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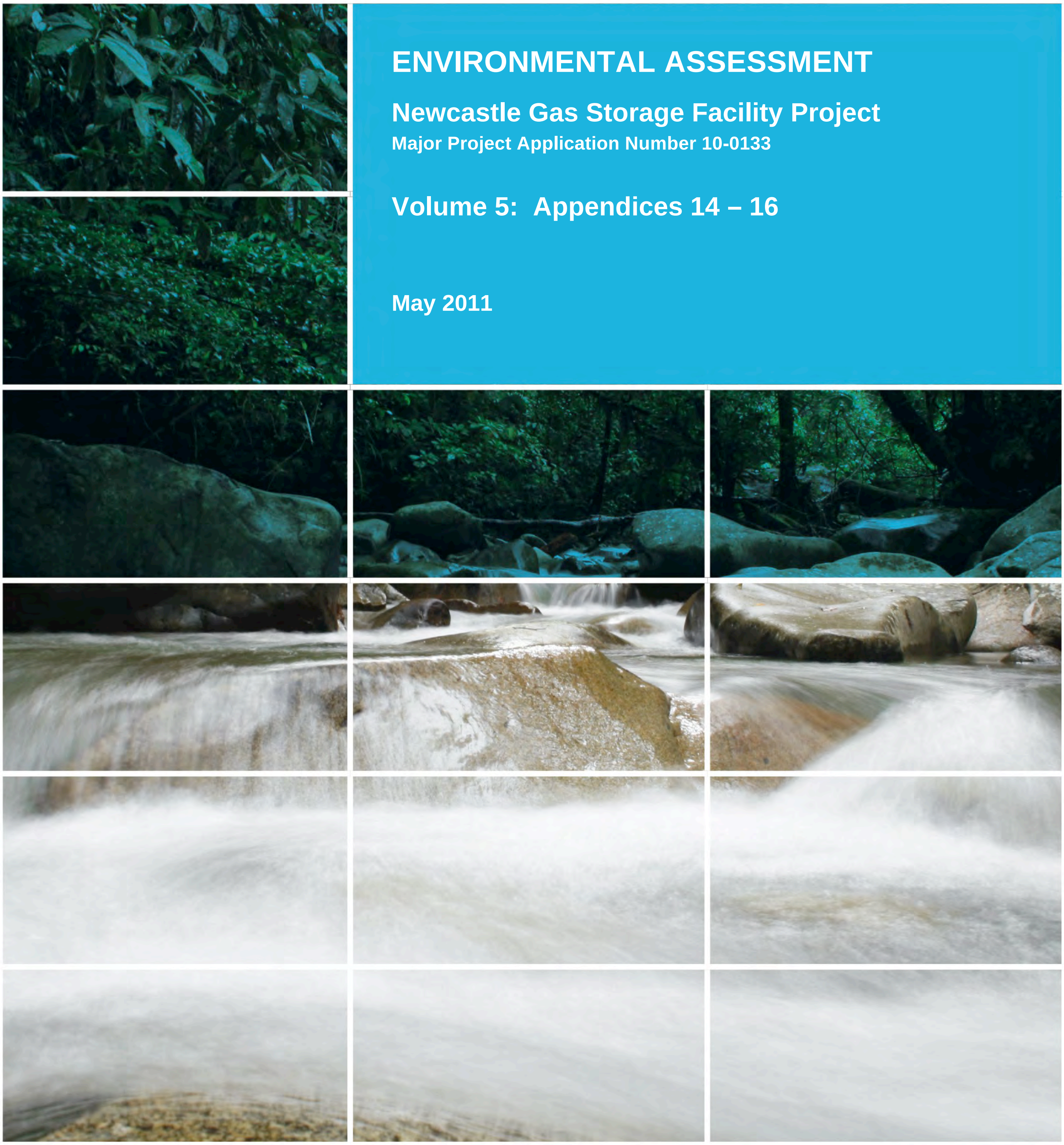
ENVIRONMENTAL ASSESSMENT

Newcastle Gas Storage Facility Project

Major Project Application Number 10-0133

Volume 5: Appendices 14 – 16

May 2011



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May 2011

CR 6023_8_v3

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Appendix 14

Air Quality and Greenhouse Gas Assessment

REPORT - FINAL

AIR QUALITY AND GREENHOUSE GAS ASSESSMENT – NEWCASTLE GAS STORAGE FACILITY

Coffey Natural Systems Pty Ltd

Job No: 3872

11 February 2011

A PEL Company

PROJECT TITLE:	**AIR QUALITY AND GREENHOUSE GAS ASSESSMENT – NEWCASTLE GAS STORAGE FACILITY**
JOB NUMBER:	**3872**
PREPARED FOR:	Philip Towler **COFFEY NATURAL SYSTEMS PTY LTD**
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ES1 EXECUTIVE SUMMARY

AGL Energy Limited (AGL) proposes to develop the Newcastle Gas Storage Facility Project (the Project) at Tomago, NSW. The project will include LNG processing, storage and re-gasification with and associated natural gas pipeline and receiving station. The main emission sources are from the operation of the gas plant including:

- Emissions from hot oil heaters at the liquefaction plant during liquefaction;
- Emissions from the sour gas flare during liquefaction;
- Emissions from the LNG vaporiser package during re-gasification;
- Minor emissions from the process flare during liquefaction (pilot fuel gas);
- Emissions from the process flare during start-up / shut-down and emergencies;

Emissions from gas combustion and flares will include oxides of nitrogen (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs) and small amounts of sulfur dioxide (SO_2) and particulates. The combustion of waste gases (i.e. hydrogen sulphide (H_2S)) in the sour gas flare will also result in emissions of SO_2. The odour impact from the H_2S emissions from the sour gas flare is also assessed.

The existing ambient air quality for the Tomago area is characterised based on monitoring data from the NSW Department of Environment, Climate Change and Water (DECCW) monitoring site at Beresfield and local monitoring sites operated by Tomago Aluminium Company (TAC). Monitoring undertaken by TAC indicates that local levels of SO_2 are approaching the National Environment Protection Measure (NEPM) air quality standards for 1-hour and 24-hour SO_2. Exceedances of the NEPM air quality standards for other pollutants are typically limited to occasional exceedances of the 24-hour average particulate matter (PM_{10}) standard and generally result from bush fires and dust storms.

Local climatic conditions and prevailing meteorology are described and meteorological input files are developed for dispersion modelling. The local meteorology was modelled using The Air Pollution Model (TAPM) and CALMET models with observed hourly surface input data from the Tomago Aluminium weather station, DECCW Beresfield Station and Bureau of Meteorology (BoM) Williamtown Royal Australian Air Force (RAAF) Base and Newcastle Nobbys Signal stations. Dispersion modelling utilises CALPUFF to account for complex flow situations expected in coastal environments.

To assess the potential impact from the proposed Project, three modelling scenarios have been considered; including normal operation (liquefaction), re-gasification and upset operations (start-up / shut-down). Modelling results for all scenarios indicate that emissions from the Project are minor for all pollutants when assessed against impact assessment criteria. The predictions incorporate a level of conservatism and the actual ground level concentrations would be expected to be lower than during liquefaction. A cumulative assessment indicates that the operation of the Project would not result in any additional exceedances of impact assessment criteria.

Dust emissions from construction are expected to be relatively short lived across different areas of the site and generally manageable through commonly applied dust control measures.

An assessment of greenhouse gas emissions indicates that the project would contribute to 0.01 % of total Australian emissions and a 0.05 % increase on total NSW emissions.

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1 INTRODUCTION

AGL Energy Limited (AGL) proposes to develop the Newcastle Gas Storage Facility (NGSF) Project (the Project) at Tomago, NSW. The proposed Project will consist of:

- A gas plant including Liquifed Natural Gas (LNG) processing plant, LNG storage tank, re-gasification unit and associated ancillary equipment;
- A natural gas pipeline to connect the processing plant to a receiving station; and
- A receiving station at Hexham to link the Project into the NSW gas network via the existing Sydney to Newcastle pipeline.

AGL has commissioned Coffey Natural Systems to prepare an environmental assessment (EA) for the Project, which is required in support of the development application under Part 3A of the Environmental Planning and Assessment Act 1979. PAEHolmes has been commissioned to prepare an Air Quality and Greenhouse Gas Assessment for the Project, which will form part of the overall EA.

1.1 Objectives of the Study

The primary objective of the study is to assess the potential air quality impacts from the operation of the Newcastle Gas Storage Facility. The following outlines the proposed scope of work:

- Conduct an Air Quality Impact Assessment in accordance with the NSW Department of Environment, Climate Change and Water (DECCW) "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**NSW DEC, 2005**);
- Quantify emissions to air from the operation of the Project, principally from the gas fired heaters, waste gases and flaring of hydrocarbons;
- Provide a detailed description of the ambient receiving environment, including background pollution concentrations, prevailing meteorological conditions, terrain, topography, landuse and closest sensitive receptors; and
- Provide a cumulative impact assessment based on regulatory dispersion model predictions and representative background pollution concentrations.

2 PROJECT OVERVIEW

2.1 Introduction

The Project is required to meet AGL's peak gas market requirements over winter and to provide additional security of supply during supply disruption events.

The Project typically consists of the construction and operation of:

- The gas plant site, which includes:
    - A processing plant which will convert pipeline natural gas to LNG by cooling it to -162°C. It will be capable of processing up to 65,500 tonnes of LNG per year;
    - An insulated non-pressurised LNG storage tank (capable of containing 30,000 tonnes or 63,000 m^3 of LNG) and an associated containment bund to contain any potential spills or leaks;
    - A re-gasification unit to convert the LNG in the storage tank back into natural gas for supply;
    - A flare stack;
    - A truck loading facility to allow the dispatch of up to 1,000 tankers of LNG per year;
    - An access road to connect the gas plant site to the TAC Northern Access Road;
    - Infrastructure and utility connections;
    - An emergency access road; and
    - The subdivision of land.
- A natural gas pipeline connecting the gas plant site to the receiving station; and
- A receiving station to link the Project into the NSW gas network via the existing Sydney to Newcastle pipeline.

The estimated capital cost of the Project is $300 million. AGL is currently the proponent for the Project but the proponent may ultimately be a successor or assignee to AGL. AGL is targeting to have the facility in operation by Winter 2014 with construction starting in 2011.

A conceptual plant layout is presented in **Figure 2.1** showing emission points at the flare, the gas pre-treatment plant and the re-gasification units.

The focus of this assessment is the operation of the gas plant, where the most significant emissions to air will occur.

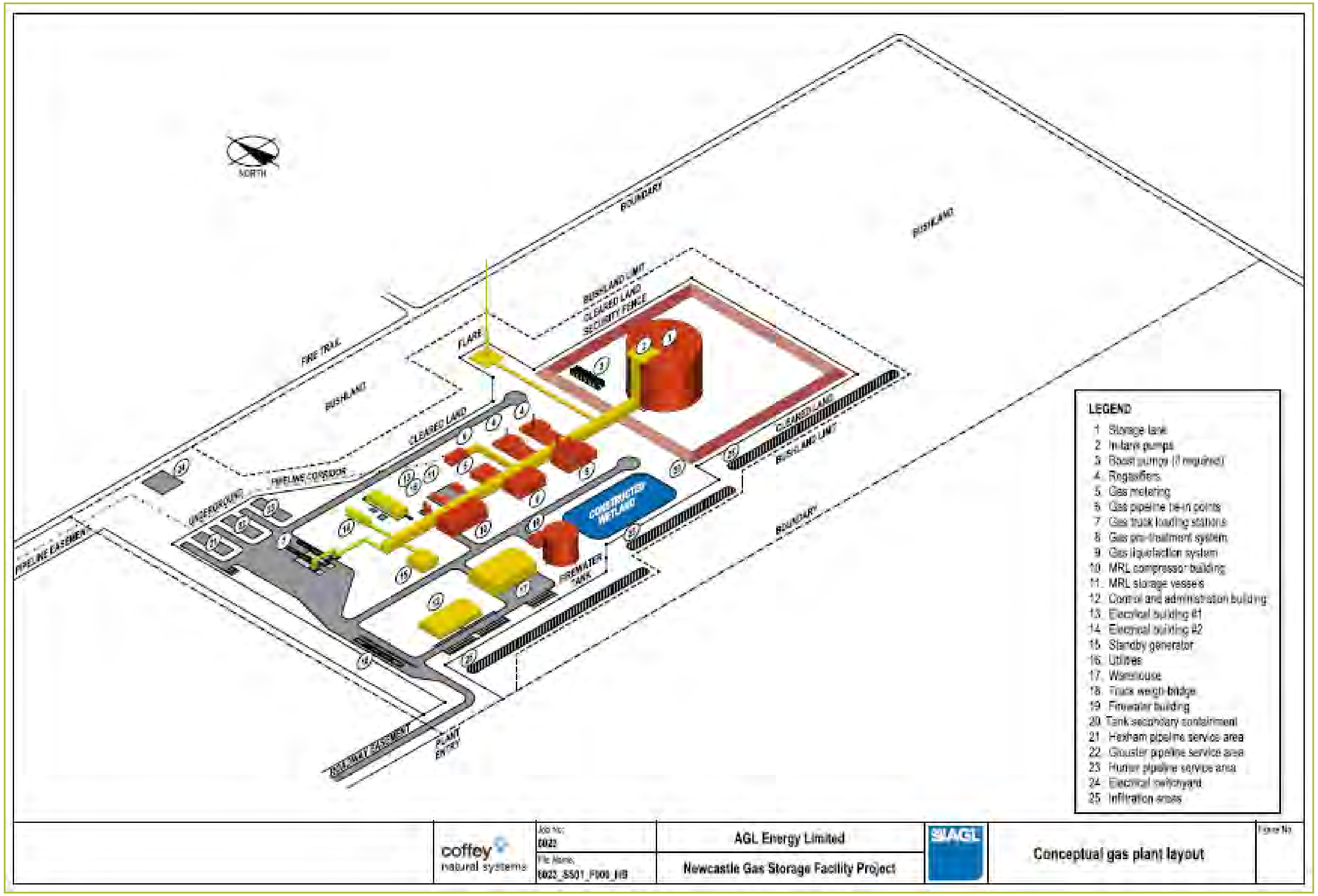

Figure 2.1: Concept Site Layout and Emissions Points

2.2 Local Setting

The proposed gas plant will be located in the northeast corner of Lot 105 DP 1125747, in the Port Stephens Local Government Area (LGA). The site is north of the Tomago Aluminium Smelter on land currently owned by Tomago Aluminium Company (TAC). This lot is also known as 5 Old Punt Road, Tomago. The site is approximately 13 km northwest of the Newcastle central business district, 8 km south of Raymond Terrace and 4 km northeast of the Hexham industrial area.

Figure 2.2 shows the Project key components, the local setting and selected sensitive receptor locations.

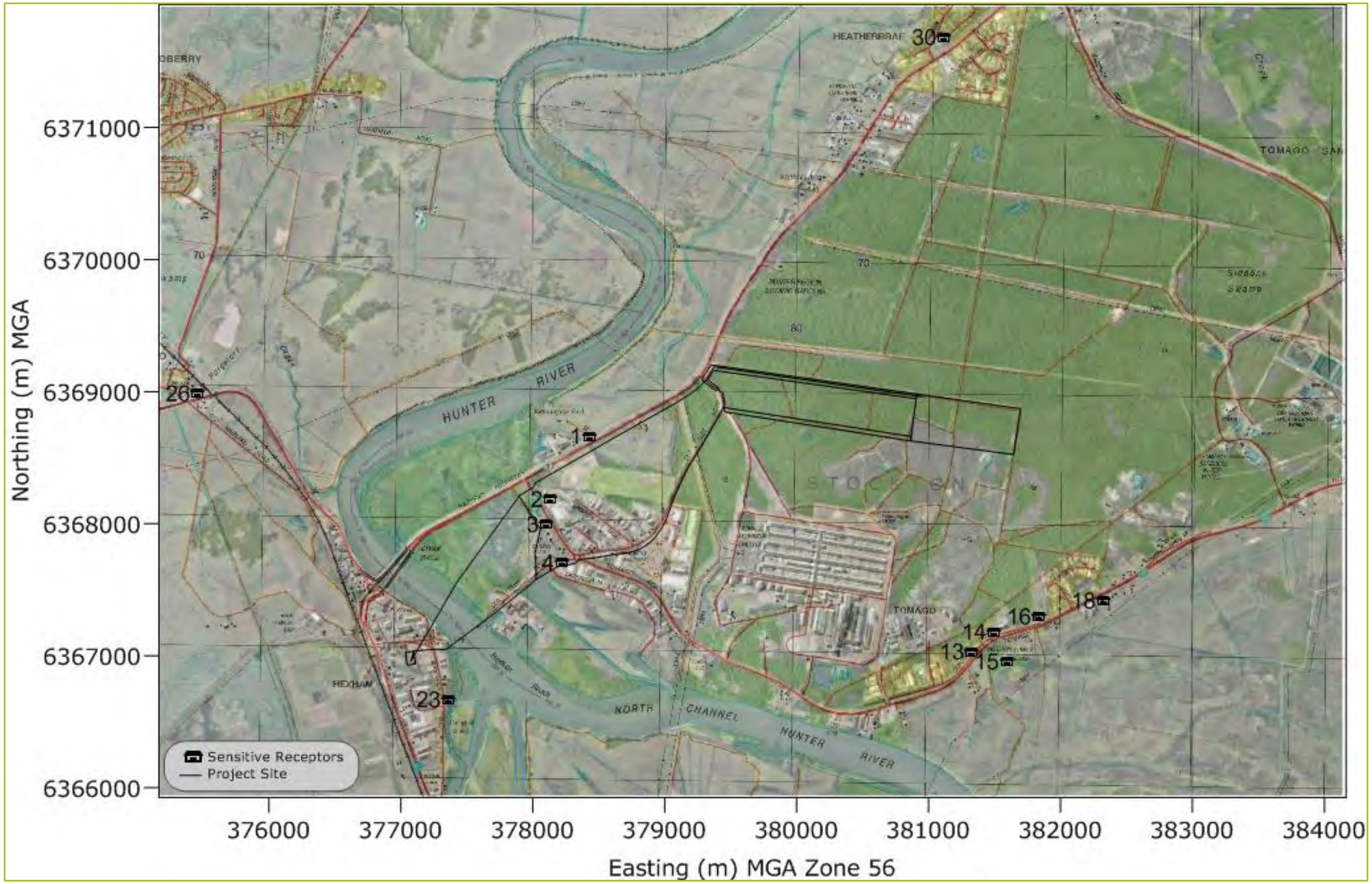

Figure 2.2: Local Setting and Selected Sensitive Receptors

Existing land use in the vicinity of the gas plant includes a mix of industrial and commercial, including the Tomago Aluminum Smelter to the south and Hexham industrial area to the southwest. The closest residential areas are approximately 2.5 km east at Tomago and approximately 2.5 km north at Heatherbrae. The closest residential dwelling is 1.3 km to the south at School Drive. Other sensitive receptor locations include the Tomago Caravan Park, located approximately 3 km to the southwest of the site and the Hunter Region Botanic Gardens, located approximately 1.5 km north west.

The discrete receptor locations presented in **Table 2.1** were chosen for the purposes of assessing impacts from the Project. These locations are the closest potentially effected residence locations to the site.

The locations of selected sensitive receptors are shown in **Figure 2.2**. Contour plots of potential impact are also presented to assess impacts at recreational / environmental receptors such as the Hunter Botanical Gardens.

Table 2.1: Selected Discrete Closest Receptor Locations

ID	Location	Easting (m)	Northing (m)	Elevation (m)	Approximate Distance from Site (m) and Direction
1	1877 Pacific Highway	378429	6368661	9	2.4 km W
2	838 Tomago Rd	378133	6368184	6	2.8 km WSW
3	Tomago Caravan Park	378103	6367994	6	2.8 km WSW
4	33a Old Punt Rd	378221	6367704	11	2.8 km SW
13	37 School Dr	381326	6367029	10	1.5 km S
14	47 School Dr	381495	6367179	8	1.3 km S
15	403 Tomago Rd	381590	6366954	12	1.4 km S
16	374 Tomago Rd	381835	6367294	8	1.3 km S
18	325 Tomago Road	382323	6367416	6	1.3 km SE
23	167 Old Maitland Rd	377361	6366666	4	4 km SW
26	7A New England Hwy Tarro	375460	6368985	5	5.5 km W
30	2297 Pacific Hwy Heatherbrae	381118	6371683	10	2.7 km N

2.3 Topography

A three-dimensional representation of the regional topography is shown in **Figure 2.3** reflecting the terrain used in the dispersion modelling for this assessment. The proposed site is located in a low lying region approximately 10km west of the coast. There are no significant topographical features that would influence the general diurnal wind patterns that can be expected in a coastal environment. The gas plant site has elevations ranging approximately from 6 m to 12 m AHD with a final site level of 6.3 m AHD.

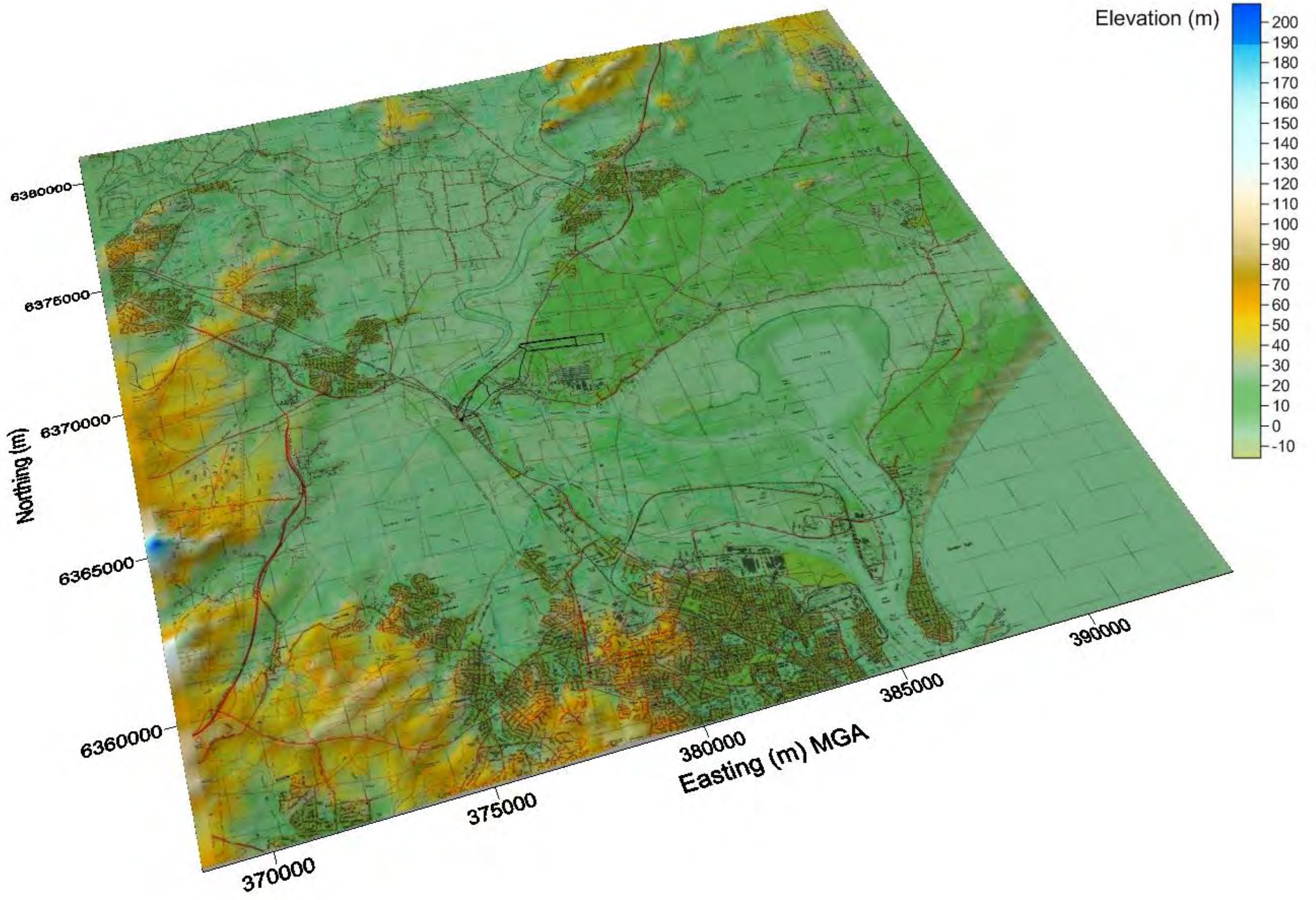

Figure 2.3 Three-Dimensional Representation of Regional Topography

3 AIR POLLUTANTS AND EFFECTS

3.1 Expected Emissions from the Project

During operation, the Project will result in emissions from the combustion of fuel gas in the fired heaters and also from the flaring of excess hydrocarbons and waste gases. The key emissions will be oxides of nitrogen (NO_x) with smaller amounts of volatile organic compounds (VOCs), particulate matter (PM_{10} and $PM_{2.5}$) and sulfur dioxide (SO_2) expected. The destruction of waste gases (i.e hydrogen sulphide) will also result in emissions of SO_2 from the sour gas flare. Minor emissions of unburnt hydrogen sulphide (H_2S) will also occur from the sour gas flare.

Emissions of carbon monoxide (CO) are typically not high enough to compromise air quality goals. The emission factors for CO from gas combustion are lower than emission factors for NO_x, and the air quality goals for CO are higher than NO_x (NO_2). Therefore, if the Project complies with the NO_x criteria, it will also comply with the CO criteria. CO is not therefore considered further in this assessment.

Ozone (O_3) is a secondary pollutant formed in a chemical reaction when emissions of NO_x and VOCs react in the presence of sunlight. While ground-level ozone continues to be a problem in Sydney during summer months it is not an issue in the Lower Hunter Region (**NSW DECCW, 2009**) and does not warrant consideration in this assessment.

Emissions from the Hexham receiving station and pipeline will be limited to very small levels of fugitive gas emissions and are not considered further in this report. The mercaptan odorant will be stored in a building with adsorbent beds on vent air to minimise any potential odour impacts.

During construction, fugitive dust emissions from surface activities can also be expected. In addition, emissions of CO, NO_2, and SO_2 will occur from diesel-powered construction equipment and generators. However these are typically too small and too widely dispersed to give rise to significant off-site concentrations. Control and management methods for impacts during construction are outlined in **Section 10**.

3.2 Oxides of Nitrogen

Oxides of nitrogen are produced when fossil fuels are combusted. Nitrogen oxides (NO_x) emitted by fossil fuel combustion are comprised mainly of nitric oxide (NO) and nitrogen dioxide (NO_2). NO is much less harmful to humans than NO_2 and is not generally considered a pollutant at the concentrations normally found in urban environments.

NO_2 is the regulated oxide of nitrogen in NSW and effects of exposure to NO_2 include irritation of the lungs and lower resistance to respiratory infections such as influenza. The effects of short-term exposure are still unclear, but continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children. Concern with NO is related to its transformation to NO_2 and its role in the formation of photochemical smog.

Typically, close to the combustion sources, NO_2 makes up 5 to 20 per cent by weight of the total oxides of nitrogen. At the point of emission, NO_x would consist of approximately 90-95% of NO and 5-10% of NO_2, the regulated oxide. The dominant short term conversion is NO to NO_2 through oxidation with atmospheric ozone (O_3) as the plume travels from source.

$$NO + O_3 \equiv NO_2 + O_2$$

Therefore, to predict the ground level concentration of NO_2 it is necessary to account for the transformation of NO_x to NO_2.

3.3 Particulate Matter

Emissions of particulate matter are generally considered in three separate size fractions. These are described as total suspended particulate matter (TSP), particulate matter with equivalent aerodynamic diameters[a] 10 μm or less (PM_{10}) and particles with equivalent aerodynamic diameters of 2.5 μm and less ($PM_{2.5}$). Goals for TSP were developed before more recent health studies suggested stronger relationships between health impacts and exposure to smaller size fractions of particulate matter, including PM_{10} and $PM_{2.5}$.

Particulate matter has the capacity to affect health and to cause nuisance effects. The extent to which health or nuisance effects occur, relates to the size and/or by chemical composition of the particulate matter. Generally the finer the particle, the greater the health effect, based on the particle's ability to penetrate deep into the lungs. Particles larger than PM_{10} tend to be trapped in the nose, mouth, throat or major bronchi and are typically expelled relatively quickly from the body.

Impact assessment criteria for particulate matter provide benchmarks, which if met, are intended to protect the community against the adverse effects of air pollutants. These criteria are generally considered to reflect current Australian community standards for the protection of health and protection against nuisance effects. To assist in interpreting the significance of predicted concentration, some background discussion on the potential harmful effects is provided below.

The human respiratory system has in-built defensive systems that prevent particles larger than approximately 10 μm from reaching the more sensitive parts of the respiratory system. Particles with aerodynamic diameters less than 10 μm are referred to as PM_{10}. Particles larger than 10 μm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. In practice, particles larger than 30 to 50 μm settle out of the atmosphere too quickly to be regarded as air pollutants but are considered for their impacts on amenity.

The health-based assessment criteria used by NSW DECCW (**NSW DEC, 2005**) have, to a large extent, been developed by reference to epidemiological studies undertaken in urban areas with large populations where the primary pollutants are the products of combustion. This means that, in contrast to dust of crustal[b] origin, the particulate matter would be composed of smaller particles and would generally contain acidic and carcinogenic substances that are associated with combustion.

The majority of dust generated during construction would be in coarse size from (PM_{10} and larger) and the majority of combustion particles (i.e. from diesel equipment) would be in the fine size range ($PM_{2.5}$ and less).

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[a] An equivalent aerodynamic diameters of less than 10μm means that all particles behave aerodynamically in the same way as spherical particles with a unit density, even though they are not spherical themselves.

[b] The term crustal dust is used to refer to dust generated from materials that constitute the earth's crust.

3.4 Volatile Organic Compounds (VOCs)

Organic hydrocarbons are comprised of a collection of various volatile organic compounds (VOCs), and several of these compounds may be toxic, including benzene, 1,3-butadiene, toluene and xylenes. Formaldehyde is formed from the combustion of natural gas.

Air toxics are present in the air in low concentrations, however characteristics such as toxicity or persistence means they can be hazardous to human, plant or animal life. There is evidence that cancer, birth defects, genetic damage, immuno-deficiency, respiratory and nervous system disorders can be linked to exposure to occupational levels of air toxics. Organic hydrocarbons also include reactive organic compounds, which play a role in the formation of photochemical smog.

3.5 Sulfur Dioxide (SO_2)

Sulfur dioxide belongs to the family of sulfur oxide gases (SO_x). These gases are formed when fuel containing sulfur is burned. The major health concerns associated with exposure to high concentrations of SO_2 include effects on breathing, respiratory illness, alterations in pulmonary defences, and aggravation of existing cardiovascular disease. SO_2 is a major precursor to acid rain, which is associated with the acidification of lakes and streams, accelerated corrosion of buildings and monuments, and reduced visibility. However, this is not currently a significant problem in Australia.

4 LEGISLATIVE SETTING AND AIR QUALITY CRITERIA

4.1 Prescribed Limits

The Protection of the Environment Operations (Clean Air) Regulations 2010 sets standards of concentration for emissions to air from scheduled activities. The relevant maximum pollution levels that are allowed under the regulations are provided in **Table 4.1**.

Table 4.1: Maximum Allowable Emission Levels

Air Impurity	Activity or Plant	Standard of Concentration
Solid Particles	Any process emitting solid particles	50 mg/m^3
NO_x	Any activity or plant, any boiler operating on gas	350 mg/m^3
VOCs	Any activity or plant involving combustion	40 mg/m^3 VOCs or 125 mg/m^3 CO
Smoke	Any flare	No visible emissions other than for a total period of no more than 5 minutes in any 2 hours

4.2 Air Quality Criteria and Standards

The NSW DECCW prescribe ambient impact assessment criteria which is outlined in their "Approved Methods for Modelling and Assessment of Air Pollutants in NSW" (the Approved Methods) (**NSW DEC, 2005**).

The impact assessment criteria refer to the total pollutant load in the environment and impacts from new sources of these pollutants must be added to existing background levels for compliance assessment.

In June 1998, the National Environment Protection Council (NEPC) of Environment Ministers agreed to set uniform standards for ambient air quality to apply to all States and Territories. These standards are contained in the National Environment Protection Measure (NEPM) for ambient air quality. These NEPM set standards for ambient levels of "criteria pollutants" to be achieved within 10 years of commencement and aim to protect the community against the detrimental health impacts of air pollution.

In July 2003 a variation to the Ambient Air Quality NEPM was made to extend its coverage to $PM_{2.5}$ and set "Advisory Reporting Standards" for averaging periods of 1-day and 1-year. It is important to note that the advisory reporting standards were established to assess monitoring data representative of average population and are not yet used for compliance or impact assessment for specific projects. **Table 4.2** summarises the air quality goals that are relevant to this study.

Table 4.2: Air quality standards / goals for particulate matter concentrations

Pollutant	Standard	Averaging Period	Source
PM_{10}	50 $\mu g/m^3$	24-Hour	NSW DEC (2005) (assessment criteria)
	30 $\mu g/m^3$	Annual	NSW DEC (2005) (assessment criteria)
	50 $\mu g/m^3$	24-Hour	NEPM (allows five exceedances per year)
$PM_{2.5}$	25 $\mu g/m^3$	24-Hour	NEPM Advisory Reporting Standard
	8 $\mu g/m^3$	Annual	NEPM Advisory Reporting Standard
Nitrogen Dioxide	246 $\mu g/m^3$	1-Hour	NSW DEC (2005) (assessment criteria)
	62 $\mu g/m^3$	Annual	NSW DEC (2005) (assessment criteria)
Sulfur Dioxide	570 $\mu g/m^3$	1-Hour	NSW DEC (2005) (assessment criteria)
	228 $\mu g/m^3$	24-Hour	NSW DEC (2005) (assessment criteria)
	60 $\mu g/m^3$	Annual	NSW DEC (2005) (assessment criteria)
Volatile Organic Compounds / Air Toxics			
Formaldehyde	0.02 mg/m^3	1-Hour	NSW DEC (2005) (assessment criteria)
Benzene	0.029 mg/m^3	1-Hour	NSW DEC (2005) (assessment criteria)
PAH as Benzo(a)pyrene	0.0004 mg/m^3	1-Hour	NSW DEC (2005) (assessment criteria)

In addition to health impacts, the NSW DECCW list impact assessment criteria for individual odorous air pollutants. **Table 4.3** presents a summary of the impact assessment criteria for hydrogen sulfide as a function of population density, expressed as peak concentrations (nose response times), and reported against 99th percentiles of dispersion modelling predictions.

Table 4.3: Impact assessment criteria for hydrogen sulfide (nose response time average 99th percentile)

Population of affected community	Impact assessment ctiteria ($\mu g/m^3$)
Urban (.~2000)	1.38
~500	2.07
~125	2.76
~30	3.45
~10	4.14
Single residence (<~2)	4.83

Airborne dust also has the potential to cause nuisance impacts by depositing on surfaces. **Table 4.4** shows the dust deposition criteria set out in the DECCW Approved Methods (**NSW DEC, 2005**).

Table 4.4: NSW DECCW criteria for dust (insoluble solids) fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

5 EXISTING AMBIENT AIR QUALITY

Air quality standards and goals are used to assess the total pollutant level in the environment, including the contribution from specific projects and existing sources. To fully assess impacts against all the relevant air quality standards and goals, it is necessary to have information on the background concentrations to which the project is likely to contribute.

Existing industrial sources in the vicinity of gas plant site include the adjacent Tomago Aluminum Smelter, Industrial Galvanisers (located at Hexham), Hunter Galvanising (located at Tomago) and Omega Chemicals, Tomago.

The DECCW collects ambient monitoring data at Beresfield located approximately 6 km west of the gas plant site. The monitoring station collects data for the following pollutants which are of relevance to this study: PM_{10}, $PM_{2.5}$, NO_2, and SO_2. The most recent year of data (2009) can be used to obtain an indication of ambient background levels in the proximity of the gas plant site.

Monitoring for SO_2 is also conducted in the vicinity of the TAC plant as discussed in **Section 5.1**. Monitoring during 2008 and 2009 was conducted at three sites know as the Farm site, the Met site and the Highway site. An additional two sites were installed in 2010 known as the School drive site and the Laverick Ave site.

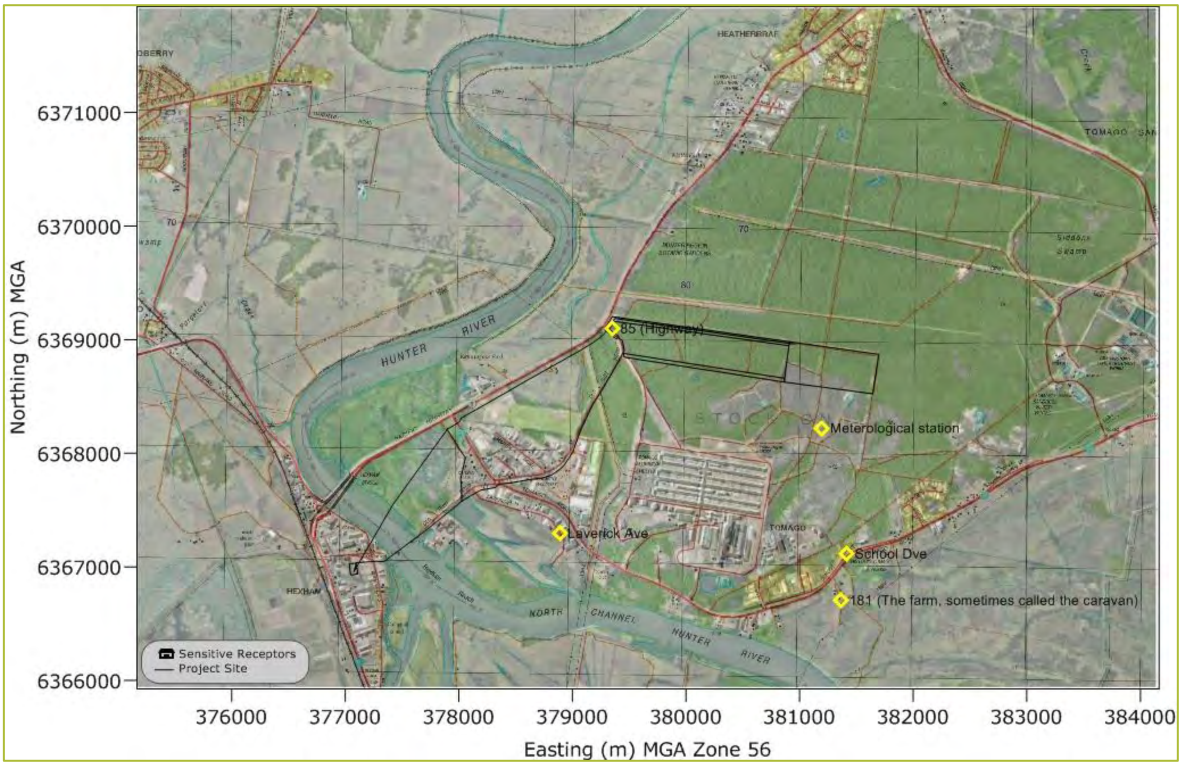

Figure 5.1: Locations of TAC Monitoring Sites

Monitoring indicates that levels of SO_2 in the vicinity of TAC are approaching the air quality goals for 1-hour and 24-hour average SO_2 concentrations. Cumulative assessment of SO_2 is discussed further in **Section 8.3**.

The 24-hour average PM_{10} concentrations for 2009 recorded at Beresfield are presented in **Figure 5.2**. Plots are presented for data including significant weather events (i.e. dust storms) which contributed to unusually high dust levels. For example, a PM_{10} concentration of 1,999 µg/m^3 was recorded on 23 September 2009. This high concentration was due to severe dust storms occurring in and around NSW during this time. The lower graph in **Figure 5.2** shows data for the same period but with dust storm data removed to provide more representative background ambient levels of 24-hour PM_{10}.

In most cases the peak concentration due to a new emission source will not occur at the same time as a background peak, which in NSW is often as a result of a dust storm or bushfire. When considering background pollutant concentrations for assessment purposes, it is sensible to exclude these anomalous events and the approach recommended by the Approved Methods is to demonstrate that no additional exceedances of the criteria would occur as a result of the development. With these data removed, the 2009 average PM_{10} concentration was 19 µg/m^3 and the maximum 24-hour average was 33 µg/m^3.

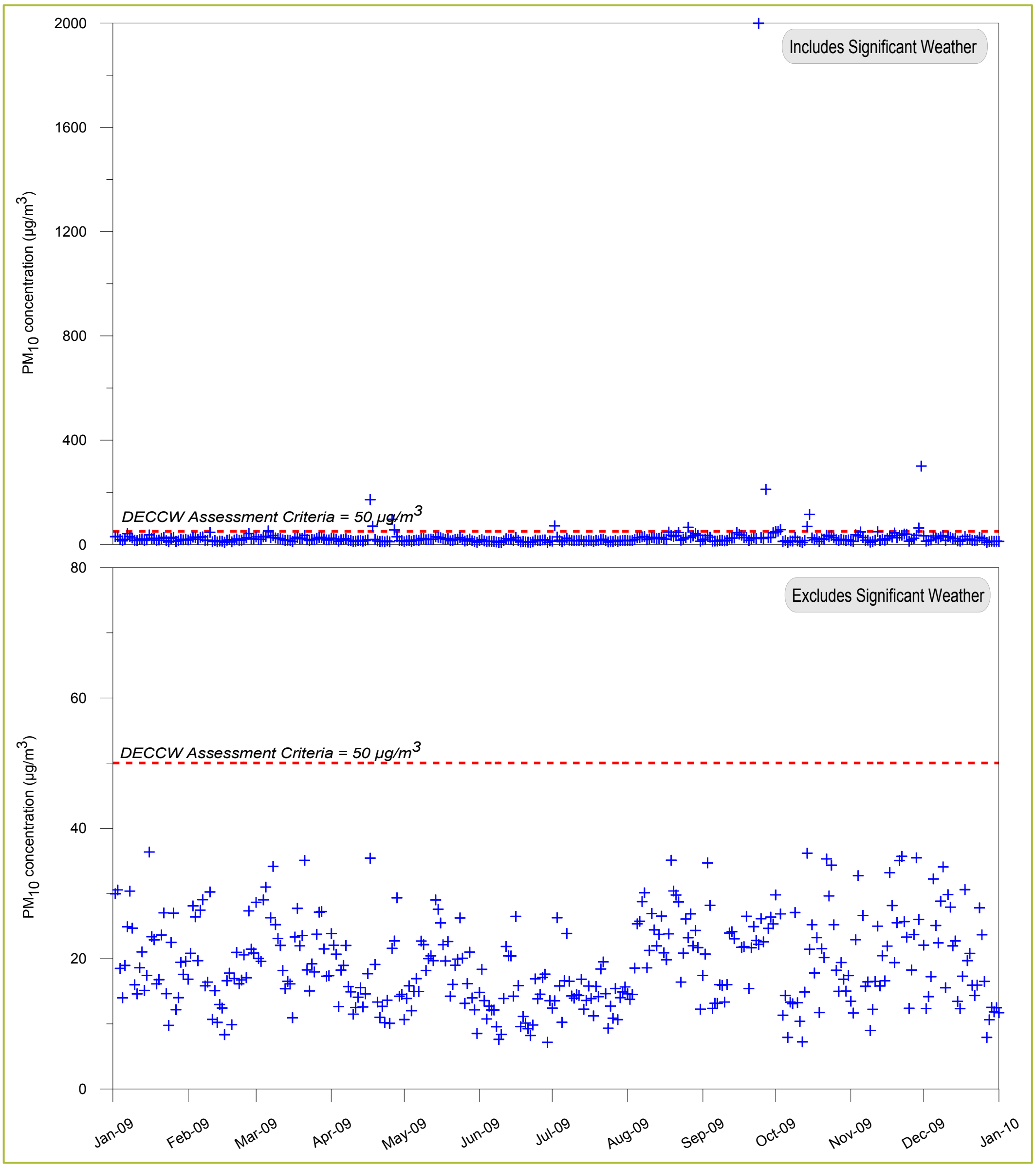

Figure 5.2: 24-hour Average PM_{10} Concentrations – 2009 Beresfield

24-hour average $PM_{2.5}$ concentrations for 2009 are presented in **Figure 5.3**. As with the 24-hour PM_{10} concentrations, these data are shown without the significant weather events.

Excluding the significant weather events, the 2009 average $PM_{2.5}$ concentration was 10 µg/m^3 and the maximum 24-hour average was 20 µg/m^3.

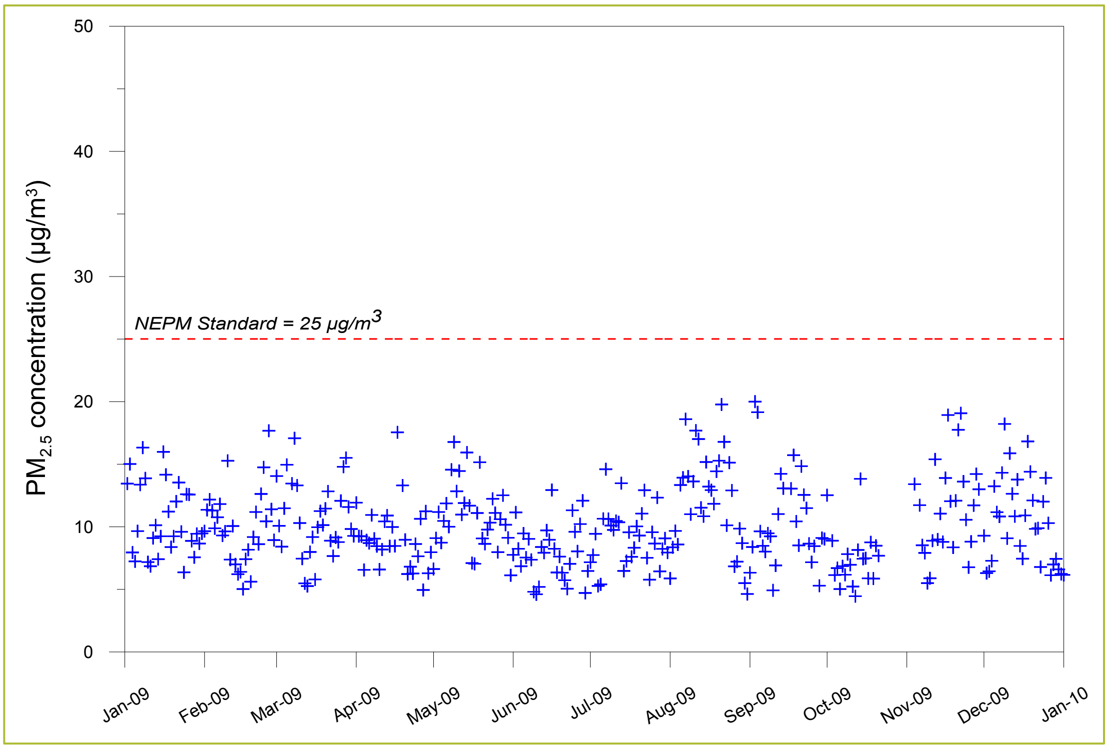

Figure 5.3: 24-Hour Average $PM_{2.5}$ Concentration – 2009 Beresfield

1-hour average NO_2 concentrations for 2009 recorded at Beresfield are presented in **Figure 5.4**. There were no exceedances of the NEPM 1-hour average goal of 246 µg/m^3. The 2009 average NO_2 concentration was 16 µg/m^{3}with a maximum 1-hour concentration of 74 µg/m^3.

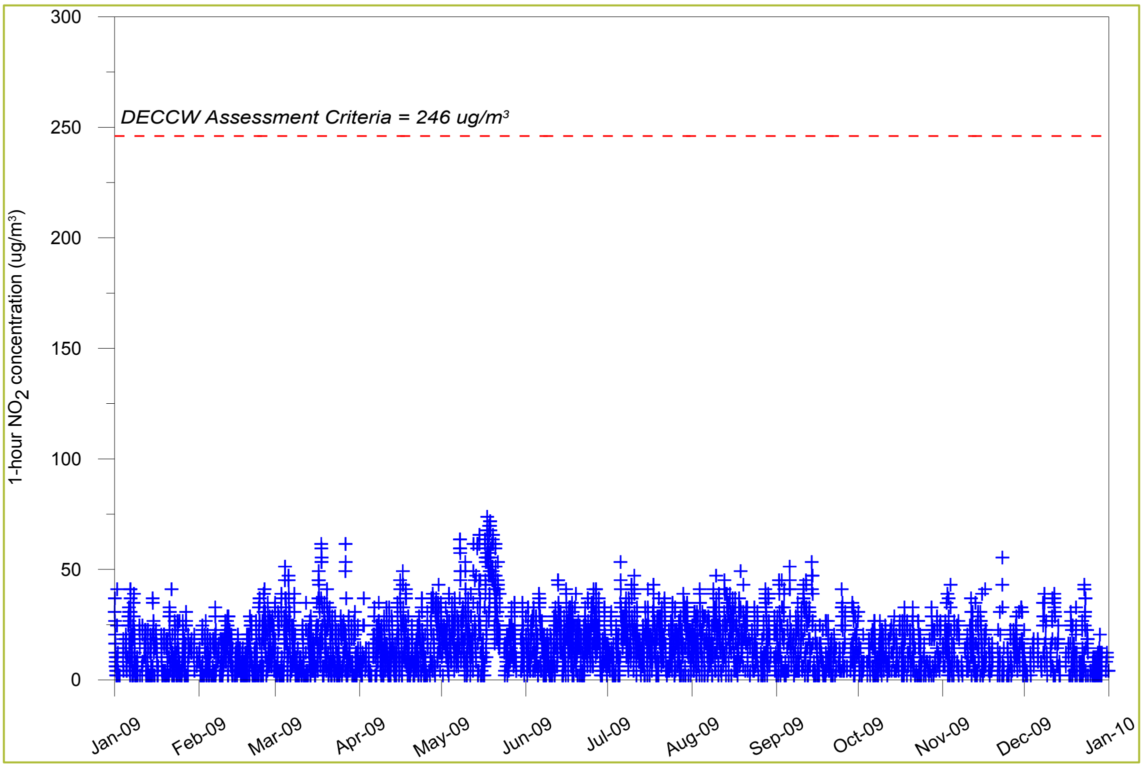

Figure 5.4: Hourly NO_2 Concentration - 2009 Beresfield

1-hour average SO_2 concentrations for 2009 recorded at Beresfield are presented in **Figure 5.5**. There were no exceedances of the DECCW 1-hour average goal of 570 µg/m^3. The 2009 average SO_2 concentration was 6 µg/$m^3$with a maximum 1-hour concentration of 140 µg/m^3.

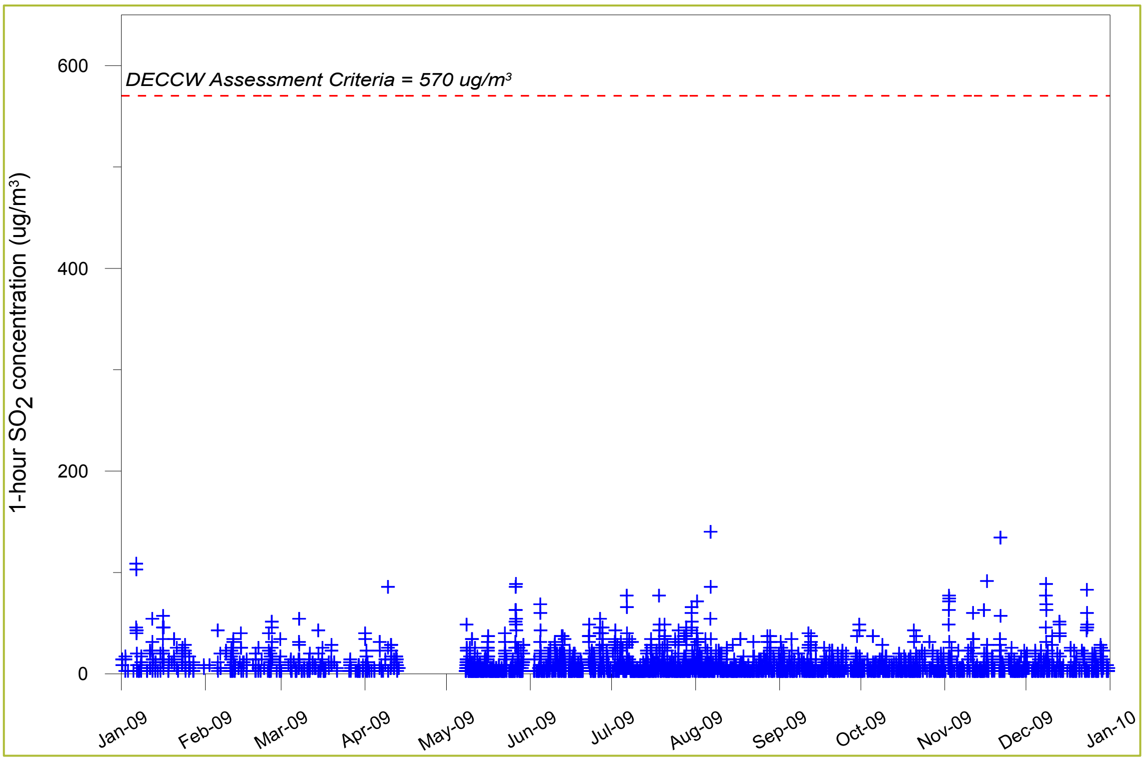

Figure 5.5: 1-Hour SO_2 Concentration – 2009 Beresfield

5.1 TAC Monitoring Data

Monitoring for SO_2 is also undertaken by TAC at a number of locations around the site and this is better used to describe background for the local area. **Figure 5.6** to **Figure 5.10** show the 1-hour and 24-hour average SO_2 concentrations recorded at the Farm, Met and Highways sites for 2008 and 2009.

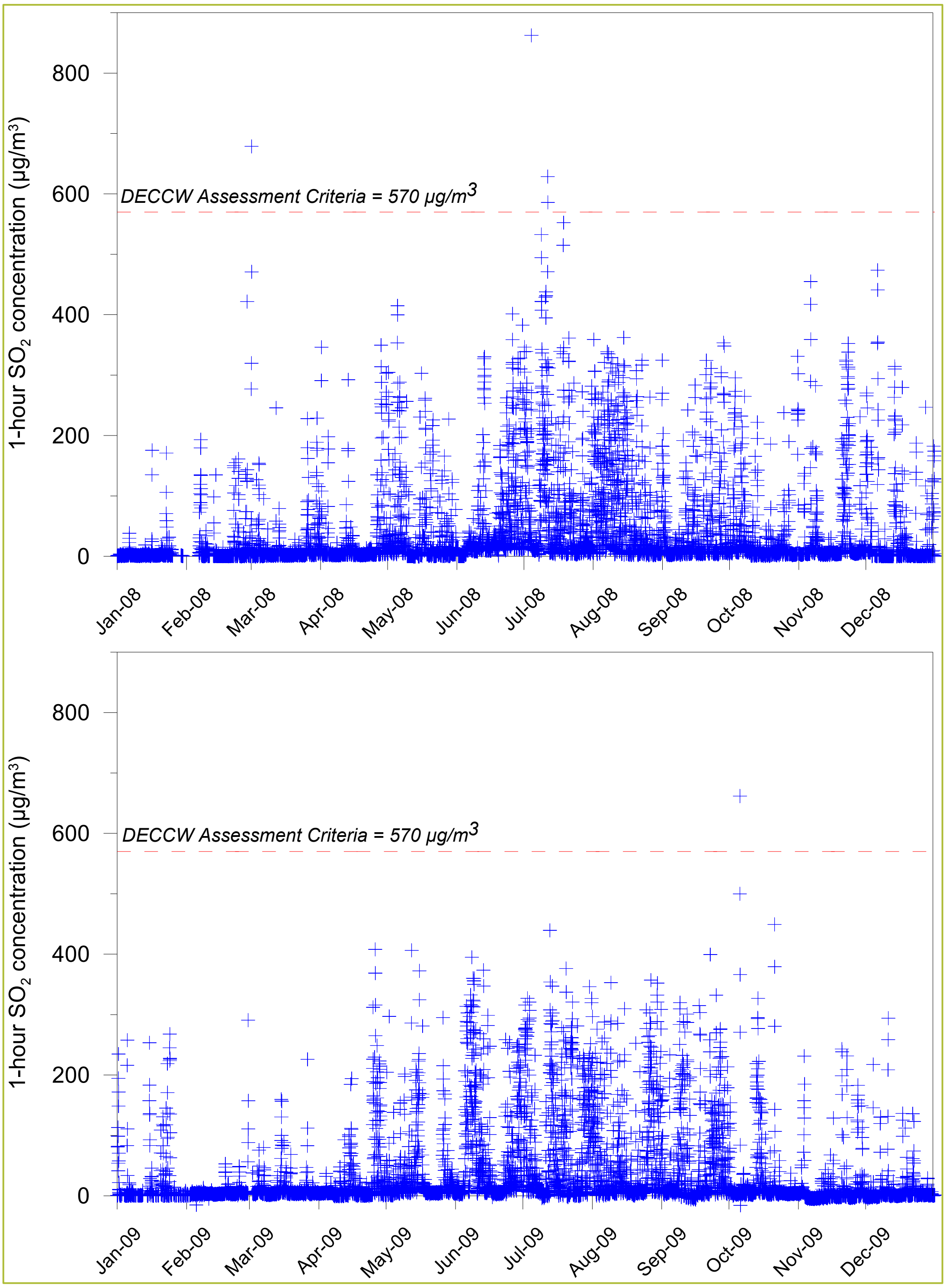

Figure 5.6: 1-Hour SO_2 Concentration – 2008 and 2009 – Farm Site

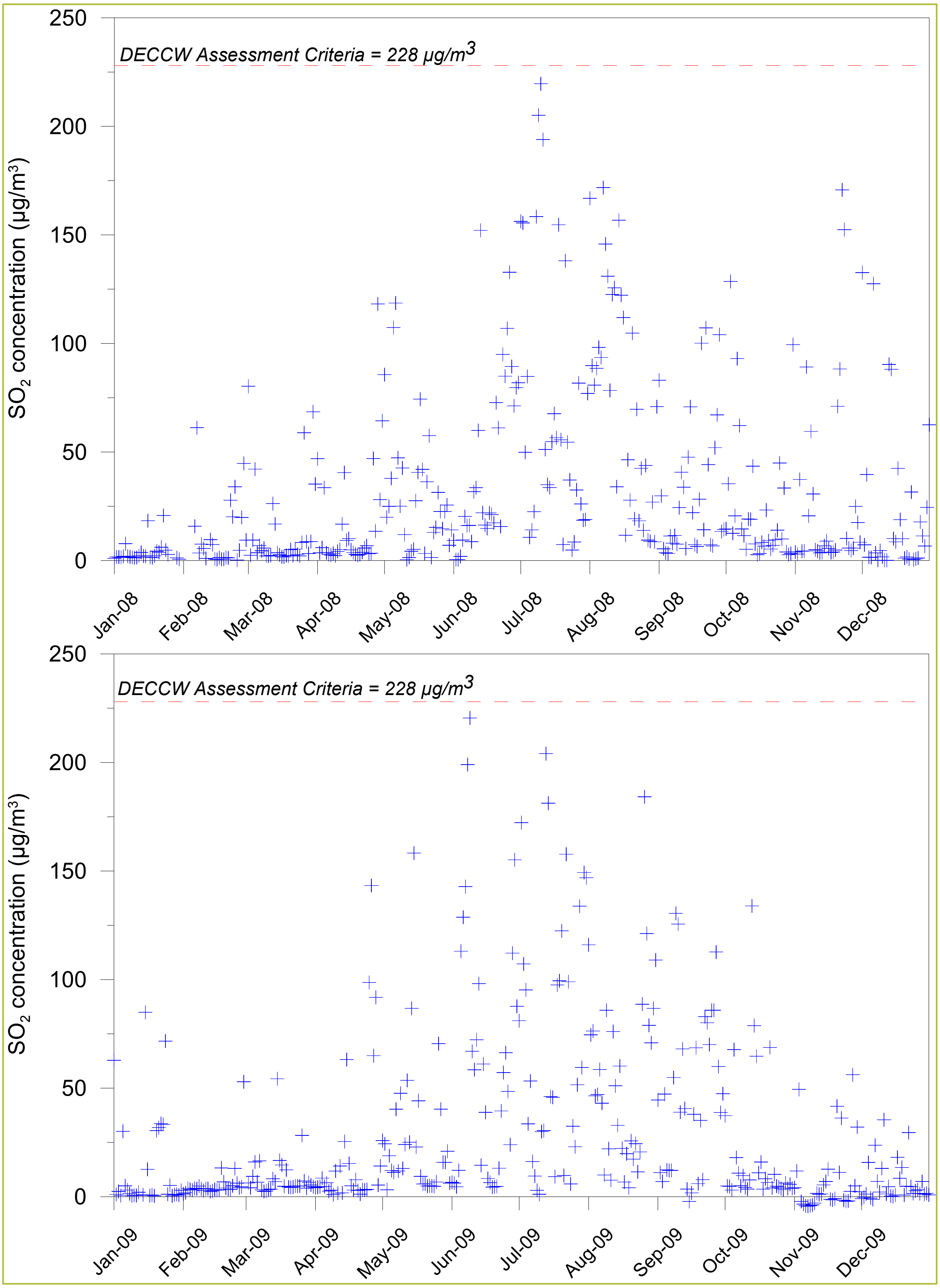

Figure 5.7: 24-Hour SO$_2$ Concentration – 2008 and 2009 – Farm Site

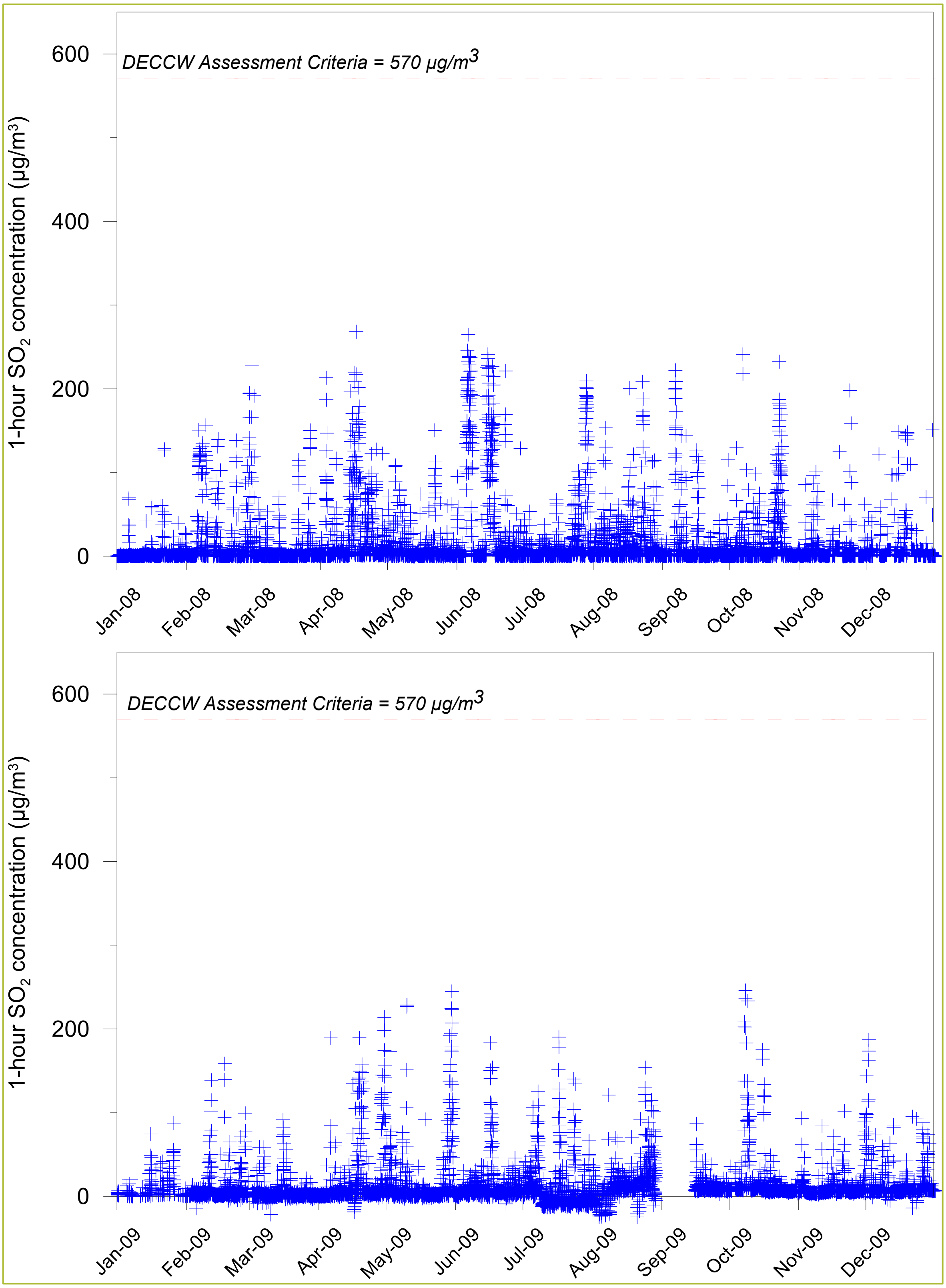

Figure 5.8: 1-Hour SO_2 Concentration – 2008 and 2009 – Met Site

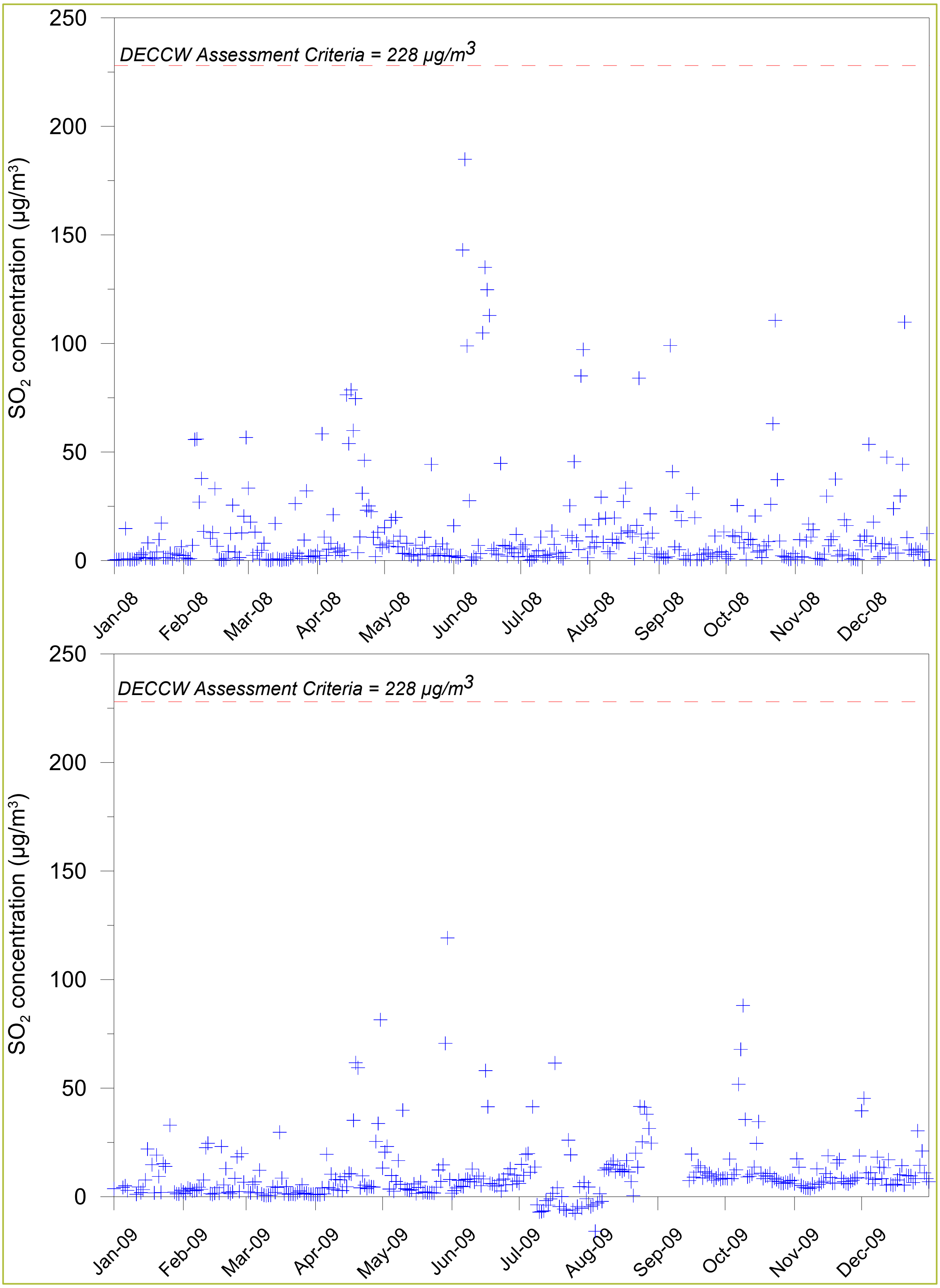

Figure 5.9: 24-Hour SO$_2$ Concentration – 2008 and 2009 – Met Site

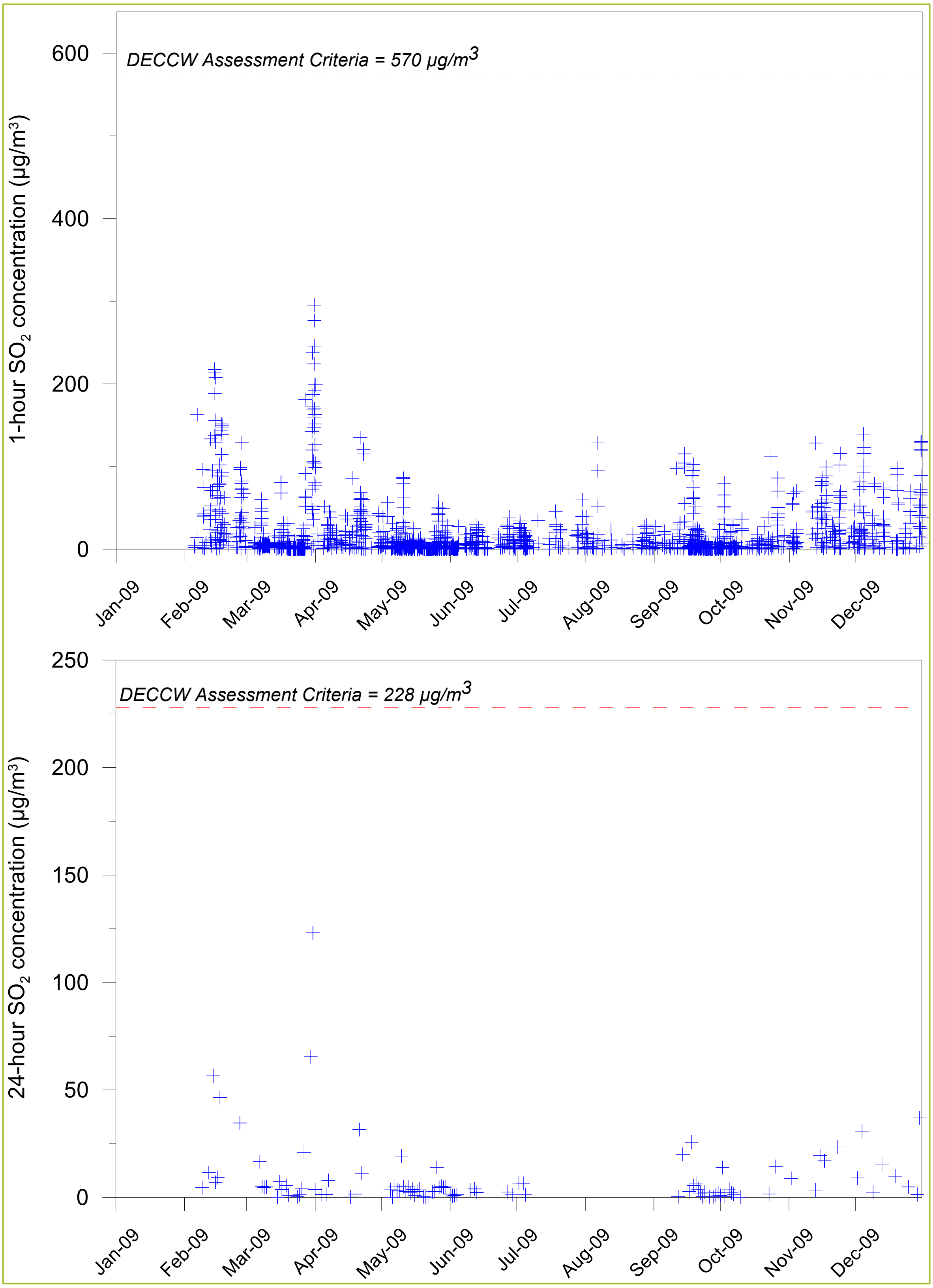

Figure 5.10: 1-hour and 24-Hour SO_2 Concentration – 2009 – Highway Site

6 PREVAILING METEOROLOGY

6.1 Climatic Features

Newcastle has a borderline oceanic/humid subtropical climate like much of central and northern New South Wales. Summers tend to be warm and winters are generally mild. Precipitation is heaviest in late autumn and early winter.

Climate averages for Williamtown RAAF base are presented in **Table 6.1**. January is the warmest month with an annual average maximum temperature of 28°C. July is the coolest month with an average minimum temperature of 6.4°C.

Annual average rainfall is 1123.8 mm, with February, March and June producing the highest monthly totals on average (**Table 6.1**). The wind speed at 9 am averages 13.6 km/h for the year, with July and August being the windiest months in the morning on average (**Table 6.1**). Wind speed at 3 pm averages 20.2 km/h with November and December being the windiest months in the afternoon.

Table 6.1: Climate Averages for Williamtown RAAF – 1942 to 2010

Month	Average Minimum Temperature (°C)	Average Maximum Temperature (°C)	Median Rainfall (mm)	Rain Days (>0.1mm)	Average 9 AM Wind Speed (km/h)	Average 3 PM Wind Speed (km/h)
January	18.0	28.0	97.9	7.2	11.9	21.9
February	18.1	27.5	121.7	7.3	10.6	20.6
March	16.3	26.2	121.1	8.2	10.2	18.9
April	13.2	23.6	104.5	7.3	11.4	17.2
May	10.1	20.3	114.5	8.0	13.7	15.8
June	7.9	17.6	121.4	8.1	15.9	17.5
July	6.4	17.0	72.2	6.3	16.4	18.7
August	6.8	18.6	75.8	6.2	16.7	20.7
September	9.1	21.3	60.7	5.6	15.2	22.0
October	12.0	23.6	74.8	7.3	14.4	22.5
November	14.3	25.4	81.2	7.4	14.4	23.5
December	16.5	27.2	79.9	7.0	12.9	23.5
Annual	**12.4**	**23.0**	**1123.8**	**85.9**	**13.6**	**20.2**

Source: Bureau of Meteorology

6.2 Meteorological Modelling

The local meteorology was modelled using TAPM and CALMET models. Output from TAPM, plus regional observational weather station data was entered into CALMET, a meteorological pre-processor endorsed by the US EPA and recommended by the NSW DECCW for use in non-steady state conditions. From this, a 1-year representative meteorological dataset suitable for use in the 3-dimensional plume dispersion model, CALPUFF, was compiled. Details on the model configuration and data inputs are provided in the following sections.

The choice of the CALMET/CALPUFF modelling system for this study is based on the fact that simple Gaussian dispersion models such as AUSPLUME assume that the meteorological conditions are uniform spatially over the entire modelling domain for any given hour. While this may be valid for some applications, in complex flow situations, such as coastal environments, the meteorological conditions may be more accurately simulated using a wind field model such as CALMET.

6.2.1 TAPM

The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed description of the TAPM model and its performance is provided elsewhere (**Hurley, 2002a, 2002b; Hibberd *et al.*, 2003; Luhar & Hurley, 2003**).

TAPM solves the fundamental fluid dynamics and scalar transport equations to predict meteorology and (optionally) pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

For the Project Assessment, TAPM was set up with 4 domains, composed of 30 grids along both the x and the y axes, centred on -32° 49.5′ Latitude and 151° 43′ Longitude. Each nested domain had a grid resolution of 30 km, 10 km, 3 km and 1 km respectively.

To improve model accuracy, observed wind conditions from TAC weather station (approximately 400 m south of the gas plant site), DECCW Beresfield Station, BoM Williamtown RAAF and BoM Newcastle Nobbys Signal Stations were used to improve the TAPM solution (**Figure 6.1**).

Default TAPM terrain values are based on a global 30-second resolution (approximately 1 km) dataset provided by the US Geological Survey, Earth Resources Observation Systems (EROS). For the purposes of modelling, a higher resolution terrain dataset was extracted from the 9-second resolution (approximately 250m) Digital Elevation Model (DEM) from Geoscience Australia. Default land use and soils data sets for TAPM were used (**Hurley, 2002a**).

6.2.2 CALMET

CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model.

CALMET was run with an outer domain covering a 25 km x 25 km area, with the origin (SW corner) at 368.754 km Easting and 6356.264 km Northing (UTM Zone 56 S). This consisted of 25 x 25 grid points, with a 1 km resolution along both the x and y axes. This grid was selected to include as many local meteorological observations as possible, including observations of cloud amount from Williamtown RAFF Base. An inner grid was then run incorporating the outer grid to provide finer resolution closer to the gas plant site. The origin for the inner domain was 374.999 km Easting and 6362.999 km Northing (UTM Zone 56 S). This consisted of 100 x 100 grid points, with a 0.1 km resolution along both the x and y axes. Terrain for this area was derived from 9-second DEM data sourced from GeoScience Australia. Land use data were sourced from the 1996-97 Land use data of Australia, Version 2, National Land and Water Resources Audit.

Observed hourly surface wind speed, wind direction, temperature and relative humidity data from the TAC weather station, DECCW Beresfield Station and BoM Williamtown RAAF and Newcastle Nobbys Signal Stations were used as input for CALMET. Cloud amount and cloud heights were sourced from observations at the Williamtown RAAF station. Upper air data were also extracted from TAPM to provide the necessary upper air files. Together, the surface and upper air files were used as input to CALMET to create a fine resolution three-dimensional meteorological field for the region. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to generated a three-dimensional wind field the region.

The outer meteorological modelling domain and locations of the surface station inputs are shown in **Figure 6.1**.

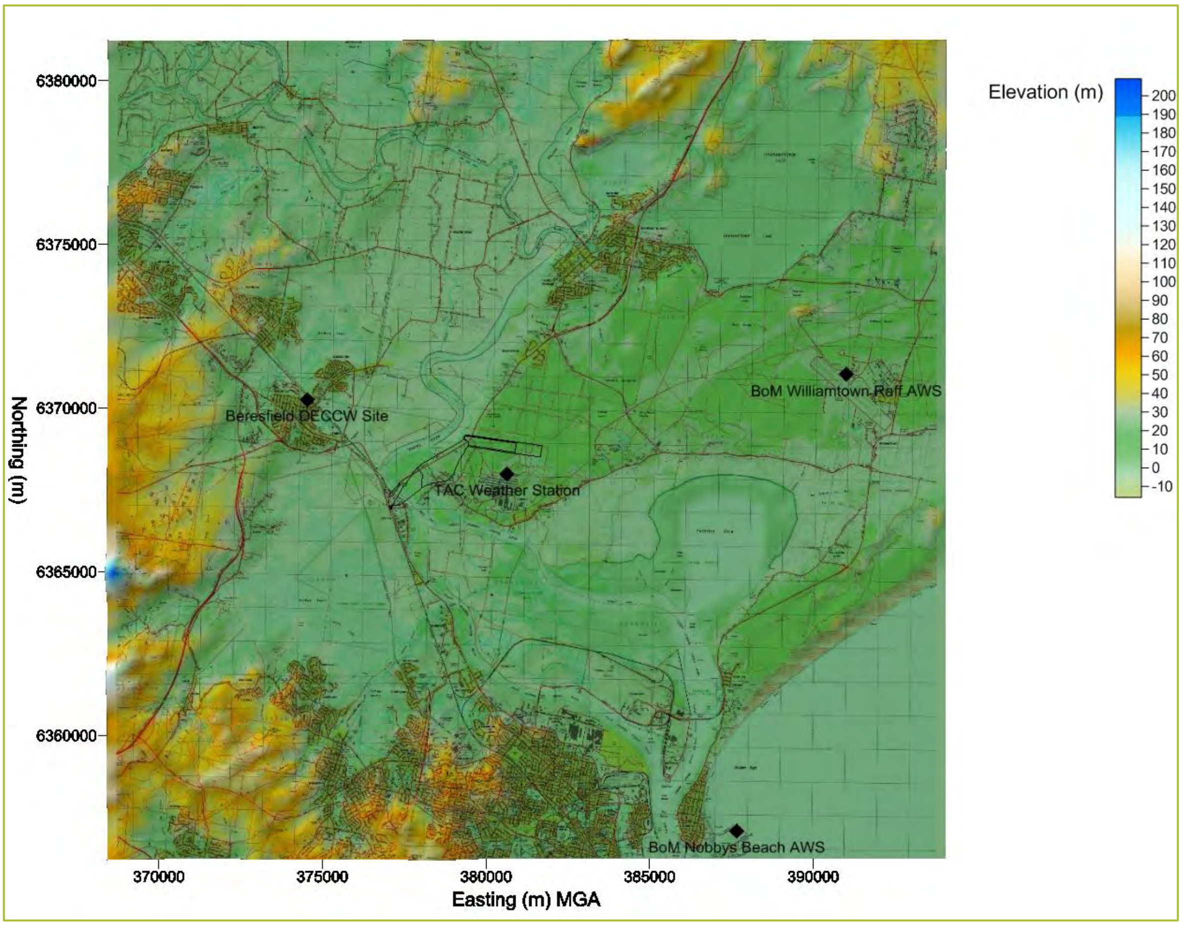

Figure 6.1: Modelling domain and meteorological input sites

6.3 Prevailing Winds

A summary of the annual wind behaviour from meteorological data from the TAC station is presented in **Figure 6.2**. The year 2008 was chosen for modelling as this was the most complete dataset available.

The wind roses also represent the surface station inputs used within the CALMET modelling as discussed in **Section 6.2**. On an annual basis, winds are predominantly from the north, south and north-west directions. Spring and summer show prominent winds from the north while autumn and winter show more prominent winds from the north-west and south-west. On an annual basis the percentage of calms is 32.3%, which is relatively high.

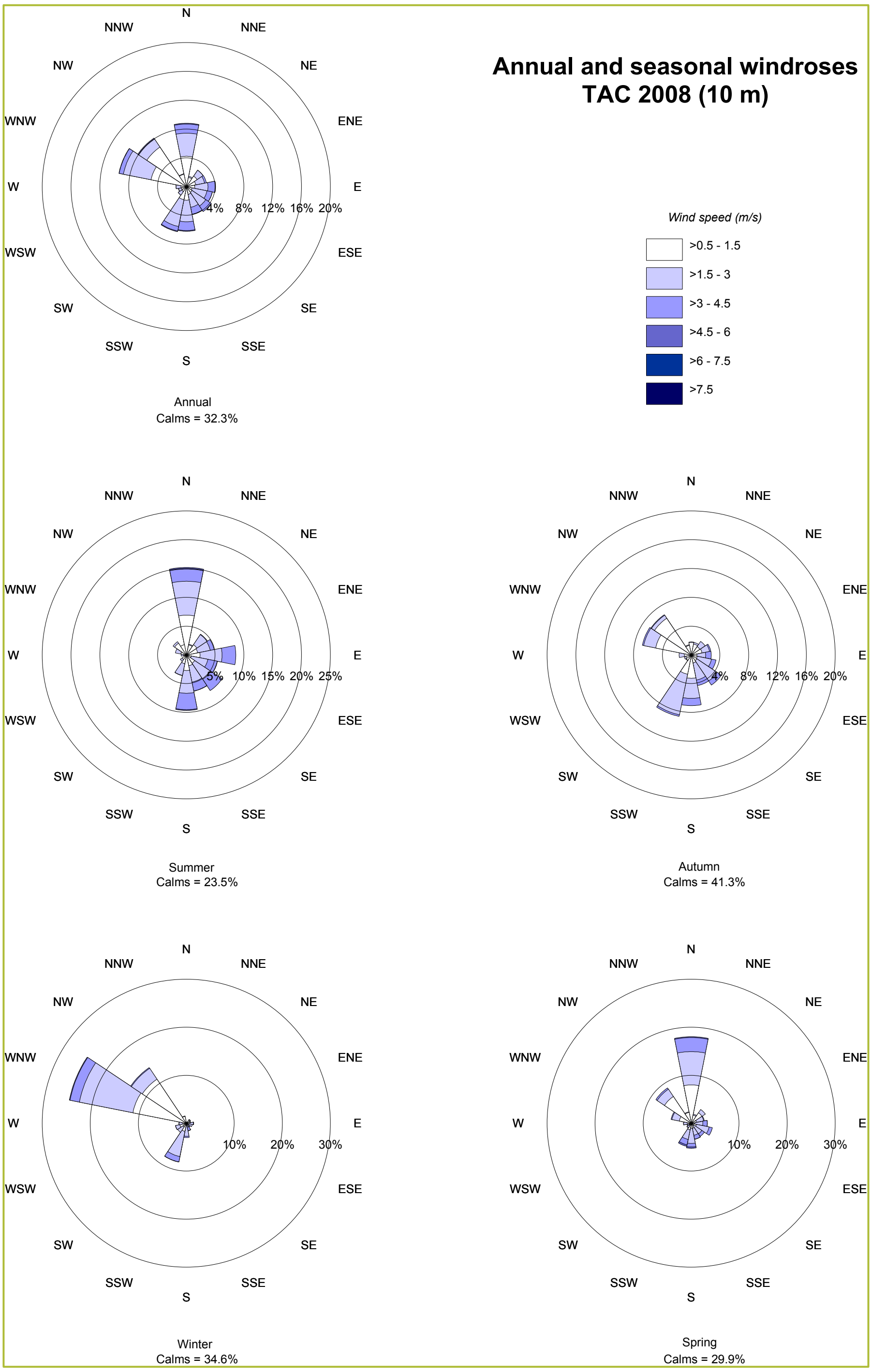

Figure 6.2: Wind Roses for TAC On-site weather station, 2008

As discussed in **Section 6.2**, a CALMET data file was generated for the modelling domain. To determine the performance of the model, meteorological data are extracted for a point in the middle of the domain at the approximate location of the gas plant site. Windroses for this CALMET generated file is shown in **Figure 6.3**. The CALMET generated windroses show very similar patterns to the TAC data (see **Figure 6.2**). Differences include slightly higher percentages of winds from each of the dominant directions in the CALMET windroses as well as lower percentages of calms in each season and annually. The annual percentage of calms for the CAMLET data is 19.1%.

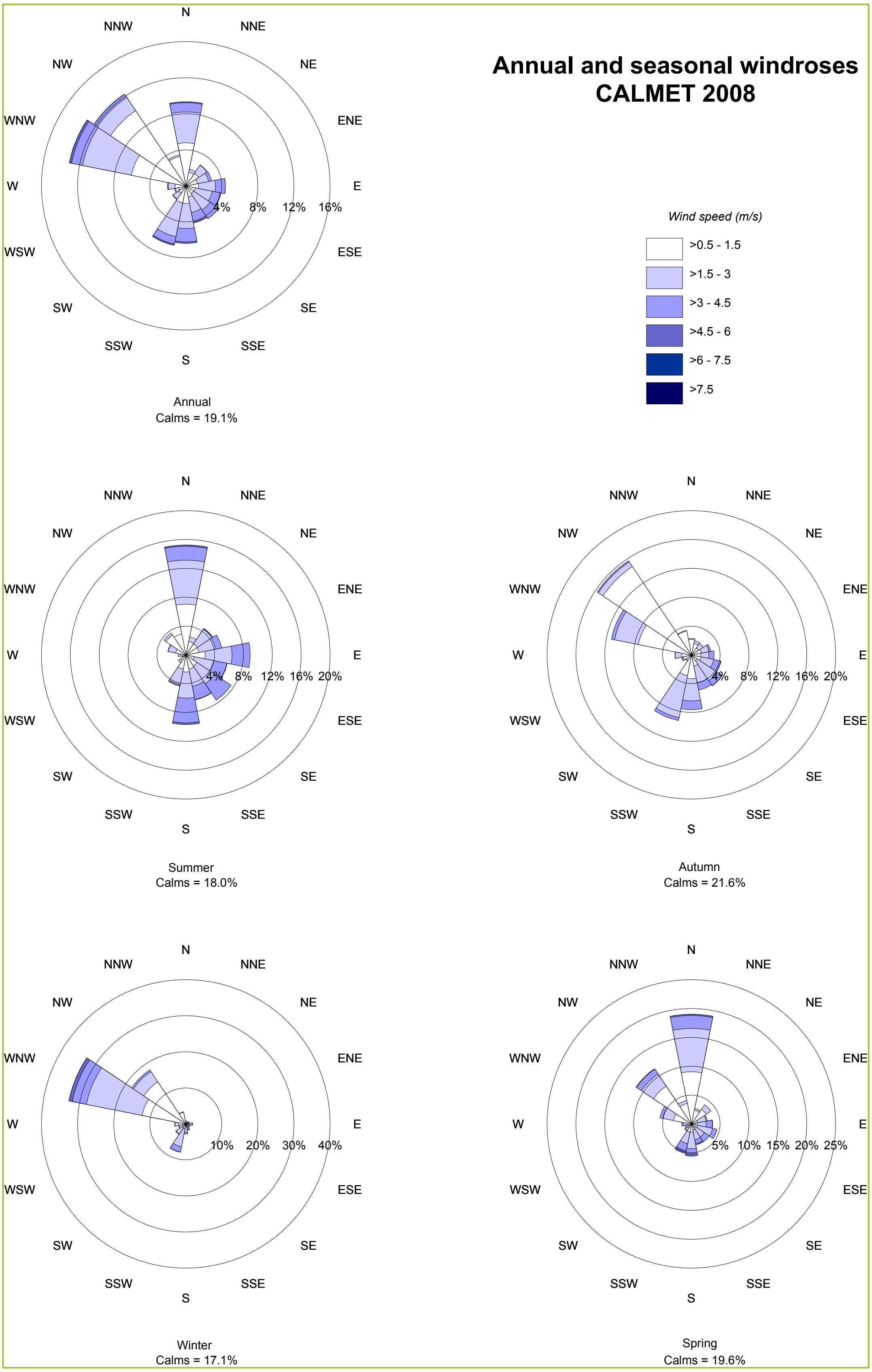

Figure 6.3: CALMET Generated Wind Rose for the site

6.4 Atmospheric Stability

An important aspect of plume dispersion is the level of turbulence in the atmosphere near the ground. Turbulence acts to dilute or diffuse a plume by increasing the cross-sectional area of the plume due to random motion. As turbulence increases, the rate of plume dilution or diffusion increases. Weak turbulence limits diffusion and is a critical factor in causing high plume concentrations downwind of a source. Turbulence is related to the vertical temperature gradient, the condition of which determines what is known as stability, or thermal stability. For traditional dispersion modelling using Gaussian plume models, categories of atmospheric stability are used in conjunction with other meteorological data to describe the dispersion conditions in the atmosphere.

The best known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, such as those that commonly occur under clear skies at night and in the early morning, especially during the cooler months. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are closely associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

The CALMET-generated meteorological data can be used to estimate stability class for the site and the frequency distribution of estimated stability classes is presented in **Figure 6.4**. The data show a large proportion of class F conditions (>45% of hours), and a total of 49.5% of hours with either E or F class.

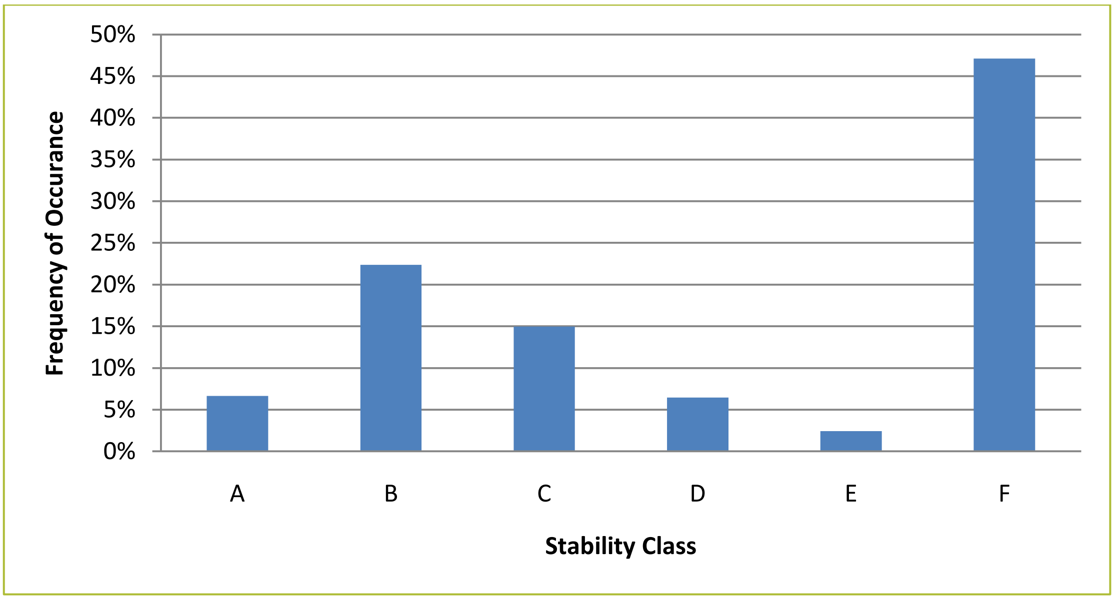

Figure 6.4: Stability Class Frequency (CALMET 2008)

6.5 Mixing Height

Mixing height is defined as the height above ground of a temperature inversion or statically stable layer of air capping the atmospheric boundary layer. It is often associated with, or measured by, a sharp increase of temperature with height, a sharp decrease of water-vapour, a sharp decrease in turbulence intensity and a sharp decrease in pollutant concentration. Mixing height is variable in space and time, and typically increases during fair-weather daytime over land from tens to hundreds of metres around sunrise up to 1–3 km in the mid-afternoon, depending on the location, season and day-to-day weather conditions. Sea breezes may, however, introduce complexities to the mixing height. The onset of a sea breeze at a particular location will often bring a reduction in the mixing height.

Mixing heights show diurnal variation and can change rapidly after sunrise and at sunset. Diurnal variation in the minimum, maximum and average mixing depths, based on the CALMET-generated meteorological data for the site, is shown in **Figure 6.5**. As expected, mixing heights begin to grow following sunrise with the onset of vertical convective mixing with maximum heights reached in mid to late afternoon.

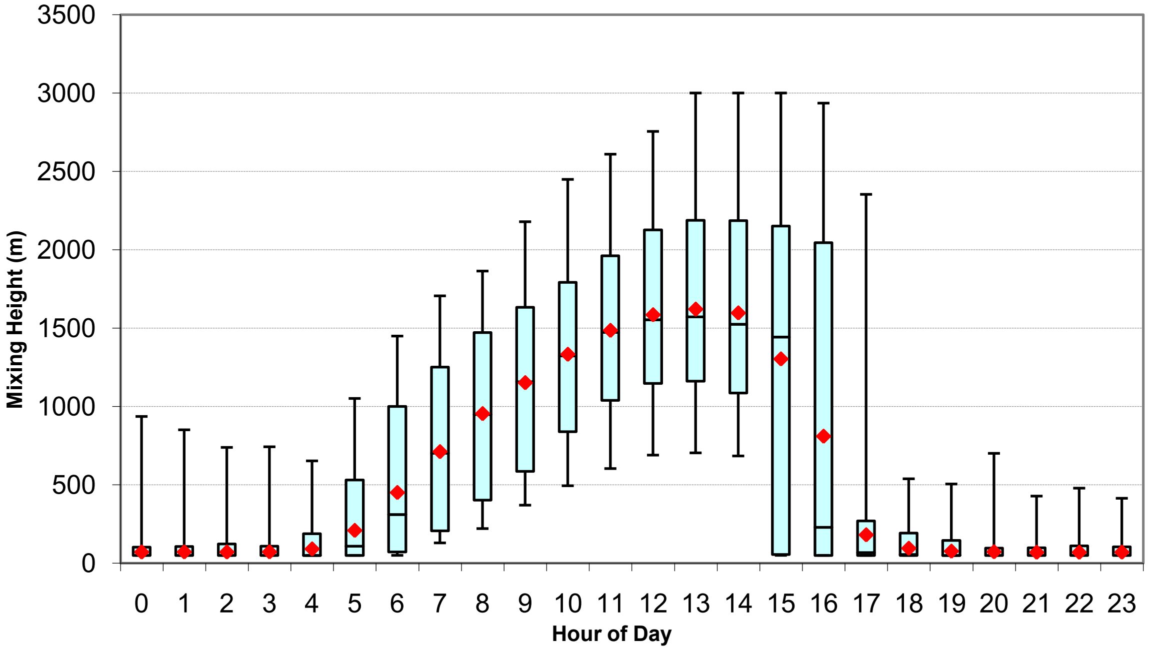

Figure 6.5: Average Daily Diurnal Variation in Mixing Layer Depth (CALMET 2008)

7 MODELLING APPROACH AND EMISSIONS TO AIR

7.1 Emissions to Air

The emission sources during operation of the project that have been included in this assessment are:

- Emissions from hot oil heaters at liquefaction plant during liquefaction;
- Emissions from the sour gas flare during liquefaction;
- LNG vaporiser package during re-gasification;
- Minor emissions from the process flare during liquefaction (pilot fuel gas);
- Emissions from the process flare during start-up / shut-down and emergencies;

The combustion of gas in the hot oil heater and LNG vaporiser will release emissions of NO_x, CO, organic compounds and small amounts of SO_2 and particulates. The combustion of waste gases (i.e. H_2S) in the sour gas flare will also result in emissions of SO_2. The proposed compressors for liquefaction are all electric motor driven.

The vapouriser unit would not be operational when the plant is in liquefaction mode and therefore these operations are modelled separately. The operation of the Sour Gas Flare is conservatively assumed to occur during both processes (liquefaction and re-gasification), although it is expected that these emissions may not occur during re-gasification.

For the Sour Gas Flare, the major pollutant of concern is SO_2 with virtually 100% conversion of H_2S to SO_2 assumed. There would be expected low concentration of H_2S (< 0.0002 g/s) and some unburnt VOC and methane (CH_4). There would be negligible emissions from the process flare during liquefaction (only pilot fuel gas and nitrogen (N_2) purge gas) with greater than 99% destruction of hydrocarbons expected. An assessment of the odour impact from the H_2S emissions from the sour gas flare has also been undertaken.

Fugitive emissions from leakages, vents etc are expected to be minor (approximately 3 kg/hr) and are not considered in this assessment as there would be negligible associated air quality impact.

Greenhouse gas emissions of carbon dioxide (CO_2) and nitrous oxide (N_2O) are also formed during combustion of fuels and these are also considered in **Section 9**.

7.2 Assessment Approach

The assessment follows a conventional approach commonly used for air quality assessment in Australia and in accordance with the NSW DECCW Approved Methods.

An estimate of the existing background air quality has been made, based on monitoring data from Beresfield and TAC monitoring stations and are assumed to include existing sources within the airshed. Dispersion modelling is performed for all new emissions sources from the proposed Project. The results obtained for each new source are added to the existing background concentrations and compared to the appropriate impact assessment criteria. The cumulative impacts are discussed in **Section 8.3**.

7.3 Pollutant Dispersion Modelling

CALPUFF is a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal (**Scire *et al.*, 2000**). The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer-range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff and takes into account the complex arrangement of emissions from point, area, volume, and line sources. CALPUFF is endorsed by the US EPA and the NSW DECCW and has been extensively used in Australia.

A CALPUFF computation grid equivalent to the inner CALMET meteorological grid (refer **Section 6**) was centred over the gas plant site.

7.4 Modelling Scenarios

To assess the potential impact from the proposed Project, the following modelling scenarios have been considered.

- **Scenario 1 – Liquefaction**: Liquefaction plant with sour gas flare emissions and minor emissions from process flare pilot;
- **Scenario 2** – **Re-gasification**: Re-gasification in the LNG vaporiser with sour gas flare emissions and minor emissions from process flare pilot; and
- **Scenario 3 – Plant Start-up / Shut-down / Emergency:** During planned maintenance, the system is shut-down and be depressurised to flare, with flaring of approximately 5,000 kg/hr of natural gas. Plant start-up and shut-downs are anticipated to occur for a maximum of 48 hours. Emergency operation of the flare is anticipated to be very infrequent (once a year) and only for a 15 min duration. This short-term and infrequent emergency scenario is therefore not considered.

Emissions data for each of the emission sources were provided by AGL and are summarised in **Table 7.1**.

Table 7.1: Emission Rates for Modelling

Source	Flow Stream	Emission Concentration (mg/Nm^3)	Emission rate (g/s)
Liquefaction (Hot Oil Heater)	2,500 Nm^3/h (flue gas) 320 °C	NOx - <250 CO - <100 PM - <5 SO$_2$ - TBC VOC - <5	NO$_x$ - <0.17 CO - <0.07 PM - <0.003 SO$_2$ < 0.04 VOC - <0.003
LNG Vapouriser	19,925 Nm^3/hr (flue gas) 40 °C	NOx - <170 CO - <125 PM - <40 SO$_2$ - TBC VOC - <20	NO$_x$ - <1.03 CO - <0.76 PM - <0.24 SO$_2$ < 0.02 VOC - <0.12
Sour Gas Flare Tip	1,216 kg/hr (sour gas flow) 114 kg/hr (assist gas flow)	N/A	Unburnt H$_2$S < 0.0002 VOC <0.22 CH4 <0.12 burnt SO$_2$ <0.11
Process Flare Tip - Normal	50 Nm3/hr continuous flow to flare for pilot	N/A	Minor
Process Flare Tip – Start-up /Shut-down	Flow to Flare 5,000 kg/hr	N/A	Unburnt VOC 5.46 kg/hr CH$_4$ 43.7 kg/hr
Process Flare Tip – Emergency	Flow to Flare 51,600 kg/hr	N/A	Unburnt VOC 411 kg/hr CH$_4$ 49.7 kg/hr

Note: [1] Scenario not considered in assessment

Emissions data for operation of the flare during liquefaction and start-up / shut-down have not been provided by AGL, other than for unburnt emissions of VOC/methane. Emission rates have therefore been derived based on Chapter 13.5 (Industrial Flares) of the US EPA AP-42 emission factors (**US EPA, 1995**) and based on the gas flow to flare.

The emission rates derived for flares are presented in **Table 7.2**.

Table 7.2: US EPA derived emission rates for flares (g/s)

Scenario	NOx	CO	VOC
Process Flare Tip - Normal	0.002	0.009	0.003
Process Flare Tip – Startup Shut-down	2.6	14.2	5.4

The modelled stack parameters for liquefaction and re-gasification are presented in **Table 7.3**.

Table 7.3: Stack Parameters – Liquefaction

Parameter	Hot Oil Heater Liquefaction	Vaporiser Package	Pilot Flare [1]	Sour Gas Flare
Approximate Location - Easting, Northing (MGA)	381151, 6368752	381137, 6368790 381162, 6368787	381210, 6368871	381210, 6368871
Base Elevation (m AHD)	17	16 - 17	17	17
Height (m)	15	10	31.2	32.7
Internal Diameter (m)	1	1	1.9	0.719
Exit Velocity (m/s)	10	10	2.0	10.6
Temperature (K)	320	40	1273	1273

Note: 1 The effective release height, effective release diameter and effective release velocity for the flare has been calculated from the actual height (30 m) and diameter (200 mm) and based on the gas flow rate, lower heating value and heat released (MJ/s) during combustion.

Modelling flare emissions differs from conventional plumes in that the buoyancy flux is affected by the radiative heat loss during plume rise. The flare emission source has been modelled separately in CALPUFF, replacing Briggs plume rise with numerical plume rise to allow for radiative heat loss, vertical wind shear and ambient temperature stratification, with the "no stack tip downwash" option chosen (**Robe, 2009**).

During planned maintenance and upset / emergency, it is assumed that the entire system is shut-down and flaring occurs at the maximum rate. The total gas flow rate to flare during upset conditions is assumed to be 5,000 kg/hr. The derived parameters for emergency flaring are shown in **Table 7.4**. The effective release height, effective release diameter and effective release velocity for the flare has been calculated from the gas flow rate, lower heating value and heat released (MJ/s) during combustion.

Table 7.4: Stack Parameters for Start-up / Shut-Down Flaring

Parameter	Flare
Location - Easting, Northing (MGA)	381210, 6368871
Base Elevation (m AHD)	17
Effective Release Height (m)	43.2
Effective Flame Diameter (m)	1.9
Effective Exit Velocity (m/s)	41.2
Temperature (^{o}C)	1273

7.5 Building Wake Effects

Building wake effects were included in the modelling simulations for the stack sources servicing the fired heaters. Building wake effects were incorporated into the CALPUFF modelling using the PRIME downwash algorithm.

8 EMISSIONS ASSESSMENT

8.1 In Stack Concentration Limits

A comparison between the in-stack concentrations provided by AGL for the gas plant and the standards of concentration set out in the Protection of the Environment Operations (Clean Air) Regulation, 2010 indicates that Project will comply with the relevant limits (**Table 8.1**).

Table 8.1: Comparison to Emission Standards

Pollutant	Applicability	Limit	Applicable Stack	Estimated Emission Concentration
NO_x	Any activity or plant, Any boiler operating on gas	350 mg/m^3	Fired Heaters – Amine Unit	< 250 mg/Nm^3
			Fired Heaters – Vaporiser	< 170 mg/Nm^3
Solid Particles	Any process emitting solid particles	50 mg/m^3	Fired Heaters – Amine Unit	< 5 mg/Nm^3
			Fired Heaters – Vaporiser	< 40 mg/Nm^3
VOC	Any activity or plant involving combustion	40 mg/m^3 or 125 mg/m^3 CO	Fired Heaters – Amine Unit	< 5 mg/Nm^3 VOC <100 mg/Nm^3 CO
			Fired Heaters – Vaporiser	<20 mg/Nm^3 VOC <125 mg/Nm^3 CO
Smoke	Any flare	No visible emissions other than for a total period of no more than 5 minutes in any 2 hours	Flare	Flare will be smoke free

8.2 Assessment of Impacts

8.2.1 Scenario 1: Liquefaction

Modelling results are presented for liquefaction, including emissions from the liquefaction plant (hot oil heater), the sour gas flare and process flare. Re-gasification does not occur during liquefaction and as such these process emissions are modelled separately. Liquefaction is expected to mainly take place from September to May (approximately 70% online).

Emissions of NO_2 occur from all sources and contour plots of the predicted 1-hour and annual average NO_2 are presented in **Figure 8.1** and **Figure 8.2**. The contour plots presented conservatively show NO_2 as 100% NO_x, when in reality, the percentage of NO_2 in total oxides of nitrogen would be 10% to 20%. The contour plots show that liquefaction would not compromise the air quality criteria for NO_2.

The primary source of SO_2 is from the Sour Gas Flare with minor emissions also from the hot oil heater combustion flue gas. Contour plots 1-hour, 24-hour and annual SO_2 concentrations from liquefaction are presented in **Figure 8.3** to **Figure 8.5**. The contour plots show that air quality goals are not compromised.

There would be expected low concentration of H_2S emissions from the Sour Gas Flare and the contour plots for predicted H_2S from the operation of the project are presented in **Figure 8.6**. Results are presented as 100th percentile nose response averages (based on a peak to mean ratio of 6 for far field impacts from a tall wake-free stack)[c].

Emissions of PM_{10} from the project are expected to be minor, based on the clean burning nature of natural gas. Contour plots for 24-hour and annual PM_{10} concentrations from liquefaction are presented in **Figure 8.7** and **Figure 8.8**. The contour plots show that the contribution of the Project to PM_{10} levels is negligible.

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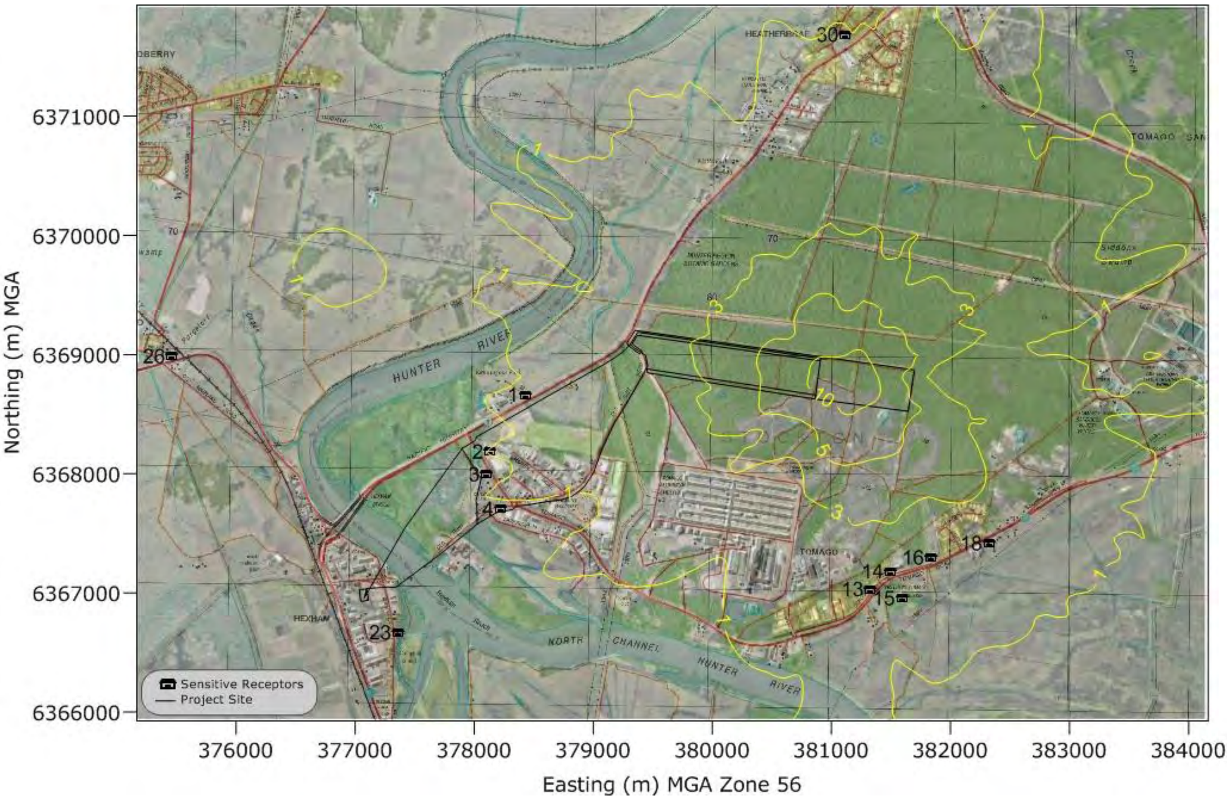
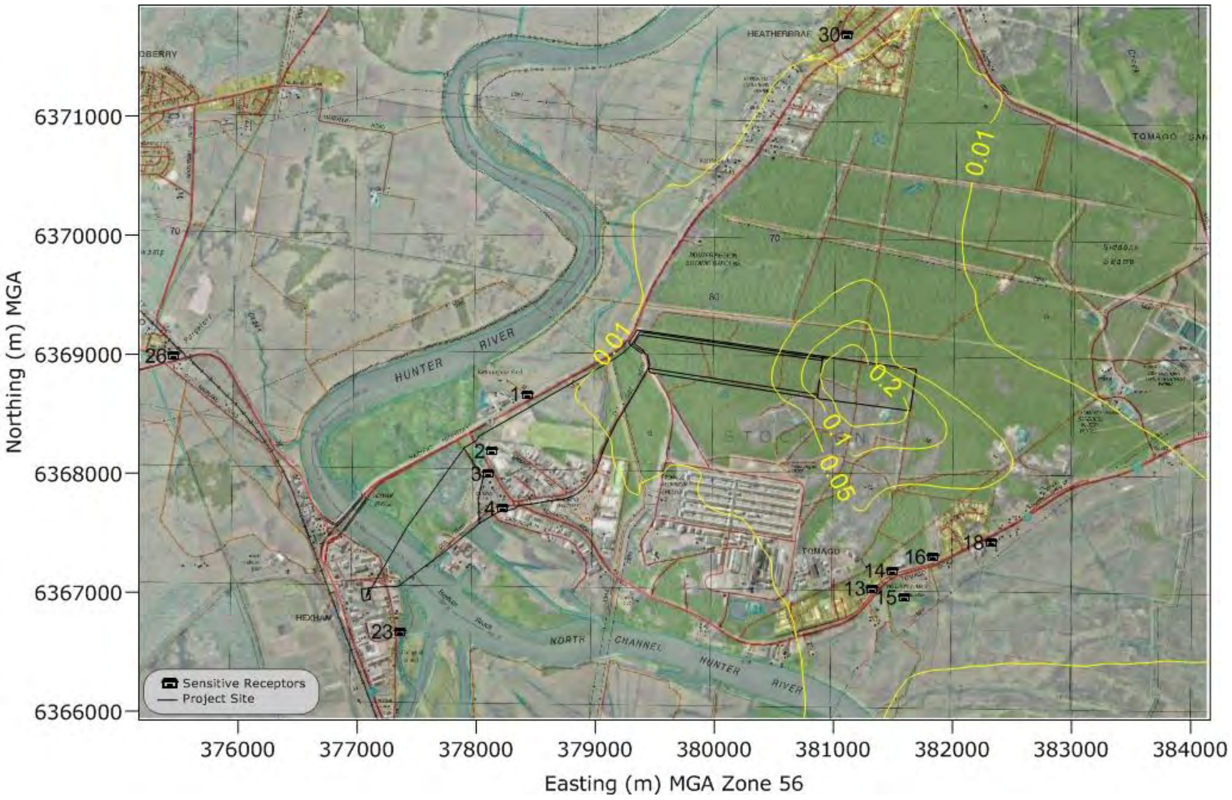
[c] It is a common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because Gaussian dispersion models are only able to directly predict concentrations over an averaging period of 3-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a 3-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source. To determine more rigorously the ratio between the one-second peak concentrations and three-minute and longer period average concentrations (referred to as the peak-to-mean ratio) that might be predicted by a Gaussian dispersion model, the DECCW commissioned a study by **Katestone Scientific Pty Ltd (1995, 1998)**. This study recommended peak-to-mean ratios for a range of circumstances. The ratio is also dependent on atmospheric stability and the distance from the source. The DECCW Approved Methods take account of this peaking factor and the goals are based on nose-response time.



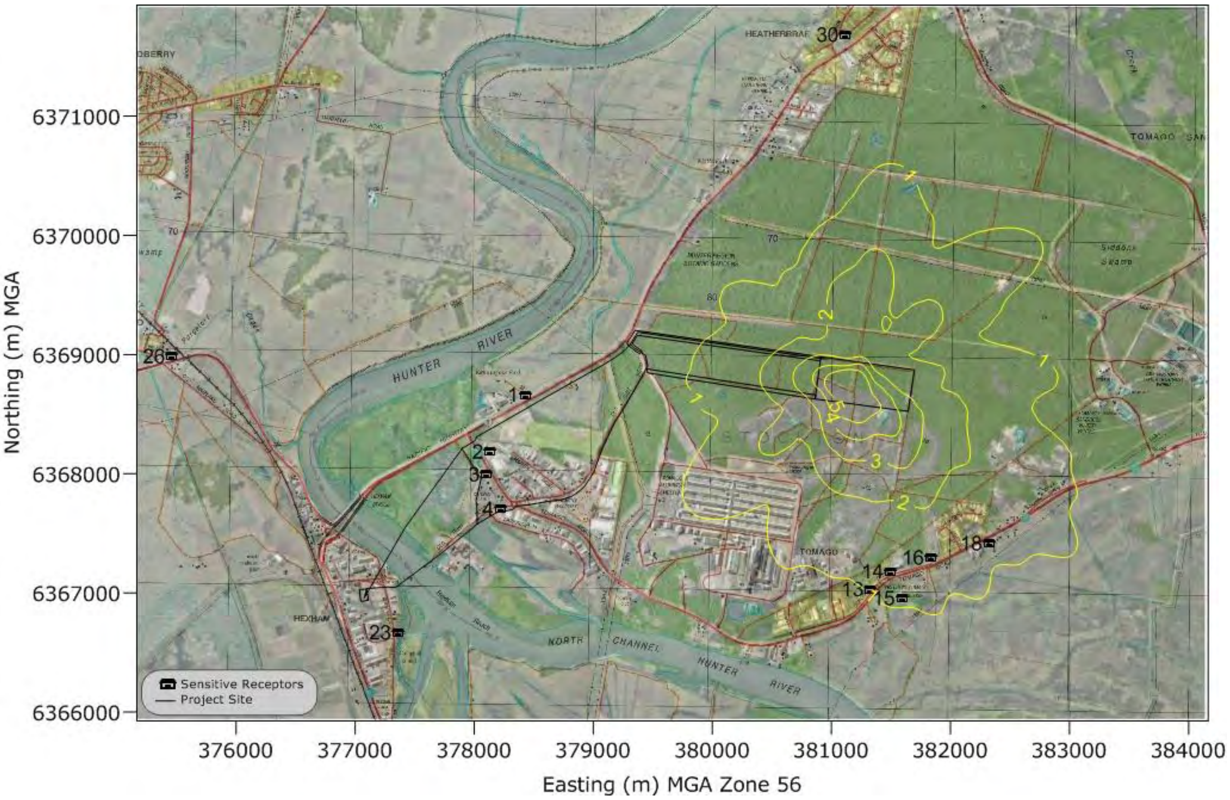
Species:	Location:	Scenario 1:	Percentile:	Averaging Time:
NO_2	NGSF	Liquefaction	Maximum	1-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.262	µg/m^3	246 µg/m^3	2008	R Kellaghan

Figure 8.1: Predicted Maximum 1-hour NO_2 Concentration for **Liquefaction**



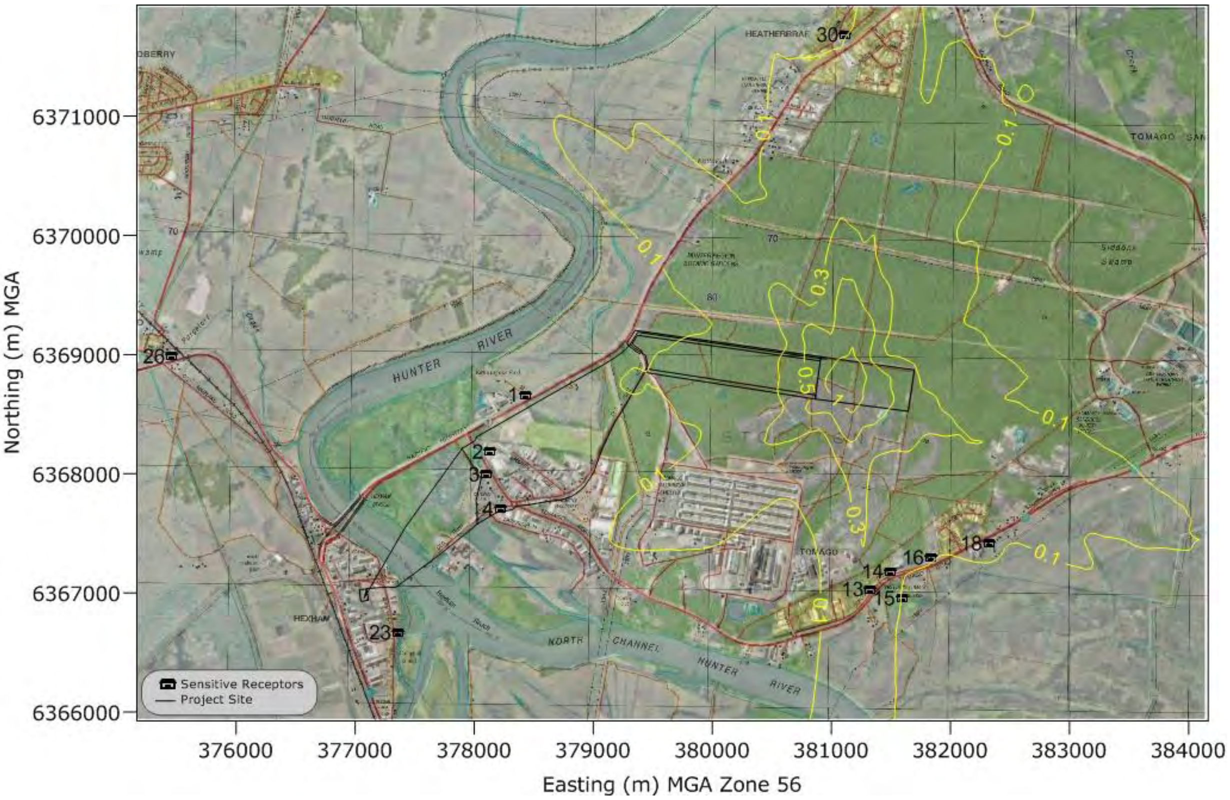
Species: NO_2	**Location:** NGSF	**Scenario 1:** Liquefaction	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 62 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.2: Predicted Annual Average NO_2 Concentration for Liquefaction



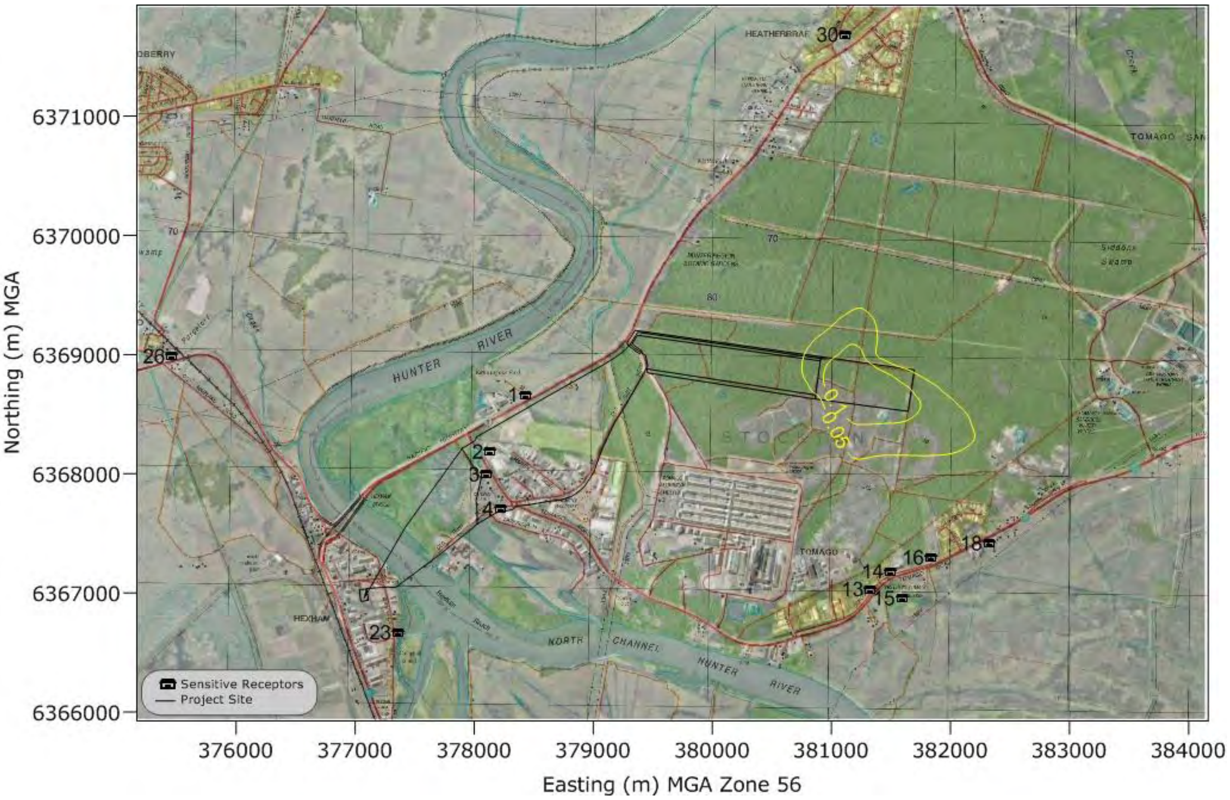
Species: SO_2	**Location:** NGSF	**Scenario 1:** Liquefaction	**Percentile:** Maximum	**Averaging Time:** 1-hour
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 570 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.3: Predicted Maximum 1-hour SO_2 Concentration for **Liquefaction**



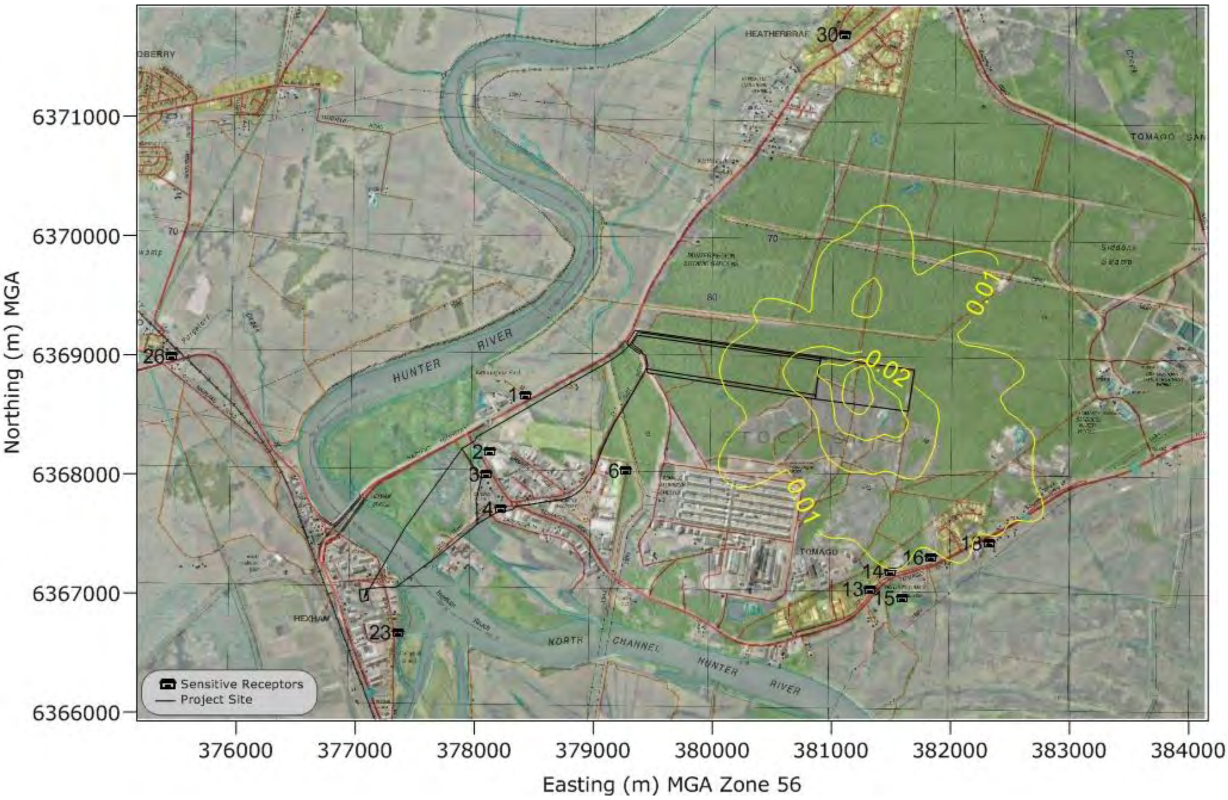
Species: SO$_2$	**Location:** NGSF	**Scenario 1:** Liquefaction	**Percentile:** Maximum	**Averaging Time:** 24-hour
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 228 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.4: Predicted Maximum 24-hour SO$_2$ Concentration for Liquefaction



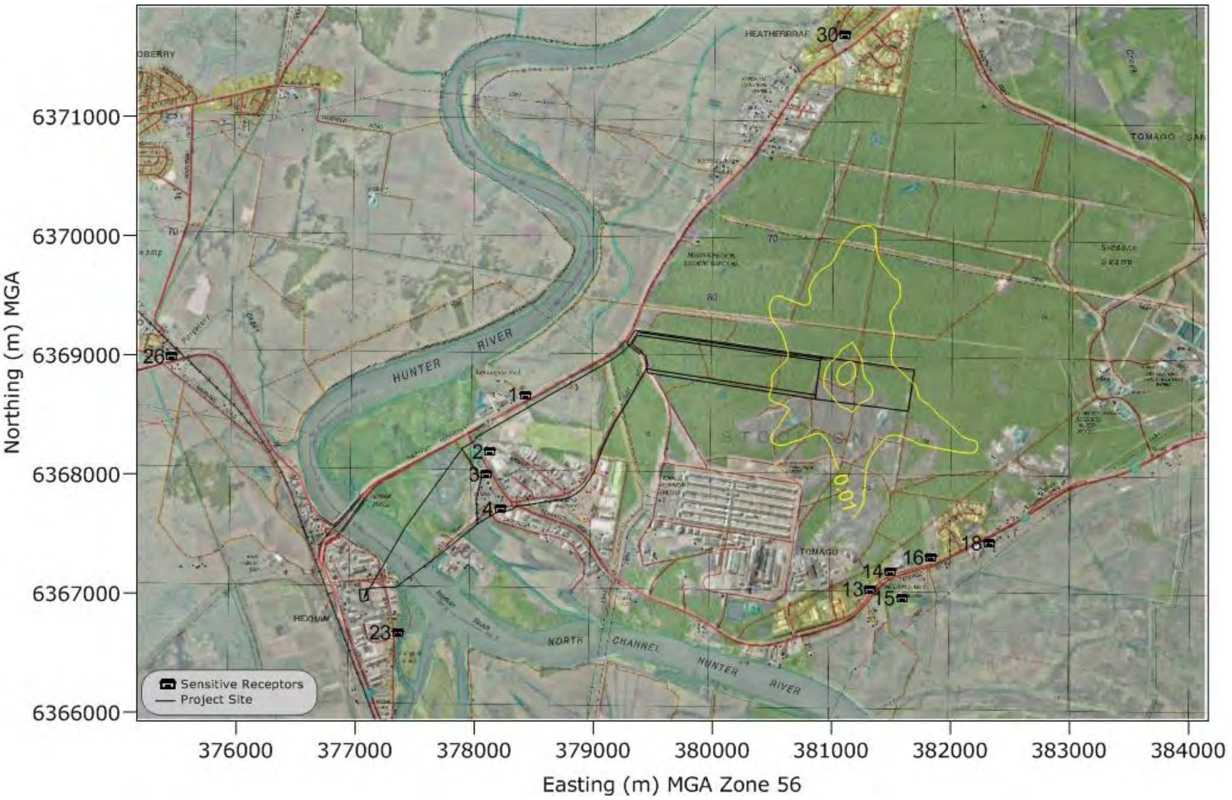
Species: SO_2	**Location:** NGSF	**Scenario 1:** Liquefaction	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 60 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.5: Predicted Annual Average SO_2 Concentration for Liquefaction



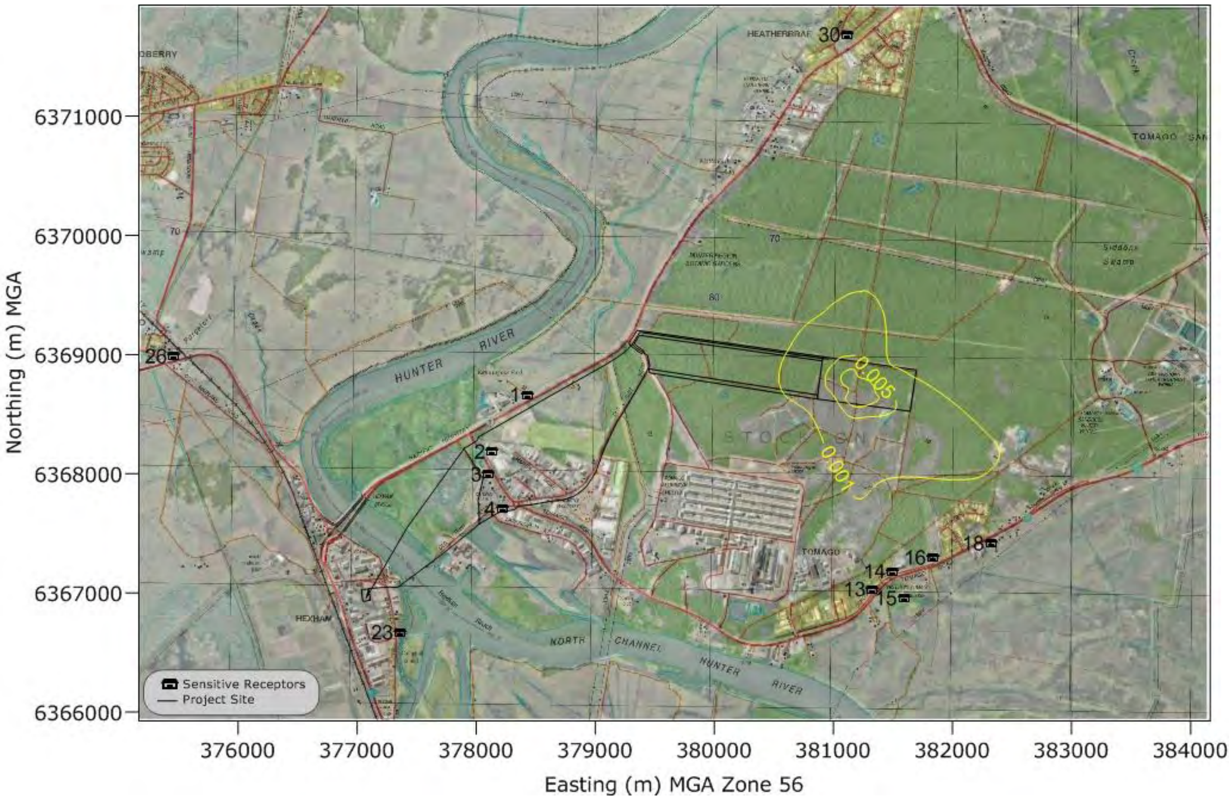
Species: H_2S	**Location:** NGSF	**Scenario 1:** Liquefaction	**Percentile:** 100th	**Averaging Time:** Nose Response (1 sec)
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 1.38 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.6: Predicted H_2S Concentration (100th Percentile – nose response)



Species:	**Location:**	**Scenario 1:**	**Percentile:**	**Averaging Time:**
PM$_{10}$	NGSF	Liquefaction	Maximum	24-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.262	µg/m^3	50 µg/m^3	2008	R Kellaghan

Figure 8.7: Predicted Maximum 24-hour PM$_{10}$ Concentration for Liquefaction



Species: PM_{10}	**Location:** NGSF	**Scenario 1:** Liquefaction	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF v6.262	**Units:** $\mu g/m^3$	**Guideline:** 30 $\mu g/m^3$	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.8: Predicted Annual Average PM_{10} Concentration for **Liquefaction**

The predicted results for each pollutant at each discrete receptor location are shown in **Table 8.2**. All results are well below the relevant air quality criteria at all receptors locations.

Results are also presented for volatile organic compounds (VOCs). There are no impact assessment criteria specified for total VOCs, however even when results for total VOCs are compared to the 1-hour impact assessment criteria for individual organic pollutants such as formaldehyde (20 µg/m^3) or benzene (29 µg/m^3) the predicted concentrations easily comply.

Table 8.2: Dispersion Modelling Results for Liquefaction

Discrete Receptor ID	NO_x (µg/m^3) 1-hour	NO_x (µg/m^3) Annual	PM_{10} (µg/m^3) 24-hour	PM_{10} (µg/m^3) Annual	SO_2 (µg/m^3) 1-hour	SO_2 (µg/m^3) 24-hour	SO_2 (µg/m^3) Annual	VOCs (µg/m^3) 1-hour
	Assessment Criteria							
	246	*62*	*50*	*30*	*570*	*228*	*60*	*N/A*
1	1.25	0.01	0.003	0.00014	0.59	0.07	0.004	0.03
2	1.02	0.01	0.002	0.00010	0.47	0.05	0.003	0.02
3	0.89	0.01	0.002	0.00009	0.47	0.05	0.003	0.02
4	0.88	0.01	0.002	0.00010	0.50	0.06	0.003	0.02
13	1.90	0.03	0.006	0.00044	1.05	0.25	0.015	0.04
14	2.23	0.02	0.004	0.00040	1.27	0.13	0.014	0.05
15	1.79	0.02	0.003	0.00031	1.07	0.09	0.011	0.05
16	2.16	0.02	0.003	0.00039	1.24	0.10	0.014	0.05
18	1.97	0.03	0.003	0.00046	1.17	0.11	0.017	0.05
23	0.58	0.00	0.001	0.00006	0.31	0.04	0.002	0.01
26	0.50	0.00	0.001	0.00005	0.38	0.04	0.002	0.02
30	0.99	0.01	0.003	0.00016	0.49	0.10	0.005	0.02

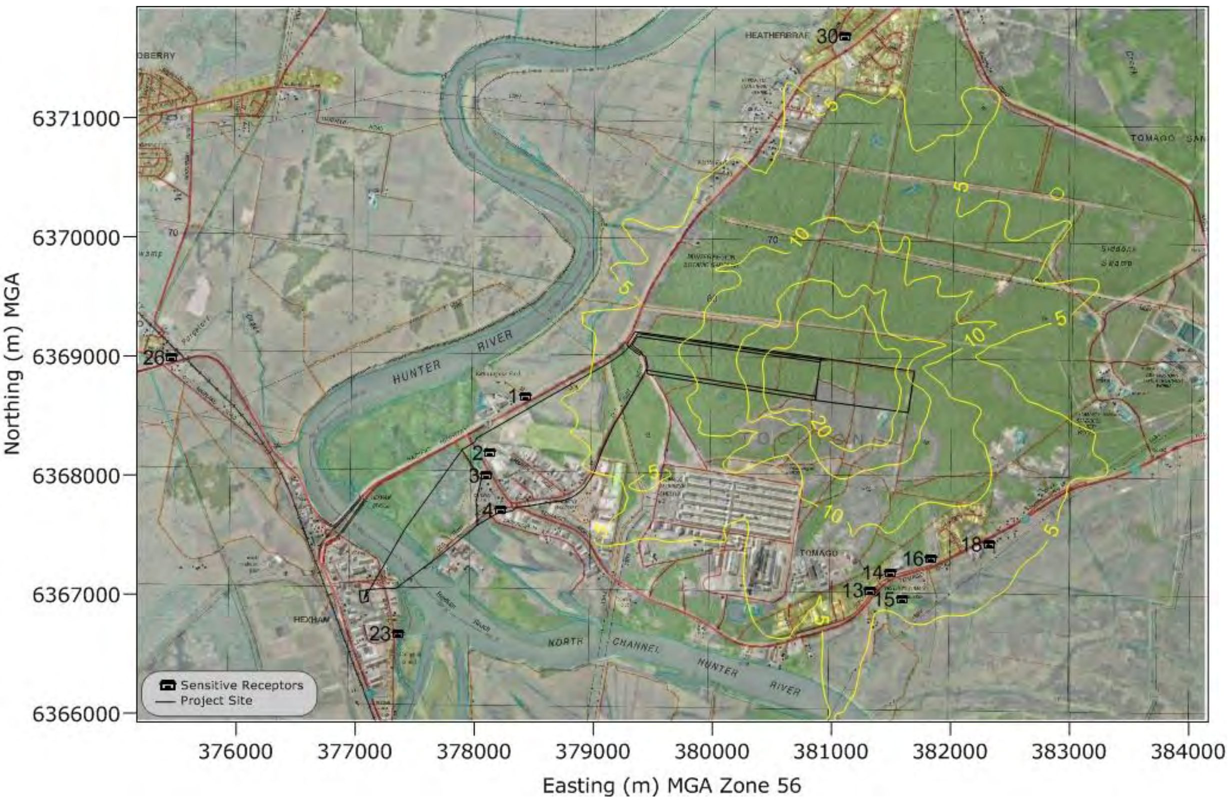
8.2.2 Scenario 2: Re-gasification

Modelling results are presented for the re-gasification process, including emissions from the vapouriser unit, the sour gas flare and process flare. Re-gasification is expected to take place as required to meet peak or emergency gas demand, primarily from June to August of each year.

Emissions of nitrogen dioxide (NO_2) occur from all sources and contour plots of the predicted 1-hour and annual average NO_2 are presented in **Figure 8.9** and **Figure 8.10**. The contour plots presented conservatively show NO_2 as 100% NO_x, when in reality, the percentage of NO_2 in total oxides of nitrogen would be 10% to 20%. The contour plots show that Re-gasification Operations of the Project would not compromise the air quality criteria for NO_2.

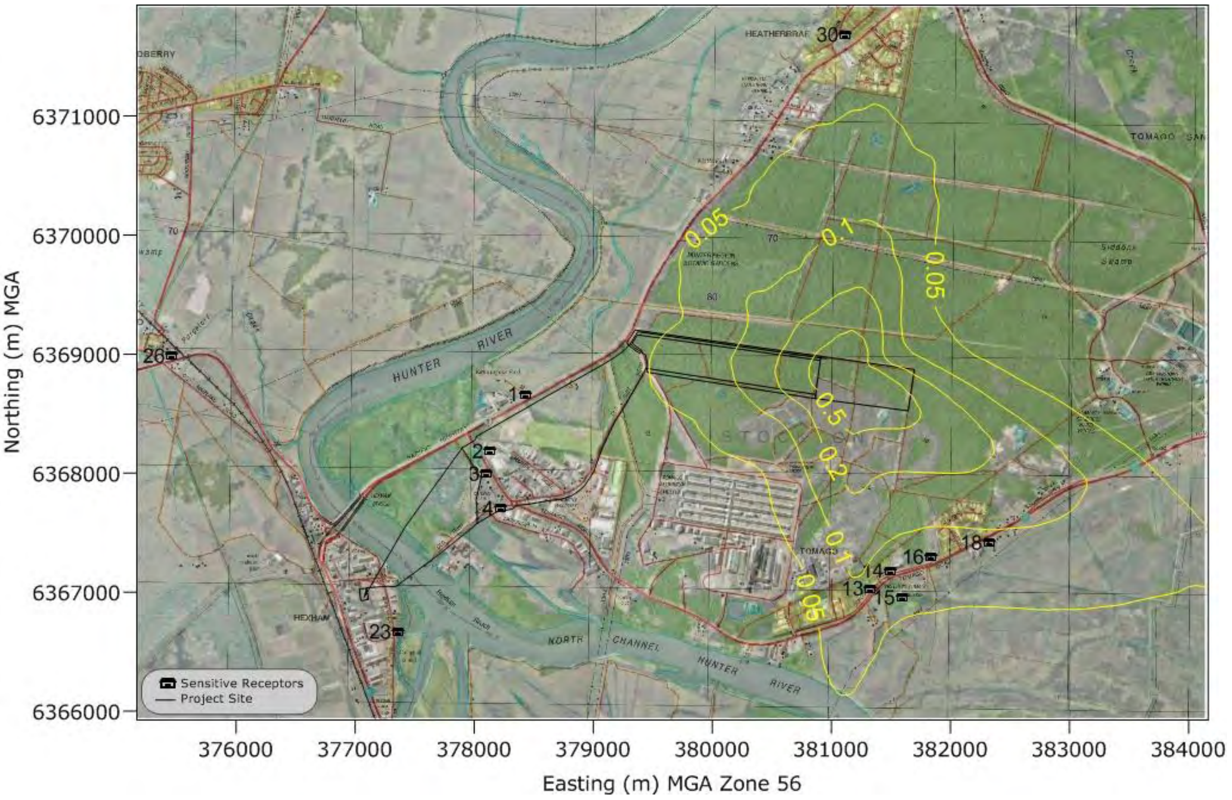
The primary source of SO_2 is from the Sour Gas Flare with minor emissions also from the vapouriser unit. Contour plots 1-hour, 24-hour and annual SO_2 concentrations from Re-gasification Operations are presented in **Figure 8.11** to **Figure 8.13**. The contour plots show that air quality goals are not compromised.

Emissions of PM_{10} from the project are expected to be minor, based on the clean burning nature of natural gas. Contour plots for 24-hour and annual PM_{10} concentrations from Re-gasification operations are presented in **Figure 8.14** and **Figure 8.15**. The contour plots show that the contribution of the Project to PM_{10} levels is negligible.



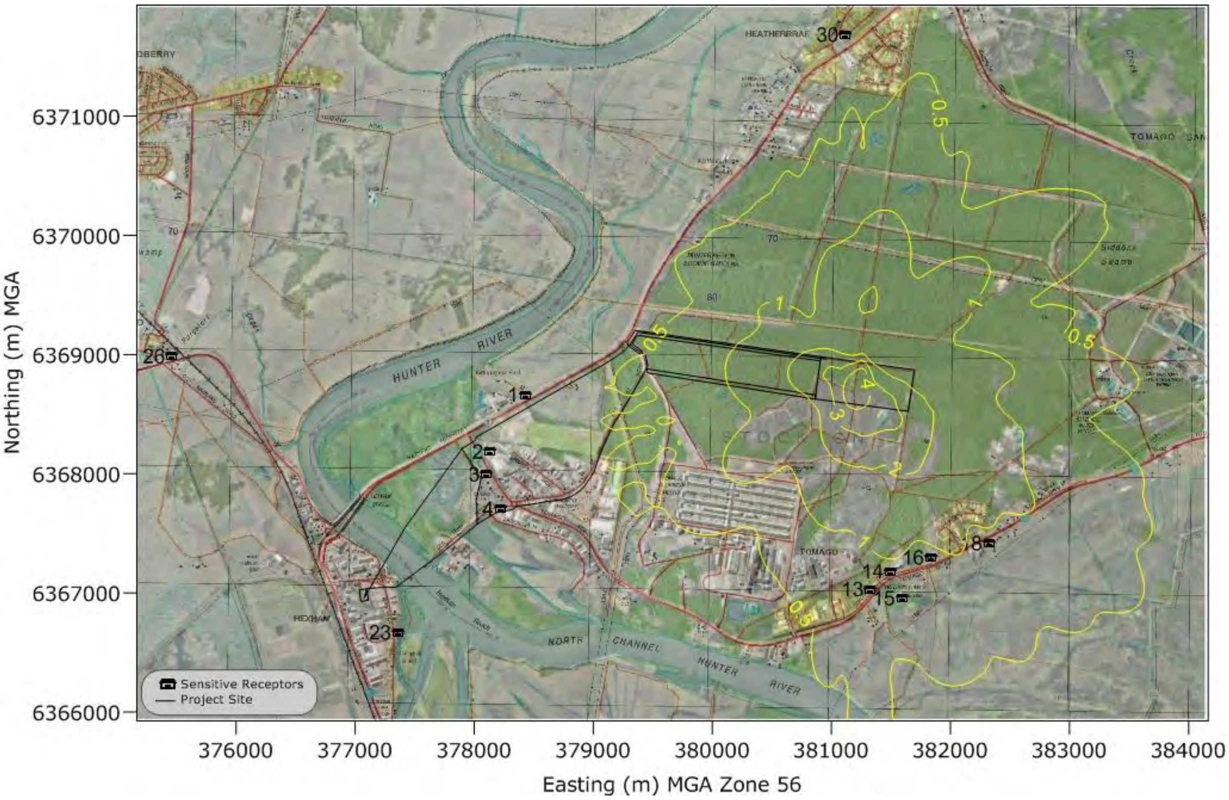
Species: NO_2	**Location:** NGSF	**Scenario 2:** Re-gasification	**Percentile:** Maximum	**Averaging Time:** 1-Hour
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 246 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.9: Predicted Maximum 1-hour NO_2 Concentration for Re-gasification



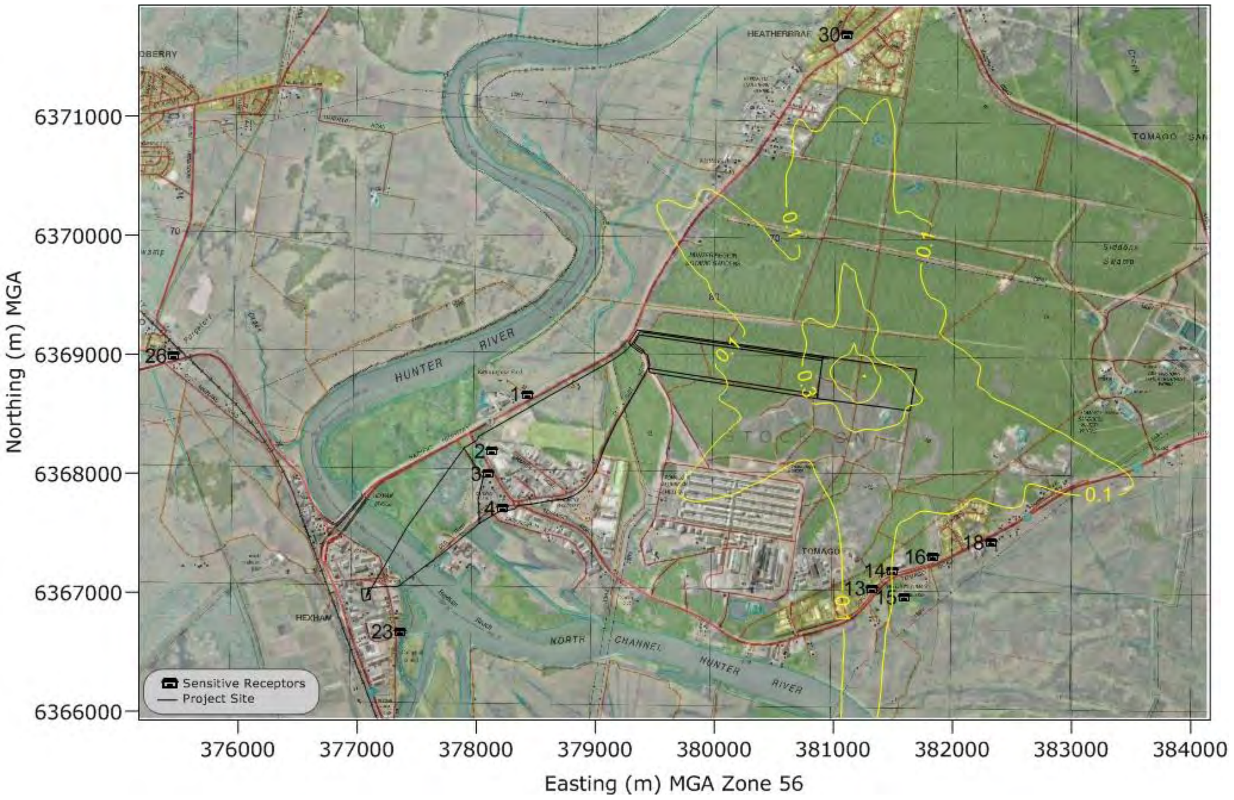
Species: NO$_2$	**Location:** NGSF	**Scenario 2:** Re-gasification	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 62 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.10: Predicted Annual Average NO$_2$ Concentration for Re-gasification



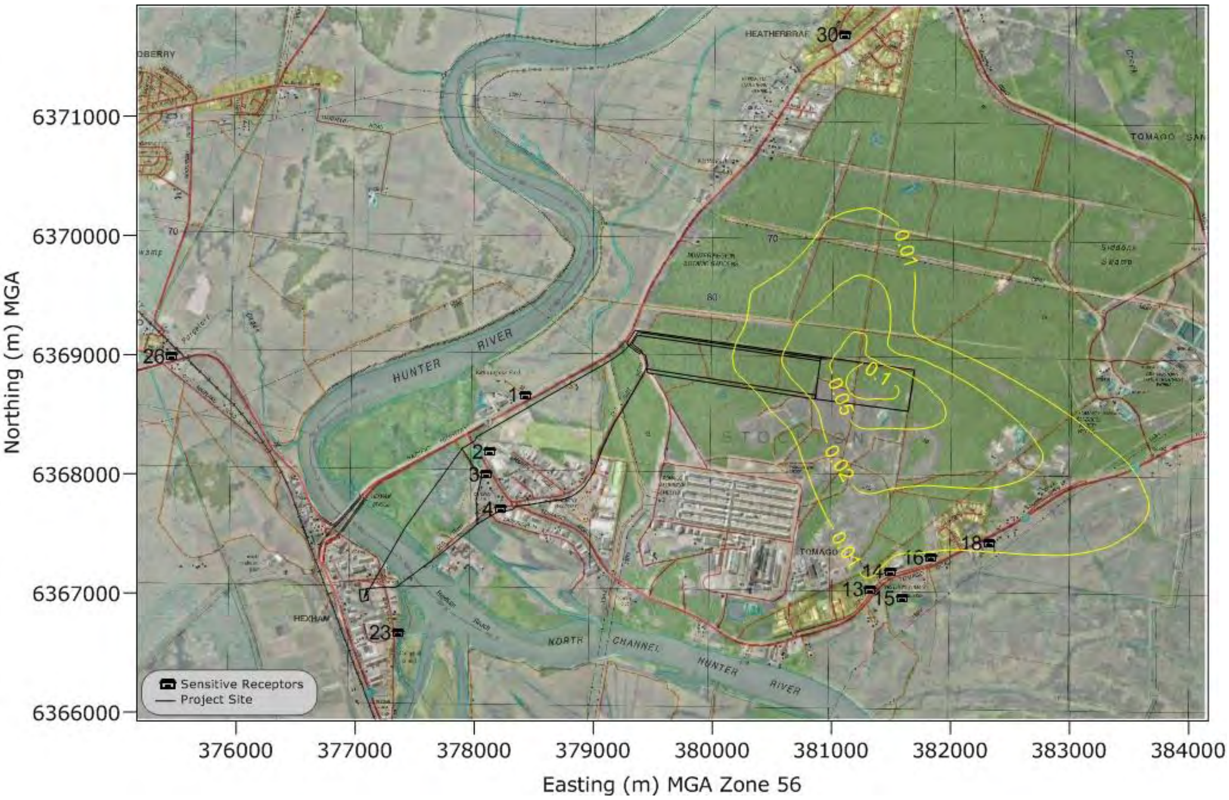
Species: SO_2	**Location:** NGSF	**Scenario 2:** Re-gasification	**Percentile:** Maximum	**Averaging Time:** 1-hour
Model Used: CALPUFF v6.262	**Units:** $\mu g/m^3$	**Guideline:** 570 $\mu g/m^3$	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.11: Predicted Maximum 1-hour SO_2 Concentration for Re-gasification



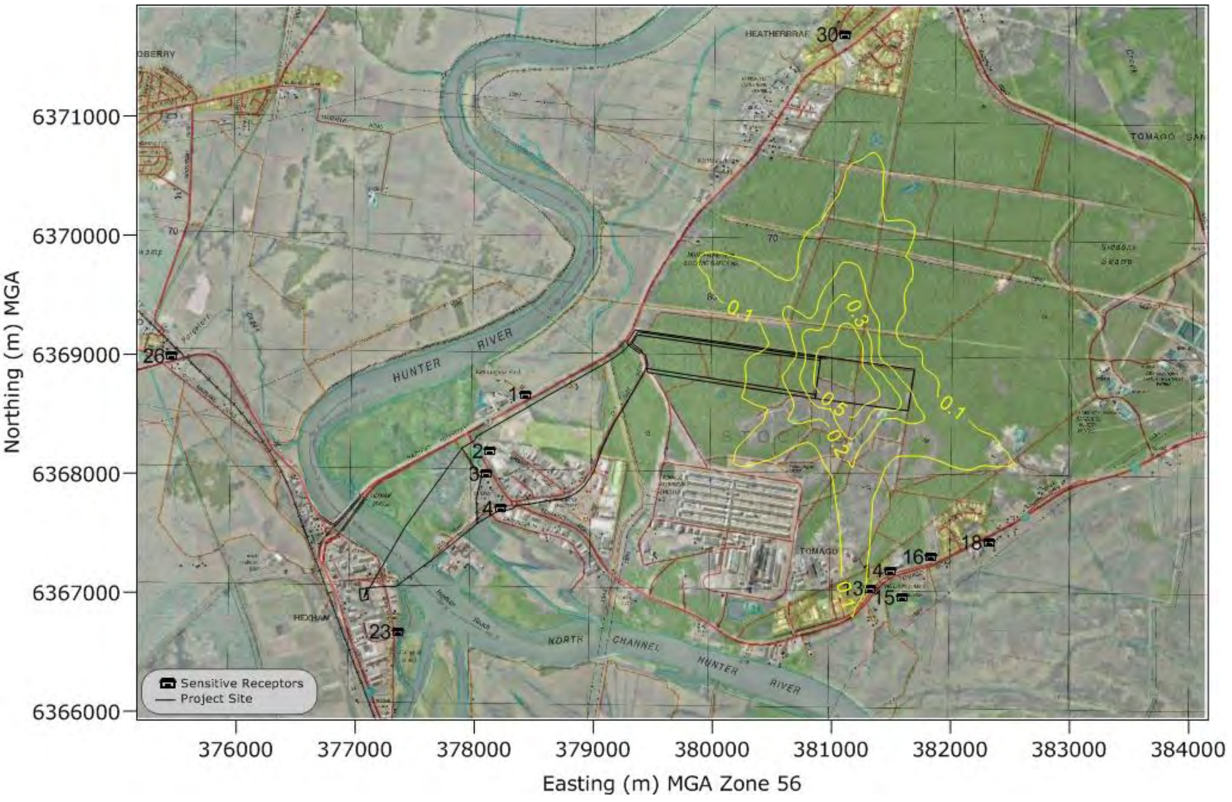
Species:	**Location:**	**Scenario 2:**	**Percentile:**	**Averaging Time:**
SO_2	NGSF	Re-gasification	Maximum	24-hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.262	µg/m^3	228 µg/m^3	2008	R Kellaghan

Figure 8.12: Predicted Maximum 24-hour SO_2 Concentration for Re-gasification



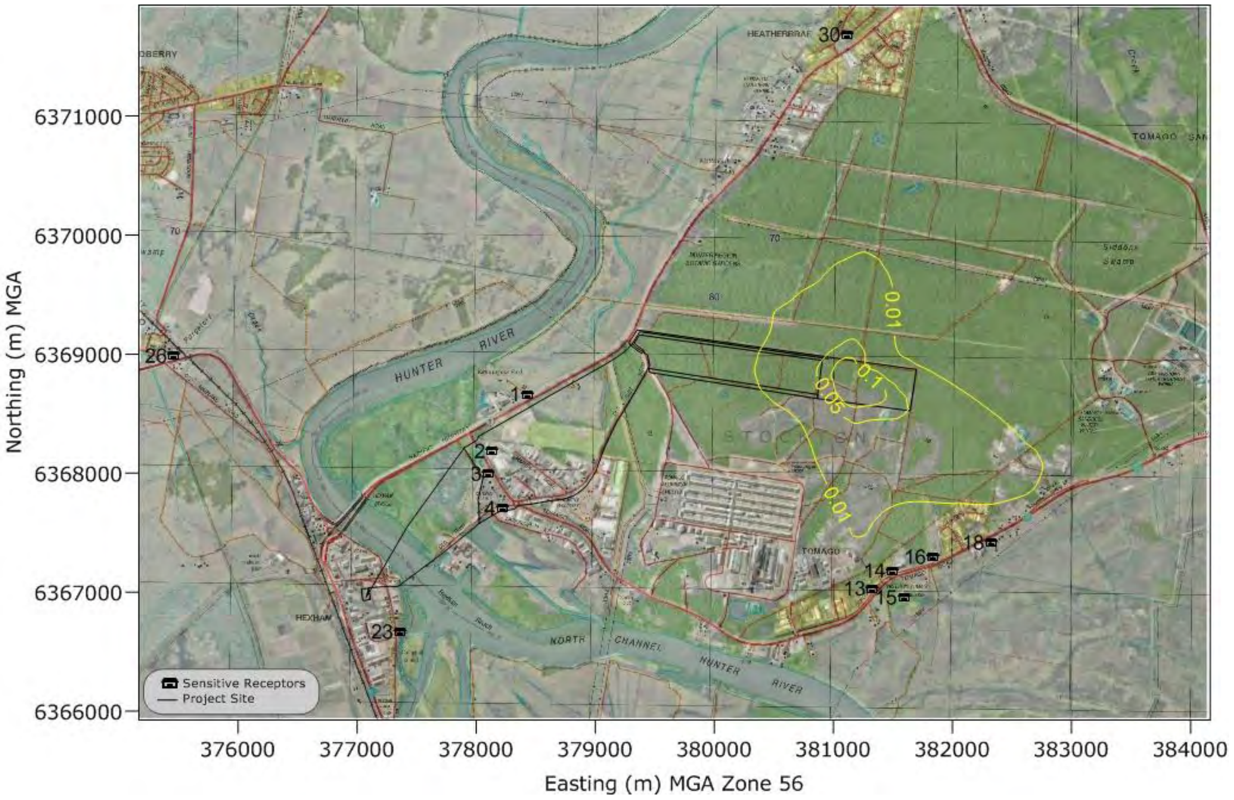
Species:	**Location:**	**Scenario 2:**	**Percentile:**	**Averaging Time:**
SO_2	NGSF	Re-gasification	N/A	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.262	µg/m^3	60 µg/m^3	2008	R Kellaghan

Figure 8.13: Predicted Annual Average SO_2 Concentration for Re-gasification



Species: PM_{10}	**Location:** NGSF	**Scenario 2:** Re-gasification	**Percentile:** Maximum	**Averaging Time:** 24-Hour
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 50 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.14: Predicted Maximum 24-hour PM_{10} Concentration for Re-gasification



Species: PM$_{10}$	**Location:** NGSF	**Scenario 2:** Re-gasification	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 30 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.15: Predicted Annual Average PM$_{10}$ Concentration for Re-gasification

The predicted results for each pollutant during re-gasification at each discrete receptor location are shown in **Table 8.3**. All results are well below the relevant air quality criteria at all receptors locations.

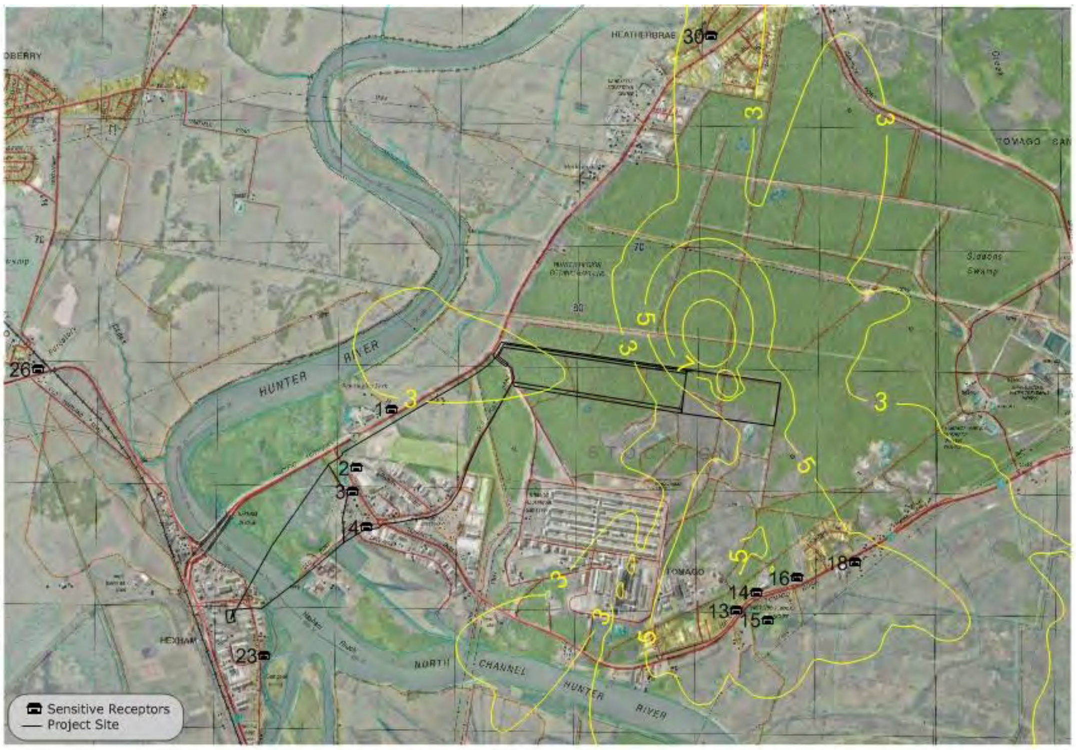
Table 8.3: Dispersion Modelling Results for Re-gasification

Discrete Receptor ID	NO_x ($\mu g/m^3$) 1-hour	NO_x ($\mu g/m^3$) Annual	PM_{10} ($\mu g/m^3$) 24-hour	PM_{10} ($\mu g/m^3$) Annual	SO_2 ($\mu g/m^3$) 1-hour	SO_2 ($\mu g/m^3$) 24-hour	SO_2 ($\mu g/m^3$) Annual	VOCs ($\mu g/m^3$) 1-hour
	Assessment Criteria							
	246	*62*	*50*	*30*	*570*	*225*	*60*	*N/A*
1	4.25	0.03	0.04	0.002	0.40	0.04	0.003	0.24
2	3.60	0.02	0.02	0.001	0.32	0.03	0.002	0.20
3	3.17	0.02	0.03	0.001	0.27	0.03	0.002	0.18
4	3.00	0.02	0.03	0.001	0.35	0.03	0.002	0.17
13	6.35	0.08	0.08	0.006	0.76	0.18	0.009	0.35
14	7.61	0.08	0.06	0.006	0.93	0.09	0.009	0.43
15	6.21	0.06	0.05	0.005	0.79	0.07	0.007	0.34
16	7.32	0.08	0.04	0.006	0.86	0.07	0.009	0.42
18	6.61	0.09	0.05	0.007	0.88	0.07	0.011	0.37
23	2.13	0.01	0.01	0.001	0.22	0.02	0.001	0.12
26	1.81	0.01	0.01	0.001	0.28	0.03	0.001	0.11
30	3.56	0.03	0.05	0.002	0.35	0.06	0.003	0.20

8.2.3 Scenario 3: Start-up / Shut-down

Modelling results are presented for the start-up / shut-down process when the system is shut-down and be depressurised to flare. Emissions of NO_x and VOCs from the flare are presented for short term average periods only. Other emissions, such as $SO_{2,}$ are not significant from the flaring of natural gas.

Contour plots of the predicted 1-hour NO_2 from the start-up and shut-down are presented in **Figure 8.16**. The contour plots presented show NO_2 as 100% NO_x and show that start-up / shut-down operations would not compromise the air quality criteria.



Species: NO_2	**Location:** NGSF	**Scenario 3:** Start-up / Shut-down	**Percentile:** Maximum	**Averaging Time:** 1-Hour
Model Used: CALPUFF v6.262	**Units:** µg/m^3	**Guideline:** 246 µg/m^3	**Met Data:** 2008	**Plot:** R Kellaghan

Figure 8.16: Predicted Maximum 1-Hour NO_2 Start-up / Shut-down

Table 8.4 presents a summary of the predicted concentrations for NO_2 and VOCs at each of the nearby sensitive receptors, due to the start-up / shut-down. NO_2 and VOCs are the most significant emissions from start-up / shut-down operation of the flare.

There are no impact assessment criteria specified for total VOCs, however even when results for total VOCs are compared to the 1-hour impact assessment criteria for individual organic pollutants such as formaldehyde (20 µg/m^3) or benzene (29 µg/m^3) the predicted concentrations easily comply.

Table 8.4: Dispersion Modelling Results for Emergency Operations

Discrete Receptor ID	NO_2 (µg/m^3) 1-hour	VOCs (µg/m^3) 1-hour
	Assessment Criteria	
	246	
1	2.6	5.4
2	1.6	3.4
3	1.9	3.9
4	2.2	4.4
13	5.1	10.5
14	5.5	11.3
15	5.8	11.9
16	6.1	12.5
18	5.2	10.7
23	1.0	2.1
26	0.7	1.5
30	4.0	8.2

8.3 Cumulative Impacts

To assess impacts against the relevant air quality standards and goals, it is necessary to have information on the background concentrations to which the Project is likely to contribute. The existing background environment is described in **Section 5**, based on monitoring data obtained at Beresfield and at locations around the TAC site. Monitoring for SO_2 in the vicinity of the TAC site indicates that levels of SO_2 are approaching the air quality goals for 1-hour and 24-hour average SO_2 concentrations (refer **Section 5.1**). Additional information is therefore presented to assess the cumulative impact of SO_2 emissions from the project on the airshed.

The highest 1-hour SO_2 concentrations from the project are predicted to occur at Residence 14 (R14) and the highest 24-hour SO_2 concentrations from the project are predicted to occur at Residence 13 (R13). These two residence locations are located closest to the monitoring site know as the Farm, where the highest background concentrations of SO_2 were recorded during 2008 (refer **Section 5.1**). An assessment of cumulative impacts is therefore presented for these residences using background data recorded at the Farm site, as a worst case. If no additional exceedances are recorded for these two residences it can be assumed that cumulative impacts will not occur at any other residence location.

Figure 8.17 to **Figure 8.20** show the cumulative 1-hour and 24-hour SO_2 impact at R13 and R14. The plots are presented as incremental increases from the Project (black bar) added to / or stacked on top of the background (grey bar). All plots show a minor incremental increase as a result of the Project and no additional exceedances are predicted to occur.

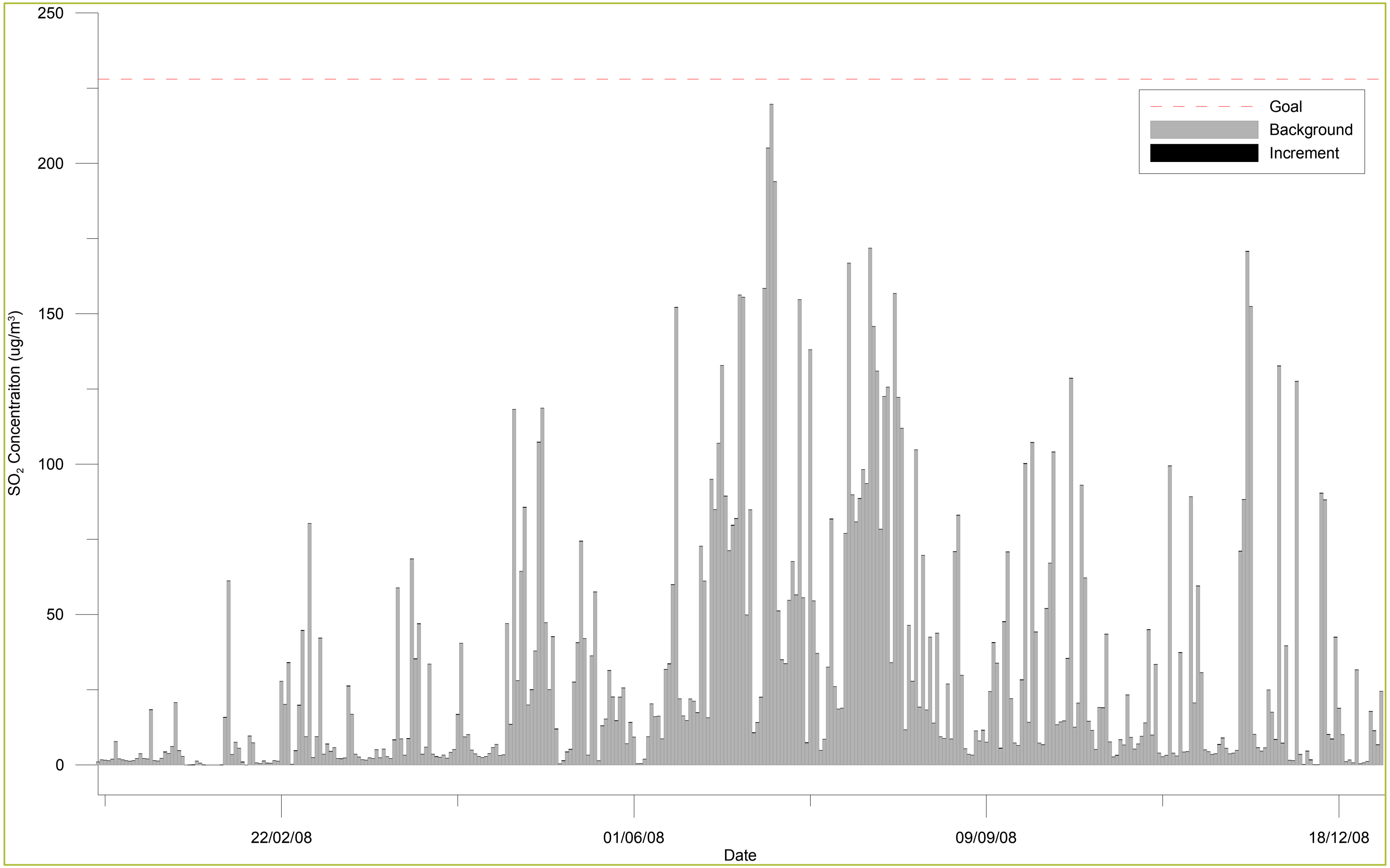


Figure 8.17: Cumulative 24-hour SO_2 Concentration for R14

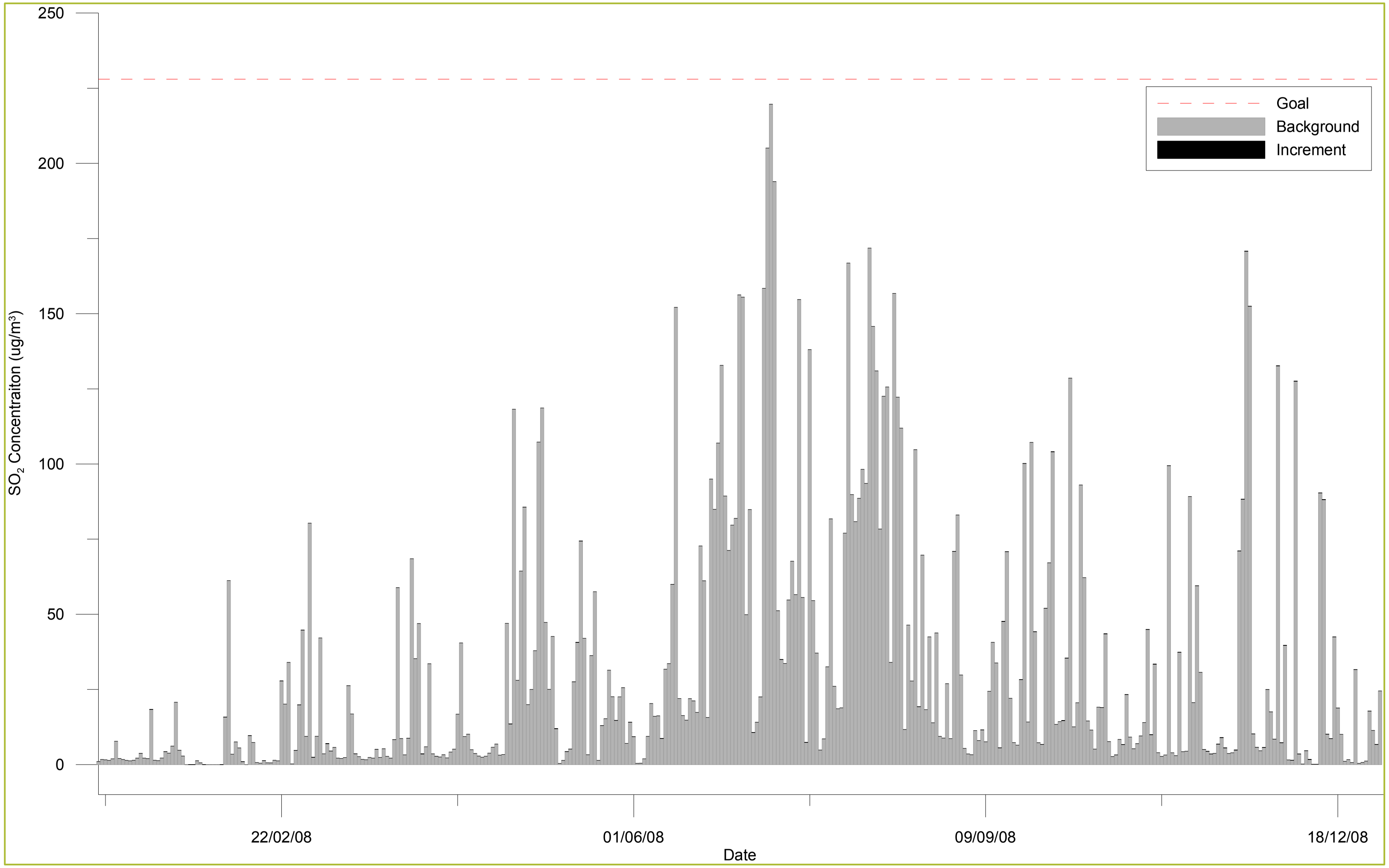


Figure 8.18: Cumulative 24-hour SO_2 Concentration for R13

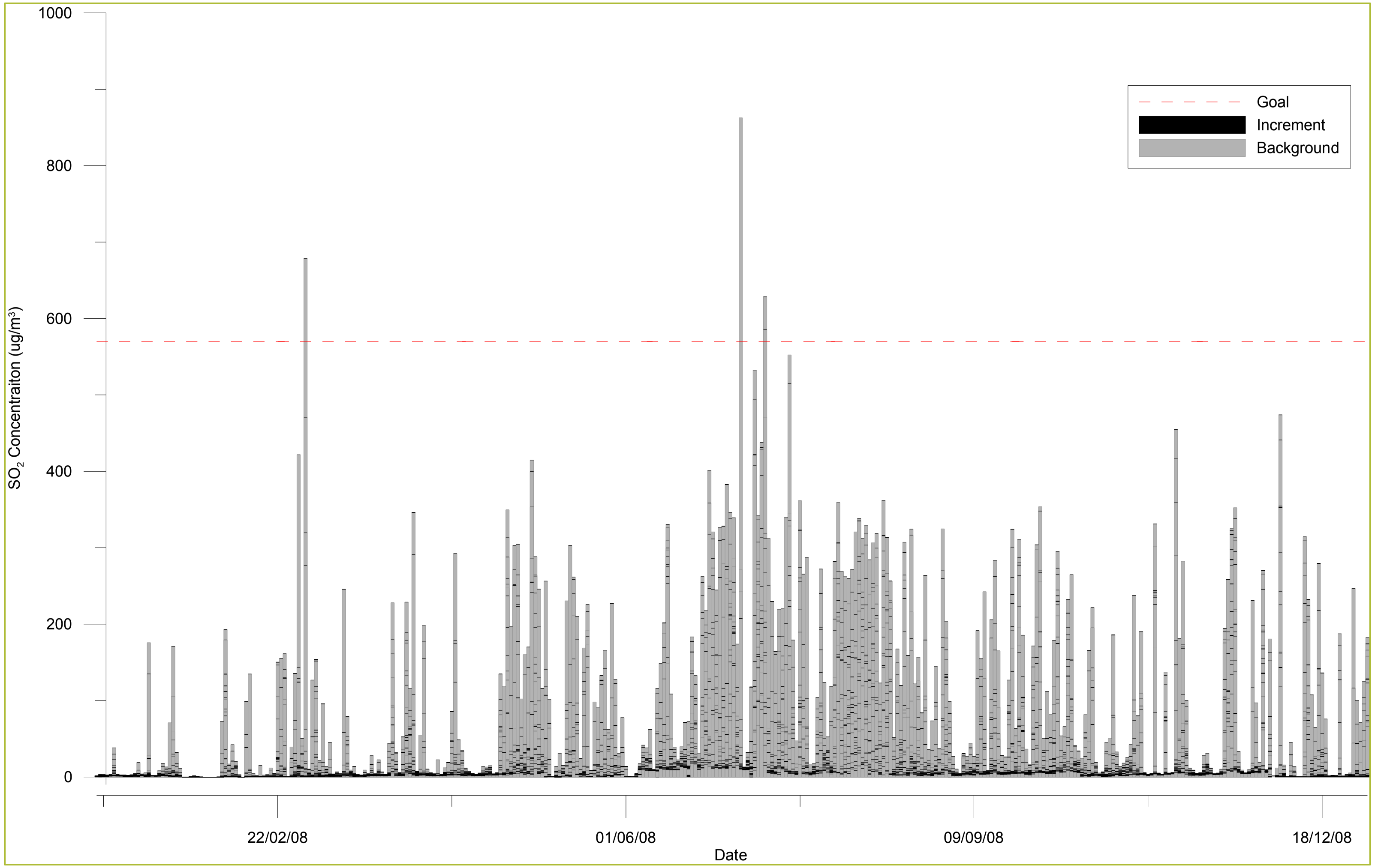


Figure 8.19: Cumulative 1-hour SO$_2$ Concentration for R14

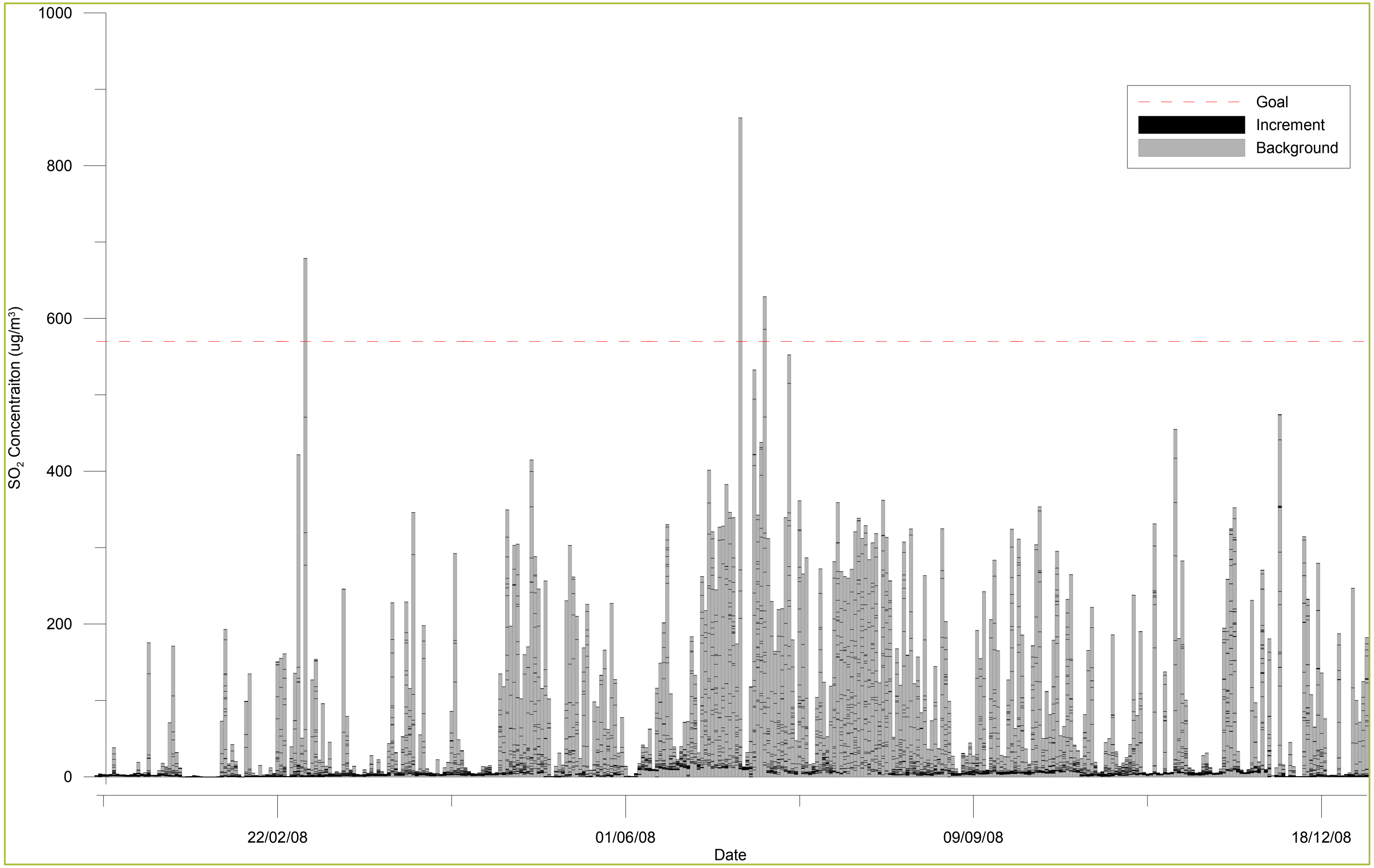


Figure 8.20: Cumulative 1-hour SO$_2$ Concentration for R13

The NSW DECCW have also requested some additional cumulative assessment for SO_2, based on more recent monitoring data obtained during 2010 at a new site know as the School Drive site. Additional modelling was conducted for 2010 and a cumulative assessment of SO_2 presented for this period. This additional analysis is presented in **Appendix A** and shows that no additional exceedances would occur from the operation of the Project.

The existing background levels of all other pollutants, with the exception of particulate matter (PM_{10}), are well below air quality goals and the predicted incremental levels from the project are low enough to not compromise air quality goals when added to existing background levels.

There are occasional exceedances of the 24-hour PM_{10} criteria, however when considering background pollutant concentrations it is sensible to exclude days when the goals are already exceeded due to, for example, dust storms or bushfires. The predicted increment from the project for PM_{10} is also too low to result in an additional exceedances of air quality goals when added to existing background levels.

8.4 Impacts on Vegetation

The Approved Methods do not prescribe impact assessment criteria to assess impacts on vegetation for pollutants other than hydrogen fluoride. However, the QLD EPA under their Environmental Protection (Air) Policy 2008 prescribes air quality objectives for the health and biodiversity of ecosystems, for pollutants including NO_2.

The annual average NO_2 concentration from the operation of the Project in the region of the Hunter Botanic Gardens is predicted to be well below 1 $\mu g/m^3$. Based on an annual average air quality objective of 33 $\mu g/m^3$ **(QLD EPP (Air) 2008)** impact from the Project on vegetation is expected to be negligible.

9 GREENHOUSE GAS ASSESSMENT

Greenhouse gas emissions have been estimated based upon the methods outlined in the following documents:

- The World Resources Institute/World Business Council for Sustainable Development Greenhouse Gas Protocol (**WBCSD/WRI, 2005**).
- National Greenhouse and Energy Reporting (Measurement) Technical Guidelines (**DCC, 2009**).
- The Australian Government Department of Climate Change and Energy Efficiency National Greenhouse Accounts Factors (**DCCEE, 2010**).

The Greenhouse Gas Protocol establishes an international standard for accounting and reporting of greenhouse gas emissions. The Greenhouse Gas Protocol has been adopted by the International Standard Organisation, endorsed by greenhouse gas initiatives (such as the Carbon Disclosure Project) and is compatible with existing greenhouse gas trading schemes.

Three 'scopes' of emissions (scope 1, scope 2 and scope 3) are defined for greenhouse gas accounting and reporting purposes. This terminology has been adopted in Australian greenhouse reporting and measurement methods and has been employed in this assessment. The 'scope' of an emission is relative to the reporting entity, indirect scope 2 and scope 3 emissions will be reportable as direct scope 1 emissions from another facility.

1) Scope 1: Direct Greenhouse Gas Emissions

Direct greenhouse gas emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct greenhouse gas emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources, the principal source of greenhouse emissions associated with the operation of the Project;
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials, e.g., the manufacture of cement, aluminium, etc;
- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources, e.g., trucks, trains, ships, aeroplanes, buses and cars;
- Fugitive emissions. These emissions result from intentional or unintentional releases, e.g., equipment leaks from joints, seals, packing, and gaskets; methane emissions from coal mines and venting; hydrofluorocarbons (HFC) emissions during the use of refrigeration and air conditioning equipment; and methane leakages from gas transport.

2) Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that account for greenhouse gas emissions from the generation of purchased energy products (principally electricity, steam/heat and reduction materials used for smelting) by the entity.

Scope 2 in relation to the Project covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity. Scope 2 emissions physically occur at the facility where electricity is generated. Entities report the emissions from the generation of purchased electricity that is consumed in its owned or controlled equipment or operations as scope 2.

3) Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of scope 3 activities provided in the Greenhouse Gas Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

In the case of the NGSF, scope 3 emissions will include emissions associated with gas transmission, fuel cycles and the combustion of fuel at downstream locations.

The Greenhouse Gas Protocol provides that reporting scope 3 emissions is optional. If an organisation believes that scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with scope 1 and scope 2. However, the Greenhouse Gas Protocol notes that reporting scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult because reporting is voluntary.

Double counting needs to be avoided when compiling national (country) inventories under the Kyoto Protocol. The Greenhouse Gas Protocol also recognises that compliance regimes are more likely to focus on the "point of release" of emissions (i.e., direct emissions) and/or indirect emissions from the purchase of electricity.

9.1 National Greenhouse and Energy Reporting (Measurement) Determination 2008

The National Greenhouse and Energy Reporting (NGER) Determination 2008 commenced on 1 July 2008 and is made under subsection 10 (3) of the *National Greenhouse and Energy Reporting (NGER) Act 2007*. It provides for the measurement of the following arising from the operation of facilities:

- Greenhouse gas emissions;
- The production of energy; and
- The consumption of energy.

The determination deals with scope 1 and scope 2 emissions. The methods are presented as tiers with higher tiers producing less uncertain results but requiring more data to employ. In the determination there are 4 categories of scope 1 emissions (in brackets the code for the IPCC classification):

- Fuel combustion (UNFCCC Category 1.A);
- Fugitive emissions from fuels, which deals with emissions released from the extraction, production, flaring of fuel, processing and distribution of fossil fuels (UNFCCC Category 1.B);
- Industrial processes emissions (UNFCCC Category 2); and
- Waste emissions (UNFCCC Category 6).

Under the NGER Act, facilities triggering greenhouse emission and energy usage thresholds are required to report scope 1 and scope 2.

9.2 National Greenhouse Accounts Factors

The National Greenhouse Accounts (NGA) Factors provides emission factors which have a general application to a broader range of greenhouse emission inventories. The NGA replaces the Australian Greenhouse Office Factors and Methods Workbook. The default emission factors listed in NGA Factors have been derived by the Department of Climate Change and Energy Efficiency using the Australian Greenhouse Emissions Information System and determined simultaneously with the production of Australia's NGA.

9.3 Greenhouse Gas Emission Estimates

This greenhouse gas assessment considers emissions associated with the operation of the project as follows:

- Scope 1 - NGSF gas consumption in gas-fired heaters, emissions associated with flaring and emissions associated with waste gas amine regeneration;
- Scope 2 – Projected electricity consumption for the site;
- Scope 3 - Emissions associated with the upstream supply and downstream use of gas and LNG and the emissions associated with electricity transport and distribution (T&D) loses;

The assessment has not considered GHG emission from the following sources:

- Scope 1 – Construction phase emissions. This would mainly be from diesel combustion in construction plant and equipment. Information on the diesel consumption for the project was not available to facilitate this calculation;
- Scope 3 - Emissions associated with the manufacture & transport of upstream products consumed during construction and operation;

9.3.1 Upstream and Downstream Fuel Use

Scope 1 greenhouse gas emissions from fuel combustion were estimated using the equations from method 1 under section 2.20 of the National Greenhouse and Energy Reporting System Measurement Technical Guidelines (NGER guidelines) June 2009 (**DCC, 2009**).

Scope 3 emissions have been estimated for the following sources:

- The transportation and combustion (usage) of downstream gas that is vapourised and injected back into the supply grid;
- The transportation and combustion (usage) of downstream LNG that is loaded to road tankers and used as a transport fuel; and
- The upstream supply (transmission) of natural gas from the network to the gas storage facility for liquefaction;

Emission factors are sourced from the DCC NGA Factors (**DCCEE, 2010**):

Scope 1:

$$E_{CO_2-e} = \frac{Q \times EF_{S1}}{1000}$$

Scope 3:

$$E_{CO_2-e} = \frac{Q \times EF_{S3}}{1000}$$

where:

E_{CO2-e}	=	Emissions of greenhouse gases from natural gas combustion	(tCO_2-e/annum)
Q	=	Actual natural gas combusted on-site and transported to and from the site (scope 3)	(GJ/annum)
EF_{S1}	=	Greenhouse gas scope 1 emission factor for natural gas combustion	(kg CO_2-e/GJ)
EF_{S3}	=	Greenhouse gas scope 3 emission factor for natural gas combustion	(kg CO_2-e/GJ)

The following parameters were used in the equation:

- Q was determined based on provided fuel consumption rates of 180 kg/hr for the fired heater at the amine unit and 2000 kg/hr for the fired heater at the vaporiser with a 70% online factor. For an assessment of Scope 3 emissions, Q is based on an estimated 18,250 tonnes LNG per annum, 48,250 tonnes natural gas per annum and a HHV of 55.43 GJ/kg.
- EF_{S1} Scope 1 emission factor in this assessment - the value 51.303 kg $CO_{2\text{-}e}$/GJ from Schedule 1, Part 2 of the NGER Guidelines (**DCC, 2009**) has been used. This value is the sum of CO_2, CH_4 and N_2O emission factors in CO_2-e for natural gas distributed in a pipeline.
- EF_{S3} Scope 3 greenhouse gas emission factor for natural gas (extraction, processing and transmission) in NSW of 14.2 kg CO_2-e/GJ sourced from Table 38 Scope 3 Emission factors – Gaseous Fuels, DCC NGA Factors (**DCCEE, 2010**). The Scope 1 emission factor is used for the downstream combustion of gas and an emission factor of 59.9 kg $CO_{2\text{-}e}$/GJ is used for the downstream combustion of LNG. A scope 3 emission factor for the downstream supply of LNG of 5.0 kg CO_2-e/GJ is sourced from Table 39 Scope 3 Emission factors – Liquid Fuels, DCC NGA Factors (**DCCEE, 2010**).

A summary of the GHG calculations for on-site fuel consumption are shown in **Table 9.1**.

Table 9.1: Annual Scope 1 GHG Estimates from on-site Gas Consumption

	Gas Consumption (GJ/Annum)	Scope 1 Emission Factor (kg CO2-e/GJ)	Scope 1 Emission (t CO2-e)
Fired Heater - Amine Unit	62,298	51.303	3,196
Fired Heater - Vapouriser	692,195	51.303	35,512
Total			**38,708**

A summary of the GHG calculations for downstream and upstream fuel are shown in **Table 9.2**.

Table 9.2: Annual Scope 3 GHG Estimates from Fuel Consumption

	Estimated Rate of use (GJ/Annum)	Emission from Combustion (t/CO2-e)	Emission from supply (t/CO2-e)	Total Scope 3 Emission (t/CO2-e)
Downstream Gas	2,674,498	137,210	37,978	175,188
Downstream LNG	1,011,598	60,595	5,058	65,653
Upstream Gas	2,555,000	N/A	36,281	36,281
Total				**277,121**

9.3.2 Flare

Greenhouse gas emissions from the operation of the flare were estimated using the following equation:

$$E_{CO_2-e} = Q_i \; x \; EF$$

where:

E_{CO2-e} = Emissions of greenhouse gases from flaring (tCO_2-e/annum)
Q_i = Estimated tonnes of gas flared (i) (t)
EF = Greenhouse gas scope 1 emission factor for flaring (tCO_2-e/t flared)

The following parameters were used in the equation:

- Q_i was estimated based on the gas flow to flare provide by AGL
- Scope 1 greenhouse gas emission factor for flaring of 2.83 tonnes CO_2-e/tonnes fuel flared sourced from Section 3.85 Division 3.3.9 "*Natural gas production or processing (emissions that are vented or flared"* of the NGER Guidelines (**DCC, 2009**);

The total estimated GHG emissions from flaring were estimated at 2,582 t CO_2-e / annum.

9.3.3 Waste Gas

The amine process is estimated to generate approximately 1216 kg/hr of waste gas flow to flare of which approximately 88% is CO_2 and small amounts of unburnt CH_4 Based on an online factor of 70%, this is estimated to generate approximately 7,466 t CO_2-e / annum.

9.3.4 Electricity Usage

Greenhouse gas emissions from electricity usage were estimated using the following equation:

Scope 2:

$$E_{CO_2-e} = \frac{Q \times EF_{S2}}{1000}$$

Scope 3:

$$E_{CO_2-e} = \frac{Q \times EF_{S3}}{1000}$$

where:

E_{CO2-e} = Emissions of greenhouse gases from electricity usage (tCO_2-e/annum)
Q = Estimated electricity usage (kWh/annum)
EF_{S2} = Scope 2 emission factor for electricity usage in NSW ($kgCO_2$-e/kWh)
EF_{S3} = Scope 3 emission factor for electricity usage in NSW ($kgCO_2$-e/kWh)

The following parameters were used in the equation:

- Annual electricity usage for the Project was estimated from a similar AGL gas storage facility located at Torrens Island, SA and scaled based on relative throughput;
- Scope 2 greenhouse gas emission factor for electricity usage in NSW of 0.9 kg CO2-e/kWh sourced from Table 5 "*Indirect emission factors for consumption of purchased electricity from the grid*", DCC NGA Factors (**DCCEE, 2010**); and
- Scope 3 greenhouse gas emission factor for electricity usage in NSW of 0.17 kg CO2-e/kWh sourced from Table 40 Scope 2 and 3 emission factors - consumption of purchased electricity by end users, DCC NGA Factors (**DCCEE, 2010**).

A summary of the GHG calculations for electricity use is shown in **Table 9.3**.

Table 9.3: Estimated GHG Emissions from Electricity

Electricity Consumption (kWh/annum)	Scope 2 Emission Factor kgCO2-e/kWh	Scope 3 Emission Factor kgCO2-e/kWh	Scope 2 t CO2-e/annum	Scope 3 t CO2-e/annum
27,500,000	0.90	0.17	24,750	4,675

9.4 Summary of GHG Emission Estimates

A summary of the total greenhouse gas emissions for the project is provided in **Table 9.4**.

A comparison is made with the baseline 1990 Australian emissions, which are reported under the Kyoto Protocol as 547.7 Mt CO_2-e (**DCC, 2009a**). The baseline is used to assign Australia's target under the Kyoto Protocol, which is 108% of the 1990 level. The total annual Scope 1 and Scope 2 emissions from the Project will account for an increase in GHG emissions of 0.01 % of total Australian emissions (1990 and 2007) and a 0.05 % increase in total NSW emissions for 2007.

Table 9.4: Summary of GHG Emissions

Source	Scope 1 Emission (t/CO2-e)	Scope 2 Emission (t CO2-e/annum)	Scope 3 Emission (t/CO2-e)	Total
Fired Heaters	38,708	-	-	**38,708**
Flare	2,582	-	-	**2,582**
Waste Gas	7,466	-	-	**7,466**
Electricity	-	24,750	4,675	**29,425**
Downstream Gas			175,188	**175,188**
Downstream LNG			65,653	**65,653**
Upstream Gas			36,281	**36,281**
Total	**48,756**	**24,750**	**281,796**	**355,302**

9.5 Greenhouse Intensity Comparisons

The proposed Project will process natural gas for storage as LNG and the stored gas will be used in one of the following ways:

- 80% will be re-gasified and transferred to the NSW gas pipeline network for sale; and
- 20% will be transferred as LNG to road tankers for sale to market.

Natural gas has advantages over other fossil fuels with respect to greenhouse emissions. Each unit of energy provided by the combustion of natural gas results in less greenhouse emissions in comparison with other fossil fuels, particularly coal. The majority of Australia's electricity is currently produced by coal-fired power stations.

Natural gas has significantly lower greenhouse emissions per unit of energy released when combusted and the storage of natural gas for use in peak demand has measureable benefits in terms of emissions intensity. LNG also has lower emissions intensity when compared to other transport fuels, for example diesel.

Table 9.5 shows the quantity of greenhouse emissions (expressed as kg CO_2-e) per unit of thermal energy produced by combustion. However, it is also important to consider the energy needed to store the gas, which would offset some of beneficial gains in emissions intensity.

Table 9.5: Greenhouse Emission per Unit of Energy Provided

Fuel	Emission Factor (Scope 1) (kg CO_2-e/GJ)	% Difference
Natural gas	51.33	-42%
Black coal	88.43	
LNG	51.33	-26%
Diesel	69.5	

10 CONSTRUCTION PHASE IMPACTS

10.1 Overview

Construction of the gas plant is expected to take approximately 3 years, with construction of the pipeline and receiving station expected to take 9 months. Key components of the construction phase are:

- Site preparation, including vegetation clearing;
- Bulk earthworks;
- Structural works;
- Landscaping; and
- Pipeline construction, including trenching, horizontal boring and directional drilling.

10.2 Construction Phase Emissions

Dust emissions from construction vary substantially from day to day, depending on the intensity of particular activities (i.e. tonnes of material handled) as well as the temporal and spatial distribution for various emission sources and location. It is therefore very difficult to confidently estimate emissions on a day-to-day basis. Typically, impacts will be relatively short lived across different areas of the site and generally manageable through commonly applied dust control measures.

The primary emissions during construction will be dust and particulate matter. The majority of the particulate matter (PM) generated from construction will be in the coarse size fractions, generally referred to as PM_{10}. Particulate matter (PM) emissions in the fine size fractions, generally referred to as $<PM_{2.5}$ are typically associated with combustion sources and are not considered significant for this assessment.

There would be some minor emissions as a result of construction vehicles (exhaust emissions) and potential on-site power generation (diesel generators) which would include oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), organic compounds and GHG emissions (primarily CO_2). However, the contribution of these emissions would not be significant enough to compromise air quality goals at nearby receptors.

The principal emissions sources from the construction phase will be dust and particulate matter, occurring from the following activities:

- Vegetation clearing during site preparation and access road construction;
- Bulk earthworks including topsoil removal and stockpiling, trenching, cut and fill;
- Handling of material;
- Movement of heavy plant and machinery within the site;
- Graders / scrapers working access road construction; and
- Wind erosion from exposed surfaces.

Prior to construction, a Construction Environmental Management Plan will be developed which will include an Air Quality / Dust Management Sub Plan, to describe control of emissions to air during construction.

The Air Quality / Dust Management Plan will:

- Outline procedures for controlling / managing dust during operation of project;
- Define roles, responsibilities and reporting requirements;
- Outline the dust control inspection regime; and
- Outline potential contingency measures for where standard dust control measures are deemed ineffective.

Procedures for controlling dust impacts during construction are discussed in the following sections.

10.2.1 Clearing / Excavation

Emissions from vegetation stripping, topsoil clearing and excavation can occur, particularly during dry and windy conditions. Emissions can be effectively controlled by increasing the moisture content of the soil / surface. Other controls that will be considered are:

- Modifying working practices by limiting excavation during periods of high winds; and
- Limiting the extent of clearing of vegetation and topsoil to the designated footprint required for construction and appropriate staging of any clearing.

10.2.2 Access Route Construction

The use of earth moving equipment can be significant sources of dust, and emissions should be controlled through the use of water sprays during road construction. Where conditions are excessively dusty and windy, and fugitive dust can be seen leaving the site, work practices should be modified by limiting earth moving activity close to residential areas. The majority of the length of the access road is a considerable distance from occupied residential receivers. Given the temporary nature of the access route construction and implementation of standard dust control measures, dust impacts are expected to be minor.

10.2.3 Pipeline Construction / Hexham Receiving Station

Modify working practices to effectively control emission by:

- Limiting clearing and excavation during periods of high winds;
- Limiting the extent of clearing of vegetation and topsoil to the designated footprint required for the pipeline corridor and receiving station;
- Using water sprays during construction for dusty activities such as trenching, boring, backfilling rolling and receiving station site preparation; and
- Increasing the moisture content of the soil / backfill.

10.2.4 Haulage and Heavy Plant and Equipment

Vehicles travelling over paved or unpaved surfaces tend to produce wheel generated dust and can result in dirt track-out on paved surfaces surrounding the work areas. The following practices and control measures should be adopted.

- All vehicles on-site should be confined to a designated route with a speed limit enforced;
- Trips and trip distances should be controlled and reduced where possible, for example by coordinating delivery and removal of materials to avoid unnecessary trips;

- Dirt that has been tracked onto sealed roads should be cleaned as soon as practicable;
- When conditions are excessively dusty and windy, and dust can be seen leaving the works site a water truck (for water spraying of travel routes) should be used; and
- Maintain the access road in a good condition to minimise dust emissions.

10.2.5 Wind Erosion

Wind erosion from exposed surfaces should be controlled as part of the best practice environmental management of the site, including by:

- Avoiding unnecessary vegetation clearing and ensuring rehabilitation occurs as quickly as possible.
- Minimising the number of stockpiles on-site and minimising the number of work faces on stockpiles.

10.2.6 Heavy Vehicle Exhaust Emissions

To minimise emissions from heavy vehicles, the following controls would be applied:

- Trucks and construction plant entering the site should be well maintained in accordance with the manufacturer's specification to comply with all relevant regulations. Vehicles with smoky exhausts (more than 10 seconds) should be stood down for maintenance;
- Unnecessary idling for trucks and plant should be avoided with engines turned off during periods of inactivity;
- Delivery of materials should be planned and coordinated to avoid congestion and excessive truck queuing / idling of trucks; and
- Trips and trip distances should be controlled and reduced where possible.

11 CONCLUSIONS

The potential air quality impacts from the operation of the proposed Newcastle Gas Storage Facility Project have been assessed, including LNG processing and storage, re-gasification, gas pipeline and receiving station.

To assess the potential impact from the proposed Project, three modelling scenarios have been considered, including liquefaction (liquefaction, sour gas incinerator, flare), re-gasification (vapouriser unit) and plant start-up/ shut-down. Construction phase emissions have been assessed qualitatively.

Modelling results for each scenario indicate that emissions from the Project are minor for all pollutants when compared to impact assessment criteria. A assessment of cumulative air quality impacts indicates that the Project would not result in any additional exceedances of air quality goals.

The predictions presented in this report incorporate a level of conservatism and the actual ground level concentrations would be expected to be lower than those predicted during operations.

Dust emissions from construction are expected to be relatively short lived across different areas of the site and generally manageable through commonly applied dust control measures.

An assessment of greenhouse gas emissions indicates that the project would contribute to 0.01 % of total Australian emissions and a 0.05 % increase on total NSW emissions.

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APPENDIX A

Additional Modelling for 2010

A.1 ADDITIONAL CUMULATIVE SO_2 ASSESSMENT FOR 2010

The NSW DECCW requested additional cumulative impact assessment for 2010, based on elevated background concentrations recorded at a new monitoring site located at School Drive. All TAC monitoring sites are shown in **Figure 5.1**. The following sections outline this additional analysis.

A.1.1 TAC Monitoring Data for 1-hour Average SO_2

Hourly average SO_2 concentrations for all TAC monitoring sites in 2010 are shown in **Figure A12.1** to **Figure A12.5**. There were no exceedances of the 1-hour DECCW goal of 570 µg/m^3 at any of the sites.

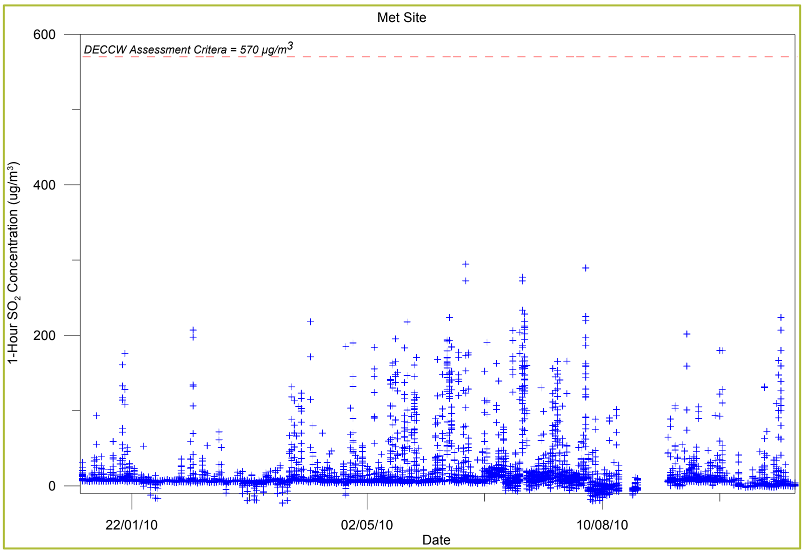


Figure A12.1: 1-hour Average SO_2 Concentration – TAC Met Station

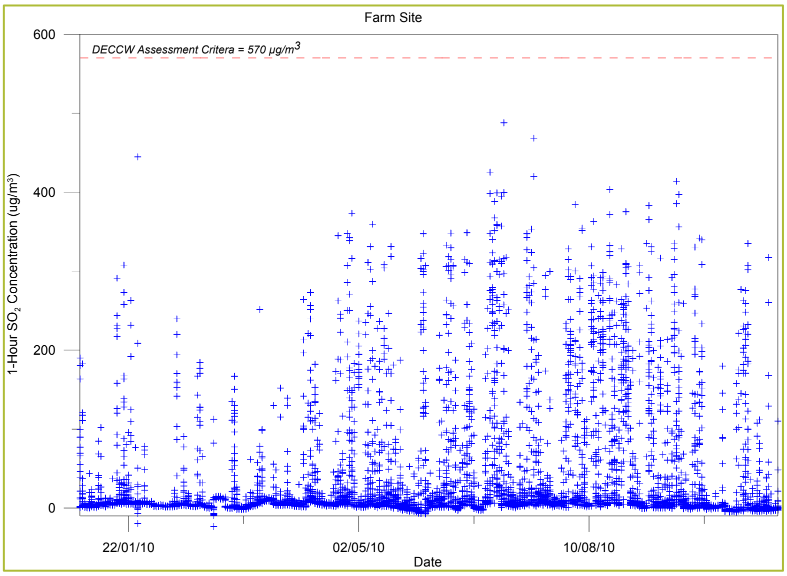


Figure A12.2: 1-hour Average SO_2 Concentration – Farm Site

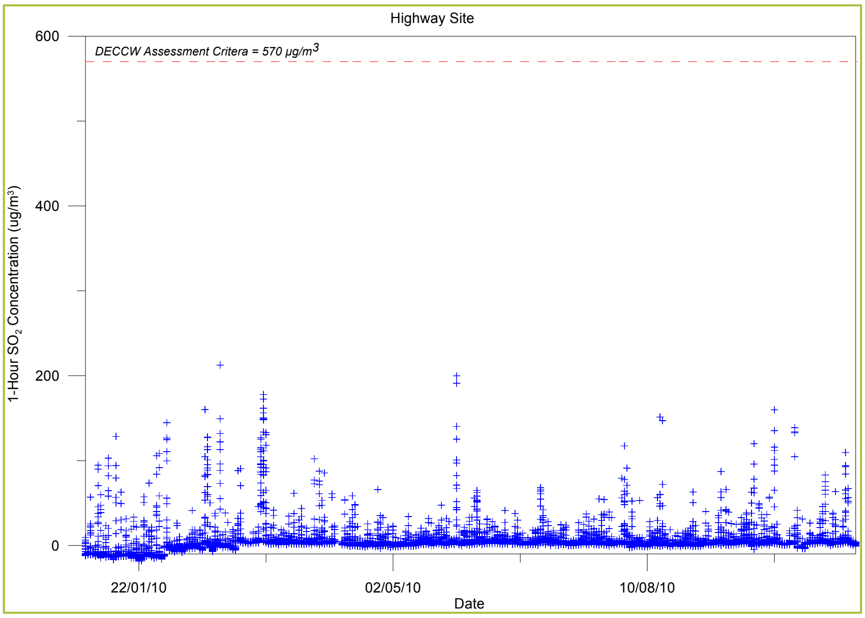


Figure A12.3: 1-hour Average SO_2 Concentration – Highway Site

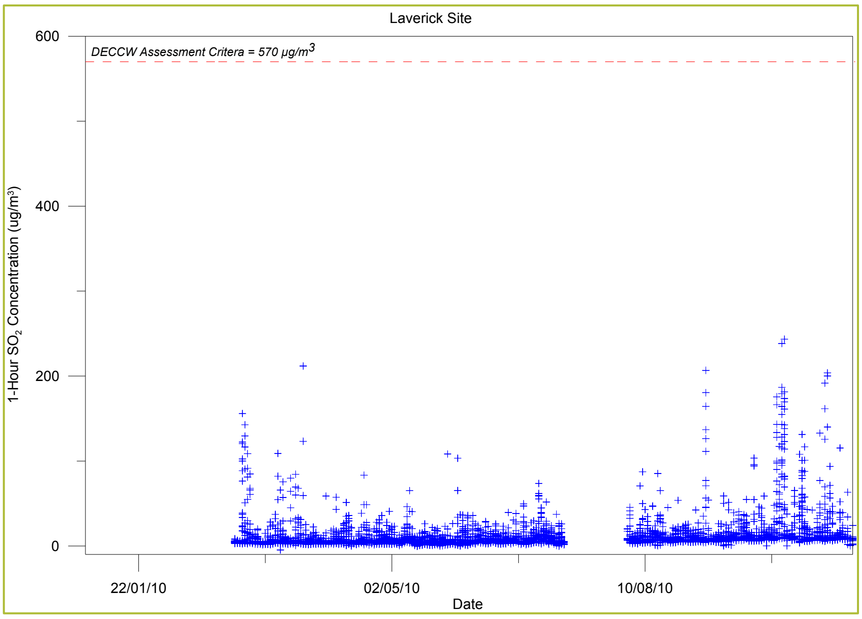


Figure A12.4: 1-hour Average SO_2 Concentration – Laverick Av Site

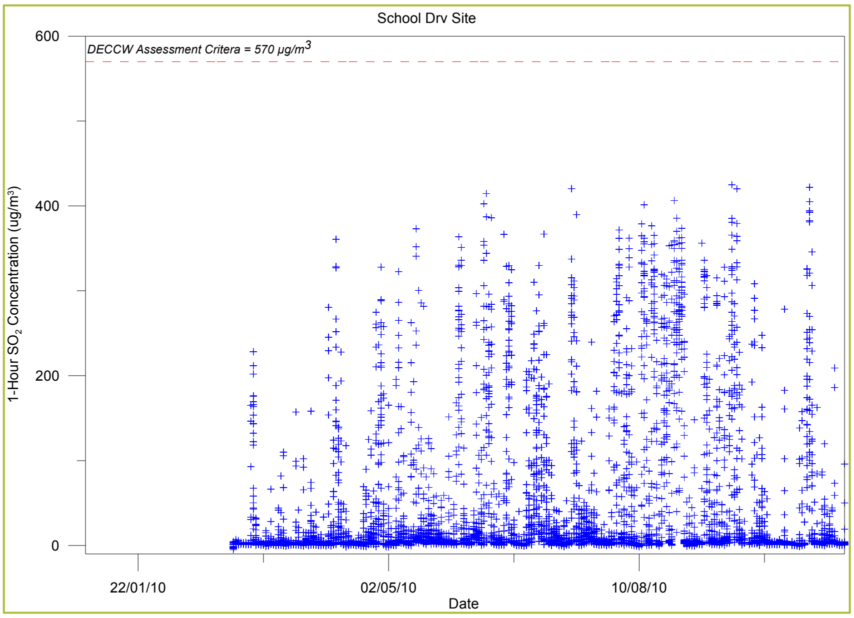


Figure A12.5: 1-hour Average SO_2 Concentration – School Drive Site

A.1.2 TAC Monitoring Data for Daily Average SO_2

Daily average SO_2 concentrations for all TAC monitoring sites during 2010 are shown in **Figure A12.6** to **Figure A12.10**. There were no exceedances of the 24-hour DECCW goal of 228 µg/m^3 at the TAC Met Station, Farm, Highway and Laverick Av sites. There was eight days at the School Drive site, when concentrations above the DECCW goal were recorded.

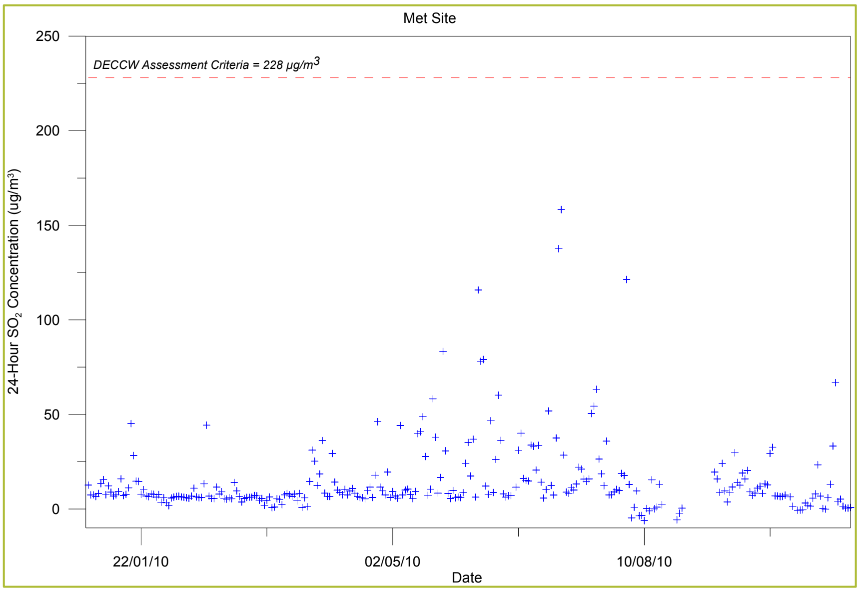


Figure A12.6: 24-hour Average SO_2 Concentration – TAC Met Station

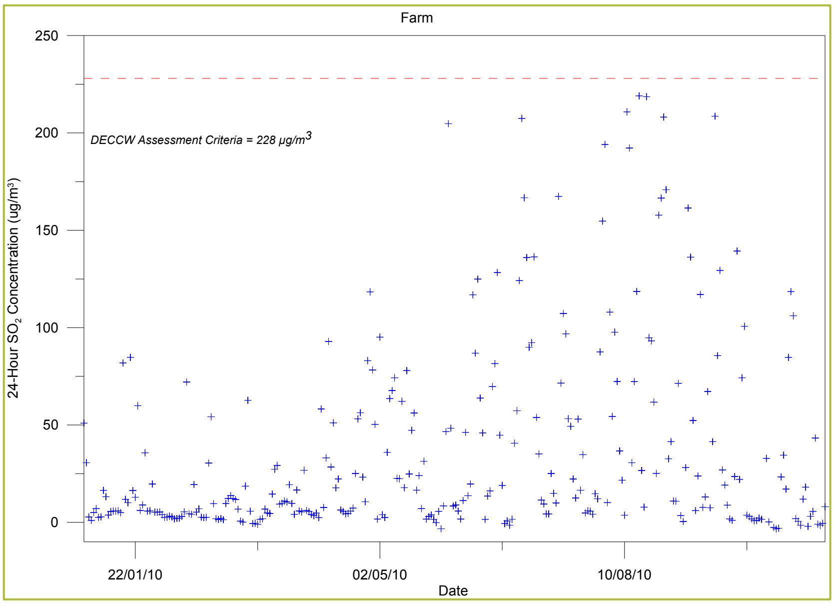


Figure A12.7: 24-hour Average SO_2 Concentration – Farm Site

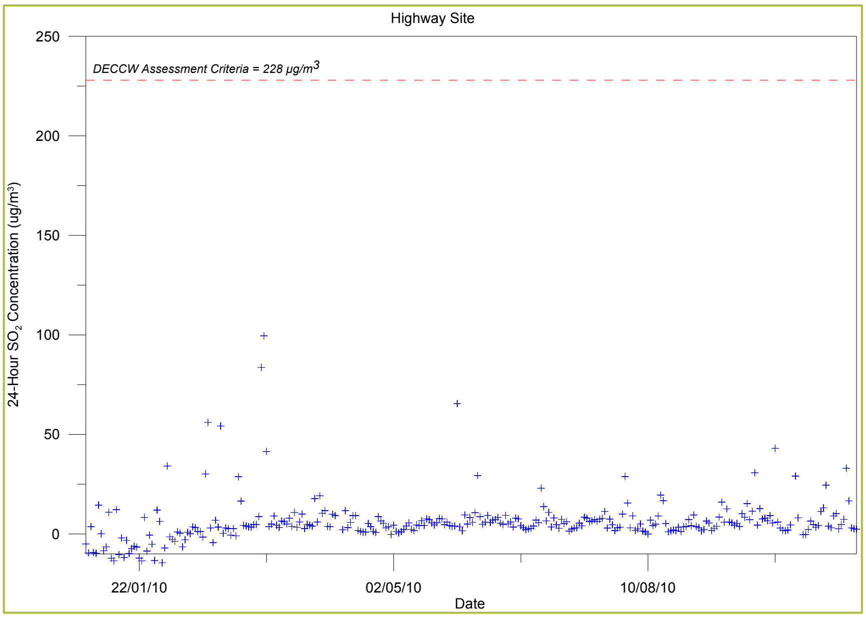


Figure A12.8: 24-hour Average SO_2 Concentration – Highway Site

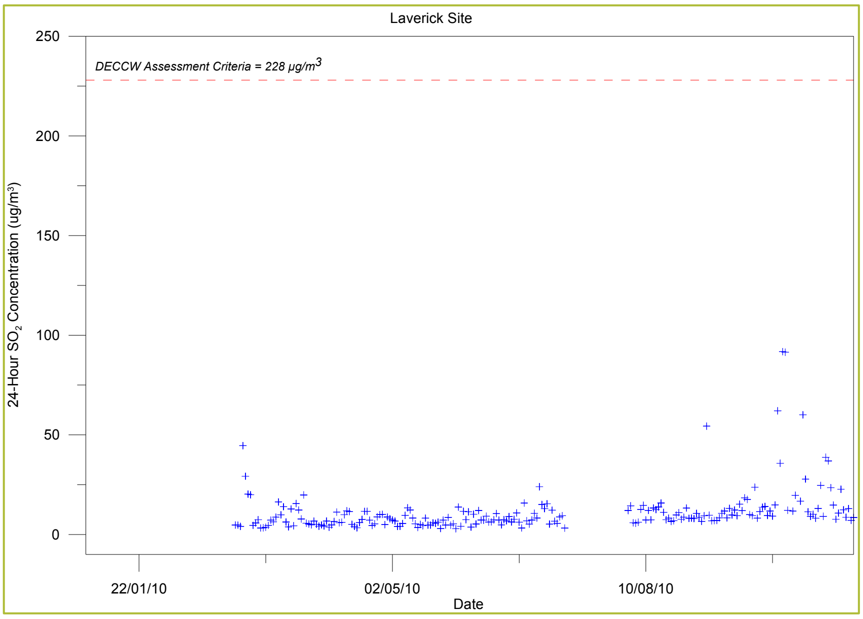


Figure A12.9: 24-hour Average SO_2 Concentration – Laverick Site

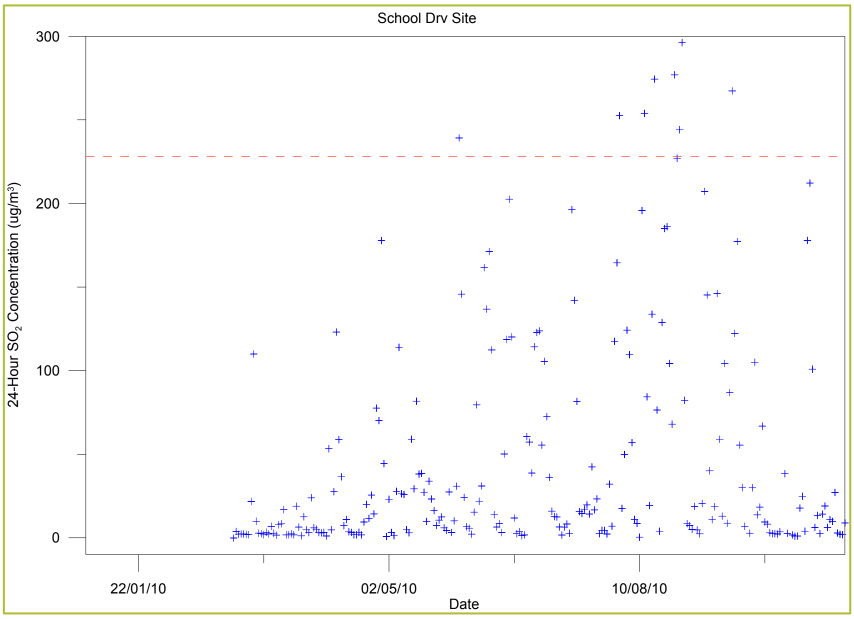


Figure A12.10: 24-hour Average SO_2 Concentration – School Drive Site

A.1.3 Additional Modelling

The NSW DECCW requested additional cumulative impact assessment for 2010, based on elevated background concentrations recorded at a new monitoring site located at School Drive.

The local meteorology was modelled for 2010 similar to that outlined in **Section 6**. The only difference from the modelling presented in **Section 6** was DECCW Beresfield data was not included as observational input, as this data was not available. The modelling period was limited to the period from 1 January 2010 to 30 September 2010. A comparison of the on-site TAC measured wind data for this period with that predicted by the CALMET modelling is presented in **Figure A12.11**. The data show very good agreement.

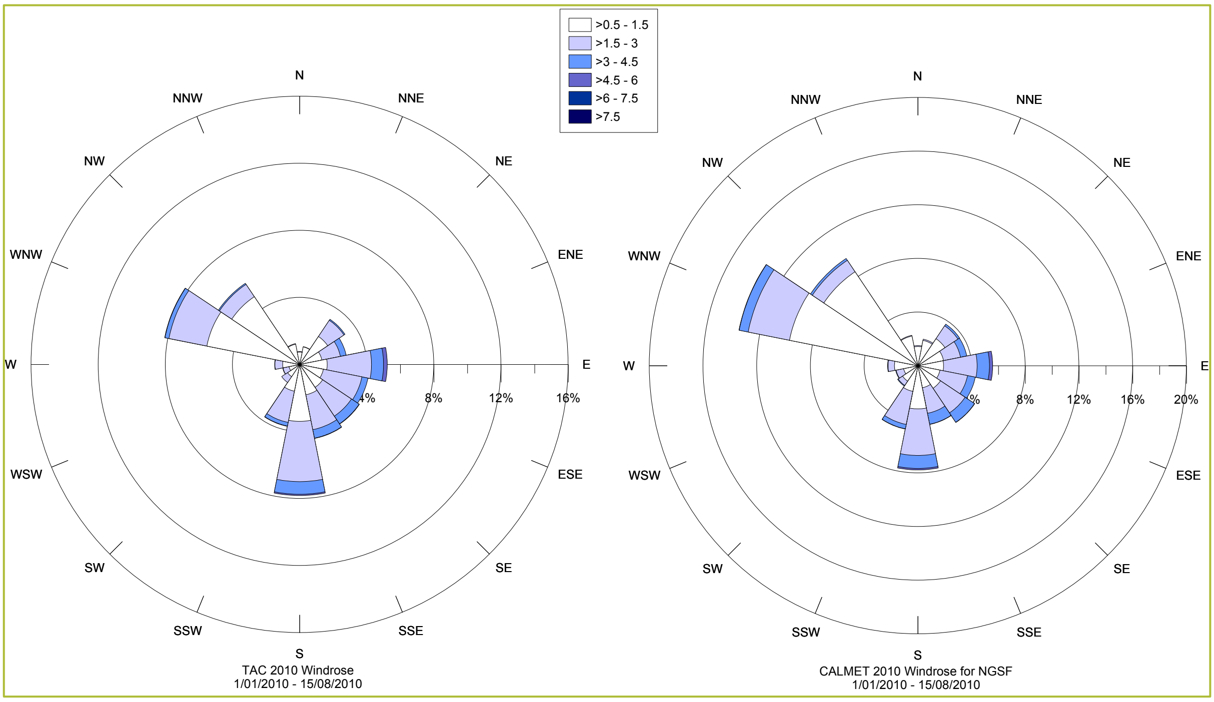


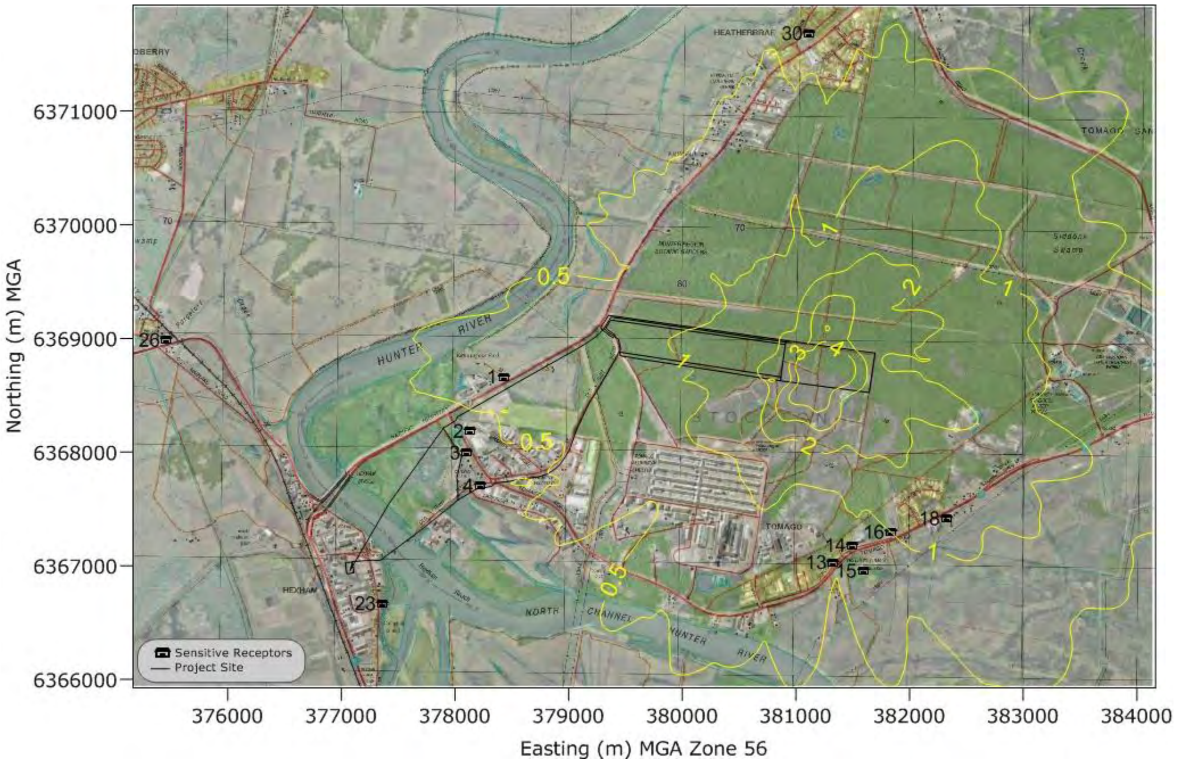
Figure A12.11: On-site TAC windrose compared to CALMET windrose (1/01/2010 – 30/09/2010)

A.1.4 Modelling Scenarios

The modelling scenarios and emissions used for the 2010 modelling are the same as those presented in Section 7 of the report for the 2008 modelling, however only emissions of SO_2 are considered, as this was the concern raised by DECCW.

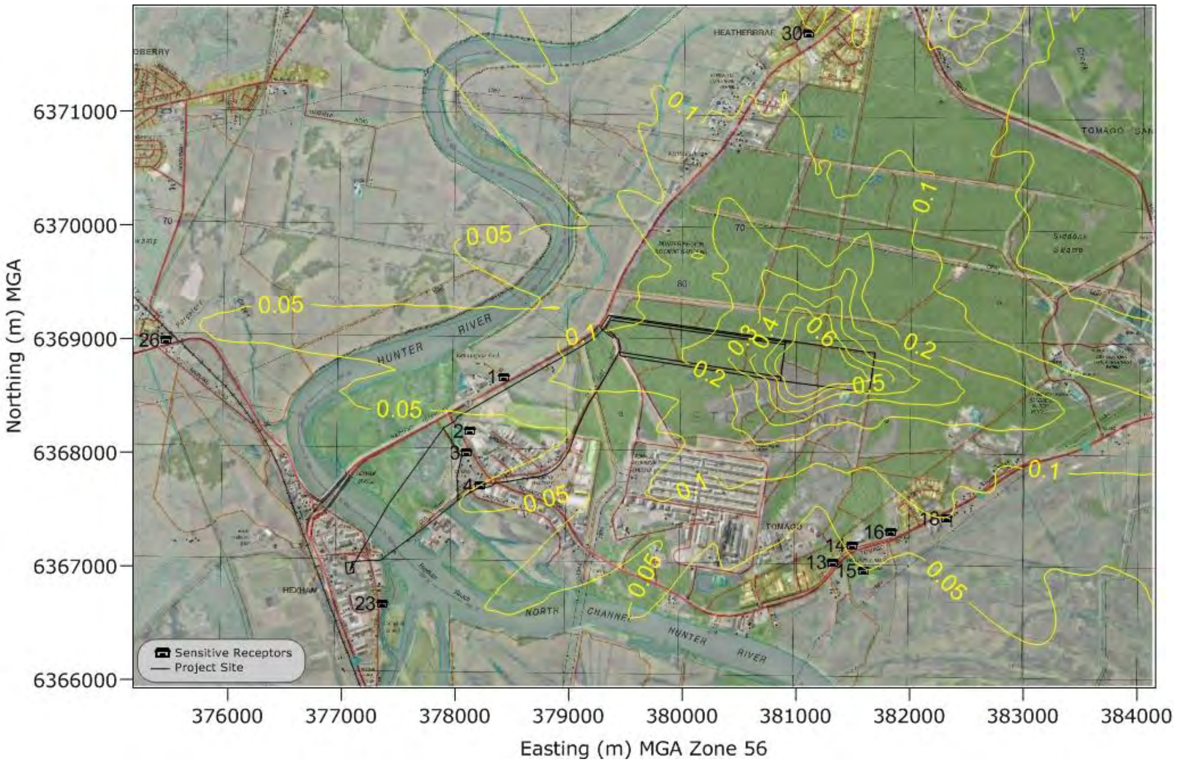
A.1.5 Modelling Results for 1-hour and 24-hour SO_2

Modelling results are presented for Liquefaction and Re-gasification Operations and contour plots for the incremental (project alone) 1-hour and 24-hour SO_2 concentrations are presented in **Figure A12.12** to **Figure A12.15**. The contour plots show that the predicted impact from the NGSF is just a small fraction of the relevant DECCW criteria.



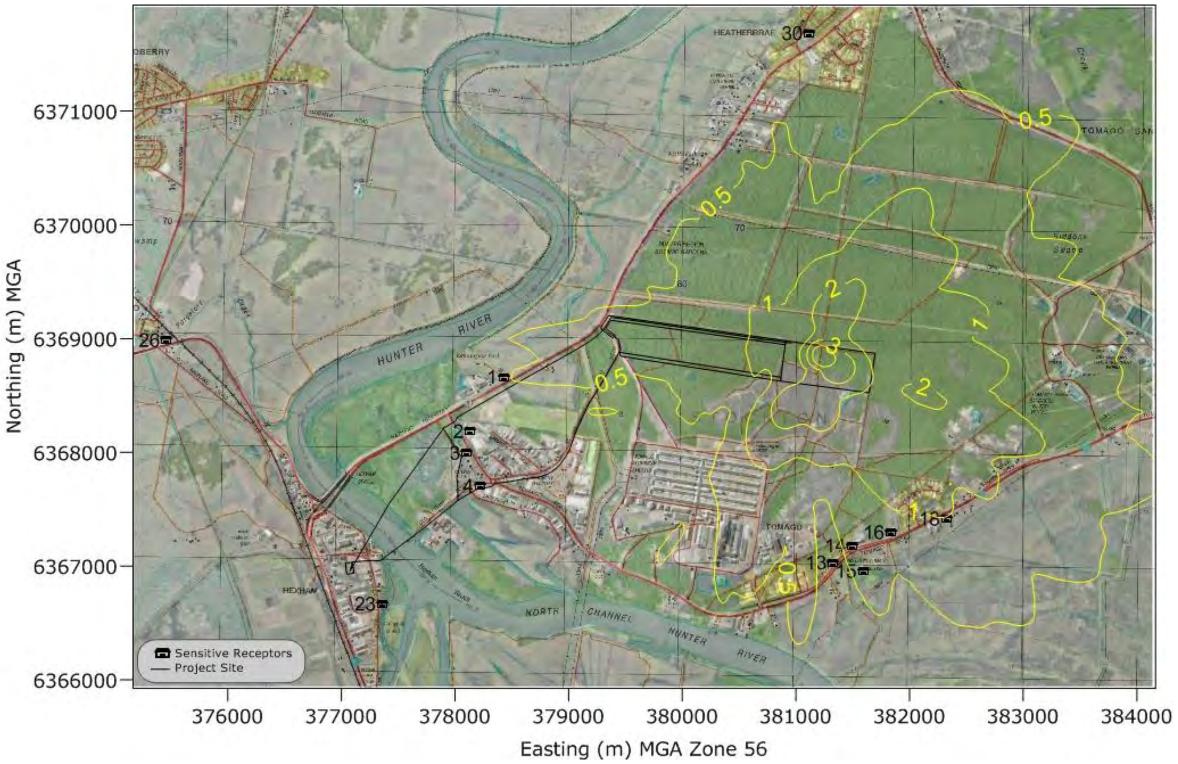
Species: SO_2	**Location:** NGSF	**Scenario:** Liquefaction plus Sour Gas Flare	**Percentile:** Maximum	**Averaging Time:** 1-hour
Model Used: CALPUFF	**Units:** µg/m^3	**Guideline:** 570 µg/m^3	**Met Data:** 2010	**Plot:** R Kellaghan

Figure A12.12: Predicted 1-Hour SO_2 Concentration from Liquefaction and Sour Gas Flare



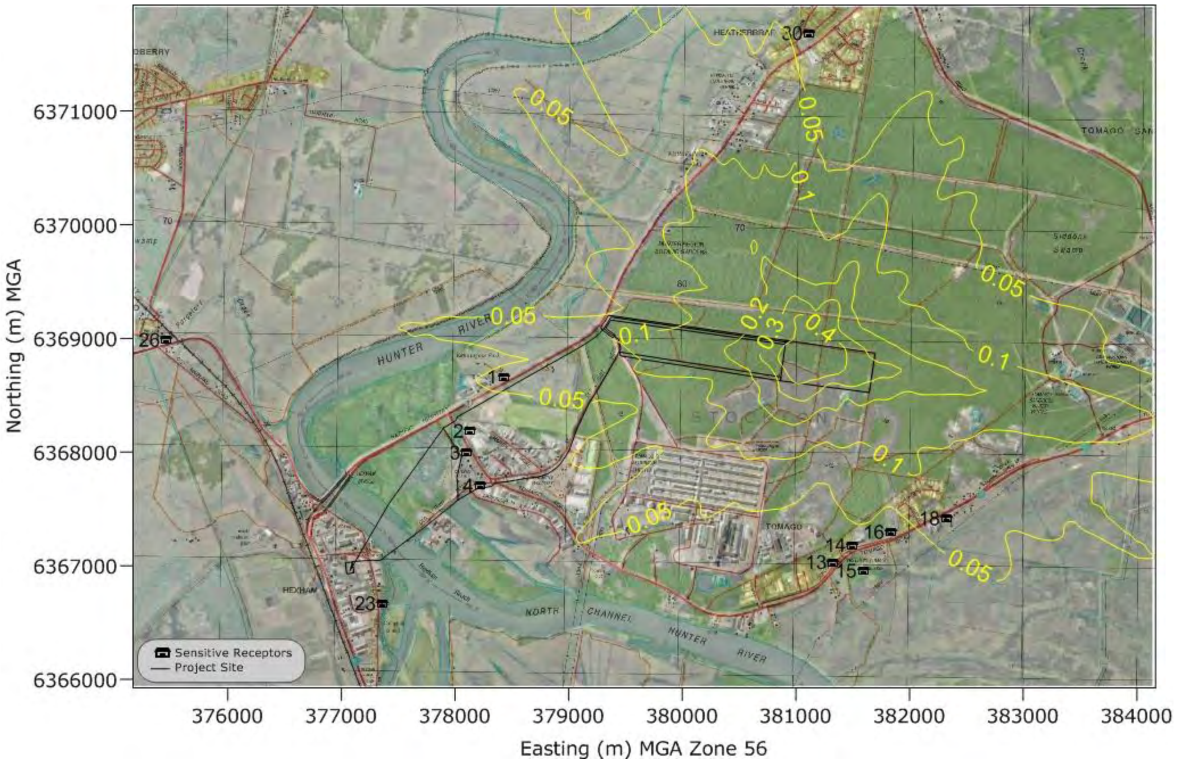
Species: SO_2	**Location:** NGSF	**Scenario:** Liquefaction plus Sour Gas Flare	**Percentile:** Maximum	**Averaging Time:** 24-hour
Model Used: CALPUFF	**Units:** µg/m^3	**Guideline:** 228 µg/m^3	**Met Data:** 2010	**Plot:** R Kellaghan

Figure A12.13: Predicted 24-Hour SO_2 Concentration from Liquefaction and Sour Gas Flare



Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
SO_2	NGSF	Gasification plus Sour Gas Flare	Maximum	1-hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF	μg/m^3	570 μg/m^3	2010	R Kellaghan

Figure A12.14: Predicted 1-Hour SO_2 Concentration from Gasification and Sour Gas Flare



Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
SO_2	NGSF	Gasification plus Sour Gas Flare	Maximum	24-hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF	µg/m^3	228 µg/m^3	2010	R Kellaghan

Figure A12.15: Predicted 24-Hour SO_2 Concentration from Gasification and Sour Gas Flare

A.1.6 Cumulative Impacts

An assessment of potential cumulative impacts for SO_2 is made by adding the modelling predictions at the location of Residence 14 with monitoring data for 2010 obtained at the School Drive monitoring site, to determine if the operation of the project would result in any additional exceedances of the SO_2 impact assessment criteria.

Table A12.1 shows the highest 10 background 1-hour concentrations with the corresponding incremental modelling prediction for 1-hour SO_2 from the project. **Table A12.2** shows the highest 10 incremental modelling predictions for 1-hour SO_2 from the project with the corresponding background for that hour.

Figure A12.16 shows the incremental 1-hour SO_2 concentration predicted at Residence 14 added (stacked) to the existing background at School Drive.

It is clear that cumulative impacts from the operation of the Gas Storage Facility do not occur.

Table A12.1: Top 10 background 1-hour concentrations plus contemporaneous increment from NGSF for that hour

Date	Background 1-hour SO_2 Concentration (µg/m^3)	Predicted 1-hour SO_2 Increment from project (µg/m^3)	Total	Goal
16/09/2010 8pm	425	0.0	425	570
14/07/2010 11pm	420	0.0	420	
18/09/2010 4am	420	0.0	420	
10/06/2010 1am	415	0.0	415	
24/08/2010 11pm	406	0.0	406	
24/08/2010 10pm	406	0.0	406	
09/06/2010 11pm	403	0.0	403	
12/08/2010 8pm	401	0.0	401	
16/07/2010 8am	390	0.0	390	
10/06/2010 12am	387	0.0	387	

Table A12.2: Top 10 increment 1-hour concentration plus contemporaneous background for that hour

Date	Background 1-hour SO_2 Concentration (µg/m^3)	Predicted 1-hour SO_2 Increment from project (µg/m^3)	Total (µg/m^3)	Goal
9/08/2010 7am	1.0	1.4	2.3	570
10/05/2010 7am	1.5	0.9	2.4	
22/02/2010 6am	Missing data	0.9	N/A	
27/09/2010 7am	3.0	0.7	3.7	
9/08/2010 8am	2.7	0.7	3.4	
15/08/2010 7am	1.3	0.7	2.0	
28/05/2010 7am	13.1	0.6	13.7	
9/01/2010 6am	Missing data	0.6	N/A	
24/04/2010 7am	2.0	0.5	2.5	
15/04/2010 7am	1.5	0.5	2.0	

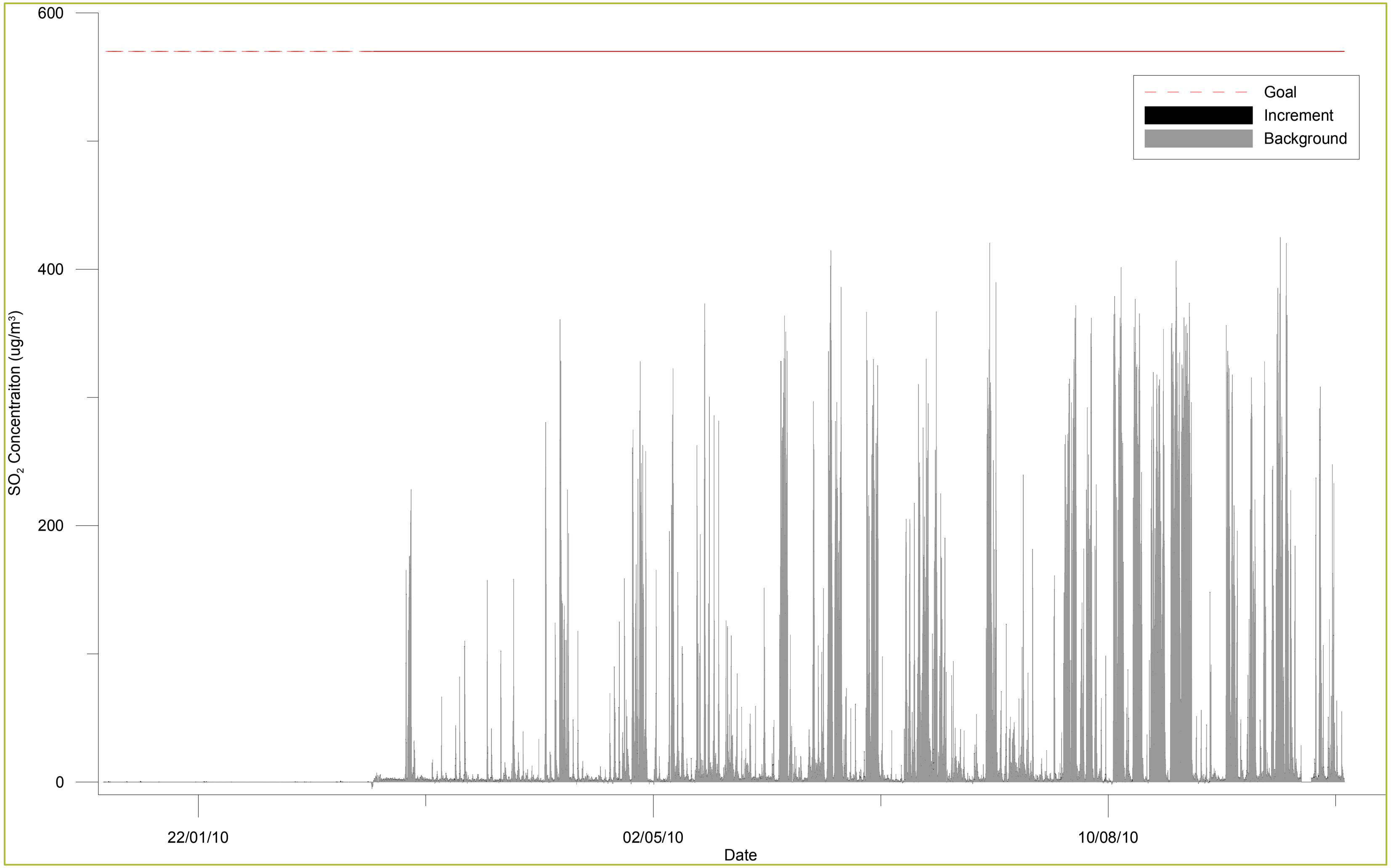


Figure A12.16: Cumulative 1-hour SO$_2$ at Residence 14 / School Drive Site

As indicated in **Section A.1.2**, there were 8 days when the 24-hour SO_2 concentration was greater than the DECCW goal of 228 µg/m^3 at the School Drive site. The days when elevated 24-hour SO_2 concentrations were recorded at the School Drive site are presented in **Table A12.3**, along with the 24-hour SO_2 increment from the project at R14 for the corresponding day. It is clear that cumulative impacts do not occur with all predicted concentrations being zero or close to zero.

Table A12.3: Top 10 background 24-hour SO_2 plus contemporaneous increment from NGSF for that day

Date	Background 24-hour SO_2 Concentration (µg/m^3)	Predicted 24-hour SO_2 Increment from project (µg/m^3)	Total	Goal
27/08/2010	296	0.0	296	288
24/08/2010	277	0.0	277	
16/08/2010	274	0.0	274	
16/09/2010	267	0.0003	267	
12/08/2010	254	0.0	254	
2/08/2010	252	0.0	252	
26/08/2010	244	0.0004	244	
30/05/2010	239	0.0004	239	
25/08/2010	227	0.0003	227	
5/09/2010	207	0.0009	207	

This is as expected when the wind directions under which these elevated background concentrations occur are considered.

Presented in **Figure A12.17** is a pollution rose which plots the 1-hour SO_2 concentration recorded at School Drive against wind directions recorded at TAC. The pollution rose shows the wind directions which are associated with the highest recorded 1-hour SO_2 concentrations, i.e. west-northwest to northwest. Each red symbol represents the measured 1-hour PM_{10} concentration and the further the red symbol is located from the centre of the plot, the higher the concentration. The pollution rose show the highest 1-hour SO_2 concentrations occur under winds from the northwest to west-northwest. Under these wind conditions, emissions from the gas plant would not be blown towards Residence 14 and therefore cumulative impacts during these conditions, would not occur.

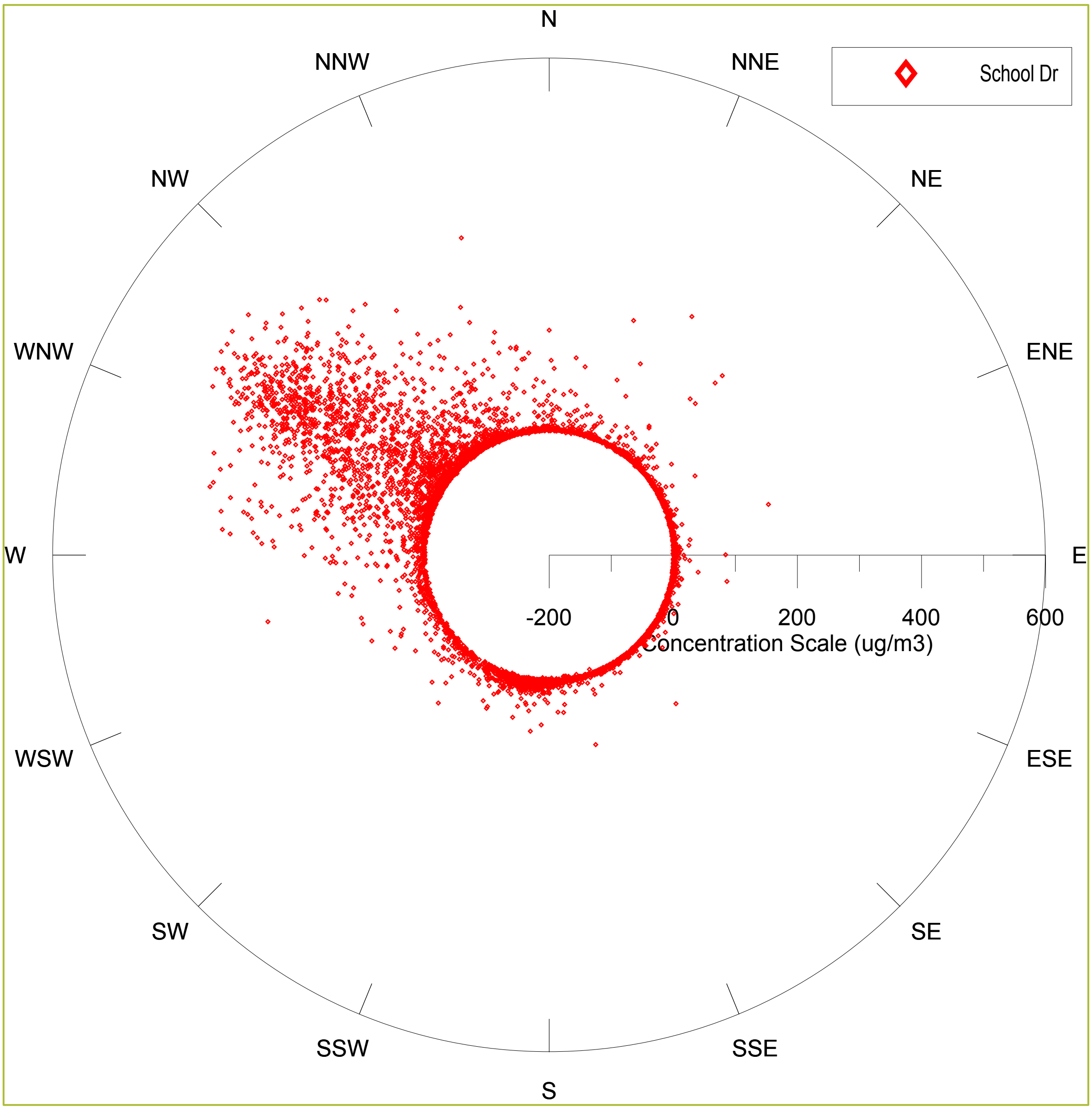


Figure A12.17: Pollution Rose for 1-hour SO_2 at School Drive with Wind Direction at TAC

The top 10 modelled (incremental) 24-hour SO_2 concentrations from NGSF predicted at Residence 14 with the corresponding background recorded for this day at School Drive (where available) are presented in **Table A12.4**. It is clear from this analysis that the addition of a minor incremental increase from the Gas Storage Facility, presents little or no risk in causing additional cumulative SO_2 impacts at this location.

Table A12.4: Top 10 incremental 24-hour SO_2 concentrations plus contemporaneous background for that day

Date	Background 24-hour SO_2 Concentration(µg/m^3)	Predicted Increment 24-hour SO_2 from project (µg/m^3)	Total (µg/m^3)	Goal
9/08/2010	8.6	0.1	8.7	288
22/02/2010	Not Measured	0.08	0.08	
23/01/2010	Not Measured	0.06	0.06	
10/05/2010	3.0	0.06	3.08	
2/01/2010	Not Measured	0.05	0.05	
9/01/2010	Not Measured	0.05	0.05	
17/06/2010	50.1	0.04	50.2	
21/03/2010	16.8	0.04	16.9	
12/02/2010	Not Measured	0.04	0.04	
19/03/2010	7.8	0.04	7.9	

This is further shown in a time series plot (**Figure A12.18**) of the background 24-hour SO_2 concentration recorded at School Drive site presented with the predicted increment from the NGSF stacked on top (black line). This is the minor contribution of the NGSF to existing levels.

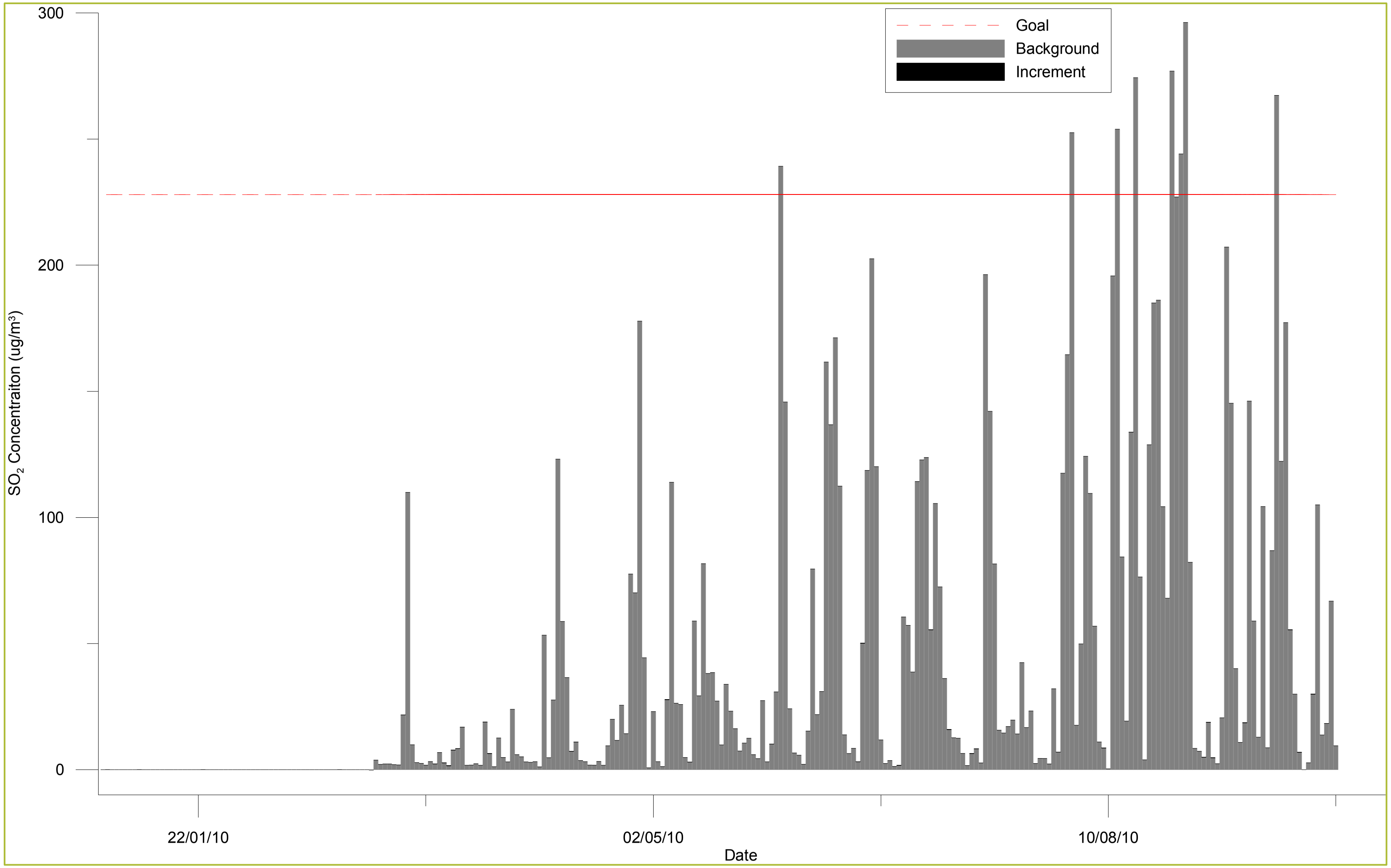


Figure A12.18: Cumulative 24-hour SO$_2$ at Residence 14 / School Drive Site