
	Small – Total site area less than 2,500 m^2, soil type with large grain size (e.g. sand), less than 5 heavy earth moving vehicles active at any one time, formation of bunds less than 4 m in height, total materials moved less than 20,000 tonnes, earthworks during wetter months.
Construction	Large – Total building volume greater than 100,000 m^3, on-site concrete batching, sandblasting.
	Medium – Total building volume between 25,000 and 100,000 m^3, potentially dusty construction material (e.g. concrete), on-site concrete batching plant.
	Small – Total building volume less than 25,000 m^3, construction material with a low potential for dust release (e.g. metal cladding or timber).
Trackout	Large – More than 50 heavy vehicle movements in any one day, potentially dusty surface material (e.g. high clay content), unpaved road lengths greater than 100 m.
	Medium – 10 to 50 heavy vehicle movements in any one day, moderately dusty surface (e.g. high clay content), unpaved road length between 50 and 100 m.
	Small – Less than 10 heavy vehicle movements in any one day, surface material with low potential for dust release, unpaved road length less than 50 m.

Using present information available for construction, the following potential dust emission magnitude classifications were developed for the Proposal:

Table 6-3 Dust emission magnitude classifications determined for the Proposal

Activity	Estimated dust emission magnitude potential
Demolition	Small
Earthworks	Large
Construction	Medium
Trackout	Large

Step 2B – Review of sensitivity of surrounding local environment

Step 2B involved the evaluation of the sensitivity of the receiving environment around the construction area. Classification of the sensitivity of these receiver areas considered:

- the specific sensitivities of receptors in the area.
- the proximity and number of nearby receivers.
- local background air quality conditions characterised based on PM_{10} concentrations.
- site-specific factors such as whether there are natural shelters, to reduce the risk of wind-blown dust (UK IAQM, 2014).

The UK IAQM method considers how sensitive surrounding receiver areas may be to the effects of dust soiling, human health, and ecosystem impacts. The evaluation tools used to determine the respective sensitivities of nearby receivers to these effects have been reproduced in **Table 6-4**, **Table 6-5** and **Table 6-6**. In **Table 6-5**, it is noted that the annually averaged PM_{10} concentration adopted for the study was 15 µg/m^3 as above in **Table 5-8**.

Table 6-4 UK IAQM Step 2B – Method for determining sensitivity of receiving area to dust soiling effects

Receiver sensitivity	Approximate number of receptors	Distance of receptors from the source (m)			
		Less than 20 m	20 to 50 m	50 to 100 m	100 to 350 m
High	More than 100	High	High	Medium	Low
	10 to 100	High	Medium	Low	Low
	1 to 10	Medium	Low	Low	Low
Medium	More than 1	Medium	Low	Low	Low
Low	More than 1	Low	Low	Low	Low

Table 6-5 UK IAQM Step 2B – Method for determining sensitivity of receiving area to human health impacts

Receiver sensitivity	Annual mean PM_{10} concentration	Approximate number of receptors	Distance of receptors from the source (m)				
			Less than 20 m	20 to 50 m	50 to 100 m	100 to 200 m	200 to 350 m
High	Greater than 32 µg/m^3	More than 100	High	High	High	Medium	Low
		10 to 100	High	High	Medium	Low	Low
		1 to 10	High	Medium	Low	Low	Low
	28 to 32 µg/m^3	More than 100	High	High	Medium	Low	Low
		10 to 100	High	Medium	Low	Low	Low
		1 to 10	High	Medium	Low	Low	Low
	24 to 28 µg/m^3	More than 100	High	Medium	Low	Low	Low
		10 to 100	High	Medium	Low	Low	Low
		1 to 10	Medium	Low	Low	Low	Low
	Less than 24 µg/m^3	More than 100	Medium	Low	Low	Low	Low
		10 to 100	Low	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low	Low
Medium	Greater than 32 µg/m^3	More than 10	High	Medium	Low	Low	Low
		1 to 10	Medium	Low	Low	Low	Low
	28 to 32 µg/m^3	More than 10	Medium	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low	Low
	24 to 28 µg/m^3	More than 10	Low	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low	Low
	Less than 24 µg/m^3	More than 10	Low	Low	Low	Low	Low
		1 to 10	Low	Low	Low	Low	Low
Low	-	More than 1	Low	Low	Low	Low	Low

Table 6-6 UK IAQM Step 2B – Method for determining sensitivity of receiving area to ecological impacts

Receiver sensitivity	Distance of receptors from the source (m)	
	Less than 20 m	20 to 50 m
High	High	Medium
Medium	Medium	Low
Low	Low	Low

Guidance from the UK IAQM used for classifying the 'receiver sensitivity' in **Table 6-4**, **Table 6-5**, and **Table 6-6** has been reproduced in **Table 6-7**.

Table 6-7 UK IAQM receiver sensitivity classifications

Receiver sensitivity	Classification
Dust soiling	High – Surrounding land where: • users can reasonably expect enjoyment of a high level of amenity; or • the appearance, aesthetics or value of a property would be diminished by soiling; and • the people or property would reasonably be expected to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Indicative examples include dwellings, museums and other culturally important collections, medium and long-term car parks and car show rooms.
	Medium – Surrounding land where: • users would expect to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home; or • the appearance, aesthetics or value of a property could be diminished by soiling; or • the people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. Indicative examples include parks and places of worship.
	Low – Surrounding land where: • the enjoyment of amenity would not reasonably be expected; or • property would not reasonably be expected to be diminished in appearance, aesthetics or value by soiling; or • there is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. Indicative examples include playing fields, farmland (unless commercially-sensitive horticultural), footpaths, short-term car parks and roads.
Human health impacts	High: • Locations where members of the public are exposed over a time period relevant to the air quality objective for PM_{10}. • Indicative examples include residential properties. Hospitals, schools and residential care homes should also be considered as having equal sensitivity to residential areas for the purpose of this assessment.
	Medium:

Receiver sensitivity	Classification
	• Locations where the people exposed are workers, and exposure is over a time period relevant to the air quality objective for PM_{10}. • Indicative examples include office and shop workers, but would generally not include workers occupationally exposed to PM_{10}, as protection is covered by relevant Health and Safety legislation.
	Low: • Locations where human exposure is transient. • Indicative examples include public footpaths, playing fields, parks and shopping streets.
Ecological effects	High: • Locations with an international or national designation and the designated features may be affected by dust soiling; or • Locations where there is a community of particularly dust sensitive species
	Medium: • Locations where there is particularly important plant species, where dust sensitivity is uncertain or unknown; or • Locations with a national or state designation where the features may be affected by dust deposition.
	Low: • Locations with a local designation where the features may be affected by dust deposition.

Using this method, the following sensitivity classifications were developed:

Table 6-8 Surrounding receiver sensitivity classifications determined for the Proposal

Sensitivity to potential impact	Surrounding receiver sensitivity rating
Dust soiling	Medium
Human health impacts	Low
Ecological effects	N/A

Step 2C – Evaluation of the risk of dust impacts

Potential dust emission magnitude ratings determined in Step 2A and the surrounding area sensitivity classifications determined in Step 2B were combined in Step 2C to 'determine the risk of impacts with no mitigation applied' (UK IAQM, 2014). This evaluation was performed using the guidance presented in Section 7.4 of the UK IAQM guideline, which has been summarised in **Table 6-9**.

Table 6-9 UK IAQM Step 2C – Method for determining unmitigated risk of dust impacts

Sensitivity of area	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
Trackout			
High	High risk	Medium risk	Low risk
Medium	Medium risk	Medium risk	Negligible
Low	Low risk	Low risk	Negligible

The highest unmitigated risk values determined for each dust-related risk (i.e. soiling, human health and ecological impacts) for each of the four phases of construction are summarised in **Table 6-10**.

Table 6-10 Unmitigated risk values determined for the Proposal

Potential impact	Unmitigated risk value			
	Demolition	Earthworks	Construction	Trackout
Dust soiling	Low risk	Medium risk	Medium risk	Medium risk
Human health impacts	Negligible	Low risk	Low risk	Low risk
Ecological effects	Negligible	Negligible	Negligible	Negligible

6.1.3 Step 3 – Development of suitable specific mitigation measures

The construction phases for which higher unmitigated risk ratings were deduced are the specific aspects of the Proposal that would require more active management and control measures in order to effectively limit potential dust-related issues. Using guidance presented in Section 8 of the UK IAQM (2014) document, the following measures were developed specific to demolition, earthworks, construction, and trackout activities. These are shown in **Table 6-11**, **Table 6-12**, **Table 6-13** and **Table 6-14** respectively. Consistent with the UK IAQM (2014), the values 'N', 'D' and 'H' refer to the stringency of application of these specific measures, with 'N' being 'not required', 'D' denoting that the measure is 'desirable', and 'H' being that it is 'highly recommended'. It is expected that these specific mitigation measures would be applied in addition to the applicable standard measures presented in **Section 9**.

Table 6-11 UK IAQM, 2014 specific mitigation measures for different risk-rated demolition activities

Mitigation measure	Low risk demolition
Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust).	D
Ensure effective water suppression is used during demolition operations. Hand held sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition, high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground.	H
Bag and remove any biological debris or damp down such material before demolition.	H

Table 6-12 UK IAQM, 2014 specific mitigation measures for different risk-rated earthworks activities

Mitigation measure	Medium risk earthworks
Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.	D
Use hessian, mulches or tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.	D
Only remove the cover in small areas during work and not all at once.	D

Table 6-13 UK IAQM, 2014 specific mitigation measures for different risk-rated construction activities

Mitigation measure	Medium risk construction
Avoid scabbling (roughening of concrete surfaces) if possible.	D
Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.	H
Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and are stored appropriately on-site.	D
For smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust.	D

Table 6-14 UK IAQM, 2014 specific mitigation measures for different risk-rated trackout activities

Mitigation measure	Medium risk trackout activities
Use water-assisted dust sweepers on the access and local roads, to remove as necessary, any material tracked out of the work areas.	H
Avoid dry sweeping of large areas.	H
Ensure vehicles entering and leaving work areas are covered to prevent escape of materials during transport.	H
Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.	H
Record all inspections of haul routes and any subsequent action taken in a site log book.	H
As applicable, install or make use of hard surfaced haul routes, which are regularly damped down with fixed, or mobile water bowsers and regularly cleaned.	H

Mitigation measure	Medium risk trackout activities
Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable).	H
Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.	H
Access gates to be located at least 10 metres from receptors where possible.	H

6.1.4 Step 4 – Evaluate significance of any residual risks

The intent of the previous step in the UK IAQM (2014) assessment process is the development of suitable measures which would reduce mitigated residual risks to the extent were impacts expected during construction would not be significant. It is expected that with the application of the specific measures identified above, and the standard measures detailed in **Section 9**, impacts are anticipated to be manageable.

7. Evaluation of emissions during operations

7.1 Overview

As identified in **Section 2.2.2**, several sources of emissions to air are expected as a result of the Proposal. Details of how emissions from each source were estimated and incorporated into the dispersion model are described in the following subsections.

7.2 Train operations

The new diesel train fleet that would replace XPT, XPLORER and Endeavour services would be maintained at the maintenance facility. Emissions from their operation were estimated using guidance presented in *Emission Factors for Locomotives EPA-420-F-09-025* (United States Environmental Protection Agency [US EPA], 2009). The new trains would achieve US EPA Tier 4 emission performance levels, and so these emission factors were applied from the standard. The guideline provides a total overall emission rate for VOCs. Emission rates for each speciated VOC of interest was estimated using the fraction in non-road diesel vehicles provided in *Speciation Profiles and Toxic Emission Factors for Non-Road Engines* (US EPA, 2015). The daily fuel consumption was estimated based on the expected hourly consumption rate (26 litres per hour) of the new locomotives for the types of operations typical at the maintenance facility (i.e. idling, low-speed movement). **Table 7-1** summarises the emission rates determined for each pollutant per locomotive, for the conservative situation whereby they were in low gear or idle for all hours of the day at the Proposal.

Table 7-1 Calculated emissions per locomotive

Substance	Emission factor (EF), Kg/KL	Amount of diesel consumed per day (A), KL/day	Overall emission rate (ER), g/sec
1,3-Butadiene	0.0010244	0.624	0.00000196
Arsenic & compounds	0.0000161		0.00000003
Benzene	0.0165306		0.00003157
CO	27.816		0.05312083
Ethylbenzene	0.0080284		0.00001533
n-Hexane	0.0069272		0.00001322
Nickel & compounds	0.0000039		0.000000007
NO_x	15.2		0.029027778
PM_{10}	0.22800		0.00043541
$PM_{2.5}$	0.22116		0.00042235
SO_2	0.061614		0.0001177
Toluene	0.0384006		0.00007333
Xylene	0.048657		0.00009292

Emissions were incorporated into CALPUFF as detailed below in **Table 7-2**. As listed, sources representing each of the individual locomotives were added along the line immediately north of the main maintenance facility. Emissions from the second train (i.e. two locomotives) within the main maintenance facility were summed and released through a passive emission location at the centre of the roof of the building. The initial horizontal and vertical spread values were set according to the dimensions of the train and main maintenance facility and guidance presented in *AUSPLUME Gaussian Plume Dispersion Model Technical User Manual* (VIC EPA, 2000).

Table 7-2 Train source CALPUFF setup

Source ID	Source type	X (m)	Y (m)	Z base (m)	Height (m)	Initial horiz. spread (m)	Initial vert. spread (m)
StabLoc1	Volume	652847	6430893	270	4.1	0.6	1.0
StabLoc2	Volume	653035	6430860	270	4.1	0.6	1.0
MainTrain2	Volume	652935	6430852	270	13.1	17.5	3.25

7.3 Fuel storage and transfers

The Proposal includes the establishment of a diesel storage tank with sufficient capacity for one fortnight of operations (estimated to be 20,000 litres). Breathing (i.e. evaporative) and working loss (i.e. through loading/transfers) emission rates were estimated using the US EPA TANKS program (version 4.0.9d). Guidance for diesel from Table 2 of *National Pollutant Inventory Emission Estimation Technique Manual for Fuel and Organic Liquid Storage Version 3.3* (DEWHA, 2012) was used to estimate the individual composition and resulting emission rates of each of the speciated VOCs of interest. Key setup values applied in TANKS are summarised below in **Table 7-3**, the rate of emission (g/s) determined for each speciated VOC are listed in **Table 7-4**, and setup details for the tank within the dispersion model shown in **Table 7-5**.

Table 7-3 Input values for proposed diesel storage tank in US EPA TANKS program

Parameter	Adopted value
ID	Tank01
Type	Vertical fixed roof
Shell height	3.1 metres
Shell diameter	2.9 metres
Maximum liquid height	3.0 metres
Average liquid height	1.5 metres
Working volume	20,000 litres
Turnovers per year	26
Shell colour and condition	White, good
Roof colour and condition	White, good
Type	Cone
Height	0.1 metres
Slope ratio	0.02
Meteorological conditions assumed	Region 10 ("*NPI Fuel and Organic Liquids Storage TANKS User Manual*" (KMH Environmental 2012)

Table 7-4 Calculated tank emissions

Speciated VOC	Working losses (g/s)	Breathing losses (g/s)	Total emission rate (g/s)
Benzene	3.74E-06	1.01E-06	4.75E-06
Cumene	5.76E-06	1.58E-06	7.34E-06
Cyclohexane	1.30E-06	4.32E-07	1.73E-06
Ethylbenzene	1.30-06	4.32E-07	1.73E-06

Speciated VOC	Working losses (g/s)	Breathing losses (g/s)	Total emission rate (g/s)
n-Hexane	2.02E-06	5.76E-07	2.59E-06
Toluene	3.60E-06	1.01E-06	4.61E-06
Xylenes	1.73E-06	4.32E-07	2.30E-06

Table 7-5 Tank source CALPUFF setup

Source ID	Source type	X (m)	Y (m)	Z base (m)	Height (m)	Initial horiz. spread (m)	Initial vert. spread (m)
Tank	Volume	652529	6430861	270	3.1	0.7	0.8

7.4 Maintenance activities

The three main operational activities that have the potential to result in emissions to air are surface preparation works (i.e. abrasive blasting); coating (i.e. painting and sealing) and graffiti removal activities. Each activity would take place in the main maintenance facility though it is unlikely that two would take place at the same time. Emissions detail for each maintenance activity is described below.

7.4.1 Surface preparation activities

Surface preparation activities such as abrasive blasting or grinding would occasionally take place at the maintenance facility. The frequency of these types of activities is expected to be low (i.e. one to two time per year), and owing to their noisiness, would be completed during standard operational hours (7 am to 6 pm). The duration of such works is also expected to be low given that only minor surface preparation activities would be completed at the facility, with more extensive work being undertaken at specialist off-site locations. Using guidance presented in *Emission estimation technique manual for Railway yard operations Version 2.0* (DEWHA, 2008), the following rates of emissions were determined for this activity:

Table 7-6 Calculated emissions from surface preparation activities

Pollutant	Emission rate (g/s)
PM_{10}	0.082
$PM_{2.5}$	0.0082
Arsenic and compounds	0.000063
Chromium III and compounds	0.000019
Copper and compounds	0.000013
Lead and compounds	0.000038
Nickel and compounds	0.000013

Table 7-7 summarises how this activity was incorporated into the dispersion model.

Table 7-7 Tank source CALPUFF setup

Source ID	Source type	X (m)	Y (m)	Z base (m)	Height (m)	Initial horiz. spread (m)	Initial vert. spread (m)
SurfPrep	Volume	652935	6430852	270	13.1	17.5	3.25

7.4.2 Surface coating and graffiti removal

Surface coating (i.e. painting and sealing) and graffiti removal activities may also occasionally take place within the main maintenance facility. Though graffiti removal activities are expected to take place on a more regular basis, green graffiti removal products exist that have a lower emission risk than solvent-based paint products and hence these works were evaluated in this assessment. Associated emissions (presented below in **Table 7-8**) were estimated using guidance from *Emission Estimation Technique Manual for Surface Coating* (QLD Department of Environment and Heritage, 1999). A small application rate of solvent-based paint of 4 l/hr was applied in these calculations on the basis of standard application rates of around 10 m^2 per litre and that only minor touchup painting would be undertaken at the facility, with more detailed work completed off-site. Details of how this activity was set up in CALPUFF are listed in **Table 7-9**. This source was programmed to occur continuously to reflect how these works could take place at any time of the day, to ensure that the 99.9th percentile concentrations accounted for all possible meteorological conditions at the site.

Table 7-8 Calculated emissions from surface coating activities

Pollutant	Emission rate (g/s)
Cyclohexane	0.0039
Ethyl acetate	0.0152
Acetone	0.0095
Methyl ethyl ketone	0.0040
Methyl isobutyl	0.0027
Xylene	0.0610
Toluene	0.2829
Ethylbenzene	0.0040

Table 7-9 Tank source CALPUFF setup

Source ID	Source type	X (m)	Y (m)	Z base (m)	Height (m)	Initial horiz. spread (m)	Initial vert. spread (m)
GR	Volume	652935	6430852	270	13.1	17.5	3.25

7.5 Vehicle movements

As assessed in the Noise and Vibration Assessment (NVA), the number of vehicle movements during operations would be low. Further the internal access route throughout the site would be sealed such that wheel-generated dust emissions would be minimal. Some exhaust emissions would result from these activities though it is expected that they would be negligible.

7.6 Summary of assessment scenarios and pollutants evaluated

As advised by Transport for NSW, the likely worst-case operational situation involves two trains at the facility. To account for the different types of maintenance activities outlined above, two operational assessment scenarios were considered:

- Scenario 1:
  - One train (i.e. two locomotives) idling at one of the standing lines to the north of the proposed maintenance facility building.

  - One train (i.e. two locomotives) idling within the maintenance facility building with surface preparation activities being undertaken.
  - Emissions from the storage and transfer of diesel at the on-site storage tank.
- Scenario 2:
  - One train (i.e. two locomotives) idling at one of the standing lines to the north of the proposed maintenance facility building.
  - One train (i.e. two locomotives) idling within the maintenance facility building with minor surface coating activities being undertaken.
  - Emissions from the storage and transfer of diesel at the on-site storage tank.

Concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO from scenarios 1 and 2 were evaluated as well as arsenic, benzene and toluene. Arsenic, benzene and toluene were selected on the basis that they had the highest ratio of emission rate to impact assessment criteria of the various air toxic pollutants (metal and non-metal) and individual odorous substances respectively. Where compliance could be demonstrated for these substances, the same would be expected for the other air toxics and individual odorous substances.

Table 7-10 Ratio of total emission rate to impact assessment criteria for air toxic pollutants and individual odorous substances

Pollutant	Total emission rate (g/s)	Impact assessment criteria (µg/m³)	Ratio
Air toxic pollutants			
Acetone	0.0095	22,000	1:2,320,022
Arsenic & compounds	**0.000006312**	**0.09**	**1:1,426**
Benzene	**0.000131**	**29**	**1:221,331**
1,3-Butadiene	0.0000078	40	1:5,111,847
Chromium III compounds	0.000019	9	1:473,684
Copper	0.000013	18	1:1,384,615
Cyclohexane	0.0039	19,000	1:4,891,365
Ethylbenzene	0.0040	8000	1:1,983,276
n-Hexane	0.0000026	3200	1:1,235,521,236
Nickel & compounds	0.000013	0.18	1:13,838
Individual odorous substances			
Cumene	0.0000073	21	1:2,861,035
Ethyl acetate	0.0152	12,100	1:794,380
Methyl ethyl ketone	0.0040	3,200	1:793,650
Methyl isobutyl	0.0027	230	1:85,565
Toluene	**0.0283**	**360**	**1:1,271**
Xylenes	0.0061	190	1:3,095

8. Assessment of operational impacts

8.1 Model setup

The dispersion model used for this assessment, CALPUFF, requires information on the meteorological conditions in the modelled region. This information is typically generated by the meteorological pre-processor, CALMET, using surface observation data from local weather stations and upper air data from radio-sondes or numerical models such as the CSIRO's prognostic model known as TAPM (The Air Pollution Model). CALMET also requires information on the local land-use and terrain. The result of a CALMET simulation is a year-long three-dimensional output of meteorological conditions that can be used as input to the CALPUFF air dispersion model. Upper air data in the vicinity of the Proposal was generated using TAPM at the nearest Bureau of Meteorology (BoM) station at Dubbo Airport, using influence from the surface observations collected at this station. CALMET was then set up with one surface observation station (BoM Dubbo Airport, and run in 'observations' mode. Key model settings for TAPM and CALMET are listed in **Table 8-1** and **Table 8-2** respectively.

Table 8-1 TAPM setup details

Parameter	Model values
Model version	4.0.4
Number of grids (spacing)	4, (30, 10, 3 and 1 kilometres)
Number of grid points	35 x 35 x 25 vertical levels
Year of analysis	2017 with one 'spin-up' day applied.
Centre of analysis	Latitude: -32 º14.5', Longitude: 148º37' (approximate location of Proposal to nearest half minute)
Terrain data source	Default
Land use data source	Default
Meteorological data assimilation	Nudged using surface observation data from BoM Dubbo Airport surface weather station.

Table 8-2 CALMET setup details

Parameter	Model values
Model version	7
Run Mode	Observations mode
Terrain data source	NASA SRTM3 30 metre resolution dataset
Land-use data source	Digitised from aerial imagery and classified as 'agricultural' or 'urban' categories specified in *CALPUFF Modeling System Version 6 User Instructions* (TRC, 2011).
Meteorological grid domain	10 kilometres x 10 kilometres x 0 to 3 kilometres depth spread over 11 vertical layers.
Meteorological grid resolution	0.1 kilometres
Meteorological grid southwest corner	647650 metres East, 6425850 metres North
Surface meteorological stations	Wind speed and direction data measured at BoM Dubbo Airport surface weather stations, with simulated data from TAPM used for ceiling height, cloud cover and air pressure.
Upper air meteorological stations	No upper air meteorological stations. Upper air data file for location of the BoM Dubbo Airport was derived by TAPM, and biased towards surface observations.
Meteorological data assimilation	1 year (2017)

8.2 Predicted results

The results from both assessment scenarios for each pollutant are discussed below, with ground level concentration contour plots presented in **Appendix A**.

8.2.1 PM_{10}, $PM_{2.5}$, NO_2, SO_2 and CO

The highest results for PM_{10}, $PM_{2.5}$, NO_2, SO_2 and CO at the most-affected representative receiver location are summarised in **Table 8-3**. As displayed, cumulative (i.e. background plus incremental contributions from the Proposal) pollutant concentrations were predicted to be well below impact assessment criteria from the Approved Methods for both assessment scenarios.

Table 8-3 Summary of highest ground-level concentrations predicted for PM_{10}, $PM_{2.5}$, NO_2, SO_2 and CO

Most affected representative receiver	Background concentration (µg/m³) unless stated	Contribution from the Proposal (µg/m³) unless stated		Total (µg/m³) unless stated		Impact assessment criteria (µg/m³) unless stated
		Scenario 1	Scenario 2	Scenario 1	Scenario 2	
Maximum 24-hour average PM_{10}						
R04	30	10.3	0.3	40.3	30.3	50
Annual average PM_{10}						
R04	15	0.9	0.03	15.9	15.03	25
Maximum 24-hour average $PM_{2.5}$						
R04	10	1.3	0.3	11.3	10.3	25
Annual average $PM_{2.5}$						
R04	6	0.1	0.03	6.1	6.03	8
Maximum 1-hour averaged NO_2						
R04	53	120	120	173	173	246
Annual average NO_2						
R04	4	1.9	1.9	5.9	5.9	62
Maximum 1-hour averaged SO_2						
R04	29	0.5	0.5	29.5	29.5	570
Maximum 24-hour averaged SO_2						
R04	11	0.09	0.09	11.09	29.5	228
Annual average SO_2						
R04	1	0.008	0.008	1.008	1.008	60
Maximum 1-hour averaged CO in mg/m³						
R04	2	0.2	0.2	2.2	2.2	30
Maximum 8-hour averaged CO in mg/m³						
R04	1	0.1	0.1	1.1	1.1	10

Arsenic, benzene and toluene

Regarding the air toxics, benzene and arsenic, **Table 8-4** summarises the highest 99.9th percentile, 1-hour averaged ground level concentrations predicted at or beyond the Proposal site boundary. As listed, for both assessment scenarios concentrations were predicted to be below the relevant impact assessment criteria.

Table 8-4 Highest 99.9th percentile 1-hour averaged air toxic ground-level concentrations predicted at/beyond the site boundary

Pollutant	Highest 99.9th percentile, 1 hour averaged ground level concentration at/beyond the site boundary (µg/m³)		Impact assessment criteria (µg/m³)
	Scenario 01	Scenario 02	
Benzene	0.1	0.1	29
Arsenic	0.05	0.0001	0.09

With regard to odour impacts from specific VOCs, toluene concentrations also were predicted to be below the Approved Methods impact assessment criteria at the most-affected representative receiver location (R04). This indicates that odour impacts are also unlikely during operations.

Table 8-5 Highest 99.9th percentile 1-hour averaged toluene ground-level concentrations predicted at the most affected sensitive receiver

Most affected receiver	Highest 99.9th percentile, 1 hour averaged ground level concentration (µg/m³)		Impact assessment criteria (µg/m³)
	Scenario 1	Scenario 2	
Toluene	0.3	161	360

9. Recommended safeguards

9.1 Construction

9.1.1 Standard measures

Section 8.2 of the UK IAQM (2014) guideline presents standards air quality measures to be applied during construction. The recommended measures vary based on the highest risk classification determined from the four phases of construction considered in the method. For this Proposal, the highest determined risk rating was ‘medium’. **Table 9-1** summarises standard air quality measures recommended for the Proposal (as applicable), with ‘N’ indicating that the measure would not generally be required, ‘D’ denoting that the measure is ‘desirable’, and ‘H’ being that it is ‘highly recommended’.

Table 9-1 UK IAQM, 2014 standard air quality measures for a medium-risk construction Proposal

Mitigation measure	Medium risk construction areas
Communications	
Develop and implement a stakeholder communications plan that includes community engagement before work commences on-site.	H
Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary.	H
Display the primary contractor head or regional office contact information.	H
Develop and implement an Air Quality Management Plan (AQMP) (or equivalent), which may include measures to control other emissions, approved by the applicable determining authority.	H
Site management	
Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.	H
Make the complaints log available to the applicable determining authority when requested.	H
Record any exceptional incidents that cause dust and/or air emissions, either on- or off-site, and the action taken to resolve the situation.	H
Hold regular liaison meetings with other high risk construction sites within 500 metres of the site boundary, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. It is important to understand the interactions of the off-site transport/deliveries which might be using the same strategic road networks.	N
Monitoring	
Carry out regular site inspections to monitor compliance with the AQMP, record inspection results, and make these records available to the determining authority as requested.	H
Increase the frequency of site inspections by the person accountable for air quality and dust issues on-site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.	H
Install dust deposition, dust flux, or real-time PM_{10} continuous monitoring devices at locations instructed by the determining authority.	N
Preparing and maintaining site	
Plan site layout so that machinery and dust causing activities are located away from receptors, as far as is possible.	H
Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If being re-used on-site, covered until required to be used.	H
Cover, seed or fence stockpiles to limit wind erosion.	H

Mitigation measure	Medium risk construction areas
Operating vehicle/machinery	
Ensure all vehicles, plant, and equipment operate in a proper and efficient manner.	H
Switch off all vehicles, plant and equipment when not in-use.	H
Avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where practicable.	H
Impose and signpost suitable maximum on-site speed limits to limit the generation of dust.	D
Construction activities	
Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction.	H
Minimise drop heights from loading and handling equipment.	H
Ensure equipment is readily available to clean any dry spillage, and clean up as soon as reasonably practicable after the event.	H

Additionally, the following standard measures are also recommended:

- Regularly water exposed and disturbed areas including stockpiles, especially during inclement weather conditions.
- Cover materials planned to be stockpiled for more than two weeks.
- Adjust the intensity of activities based on measured and observed dust levels, weather forecasts and the proximity of and direction of the works in relation to the nearest surrounding receivers.
- Ensure that all loads are covered and any loose materials/debris is removed before departure from site.
- Abide by road speed limits.
- Wherever possible and practical, limit the amount of materials stockpiled around the site.
- Clean loose materials and debris from the tailgate of vehicles unloading materials to stockpiles prior to departure from site.
- Position stockpiling areas as far as possible from surrounding receivers.
- Limit stockpiling activities during conditions where winds are blowing strongly in the direction(s) from the stockpiling location to nearby receivers.

9.1.2 Additional measures

Additional measures specific to each of the 4 phases of the Proposal were determined **in Section 6.1.3**. Recommended additional measures specific to demolition, earthworks, construction and trackout are listed above in **Table 6-11**, **Table 6-12**, **Table 6-13** and **Table 6-14** respectively.

9.2 Operations

Given that the predicted air quality concentrations from operational activities at surrounding receivers were predicted to be below the impact assessment criteria, no specific mitigation measures were determined to be necessary. This recommendation should be reviewed should operations at the Proposal differ materially from those assessed in this report.

10. Conclusion

An assessment was completed to evaluate potential air quality impacts associated with the Proposal, that would maintain a new diesel train fleet replacing the XPT, XPLORER and Endeavour services. This assessment was undertaken to meet the relevant guidance from the Approved Methods and other key guidelines described in **Chapter 3**.

The potential for impacts during construction was evaluated using the risk-based assessment approach developed by the UK IAQM (2014). This review identified that there was a moderate risk of dust impacts during construction, and standard and additional measures were recommended to mitigate and otherwise effectively manage this risk.

Air quality impacts arising during the operation of the Proposal were quantitatively assessed using the CALMET/CALPUFF meteorological and dispersion model. Emissions were estimated using information provided by TfNSW, and guidance for estimating pollutant emission rates in *Emission estimation technique manual for Railway yard operations Version 2.0* (DEWHA, 2008), and other applicable guidelines. Predicted ground-level concentrations of the various pollutants assessed were predicted to be below impact assessment criteria from the Approved Methods, and as such it was concluded that air quality impacts, including odour during operations were unlikely.

11. References

Commonwealth Department of the Environment, Water, Heritage and the Arts, 2008. Emission estimation technique manual for Railway yard operations Version 2.0.

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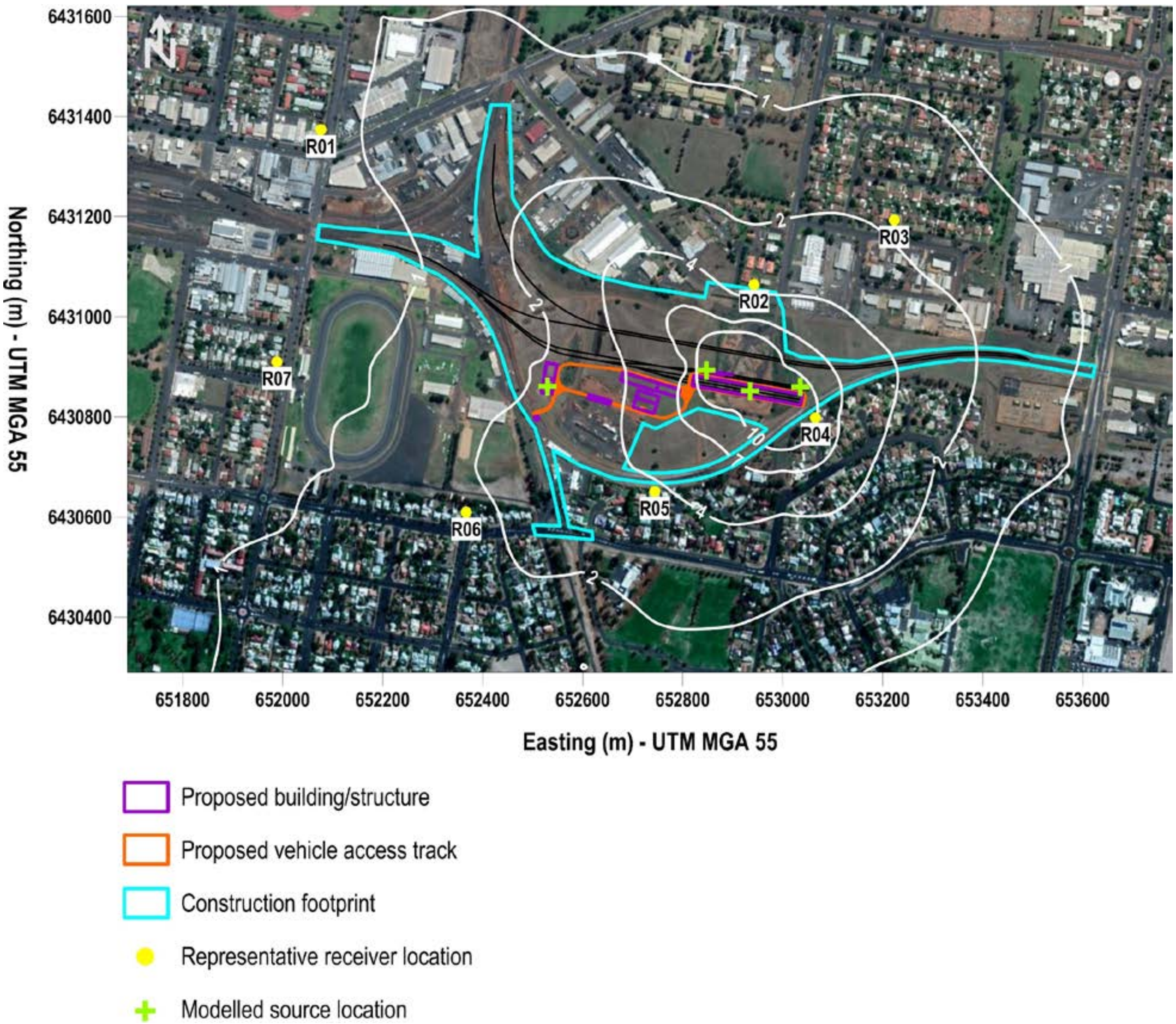
WSP, 2016. New Intercity Fleet Maintenance Facility Project Volume 1 – Review of Environmental Factors

Appendix A. Ground-level concentration contour plots

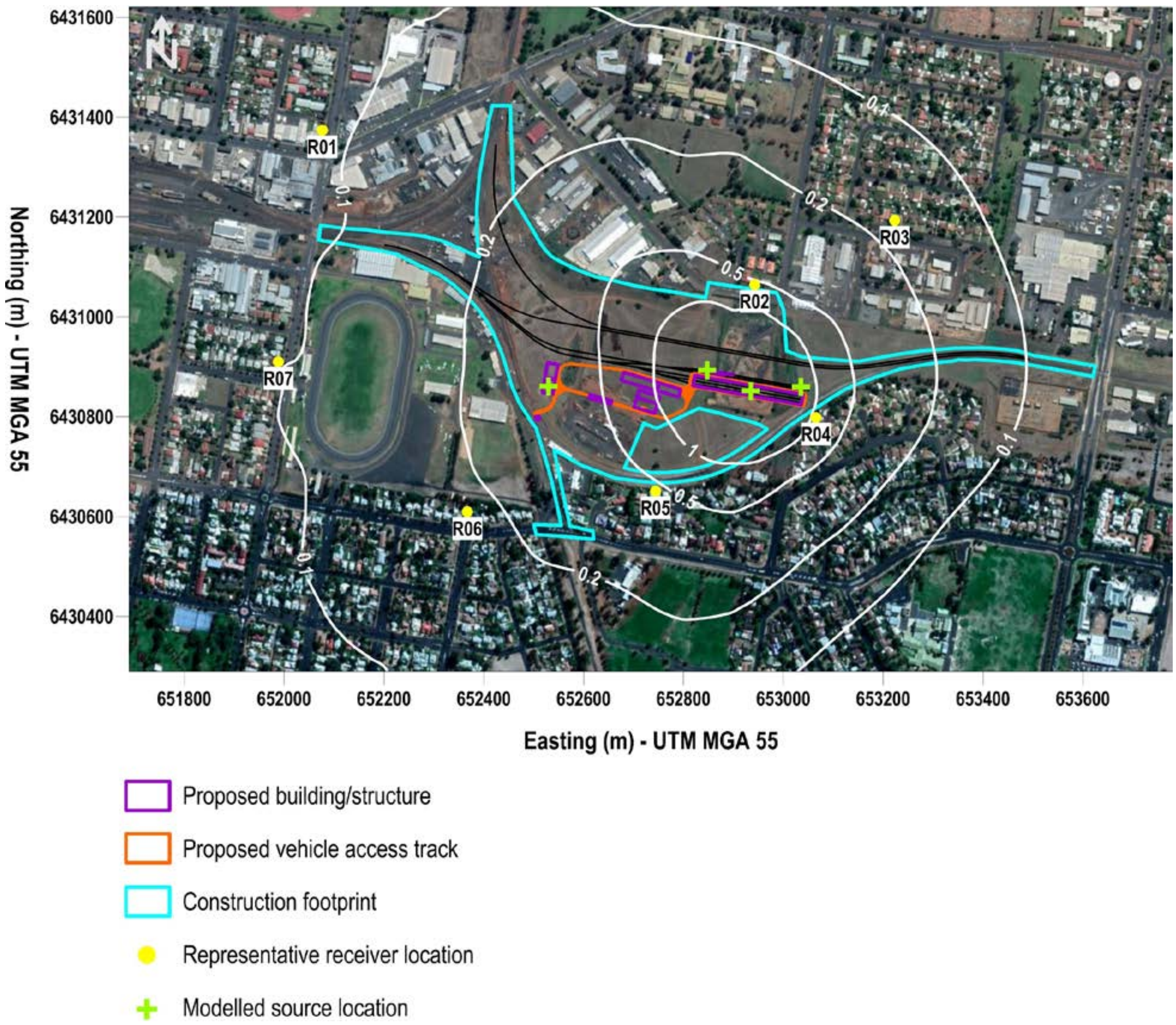
A.1 Scenario 01

A.1.1 Particulate matter (PM_{10} and $PM_{2.5}$)

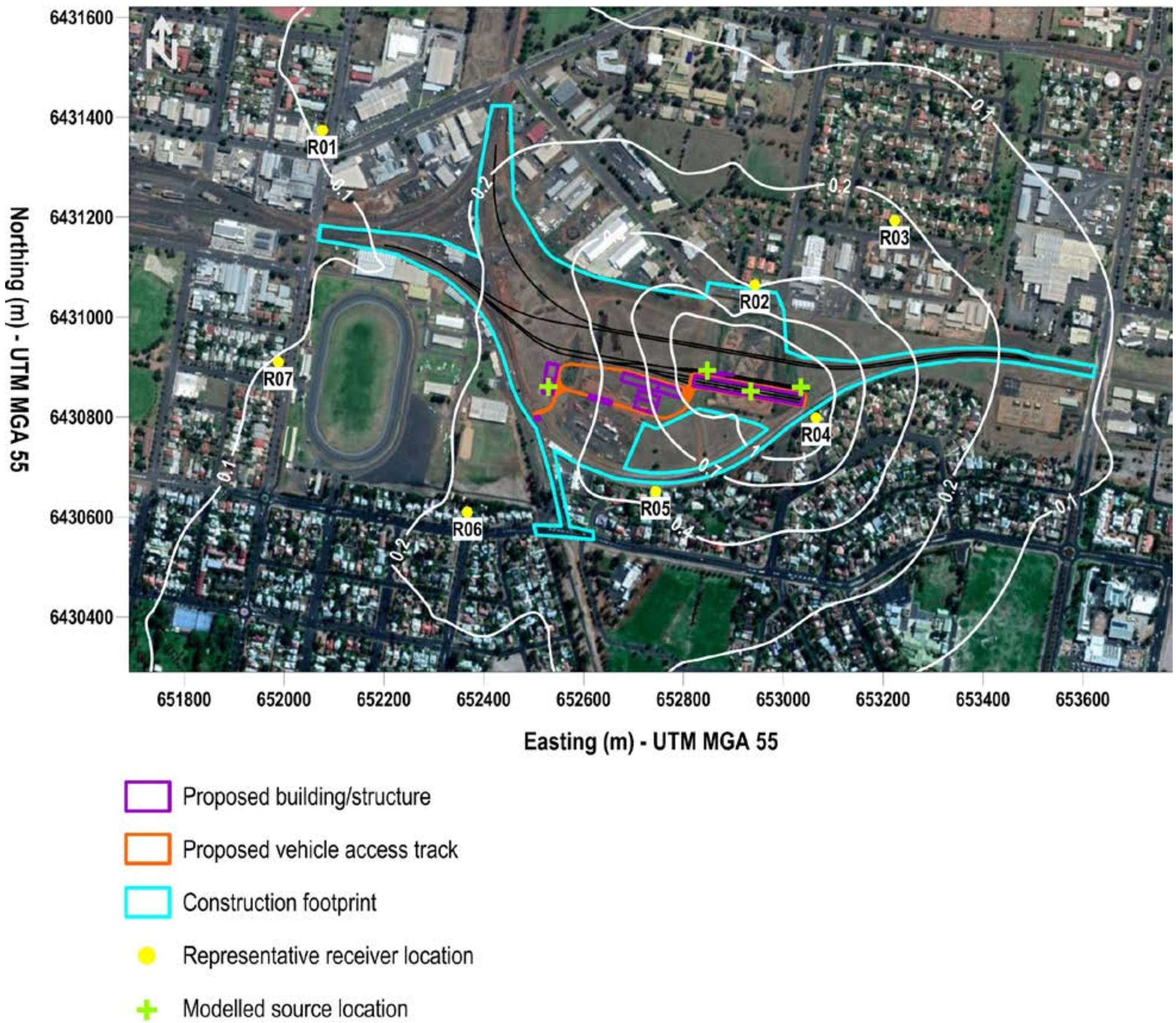
A.1.1.1 24-hour averaged, 100th percentile PM_{10} ($\mu g/m^3$)



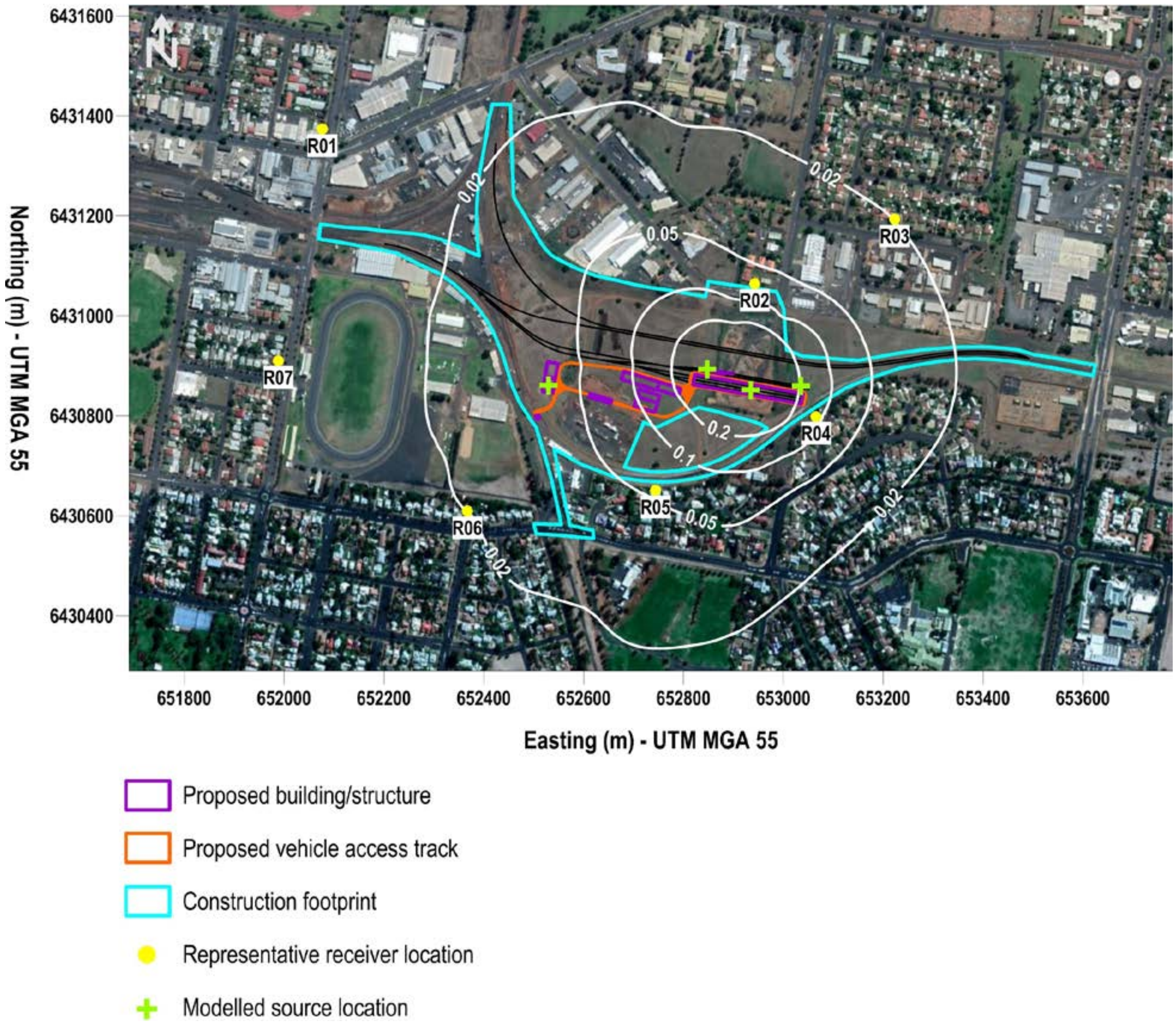
A.1.1.2 Annually averaged, 100th percentile PM_{10}



A.1.1.3 24-hour averaged, 100th percentile $PM_{2.5}$ ($\mu g/m^3$)

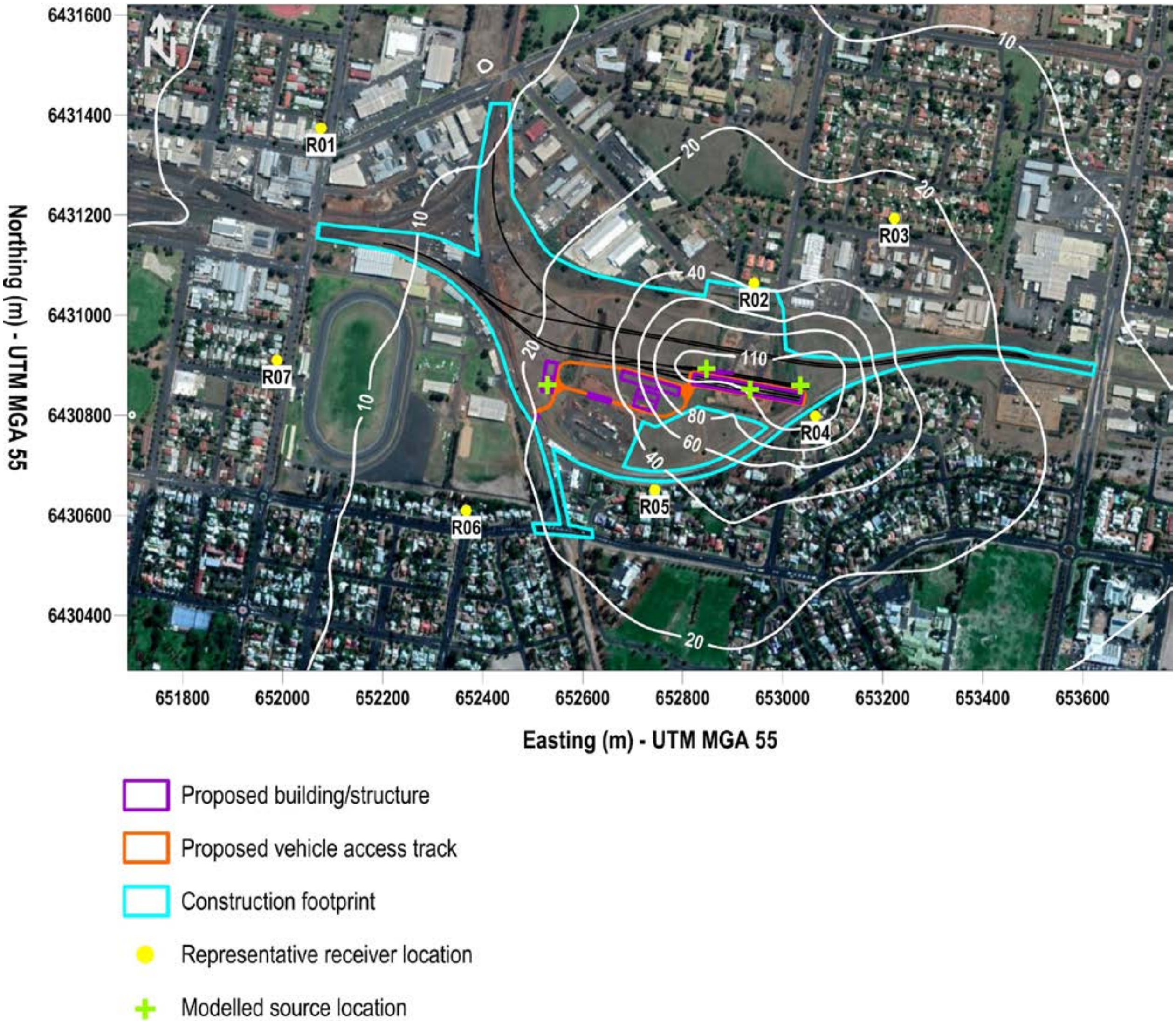


A.1.1.4 Annually averaged, 100th percentile $PM_{2.5}$ ($\mu g/m^3$)

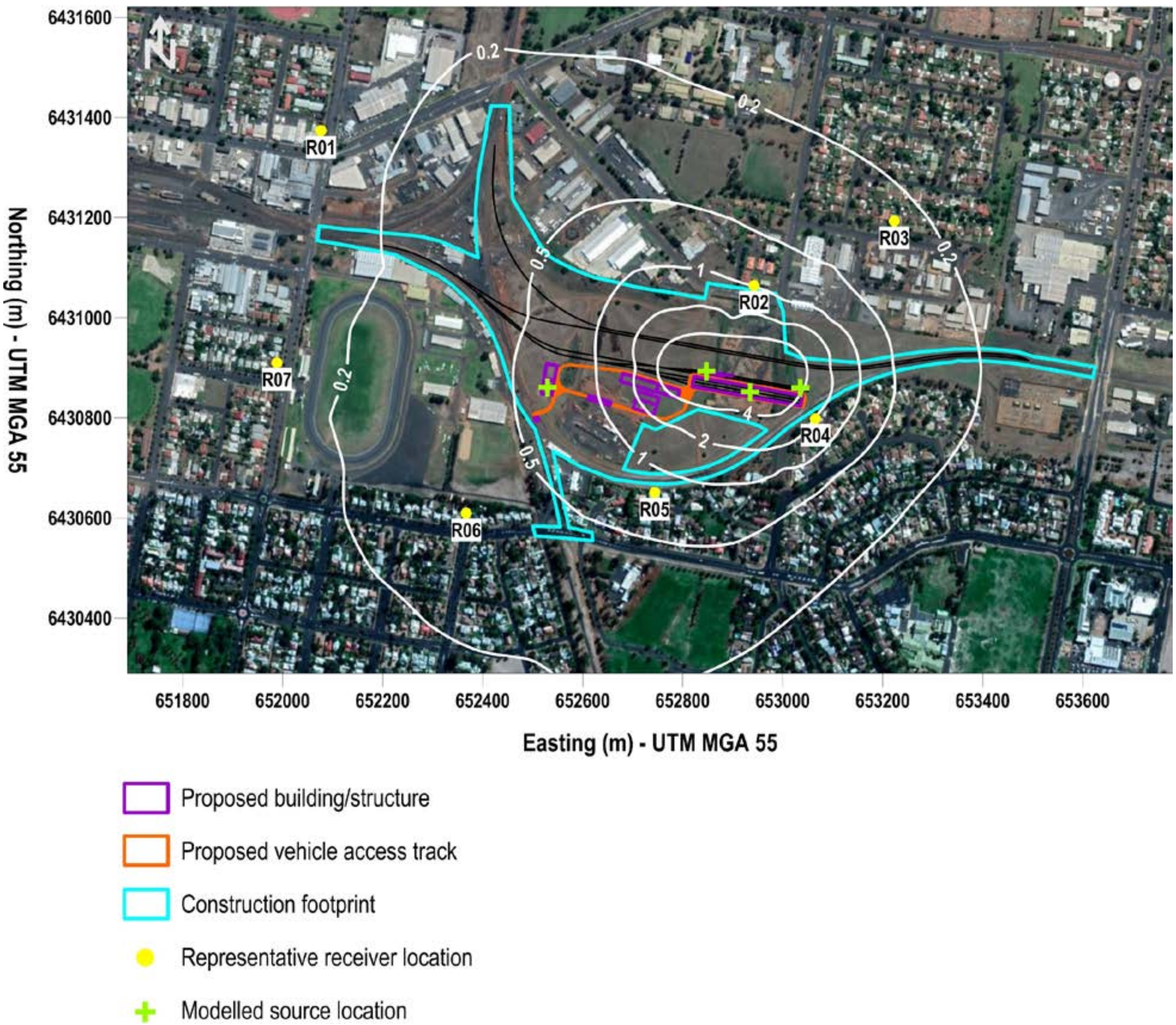


A.1.2 Nitrogen dioxide (NO_2)

A.1.2.1 1-hour averaged, 100th percentile NO_x, 100% as NO_2 ($\mu g/m^3$)

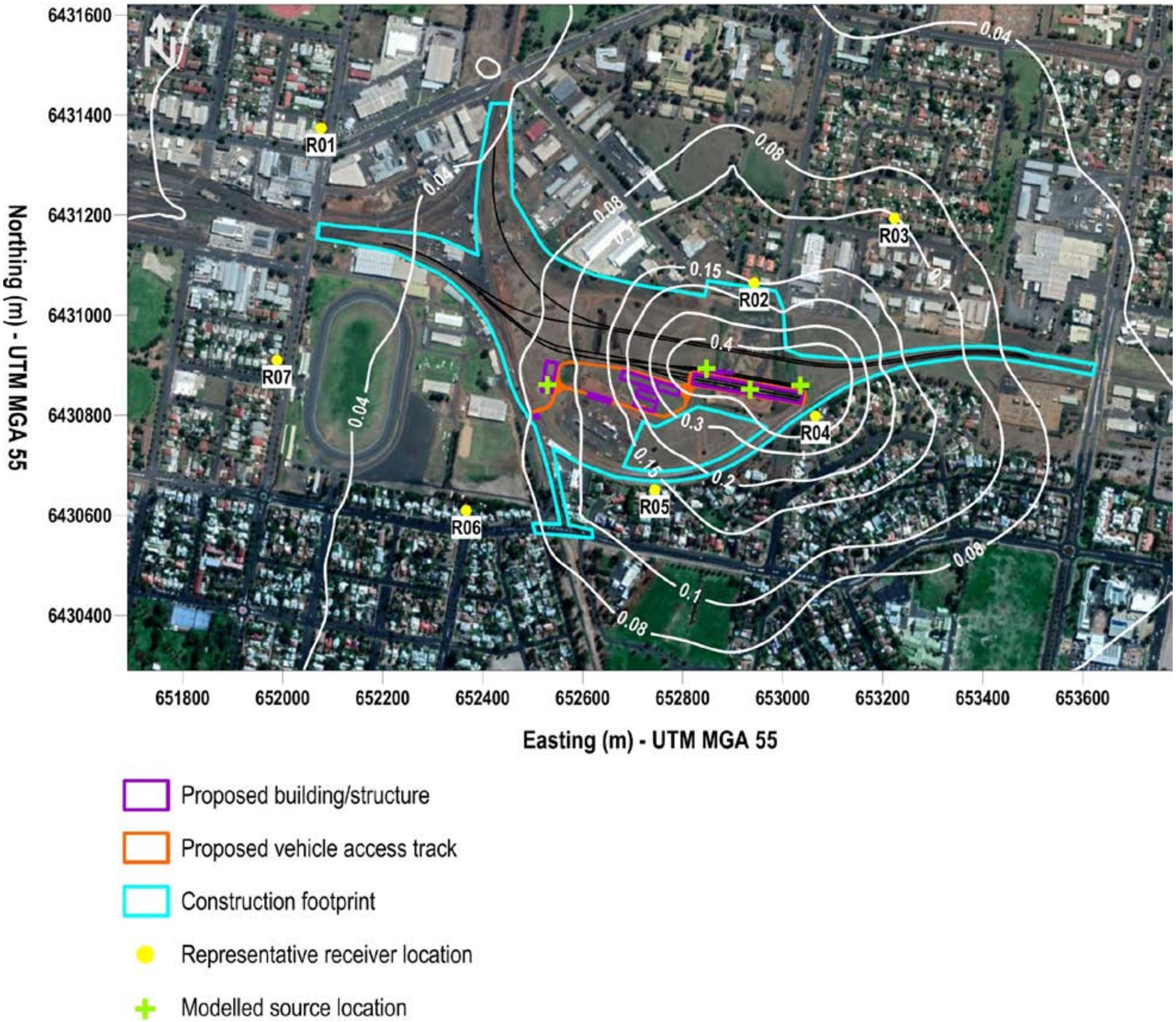


A.1.2.2 Annually averaged, 100th percentile NO_x, 100% as NO_2 ($\mu g/m^3$)

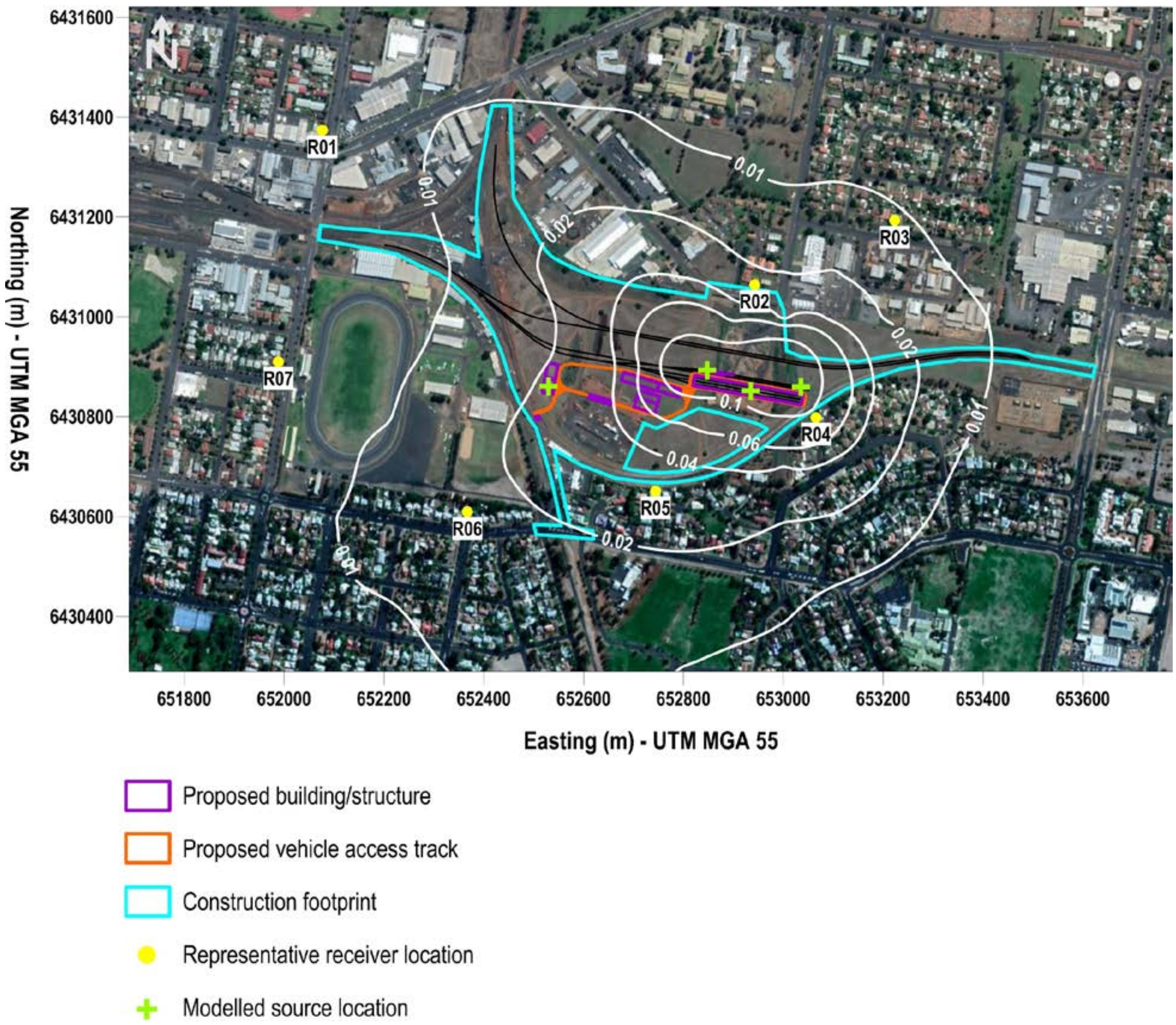


A.1.3 Sulfur dioxide (SO_2)

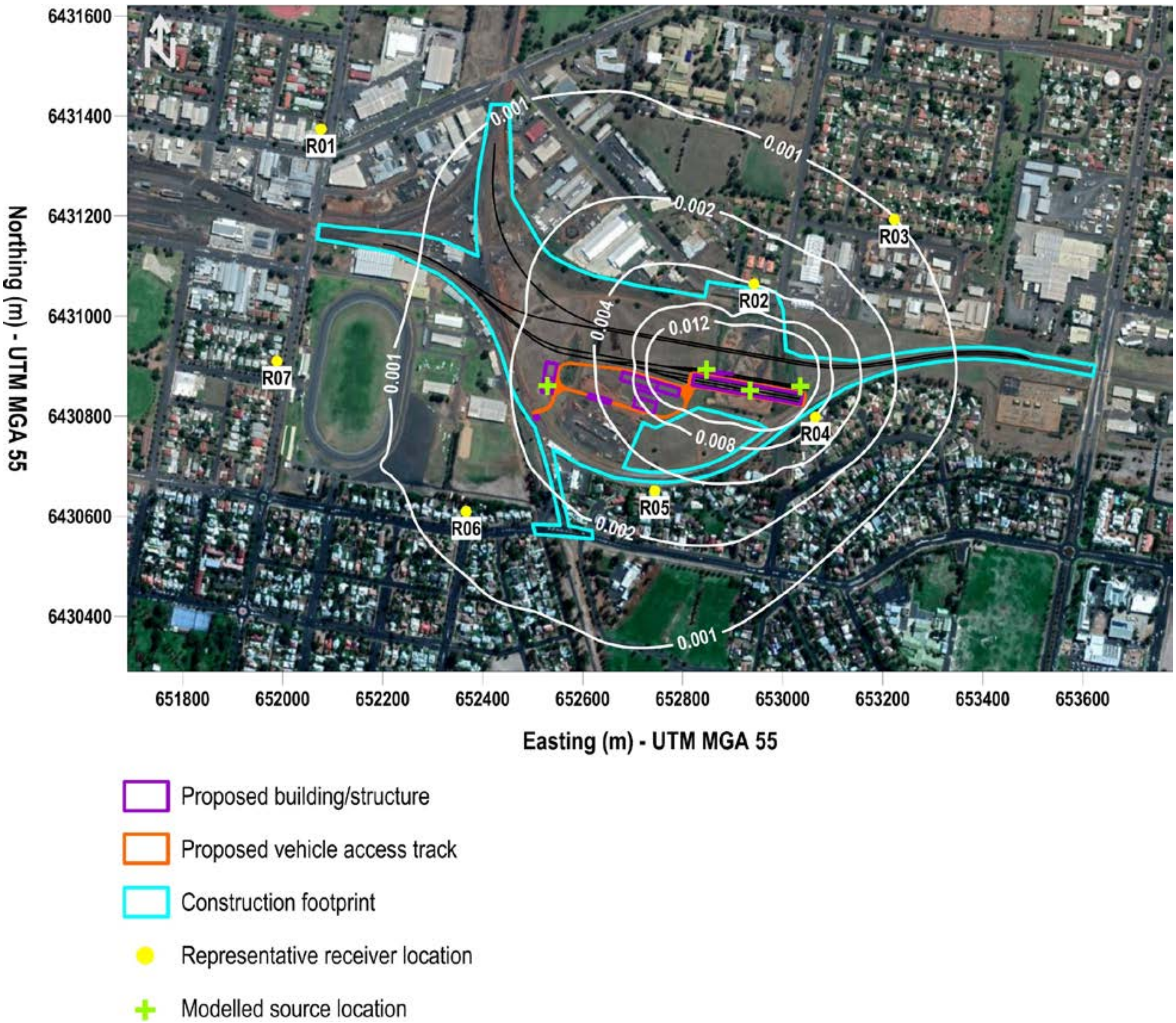
A.1.3.1 1-hour averaged, 100th percentile SO_2 (µg/m³)



A.1.3.2 24-hour averaged, 100th percentile SO_2 (µg/m^3)

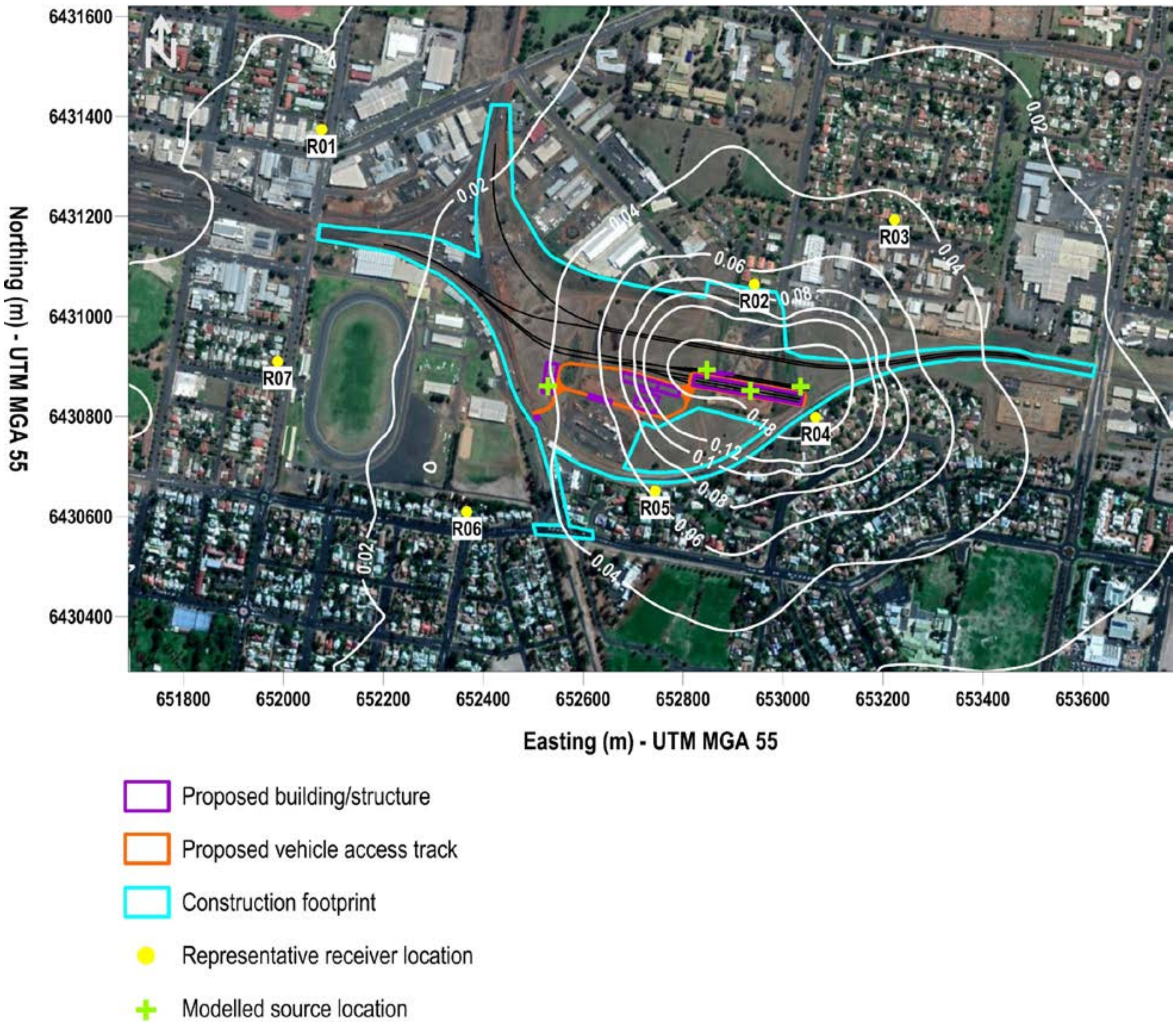


A.1.3.3 Annually averaged, 100th percentile SO_2 ($\mu g/m^3$)

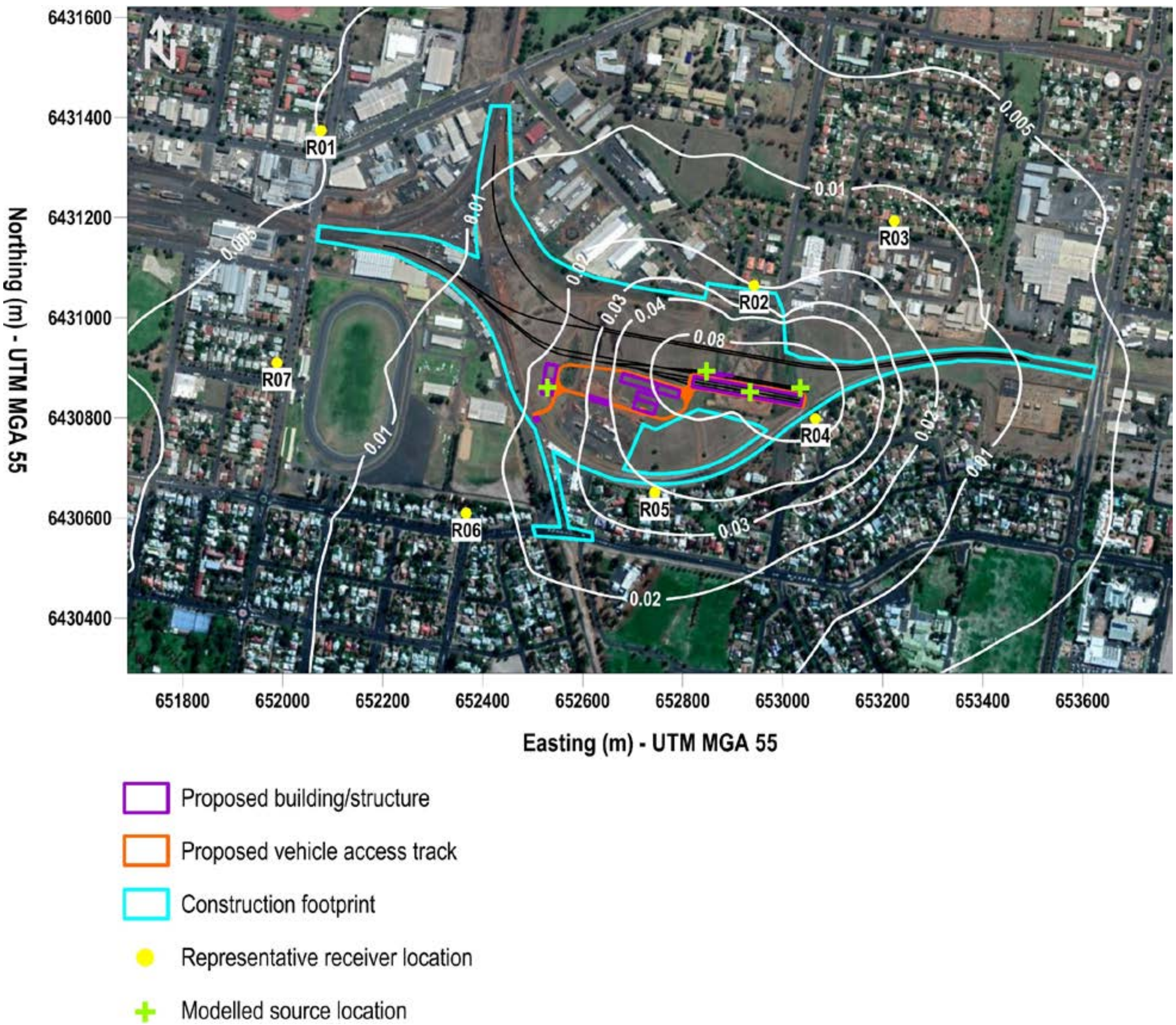


A.1.4 Carbon monoxide (CO)

A.1.4.1 1-hour averaged, 100th percentile CO (mg/m^3)

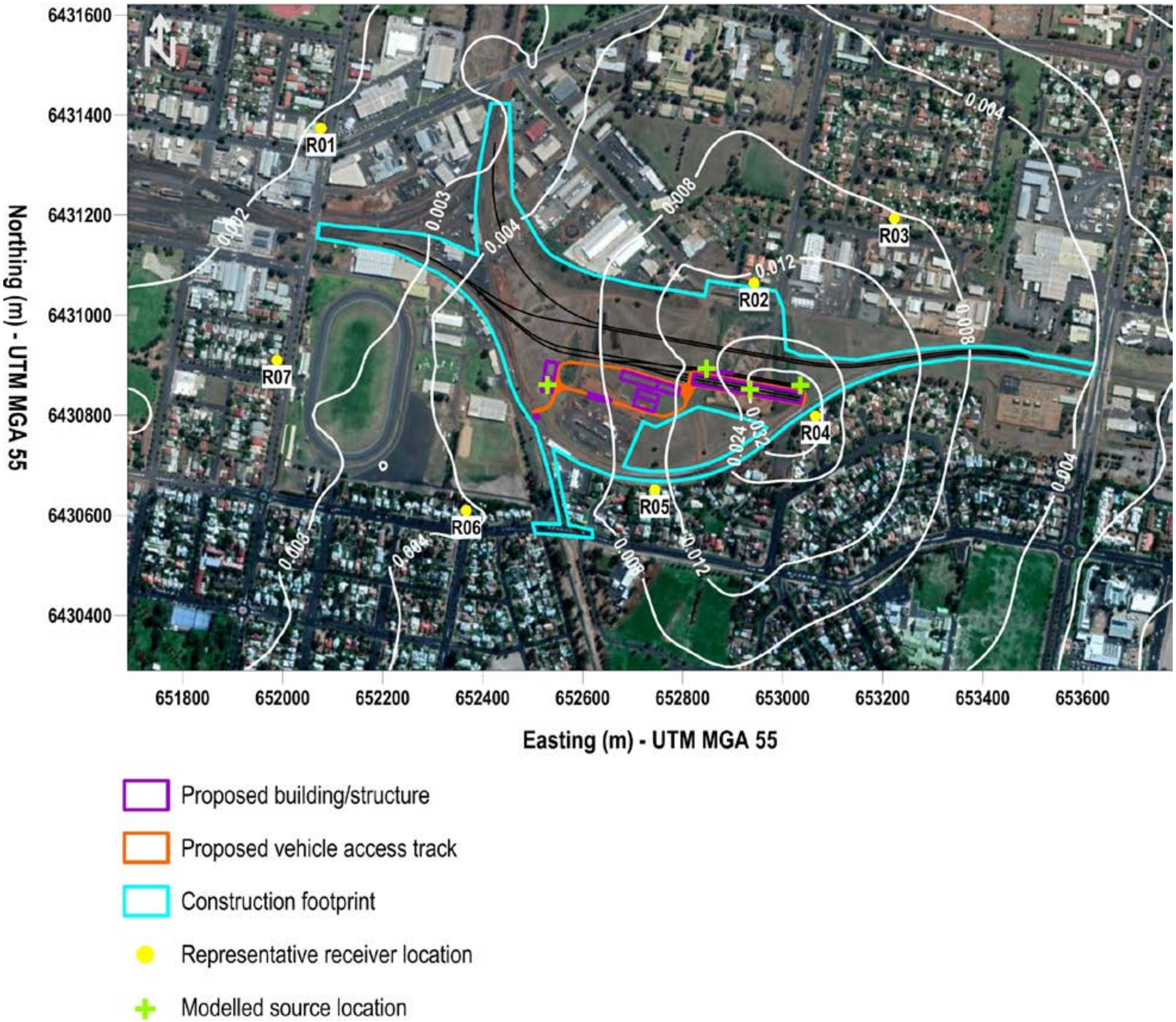


A.1.4.2 8-hour averaged, 100th percentile CO (mg/m^3)

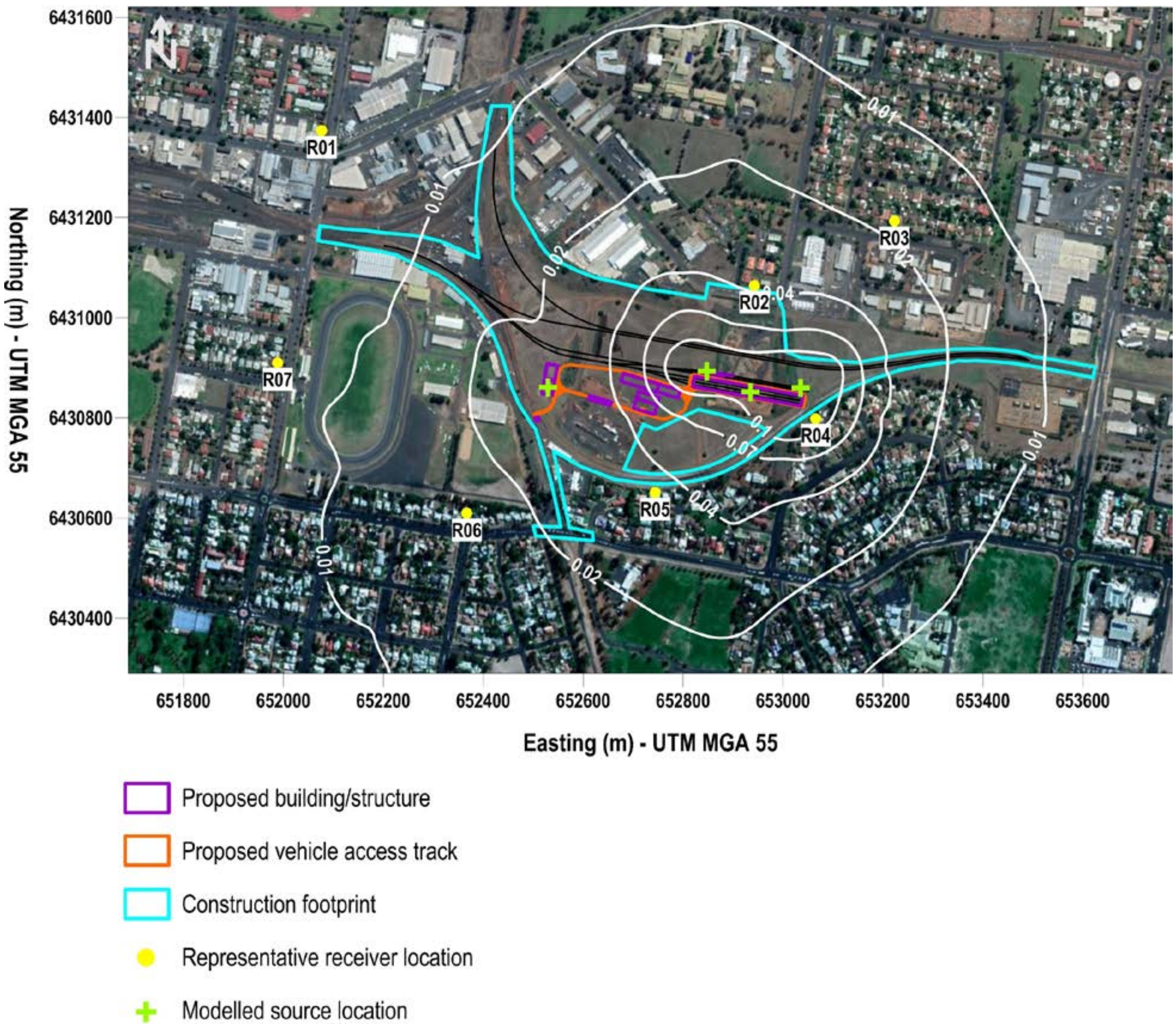


A.1.5 Arsenic, benzene and toluene

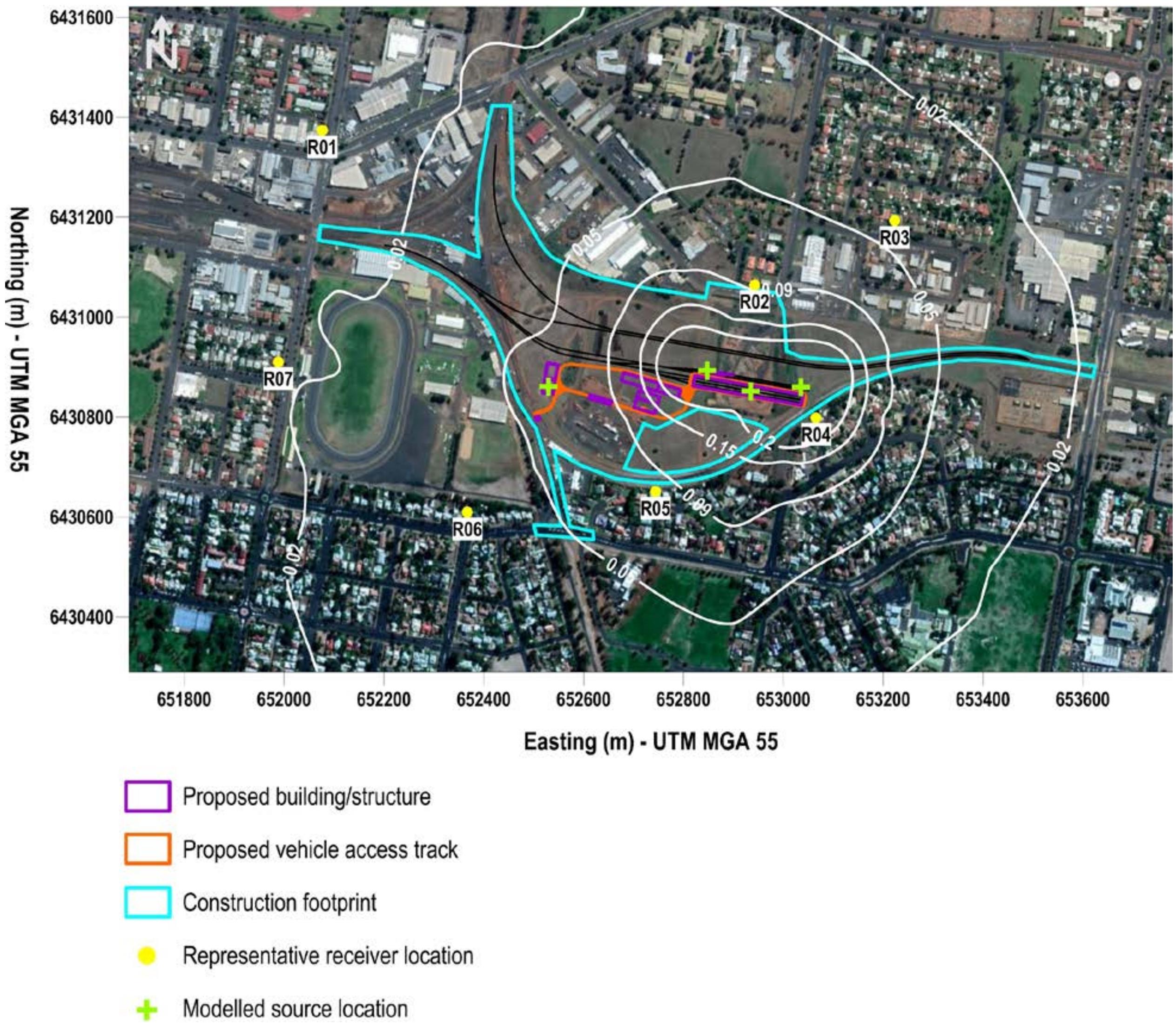
A.1.5.1 1-hour averaged, 99.9th percentile arsenic (µg/m³)



A.1.5.2 1-hour averaged, 99.9th percentile benzene (µg/m³)



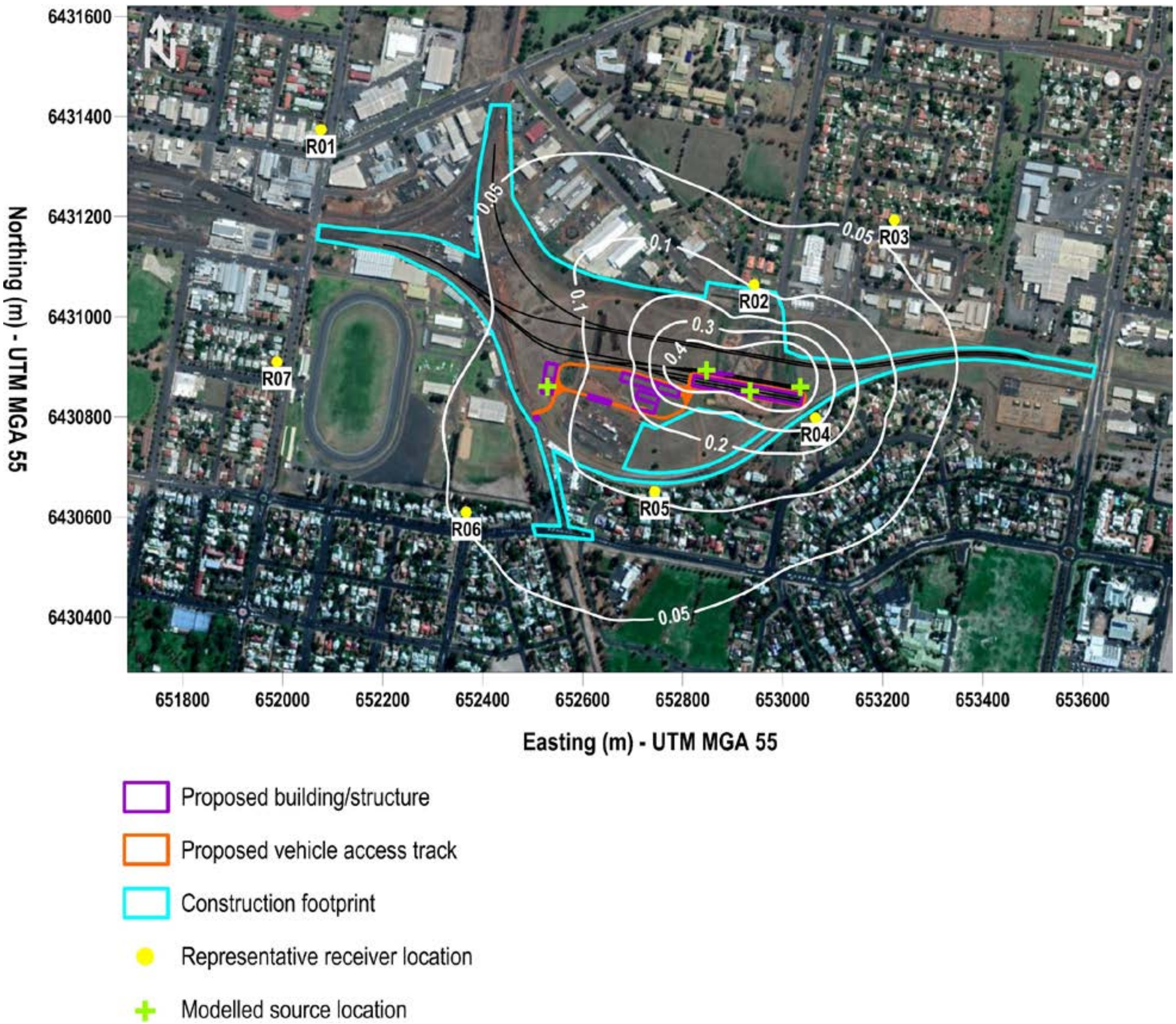
A.1.5.3 1-hour averaged, 99.9th percentile toluene (μg/m³)



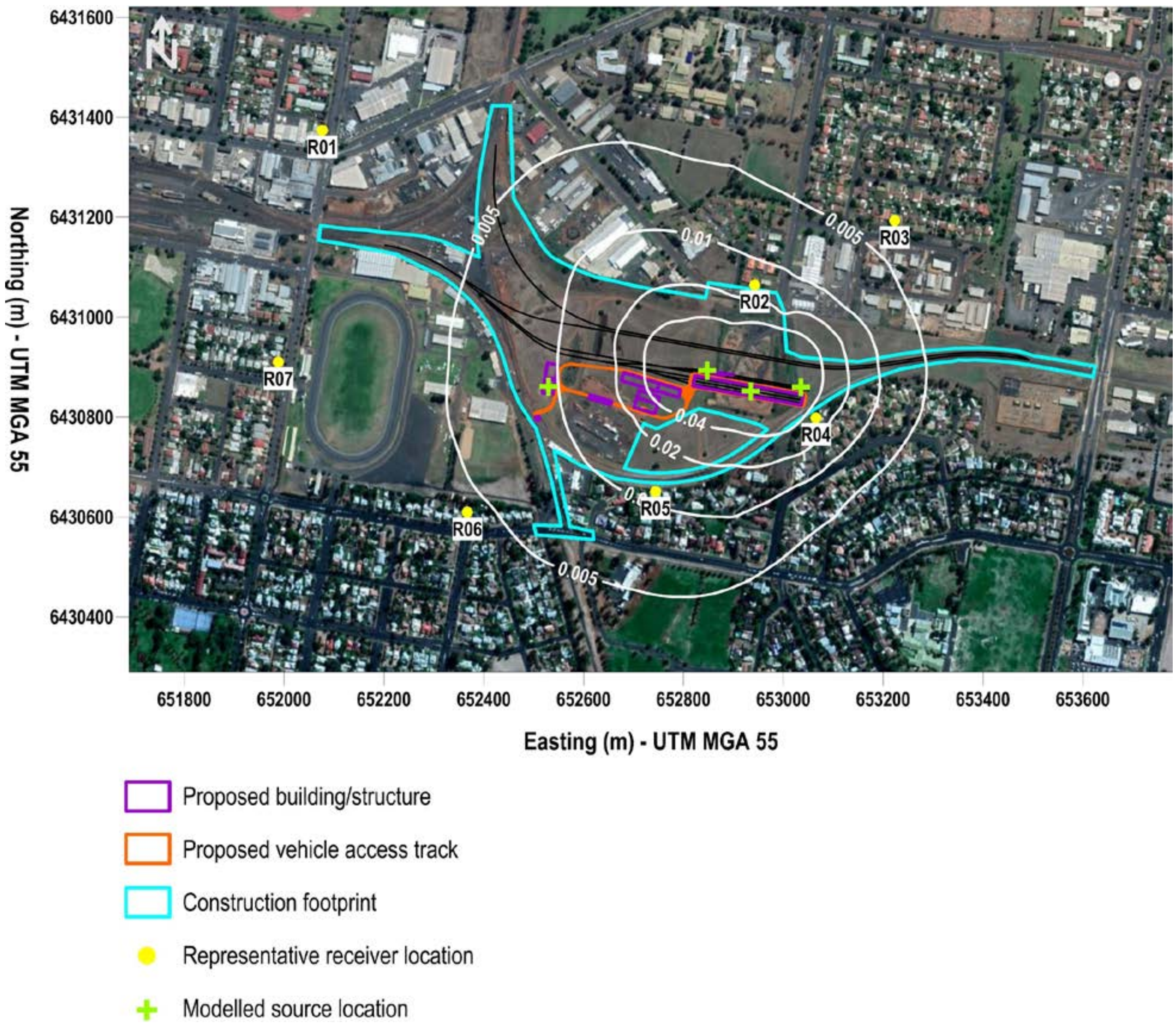
A.2 Scenario 02

A.2.1 Particulate matter (PM_{10} and $PM_{2.5}$)

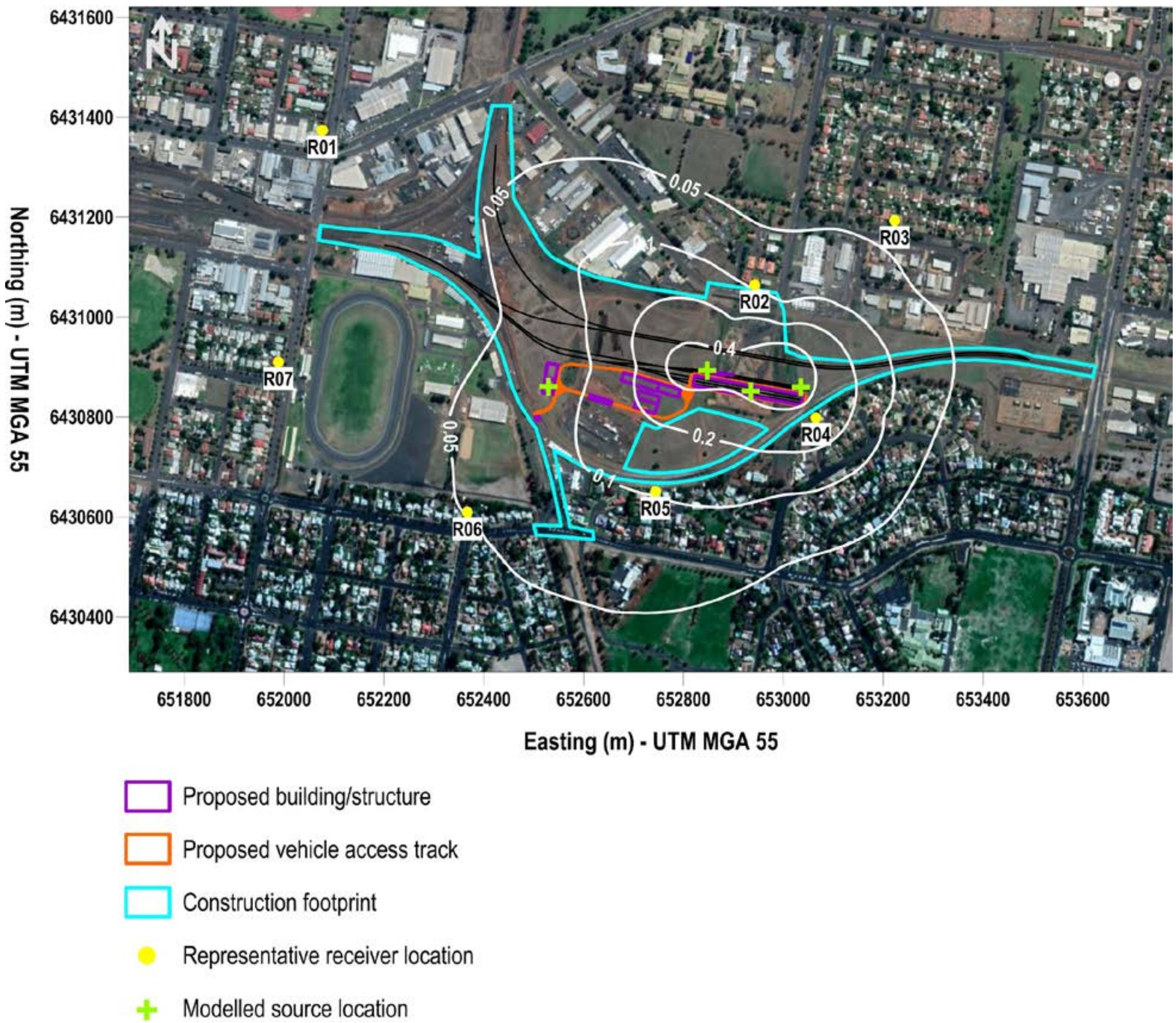
A.2.1.1 24-hour averaged, 100th percentile PM_{10} ($\mu g/m^3$)



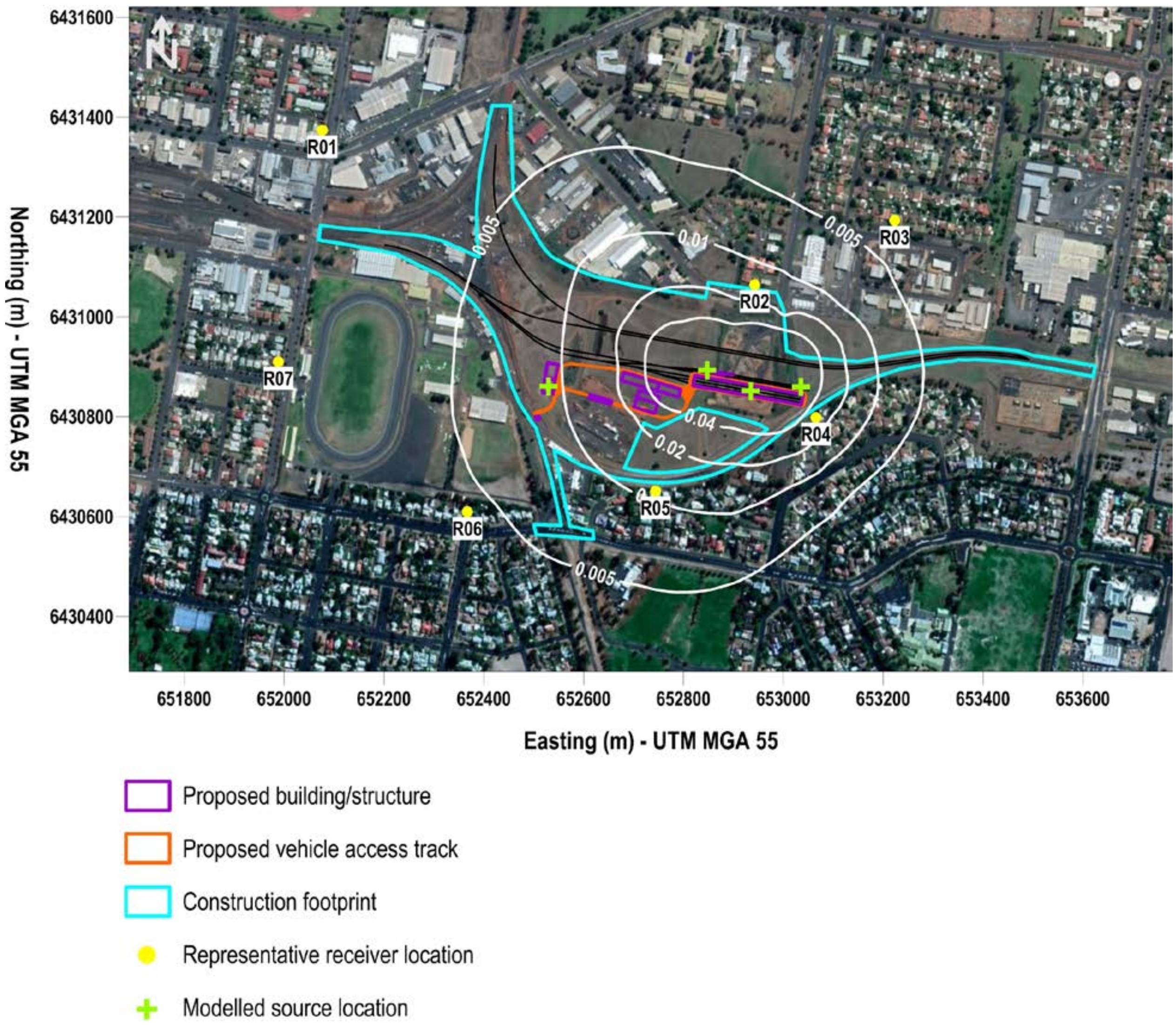
A.2.1.2 Annually averaged, 100th percentile PM_{10}



A.2.1.3 24-hour averaged, 100th percentile $PM_{2.5}$ ($\mu g/m^3$)

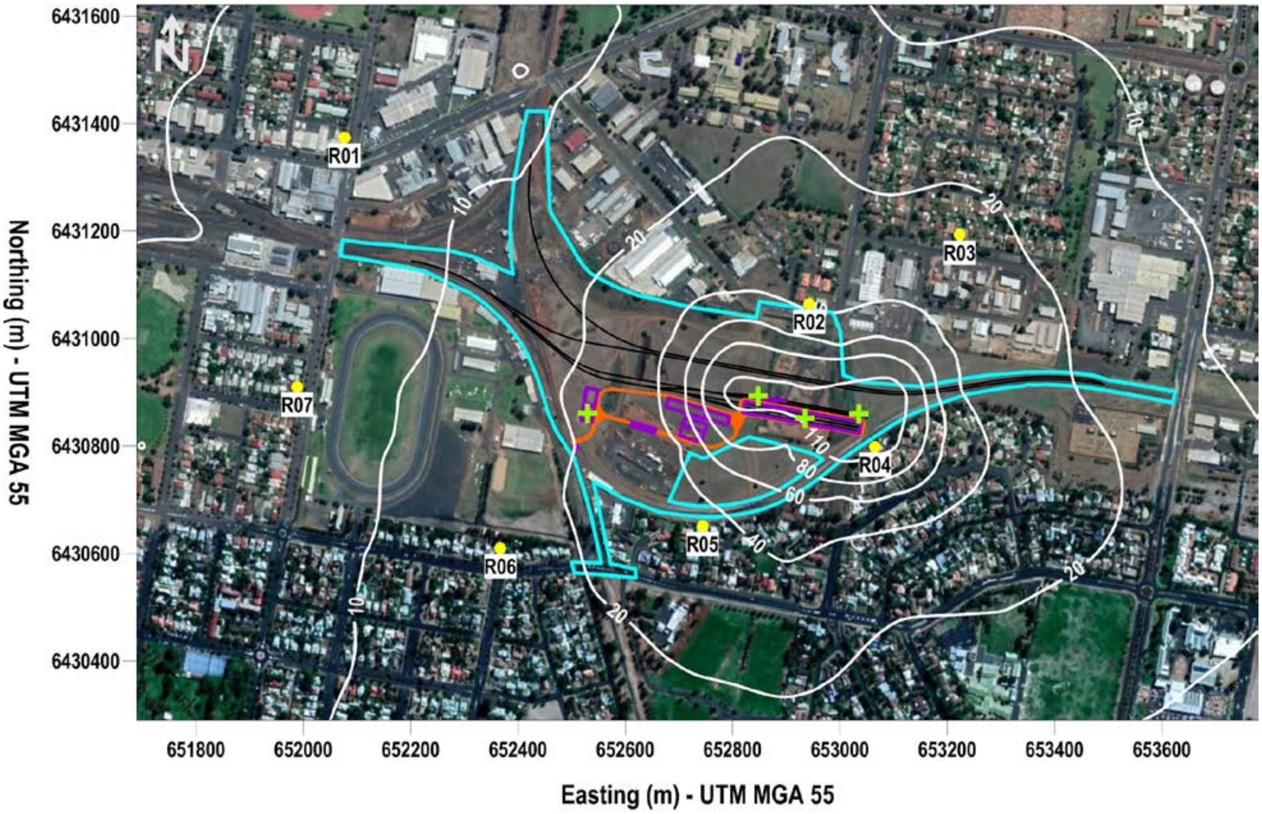


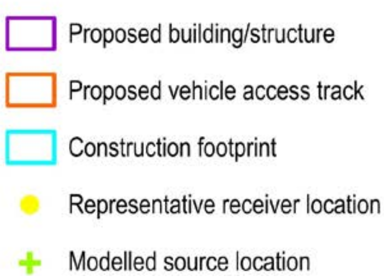
A.2.1.4 Annually averaged, 100th percentile $PM_{2.5}$ ($\mu g/m^3$)



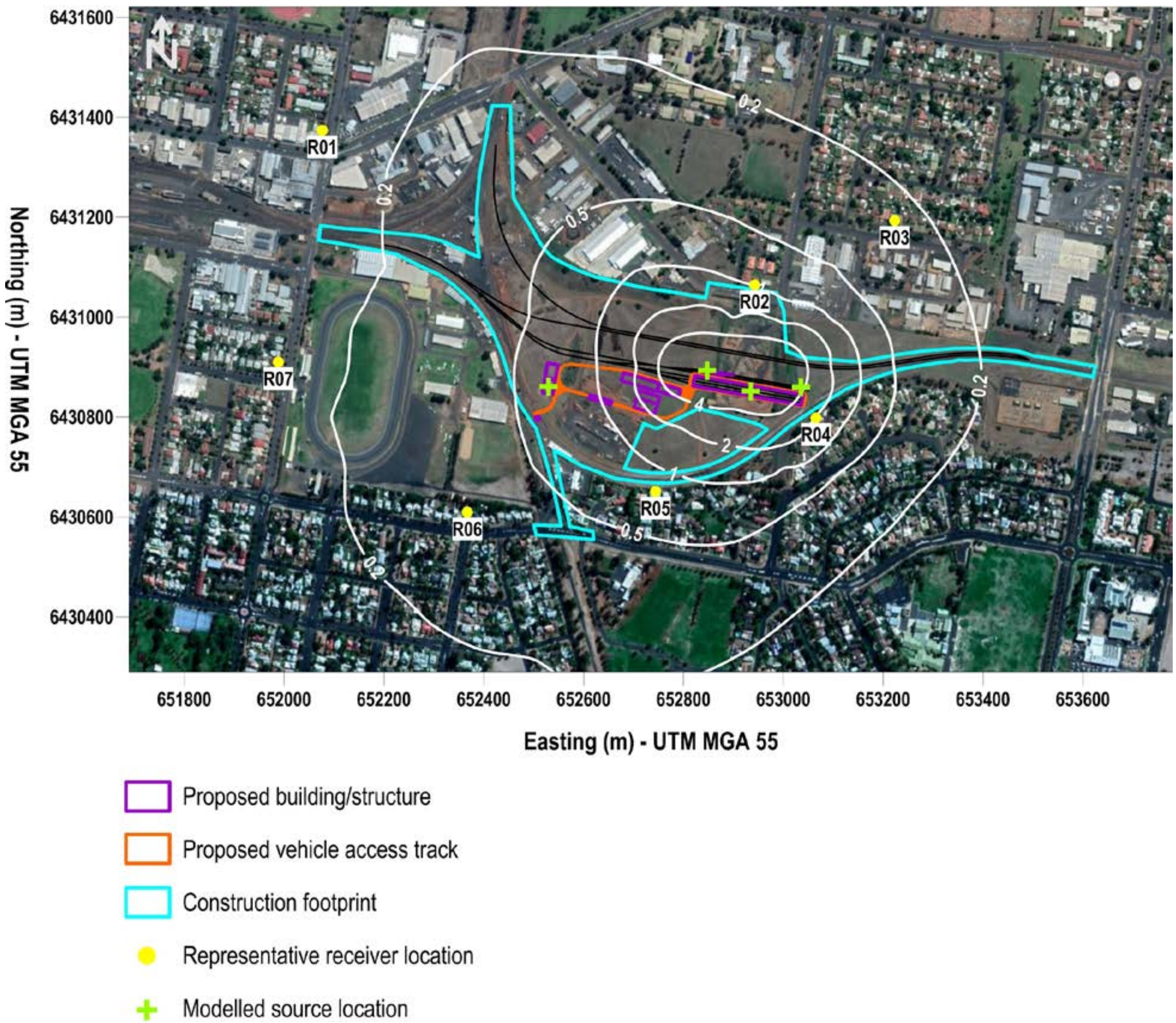
A.2.2 Nitrogen dioxide (NO_2)

A.2.2.1 1-hour averaged, 100th percentile NO_2 ($\mu g/m^3$)



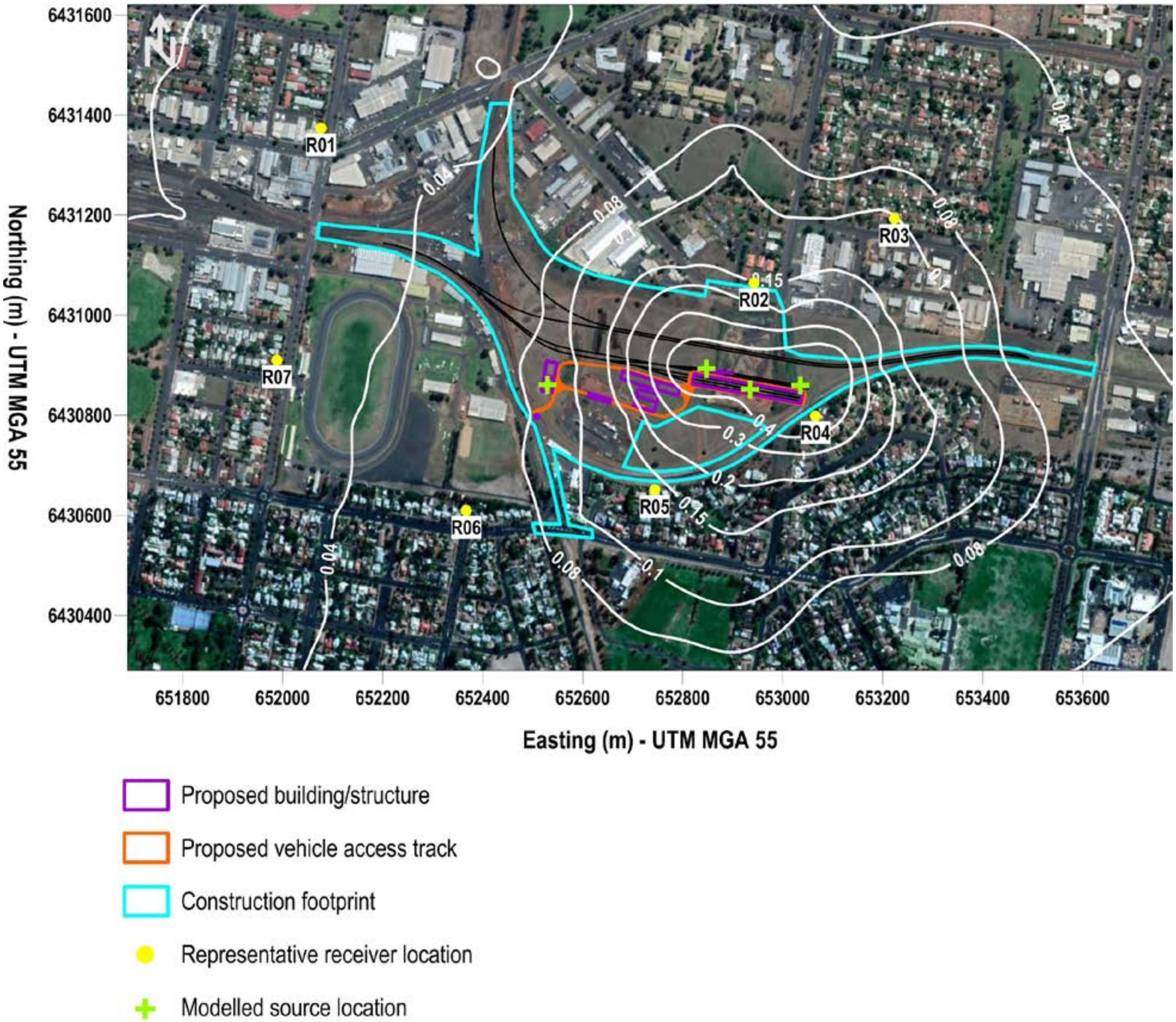


A.2.2.2 Annually averaged, 100th percentile NO_2 ($\mu g/m^3$)

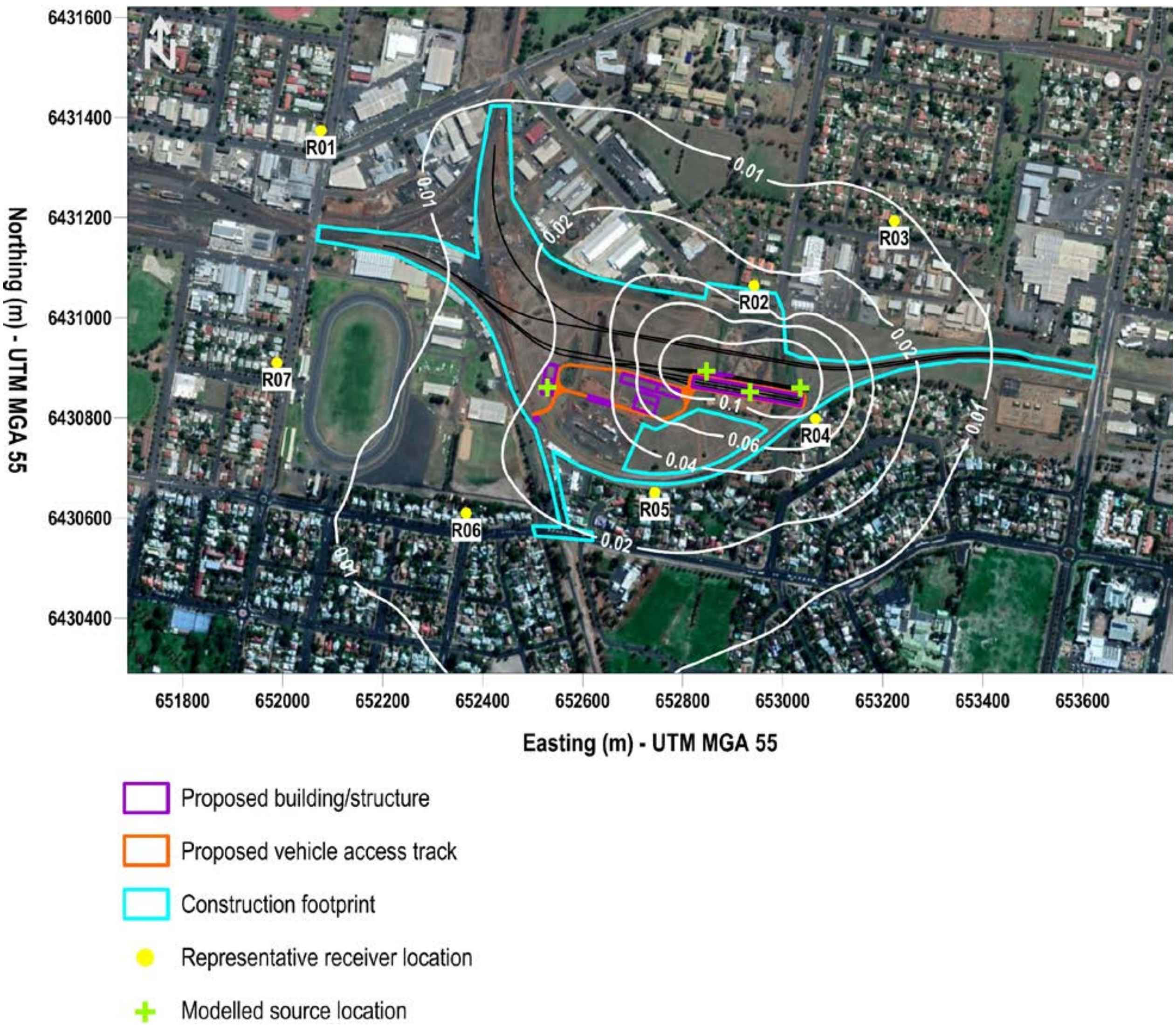


A.2.3 Sulfur dioxide (SO_2)

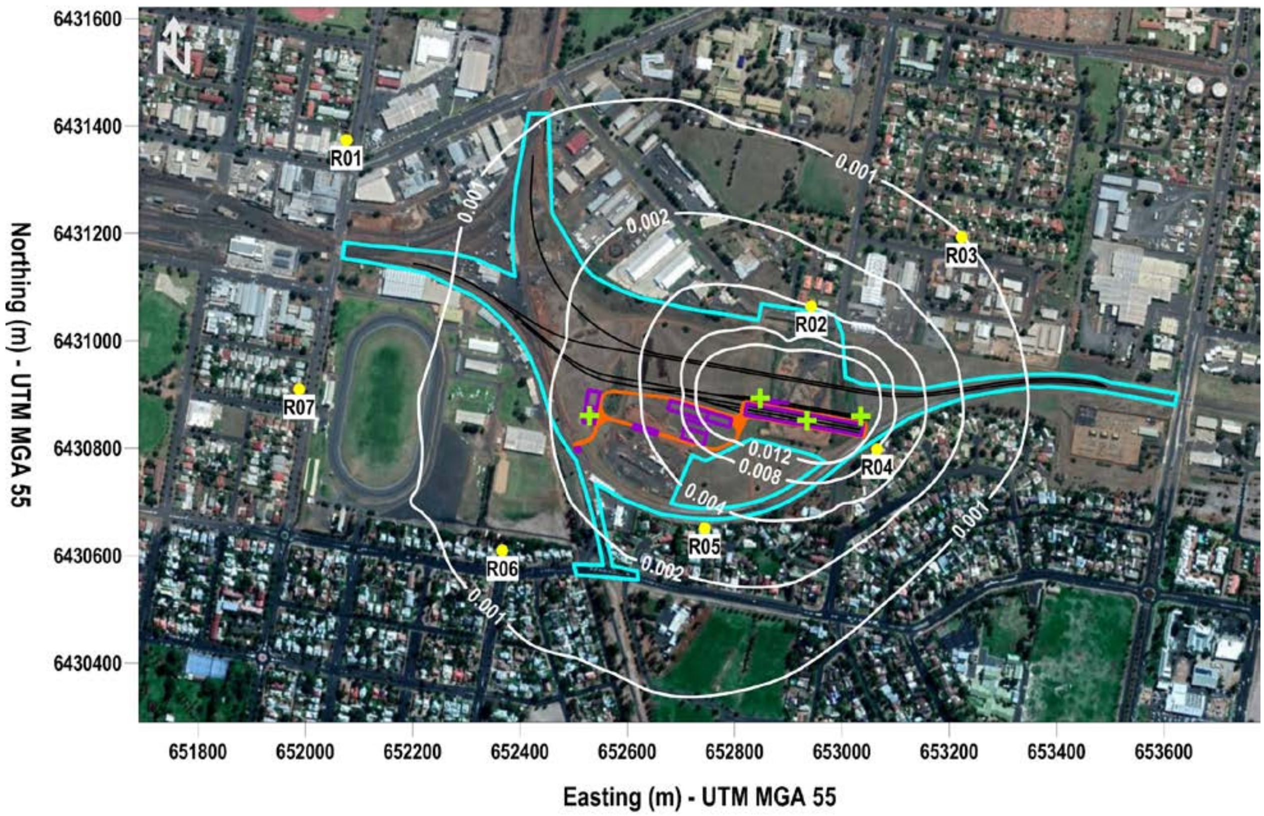
A.2.3.1 1-hour averaged, 100th percentile SO_2 (µg/m^3)

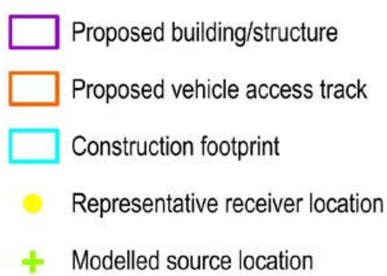


A.2.3.2 24-hour averaged, 100th percentile SO_2 ($\mu g/m^3$)



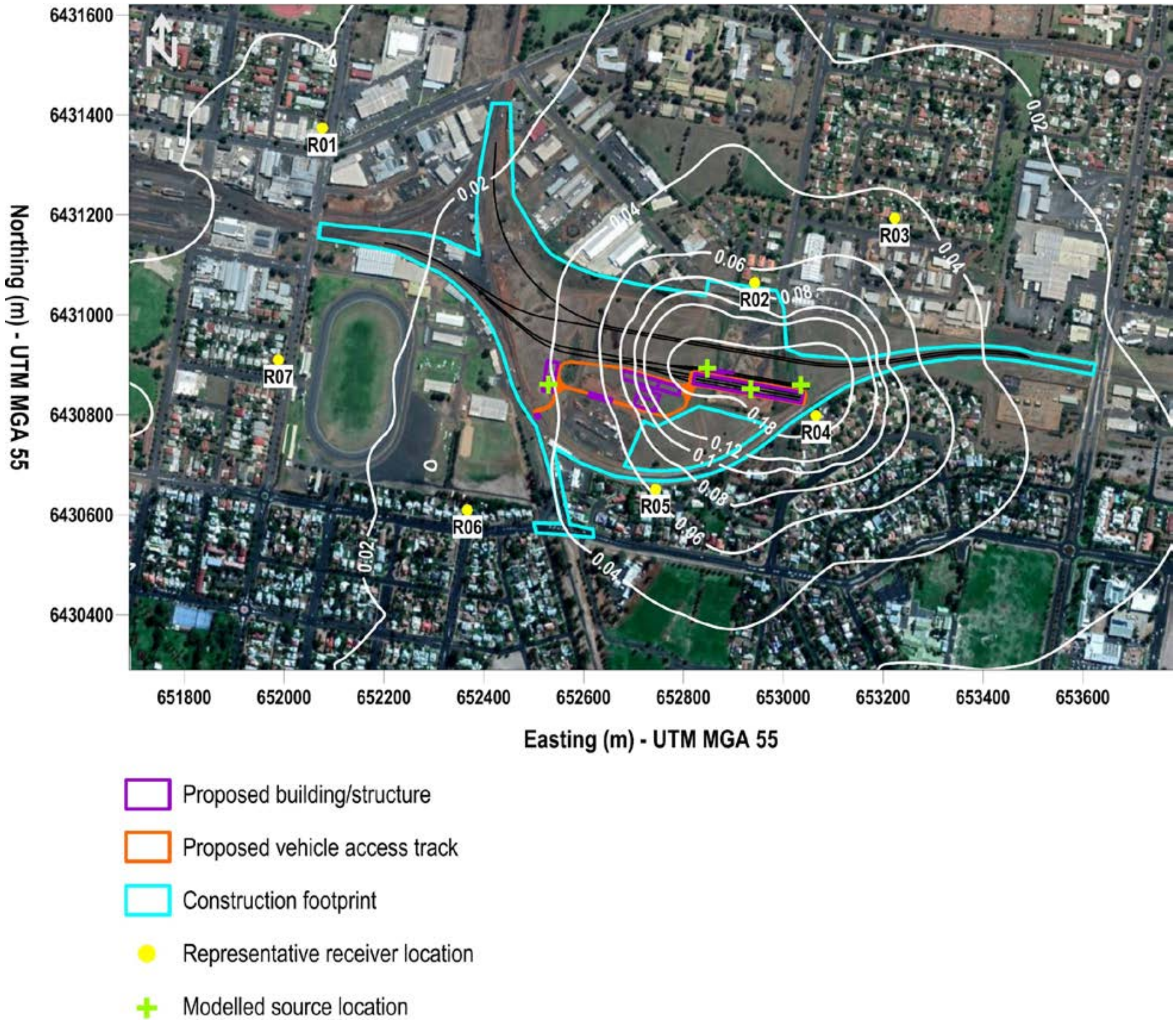
A.2.3.3 Annually averaged, 100th percentile SO_2 ($\mu g/m^3$)



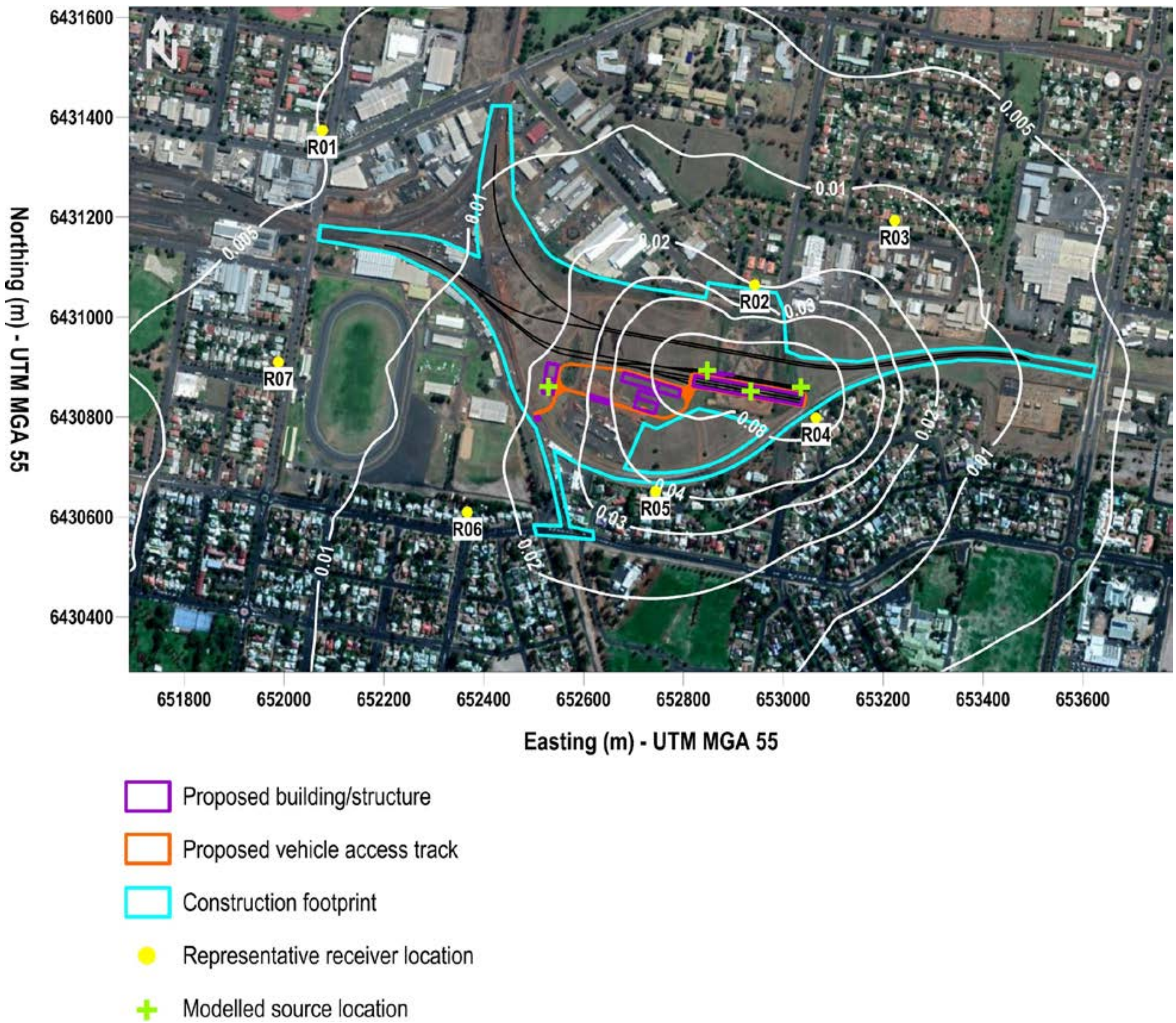


A.2.4 Carbon monoxide (CO)

A.2.4.1 1-hour averaged, 100th percentile CO (mg/m^3)

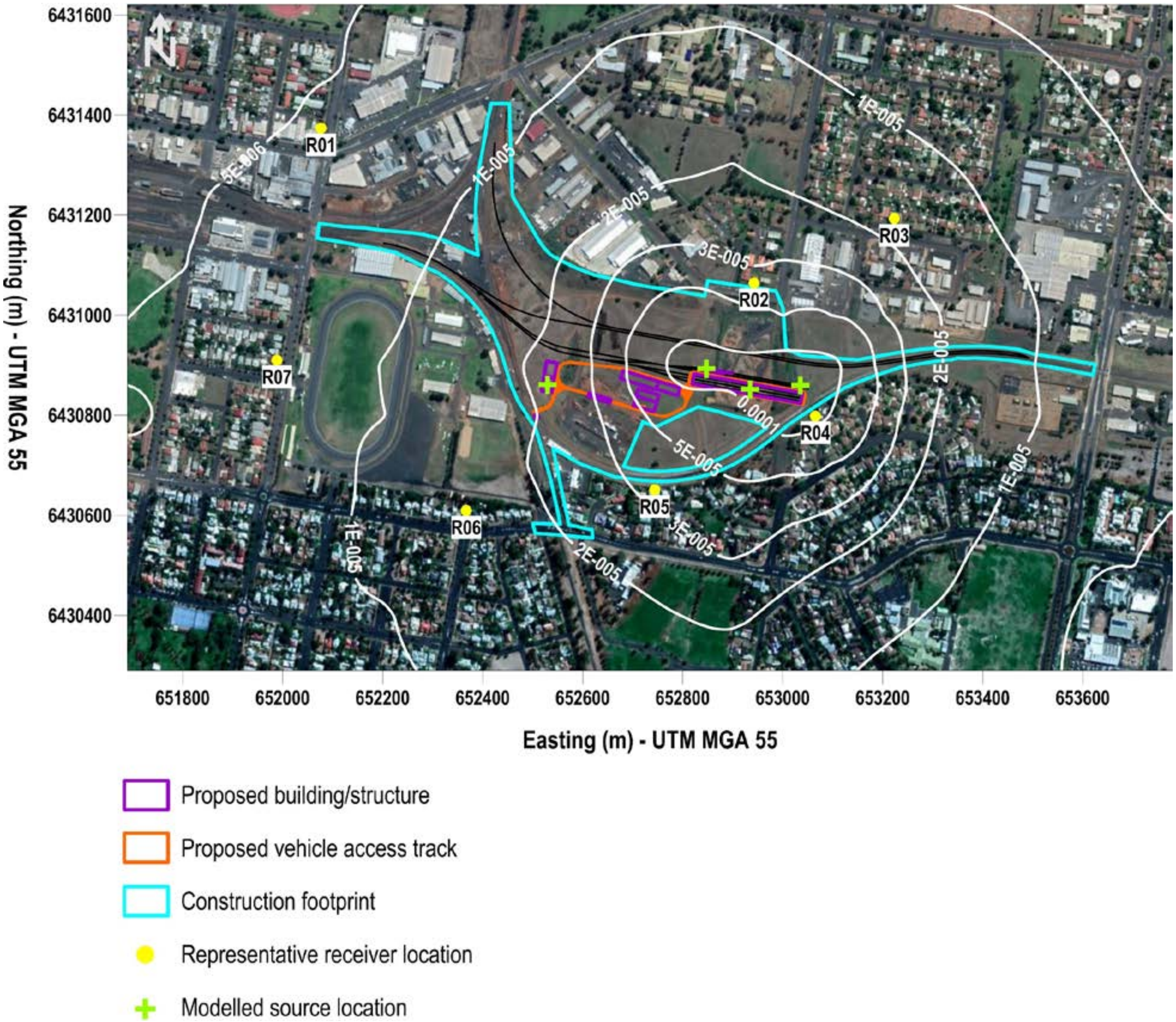


A.2.4.2 8-hour averaged, 100th percentile CO (mg/m^3)

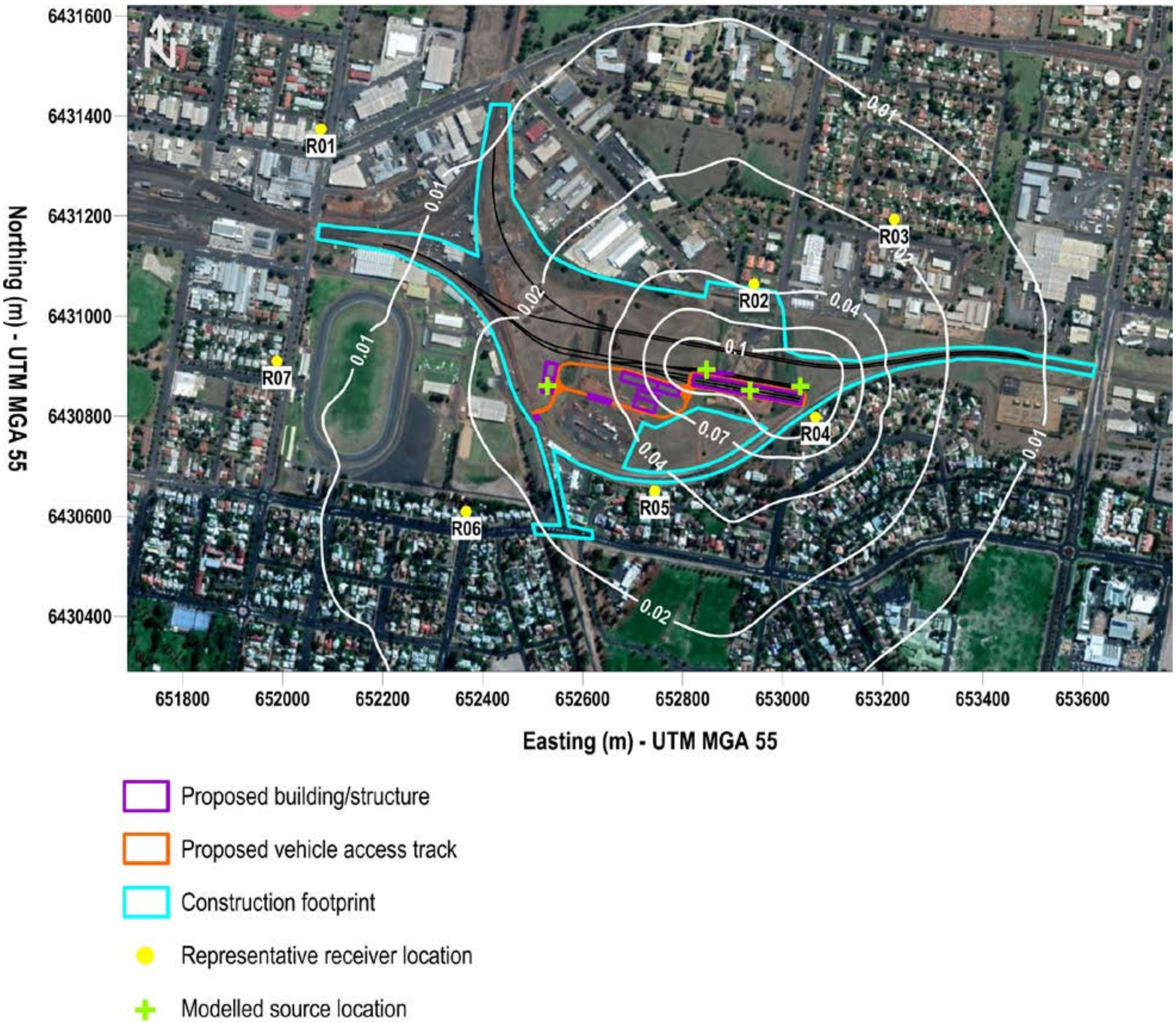


A.2.5 Arsenic, benzene and toluene

A.2.5.1 1-hour averaged, 99.9th percentile arsenic (µg/m^3)



A.2.5.2 1-hour averaged, 99.9th percentile benzene (μg/m³)



A.2.5.3 1-hour averaged, 99.9th percentile toluene (μg/m³)