CLIENTS | PEOPLE | PERFORMANCE

Dyno Nobel Asia Pacific Limited

Moranbah Ammonium Nitrate Project

Air Quality Assessment

October 2006

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

Figure Index

Appendices

1. Introduction

1.1 Context

GHD Pty Ltd (GHD) were contracted on behalf of Dyno Nobel Asia Pacific Limited (DN) to conduct an assessment of emissions to air associated with the construction and operation of the proposed ammonium nitrate (AN), nitric acid (NA), ammonia, and emulsion manufacturing facility in Moranbah, Queensland, hereafter referred to as the project.

The project will service the growing demand for ammonium nitrate in explosives due to mining development in the region, and will produce up to 350 000 tonnes per annum of AN prill (solid) and AN emulsion (liquid). This report includes emissions produced on site by nine gas-fired internal combustion generators, which will produce electricity for the production process.

This technical report forms part of an EIS for the project and provides an assessment of the potential air quality impacts from the proposed facility on the surrounding sensitive receptors. It has been developed in accordance with the draft terms of reference for the project.

The base data for this assessment have been provided by DN and Caterpillar, the latter being the supplier of the power generation component of the project.

1.2 Assessment Methodology

The methodology adopted by GHD for the assessment of emissions to air from the project at Moranbah is summarised in the points below. Each of these points is described in greater detail in the subsequent sections of this report.

- Summary of proposed Project, including anticipated emissions characteristics and abatement technologies (Section 2);
- Identification of the legislative limits and guidelines applicable to this air assessment (Section 3);
- Investigation of the existing environment, in terms of sensitive receptors, local landuse and ambient air quality (Section 4);
- Meteorological modelling, in order to synthesise site representative data (Section 5);
- Atmospheric dispersion modelling of air quality impacts during both the construction and operation of the project. Dispersion modelling was also used to determine the necessary height of the electricity generator exhaust stacks. (Section 6);
- Assessment of predicted air quality impacts during construction and operational phases. (Section 7);
- Recommendations for the monitoring of operational compliance. (Section 8); and
- Conclusions (Section 9), drawn from the above assessment, and subject to the Scope and Limitations defined in Section 10.

2. Proposed Project Development

2.1 Description

DN is proposing to build an ammonium nitrate plant 4.5 km to the north west of the township of Moranbah, Queensland. The plant will produce up to 350 000 metric tonnes per annum of ammonium nitrate and will normally operate 24-hours per day for 365 days per year.

DN have commissioned GHD to undertake an air quality assessment of the project. The assessment will form part of an Environment Impact Statement (EIS).

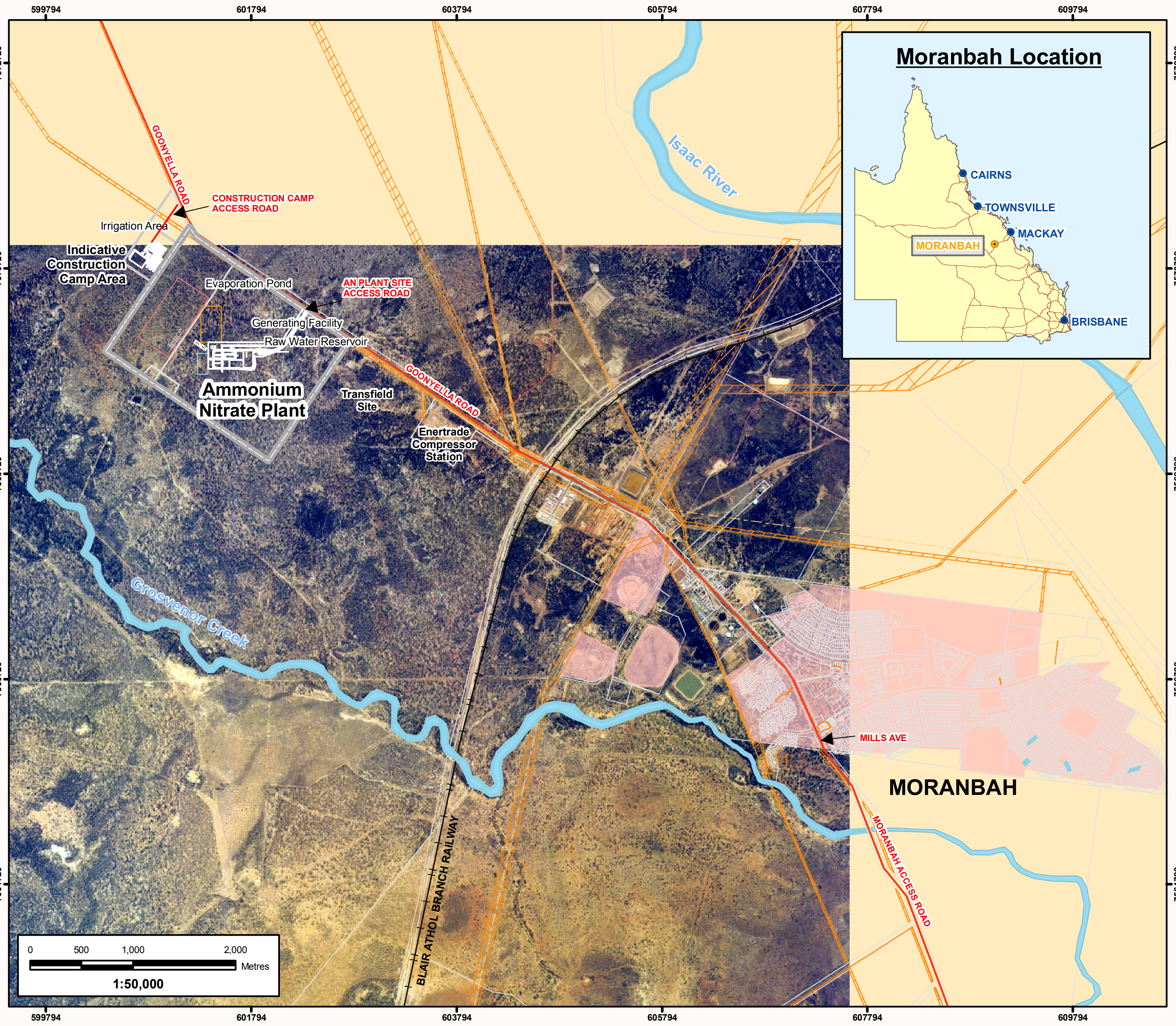
The four key components of the project are the:

1. Ammonia plant: Ammonia is produced from the methane in either natural or coal seam gas. The methane gas is processed in a steam reformer to extract hydrogen that is then combined with nitrogen extracted from the atmosphere, to produce ammonia.
2. Nitric Acid plant: Nitric Acid is produced by reacting ammonia and atmospheric air under high temperature and pressure. The ammonia is then oxidized to produce nitric oxide, then oxidized further to produce nitrogen dioxide. Nitric oxide, nitrogen dioxide, water and oxygen are then combined to form nitric acid.
3. Ammonium nitrate plant: Here the nitric acid and gaseous ammonia are combined to form a hot ammonium nitrate solution, which is then crystallized by spraying from the top of a 60 m tower, forming solid pellets (prill).
4. Base Load Power Plant: Electricity is generated from the methane in coal seam gas, which will be piped to the plant. Nine CAT 3520C lean-burn internal combustion engines will be installed for this purpose.

Figure 1 provides an aerial photograph of an existing AN plant in Moura, Queensland with the component plant areas indicated. Currently the Moura Plant has an annual AN production capacity of 180 000 tonne/annum, approximately half that of the proposed facility. A map of the proposed facility and surrounds is provided in Figure 3. A layout diagram of the proposed AN plant is provided in Fig 3.

Construction is scheduled to take place over a 22-month period with most of the construction activities expected to occur during the day (07:00-18:00) Monday to Saturday. The construction camp for the proposed AN Plant is located adjacent to the AN Plant site heading west along Goonyella Road. The construction camp is a temporary facility for housing of the construction workforce.

Figure 1: Existing QNP site, illustrating a comparable ammonium nitrate plant with main emission sources indicated



DYNO Dyno Nobel

N E S W

Date: 02-10-06 Rev C
Datum: GDA94 (MGA) Zone 55
Source: Base data sourced from the State of Queensland, Department of Natural Resources, Mines. All other infrastructure supplied by Dyno Nobel Asia Pacific Ltd.
File: G:\41\15824\GIS\Maps\Final\MXD\fig1_Site_Location_RevC.mxd

Legend

- Ammonium Nitrate Plant Site
- Evaporation Pond
- Generating Facility*
- Raw Water Reservior
- Cadastre
- Easements
- Developed Area
- Watercourse
- Major Road
- Railway
- Powerlines

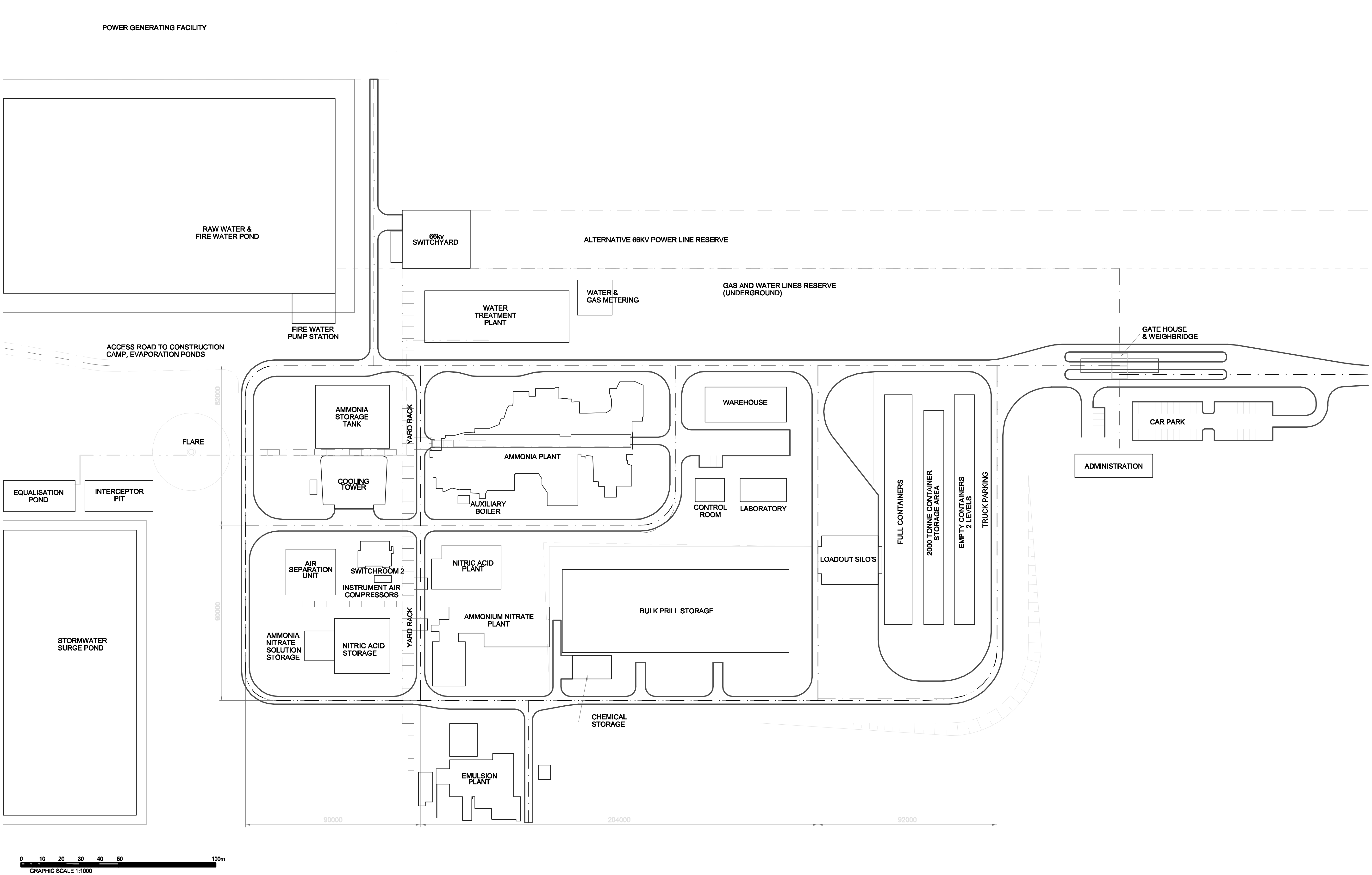
*Generating Facility location is subject to detailed engineering.

Moranbah Ammonium Nitrate Plant

Environmental Impact Statement

Figure 2 Site Location

GHD
CLIENTS | PEOPLE | PERFORMANCE



No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Checked	Approved	Date

Plot Date: 28 September, 2006 - 11:30 AM   Cad File No: G:\41\15824\CADD\Drawings\ 600001-272-3G71-0002_C_Blocks.dwg

GHD CLIENTS | PEOPLE | PERFORMANCE

Level 4, 201 Charlotte St Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001
T 61 7 3316 3000 F 61 7 3316 3333
E bnemail@ghd.com.au W www.ghd.com.au

DO NOT SCALE

Drawn	Michael Holton	Designed	
Drafting Check		Design Check	
Approved			
Date	27/09/06		
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

Client

Project **DYNO NOBEL AMMONIUM NITRATE COMPLEX**

Title **MORANBAH PLANT SITE PLANT ARRANGEMENT PLAN**

Figure 3

Original Size **A3**   **Drawing No:**   **Rev: A**

2.2 Anticipated Emissions

2.2.1 Construction Phase Emissions

During the construction of the project, it is anticipated that emissions to air will consist predominantly of particulates, originating from internal combustion engines, mechanical earth moving and wind erosion. Particulate emissions will be most intense during the 9-month period of earth works associated with site preparation and foundation construction. Construction, and associated emissions to air, will occur over an area of approximately 80 ha within the site boundary. Table 1, below, provides a summary of the construction emissions inventory for PM_{10} emission (particles with an effective diameter of less than 10 micrometres) derived by GHD for this assessment. Estimates were based on information obtained from DN's Initial Advice Statement[1] for the project. Note that the PM_{10} emission rate for mechanical activities is inclusive of both vehicle exhaust and crustal dust, and that estimates of emissions control have been applied where appropriate.

In the absence of site specific data, the assumption has been made that particulate emissions during the construction phase of the project will be 50% PM_{10}. Emission rates for Total Suspended Particulates (TSP) are, therefore, estimated as being double the emission rates quoted in Table 1.

Table 1 Construction Phase Emissions Inventory for PM_{10} Dust

Process	PM_{10} Emission Rate[2,3]	Basis and Assumptions
Excavator / Shovel / Front-End Loader	0.15 g/sec, 11 hr/day	Screening level of 0.012 kg PM_{10} per ton of material dumped. Assumed 500 tonne dumped per day.
Grader	0.69 g/sec, 11 hr/day	Screening level of 0.4 kg/Vkt, with average speed of 25 km/hr, 11 hours per day, active 25% of the time on-site.
Bulldozer	0.56 g/sec, 11 hr/day	Screening level of 4 kg/hour/dozer PM_{10}, two dozers, 11 hours per day.
Dump Trucks	0.34 g/sec, 11 hr/day	Screening level of 0.4 kg/Vkt, with average speed of 25 km/hr, two dump trucks, 11 hours per day, Level 2 watering (75% control), vehicle active 25% of the time on-site.
Wind Erosion	0.19 g/sec, all time	Screening level of 0.2 kg/ha/day PM_{10}, 80 ha of disturbed soil.

[1] *Initial Advice Statement For Moranbah Ammonium Nitrate Project,* Dyno Nobel Asia Pacific Limited, March 2006

[2] *Particulate Matter and Mining (Interim Report)*, NSW Minerals Council and Holmes Air Sciences, July 2000.

[3] *Emission Estimation Technique Manual for Mining*, Ver. 2.1, National Pollutant Inventory, October 2000, Commonwealth of Australia.

2.2.2 Operational Phase Emissions

There are twelve points of release of emissions to air from the project, these are:

- The Ammonium Nitrate Plant Vent (Prill Tower Vent) (x1);
- The Nitric Acid Vent (NA Vent) (x1);
- The Reformer Furnace (RF) (x1); and
- The Electricity Generators (x9).

Anticipated emission species of concern from these release points fall into two categories: particulate matter and nitrogen dioxide (NO_2).

Note that the draft Terms of Reference for the project acknowledge that AN plants of this type do not generate any significant odour, and, they state that no special odour assessment is required in the EIS.

In addition, DN has stated that the coal seam methane, which will be the primary resource consumed by the project and power station, is (at present) free of sulphur and will not be a source of odourous or Sulphur Dioxide emissions to air, either prior to or following combustion. A sulphur free gas is required to avoid catalyst poisoning; gasses for AN production which contain sulphur have the sulphur removed prior to use.

<u>PARTICULATES</u>

Particulate matter emissions are expected to occur from the Prill Tower and the electricity generators.

Prill Tower particulate emissions will consist of crystalline Ammonium Nitrate. A bag filter will be fitted to the Prill Tower, which, for all practical purposes, will abate the emission to air of particles above 10 micrometres in diameter. As such, the assumption was made that all particulate emissions from the Prill Tower will be less than 10 micrometres in diameter (PM_{10}).

Particulate emissions from the generators, on the other hand, will consist entirely of combustion particles, the majority of which will fall into the PM_{10} size category. It was, therefore assumed that all particulate emissions from the generators will be PM_{10}.

These two assumptions add a degree of conservatism to model predictions of both ground level PM_{10} concentration and the deposition of AN particulates.

The potential for the project to generate a dust nuisance during operation will be addressed by the Environmental Management Plan (EMP) for the facility and will, given the correct implementation of the EMP, be minimal. (See Section 2.3.2)

NITROGEN DIOXIDE (NO_2)

Emissions of Oxides of Nitrogen (NO_x) are expected to occur from the NA Vent, the Reformer Furnace and the electricity generators. NO_x consists of two components, Nitrogen Monoxide (NO) and Nitrogen Dioxide (NO_2), the latter of which is of relevance to his assessment.

In the case of NO_2 emissions from the NA Vent and Reformer Furnace stacks, DN provided GHD with a total mass emission rate for NO_x. This NO_x emission rate was converted by GHD to a NO_2 emission rate through the conservative assumption that NO_2 will constitute 30% of all NO_x emissions at the point of release.

In the case of NO_2 emissions from the electricity generators, however, Caterpillar provided GHD with a mass emission rate for NO_x, expressed as being the equivalent emission rate if 100% of NO_x emission were emitted as NO_2. However, exhaust from gas fired internal combustion engines of this nature typically has a NO_2/NO_x ratio of approximately 0.3 (30%)[4]. Given that NO has an atomic mass of approximately 2/3 that of NO_2, GHD calculated an appropriate mass emission rate for NO_2. To accommodate for uncertainties in the source data, a safety factor of 10% was added to the calculated rate.

Table 2 summarises the characteristics of the proposed emissions sources, as based on information provided by DN Asia Pacific Ltd. and Caterpillar (included in Appendix A).

WORST-CASE EMISSIONS TO AIR

Air quality assessments must take into consideration 'worst case' emissions to air that will arise during the operational phase of industrial facilities. Such emission scenarios typically occur during plant start up, shut down or recognised upset conditions. In the case of the project, correspondence between GHD and DN has indicated that:

> *"Emissions will not be higher at start-up and shutdown than during operation. Indeed, at start-up, scrubbing will be started before prilling and, at shutdown, prilling will be stopped before scrubbing. Higher emissions could be due to non-regulated prilling with superheating of AN solution leading to fumes and submicron particles formation (in general, that is the result of process control loss by operators). For preventing this case, there is a margin in the scrubber recirculation flow (flooding) and the solution is maintained slightly acidic for neutralizing ammonia emissions."*

DN has also indicated that the risk of process upset due to inconsistent feedstock composition will be mitigated by a policy of plant shutdown should operating conditions deviate from those required. In addition, DN has indicated that the feedstock for the AN plant process and power plant are known to be of adequately consistent composition to further mitigate the risk of upset conditions.

With regards to 'worst case' emissions to air from the power plant, it is anticipated that, being a base load facility, the generators will be run for 24 hours a day, 7 days a week. As such, peaks in emissions to air will be limited to periods of mechanical malfunction

[4] Determined through correspondance with manufacutruers of simalar engines to those proposed – Wartsila and Jenbacher.

and associated shutdown and startup periods. Such events are likely to occur on a sporadic and infrequent basis.

In response to this information, GHD opted to model emissions to air from the project at emission rates which are representative of everyday operation at forecast rated production (as provided by DN) and 100% generator load. (See Appendix A). The possibility of upset conditions (with a subsequent increase in emission rates) is not practically quantifiable. As such, the potential for 'worst case' emissions from the project and power plant was assessed in terms of the safety margin between predicted impacts (based on routine source emission rates) and EPP(Air) air quality goals.

Table 2 Proposed Emissions Source Characteristics

Parameter	Units	Proposed AN Plant			
		Prill Tower	NA Vent	RF	Generators (Per Exhaust Vent)
Approximate Location (GDA 94 Z55)	m	601814E, 7569878N	601814E, 7569878N	601712E, 7569784N	601865E, 7570208N (approx.)
Stack Height	m	65	65	30	**15**[1]
Exit Temperature	°C	45	127	127	457
Stack Diameter	m	2	1.05	1.3	0.5
Volumetric Flow Rate	Nm^3/s	48.91	27.74	15.94	2.63[2]
Exit Velocity	m/s	16.2	35.5	19.6	13.0
PM_{10} Emission Rate	g/s	1.85	0	0	0.02
NO_2 Emission Rate	g/s	0	0.855	1.281	0.316

1: Note that this height, determined by GHD through dispersion modelling (See Section 6), is the minimum height required in order to achieve compliance with the relevant air quality goals (See Section 3).

2: Equates to 9480 Nm^3/hr. The conversion from the flow rate quoted in Appendix B to the flow rate utilised in modelling was based on an engine power output of 2016 kw, and the worst case flow rate from several different versions of the CAT 3250C engine.

2.3 Proposed Emissions Abatement Methods

2.3.1 Construction Phase Emissions Abatement

It is anticipated that construction phase abatement of PM_{10} emissions will include such options as:

» Prompt mitigation of visible dust emissions through the application of water sprays, taking into consideration approaching weather systems and targeting areas of frequent traffic and/or unconsolidated soil;

» Defined and controlled transport routes and areas; and

» Revegetation.

Additional measures are incorporated in the draft of the Environmental Management Plan for the project.

2.3.2 Operational Phase Emissions Abatement

<u>ABATEMENT THROUGH TECHNOLOGY</u>

At the time of preparation of this report, information pertaining to the proposed emissions abatement technologies has only been obtainable for the Nitric Acid Vent. The specific abatement technology to be utilised at the NA Vent is Selective Catalytic Reduction (SCR), which, utilises a small amount of ammonia as a reducing agent and is capable of removing up to 90% of NO_x from the exhaust stream.

<u>ABATEMENT THROUGH MANAGEMENT</u>

The draft Integrated Environmental Management System (IEMS) for the existing AN plant at Moura, Queensland, outlines the following strategy for the minimisation of emissions to air[5]. It is anticipated that the IEMS for the Moranbah Facility will be similar.

> *"The main air emissions associated with an ammonium nitrate plant during operation are ammonium nitrate particulates, nitrogen oxides (NO_x) and carbon dioxide. These will be minimised by:*
>
> » *adopting a philosophy of recycling exhaust emissions, where practicable;*
>
> » *design and installation of quality equipment;*
>
> » *use of suitable materials, gaskets and sealing;*
>
> » *design of stack heights and discharge velocities to ensure that ground level concentrations under the most difficult weather conditions meet all statutory requirements;*
>
> » *all contaminants leaving the prilling tower will be treated in a counter current flow scrubber and excess air from the scrubber will be passed on to a wet cyclone washing tower;*
>
> » *regular inspection of all valves and fittings;*
>
> » *setting up work practices and procedures to ensure that fugitive emissions are minimised e.g. degas process pipelines before they are opened for maintenance;*
>
> » *covering of loads and the sealing of access roads will minimise any potential dust generation in relation to the proposed plant; and*

[5] Queensland Nitrates Pty. Ltd – Draft Integrated Environmental Management System, Supporting Document for QEPA Integrated Liscence Application. March 1999.

- *any dust emissions from final product storage stock piles will be contained within the Final Product Storage Building."*

3. Assessment Criteria

The Queensland Environmental Protection (Air) Policy of 1997, hereafter referred to as the EPP(Air), contains a list of air quality goals (to be used as design criteria), which nominate the maximum allowable levels for atmospheric contaminants (air quality indicators), applicable at all locations outside the site boundary. The impacts of emissions to air from the project, as predicted using atmospheric dispersion modelling, are assessed against the EPP(Air) air quality goals.

The draft Terms of Reference for the project require that proposed and/or modelled levels of emissions to air be compared against the 1997 National Environmental Protection Measure (Ambient Air Quality), referred to hereafter as the NEPM(Air). The NEPM(Air) defines a number of air quality goals for the airshed in which the project is to be located. These goals are designed for the assessment of existing ambient air quality via monitoring and are not directly applicable to the assessment of predicted air quality impacts from an individual industrial emitter. They are, however, commonly taken into consideration as guideline levels at areas of significant population, in this case, the Moranbah township.

The draft terms of reference calls for comparison between anticipated in-stack concentrations and the NHMRC Guidelines for Control of Emissions from New Stationary Sources[6]. These guidelines were rescinded by the NHMRC in February 2000 and are, therefore, no longer applicable to the assessment of new stationary sources. The comparison has, however, been conducted and is described in Section 8.

As identified in Section 2.2, anticipated emissions to air from the project will be in the form of particulates (assumed to be 100% PM_{10}) and NO_2, both of which are classified by the EPP(Air) as air quality indicators. Table 3 displays the EPP(Air) and NEPM(Air) air quality goals pertinent to these air quality indicators.

[6] *National Guidelines for Control of Emsissions from new Stationary Sources.* National Health and Medical Research Council (NHMRC). 1985. **Rescinded 29/02/2000**

Table 3 EPP(Air) and NEPM(Air) Air Quality Goals

	Air Quality Indicator	Air Quality Goal [1]	Averaging Time	Allowable Exceedences
EPP(Air)	NO_2	320 µg/m³	1-hour	9 hours per year[2]
	NO_2[3]	95 µg/m³	4-hours	0
	NO_2[3]	30 µg/m³	1-year	0
	PM_{10}	150 µg/m³	24-hours	0
	PM_{10}	50 µg/m³	1-year	0
	Total Deposited Nitrogen[3, 4]	3 gm/m²	1-year	0
	TSP[5]	90	1-year	0
NEPM(Air)	NO_2	246 µg/m³	1-hour	1 day per year
	NO_2	62 µg/m³	1-year	0
	$PM_{2.5}$	25 µg/m³	24-hours	0
	$PM_{2.5}$	8 µg/m³	1-year	0
	PM_{10}	50 µg/m³	24-hours	5 days per year

1: Inclusive of existing background concentration.

2: Note that for 1-hour averages, the predicted 99.9th percentile concentration is accepted as being the predicted maximum, an accommodation that is made to account for modelling anomalies and the potential for spurious input data.

3: Indicator relevant to biological integrity.

4: All Total Deposited Nitrogen attributable to operation of the project is expected to be in the form of PM_{10} AN particulates. AN is 35% Nitrogen.

5: Applicable only to the Construction phase, since all operational phase particulate emissions will be less than 10 micrometres in diameter.

4. Existing Environment

4.1 Sensitive Receptors

Sensitive receptors are generally defined as residential areas, hospitals, schools, caravan parks and other similar land uses where people are present for an extended period of time, except in the course of their employment or leisure.

There are a number of sensitive receptors in the vicinity of the project. These are predominantly located at the township of Moranbah, 4.5 km south east of site. The majority of these receptors are urban residences, however, the township also has three schools and a hospital. The location of the town relative to the project can be seen in Figure 2. In addition, there is a small cluster of temporary miner's accommodation residences located approximately mid way between the project and the township.

4.2 Local Landuse

The project site has an elevation of approximately 260 m above sea level (mASL). Within an arbitrary 10 km radius of the site, the terrain is predominantly flat. There are, however, a number of low-lying ranges of hills approximately 15 km to the north east and south west of site.

With the exception of the township, local land use is agricultural, being predominantly perennial pasture. Local industry includes agriculture and the existing Ergon peaking power station (See Figure 2). In addition, there are a number of active open-cut coal mines in operation approximately 20 km north of site.

There are two waterways within 6 km of the proposed site, the Isaac River to the northeast and Grosvenor Creek, to the southwest.

4.3 Existing Emission Sources and Ambient Air Quality

As explained in Section 2.2, the anticipated emissions to air of concern from the project include PM_{10} and NO_2. Existing local sources of both of these air quality indicators are primarily associated with combustion and include local vehicular traffic and the sporadic operation of the Ergon peaking power station. Further local emissions of PM_{10} dust (specifically, crustal dust) are likely to result from wind erosion and mechanical generation through agricultural activity. On a regional scale, coal mining activity is likely to be another source of PM_{10}. However, given the predominant south easterly winds at Moranbah (See Section 5.3.2), and given that the coal mines are located 20 km to the north west, such activities are not likely to significantly impact local air quality at Moranbah.

There are currently no known records of air quality for the Moranbah area. However, in order to produce a conservative estimate of existing air quality, data from areas that are more urbanised and industrially intensive than Moranbah have been used.

The 2005 EPA Queensland annual summary of ambient air quality monitoring[7] contains ambient air quality data recorded at a number of Queensland locations. NO_2 data from three different locations in urban Brisbane were utilised, whereas, PM_{10} data were taken from a monitoring station located in West Mackay. For both NO_2 and PM_{10}, the maximum documented values are conservatively assumed to be representative of typical conditions at Moranbah. Table 4 summarises the adopted representative data.

Table 4 Ambient Air Quality, Adopted Concentrations

Air Quality Indicator	Concentration (µg/m^3)	Averaging Time	Location of Measurements
NO_2	49.3	1-hour	Brisbane
NO_2	46.2	4-hours	Brisbane
NO_2	19.6	1-year	Brisbane
PM_{10}	45.3	24-hours	West Mackay
PM_{10}	20.6	1-year	West Mackay

4.4 Available Meteorological Data

The simulation of air quality impacts resulting from emissions to air from the project requires the use of a meteorological data set containing hourly data spanning a year. Ideally, much of these data would be obtained from on-site observations. Such observations are, however, not available for the proposed site. In such situations, recorded data from another, representative location may be used. Data are deemed to be representative if the meteorological trends, surrounding land uses and topographic features for the site of interest are similar to, or are expected to be similar to, those of the site at which the data were recorded. Where site-representative meteorological data are not available, or are not of suitable temporal resolution or extent for dispersion modelling, the alternative is to synthesise meteorological data for the site using prognostic 3D meteorological modelling.

[7] Ambient Air Quality Monitoring in Queensland – 2004 Annual Summary and Trend Report – EPA QLD. 2005.

The nearest available meteorological observations to the proposed plant site are recorded on a 3-hourly basis at the Moranbah Waste Water Treatment Plant (WWTP) approximately 4 km to the south east. Recorded parameters include wind direction, wind speed, temperature and relative humidity. Given the proximity of the WWTP to the proposed site, and given that the intervening terrain is flat and the surrounding land uses are similar, the recorded data are deemed to be site representative. However, because the data are recorded on a 3-hourly rather than 1-hourly basis, they are not suitable for inclusion in dispersion modelling.

Consequently, GHD opted to utilise a regional-scale prognostic meteorological model, TAPM, to simulate the climate over the proposed site. The observations from the WWTP were used for model calibration and validation purposes. TAPM was used to produce representative hourly surface meteorological data at the proposed site. This information, in conjunction with the determined source characteristics and emissions inventory, was later used with the AUSPLUME dispersion model, to assess the impacts of emissions on the surrounding land uses. The use of TAPM to generate site representative meteorology has been previously accepted at numerous Australian sites for regulatory purposes, and its configuration and use are described below.

5. Meteorological Modelling

5.1 TAPM

TAPM (V 3.0.6) was developed at CSIRO Division of Atmospheric Research and is a PC-based prognostic modelling system that can predict regional scale 3D meteorology. It is suitable for use with complex geographic sites and/or for situations when the available site representative meteorological data are not adequate (as is the case for this assessment). TAPM accesses databases of synoptic weather analyses from the Bureau of Meteorology (BoM). The model then provides the link between the synoptic large-scale flows and local climatology, which, in this case, includes such factors as local land use, topography, atmospheric stability and mixing height.

5.2 Model Configuration and Use

TAPM was initially configured with a nested model grid coverage designed to capture:

- The location of the project;
- Broad scale synoptic flows;
- Regional to local scale land breezes and wind channelling; and
- The influence of local land use.

The nested grids were then configured with surface characteristics, such as terrain elevation, surface type (land use and vegetation type), soil type and deep soil moisture content. The terrain elevation data, at a 9-second (250 – 300 m) resolution, were obtained from AusLig. The categorized vegetation / land use and soil type information was input from the default US Geological Survey Dataset provided with the model and was adjusted based upon information obtained during a site visit by GHD staff, from an aerial photograph and from a regional topographic map. The BoM synoptic analyses for the year 2004 were used.

Specific model settings were as follows:

- Four nested grids at 1 000 m, 2 000 m, 6 000 m and 24 000 m resolution, with 45 x 45 grid points;
- Deep soil volumetric moisture content was initially set as default, although was later reduced slightly for model calibration purposes; and
- Air sea temperature differences were set at default values.

Surface vegetation and precipitation processes were included, whereas, snow and non-hydrostatic processes were not included.

Following a trial model run, model output was compared with data recorded at the WWTP. Specifically, the predicted mean temperature for each month and the annual wind rose were compared with corresponding recordings. Subsequent to this comparison, the deep soil volumetric moisture content was reduced slightly so as to increase predicted ambient temperatures and, thereby, improve TAPM's simulation of the surface energy balance. Additionally, the nested grids were expanded in order to better capture the effect of broad scale wind channelling.

5.3 TAPM Synthesised Met Data

As previously mentioned, the simulation of air quality impacts resulting from emissions to air from the project required the use of a meteorological data set containing hourly data spanning a year. More specifically, the required hourly meteorological data includes: air temperature (ºC), wind speed (m/s), wind direction (degrees), atmospheric stability (Pasquill stability class) and mixing height (m). Hourly varying predictions of each of these parameters were extracted from the broad three-dimensional simulation for a location over Moranbah. These predictions were then subjected to quality assurance procedures prior to use with the AUSPLUME dispersion model. This section describes the trends exhibited by each of the predicted parameters.

5.3.1 Air Temperature

Figure 3 shows the mean temperature at 3:00 pm for each month, as predicted by TAPM and recorded by the Bureau of Meteorology at the Moranbah WWTP. The comparison between the predicted and recorded data is favourable and demonstrates only marginal (less than 5%) under-prediction across all months. The seasonal trend of the data is typical of the region, showing a fluctuation between approximately 34ºC and 23ºC for summer and winter months respectively. The strong correlation between predicted and recorded temperature indicates that the model is accurately calculating the surface energy balance, which, in turn, adds confidence to the predictions made for atmospheric stability.

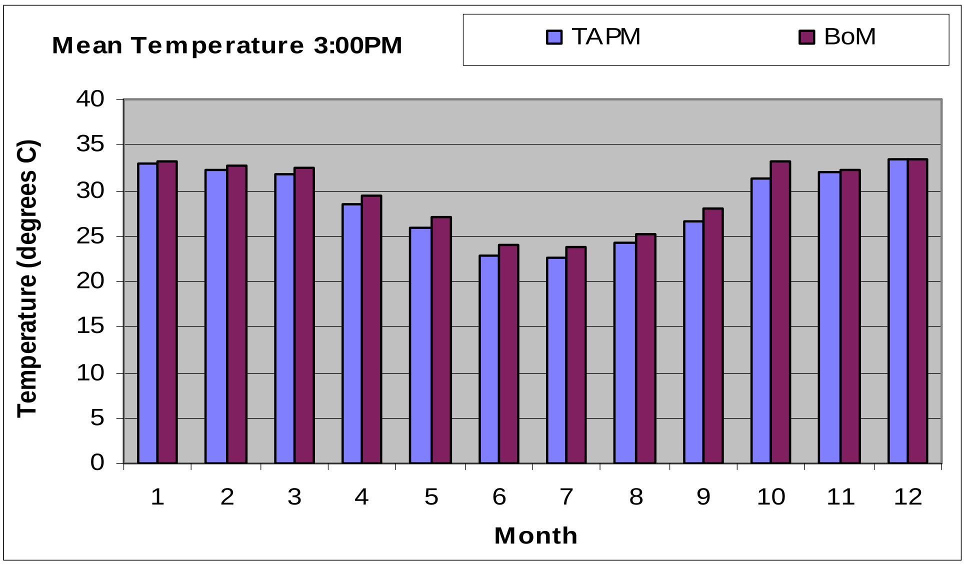


Figure 4: Monthly Average 3:00 pm Temperature at Moranbah, as predicted using TAPM and recorded by the BoM

5.3.2 Wind Distribution

The TAPM predicted annual average wind speed for Moranbah is 3.08 m/s. The predicted annual wind rose for Moranbah (Figure 4) shows a strong predominance of east-south-easterly winds. This is indicative of the influence of synoptic scale flow, which has an easterly prevalence at the latitude of the site. Local to regional scale wind channelling, between the Denham and Kerlong ranges, acts to enhance this predominance.

Figure 5, which provides a seasonal breakdown of the predicted wind distribution at Moranbah, reveals a north easterly predominance during summer and spring and a south easterly predominance during winter and autumn. This shift in predominance is caused by the differences in synoptic scale trends between the seasons, a result of the annual north-south oscillation of global circulation patterns caused by the tilt of the earth's axis.

For the purpose of comparison, Figures 6 and 7 show the predicted and recorded wind roses (respectively) at 6:00 am, 9:00 am and 3:00 pm. The directional distribution of winds predicted by TAPM shows a strong concordance with the recorded observations. However, a consistent, although marginal, under prediction in the frequency of light winds can be noted. This marginal under prediction is, for this application, beneficial, as it adds a degree of conservatism to the predictions made by the AUSPLUME dispersion model. As explained in later sections, the high impacts associated with emissions to air from a non-wake effected stack sources (such as those proposed for the AN plant) can occur during neutral atmospheric conditions, which, in turn, are often associated with moderate to high wind speeds.

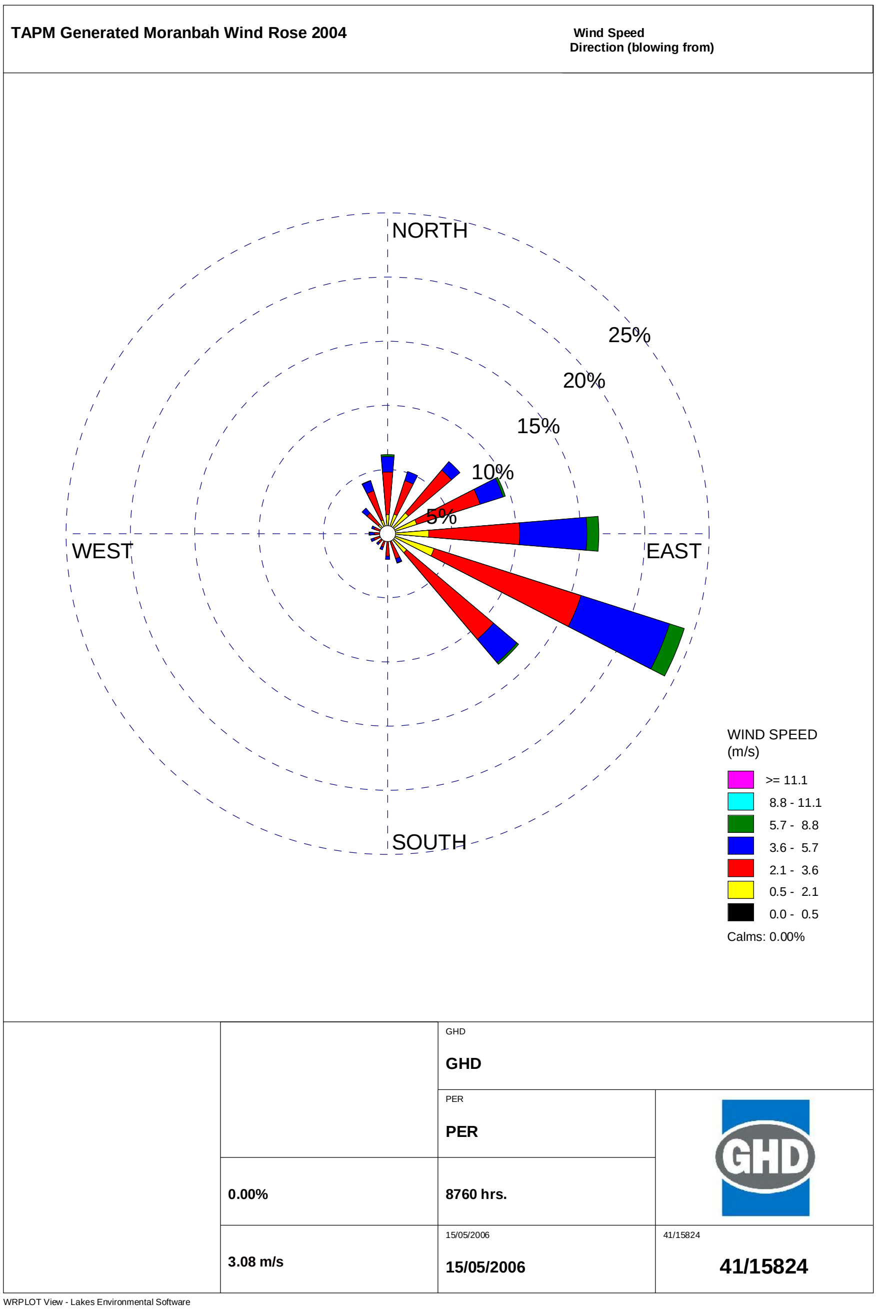
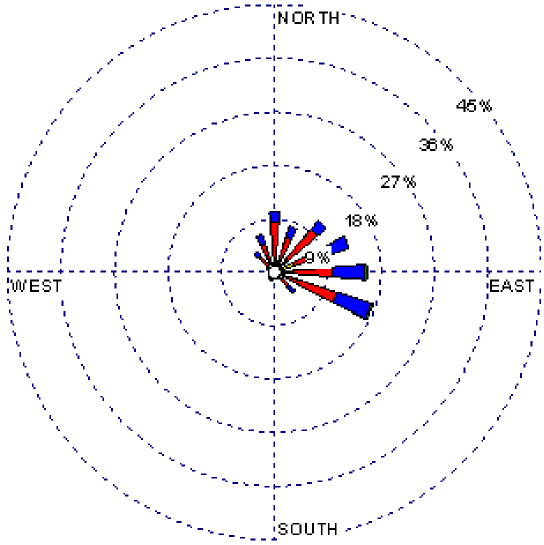
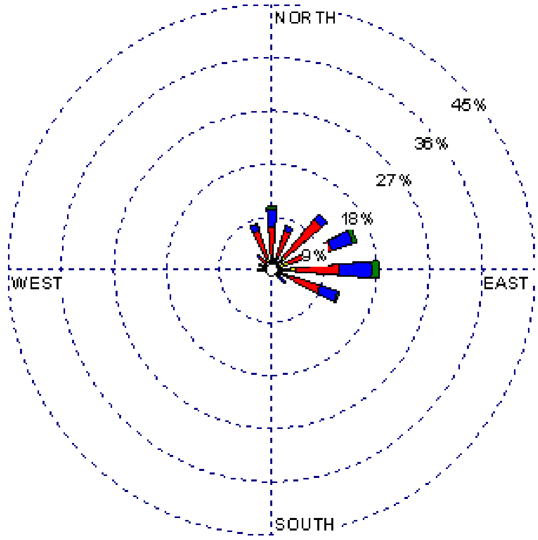
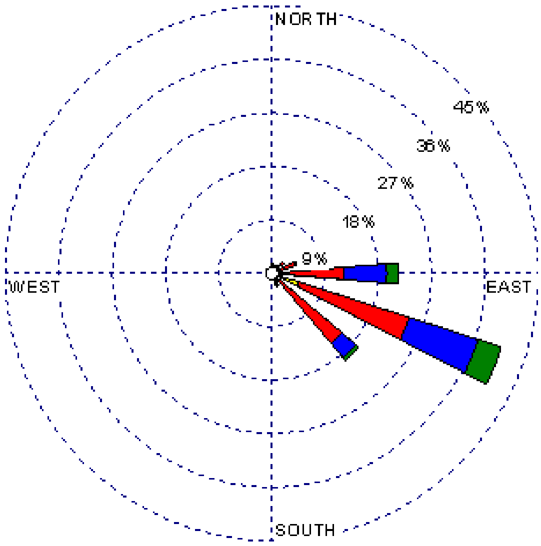
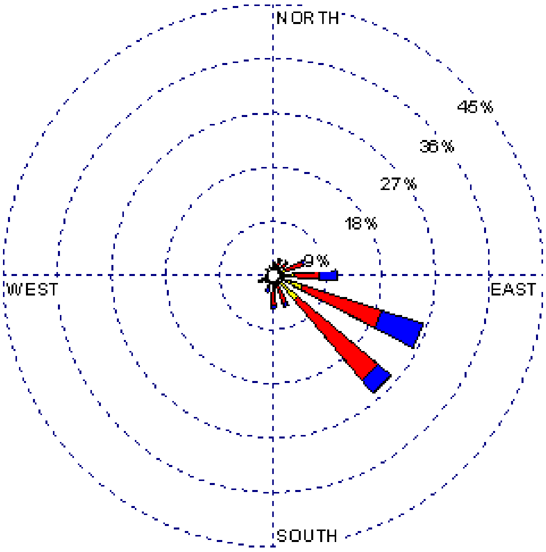


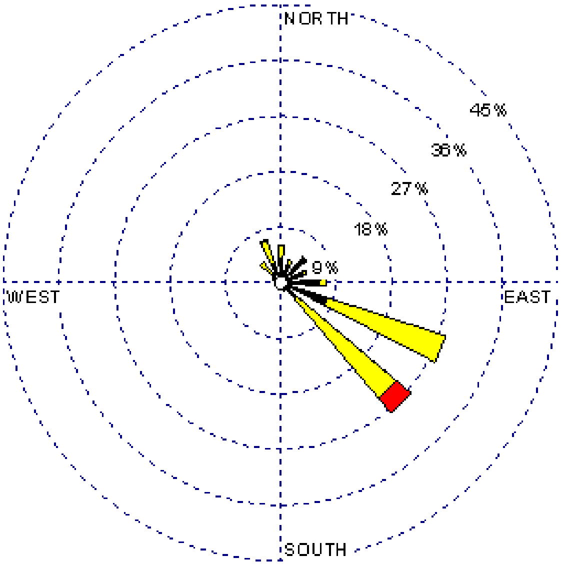
Figure 5: TAPM Synthesised Annual Wind Rose, Moranbah 2004

Figure 6: TAPM Synthesised Seasonal Wind Roses, Moranbah 2004	
Spring	**Summer**
	
Autumn	**Winter**
	

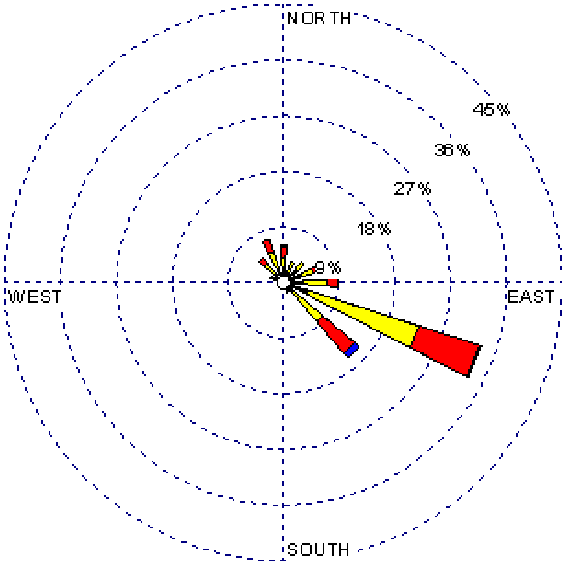
Legend	Comments:	
WIND SPEED (m/s) >= 11.1 8.8 - 11.1 5.7 - 8.8 3.6 - 5.7 2.1 - 3.6 0.5 - 2.1 0.0 - 0.5	Project No.: **41/15824**	CLIENTS | PEOPLE | PERFORMANCE

Figure 7: TAPM Moranbah 2004 Wind Roses 0600, 0900, 1500 (0.5 m/s threshold)

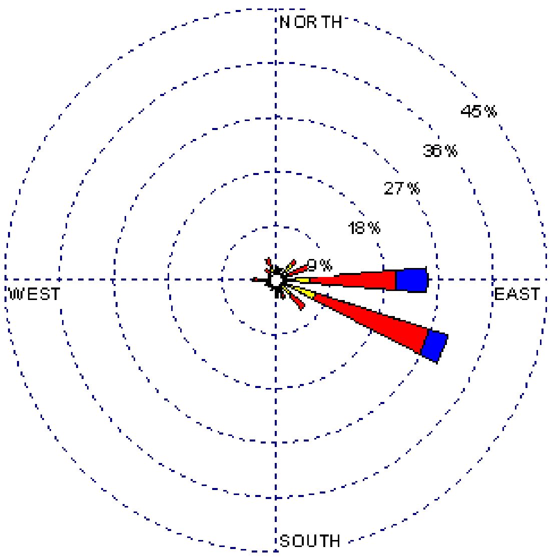
0600



0900



1500



WIND SPEED (m/s)

- >= 11.1
- 8.8 - 11.1
- 5.7 - 8.8
- 3.6 - 5.7
- 2.1 - 3.6
- 0.5 - 2.1

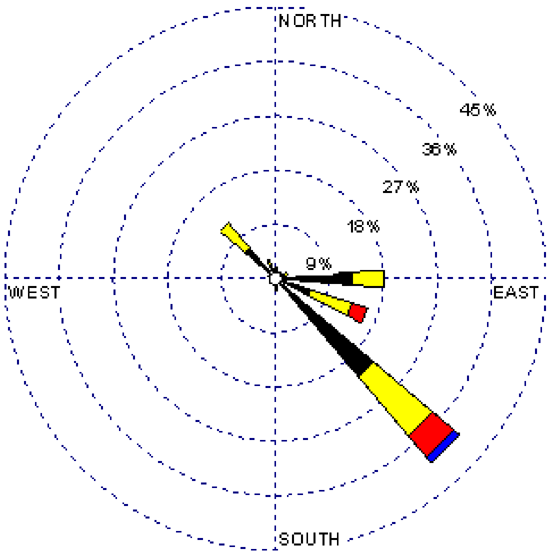
CLIENTS | PEOPLE | PERFORMANCE

Project No:

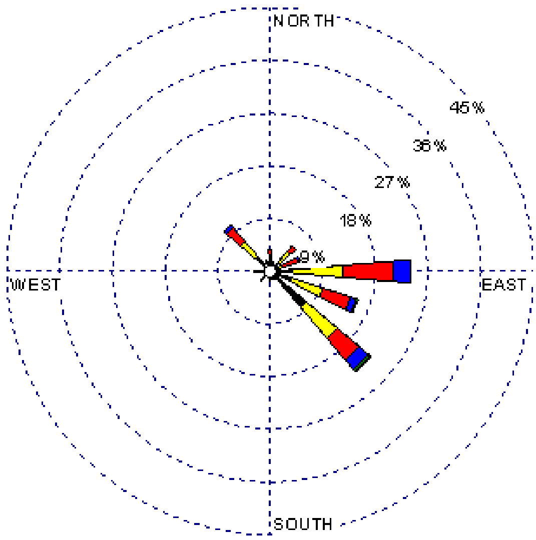
41 / 15824

Figure 8: BoM Moranbah 2004 Wind Roses 0600, 0900, 1500 (0.5 m/s threshold)

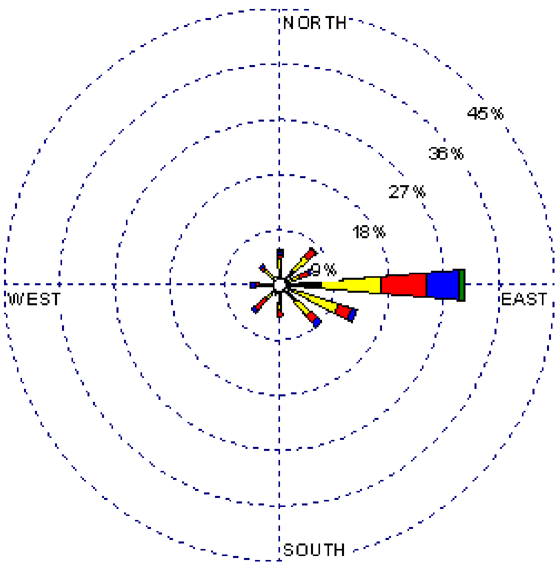
0600

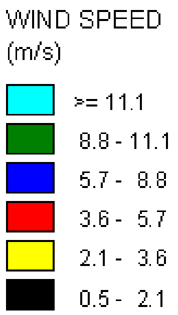


0900



1500





CLIENTS | PEOPLE | PERFORMANCE

Project No:

41 / 15824

5.3.3 Atmospheric Stability

Dispersion modelling requires hourly varying atmospheric stability data, represented as a time series of Pasquill stability categories. Each of these categories can be broadly defined as follows:

- » Stability Category A: Extremely unstable atmospheric conditions, occurring near the middle of day, with very light winds, no significant cloud;
- » Stability Category B: Moderately unstable atmospheric conditions occurring during mid-morning/mid-afternoon with light winds or very light winds with significant cloud;
- » Stability Category C: Slightly unstable atmospheric conditions occurring during early morning/late afternoon with moderate winds or lighter winds with significant cloud;
- » Stability Category D: Neutral atmospheric conditions, occurring during the day or night with stronger winds. Or during periods of total cloud cover, or during the twilight period;
- » Stability Category E: Slightly stable atmospheric conditions occurring during the night-time with significant cloud and/or moderate winds; and
- » Stability Category F: Moderately stable atmospheric conditions occurring during the night-time with no significant cloud and light winds.

The occurrence of unstable and neutral air flows are of significance as these generally provide the conditions for the highest ground level concentrations due to emissions to air from elevated stack sources. This impact may be due to one of two phenomena: looping (whereby a plume may be brought to ground level by large-scale vertical turbulence in an unstable atmosphere) or, reflection (whereby a capping inversion, associated with a low mixing height, and a neutral lower atmosphere can reflect a plume downwards).

Table 5 illustrates the diurnal distribution of Pasquil stability categories for the 365 days of the TAPM synthesised meteorological data. As expected, stable conditions occur at night, which for this location generally occurs between approximately 7 pm and 7 am. Neutral conditions peak during the transitional twilight periods. Unstable conditions peak around the middle of the day when solar radiation and subsequent thermal convection are high. Stable conditions occur frequently, a result of the relatively low average wind speeds at Moranbah during 2004.

Table 5 TAPM Synthesised Stability Category Distribution

	Pasquill Stability Category					
Hour	**A**	**B**	**C**	**D**	**E**	**F**
1				11	110	244
2				17	127	221
3				20	154	191
4				26	167	172
5				39	161	165
6				184	63	118
7			57	308		
8		95	151	119		
9	44	205	112	4		
10	92	203	67	3		
11	106	162	87	10		
12	92	149	108	16		
13	103	129	115	18		
14	88	136	117	24		
15	45	176	118	26		
16	11	134	189	31		
17		31	176	158		
18			21	344		
19				153	30	182
20				4	81	280
21				10	62	293
22				9	57	299
23				8	57	300
24				10	84	271
Count	581	1420	1318	1552	1153	2736
Prop. %	6.63%	16.21%	15.05%	17.72%	13.16%	31.23%

5.3.4 Mixing Height

Mixing height influences the extent and behaviour of vertical plume dispersion. As mentioned above, low mixing heights can result in a downward reflection of a plume and subsequent elevated ground level pollutant concentrations nearby the site. Such events are consequent to unstable or neutral atmospheric conditions, which occur during the day and early morning (respectively). Note, however, that mixing height approaching or set below the stack height can act to 'loft' the plume, preventing it from mixing to ground level. Conversely, high mixing heights allow vertical dispersion of a plume, resulting in reduced impact at ground level. The minimum mixing height has, therefore, been set to 85 m in order to ensure the conservatism of atmospheric dispersion modelling by under estimating the effect of plume lofting. Figure 8 below shows the distribution of predicted mixing height. Low mixing heights, between 100 and 250 m are common. Figure 9 shows the diurnal distribution of the average predicted mixing height. This distribution is concordant with meteorological theory in that the mixing height is consistently low during the night, at its lowest during dawn and dusk transition hours and is at its maximum during the afternoon. This concordance adds weight to the validity of the TAPM predictions.

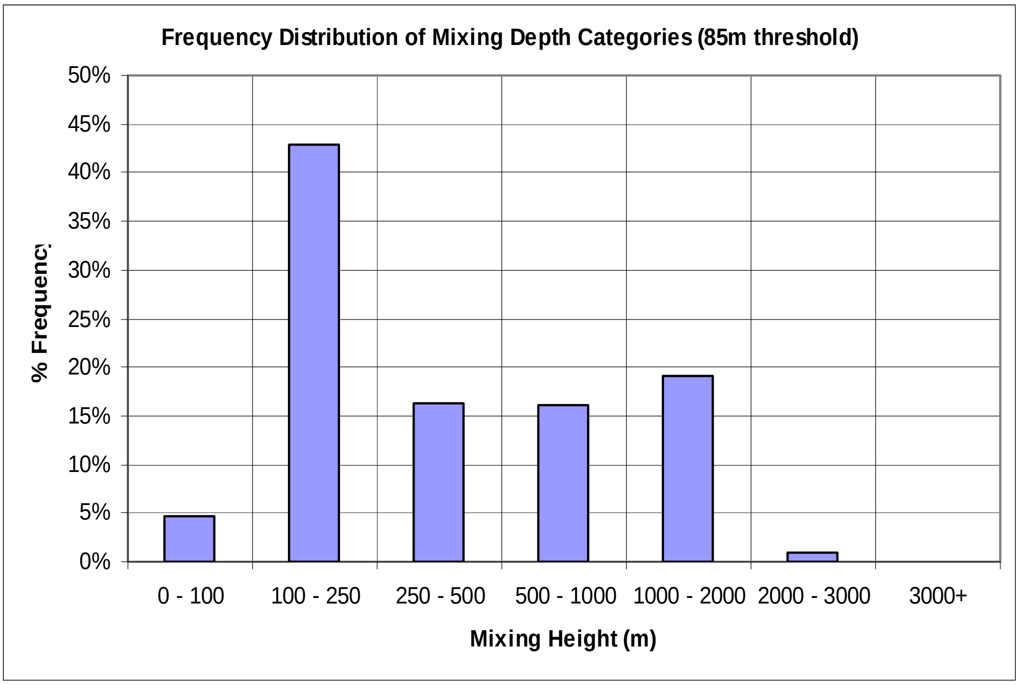


Figure 9: TAPM Synthesised Mixing Height Frequency Distribution

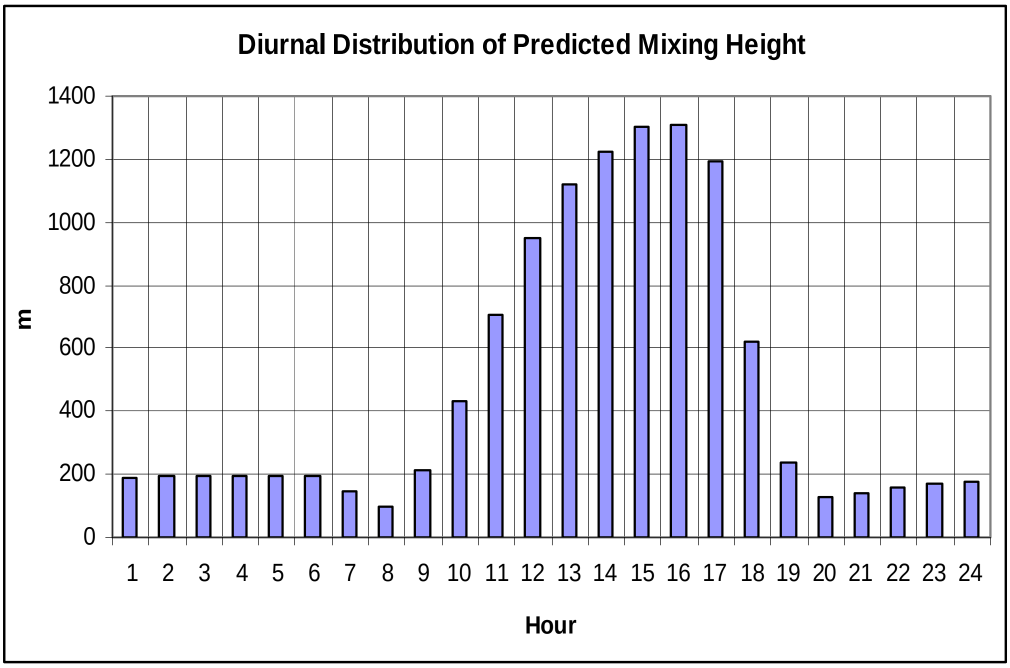


Figure 10: TAPM Synthesised Mixing Height Mean Diurnal Distribution

6. Atmospheric Dispersion Modelling

6.1 Model

The AUSPLUME plume dispersion model (version 6.0) is the approved regulatory model for predicting the effects of industrial emissions on air quality. This model is a steady-state Gaussian plume model that can be used to predict off-site pollutant concentrations for a wide variety of sources, which include stacks, area, line and volume initial geometries with arbitrary orientation. It is highly flexible and has a range of options, which allow the user to adapt the model to suit particular applications and make best use of available source and meteorological data.

6.2 Meteorological Data

AUSPLUME requires a meteorological data-set that includes wind speed, wind direction (at typically 10 m above ground level) and temperature, as well as derived parameters that include atmospheric stability and the depth of the mixed layer. A dataset of 1 year of hourly data representative of the project location was synthesised for the year 2004. This meteorological modelling is detailed in Section 5.

6.3 Background Air Quality

Estimates of existing background air quality at the project site are detailed in Section 4.3 of this report. These estimates were not included directly in the dispersion modelling process, which was conducted only for the source emissions 'signal'. The background estimates were taken into consideration during the assessment of the predicted impact of the project upon local air quality, which is discussed in Section 7 of this report.

6.4 Source Characteristics and Emission Rates

6.4.1 Construction Phase

Emissions to air associated with the construction phase of the project (as detailed in Section 2.2.1) were modelled as a 60 ha area source (shown in Figure 10) due to their spatially distributed nature. Mechanically induced emissions were summed and modelled for working hours only, whereas wind induced emissions, were modelled as being continuous. Greater detail on emission rates is available in Table 1. Whilst particulate emissions during the construction phase are likely to be at their highest during the initial 9-months of earthworks, the model was run for a full 12-months under earthwork conditions. This was done in order to account for seasonal differences in weather patterns and the potential for project delays.

6.4.2 Operational Phase

The three emissions sources associated with the proposed AN plant, and the nine sources associated with the proposed power plant, were modelled as stack sources in AUSPLUME for a 12-month simulation period. The specific characteristics of each stack source are displayed in Table 2 (Section 2.2.2).

The heights for the power generator exhaust vents were determined through an iterative adjustment process involving a number of AUSPLUME model runs. Vent heights were adjusted for each model run until the predicted ground level concentrations for each pollutant showed compliance with the relevant criteria. In this regard, compliance with the EPP(Air) air quality goal for NO_2 (4-hour average) was the critically constraining factor. Including a safety factor of 1 m, it was found that a minimum exhaust vent height of 15 m was required for compliance.

For lower release heights, turbulence in the wakes of the power generation units was predicted to bring exhaust plumes to ground level, resulting in significantly increased ground level concentrations. For example, for a release height of 7.5 m, it was predicted that the EPP(Air) air quality goal for NO_2 (4-hour average) would be exceeded at up to 1 km outside the site boundary (excluding background).

The final model input parameters for each stack are summarised in Table 2 (Section 2.2.2).

6.5 Model Configuration

AUSPLUME (V. 6.0) was configured to adapt the model to the project. Key components of the model configuration are summarised below:

- Ground level concentrations were predicted over a 5 km square Cartesian receptor grid, centred over the plant with a grid resolution of 50 m;
- Averaging periods specific to the EPP(Air) air quality goals were selected;
- The influence of terrain on the dispersion of the stack/area plume over the area of interest was considered to be insignificant;
- Building wake effects were included, with characteristic building dimensions determined by inspection of a plan of the site. The Building Profile Input Program (BPIP) module within the AUSPLUME model was used to generate the characteristic dimensions for each 10-degree wind-directional arc. For wind directions where the potential for building wake influences was considered significant by AUSPLUME, the PRIME building wake algorithm was used to provide a conservative estimate of ground level concentrations;
- Irwin's "Rural" wind profile exponents were used;
- Default vertical temperature gradients were assumed;
- Plume rise was computed as a function of distance downwind;
- Horizontal dispersion and vertical dispersion were parameterised according to equations for the Pasquill-Gifford curves; and

- An aerodynamic roughness height of 0.1 metres was used to represent the area of interest.

Further information on the options selected and the model configuration is provided in the sample AUSPLUME output file presented in Appendix B.

7. Assessment of Impacts

The regulatory approved atmospheric dispersion model AUSPLUME was used to predict ground level concentrations of NO_2 and PM_{10}, for which air quality goals exist under the EPP(Air), during the construction and operational phases of the project. This section of the report discusses the predictions made using AUSPLUME in terms of the air quality goals contained within the EPP(Air) (for assessment purposes) and the NEPM(Air) (for comparison purposes).

7.1 Construction Phase Assessment

As explained in Section 2.2.1, the only emission to air of concern during the construction phase is particulate matter. Ground level concentration predictions of PM_{10}, made using AUSPLUME, are displayed in Figures 10 and 11, and show the predicted maximum 24-hour average and the predicted annual average, respectively.

Figure 10 exhibits a maximum predicted off site 24-hour average concentration of less than 75 µg/m^3, which, in addition to the conservative background estimate of 45.3 µg/m^3 (See Section 4.3) shows compliance with the EPP(Air) air quality goal of 150 µg/m^3. Predicted maximum ground level concentrations are seen to reduce rapidly with distance from the site boundary.

Figure 11 exhibits a maximum predicted off site annual average PM_{10} concentration of less than 20 µg/m^3, which, in addition to the conservative background estimate of 20.6 µg/m^3 (See Section 4.3) shows compliance with the EPP(Air) air quality goal of 50 µg/m^3.

Given the assumption, described in Section 2.2.1, that PM_{10} constitutes 50% of TSP emissions during the construction phase, a doubling of the calculated contour values displayed in Figure 11 gives an indication of the potential impact upon ambient TSP concentration due to the construction of the project. That is, the maximum predicted offsite annual average PM_{10} concentration equates to approximately 40 µg/m^3 of TSP. When the assumed (conservative) background of 41.2 µg/m^3 is included[8], the total comes to 81.2 µg/m^3, which equates to 90% of the corresponding EPP(Air) air quality goal of 90 µg/m^3. Compliance is, therefore, indicated.

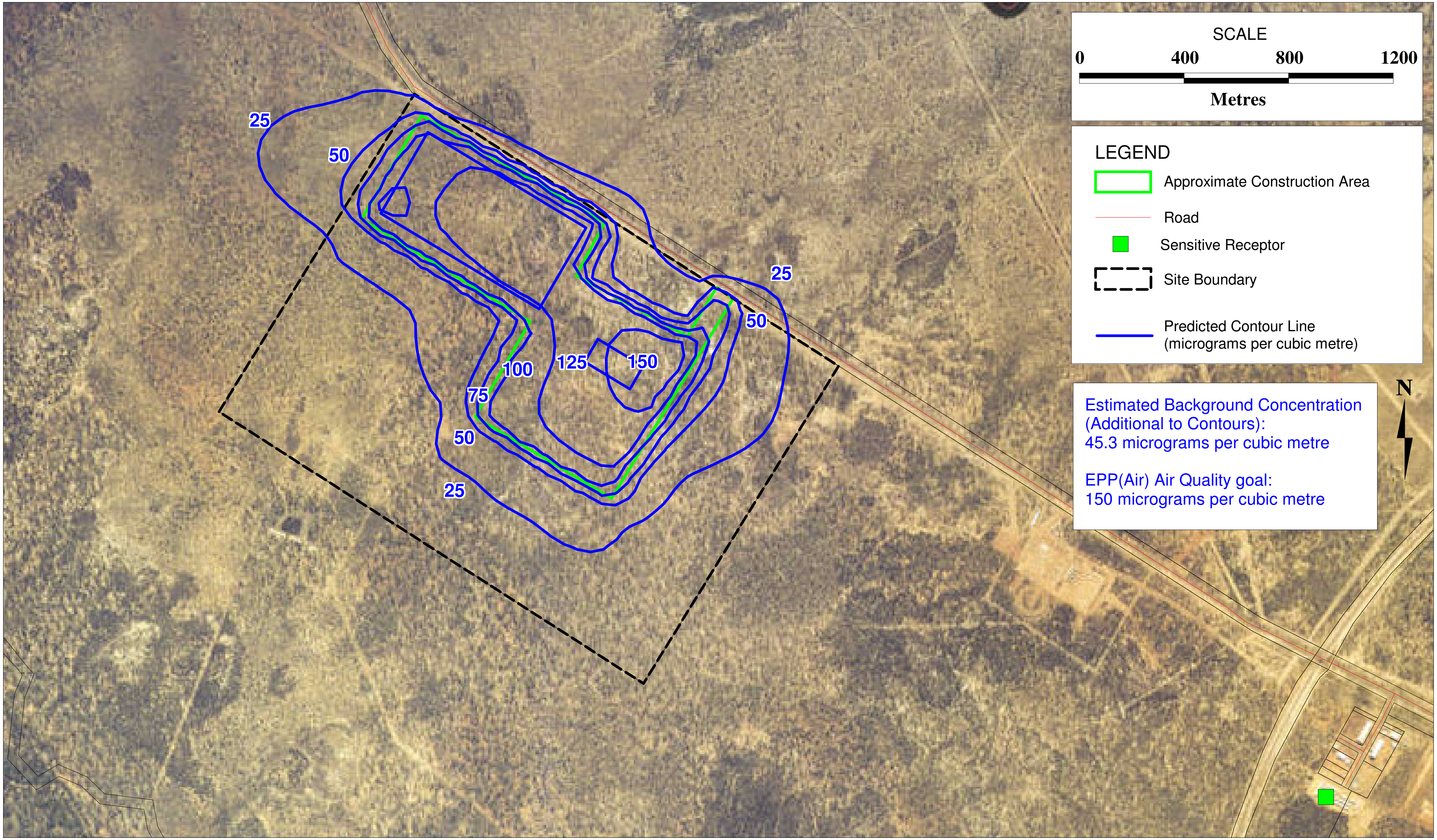
[8] Note that it has been conservatively assumed that 50% of background total suspended particulates (TSP) fall within the PM_{10} size category. The adopted annual average background PM_{10} concentration (20.6 µg/m^3, See Section 4.3) can, therefore, be scaled upwards to provide an estimate of annual average TSP concentration (41.2 µg/m^3).

Further to the demonstrated compliance with EPP(Air) goals, it is noteworthy that the modelling of construction impacts is highly conservative and that there are no nearby sensitive receptors in the directions of maximum predicted off site impact (north and west of the site). The nearest sensitive receptors (temporary miner's accommodation) are shown to experience minimal impact from dust emissions during the construction phase. In addition, emissions from bulldozing and grading constitute 65% of the total inventory. Screening level emission factors have been applied to these activities. The application of emissions control measures described in Section 2.3.1 will substantially abate these dust emissions and so reduce localised impact just beyond the site boundary.

Table 6 summarises the assessment of AUSPLUME predictions against the EPP(air) air quality goals. Note that the short-term and transient nature of the construction phase renders comparison against NEPM(Air) goals inapplicable.

Table 6 Construction Phase Assessment Summary

	Air Quality Indicator	Air Quality Goal (μg/m^3)	Averaging Time	Allowable Exceedences	Compliance
EPP(Air)	PM_{10}	150	24-hours	0	P
	PM_{10}	50	1-year	0	P
	TSP	90	1-year	0	P



DATA SOURCE				
Prepared.	BPS	09/08/2006	Workspace	Construction_24hr.wor
Checked.	AML	09/08/2006	Location	G:\41\15824\GIS\Projects
Approved.	AML	09/08/2006	Map Grid	GDA 94 (Zone 55)

GHD

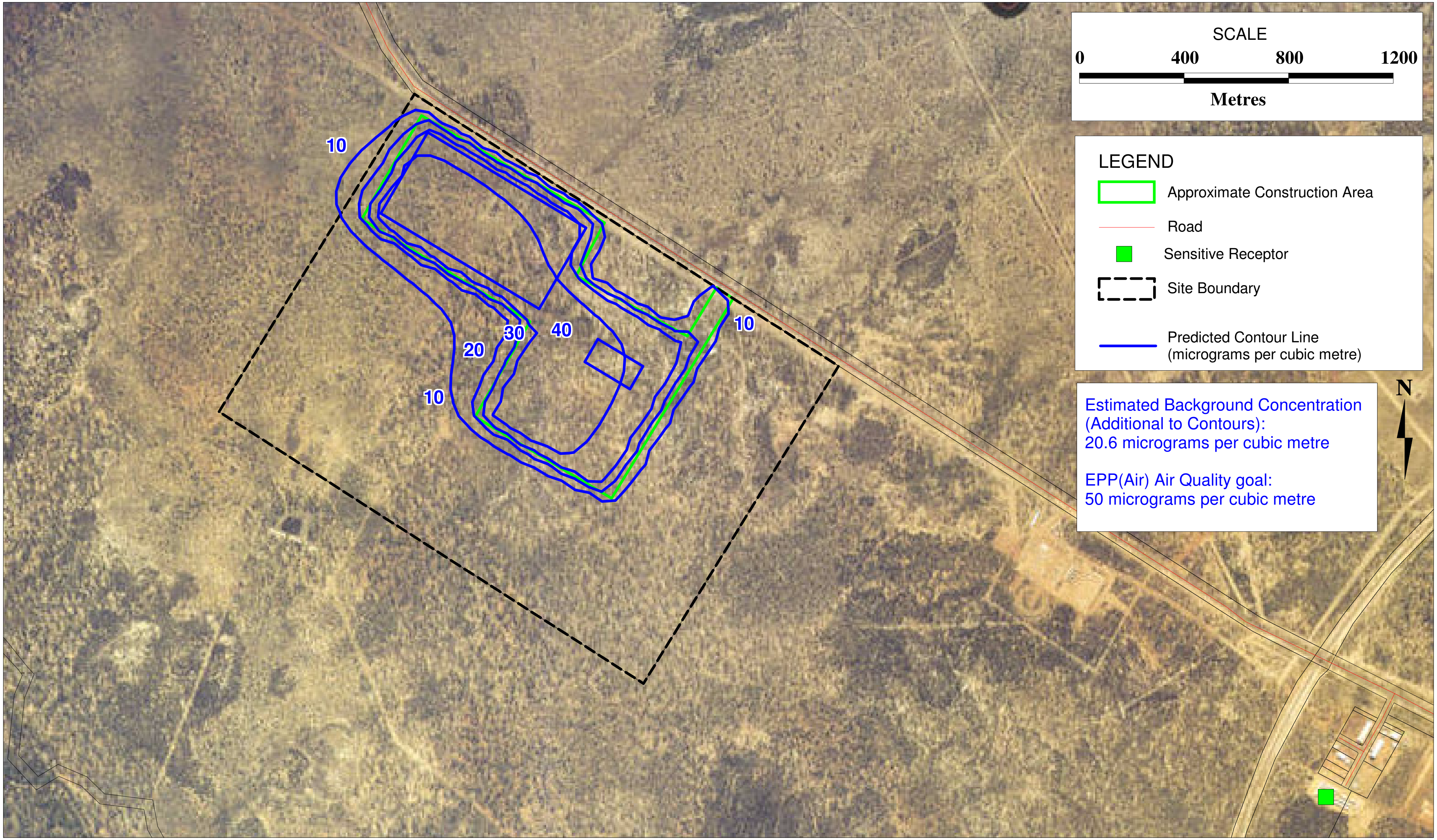
180 Lonsdale Steet
Melbourne Vic 3000

Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Project: **Dyno Nobel Proposed Ammonium Nitrate Plant - Moranbah, Qld**

Title: **Figure 11: Predicted Maximum 24-Hour Average PM10 Contours - Construction**

Project No: **41 / 15824** | Date: **09/08/2006** | **A4** | Scale: **1:20,000** | Sh **1** of **1** | Rev. **0**



DATA SOURCE				
Prepared.	BPS	09/08/2006	Workspace	Construction_1yr.wor
Checked.	AML	09/08/2006	Location	G:\41\15824\GIS\Projects
Approved.	AML	09/08/2006	Map Grid	GDA 94 (Zone 55)

GHD

180 Lonsdale Steet
Melbourne Vic 3000

Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Project: **Dyno Nobel Proposed Ammonium Nitrate Plant - Moranbah, Qld**

Title: **Figure 12: Predicted Annual Average PM10 Contours - Construction**

Project No: **41 / 15824** | Date: **09/08/2006** | **A4** | Scale: **1:20,000** | Sh **1** of **1** | Rev. **0**

7.2 Operational Phase Assessment

A total of six AUSPLUME model runs were made for the purpose of assessing air quality impacts associated with the operation of the proposed DN AN Plant. Figures 12 to 17 show ground level concentration contours, as predicted by AUSPLUME, corresponding to each of the relevant EPP(Air) air quality goals. The following eight sections of this report discuss:

1. The assessment of NO_2 emissions;
2. The assessment of PM_{10} emissions;
3. The assessment of deposited Nitrogen, resulting from AN particulate emissions;
4. The assessment of emissions during ‘upset’ conditions at the project;
5. The comparison of predicted air quality impacts at the township of Moranbah against NEPM (Air) air quality goals;
6. A qualitative assessment of the potential for photochemical smog;
7. A comparison between air quality impacts predicted for the project and the air quality impacts predicted for a similar plant at Moura, Queensland; and
8. A summary of all results.

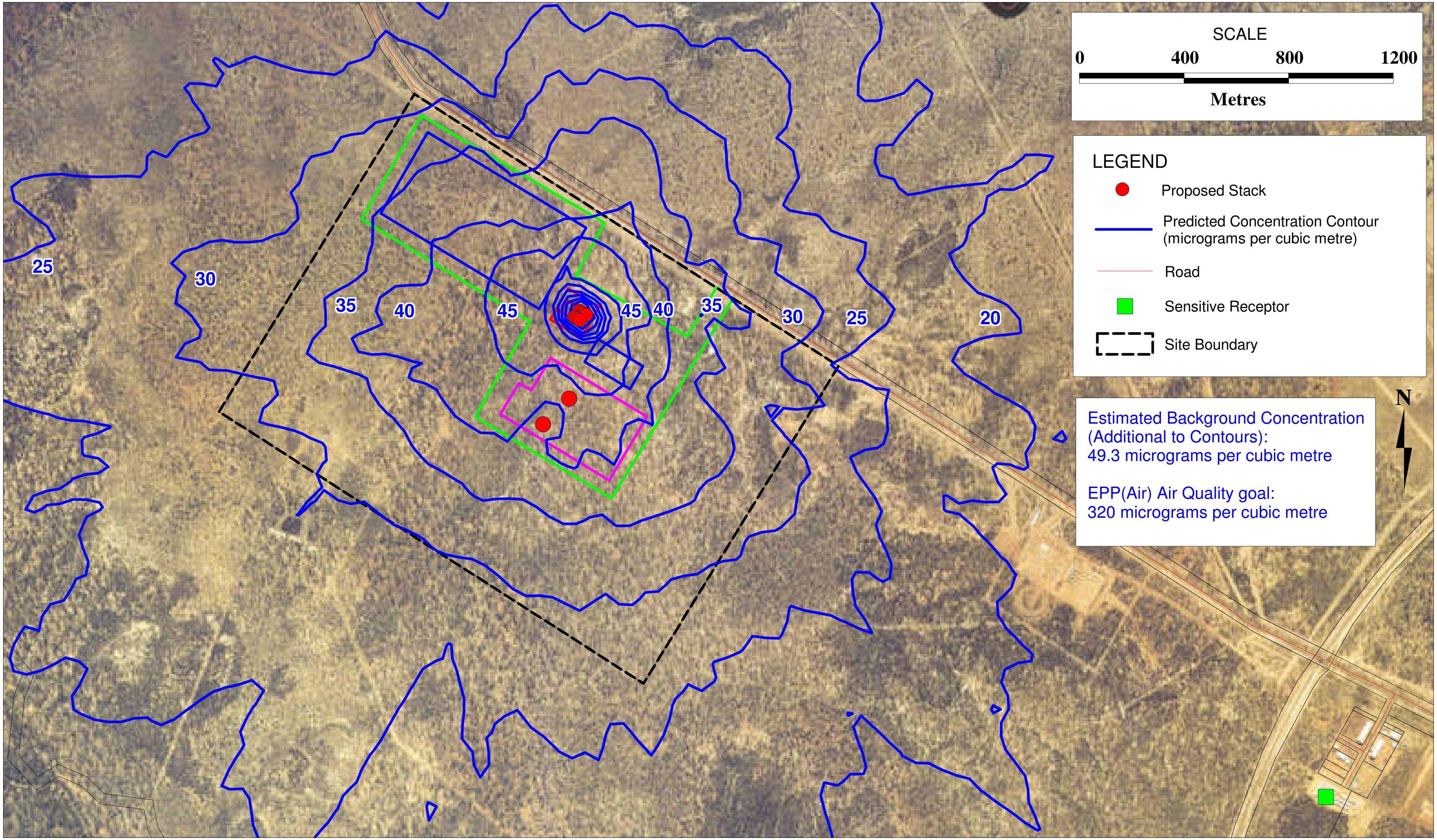
7.2.1 Nitrogen Dioxide

Figure 12 shows the predicted 99.9th percentile 1-hour average ground level concentrations of NO_2. The maximum off site impact (less than 45 µg/m^3) is seen to occur near the northern boundary of site. The predicted impact at the nearest sensitive receptor (temporary miner’s accommodation) is shown to be less than 20 µg/m^3. When the estimated peak background concentration of 49.3 µg/m^3 is added to the predicted impact, strong compliance with the EPP(Air) air quality goal of 320 µg/m^3 is demonstrated. More specifically, the maximum predicted off site impact, when inclusive of background is only 30% of the EPP(Air) goal.

Figure 13 shows the maximum predicted 4-hour average ground level concentrations of NO_2. Maximum off site impact (between 35 and 40 µg/m^3) is seen to occur near the northern boundary of site. The predicted impact at the temporary miner’s accommodation, however, is significantly less than 20 µg/m^3. When the estimated peak background concentration of 46.2 µg/m^3 is added to the predicted impact, compliance with the EPP(Air) air quality goal of 95 µg/m^3 is demonstrated. More specifically, the maximum predicted off site impact, when inclusive of peak background is 90% of the EPP(Air) goal.

Figure 14 shows the predicted annual average ground level concentrations of NO_2. Maximum off site impacts (between 3 and 4 µg/m^3) are seen to occur near the western boundary of site. The predicted impact at the temporary miner’s accommodation is shown to be substantially less than 1 µg/m^3. When the predicted maximum impact is added to the estimated annual background (19.6 µg/m^3), compliance with the EPP(Air) air quality goal (30 µg/m^3) is demonstrated. More specifically, the maximum predicted off site impact, when inclusive of conservative background is 79% of the EPP(Air) goal.

Note that the predicted ground level concentrations are dominated by the impact associated with the nine generator units, despite their combined emissions being just 60% of the total for the project. The proportionately high impact is due to differences between the release geometries of the generators and the release geometries of other stacks (NA Vent and Reformer Furnace). The generators have 15m stacks, which are significantly closer to ground level and have a smaller exhaust velocities than either the NA Vent or Reformer Furnace. Both of these factors act to reduce the amount of time, and consequently, the dispersion of the plume, before the plume first creates an impact at ground level. The result is that the observed peak ground level concentrations are predominantly due to the shorter generator stacks.



DATA SOURCE				
Prepared.	BPS	09/08/2006	Workspace	NO2_1hr.wor
Checked.	AML	09/08/2006	Location	G:\41\15824\GIS\Projects
Approved.	AML	09/08/2006	Map Grid	GDA 94 (Zone 55)

GHD

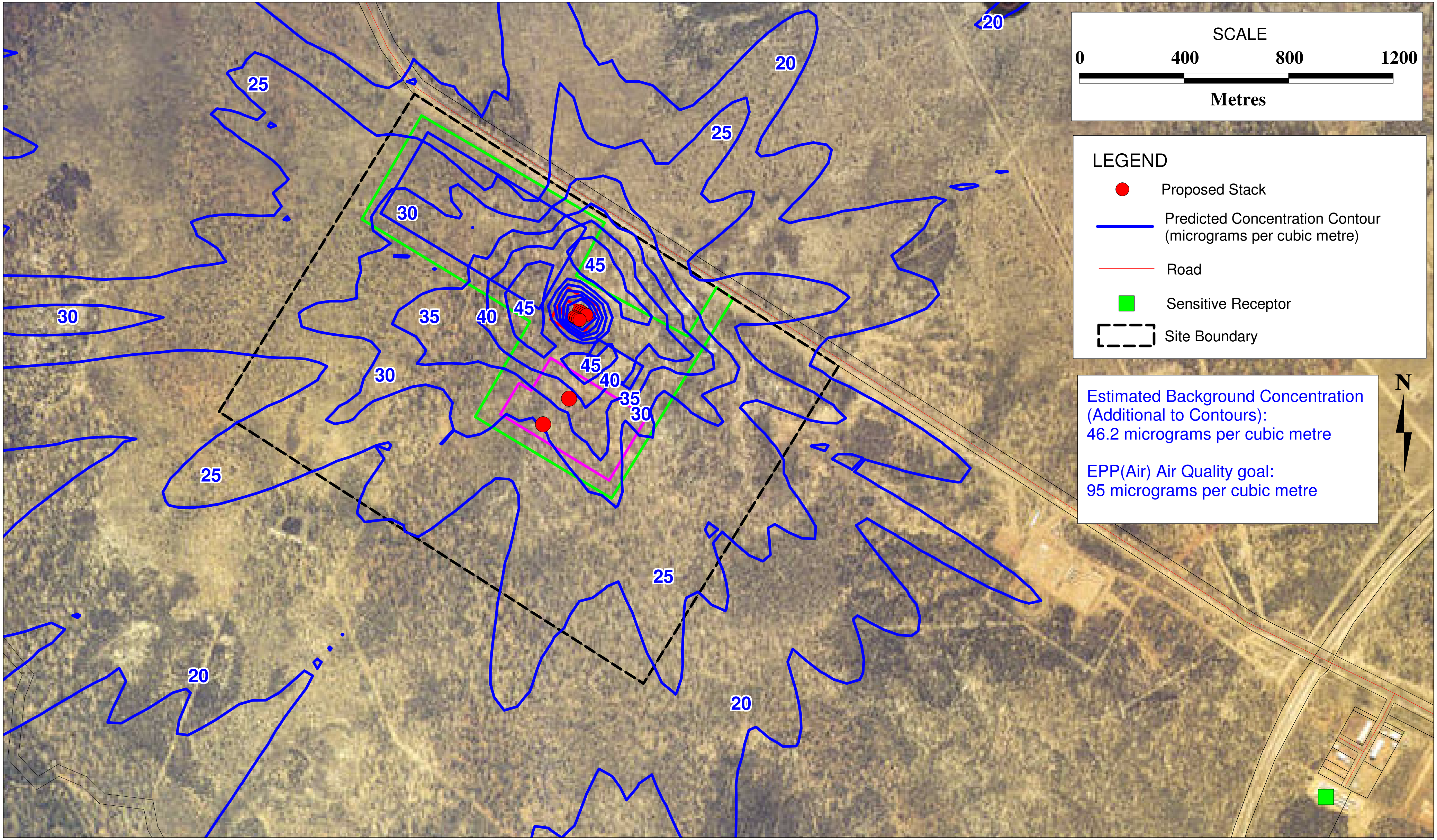
180 Lonsdale Steet
Melbourne Vic 3000

Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Project: **Dyno Nobel Proposed Ammonium Nitrate Plant - Moranbah, Qld**

Title: **Figure 13: Predicted 9th Highest 1-Hour Average NO2 Contours**

Project No: **41 / 15824** | Date: **09/08/2006** | **A4** | Scale: **1:20,000** | Sh **1** of **1** | Rev. **0**



DATA SOURCE			
Prepared.	BPS	09/08/2006	Workspace NO2_4hr.wor
Checked.	AML	09/08/2006	Location G:\41\15824\GIS\Projects
Approved.	AML	09/08/2006	Map Grid GDA 94 (Zone 55)

GHD

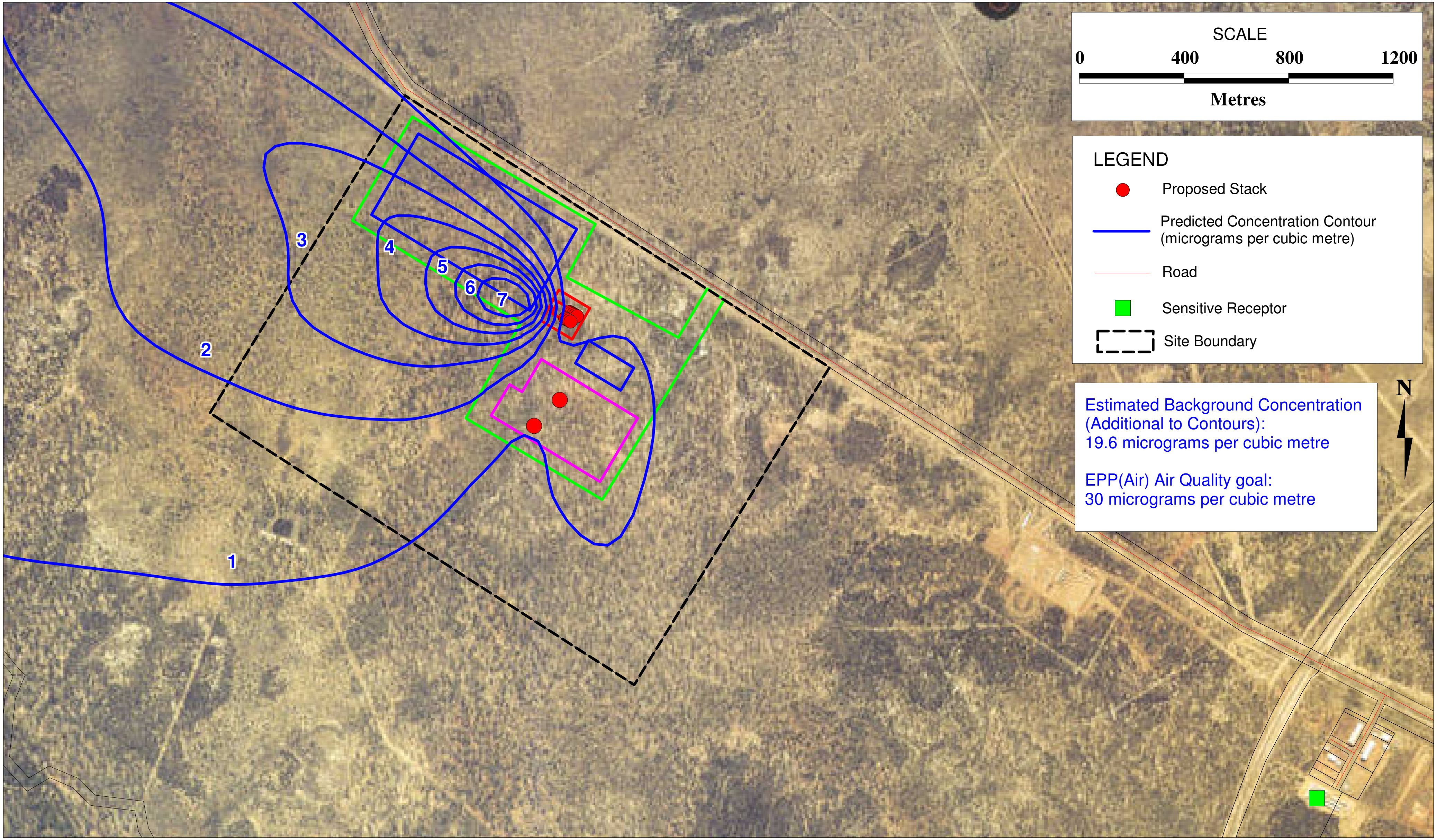
180 Lonsdale Steet
Melbourne Vic 3000

Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Project: **Dyno Nobel Proposed Ammonium Nitrate Plant - Moranbah, Qld**

Title: **Figure 14: Predicted Maximum 4-Hour Average NO2 Contours**

Project No:	Date:		Scale:	Sh	Rev.
41 / 15824	09/08/2006	A4	1:20,000	1 of 1	0



DATA SOURCE				
Prepared.	BPS	09/08/2006	Workspace	NO2_1yr.wor
Checked.	AML	09/08/2006	Location	G:\41\15824\GIS\Projects
Approved.	AML	09/08/2006	Map Grid	GDA 94 (Zone 55)

GHD
180 Lonsdale Steet
Melbourne Vic 3000
Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Project: **Dyno Nobel Proposed Ammonium Nitrate Plant - Moranbah, Qld**

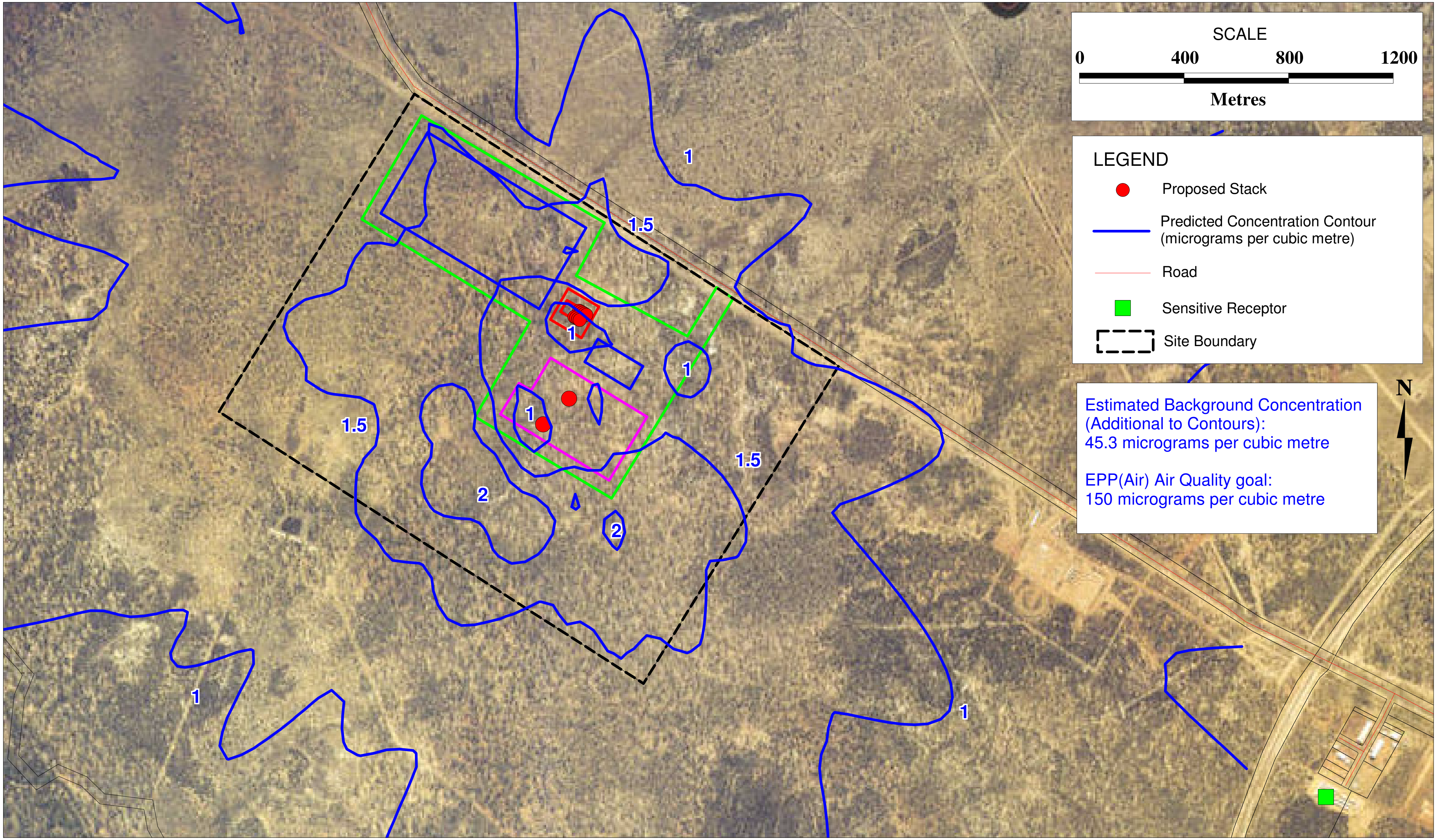
Title: **Figure 15: Predicted Annual Average NO2 Contours**

Project No: **41 / 15824** | Date: **09/08/2006** | **A4** | Scale: **1:20,000** | Sh **1** of **1** | Rev. **0**

7.2.2 Particulate Matter as PM_{10}

Figure 15 shows the maximum predicted 24-hour average ground level concentrations of PM_{10}. Maximum off site impacts (also between 1.5 and 2 µg/m^3) are seen to occur to the north and south of site. The predicted maximum 24-hour average impact at the temporary miner's accommodation is less than 1 µg/m^3. When the estimated peak background concentration of 45.3 µg/m^3 (See Section 4.3) is added to the predicted impact, compliance with the EPP(Air) air quality goal of 150 µg/m^3 is clearly demonstrated. More specifically, the maximum predicted off site impact, when inclusive of estimated peak background is 32% of the EPP(Air) goal.

In terms of the predicted annual average PM_{10} impact, Figure 16 exhibits a maximum offsite impact of between 0.4 and 0.5 µg/m^3 near the north west site boundary. The predicted impact at the temporary miner's accommodation is substantially less than 0.1 µg/m^3. The impact of the project represents only a marginal increase over the estimated annual average background of 20.6 µg/m^3. When the predicted maximum impact and estimated background are summed, the total is only 42% of the EPP(Air) air quality goal of 50 µg/m^3. Strong compliance is, therefore, indicated.



DATA SOURCE				
Prepared.	BPS	09/08/2006	Workspace	**PM10_24hr.wor**
Checked.	AML	09/08/2006	Location	**G:\41\15824\GIS\Projects**
Approved.	AML	09/08/2006	Map Grid	**GDA 94 (Zone 55)**

GHD

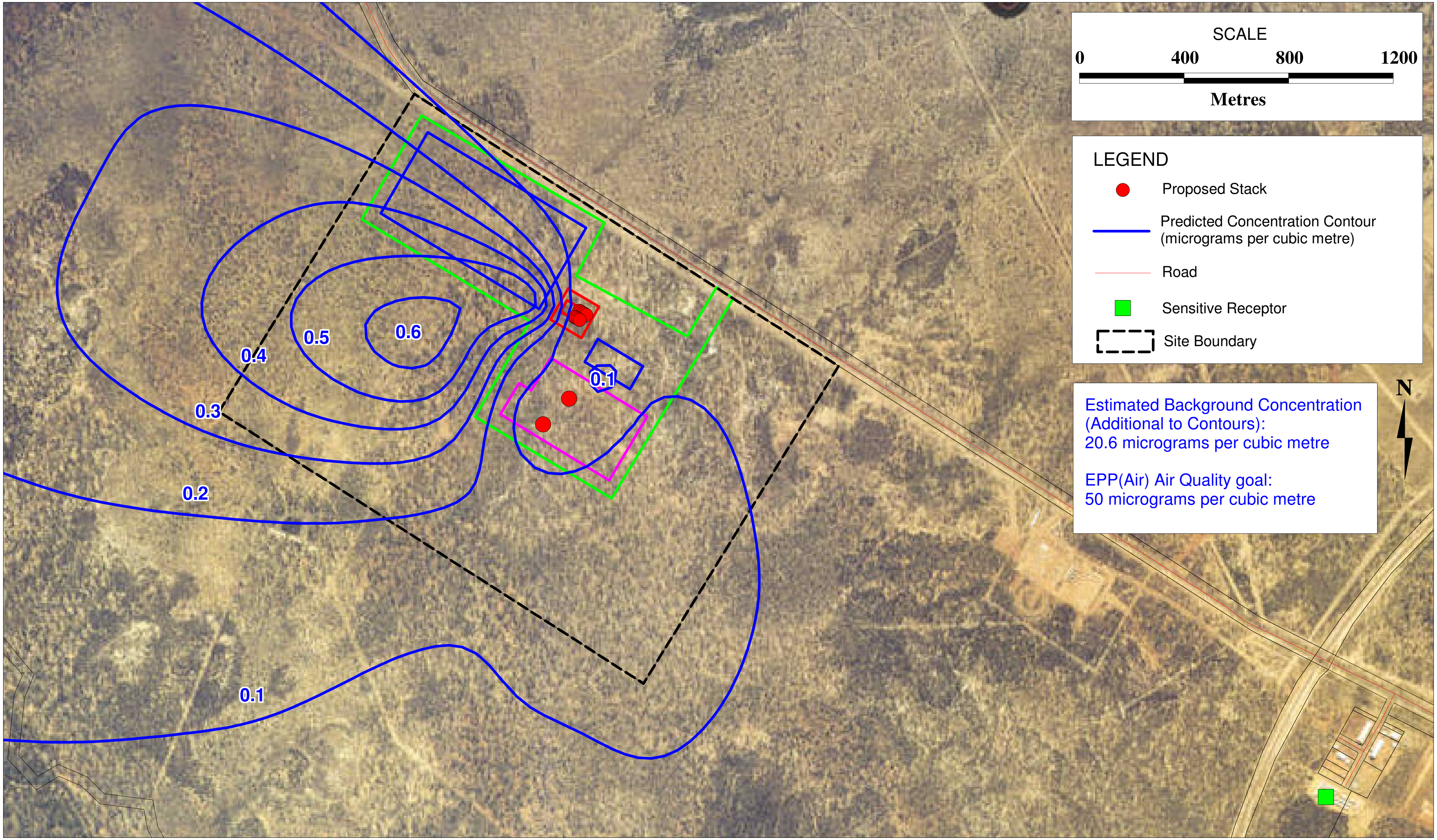
180 Lonsdale Steet
Melbourne Vic 3000

Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Project: **Dyno Nobel Proposed Ammonium Nitrate Plant - Moranbah, Qld**

Title: **Figure 16: Predicted Maximum 24-Hour Average PM10 Contours**

Project No: **41 / 15824**	Date: **09/08/2006**	**A4**	Scale: **1:20,000**	Sh **1** of **1**	Rev. **0**



DATA SOURCE				
Prepared.	BPS	09/08/2006	Workspace	PM10_1yr.wor
Checked.	AML	09/08/2006	Location	G:\41\15824\GIS\Projects
Approved.	AML	09/08/2006	Map Grid	GDA 94 (Zone 55)

GHD

180 Lonsdale Steet
Melbourne Vic 3000

Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Project: **Dyno Nobel Proposed Ammonium Nitrate Plant - Moranbah, Qld**

Title: **Figure 17: Predicted Annual Average PM10 Contours**

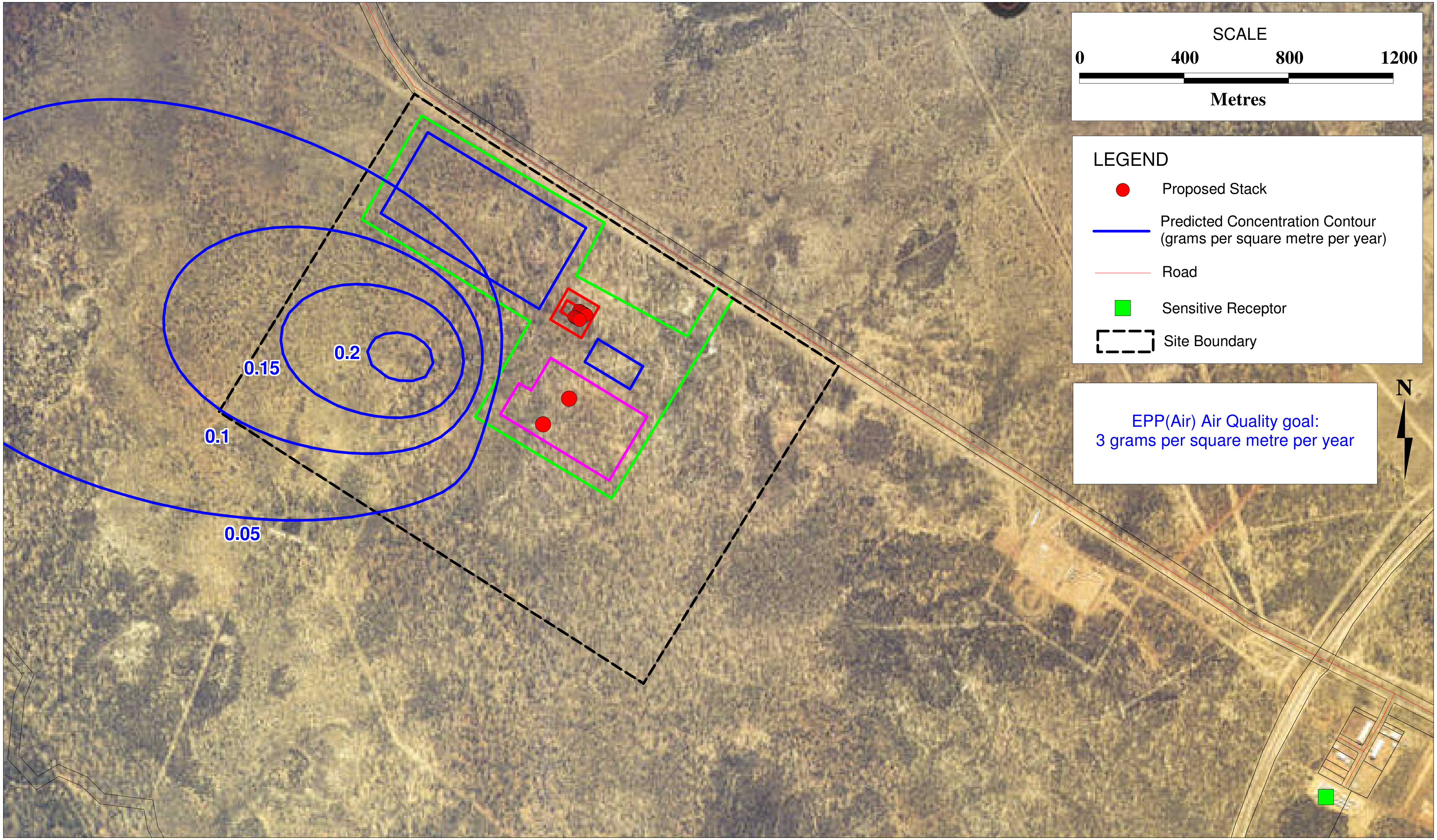
Project No: **41 / 15824** | Date: **09/08/2006** | **A4** | Scale: **1:20,000** | Sh **1** of **1** | Rev. **0**

7.2.3 Total Deposited Nitrogen

Figure 17 shows the predicted annual deposition of Nitrogen nearby the project. Note that Nitrogen constitutes 35% of the anticipated AN particulate emissions to air. The maximum off site deposition is calculated to be less than 0.15 gm/m^2/year. Given that the relevant EPP(Air) air quality goal is 3 gm/m^2/year, emphatic compliance is demonstrated.

The purpose of the EPP(Air) air quality goal for total deposited Nitrogen is to protect biological integrity. Compliance with this goal, therefore, indicates that there will be minimal impact upon the water quality of the nearby Isaac River and Grosvenor Creek due to deposition of particulate AN from the project. (See Figure 2)

Note that compliance has also been shown with the two other relevant EPP(Air) air quality goals for biological integrity (4-hour and 1-year average ground level NO_2 concentrations). (See Section 7.2.1)



DATA SOURCE				
Prepared.	BPS	09/08/2006	Workspace	Deposition_1yr.wor
Checked.	AML	09/08/2006	Location	G:\41\15824\GIS\Projects
Approved.	AML	09/08/2006	Map Grid	GDA 94 (Zone 55)

GHD
180 Lonsdale Steet
Melbourne Vic 3000
Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Project: **Dyno Nobel Proposed Ammonium Nitrate Plant - Moranbah, Qld**

Title: **Figure 18: Predicted Annuall Nitrogen Deposition Contours**

Project No: **41 / 15824** | Date: **09/08/2006** | **A4** | Scale: **1:20,000** | Sh **1** of **1** | Rev. **0**

7.2.4 Upset Conditions

As discussed in Section 2.2.2, there exists the possibility that increased rates of emission to air of NO_x and PM_{10} may result from upset conditions caused by process upsets, or due to impurities in the coal seam methane. The magnitude of increase in emissions due to such events is not practically quantifiable and, as such, was not directly modelled by GHD. However, there exists a safety factor by which emissions may be increased (due to unforeseen and irregular upset events) before the EPP(Air) air quality goals are exceeded.

More specifically, for worst case atmospheric conditions, and inclusive of the maximum estimated background concentration from an area that will have poorer air quality than Moranbah, emissions of NO_2 from the project may be increased by 20% before the 4-hour average EPP(Air) air quality goal for biological integrity is exceeded. The magnitude of this safety factor is greater for all other relevant EPP(Air) air quality goals. See Table 7.

7.2.5 Comparison Against NEPM(Air) Airshed Goals at Moranbah

Unlike the EPP(Air) air quality goals, which are applicable to *predicted* air quality impacts at and beyond site boundary, the NEPM(Air) air quality goals apply to the overall *recorded* quality of the airshed and the exposure of populated areas to air quality indicators. The nearest permanent populated areas are located on the western outskirts of Moranbah.

Whilst the NEPM(Air) air quality goals are not directly applicable to the assessment of proposed facilities, they are useful for the purpose of comparison. To this end, GHD performed additional modelling to predict the exposure of these populated areas to airborne particulates and NO_2 from the project.

Strong compliance with the NEPM(Air) goals for NO_2 was indicated. Inclusive of background, the maximum predicted 1-hour and annual average ground level concentrations are only 26% and 32% (respectively) of the 246 and 62 $\mu g/m^3$ NEPM(Air) goals. The contribution from the project to these figures is only 0.1% and 0.6% respectively.

In terms of the NEPM(Air) Air quality goal for PM_{10} (a 24-hour average of 50 $\mu g/m^3$ with five allowable exceedences per annum), compliance is clearly demonstrated given that the maximum highest predicted 24-hour average ground level concentration, inclusive of the conservative maximum background estimate, is 45.6 $\mu g/m^3$.

Unlike the EPP(Air), the NEPM(Air) includes air quality goals for $PM_{2.5}$. Whilst the size distribution of particulate emissions from the project is not yet known for particles smaller than PM_{10}, the minimal predicted impact of PM_{10} emissions upon local air quality, when compared to background levels, indicates that the impact of $PM_{2.5}$ emissions would also be minimal. Compliance with NEPM(Air) goals for $PM_{2.5}$ would, therefore, be dictated more by regional ambient air quality than by the localised impact of emissions from the project.

See Table 7 for a summary of this section.

7.2.6 Visibility of Emissions

The occurrence of atmospheric haze or smog is highly improbable in Moranbah due to the low local emissions of the pollutants that are typically responsible for these effects, namely, particulates, NO_x and VOCs (Volatile Organic Compounds). It is unlikely that the predicted increase in atmospheric PM_{10} and NO_2, associated with the project, over existing background levels, will result in the formation of visible haze or smog. In addition, the prevailing wind direction at Moranbah is from the east south east. Winds from this direction will act to disperse emissions to air from the project in a direction that is away from the township of Moranbah, thereby further reducing the risk of haze and/or smog.

7.2.7 Comparison with a Previous Air Assessment

In October 2005 QNP proposed an expansion of their existing Ammonium Nitrate Plant at Moura, Queensland (See Figure 1). The proposed expansion wwould increase the production capacity of the Moura Plant from the current 180 000 tonne/annum to 430 000 tonne/annum (22% greater than the proposed Moranbah AN plant). Katestone Environmental conducted an Air Quality Impact Assessment for the proposed Moura AN plant augmentation[9], the results of which are included in Table 7 for comparison against the predicted impact of the proposed Moranbah AN plant.

In comparing the predicted impact associated with the Moura AN plant with that of the proposed Moranbah AN plant, the following should be taken into consideration:

» Geographic and meteorological differences between Moura and Moranbah;

» The fact that, unlike the proposed Moranbah AN Plant, the AN Plant at Moura does not (and will not) produce electricity from coal seam gas on site; and

» The fact that the maximum predictions at Moura are quoted for the nearest sensitive receptor rather than at the site boundary (as is the case for Moranbah).

Given these differences, the predicted PM_{10} impacts for the two locations are similar. The predicted NO_2 impacts, however, are several times higher for the Moranbah AN Plant than for the Moura AN Plant. This difference is largely attributable to the proposed power plant on site at Moranbah.

The predicted air quality impacts associated with both sites are relatively localised and extend only several kilometres from the proposed plants. Given that a distance of approximately 300 km separates Moranbah and Moura, the cumulative air quality impact upon regional air quality associated with the operation of both plants is expected to be minimal.

[9] *Air Quality Impact Assessment of the Proposal to Expand the Ammonium Nitrate Plant at Moura:* Katestone Environmental (October 2005)

7.2.8 Operational Phase Assessment Results Summary

Table 7 Operational Phase Assessment Summary

	Air Quality Indicator	Air Quality Goal ($\mu g/m^3$)	Averagin g Time	Allowable Exceedences	Maximum Background Estimate ($\mu g/m^3$)	Max. Prediction for Moranbah AN Plant ($\mu g/m^3$)	Total ($\mu g/m^3$)	Approximate Safety Factor[1]	Compliance	Max. Prediction for Moura AN plant ($\mu g/m^3$)[3]
EPP(Air)	NO_2	320	1-hour	9 hours per year	49.3	45[5]	**89.3**	6	P	14.1
	NO_2	95	4-hours	0	46.2	40[5]	**86.2**	1.2	P	7.5
	NO_2	30	1-year	0	19.6	4[5]	**23.6**	2.6	P	0.2
	PM_{10}	150	24-hours	0	45.3	2[5]	**47.3**	52	P	1.5
	PM_{10}	50	1-year	0	20.6	0.5[5]	**21.1**	59	P	0.1
	Total Deposited Nitrogen[3]	3 **gm/m^2**	1-year	0	-	0.15 **gm/m^2** [5]	**0.15 gm/m^2**	20	P	-
NEPM(Air)	NO_2	246	1-hour	1 day per year	49.3	14.9[4]	**64.2**	-	P	-
	NO_2	62	1-year	0	19.6	0.07[4]	**19.7**	-	P	-
	$PM_{2.5}$	25	24-hours	0	-	-	**-**	-	NA[2]	-
	$PM_{2.5}$	8	1-year	0	-	-	**-**	-	NA[2]	-
	PM_{10}	50	24-hours	5 days per year	45.3	0.3[4]	**45.6**	-	P	-

1: The safety factor is equal to the air quality goal (minus the background estimate) divided by the maximum prediction.

2: Dependant on particle size distribution of emissions to air from the project (as yet unknown) and on existing background levels (no available data).

3: As predicted by Katestone Environmental for the nearest receptor to site. Excludes background concentration.

4: Predictions made for the Western-most point of the township of Moranbah (approx. 606,000E 7567,700N – MGA 94 Z55)

5: Predictions made for the DN site boundary.

7.3 Health Risk Impact

The predicted off site ground level concentrations for PM_{10} and NO_2 are below the relevant EPP(Air) Air Quality Goals, during both construction of the plant and plant operation. EPA requirements are, therefore, met.

PM_{10}

The worst case PM_{10} emission results during the construction phase, with a maximum offsite 24-hour average concentration of approximately 120 $\mu g/m^3$ and an annual average concentration of approximately 40 $\mu g/m^3$ (inclusive of background estimates). The PM_{10} emissions from plant operation are significantly lower than the construction phase with a predicted maximum 24-hour average concentration at the temporary miners cottage of less than 0.5 $\mu g/m^3$, and on the plant boundary approximately 1.5 $\mu g/m^3$.

The duration of heavy earthworks during construction is likely to be no more than 9 months.

The PM_{10} ambient air goal in the NEPM(Air) of 50 $\mu g/m^3$ for a 24-hour average is considered to be conservative and is the long term goal for the NEPM. The goal was based on evidence of increased mortality rate from respiratory and cardiovascular disease, especially associated with sensitive subgroups such as elderly and young children leading to increased frequency of respiratory tract infections, coughing and wheezing. This goal is more conservative than the EPP(Air) goal of 150 $\mu g/m^3$ for 24 hour average.

It should be noted that while the maximum 24-hour PM_{10} concentration on the site boundary is approximately 120 $\mu g/m^3$, the concentration drops significantly further away from the site, being less than 25 $\mu g/m^3$ approximately 500 m from the north western site boundary, which including the conservative background level of 45.3 $\mu g/m^3$ is in excess of the NEPM(Air) goal. However, the nearest sensitive receptor is the temporary minors cottage, which is over 2 km south east of the site boundary. At this location, construction activities are unlikely to present any significant impact. Neither are construction activities likely to present any significant impact to the township 4.5 km away.

Health impacts from PM_{10} during plant operation to sensitive receptors are considered to be insignificant compared to background levels.

NO_2

The EPP(Air) goals for NO_2 may be divided into two categories. Schedule 1, Part 3 goals present a 1-hour average NO_2 goal of 320 $\mu g/m^3$ (0.16 ppm). The NEPM(Air) goal is slightly more stringent with a value of 246 $\mu g/m^3$ (0.12 ppm) for a 1-hour average. The NEPM indicates that this goal provides a high level of protection for asthmatics and people with lung diseases.

The predicted maximum 1-hour average NO_2 concentration during plant operation (including background) is 89.3 $\mu g/m^3$, which is significantly below both the EPP(Air) and NEPM(Air) goals.

The second category is Schedule 1, Part 2 goals in the EPP(Air), which are for biological integrity (eg protection of plant life and ecosystems). Two air quality goals are presented for NO_2; 95 $\mu g/m^3$ (0.046 ppm) for a 4-hour average and 30 $\mu g/m^3$ (0.015 ppm) for an annual average. Note that the annual average NO_2 goal for biological protection is more stringent than the NEPM(Air) annual average goal of 62 $\mu g/m^3$ (0.03 ppm), which is for human health protection.

Estimates of background levels of NO_2 make up approximately two thirds of the goals for both averaging times. Inclusive of the maximum offsite increase in NO_2 concentrations, resulting from site operation, the estimated impacts comply with Schedule 1 Part 2 of the EPP(Air) goals for biological integrity, and the NEPM(Air) annual air goal for human health protection.

8. Monitoring of Emissions to Air

GHD recommends that emissions to air from the project discharge points be tested in accordance with the Queensland EPA Air Quality Sampling manual[10]. Emission tests should be conducted upon commissioning and thereafter at a frequency denoted in the terms and conditions within the development approval documentation (this may be in the order of every twelve months). All emission testing and sample analysis should be conducted by National Association of Testing Authorities (NATA) accredited laboratories and consultants. Comparison of recorded emissions shall be made against the in-stack concentrations listed in Table 8 below. These concentrations were based on information provided by DN and Caterpillar[11] (See Appendix A).

Note that the draft terms of reference for the project called for comparison between anticipated in-stack concentrations and the NHMRC Guidelines for Control of Emissions from New Stationary Sources[12]. These guidelines were rescinded by the NHMRC in February 2000 and are, therefore, no longer applicable to the assessment of new stationary sources. The project would have shown emphatic compliance with these guidelines: 0.25 g/Nm^3 for particulates and 2.0 g/Nm^3 for oxides of Nitrogen.

[10] *Air Quality Sampling Manual.* Queensland Government EPA, November 1997.

[11] Note that the NO_2/NO_x ratio estimate (0.3) was determined through correspondance with manufacutruers of simalar engines to those proposed – Wartsila and Jenbacher.

[12] *National Guidelines for Control of Emsissions from new Stationary Sources.* National Health and Medical Research Council (NHMRC). 1985. **Rescinded 29/02/2000**

Table 8 In-Stack Concentrations

		Particulates	NO_x
AN Plant	*Flow Rate (Nm^3/s)[1]*	48.91	-
	Emission Rate (g/s)	1.85	-
	In-Stack Conc. (g/Nm^3)[1]	0.038	-
NA Vent	*Flow Rate (Nm^3/s)[1]*	-	27.74
	Emission Rate (g/s)	-	2.78
	In-Stack Conc. (g/Nm^3)[1]	-	0.1
Reformer Furnace	*Flow Rate (Nm^3/s)[1]*	-	15.94
	Emission Rate (g/s)	-	3.15
	In-Stack Conc. (g/Nm^3)[1]	-	0.27
Generators (Per Unit)	*Flow Rate ($Nm^3/hr.$)[1]*	9480	9480
	Emission Rate (g/s)	0.02 [2]	1.45[2]
	In-Stack Conc. (g/Nm^3)[1]	0.008 [2]	0.55 [2]

1: Gas volumes expressed as Normalised cubic metres (Nm^3). (0% moisture, 0ºC and atmosphere)

2: Emission rate includes 10% safety factor. (See Section 2.2.2)

3: Expressed as NO_x (as NO_2). Calculated under the assumption that the NO_2/NO_x ratio is 0.3. (See Section 2.2.2.)

9. Conclusions

Subject to the scope and limitations defined in Section 10 of this report, GHD draws the following conclusions from the above detailed air quality assessment.

Through the application of meteorological and atmospheric dispersion modelling, this air quality assessment for the proposed DN Ammonium Nitrate plant at Moranbah, Queensland has shown that:

» In order to achieve compliance with the relevant air quality goals contained within the Queensland Environmental Protection Policy for Air (1997), the exhaust vent of each of the nine electricity generation units must be 15 m (or greater) in height. Note that a 15 m exhaust stack height is a prerequisite for the validity of the following conclusions;

» During both the construction and operational phases, the predicted air quality impact due to emissions to air of particulates and Nitrogen Dioxide from the facility, inclusive of conservative estimates of background levels, is compliant with the relevant air quality goals contained within the Queensland Environmental Protection Policy for Air (1997);

» During both the construction and operational phases, the predicted air quality impacts, inclusive of conservative estimates of background levels, compare favourably with the relevant airshed air quality monitoring goals contained within the National Environmental Protection Measure for Air;

» Given that the predicted impact of emissions to air from the project are low when compared to conservative estimates of existing background, there exists a minimum safety factor of 1.2, by which emissions may be increased (due to unforeseen and irregular upset events) before the EPP(Air) air quality goals are exceeded. This safety factor is applicable to worst-case background concentration and meteorological conditions; and

» Given the low existing concentrations of atmospheric particulates, NO_x and VOCs, and given the small increase in atmospheric PM_{10} and NO_2 predicted to result from the operation of the project and power station, adverse impacts upon visible amenity at Moranbah due to haze and/or smog are highly unlikely.

10. Scope and Limitations

This report presents the results of an air quality assessment prepared for the purpose of this commission. The data and advice provided herein relate only to the project and structures described herein and must be reviewed by a competent engineer / scientist before being used for any other purpose. GHD Pty Ltd (GHD) accepts no responsibility for other use of the data.

Where monitoring results, physical tests, data collection and similar work have been performed and recorded by others the data is included and used in the form provided by others. The responsibility for the accuracy of such data remains with the issuing authority, not with GHD.

An understanding of a site's air quality depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experience based. Hence this report should not be altered, amended or abbreviated, issued in part or issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances, which arise from the issue of a report which has been modified in any way as outlined above.

Appendix A

Emission Calculations provided by Dyno Nobel and Caterpillar

AN Plant Emission Rates - Source: Dyno Nobel Asia Pacific Ltd.

		Reformer Furnace	Nitric Acid Vent	AN Plant Wash Column	Plant
Plant output	T/d	230.00	405.00	515.00	QN1
	T/d	454.00	764.00	1000.00	QNB
Flow Rate (kmol/hr)	kmol/h	1759.00	1833.00	3781.00	QN1
(Stack)	kmol/h	3162.00	4485.00	7860.70	QNB
Flow Rate (m3/s)	Nm3/s	10.94	11.41	23.53	QN1
	Nm3/s	19.70	27.90	48.91	QNB
Exit Temperature	Deg C	173	130	40	QN1
	Deg C	127	127	45	QNB
Flow Rate (m3/s)	m3/s	17.88	16.84	26.97	QN1
	m3/s	28.80	40.89	50.57	QNB
Stack Height (m)	m	31	66	65	QN1
	m	21	65	65	QNB
Stack Diameter (m)	m	1.1	0.92	1.5	QN1
	m	1.3	1.05	2.0	QNB
Velocity	m/s	18.82	25.34	15.27	QN1
	m/s	19.63	35.50	16.20	QNB
NOx Emission rate	mol ppm	200	150	na	QN1
	mol ppm	78.00	49.00	na	QNB
NOx Emission rate	g/s	2.93	2.29	na	QN1
	g/s	3.15	2.78	na	QNB
TSP Emission rate	mg/Nm3	na	na	40	QN1
	mg/Nm3	na	na	37.80	QNB
	g/s	na	na	0.94	QN1
	g/s	na	na	1.85	QNB

Notes: 1 QN1 values have been extracted from the original EIS for the AN plant at Mouta

G3520C LE

GAS ENGINE TECHNICAL DATA

CATERPILLAR®

ENGINE SPEED:	1500	FUEL:	SITE SPECIFIC
COMPRESSION RATIO:	11.3:1	FUEL SYSTEM:	LPG IMPCO
AFTERCOOLER - STAGE 1 MAX. INLET (°C):	92		WITH AIR FUEL RATIO CONTROL
AFTERCOOLER - STAGE 2 MAX. INLET (°C):	54	FUEL PRESS. RANGE (KPAg):	3.4 - 34.5
JACKET WATER - MAX. OUTLET (°C):	99	MIN. METHANE NUMBER:	99.1
COOLING SYSTEM:	JW+OC+1AC, 2AC	RATED ALTITUDE (m):	345
IGNITION SYSTEM:	ADEM3	AT AIR TO TURBO. TEMP. (°C):	25
EXHAUST MANIFOLD:	DRY	NOx EMISSION LEVEL:	500.0 mg/Nm3
COMBUSTION:	LOW EMISSION	FUEL LHV (MJ/Nm3):	35
		APPLICATION:	50 Hz GENSET

RATING AND EFFICIENCY		NOTES	LOAD	100%	75%	50%
ENGINE POWER	(WITHOUT FAN)	(1)	KW	2055	1541	1035
GENERATOR POWER	(WITHOUT FAN)	(2)	EKW	1979	1484	997
ENGINE EFFICIENCY	**(ISO 3046/1)**	**(3)**	**%**	**41.2**	**40.3**	**38.9**
ENGINE EFFICIENCY	(NOMINAL)	(3)	%	40.2	39.3	38.0
THERMAL EFFICIENCY	(NOMINAL)	(4)	%	44.5	45.2	46.3
TOTAL EFFICIENCY	(NOMINAL)	(5)	%	84.7	84.5	84.3

ENGINE DATA						
FUEL CONSUMPTION	**(ISO 3046/1)**	**(6)**	**MJ/bkW-hr**	**8.74**	**8.94**	**9.26**
FUEL CONSUMPTION	(NOMINAL)	(6)	MJ/bkW-hr	8.95	9.16	9.48
AIR FLOW (0 °C, 101.3 kPa)		(7)	Nm3/bkW-hr	4.28	4.32	4.39
AIR FLOW		(7)	kg/bkW-hr	5.53	5.59	5.67
COMPRESSOR OUT PRESSURE			kPa (abs)	331	253	171
COMPRESSOR OUT TEMPERATURE			°C	181	142	95
AFTERCOOLER AIR OUT TEMPERATURE			°C	56	56	56
INLET MAN. PRESSURE		(8)	KPAa	299	227	157
INLET MAN. TEMPERATURE	(MEASURED IN PLENUM)	(9)	°C	57	57	57
TIMING		(10)	°BTDC	24	24	24
EXHAUST STACK TEMPERATURE		(11)	°C	464	489	516
EXHAUST GAS FLOW (0 °C, 101.3 kPa)		(12)	Nm3/bkW-hr	4.54	4.59	4.66
EXHAUST MASS FLOW		(12)	kg/bkW-hr	5.71	5.78	5.86

EMISSIONS DATA					
NOx (as NO2) (corr. 5% O2)	(13)	mg/Nm3 (dry)	500	500	500
CO (corr. 5% O2)	(14)	mg/Nm3 (dry)	1035	1011	962
THC (corr. 5% O2), molecular weight of 15.84)	(14)	mg/Nm3 (dry)	2381	2627	2750
NMHC (corr. 5% O2, molecular weight of 15.84)	(14)	mg/Nm3 (dry)	358	395	413
EXHAUST O2	(15)	% DRY	9.2	9.2	9.1
LAMBDA	(15)		1.78	1.76	1.73

HEAT BALANCE DATA					
LHV INPUT	(16)	KW	5107	3919	2725
HEAT REJECTION TO JACKET	(17)	KW	608	511	407
HEAT REJECTION TO ATMOSPHERE	(18)	KW	137	115	92
HEAT REJECTION TO LUBE OIL	(19)	KW	129	115	98
HEAT REJECTION TO EXHAUST (LHV to 25°C)	(20)	KW	1731	1396	1011
HEAT REJECTION TO EXHAUST (LHV to 120°C)	(20)	KW	1257	1025	753
HEAT REJECTION TO A/C - STAGE 1	(21)	KW	278	117	4
HEAT REJECTION TO A/C - STAGE 2	(22)	KW	154	107	62
HEAT REJECTION TO ENGINE PUMPS		KW	15.4	15.4	15.4

CONDITIONS AND DEFINITIONS

ENGINE RATING OBTAINED AND PRESENTED IN ACCORDANCE WITH ISO 3046/1. DATA REPRESENTS CONDITIONS OF 25°C, 100 KPA BAROMETRIC PRESSURE, 30% RELATIVE HUMIDITY, 2.5 KPA AIR FILTER RESTRICTION, AND 5 KPA EXHAUST STACK PRESSURE. ENGINE EFFICIENCY AND FUEL CONSUMPTION SPECIFICALLY NOTED AS ISO 3046/1 ARE REPRESENTED WITH 1.25 KPA AIR FILTER RESTRICTION AND 0 KPA EXHAUST STACK PRESSURE. CONSULT ALTITUDE CURVES FOR APPLICATIONS ABOVE MAXIMUM RATED ALTITUDE AND/OR TEMPERATURE. NO OVERLOAD PERMITTED AT RATING SHOWN.

EMISSION LEVELS ARE BASED ON THE ENGINE OPERATING AT STEADY STATE CONDITIONS AND ADJUSTED TO THE SPECIFIED NOx LEVEL AT 100% LOAD. EMISSION TOLERANCES SPECIFIED ARE DEPENDANT UPON FUEL QUALITY. METHANE NUMBER CANNOT VARY MORE THAN ± 3. PUBLISHED PART LOAD DATA IS WITH LAMBDA CONTROL.

ENGINE RATING IS WITH 1 ENGINE DRIVEN AFTERCOOLER WATER PUMP.

FOR NOTES INFORMATION CONSULT PAGE THREE.

ALTITUDE DERATION FACTORS

AIR TO TURBO (°C)	345
50	0.92
45	0.94
40	0.95
35	0.97
30	0.98
25	1.00
20	1.00
15	1.00
10	1.00

ALTITUDE (METERS ABOVE SEA LEVEL)

AFTERCOOLER HEAT REJECTION FACTORS

AIR TO TURBO (°C)	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
50	1.28	1.32	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
45	1.22	1.26	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
40	1.16	1.20	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
35	1.10	1.14	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
30	1.04	1.08	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
25	1.00	1.01	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

ALTITUDE (METERS ABOVE SEA LEVEL)

FREE FIELD MECHANICAL & EXHAUST NOISE

100% Load Data			dB(A)	(dB)							
Free Field Mechanical	DISTANCE FROM THE ENGINE (METERS)	1	111.8	62.4	88.1	89.8	95.3	99.3	98.6	97.3	107.6
		7	94.9	45.5	71.2	72.9	78.4	82.4	81.7	80.4	90.7
		15	88.3	38.9	64.6	66.3	71.8	75.8	75.1	73.8	84.1
Free Field Exhaust	DISTANCE FROM THE ENGINE (METERS)	1.5	114.6	90.4	100.0	98.9	103.0	99.1	102.4	99.8	101.5
		7	101.2	77.0	86.6	85.5	89.6	85.7	89.0	86.4	88.1
		15	94.6	70.4	80.0	78.9	83.0	79.1	82.4	79.8	81.5
			Overal SPL	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**	**4 kHz**	**8 khz**

Octave Band Center Frequency (OBCF)

ALTITUDE DERATION FACTORS:

This table shows the deration required for various air inlet temperatures and altitudes. Use this information along with the fuel usage guide chart to help determine actual engine power for your site.

INLET AND EXHAUST RESTRICTION CORRECTIONS FOR ALTITUDE CAPABILITY:

To determine the appropriate altitude derate factor to be applied to this engine for inlet or exhaust restrictions differering from the standard conditions listed on page 1, a correction to the site altitude can be made to adjust for this difference. Add 42 meters to the site altitude for each additional KPA of exhaust stack pressure greater than spec sheet conditions. Add 37 meters to the site altitude for each additional KPA of inlet restriction greater than spec sheet conditions. If site inlet restriction or exhaust stack pressure are less than spec sheet conditions, the same trends apply to lower the site altitude.

ACTUAL ENGINE RATING:

It is important to note that the Altitude/Temperature deration and the Fuel Usage Guide deration are not cumulative. They are not to be added together. The same is true for the Low Energy Fuel deration (reference the Caterpillar Methane Number Program) and the Fuel Usage Guide deration. However, the Altitude/Temperature deration and Low Energy Fuel deration are cumulative; and they must be added together in the method shown below. To determine the actual power available, take the lowest rating between 1) and 2).

1) (Altitude/Temperature Deration) + (Low Energy Fuel Deration)
2) Fuel Usage Guide Deration

Note: For NA's always add the Low Energy Fuel deration to the Altitude/Temperature deration. For TA engines only add the Low Energy Fuel deration to the Altitude/Temperature deration whenever the Altitude/Temperature deration is less than 1.0 (100%). This will give the actual rating for the engine at the conditions specified.

AFTERCOOLER HEAT REJECTION FACTORS:

Aftercooler heat rejection is given for standard conditions of 25°C and 152 m altitude. To maintain a constant air inlet manifold temperature, as the air to turbo temperature goes up, so must the heat rejection. As altitude increases, the turbocharger must work harder to overcome the lower atmospheric pressure. This increases the amount of heat that must be removed from the inlet air by the aftercooler. Use the aftercooler heat rejection factor to adjust for ambient and altitude conditions. Multiply this factor by the standard aftercooler heat rejection. Failure to properly account for these factors could result in detonation and cause the engine to shutdown or fail. For 2 Stage Aftercoolers with separate circuits, the 1st stage will collect 90% of the additional heat.

SOUND DATA:

Data determined by methods similar to ISO Standard DIS-8528-10. Accuracy Grade 3. SPL = Sound Pressure Level.

NOTES

1 LOAD.

2 GENERATOR POWER DETERMINED WITH AN ASSUMED GENERATOR EFFICIENCY OF 96.3% AND POWER FACTOR OF 0.8 [GENERATOR POWER = ENGINE POWER x GENERATOR EFFICIENCY].

3 ISO 3046/1 ENGINE EFFICIENCY TOLERANCE IS (+)0, (-)5% OF FULL LOAD % EFFICIENCY VALUE. NOMINAL ENGINE EFFICIENCY TOLERANCE IS ± 2.5% OF FULL LOAD % EFFICIENCY VALUE.

4 THERMAL EFFICIENCY: JACKET HEAT + LUBE OIL HEAT + STAGE 1 A/C HEAT + EXH. HEAT TO 120°C.

5 TOTAL EFFICIENCY = ENGINE EFF. + THERMAL EFF. TOLERANCE IS ± 10% OF FULL LOAD DATA.

6 ISO 3046/1 FUEL CONSUMPTION TOLERANCE IS (+)5, (-)0% OF FULL LOAD DATA. NOMINAL FUEL CONSUMPTION TOLERANCE IS ± 2.5 % OF FULL LOAD DATA.

7 UNDRIED AIR. FLOW TOLERANCE IS ± 5 %

8 INLET MANIFOLD PRESSURE TOLERANCE IS ± 5 %

9 INLET MANIFOLD TEMPERATURE TOLERANCE IS ± 5°C.

10 TIMING INDICATED IS FOR USE WITH THE MINIMUM FUEL METHANE NUMBER SPECIFIED. CONSULT THE APPROPRIATE FUEL USAGE GUIDE FOR TIMING AT OTHER METHANE NUMBERS.

11 EXHAUST STACK TEMPERATURE TOLERANCE IS (+)35°C, (-)30°C.

12 WET EXHAUST. FLOW TOLERANCE IS ± 6 %

13 NOX TOLERANCES ARE ± 18 % OF SPECIFIED VALUE.

14 CO, CO2, THC, and NMHC VALUES ARE "NOT TO EXCEED".

15 O2% TOLERANCE IS ± 0.5; LAMBDA TOLERANCE IS ± 0.05. LAMBDA AND O2 LEVEL ARE THE RESULT OF ADJUSTING THE ENGINE TO OPERATE AT THE SPECIFIED NOX LEVEL.

16 LHV RATE TOLERANCE IS ± 2.5%.

17 TOTAL JW HEAT (based on treated water) = JACKET HEAT + LUBE OIL HEAT + STAGE 1 A/C HEAT + 0.90 x (STAGE 1 + STAGE 2) x (ACHRF-1). TOLERANCE IS ± 10 % OF FULL LOAD DATA. HEAT REJECTION BASED ON LITERS/MIN WATER FLOW.

18 RADIATION HEAT RATE BASED ON TREATED WATER. TOLERANCE IS ± 50% OF FULL LOAD DATA.

19 LUBE OIL HEAT RATE BASED ON TREATED WATER. TOLERANCE IS ± 20% OF FULL LOAD DATA.

20 EXHAUST HEAT RATE BASED ON TREATED WATER. TOLERANCE IS ± 10% OF FULL LOAD DATA.

21 STAGE 1 A/C HEAT (based on treated water) = STAGE 1 A/C HEAT + 0.90 x (STAGE 1 + STAGE 2) x (ACHRF-1). TOLERANCE IS ± 5 % OF FULL LOAD DATA.

22 STAGE 2 A/C HEAT (based on treated water) = STAGE 2 A/C HEAT + (STAGE 1 + STAGE 2) x 0.10 x (ACHRF - 1). TOLERANCE IS ± 5 % OF FULL LOAD DATA.

Appendix B

Sample AUSPLUME Output File

Operational Impact (NO_2) 4-hour

1 ____

Dyno AN plant and Generators_NO2_4hr_R06_15m Ex._5.4 m builds

____

Concentration or deposition Concentration
Emission rate units grams/second
Concentration units microgram/m3
Units conversion factor 1.00E+06
Constant background concentration 0.00E+00
Terrain effects None
Smooth stability class changes? No
Other stability class adjustments ("urban modes") None
Ignore building wake effects? No
Decay coefficient (unless overridden by met. file) 0.000
Anemometer height 10 m
Roughness height at the wind vane site 0.100 m
Use the convective PDF algorithm? No

DISPERSION CURVES
Horizontal dispersion curves for sources <100m high Pasquill-Gifford
Vertical dispersion curves for sources <100m high Pasquill-Gifford
Horizontal dispersion curves for sources >100m high Briggs Rural
Vertical dispersion curves for sources >100m high Briggs Rural
Enhance horizontal plume spreads for buoyancy? Yes
Enhance vertical plume spreads for buoyancy? Yes
Adjust horizontal P-G formulae for roughness height? Yes
Adjust vertical P-G formulae for roughness height? Yes
Roughness height 0.100m
Adjustment for wind directional shear None

PLUME RISE OPTIONS
Gradual plume rise? Yes
Stack-tip downwash included? Yes
Building downwash algorithm: PRIME method.
Entrainment coeff. for neutral & stable lapse rates 0.60,0.60
Partial penetration of elevated inversions? No
Disregard temp. gradients in the hourly met. file? No

and in the absence of boundary-layer potential temperature gradients
given by the hourly met. file, a value from the following table
(in K/m) is used:

Wind Speed Category	Stability Class A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.020	0.035
2	0.000	0.000	0.000	0.000	0.020	0.035
3	0.000	0.000	0.000	0.000	0.020	0.035
4	0.000	0.000	0.000	0.000	0.020	0.035
5	0.000	0.000	0.000	0.000	0.020	0.035
6	0.000	0.000	0.000	0.000	0.020	0.035

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Rural" values (unless overridden by met. file)

AVERAGING TIMES
4 hours

____

1 ____

Dyno AN plant and Generators_NO2_4hr_R06_15m Ex._5.4 m builds

SOURCE CHARACTERISTICS

STACK SOURCE: WASHCO

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601814	7569878	0m	65m	2.00m	45C	16.2m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	0	0	0	0	0	0	0	0	0	0	0	0
Effective building height	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow building length	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0
Across-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	0	0	0	0	0	0	0	0	0	0	0	0
Effective building height	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow building length	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0
Across-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	0	0	0	0	0	0	0	0	0	0	0	0
Effective building height	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow building length	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0
Across-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0

(Constant) emission rate = 0.00E+00 grams/second
No gravitational settling or scavenging.

STACK SOURCE: NAVENT

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601814	7569878	0m	65m	1.05m	127C	35.5m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	0	0	0	0	0	0	0	0	0	0	0	0
Effective building height	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow building length	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0
Across-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	0	0	0	0	0	0	0	0	0	0	0	0
Effective building height	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow building length	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0
Across-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	0	0	0	0	0	0	0	0	0	0	0	0
Effective building height	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow building length	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0
Across-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0

(Constant) emission rate = 8.34E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: REFFUR

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601712	7569784	0m	21m	1.30m	127C	19.6m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	0	0	0	0	0	0	0	0	0	0	0	0
Effective building height	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow building length	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0
Across-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	0	0	0	0	0	0	0	0	0	0	0	0
Effective building height	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow building length	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0
Across-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	0	0	0	0	0	0	0	0	0	0	0	0
Effective building height	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow building length	0	0	0	0	0	0	0	0	0	0	0	0
Along-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0
Across-flow distance from stack	0	0	0	0	0	0	0	0	0	0	0	0

(Constant) emission rate = 9.45E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GEN1

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601865	7570208	0m	15m	0.50m	457C	13.0m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	8	6	12	6	8	10	12	13	14	15	15	14
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	15	15	15	14	14	14	13	12	10	8	6	4
Along-flow distance from stack	-9	-10	-34	-10	-10	-7	-5	-9	-8	-7	-5	-4
Across-flow distance from stack	3	3	-1	2	2	-7	-7	-1	-1	-1	-2	-3

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	15	14	14	13	12	10	8	6	12	6	8	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	6	9	10	12	13	14	15	15	16	14	14	14
Along-flow distance from stack	-5	-6	-6	-6	-6	-6	-6	-6	-5	-4	-4	-4
Across-flow distance from stack	-3	-3	-3	-3	-3	-3	-3	-3	2	-2	-1	-1

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	12	13	14	15	15	14	14	14	14	13	12	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	14	12	10	8	6	4	6	9	10	12	13	14
Along-flow distance from stack	-8	-3	-2	-1	-1	0	-1	-3	-26	-6	-7	-8
Across-flow distance from stack	7	1	1	2	2	2	3	3	-8	3	3	3

(Constant) emission rate = 3.16E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GEN3

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601879	7570200	0m	15m	0.50m	457C	13.0m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	8	6	12	6	8	10	12	13	14	15	15	14
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	15	15	15	15	15	14	13	13	10	8	6	4
Along-flow distance from stack	-13	-12	-11	-11	-12	-15	-16	-10	-22	-22	-21	-20
Across-flow distance from stack	-4	-5	-2	2	1	8	6	-2	7	4	1	-3

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	14	13	14	13	11	10	8	6	12	6	8	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	6	8	10	12	13	14	15	15	15	15	15	15
Along-flow distance from stack	4	10	2	7	5	-1	-2	-3	-4	-4	-4	-3
Across-flow distance from stack	-3	1	-1	6	8	3	4	5	2	-2	-1	-1

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	12	13	14	15	15	14	14	14	14	13	11	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	14	12	11	9	7	4	6	8	10	12	13	14
Along-flow distance from stack	2	4	5	6	7	-8	7	-18	-12	-19	-19	-13
Across-flow distance from stack	-6	-4	-2	0	2	4	5	-1	1	-6	-8	-3

(Constant) emission rate = 3.16E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GEN2

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601872	7570204	0m	15m	0.50m	457C	13.0m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	8	6	12	6	8	10	12	13	14	15	15	14
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	15	15	15	14	15	14	13	12	10	8	6	4
Along-flow distance from stack	-35	-35	-34	-11	-9	-11	-11	-15	-15	-14	-13	-12
Across-flow distance from stack	4	-1	7	2	-7	1	-1	5	3	1	-1	-3

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	15	14	14	13	12	11	9	7	12	6	8	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	6	9	10	12	14	14	15	15	16	15	15	14
Along-flow distance from stack	-13	-13	-13	-13	5	-5	-2	-3	-5	-4	-7	0
Across-flow distance from stack	-4	-6	-7	-8	8	-4	5	5	-6	-2	7	-8

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	12	13	14	15	15	14	14	14	14	13	12	11
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	14	12	10	8	6	4	6	8	10	12	13	14
Along-flow distance from stack	-3	4	5	6	8	8	7	-26	-19	0	-18	-9
Across-flow distance from stack	1	-5	-3	-1	1	2	4	-3	-4	8	-8	4

(Constant) emission rate = 3.16E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GEN4

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601886	7570195	0m	15m	0.50m	457C	13.0m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	8	6	12	6	8	10	12	13	14	15	15	14
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	15	15	15	14	15	14	14	13	11	8	6	4
Along-flow distance from stack	-9	-10	-10	-9	-34	-11	-16	-16	-23	-30	-30	-29
Across-flow distance from stack	4	3	7	-5	-6	1	7	5	7	8	3	-2

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	14	13	14	13	11	10	8	6	12	6	8	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	6	8	10	12	13	14	15	15	15	14	14	14
Along-flow distance from stack	-6	2	-6	0	-1	-6	-6	-5	-5	-4	-4	-3
Across-flow distance from stack	-4	-1	-4	1	2	-4	-4	-3	-7	-2	-2	-2

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°

Effective building width	12	13	14	15	15	14	14	14	14	13	11	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	13	13	11	9	7	4	6	8	10	12	13	14
Along-flow distance from stack	-7	4	5	6	8	1	-1	-10	-4	-12	-12	-8
Across-flow distance from stack	6	-5	-3	-1	1	3	3	1	4	-1	-2	4

(Constant) emission rate = 3.16E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GEN5

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601892	7570191	0m	15m	0.50m	457C	13.0m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	8	6	4	6	8	10	12	13	14	15	15	14
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	15	15	14	14	15	14	13	12	11	9	7	4
Along-flow distance from stack	-9	-9	-10	-10	-36	-36	-15	-15	-22	-30	-21	-12
Across-flow distance from stack	3	2	2	2	1	-4	6	5	7	7	1	-2

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	14	13	14	13	11	10	8	6	4	6	8	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	6	8	10	12	13	14	15	15	14	14	14	14
Along-flow distance from stack	-13	-6	-13	-6	-6	-6	-6	-5	-5	-4	-4	1
Across-flow distance from stack	-5	-4	-7	-3	-3	-3	-3	-2	-2	-2	-1	-8

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	12	13	14	15	15	14	14	14	14	13	11	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	13	12	10	8	6	4	6	8	10	12	13	14
Along-flow distance from stack	-3	4	5	6	8	9	7	-3	3	-6	-7	-8
Across-flow distance from stack	0	-5	-3	-1	1	3	4	3	7	3	3	3

(Constant) emission rate = 3.16E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GEN6

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601846	7570185	0m	15m	0.50m	457C	13.0m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	9	7	12	6	9	10	12	13	14	15	15	14
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	15	15	15	15	15	15	14	12	11	9	7	5
Along-flow distance from stack	-6	-6	-5	-5	-4	-4	-3	4	-2	-1	-1	0
Across-flow distance from stack	-3	-3	-6	-2	-1	-1	0	-5	1	2	2	3

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	15	14	14	13	13	11	9	7	12	6	8	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	6	8	11	12	13	14	15	15	14	14	14	15
Along-flow distance from stack	-2	5	3	1	-7	-8	-9	-9	-10	-34	-34	-40
Across-flow distance from stack	3	6	7	8	4	4	3	3	6	-2	-7	3

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	12	13	14	14	14	14	14	14	14	13	13	11
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	14	13	11	9	7	5	6	8	10	12	13	14
Along-flow distance from stack	-34	-38	-9	-30	-30	-29	-13	-13	-13	-13	-6	-6
Across-flow distance from stack	-8	-8	-1	7	3	-2	-4	-6	-7	-8	-4	-4

(Constant) emission rate = 3.16E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GEN7

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601853	7570181	0m	15m	0.50m	457C	13.0m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	8	6	12	6	8	10	12	13	14	15	15	14
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	15	15	15	14	15	15	14	12	11	9	7	5
Along-flow distance from stack	-6	-6	-5	-5	-5	-8	-9	-3	-9	-9	-9	-8
Across-flow distance from stack	-3	-2	2	-2	-2	7	6	1	5	4	3	3

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	15	14	14	13	12	10	8	6	12	6	8	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	6	8	11	12	13	14	15	15	14	15	15	15
Along-flow distance from stack	-10	-3	-5	-6	-7	-8	-35	-35	-10	-34	-36	-35
Across-flow distance from stack	2	3	3	3	3	3	4	0	-2	-2	2	-4

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	12	13	13	14	14	14	14	14	14	13	12	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	14	12	11	9	7	5	6	8	10	12	13	14
Along-flow distance from stack	-6	-37	-22	-22	-22	-21	-5	-5	-6	-6	-6	-6
Across-flow distance from stack	-6	-8	8	5	1	-2	-3	-3	-3	-3	-3	-3

(Constant) emission rate = 3.16E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GEN8

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601860	7570176	0m	15m	0.50m	457C	13.0m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	8	6	12	6	8	10	11	13	13	14	14	14
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	15	15	15	14	14	14	13	13	11	9	7	5
Along-flow distance from stack	-2	-4	-4	-4	-4	0	2	3	4	5	6	7
Across-flow distance from stack	5	-2	-6	-1	-1	-7	-6	-4	-3	-1	1	2

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	14	14	14	13	12	10	8	6	12	6	8	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	6	8	11	12	13	14	15	15	15	15	14	14
Along-flow distance from stack	7	-11	-13	-13	-37	-38	-10	-10	-34	-34	-36	-35
Across-flow distance from stack	4	1	-1	-2	7	2	3	2	6	-3	1	-5

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	11	12	13	14	14	14	14	14	14	13	12	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	14	12	11	9	7	5	6	8	10	12	13	14
Along-flow distance from stack	-15	-15	-15	-14	-14	-12	4	3	2	1	0	-1
Across-flow distance from stack	6	4	3	1	-1	-3	-2	-1	1	2	3	4

(Constant) emission rate = 3.16E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GEN9

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
601867	7570172	0m	15m	0.50m	457C	13.0m/s

______ Effective building dimensions (in metres) ______

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	8	7	12	6	8	10	11	13	13	14	14	14
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	15	14	15	14	15	14	13	13	11	9	7	5
Along-flow distance from stack	-2	-5	-4	-5	-5	-4	-4	-4	-3	-2	-2	-1
Across-flow distance from stack	5	-2	2	-1	-1	0	1	1	2	2	2	2

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	14	14	14	13	12	10	8	7	12	6	8	9
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	6	8	11	12	14	14	15	15	15	14	14	14
Along-flow distance from stack	-2	-19	-20	-19	-14	-13	-13	-35	-34	-35	-10	-10
Across-flow distance from stack	3	-2	-5	-7	-3	-4	-5	-1	-2	5	1	1

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	11	12	13	14	14	14	14	14	14	13	12	10
Effective building height	5	5	5	5	5	5	5	5	5	5	5	5
Along-flow building length	14	12	11	9	7	5	6	8	10	12	13	14
Along-flow distance from stack	-10	-9	-8	-7	-6	-4	4	11	9	7	0	-1
Across-flow distance from stack	0	-1	-2	-2	-3	-3	-2	2	5	7	3	4

(Constant) emission rate = 3.16E-01 grams/second
No gravitational settling or scavenging.

1

Dyno AN plant and Generators_NO2_4hr_R06_15m Ex._5.4 m builds

RECEPTOR LOCATIONS

The Cartesian receptor grid has the following x-values (or eastings):
599350.m 599400.m 599450.m 599500.m 599550.m 599600.m 599650.m
599700.m 599750.m 599800.m 599850.m 599900.m 599950.m 600000.m
600050.m 600100.m 600150.m 600200.m 600250.m 600300.m 600350.m
600400.m 600450.m 600500.m 600550.m 600600.m 600650.m 600700.m
600750.m 600800.m 600850.m 600900.m 600950.m 601000.m 601050.m
601100.m 601150.m 601200.m 601250.m 601300.m 601350.m 601400.m
601450.m 601500.m 601550.m 601600.m 601650.m 601700.m 601750.m
601800.m 601850.m 601900.m 601950.m 602000.m 602050.m 602100.m
602150.m 602200.m 602250.m 602300.m 602350.m 602400.m 602450.m
602500.m 602550.m 602600.m 602650.m 602700.m 602750.m 602800.m
602850.m 602900.m 602950.m 603000.m 603050.m 603100.m 603150.m
603200.m 603250.m 603300.m 603350.m 603400.m 603450.m 603500.m
603550.m 603600.m 603650.m 603700.m 603750.m 603800.m 603850.m
603900.m 603950.m 604000.m 604050.m 604100.m 604150.m 604200.m
604250.m 604300.m 604350.m

and these y-values (or northings):
7567350.m 7567400.m 7567450.m 7567500.m 7567550.m 7567600.m 7567650.m
7567700.m 7567750.m 7567800.m 7567850.m 7567900.m 7567950.m 7568000.m
7568050.m 7568100.m 7568150.m 7568200.m 7568250.m 7568300.m 7568350.m
7568400.m 7568450.m 7568500.m 7568550.m 7568600.m 7568650.m 7568700.m
7568750.m 7568800.m 7568850.m 7568900.m 7568950.m 7569000.m 7569050.m
7569100.m 7569150.m 7569200.m 7569250.m 7569300.m 7569350.m 7569400.m
7569450.m 7569500.m 7569550.m 7569600.m 7569650.m 7569700.m 7569750.m
7569800.m 7569850.m 7569900.m 7569950.m 7570000.m 7570050.m 7570100.m
7570150.m 7570200.m 7570250.m 7570300.m 7570350.m 7570400.m 7570450.m
7570500.m 7570550.m 7570600.m 7570650.m 7570700.m 7570750.m 7570800.m
7570850.m 7570900.m 7570950.m 7571000.m 7571050.m 7571100.m 7571150.m
7571200.m 7571250.m 7571300.m 7571350.m 7571400.m 7571450.m 7571500.m
7571550.m 7571600.m 7571650.m 7571700.m 7571750.m 7571800.m 7571850.m
7571900.m 7571950.m 7572000.m 7572050.m 7572100.m 7572150.m 7572200.m
7572250.m 7572300.m 7572350.m

METEOROLOGICAL DATA : TAPM simulation 2004, Morumbah, Z0 = 0.03m, Ht=10m, m

---

1 Peak values for the 100 worst cases (in microgram/m3)
Averaging time = 4 hours

Rank	Value	Time Recorded hour,date	Coordinates (* denotes polar)	
1	5.04E+01	16,20/06/04	(601900, 7570400,	0.0)
2	4.90E+01	12,20/06/04	(601900, 7570400,	0.0)
3	4.89E+01	16,06/05/04	(601650, 7570250,	0.0)
4	4.87E+01	16,21/09/04	(601650, 7570250,	0.0)
5	4.86E+01	16,22/04/04	(601650, 7570250,	0.0)
6	4.86E+01	16,17/06/04	(602000, 7570350,	0.0)
7	4.85E+01	16,23/03/04	(601850, 7570400,	0.0)
8	4.83E+01	16,26/11/04	(601650, 7570250,	0.0)
9	4.82E+01	16,15/04/04	(601650, 7570250,	0.0)
10	4.82E+01	16,31/01/04	(602100, 7570200,	0.0)
11	4.82E+01	16,18/12/04	(601650, 7570200,	0.0)
12	4.81E+01	16,28/06/04	(601650, 7570300,	0.0)
13	4.80E+01	16,12/03/04	(601650, 7570200,	0.0)
14	4.79E+01	16,13/03/04	(601650, 7570200,	0.0)
15	4.79E+01	12,29/12/04	(601700, 7570300,	0.0)
16	4.78E+01	16,31/05/04	(601650, 7570200,	0.0)
17	4.78E+01	16,27/06/04	(601700, 7570350,	0.0)
18	4.77E+01	12,24/11/04	(601650, 7570250,	0.0)
19	4.77E+01	16,17/12/04	(601650, 7570150,	0.0)
20	4.77E+01	16,07/02/04	(601650, 7570200,	0.0)
21	4.76E+01	16,27/04/04	(601650, 7570200,	0.0)
22	4.76E+01	12,02/02/04	(602000, 7570000,	0.0)
23	4.75E+01	16,18/08/04	(601950, 7570350,	0.0)
24	4.75E+01	16,26/04/04	(601650, 7570200,	0.0)
25	4.75E+01	16,01/04/04	(601700, 7570300,	0.0)
26	4.75E+01	16,13/11/04	(601950, 7570300,	0.0)
27	4.74E+01	12,17/03/04	(601650, 7570250,	0.0)
28	4.74E+01	16,06/03/04	(602100, 7570150,	0.0)
29	4.73E+01	16,21/07/04	(601650, 7570300,	0.0)
30	4.73E+01	16,11/02/04	(601700, 7570100,	0.0)
31	4.73E+01	16,20/10/04	(602100, 7570200,	0.0)
32	4.73E+01	16,07/12/04	(601900, 7570000,	0.0)
33	4.72E+01	16,23/04/04	(601650, 7570250,	0.0)
34	4.72E+01	12,03/10/04	(601650, 7570300,	0.0)
35	4.72E+01	16,16/04/04	(601650, 7570250,	0.0)
36	4.72E+01	16,13/04/04	(601650, 7570250,	0.0)
37	4.71E+01	16,16/03/04	(601650, 7570250,	0.0)
38	4.71E+01	16,12/10/04	(601650, 7570250,	0.0)
39	4.71E+01	12,22/03/04	(601750, 7570350,	0.0)
40	4.71E+01	16,13/10/04	(601650, 7570200,	0.0)
41	4.71E+01	16,03/05/04	(601700, 7570300,	0.0)
42	4.71E+01	16,07/04/04	(601650, 7570250,	0.0)
43	4.70E+01	16,14/11/04	(601900, 7570350,	0.0)
44	4.70E+01	16,19/02/04	(601700, 7570250,	0.0)
45	4.70E+01	12,21/11/04	(601700, 7570200,	0.0)
46	4.70E+01	12,07/12/04	(601900, 7569950,	0.0)
47	4.70E+01	16,04/10/04	(601700, 7570250,	0.0)
48	4.70E+01	16,23/10/04	(601950, 7570050,	0.0)
49	4.70E+01	16,09/04/04	(601650, 7570300,	0.0)
50	4.69E+01	16,02/01/04	(601750, 7570300,	0.0)
51	4.69E+01	16,31/10/04	(601650, 7570150,	0.0)
52	4.68E+01	12,27/06/04	(601700, 7570350,	0.0)
53	4.68E+01	12,08/12/04	(601850, 7569950,	0.0)
54	4.68E+01	16,14/04/04	(601650, 7570200,	0.0)
55	4.68E+01	16,17/03/04	(601650, 7570250,	0.0)
56	4.68E+01	16,29/02/04	(601700, 7570250,	0.0)
57	4.68E+01	12,22/09/04	(601650, 7570250,	0.0)
58	4.68E+01	12,12/02/04	(601700, 7570100,	0.0)

59	4.68E+01	16,04/11/04	(601800, 7570050,	0.0)
60	4.67E+01	16,29/11/04	(601650, 7570250,	0.0)
61	4.67E+01	16,22/03/04	(601750, 7570400,	0.0)
62	4.67E+01	16,21/04/04	(601650, 7570250,	0.0)
63	4.67E+01	12,05/03/04	(601750, 7570350,	0.0)
64	4.67E+01	16,25/08/04	(601650, 7570200,	0.0)
65	4.67E+01	16,15/02/04	(601650, 7570250,	0.0)
66	4.67E+01	16,21/03/04	(601650, 7570300,	0.0)
67	4.67E+01	16,19/09/04	(601700, 7570250,	0.0)
68	4.67E+01	16,25/03/04	(601700, 7570200,	0.0)
69	4.66E+01	12,21/03/04	(601700, 7570300,	0.0)
70	4.66E+01	16,10/04/04	(601650, 7570300,	0.0)
71	4.66E+01	12,01/11/04	(601700, 7570200,	0.0)
72	4.66E+01	12,18/03/04	(601650, 7570250,	0.0)
73	4.65E+01	16,20/03/04	(601650, 7570250,	0.0)
74	4.65E+01	12,05/11/04	(601900, 7570000,	0.0)
75	4.65E+01	12,12/11/04	(601950, 7570050,	0.0)
76	4.65E+01	16,11/11/04	(601900, 7570000,	0.0)
77	4.65E+01	12,07/01/04	(601950, 7570050,	0.0)
78	4.64E+01	16,15/09/04	(601700, 7570250,	0.0)
79	4.64E+01	16,20/09/04	(601700, 7570250,	0.0)
80	4.64E+01	16,10/10/04	(601650, 7570200,	0.0)
81	4.63E+01	16,11/04/04	(601650, 7570250,	0.0)
82	4.63E+01	16,22/10/04	(602000, 7570100,	0.0)
83	4.63E+01	12,06/04/04	(601650, 7570300,	0.0)
84	4.63E+01	16,15/03/04	(601650, 7570200,	0.0)
85	4.62E+01	12,13/09/04	(601700, 7570350,	0.0)
86	4.62E+01	12,23/10/04	(601950, 7570050,	0.0)
87	4.62E+01	16,27/03/04	(601700, 7570250,	0.0)
88	4.62E+01	16,19/01/04	(601650, 7570200,	0.0)
89	4.62E+01	16,05/01/04	(601700, 7570250,	0.0)
90	4.62E+01	16,30/11/04	(601700, 7570200,	0.0)
91	4.62E+01	16,08/02/04	(601650, 7570200,	0.0)
92	4.62E+01	16,10/03/04	(601650, 7570250,	0.0)
93	4.61E+01	16,25/11/04	(601650, 7570200,	0.0)
94	4.61E+01	12,19/12/04	(601700, 7570200,	0.0)
95	4.61E+01	12,27/11/04	(601650, 7570250,	0.0)
96	4.60E+01	12,19/11/04	(601700, 7570100,	0.0)
97	4.60E+01	16,14/08/04	(602050, 7570250,	0.0)
98	4.60E+01	16,14/12/04	(602000, 7570300,	0.0)
99	4.59E+01	16,02/04/04	(601650, 7570300,	0.0)
100	4.59E+01	16,01/11/04	(601700, 7570200,	0.0)

GHD Pty Ltd ABN 39 008 488 373

180 Lonsdale Street
Melbourne, Victoria 3000
T: (03) 8687 8000 F: (03) 8687 8111 E: melmail@ghd.com.au

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft	B Sichlau	A Lewis	*AML	D McLean	*DJM	14/08/06
DraftB	B Sichlau	A Lewis	*AML	D McLean	*DJM	15/08/06
DraftC	B Sichlau	A Lewis	*AML	D McLean	*DJM	21/08/06

*Denotes signature on original