9

AIR QUALITY

ENTER HERE
BACK TO CONTENTS

arrow energy
go further

9 Air Quality

This section provides a description of the air quality environmental values within the Project area and an assessment of the potential direct and indirect impacts of the Project on these values. The potential impacts have been assessed using the compliance assessment method, which is described in the Impact Assessment Method chapter (Section 6) of this EIS. For the detailed description of the findings of the air quality assessment refer to the Air Quality Technical Report (Appendix H) of this EIS.

Air quality assessment criteria were developed for the Project based on national and state legislative air quality objectives. Compliance with the Project criteria was tested through quantitative analysis. The mitigation and management measures required to protect the environmental values are described.

A cross reference to the locations where each of the requirements of the ToR has been addressed is given in Appendix B which references both the study chapters (Sections 1 through 34) and/or the Appendices (A through EE).

9.1 Legislative Context

The following legislation, policies and guidelines were used to develop Project criteria for the protection of the air quality environment in the Project area.

9.1.1 National Environment Protection Measure

The *National Environment Protection Council Act 1994* (NEPC Act) and subsequent amendments define the National Environment Protection Measures (NEPM) as instruments for setting environmental objectives in Australia. The NEPM for Ambient Air Quality was first released in 1998 with subsequent amendments in 2003 (NEPC, 2003). The Air Toxics NEPM was released in 2004 (NEPC, 2004).

The National Pollutant inventory NEPM, introduced in 1998, with subsequent amendments in 2008, requires Australian facilities to report their use, emissions and transfers of a prescribed list of substances (NEPC, 2008).

9.1.2 Queensland Environmental Protection Policies

In Queensland, air quality is managed under the *Environment Protection Act 1994* (EP Act), the Environmental Protection Regulation 2008 (the EP Regulation) and the *Environmental Protection (Air) Policy 2008* (EPP (Air)). The Act provides for long-term protection for the environment in Queensland in a manner that is consistent with the principles of ecologically sustainable development. The Regulation aims to protect and enhance environmental values relating to Queensland's environment.

Schedule 1 of the EPP (Air) specifies the air quality objectives that are designed to enhance or protect the following environmental values with relevance to the Project:

- The qualities of the air environment that are conducive to human health and wellbeing;
- The qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and

- Avoid, minimise and manage Project-related emissions to the air environment to minimise impacts on the existing environment, health and biodiversity of ecosystems and agriculture.

The primary purpose of the EPP (Air) is to achieve the objectives of the Act in relation to Queensland's air environment. The air quality objectives implemented in the EPP (Air) are based on the NEPMs for Ambient Air Quality and Air Toxics with subsequent amendments.

9.1.3 Project Assessment Criteria

The air quality assessment criteria (Project criteria) adopted for this assessment are based on the NEPM (Ambient Air Quality) and the EPP (Air). The Project criteria are presented in Table 9-1.

Table 9-1 Project Air Quality Criteria

Pollutant	Averaging Period	Criteria	Jurisdiction	Allowable Exceedences
Carbon monoxide (CO)	8-hour	11 mg/m^3	NEPM / EPP(Air) [a]	1 day per annum
Nitrogen dioxide (NO_2)	1-hour	250 µg/m^3	NEPM / EPP(Air) [a]	1 day per annum
	Annual	62 µg/m^3	NEPM / EPP(Air) [a]	
	Annual	33 µg/m^3	EPP(Air) [b]	
Ozone (O_3)	1-hour	210 µg/m^3	NEPM / EPP(Air) [a]	1 day per annum
	4-hour	160	NEPM / EPP(Air) [a]	1 day per annum
Particulates with aerodynamic diameter less than 10 micrometres (PM_{10})	24-hour	50 µg/m^3	NEPM / EPP(Air) [a]	5 days per annum
Particulates with aerodynamic diameter less than 2.5 micrometres ($PM_{2.5}$)	24-hour	25 µg/m^3	NEPM / EPP(Air) [a]	
	Annual	8 µg/m^3	NEPM / EPP(Air) [a]	
Total suspended particulates (TSP)	Annual	90 µg/m^3	EPP(Air) [a]	
Sulphur dioxide (SO_2)	1-hour	570 µg/m^3	NEPM / EPP(Air) [a]	1 day per annum
	24-hour	230 µg/m^3	NEPM / EPP(Air) [a]	1 day per annum
	Annual	57 µg/m^3	NEPM / EPP(Air) [a]	
	Annual	32 µg/m^3	EPP(Air) [c]	
	Annual	22 µg/m^3	EPP(Air) [b]	
1,2-dichloroethane	24-hour	750 µg/m^3	EPP(Air) [a]	
1,3-Butadiene	Annual	2.4 µg/m^3	EPP(Air) [a]	
Benzene	Annual	10 ng/m^3	EPP(Air) [a]	

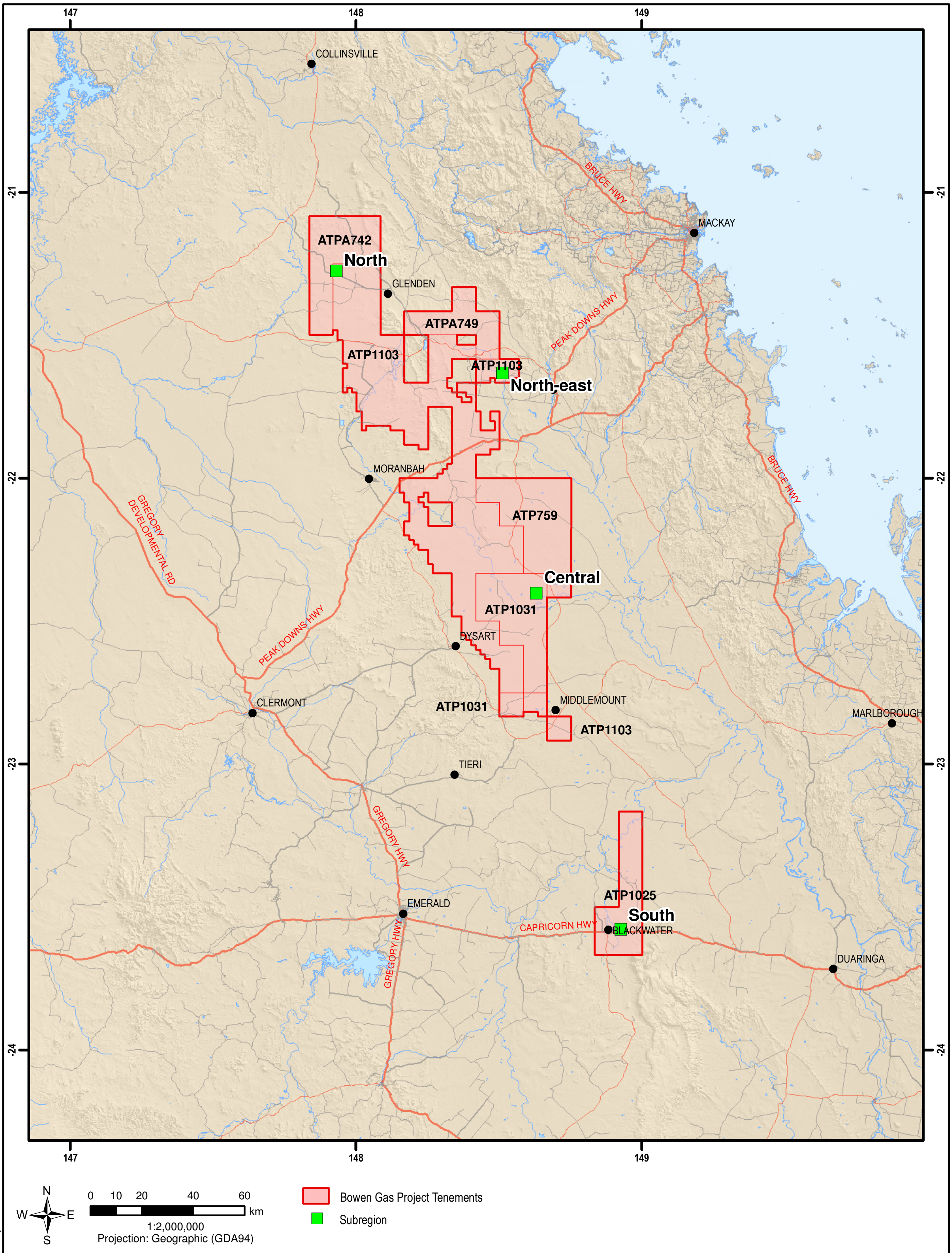
Pollutant	Averaging Period	Criteria	Jurisdiction	Allowable Exceedences
Toluene	24-hour	4100 µg/m^3	EPP(Air) [a]	
	Annual	410 µg/m^3	EPP(Air) [a]	
Xylene	24-hour	1200 µg/m^3	EPP(Air) [a]	
	Annual	950 µg/m^3	EPP(Air) [a]	

[a] EPP (Air) objective for human health and wellbeing
[b] EPP (Air) objective for ecological health and biodiversity (for forests and natural vegetation)
[c] EPP (Air) objective for protecting agriculture
µg/m^3: micrograms per cubic metre

9.2 Study Area

The Project study area (airshed) was defined to allow modelling on a regional scale incorporating major terrain features and the coast. However, regional modelling does not provide sufficient resolution to determine localised air quality impacts. Therefore, smaller study areas or sub-regions were chosen to allow evaluation of localised impacts. Detailed definitions of the study areas for the regional and local air quality assessments can be found in Section 4 of the Air Quality Technical Report (Appendix H) of this EIS.

The Project study area with the selected subregions is shown in Figure 9-1.



arrow energy go further

BOWEN GAS PROJECT EIS

AIR QUALITY STUDY AREA AND SELECTED SUBREGIONS

URS

AIR QUALITY

Figure: **9-1**

File No: **42626960-g-1054.mxd** Drawn: **XL** Approved: **DS** Date: **18-10-2012** Rev. **A** A4

9.3 Existing Environment

9.3.1 Climate and Meteorology

Meteorological monitoring data were used to determine long term, local climate characteristics and seasonal conditions in the study area (BOM 2012). These were used to explain the effect of local meteorology on the dispersion of air pollutants.

The climate of the study area can be summarised as follows.

- Winter months are more arid than summer months, with nearly half of the annual rainfall occurring in the summer months of December through to February. Rainfall decreases from north to south and with inland distance from the coast. Monthly rainfall ranges from less than 26 mm in winter to above 100 mm in summer at inland locations (Blackwater, Clermont, Emerald and Moranbah). The coastal section of the airshed, represented by data from Mackay, has the highest average monthly rainfall in summer (371 mm) and the lowest in early spring (28 mm).
- The average daily temperatures across the airshed are similar. The mean maximum temperature ranges from approximately 30°C to 34°C in summer (December-February) to 22°C to 25°C during winter (June-August). The mean daily minimum temperature varies from approximately 7°C (July) to 23°C (January).
- Mean daily solar exposure is similar across the study area and changes throughout the year in line with the seasons, with values ranging from 14.5 megajoules per square metre (MJ/m^2) in winter (June) to 26 MJ/m^2 in summer (December). Evaporation rates are highest during the summer months because of higher temperatures and solar radiation. Evaporation rates range from 3.0 mm in winter to 8.6 mm in summer.
- Relative humidity varies with season, reaching a maximum in summer (February) and winter (June) and falling in autumn and spring. The lowest relative humidity levels across the sites occur in September and October (spring). Relative humidity is higher at 9 am (53% to 79%) and lower at 3 pm (29% to 48%). Relative humidity is higher on the coast with a smaller difference between 9 am and 3 pm.
- Wind speeds vary across the airshed. The highest wind speeds are observed at Mackay on the coast and the lowest at Moranbah, close to the central part of the Project area. In general, 9 am wind speeds are lower than the 3 pm wind speeds. The lowest wind speeds were observed in the winter months.
- The predominant wind flow in the area is from the north-east to south-east. However, at Blackwater (located in the south-east of the study area) and Moranbah (centrally located within the study area) winds from the southeast are the least frequent. Calm and light winds are more frequent inland.
- The study area is subject to extreme climate events such as droughts, floods and cyclones.

The study area experiences a subtropical, subhumid climate, with a marked wet summer and moderately dry winter typical of central Queensland. However, the north east area of the airshed is impacted by coastal meteorology such as increased rainfall and land sea breezes, which penetrate inland. A detailed description of the climate of the study area can be found in the Climate chapter (Section 8) of this EIS.

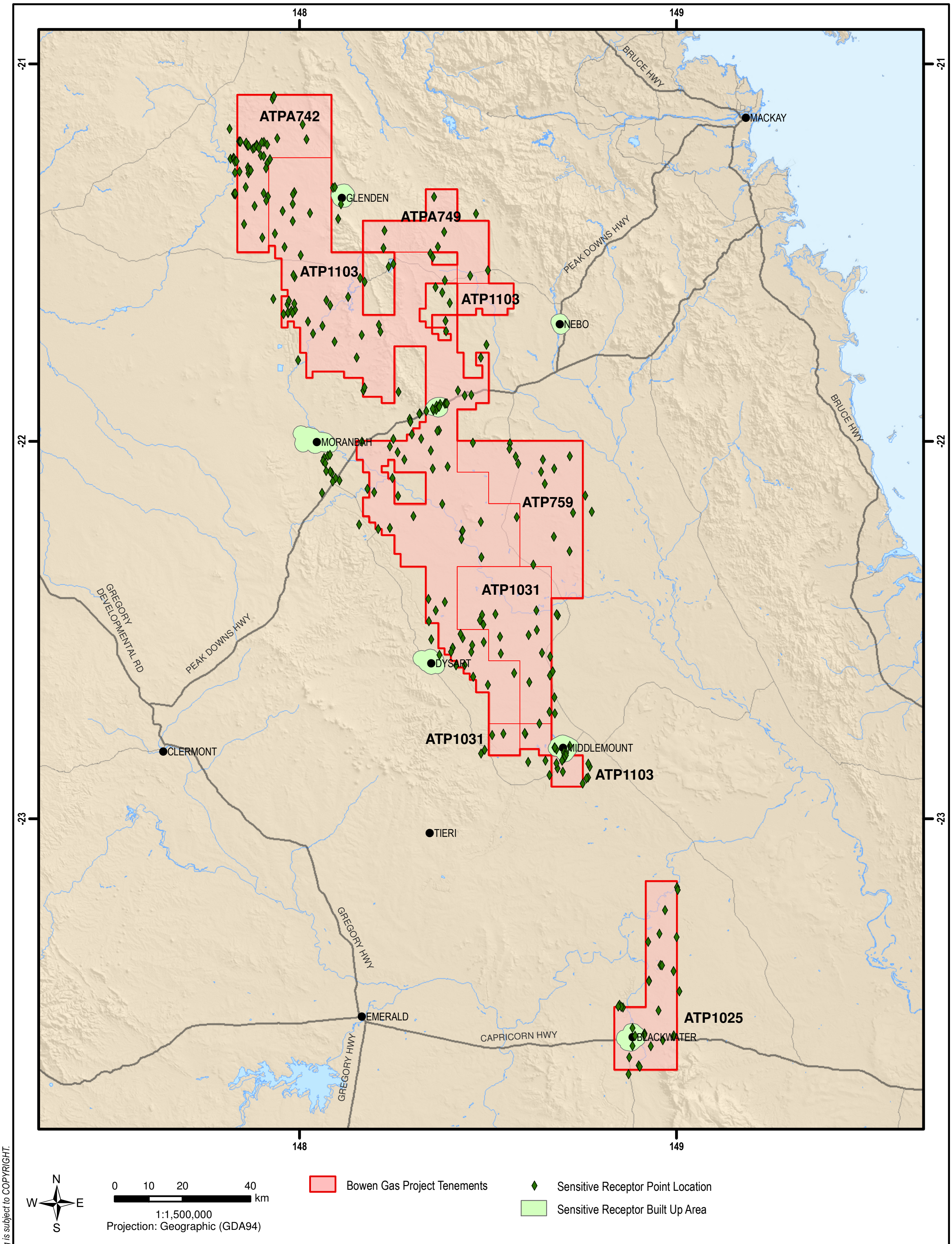
9.3.2 Terrain and Land Use

The Project is located in the Bowen Basin and covers an area of approximately 8,000 km^2. The terrain in the region is gently sloping with the Connors Range to the east and the Denham Range to the west. The existing land use within the study area consists primarily of bushland and forest. The area is used for grazing and agriculture, black coal mining, metals processing, oil and gas development and forestry.

9.3.3 Location of Sensitive Receptors

The sensitive receptors that may be affected by the Project were determined in a desktop survey and are described in Constraints Mapping (Appendix BB of this EIS). Sensitive receptors will be ground truthed at a later stage.

Figure 9-2 shows the locations of sensitive receptors in the study area.



Source: This product may contain information that is © Mapinfo Australia Pty Ltd and PSMA Australia Ltd., © Copyright Commonwealth of Australia (Geoscience Australia) 2006 , © Copyright The State of Queensland (Department of Natural Resources and Water) 2008, © The State of Queensland (Department of Mines and Energy) 2006-2008,© The State of Queensland (Department of Environment and Resource Management) 2010, Bing Maps © Microsoft Corporation and its data suppliers, Images from Client Feb 2012.

arrow energy go further

BOWEN GAS PROJECT EIS

SENSITIVE RECEPTOR LOCATIONS

URS

AIR QUALITY

Figure: **9-2**

File No: **42626960-g-1055.mxd** Drawn: **XL** Approved: **DS** Date: **18-10-2012** Rev. **A** A4

9.3.4 Existing Air Quality

Background concentrations of the pollutants considered in the assessment are summarised and compared to the respective Project criteria in Table 9-2. Note that PM_{10}, $PM_{2.5}$, SO_2 and CO concentrations were estimated using air quality data from monitoring stations operated by EHP. NO_2 and O_3 concentrations were modelled using The Air Pollution Model (TAPM) with a photochemical dispersion module, the Generic Reaction Scheme (TAPM-GRS). It was not possible to determine background concentrations for the volatile organic compounds (VOC) assessed in the study.

Table 9-2 Existing Maximum Ground Level Concentrations of Key Pollutants

Pollutant	Averaging Period	EPP(Air) Objective (µg/m³)	Monitored / Predicted Data	
			Concentration (µg/m³)	Data Source
PM_{10}	24-hour	50	28	Moranbah Station
$PM_{2.5}$	24-hour	25	8	Clinton and Boyne Island Stations
	Annual	8	6	
CO	8-hour	11,000	646	Boyne Island Station
SO_2	1-hour	570	69	Targinie and Boyne Island Stations
	24-hour	230	124	
	Annual	57	3	
NO_2	1 hour	250	144	Modelling (TAPM-GRS)
	Annual	62	19	
O_3	1 hour	210	84	Modelling (TAPM-GRS)
	4 hour	160	71	

Where monitored data were used to represent the background concentrations (PM_{10}, $PM_{2.5}$, CO and SO_2), they were assumed to be consistent across the whole study area. However, modelled background concentrations (NO_2 and O_3) varied across the study area depending on emissions from background sources. The values presented in Table 9–2 are the maximum values predicted in the study area and shows that ground level concentrations of all key pollutants were estimated to be below the Project criteria.

It is important to note that the maximum 1-hour average background concentration of NO_2 was predicted for a limited area surrounding Goonyella Riverside Mine. For the assessment of localised impacts, the highest predicted value (32.5 µg/m^3) for the selected subregions was adopted to represent the maximum 1-hour average background concentration of NO_2.

9.4 Assessment Methodology

The objective of the air quality impact assessment is to investigate the potential for emissions to adversely impact on regional and local air quality. The assessment methodology was developed to meet the requirements of the ToR and is mainly quantitative. The methodology is based on atmospheric dispersion modelling and is focused on testing compliance of the predicted ground-level concentrations of air pollutants with Project criteria developed for the protection of the environmental values in the study area.

The modelling methodology includes the following major stages:

- Identifying the geographical scale and significance of potential effects on air quality to select an appropriate study area;
- Quantification of sources emission rates and development of an emissions inventory for the life of the Project;
- Determination of meteorology using TAPM for use in the regional and local air quality modelling studies (Hurley 2008);
- Identification of meteorological data that represent the most conservative dispersion conditions in the study area;
- Screening level prediction of regional ground-level concentrations of air pollutants using TAPM with a photochemical dispersion module, the Generic Reaction Scheme (TAPM-GRS), for the baseline (existing sources) and with Project (baseline plus Project emissions) scenarios;
- Predicting local (near field) ground-level concentrations of Project air pollutants using Ausplume (Victoria EPA 2000);
- Assessing compliance of the predicted concentrations with Project criteria; and
- Providing, where appropriate, a detailed description of avoidance, management and mitigation strategies.

9.4.1 Pollutants

Definitions of the relevant air pollutants and the potential impacts of their emissions on the environmental values are provided in Table 9-3.

Table 9-3 Air Pollutant Description and Related Impacts

Species	Description	Impacts	
		Health	Environmental
Nitrogen oxides (NO_x)	NO_x is a term used to describe the mixture of nitrogen oxide (NO) and nitrogen dioxide (NO_2). Anthropogenic sources include combustion reactions in both industry and vehicle engines. At the point of release from combustion sources, NO_x is predominantly composed of NO (~95%), with the remainder consisting of NO_2.	NO_2 is the primary concern for effects on health, and is the species for which health-based standards are expressed. NO_2 is associated with both acute and chronic health effects, particularly in people with pre-existing respiratory conditions.	NO_x can react with hydrocarbons in the atmosphere to contribute to the formation of ozone. NO_x can also affect ecologically sensitive sites through deposition, causing acidification and eutrophication. Eutrophication can affect a range of ecosystems, including an increase in the productivity of phytoplankton blooms in ocean waters.
Sulphur dioxide (SO_2)	SO_2 results from activities associated with the combustion of fossil fuels containing sulphur. 95% of pollution relating to sulphur oxide emissions are in the form of SO_2, a heavy, odorous, colourless gas. SO_2 is readily soluble and can combine with atmospheric water vapour forming aerosols of sulphurous acid (H_2SO_3), a colourless, mildly corrosive liquid. This liquid may then combine with oxygen in the air, forming sulphate aerosol that includes the irritant and corrosive sulphuric acid (H_2SO_4).	SO_2 can immediately irritate the respiratory system at concentrations greater than 17,000 $\mu g/m^3$. People with asthma or chronic lung or heart disease are the most sensitive to SO_2.	Acidification through mainly wet ('acid rain') and also dry deposition. Increasing particulate load through formation of aerosol, which has an impact on climate.
Particulate matter (TSP, PM_{10} and $PM_{2.5}$)	Particulate matter includes a variety of particles, such as minerals, combustion products, or natural materials (e.g. sand and sea salt) which are small enough to be inhaled. Smaller particles can reach the lower (gas exchange) region of the lungs. TSP are all particles suspended in the air, PM_{10} particles are those with a mean aerodynamic diameter of less than 10 micrometres (µm) and $PM_{2.5}$ particles less than 2.5 µm.	It has been suggested that coarse particles might cause throat irritation and fine particles cause lung inflammation. Exposure to elevated levels of fine particles is associated with both cardiovascular and pulmonary illness in susceptible individuals. The smaller the particle, the deeper the penetration into the lungs.	Impacts on climate through cloud forming 'hygroscopic' nuclei, and effects on cloud physics and radiative balance.
Carbon monoxide (CO)	CO is primarily emitted from industrial combustion processes and petrol engine vehicle exhausts due to incomplete combustion. The	CO inhibits the blood's ability to carry oxygen to body tissues including vital organs and also blocks essential	No significant impact.

Species	Description	Impacts	
		Health	Environmental
	highest concentrations are generally found close to the source in areas of industrial activity and at roadside locations. CO is a colourless, odourless, tasteless and toxic gas.	biochemical reactions in cells. Observed health effects include headache, dizziness, nausea and, at very high concentrations, unconsciousness and death.	
VOCs	VOCs are a family of organic materials with low boiling points used in a variety of industrial applications, such as paints and solvents. The VOCs released by the Project are likely to be 1,2-dichloroethane, 1,3-Butadiene, benzene, ethane, propane, methane toluene and xylene.	VOCs may have short- and long-term adverse health effects. Health effects may include eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some organics can cause cancer in animals; some are suspected or known to cause cancer in humans. Key signs or symptoms associated with exposure to VOCs include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, nausea, fatigue, and dizziness.	Non methane VOC emissions are major pre-cursors of ground-level ozone and smog.
Ozone (O_3)	O_3 is a reactive oxidant gas. 10% of the Earth's ozone present within the troposphere, known as 'ground level ozone'. Here. O_3 is formed during photochemical smog events.	When inhaled, ozone can cause short-term effects, including: irritation of the respiratory system and acute respiratory problems; aggravation of asthma and other chronic lung diseases, inflammation of and temporarily damage lung tissue and reduce functionality; and impair the human immune system, increasing susceptibility to chronic lung diseases (e.g. emphysema, bronchitis). Repeated exposures to ozone may lead to permanent lung damage or respiratory problems.	Adverse impacts to plant growth / tree maturation; increase susceptibility to disease and environmental stresses; reduce the yield of economically important agricultural crops (e.g. wheat).

9.4.2 Emission Sources

Air pollutants will be released during the construction, operation and decommissioning of the Project.

9.4.2.1 Construction Phase

Construction activities which will generate pollutants are as follows:

- Clearing of vegetation and topsoil;
- Excavation and transport of earth material;
- Emissions from well construction and completion;
- Vehicles travelling on unpaved roads; and
- Vehicles and machinery exhausts.

During construction, dust associated with earthworks and the movement of vehicles will be the main source of air pollutant emissions. Other pollutants such as NO_x and CO will also be released from the combustion of vehicle fuels. However, such emissions will be infrequent and transient and have therefore not been assessed.

During well construction and completion, there is the potential for unburnt gas and flaring combustion pollutants; NO_x, TSP, PM_{10}, $PM_{2.5}$, VOCs and CO to be released.

9.4.2.2 Operational Phase

Emissions to air from Project activities are primarily associated with power generation and flaring of CSG during operation. They include the air pollutants; NO_x, TSP, PM_{10}, $PM_{2.5}$, CO, O_3 and VOCs. Carbon dioxide (CO_2), nitrogen (N_2) and VOCs will also be released.

Emissions of N_2 have not been assessed as they expected to be minimal.

VOCs are a family of related compounds which include methane (CH_4). CH_4 is a greenhouse gas, which contributes little to ozone formation. Therefore, CH_4 has not been considered in this study. Fugitive gas emissions associated with gas processing facilities, water gathering lines, degassing of feed dams, production well surface facilities and related gas production infrastructure were assumed as non-methane hydrocarbons with potential to contribute to ozone formation. Toxic VOCs associated with gas combustion considered in this study include 1,2-dichloroethane, 1,3-butadiene, benzene, toluene and xylene.

Note that Project emissions of CH_4, CO_2 and nitrous oxide (N_2O) have been evaluated in a separate greenhouse gas assessment. For the detailed description of the findings of the greenhouse gas assessment refer to the Greenhouse Gas Impact Assessment (Appendix I) of this EIS. Generation of electrical power from the combustion of CSG through a series of gas fired engines is likely to be the largest emission source.

The following emission sources were included within the regional assessment:

- Fugitive gas emissions from project processes;
- Facility power generation; and
- Well head power generation.

Ramp-up and upset condition flaring were not included in the regional assessment because flaring emissions will be intermittent and therefore unlikely to impact on regional air quality.

In the localised assessment the following emission sources were included:

- Ramp-up facility flaring;
- Upset condition flaring;
- Facility power generation; and
- Well head power generation.

9.4.2.3 Decommissioning

Decommissioning phase activities, and therefore pollutant sources, are likely to be similar to those anticipated in the construction phase.

9.4.3 Meteorological Modelling

TAPM was used to develop regional and local meteorology for dispersion modelling incorporating the influence of terrain. The meteorological data were generated for a selected year representative of conservative conditions for air pollutant dispersion, based on analysis of long term observations of wind speed and direction. The meteorological data were used in the assessment of both the regional and local scale impacts.

9.4.4 Baseline Assessment Methodology

To establish ambient concentrations of relevant air pollutants, data from the Moranbah monitoring station were obtained for PM_{10}. Monitoring data from the Gladstone region for SO_2, $PM_{2.5}$ and CO were used.

In the absence of monitoring data representative of the Project area, photochemically reactive compounds such as NO_2 and O_3 were estimated using TAPM-GRS. The pollutants considered in TAPM-GRS modelling were NO_x, VOCs, O_3, SO_2 and particulate matter. The emission sources considered in TAPM-GRS included biogenic and industrial sources.

9.4.5 Impact Assessment Methodology

9.4.5.1 Regional Scale Impacts

Regional impacts of NO_2 and O_3 were modelled using TAPM-GRS. Emissions from existing and approved industrial facilities (background sources) were included in the regional scale modelling. VOC emissions associated with fugitive leaks were also modelled.

Two scenarios were considered in the regional impact assessment as follows.

- **Scenario 1 – Project Operations in 2023**
  Scenario 1 considered the emissions in year 2023; two years after to the Project reaches full production capacity. In 2023, it is expected that seven production facilities will be operational

across the production areas. This scenario assumes 1,699 wellhead engines will operate at full capacity continuously for the year.

- **Scenario 2 – Project Operations at Maximum Capacity**
  Scenario 2 considered the 17 proposed production facilities and 1,980 wellhead engines operating simultaneously at maximum capacity. Given that field development will be undertaken in stages, this scenario is highly conservative and considers 'worst-case' emissions from Project operations.

Both scenarios considered emissions from point sources representing power generation at each gas processing facility (integrated processing facility (IPF), field compressor facility (FCF) and central gas processing facility (CGPF)) and at wellheads. Since the final locations of these facilities have not been finalised, a single location within each production area were selected for the purposes of evaluation. Wellheads were also randomly distributed at the relevant production areas taking into account an assumed well separation distance. Additionally, VOC (non-methane hydrocarbons) emissions associated with fugitive leaks were included as an area source.

The key pollutants of concern regionally are NO_2 and O_3, commonly used as indicators of photochemical smog. The main emission sources likely to affect smog production in the Project area are anthropogenic (associated with human activity such as various industrial and agricultural sources) and biogenic (produced by living organisms or biological sources). Both source types were included in the modelling.

9.4.5.2 Local Scale Impacts

Localised impacts from flaring and power generation were assessed using Ausplume, which is a Gaussian steady-state plume dispersion model. Hourly meteorological data generated by TAPM were used to represent meteorological conditions in specific regions of the airshed. The pollutants NO_x, CO, VOCs and particulate matter were modelled in Ausplume. Local impacts of odour and SO_2 emissions were assessed qualitatively as no significant releases are anticipated.

Background (existing) maximum 1-hour NO_2 concentrations were obtained from the results of the regional scale atmospheric dispersion modelling for each meteorological subregion. The highest maximum predicted value for the selected subregions was used to represent background NO_2 which is a conservative approach.

Source groups were considered separately in the localised impact assessment as follows.

- **Flaring sources**
  Flaring was assumed to be continuous for the purposes of evaluation, to capture all potential meteorological conditions throughout the modelled period. This is considered conservative because it is assumed that flaring occurs at the same time as the worst case conditions for atmospheric dispersion. For each meteorological subregion, Ausplume was used to model flaring emissions associated with individual gas field ramp-up and upset conditions during operations.
- **Power generation sources**
  Emissions associated with the maximum facility (FCF, CGPF, and IPF) and typical wellhead power requirements were modelled for each meteorological subregion. Power generation was assumed to be continuous throughout the modelled period which is a conservative assumption.

9.5 Impact Assessment

This section provides a summary of all emission rates used in the modelling assessment and the predicted results. Unless otherwise stated, background concentrations are included in all results presented.

The potential direct and indirect impacts of the Project on environmental values have been assessed using one of three impact assessment methods: significance assessment, risk assessment and compliance assessment. For the assessment of air quality, compliance assessment has been used. For further details see the Impact Assessment Method chapter (Section 6) of this EIS.

9.5.1 Project Related Emissions

A summary of the key power generation and flaring sources and the emission rates used in the TAPM-GRS and Ausplume dispersion models are presented.

9.5.1.1 Power Generation

Emissions for each production facility were estimated based on the maximum compression / power requirements per facility. The maximum power requirements for each facility expressed as total megawatt (MW) and number of 3 MW gas engines are presented in Table 9-4.

Table 9-4 Maximum Power Generation Gas Engine Requirements per Facility

Facility	Catchment area	Peak Gas flow (TJ/d)	Peak Power Demand (MW)	No. of 3 MW Units
IPF	7	176	58	20
CGPF	11	206	60	21
FCF	14	119	19	7

TJ/d: terajoules per day

The physical stack and gas consumption specifications for gas engines at the facilities and well heads are presented in Table 9-5.

Table 9-5 Gas Engine Stack and Emission Specifications

Source	Location	Height of release (m)	Stack diameter (m)	Exit velocity (m/s)	Gas volume flow rate (Nm^3/s)	Exhaust volume flow rate (Nm^3/s)	Exit temp (K)
3 MW gas engine	Facilities	7	0.6	28.4	0.2	9	658
60 kVA gas engine	Wellheads	2.5	0.1	29.1	0.01	0.1	922

m/s: metres per second. Nm^3/s: normalised cubic metres per second. K: Kelvin. kVa: kilovolt ampere

Estimated pollutant emission rates for gas engines at the facilities and well heads are presented in Table 9–6.

Table 9-6 Gas Engine Emission Rates

Pollutants	Emission Rate (grams per second (g/s))	
	3 MW gas engine	60 kVA gas engine
CO	3	0.3
NO_x	1.5	0.2
Non-methane hydro-carbons	0.5	0.01
PM_{10}	0.04	0.001

Flaring

Flaring is expected to occur during 'ramp-up' of facilities and under 'upset' / maintenance conditions during the operational phase. The expected gas flow rates and frequencies per facility are as follows:

- 150 TJ/d for twenty-four hours per year (one emergency occurrence);
- 30 TJ/d for eight hours per month (two emergency occurrences);
- 10 TJ/d for eight hours per month (four emergency occurrences); and
- 27 TJ/d for three months (ramp-up flaring).

The physical stack parameters for flaring sources are presented in Table 9-7.

Table 9-7 Physical Flare Parameters

Source	Height of Release (m)	Stack Diameter (m)	Exit Temperature (°C)	Exit Velocity (m/s)
Flare – emergency	80	0.56	1000	20
Flare – ramp-up	9.1	0.56	480	20

Estimated pollutant emission rates for flaring are presented in Table 9-8.

Table 9-8 Flaring Emission Rates

Source	Flaring Rate TJ/d	Emission Estimates per Facility (IPF / CGPF) g/s			
		CO	NO_x	VOC	PM_{10}
Flare-emergency	10	19.6	3.4	33.8	0.3
	30	58.8	10.1	101.4	0.8
	150	294.1	50.7	507.0	4.1
Flare-ramp-up	27	52.9	9.1	91.3	0.7

9.5.1.2 Fugitive Leaks

A conservative emission estimate of 10,000 kilograms per annum (kg/a) of VOCs was adopted to represent fugitive gas emissions associated with gas processing facilities, water gathering lines, degassing of feed dams, production well surface facilities and related gas production infrastructure.

9.5.2 Regional Impacts on Air Quality

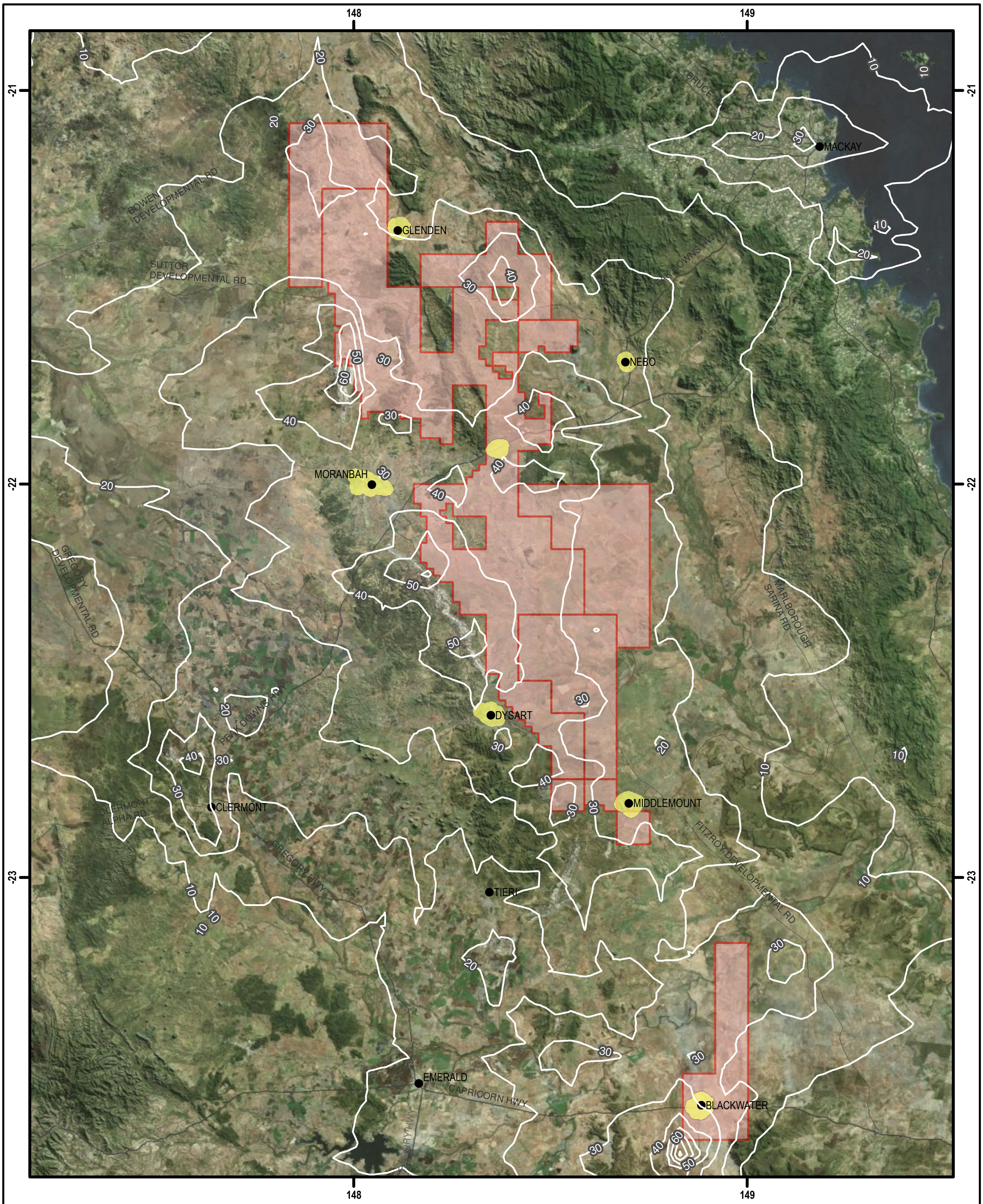
A comparison of the maximum and average predicted NO_2 and O_3 concentrations is made with the Project criteria for Scenarios 1 and 2 in Table 9-9.

Table 9-9 Predicted Concentrations for Regional Scale Scenario 1 (Year 2023) and Scenario 2 (worst case)

Pollutant	Air EPP Objective (µg/m³)	Averaging Period	Maximum Concentration (µg/m³)		Average Concentration (µg/m³)	
			Scenario 1 (2023)	Scenario 2 (worst case)	Scenario 1 (2023)	Scenario 2 (worst case)
NO_2	250	1 hour	81.9	82.6	15.1	15.2
	62	Annual	18.7	18.8	1.2	1.3
O_3	210	1 hour	83.7	83.8	57.9	58.2
	160	4 hour	73	73.2	52.4	52.7

Table 9-9 shows that Project operations were predicted to increase the maximum and average ground level concentrations of NO_2 and O_3 in the region. However, all predicted concentrations are well below the Project criteria and no exceedences were predicted at the sensitive receptor locations shown in Section 9.3.3. Modelling results for Scenario 1 and Scenario 2 demonstrate that there is little difference in the maximum predicted concentrations within the study area, despite some differences in spatial variability of concentrations between the scenarios. This indicates that separation distances between the conceptual locations (Figure 7-5 of Appendix H of this EIS) of production facilities are sufficient to ensure that the dispersion of plumes does not result in a significant cumulative air quality impact.

Scenario 2 (worst case) contour plots are shown in Figure 9-3 to Figure 9-6 for all averaging periods.



N
W E
S

0 10 20 40 km
1:1,500,000
Projection: Geographic (GDA94)

Bowen Gas Project Tenements
Sensitive Receptor Built Up Area
Contour (µg/m^3)

This drawing is subject to COPYRIGHT.

arrow energy go further

BOWEN GAS PROJECT EIS

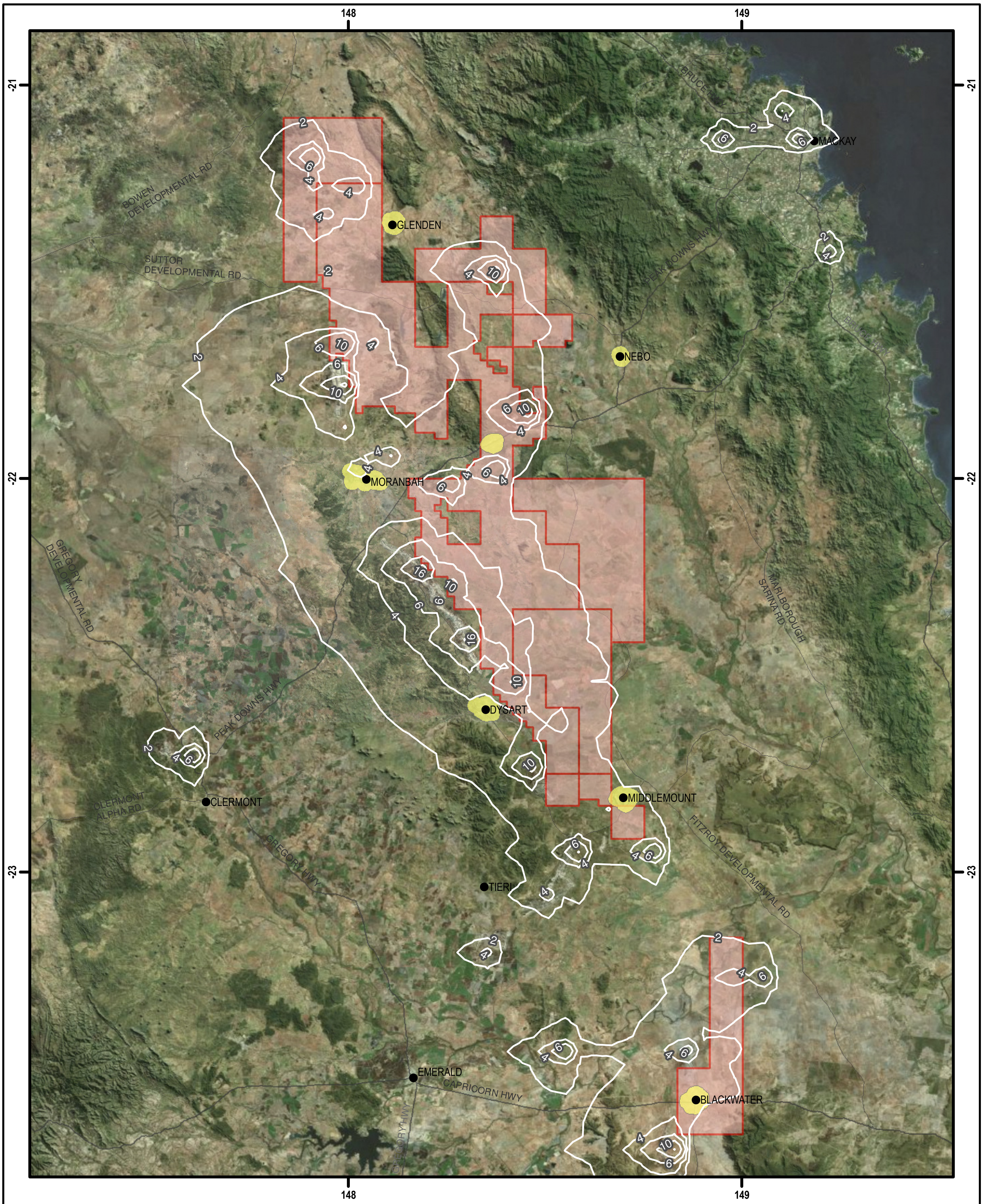
1-HOUR AVERAGE PREDICTED CONCENTRATION OF NO_2: WORST CASE SCENARIO

URS

AIR QUALITY

Figure: **9-3**

File No: **42626960-g-1056.mxd** Drawn: **XL** Approved: **DS** Date: **18-10-2012** Rev. **B** A4



N
W E
S

0 10 20 40 km

1:1,500,000

Projection: Geographic (GDA94)

Bowen Gas Project Tenements

Sensitive Receptor Built Up Area

Contour (µg/m^3)

arrow energy go further

BOWEN GAS PROJECT EIS

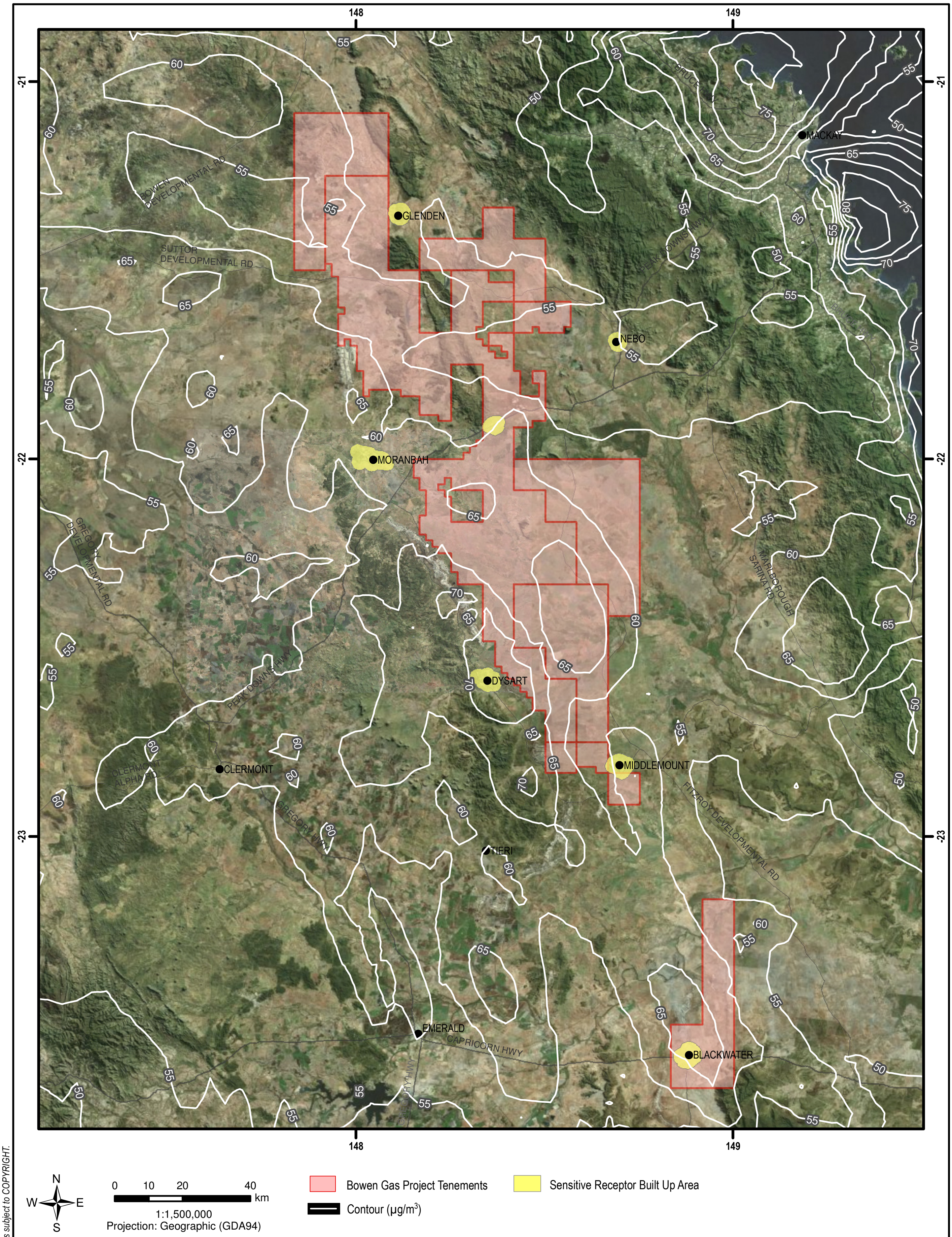
ANNUAL PREDICTED CONCENTRATION OF NO_2: WORST CASE SCENARIO

URS

AIR QUALITY

Figure: **9-4**

File No: **42626960-g-1057.mxd** Drawn: **XL** Approved: **DS** Date: **18-10-2012** Rev. **B** A4



Source: This product may contain information that is © Mapinfo Australia Pty Ltd and PSMA Australia Ltd., © Copyright Commonwealth of Australia (Geoscience Australia) 2006 , © Copyright The State of Queensland (Department of Natural Resources and Water) 2008, © The State of Queensland (Department of Mines and Energy) 2006-2008,© The State of Queensland (Department of Environment and Resource Management) 2010, Bing Maps © Microsoft Corporation and its data suppliers, Images from Client Feb 2012.

arrow energy go further

BOWEN GAS PROJECT EIS

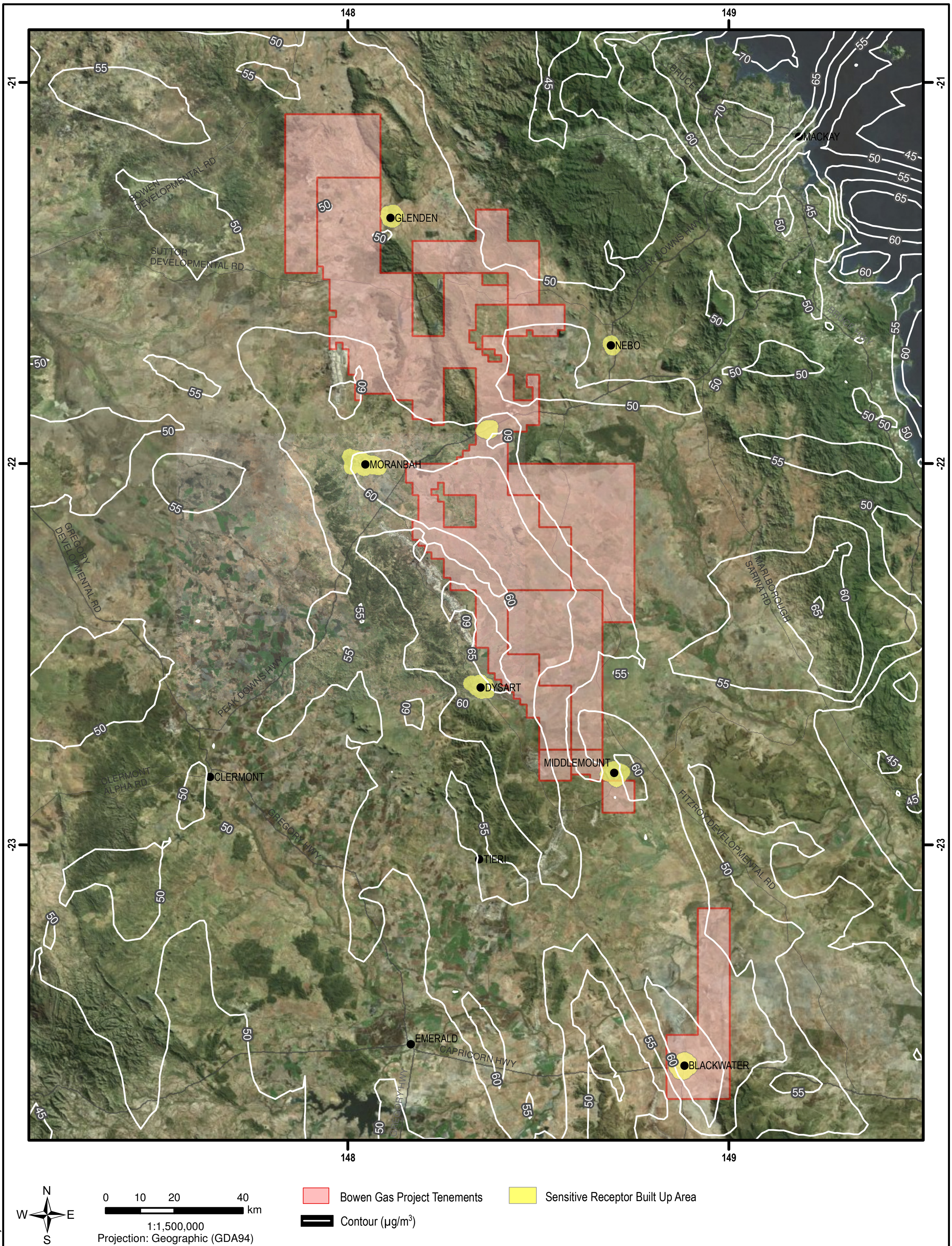
1-HOUR AVERAGE PREDICTED CONCENTRATION OF O_3: WORST CASE SCENARIO

URS

AIR QUALITY

Figure: 9-5

File No: 42626960-g-1058.mxd Drawn: XL Approved: DS Date: 18-10-2012 Rev. B A4



This drawing is subject to COPYRIGHT.

arrow energy go further

BOWEN GAS PROJECT EIS

4-HOUR AVERAGE PREDICTED CONCENTRATION OF O_3: WORST CASE SCENARIO

URS

AIR QUALITY

Figure: 9-6

File No: 42626960-g-1059.mxd Drawn: XL Approved: DS Date: 18-10-2012 Rev. B A4

The key predicted regional impacts from Project related emissions can be summarised as follows:

- Figure 9-3 to Figure 9-6 show that the highest ground level concentrations of NO_2 were predicted for areas surrounding existing sources such as Blackwater, Saraji, Peak Downs and Goonyella Riverside Mines. However, no exceedences of the Project criteria were predicted at these locations.
- A significant decrease in the maximum NO_2 1-hour average concentration of up to 75 µg/m^3 and 43 µg/m^3 (Figure 9-3) was observed in the limited areas surrounding the Goonyella Riverside and Saraji Mines, respectively. An increase in the predicted 1-hour average O_3 concentration of up to 12 µg/m^3 was observed at 10 km to the east of each mine (Figure 9-5).
- For annual average NO_2, (Figure 9-4) the highest increase of 5 µg/m^3 is predicted for the area near the Saraji Mine. An increase of 1 µg/m^3 is predicted for distances up to 10 km from the sources. The maximum prediction represents a 30% increase on background concentration. However, it is still under half the Project criterion for the protection of the human health and under two thirds of the criterion for the protection of the health and biodiversity of ecosystems.
- There is significant variation in O_3 increase across the region. Figure 9-5 shows a 1-hour average increase of 12 µg/m^3 predicted on-site to the east of Dysart and 8 µg/m^3 for 10 km to the west of Mackay. These predictions represent a 20% increase on background concentration. The increase in 4-hour average O_3 (Figure 9-6) is predicted to be of a similar magnitude. The maximum predictions for both averaging periods are predicted to be approximately one-third of the Project criteria.

No exceedences of any of the Project criteria were predicted in the regional scale modelling for all pollutants and averaging periods. Therefore, air quality in the airshed is not predicted to be materially changed by emissions from the Project.

9.5.3 Localised Impacts on Air Quality

The localised impacts of emissions from flaring (NO_2, particulate matter and CO) and power generation (NO_2, particulate matter and VOCs) assessed using Ausplume are as follows. Note that VOCs (non-methane) emissions from flaring and CO emissions from power generation were considered minimal in comparison to emission rates necessary to cause adverse impacts.

9.5.3.1 Flaring

Nitrogen Dioxide

The maximum predicted ground level NO_2 concentrations are presented in Table 9–10.

Table 9-10 Maximum Predicted 1-Hour Average NO_2 Concentrations for Flaring Sources Modelled within Ausplume

Meteorological Subregion	Flow Rate (TJ/d)	Flaring Conditions	Max. 1-hour NO_2 Ground Level Concentration (µg/m³)
1 (NE)	150	Upset / maintenance	40.2
	30	Upset / maintenance	54.5
	10	Upset / maintenance	136.7
	27	Ramp-up	140.7
2 (S)	150	Upset / maintenance	41.2
	30	Upset / maintenance	57.7
	10	Upset / maintenance	157.2
	27	Ramp-up	156.5
3 (N)	150	Upset / maintenance	40.4
	30	Upset / maintenance	55.3
	10	Upset / maintenance	149.9
	27	Ramp-up	144.6
4 (Central)	150	Upset / maintenance	43.4
	30	Upset / maintenance	64.3
	10	Upset / maintenance	147.3
	27	Ramp-up	189.5
Project Criterion (µg/m³)			**250**

Table 9–10 shows that maximum 1-hour average concentrations of NO_2, for ramp-up and upset condition flaring, are predicted to be below the 1-hour NO_2 criterion for all modelled subregions.

Particulate Matter

The maximum predicted ground level particulate concentrations are presented in Table 9-11.

Table 9-11 Maximum Predicted Particulate Concentrations for Ramp-Up Flaring Modelled in Ausplume

Averaging Period	Maximum Ground Level Concentration (µg/m³) for Scenario 3 (Ramp-up Flaring)		
	PM_{10}	**$PM_{2.5}$**	**TSP#**
24-hour	40.5	20.5	-
Annual	-	7.3	1.3
Project Criteria (µg/m³)	**50 (24-hour)**	**25 (24-hour) 8 (Annual)**	**90 (Annual)**

TSP will be heavily influenced by local sources such as dirt roads and mines

Table 9-11 shows the results for ramp-up flaring, for which the highest maximum ground level concentrations were predicted for the respective averaging periods. This table shows that maximum concentrations of the respective particulate fractions are predicted to be below the Project criteria.

Carbon Monoxide

The CO Project criterion is not predicted to be exceeded at any location as a result of flaring emissions. The maximum predicted concentration of 1,946 µg/m^3 is less than 18% of the Project criterion.

9.5.3.2 Power Generation

Nitrogen Dioxide

For NO_2, the minimum separation distances between combustion equipment and any proximate sensitive receptors were determined. Figure 9-7 to Figure 9-10 show the predicted NO_2 concentrations as a function of distance from each of the proposed power generation sources. Each plot presents five lines, four of which relate to the maximum concentrations for each modelled meteorological subregion (northeast, south, north, and central). The fifth line represents the 1-hour NO_2 EPP (Air) objective. It is important to note that the lines represent the maximum predicted concentration at a given distance from the source.

Figure 9-7 Maximum Predicted 1-Hour NO_2 Concentrations as a Function of Distance from the Proposed IPF Source

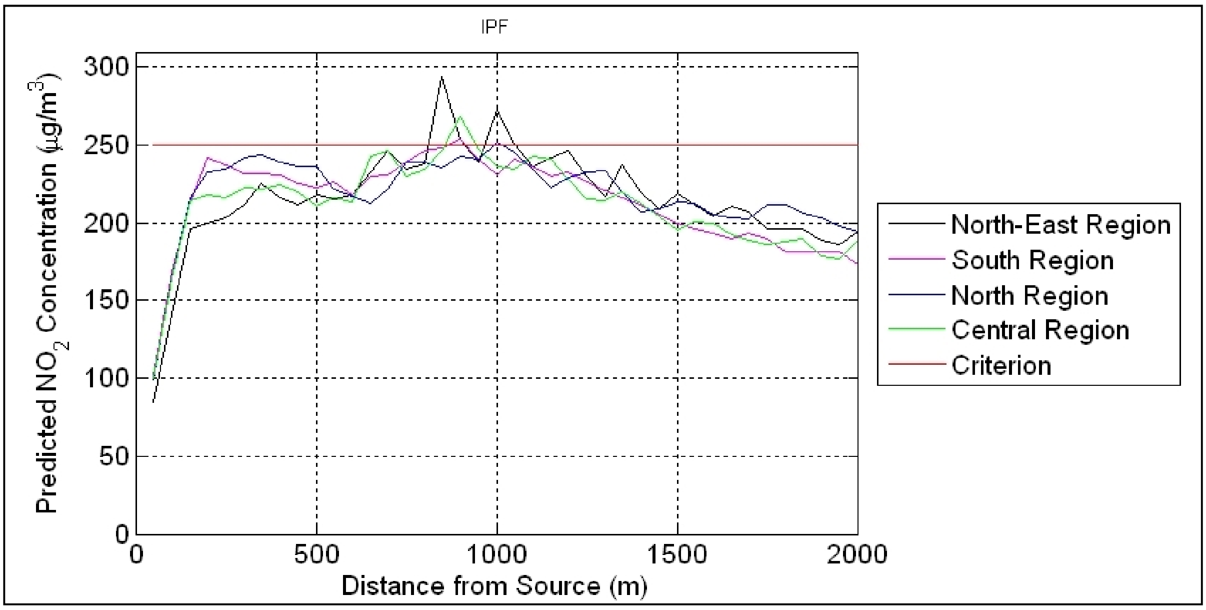


Figure 9-8 Maximum Predicted 1-Hour NO_2 Concentrations as a Function of Distance from the Proposed CGPF Source

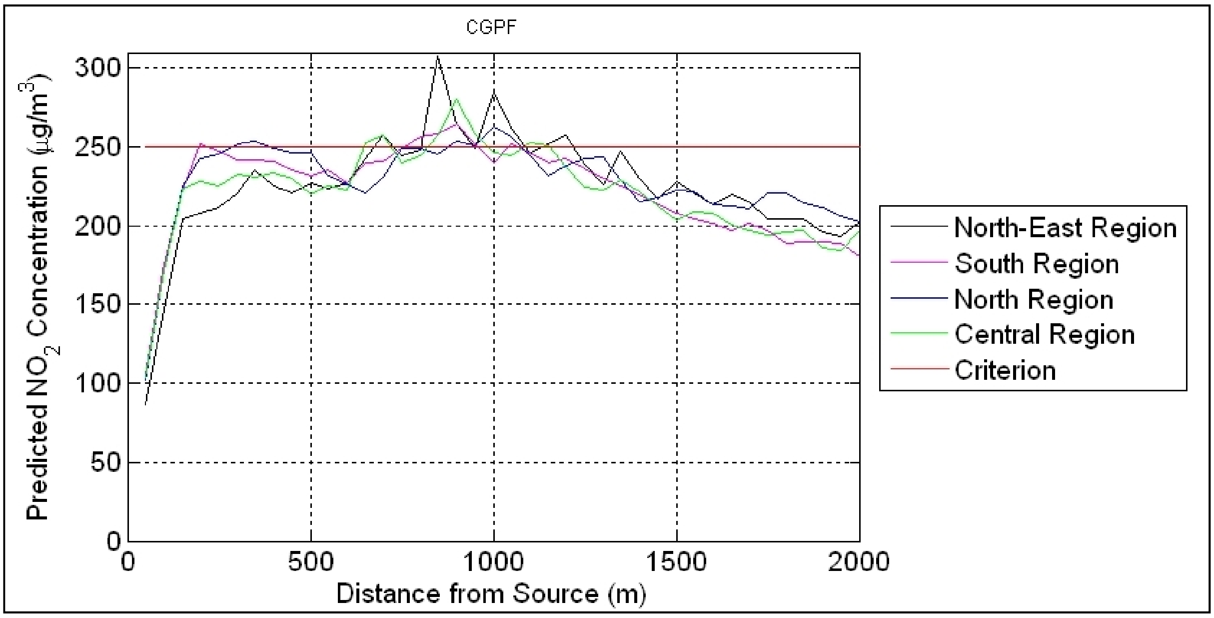


Figure 9-9 Maximum Predicted 1-Hour NO_2 Concentrations as a Function of Distance from the Proposed FCF Source

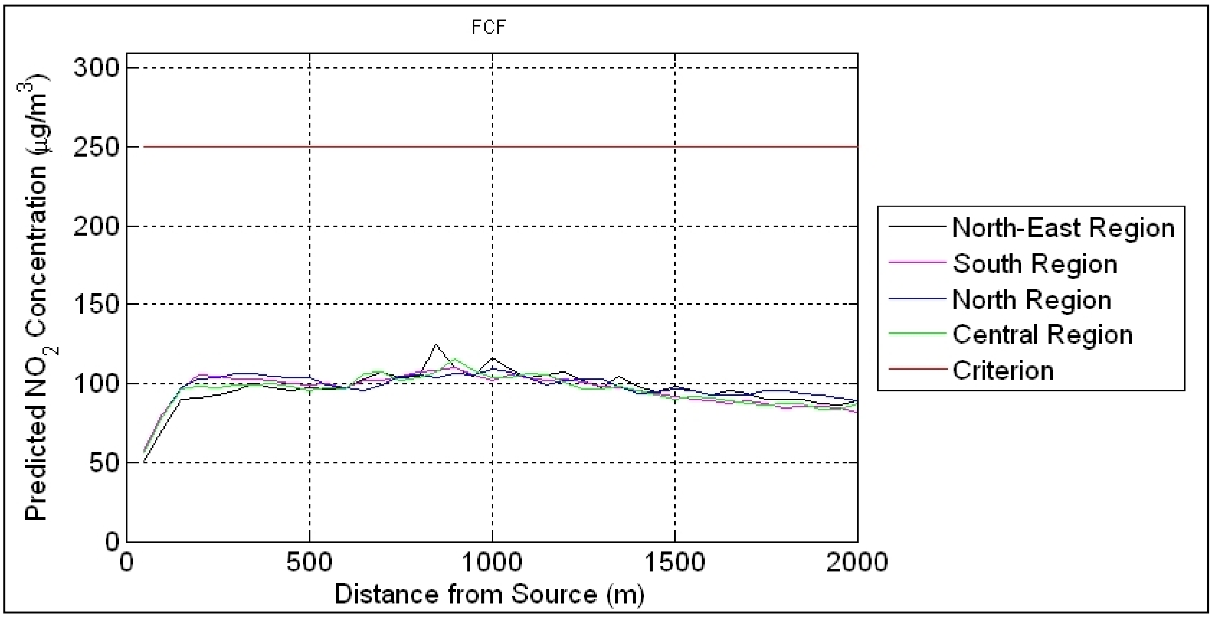


Figure 9-10 Maximum Predicted 1-Hour NO_2 Concentrations as a Function of Distance from the Proposed Wellhead Source

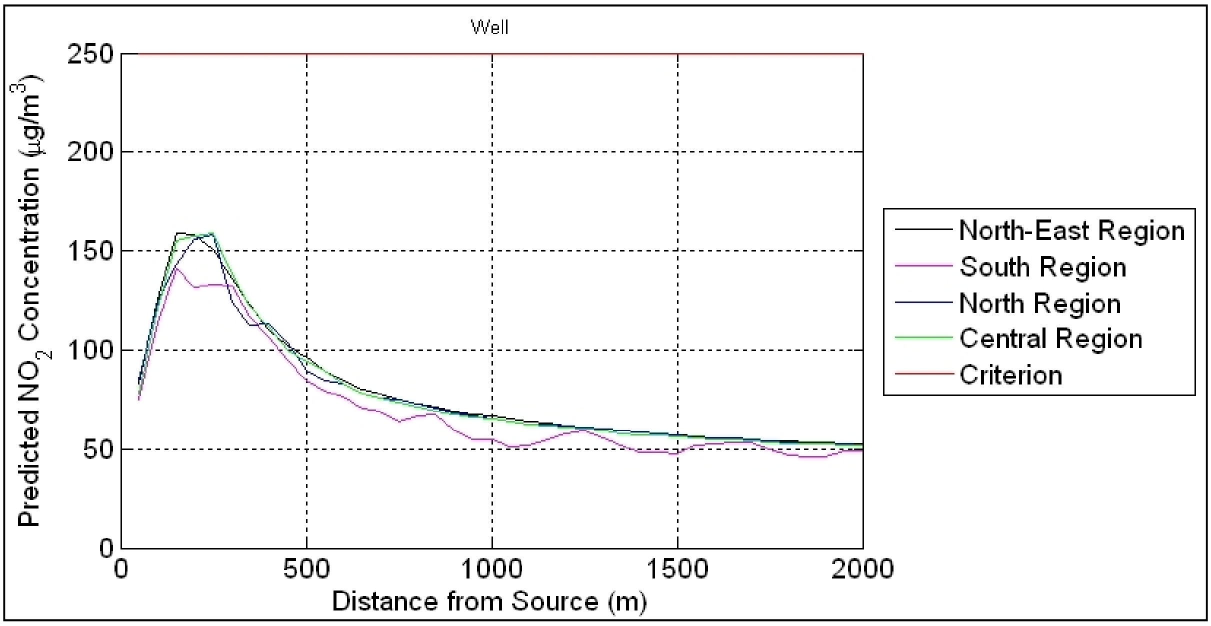


Figure 9-7 and Figure 9-8 show that for both the IPF and CGPF power sources, the exceedences of the criterion for NO_2 were predicted within 1,100 to 1,400 m depending on the selected subregion. Thus, it is recommended that the locations of IPF and CGPF facilities are selected no nearer than 1,400 m from any proximate sensitive receptors.

Figure 9-9 and Figure 9-10 show that neither the FCF nor wellhead gas engine emissions were predicted to exceed the Project criterion. Therefore, no constraint on well or FCF placement is required as a result of potential impacts at sensitive receptor locations.

Particulate Matter

Emissions data were received for PM_{10} only, therefore for modelling purposes these data were adopted to represent both $PM_{2.5}$ and TSP. The maximum predicted ground level particulate concentrations are presented in Table 9-12.

Table 9-12 Maximum Predicted Particulate Concentrations for the Proposed CGPF Source Modelled in Ausplume

Averaging Period	Maximum Ground Level Concentration (µg/m³) for Proposed CGPF Source		
	PM_{10}	**$PM_{2.5}$**	**TSP**
24-hour	30.5	10.5	-
Annual	-	6.8	0.8
Project Criteria (µg/m³)	**50 (24-hour)**	**25 (24-hour) / 8 (Annual)**	**90 (Annual)**

Table 9-12 shows that maximum concentrations of the respective particulate fractions are predicted to be below the equivalent Project criteria.

Volatile Organic Compounds

VOC results presented for the CGPF as emission rates are expected to be at their highest from this source. Predicted VOC concentrations were modelled as total non-methane VOCs within Ausplume. The maximum ground level total VOC output from the model was subsequently weighted depending on the relevant VOC species. Results of the VOC modelling assessment are provided in Table 9-13.

Table 9-13 Maximum Predicted Ground Level VOC Concentrations for the Proposed CGPF Source Modelled in Ausplume

VOC Species	Averaging Period	Project Criteria (µg/m³)	Emission Factor (kg/Sm³)	Weighting Factor (% of total VOCs)	Max Predicted Ground Level Concentration (µg/m³)
1,2-dichloroethane	24-hour	750	1.89×10^{-6}	0.4	0.3
1,3-Butadiene	Annual	2.4	1.11×10^{-5}	22.1	1.0
Benzene	Annual	10	2.64×10^{-5}	52.5	2.4
Toluene	24-hour	4100	9.34×10^{-6}	18.6	16.2
	Annual	410		18.6	0.8
Xylene	24-hour	1200	3.26×10^{-5}	6.5	5.7
	Annual	950		6.5	0.3

Table 9-13 shows that all Project criteria for VOCs are not predicted to be exceeded at any location, with respect to VOC emissions from the proposed CGPF.

Odour and SO_2

It is not expected that any significant releases of odour and SO_2 will occur from flaring, fugitive leaks or power generation. The impact of emissions of odour and SO_2 from the Project are therefore expected to be negligible.

9.6 Avoidance, Mitigation and Management Measures

The impacts of the Project activities will be managed through the EM Plan. Mitigation measures will be established to ensure the Project is compliant with all Project criteria and therefore all statutory objectives. The EM Plan will include commitments to practical and achievable strategies and design standards to ensure that, where practicable, emissions are minimised in all stages of the Project.

Avoidance, mitigation and management measures to meet the Project criteria include, but may not be limited to, the following:

9.6.1 Construction and Decommissioning Phase

Best practice management tools for construction site dust control:

- The land cleared for construction purposes will be kept to the minimum necessary, especially during the drier months of the year [B018];
- The number and sizes of stockpiles will be kept to minimum [B019];
- The cleared areas and stockpiles will be progressively rehabilitated through revegetation and/or mulching [B021]; and
- Dust suppression shall be undertaken during construction and clearing activities, particularly during high wind conditions. Haul roads and other unsealed areas may be watered to suppress dust [B020].

Mitigation measures to reduce emissions include:

- Prevent venting and flaring of gas as far as practicable and where safe to do so, in accordance with the P&G Act [B022]; and
- Minimise potential fugitive emissions from construction of production wells and gas production infrastructure [B025].

9.6.2 Operational

Mitigation measures to reduce potential emissions during operational activities include:

- Implementation of a preventative maintenance program to ensure gas engines operating efficiently to minimise emissions of incomplete combustion products – CO and hydrocarbons (primarily methane, with minor VOC emissions) [B024];
- Minimise potential fugitive emissions from operation of production wells and gas production infrastructure [B025];
- Use of low NOx equipment, where practical [B026];
- Prevent venting and flaring of gas as far as practicable and where safe to do so, in accordance with the P&G Act [B022];
- Minimisation of emissions from gas dehydration [B028];
- Optimisation of gas driven generator operations to minimise time periods of operation at low efficiency levels that may result in elevated NOx emissions [B029];
- Implementation of a quantifiable monitoring and measuring program [B030]; and
- Use of efficient gas and water separation methods on wellheads, gathering and process facilities to minimise fugitive gas release [B031].

To supplement these avoidance, mitigation and management measures, constraints may be applied to the site selection of the power generation facilities, based on the modelled minimum separation distance to sensitive receptors. For both the IPF and CGPF, modelling indicated that a distance of between 1,100 m and 1,400 m is required between the stack and sensitive receptor, dependent on the subregion, to achieve the respective hourly NO_2 objective for human health. Alternatively mitigation of some form may be considered, such as increasing stack height or selective catalytic reduction. It should also be noted that the modelling was based on emission sources, which represent the best available technology at this time. Improvements in the combustion efficiency of such equipment have the potential to reduce the risk of exceedences if implemented in the future.

9.7 Summary

The key predicted regional impacts from Project related emissions can be summarised as follows:

- The highest ground level concentrations of NO_2 were predicted for areas surrounding existing sources such as Blackwater, Saraji, Peak Downs and Goonyella Riverside Mines. However, no exceedences of the Project criteria were predicted at these locations.
- A significant decrease in the maximum NO_2 1-hour average concentration of up to 75 µg/m^3 and 43 µg/m^3 was predicted for the limited areas surrounding the Goonyella Riverside and Saraji Mines, respectively. An increase in the predicted 1-hour average O_3 concentration of up to 12 µg/m^3 was observed at 10 km to the east of each mine;
- For annual average NO_2, the highest increase of 5 µg/m^3 is predicted for the area near the Saraji Mine. An increase of 1 µg/m^3 is predicted for distances up to 10 km from the sources. The maximum prediction represents a 30% increase on background concentration. However, it is still under half the Project criterion for the protection of the human health and under two thirds of the criterion for the protection of the health and biodiversity of ecosystems; and
- There is significant variation in O_3 increase across the region. For the worst case scenario, a 1-hour average increase of 12 µg/m^3 predicted on-site to the east of Dysart and 8 µg/m^3 for 10 km to the west of Mackay. These predictions represent a 20% increase on background concentration. The increase in 4-hour average O_3 (Figure 9-6) is predicted to be of a similar magnitude. The maximum predictions for both averaging periods are predicted to be approximately one-third of the Project criteria.

These results show that the environmental values for air quality in the region are not predicted to be materially impacted by emissions from the Project.

The key predicted local impacts from Project related emissions can be summarised as follows:

- The maximum concentrations of NO_2, for ramp-up and upset condition flaring, are predicted to be below the 1-hour NO_2 criterion for all modelled subregions;
- The maximum concentrations of particulate fractions TSP, PM_{10} and $PM_{2.5}$ are predicted to be below the Project criteria;
- The maximum predicted ground level 8-hour average CO Project criterion is not predicted to be exceeded at any location during flaring;
- Neither FCF nor wellhead gas engine emissions were predicted to exceed the Project criteria for NO_2. Therefore, no constraint on well or FCF placement is required with respect to sensitive receptor locations;
- For both the IPF and CGPF power sources, exceedences of the Project criterion 1-hour maximum NO_2 were predicted within 1,100 to 1,400 m depending on the selected subregion. It is recommended that the locations of IPFs and CGPFs facilities to be constrained such that they maintain a separation distance of approximately 1,400 m from the nearest sensitive receptors;

- The maximum concentrations of TSP, PM_{10} and $PM_{2.5}$ from power generation emissions are predicted to be below the Project criteria;
- The Project criteria for the VOCs 1,2-dichloroethane, 1,3-butadiene, benzene, toluene and xylene are not predicted to be exceeded at any location from power generation emissions; and
- Emissions of odour and SO_2 from power generation are expected to be minimal and the impact on local air quality negligible.

These results show that the environmental values for local air quality are not predicted to be materially impacted by emissions from the Project. However, for 1-hour NO_2, constraints in the location of the equipment are required to ensure that air quality values are not unacceptably impacted. With these constraints applied the residual impact of emissions will be minor.

Further assessment of cumulative impacts from all emission sources in the local airshed is recommended once potential Project facility and well locations have been identified, especially in the case of possible clustering and the suitability of these locations [B001].