APPENDIX 4

Air Quality Assessment

Air Assessments

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Attn: Mr Peter Jamieson

Dear Peter

KWINANA ETHANOL – BIO REFINERY

AIR QUALITY IMPACT MODELLING REVIEW

In response to the EPAs letter of 16 October 2006 requesting a review of the revised air quality modelling for the above project, I have reviewed the modelling by Heggies as reported in "Kwinana Bio Refinery Air Quality Impact Assessment" Report 3-1540-R1, dated 6 December 2006.

In the EPAs letter the major concerns with the initial modelling and reporting were the:

- Use of screening meteorology to estimate 24-hour and annual average concentrations;
- Methodology used to predict odour concentrations and 99.9^{th} and 99.5^{th} percentiles; and
- Implication of the lack of "provision of researched and demonstrated input data".

Based on the above report and the points highlighted by the EPA, I consider that the revised work has addressed the modelling issues (points 1 and 2) using an acceptable methodology to predict the concentration statistics and longer term concentrations based on local data. The revised report also contains sufficient detail on the derivation of emissions and the assumptions used in the input data and modelling, to allow the key issues to be highlighted and therefore to be assessed by the EPA.

I note that details on the commitments regarding possible vegetation impacts are to be finalised in the proponent's commitments, and the proponent is committing to remodelling all sources once the plant design is finalised during the works approval process.

Yours sincerely

Owen Pitts
7 December 2006

REPORT 30-1540-R1

Revision 0

Kwinana Bio-Refinery
Air Quality Impact Assessment

PREPARED FOR

Umwelt (Australia) Pty Ltd
2/20 The Boulevarde
Toronto NSW 2283

5 FEBRUARY 2007

Kwinana Bio-Refinery

Air Quality Impact Assessment

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Heggies Pty Ltd is a Member Firm of the Association of Australian Acoustical Consultants.

Quality System
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ISO 9001 Lic 3236
SAI Global

Heggies Pty Ltd operates under a Quality System which has been certified by Quality Assurance Services Pty Limited to comply with all the requirements of ISO 9001:2000 "Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation and Servicing" (Licence No 3236).

This document has been prepared in accordance with the requirements of that System.

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
30-1540-R1	Revision 0	6 December 2006	Martin Doyle	Ronan Kellaghan	Damon Roddis
30-1540-R1R1	Revision 1	5 February 2007	Martin Doyle	Damon Roddis	Damon Roddis

EXECUTIVE SUMMARY

Heggies Pty Ltd (Heggies) has been commissioned by Umwelt Australia Pty Ltd (Umwelt) to conduct an air quality impact assessment for the proposed bio-refinery, located at Kwinana Beach Road, Kwinana, WA.

The site, plan number DP 047607, lots 1001, 1003 and 8001, on Kwinana Beach Road, is located within the southern section of the industrial area of Kwinana. The site is rectangular in shape and fronts Kwinana Beach Road and has a 1,200 m border with the adjacent recreational reserve. The proposed site has a total area of approximately 19 hectares.

For the purpose of the assessment, background hourly average Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) data from the North Rockingham monitoring station as well as 24-hour average PM_{10} data from South Lake monitoring station was obtained from the Western Australia Department of Environment and Conservation (WA DEC) for the year 2004. Hourly average Ozone data was also obtained from the North Rockingham monitoring station to more accurately calculate ground level NO_2 concentrations from total modelled Oxides of Nitrogen (NO_X) using the an empirical relationship (Janssen et al, 1988) and the ozone limiting method (OLM) for comparative purposes. Data for 2004 has been selected because this calendar year represents the most recent validated data set available from the WA DEC at the time of writing.

The WA DEC routinely adopt (where necessary) ambient air quality guideline values in the assessment of new proposals and in the management of both local and regional ambient air quality. As a matter of policy the WA DEC have adopted the National Environment Protection Measure (NEPM) standards for ambient air quality.

The impact of pollutant emissions from the proposed plant has been assessed at the following representative sensitive receivers surrounding the subject site. These locations are:

- The Caravan Park at North Rockingham – located approximately 650 m southwest of the project site;
- Kwinana Township – located approximately 3,700 m northeast of the project site; and
- Wells Park – located approximately 180 m northwest of the project site.
- Five additional receptors have been identified in the recreational reserve adjacent to the proposed site as although NEPM guidelines are not applicable, vegetation may be affected by pollutant emissions from the proposed plant.

The atmospheric dispersion modelling carried out in the present assessment utilises the Ausplume Gaussian Plume Dispersion Model software developed by EPA Victoria, Version 6.0.

The results of the modelling indicate that:

- The predicted odour concentrations are anticipated to be below the project odour goals at all sensitive receivers. The odour concentrations are below 2 OU for a 3 minute average in the 99.5^{th} percentile and are below 4 OU for a 3 minute average in the 99.9^{th} percentile. This satisfies the two-part “green-light” criteria, as set out in the *EPA Guidance Statement No 55*. At the closest receptor to the project site, Wells Park, the 99.9^{th} and 99.5^{th} percentile odour concentrations are predicted to be 0.167 OU and 0.098 OU respectively. At the Caravan Park at North Rockingham, the 99.9^{th} and 99.5^{th} percentile odour concentrations are also predicted to be 0.033 OU and 0.008 OU respectively
- The predicted 24-hour average PM_{10} concentrations are anticipated to be within the NEPM air quality goal of 50 $\mu g/m^3$ at the sensitive receivers (not to be exceeded more than 5 times per year).

- At Wells Park, the contribution of the Bio-Refinery to maximum 24-hour average PM_{10} concentrations is predicted to be 0.1 $\mu g/m^3$ resulting in a total maximum 24-hour average PM_{10} concentration of 50.6 $\mu g/m^3$. The 6th highest 24-hour average concentration is predicted to be 34.6 $\mu g/m^3$ with a contribution from the Bio-Refinery of 0 $\mu g/m^3$.
- At the Caravan Park at North Rockingham, the contribution of the Bio-Refinery to maximum 24-hour average PM_{10} concentrations is predicted to be 0 $\mu g/m^3$, the maximum 24 hour PM^{10} concentration being caused by a bushfire event on the 20th December 2004 (50.5 $\mu g/m^3$). The 6th highest 24-hour average concentration is predicted to be 34.5 $\mu g/m^3$ with a contribution from the Bio-Refinery of 0 $\mu g/m^3$.

- The predicted NO2 concentrations are anticipated to be below the health based project goals of 226 $\mu g/m^3$ 1 hour maximum and 56 $\mu g/m^3$ annual average at all sensitive receivers. At Wells Park, NO_2 concentrations are predicted to be 84 $\mu g/m^3$ as a 1 hour maximum and 12.8 $\mu g/m^3$ as an annual average. At the Caravan Park at North Rockingham, NO_2 concentrations are predicted to be 89.6 $\mu g/m^3$ as a 1 hour maximum and 12.3 $\mu g/m^3$ as an annual average. A detailed discussion of the possible exceedances of vegetation based NOx standards is included within this report.
- The predicted SO_2 concentrations are anticipated to be below the project goal of 520 $\mu g/m^3$ as a 1 hour maximum (within the DEC's *Revised Draft Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999*), 210 $\mu g/m^3$ as a 24 hour mean and 52 $\mu g/m^3$ as an annual average at all sensitive receivers. Predicted concentrations at Wells Park are 100.9 $\mu g/m^3$ as a 1 hour maximum, 15.3 $\mu g/m^3$ as a 24-hour mean and 1.73 $\mu g/m^3$ as an annual average. At the Caravan Park at North Rockingham, predicted concentrations are 100.9 $\mu g/m^3$ as a 1 hour maximum, 15.3 $\mu g/m^3$ as a 24-hour mean and 1.73 $\mu g/m^3$ as an annual average. The values are the same for many locations as the increments due to the Bio-Refinery are predicted to be so low. The maximum hourly, 24-hour mean and the annual average are driven by background concentrations of SO_2 rather than that which is generated by the Bio-Refinery itself.
- The predicted 8-hour average CO concentrations are anticipated to be below the project goal of 10 mg/m^3 at all sensitive receivers. At Wells Park concentrations are predicted to be 4.34 mg/m^3, and at the Caravan Park at North Rockingham, concentrations are predicted to be 4.1 mg/m^3.
- The predicted 1-hour average ethanol concentrations are anticipated to be below the project goal of 2.1 mg/m^3 at all sensitive receivers. At Wells Park the 99.9th percentile concentration is predicted to be 0.08 mg/m^3 and at the Caravan Park at North Rockingham concentrations are predicted to be 0.06 mg/m^3.

Considering the above air quality modelling results, it is concluded that the proposed Kwinana Bio-Refinery will not have a detrimental health impact upon the surrounding sensitive receivers. Additional monitoring is required and will be undertaken by the proponent to confirm that vegetation standards are not exceeded within the Recreation Reserve.

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1 INTRODUCTION

Heggies Pty Ltd (Heggies) has been commissioned by Umwelt Australia Pty Ltd (Umwelt) to conduct an air quality impact assessment for a proposed bio-refinery, located at Kwinana Beach Road, Kwinana WA.

The purpose of this assessment is to determine the impact of the operation of the Kwinana Bio-Refinery, in terms of air quality, on nearby sensitive receptors.

This assessment was conducted in accordance with the Western Australian Department of Environment and Conservation (WA DEC) *Air Quality Modelling Guidance Notes,* March 2006.

2 PROJECT DETAILS

2.1 Local Setting

The site, plan number DP 047607, lots 1001, 1003 and 8001, on Kwinana Beach Road, is located within the southern section of the industrial area of Kwinana. The site is rectangular in shape and fronts Kwinana Beach Road and has a 1,200 m border with the adjacent recreational reserve. The proposed site has a total area of approximately 19 hectares.

The lots adjoining the site are occupied by:

- A Nickel Refinery;
- Cooperative Bulk Handling;
- A bottle shop; and
- A recreational reserve.

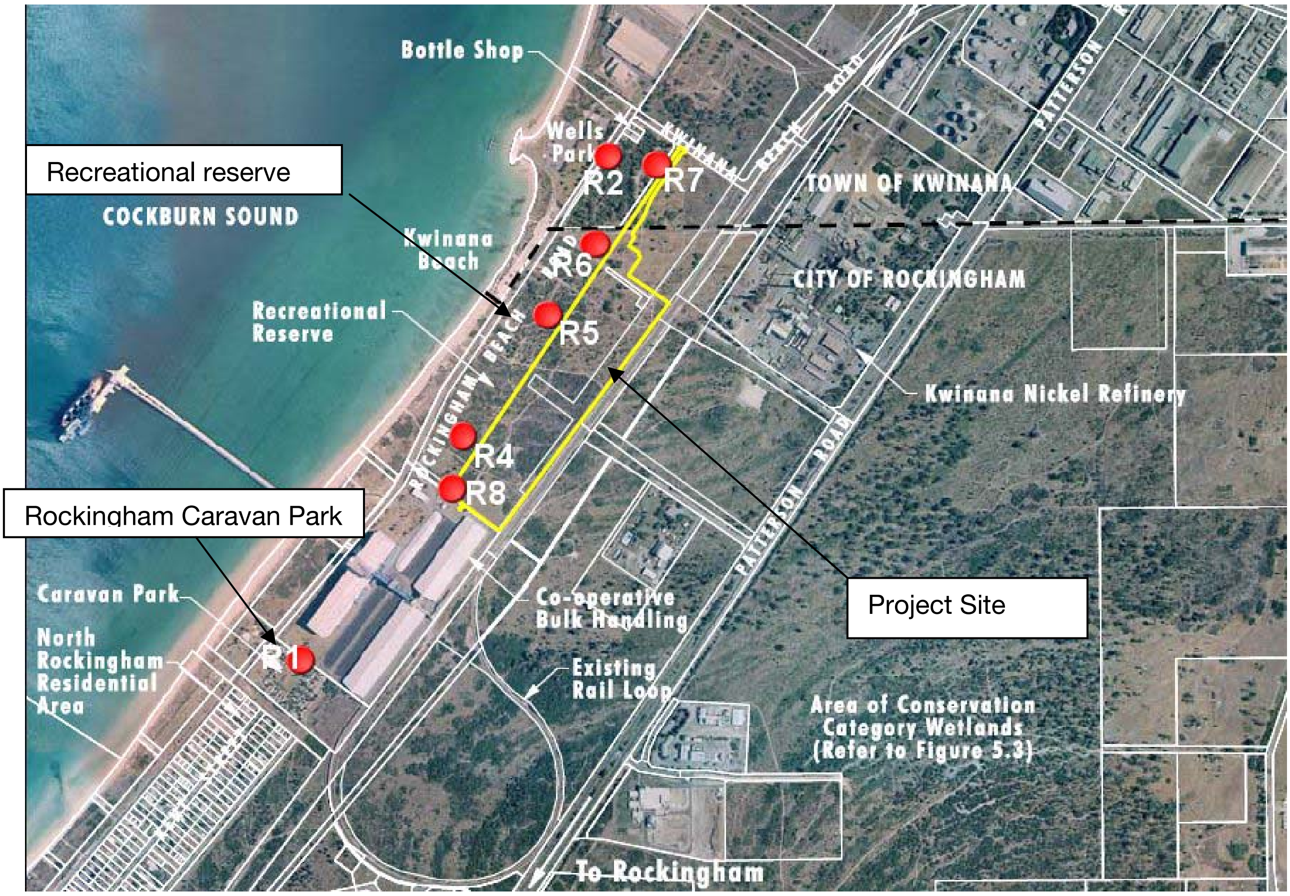
The site is currently vacant.

The nearest residential area is the caravan park at North Rockingham, approximately 650 m to the south of the site, and the Kwinana township, which is approximately 3,700 m northeast of the project site.

Two other areas of interest have been considered, including the adjacent recreational reserve along the western boundary of the project site and Wells Park, located approximately 180 m northwest of the project site.

The locality of the site is presented in **Figure 1** and **Figure 2**.

Figure 1 Project site locality and nearest receivers



Note: Areas of Interest within the Recreational Reserve are indicated by five labelled points (R4 – R8) along the boundary of the project site.

Figure 2 Project site locality and Kwinana Township

2.2 Overview of the Facility

The proposed Kwinana Bio-Refinery (hereafter, "the bio-refinery") has been designed to produce the following per annum:

- Fuel grade ethanol – 160 ML;
- Fertiliser – 350,000 tonnes;
- Aqueous Ammonia – 16,000 tonnes; and
- Green Electricity – up to 23 MW.

The bio-refinery consists of four main processing units including the ethanol plant, anaerobic digester plant, the fertiliser plant and a Combined Heat and Power Plant (CHPP). The exact configuration of the plant is to be the first of its kind in Australia. However, all of the proposed individual processing units are well established Internationally. Thus, the impact on air quality of each unit of the plant has been examined in detail using, where possible, data derived from equivalent operational plant such that the emissions to air have been quantified as fully as possible.

The proposed bio-refinery will consist of the following four processing units:

2.2.1 Ethanol Plant

The ethanol plant requires wheat and liquid starch as feed stock inputs. The wheat feedstock will be conveyed for 2-3 hours a day from the CBH facility to the plant without impacting train movements. It will be stored in day silos to allow a continuous feed supply. The liquid starch will be delivered by 8 to 10 road tankers per day. Grain will be fed into the fully enclosed hammer mills (to minimise dust emissions), combined with the liquid starch, recycled process water and enzymes in the liquefaction tank to form a slurry. The slurry will be transferred through cook tubes, where starch will be converted to sugar. Steam generated by 4 boilers will be used in this process. The material undergoes a fermentation process over a 48 hour period, with a subsequent distillation and dehydration processes. Whole stillage from the distillation plant will be transferred to an intermediate storage tank for processing within the Anaerobic Digester Plant. Fuel grade ethanol will be tested for grade and denaturant added. The ethanol will be transferred to the storage tank. Fuel grade ethanol will either be loaded out via a bottom loading truck gantry or transferred via pipeline to the Kwinana BP Refinery. It is anticipated that ethanol loading will only occur for 870 hours per annum. Transport of ethanol grade fuel will require approximately 8 to 10 B-Double tankers per day.

2.2.2 Anaerobic Digester Plant

The whole stillage from the distillation plant will be transferred to an intermediate storage tank for processing within the Anaerobic Digester Plant. It is received in the Anaerobic Digestion Plant by a pipeline. Wheat dust delivered by truck will be mixed with the whole stillage in an enclosed building (to minimise dust emissions). The material will be transferred into one of twelve digester tanks and is converted into methane and carbon dioxide. The biogas will be cooled, condensing surplus water, and transferred via a gas storage vessel to the Combined Heat and Power Plant. In the event of emergency, a gas flare will be available to vent surplus gas (see **section 2.3.5**). By-products of the digester process, including decanted sludge, will be conveyed directly to the fertiliser plant and ammonia which will be transferred to a storage tank for further use within the ethanol plant or transported off site in up to 1 or 2 B-Double tankers for fertiliser use. All other by-products will be reused within the bio-refinery processes.

2.2.3 Combined Heat and Power Plant (CHPP)

The CHPP will consist of eleven 2 MW Caterpillar CAT G3520C gas engines. These engines are lean burn NOx engines and are considered best practice. Exhaust gas from the engines will be manifolded to feed into the Fertiliser Drying Plant where natural gas burners will be utilised to increase the temperature of CAT G3520C exhaust gas from 450ºC to 600ºC. This gas is then fed into 4 Thermal Drying Plants in the Fertiliser Plant.

2.2.4 Fertiliser Plant

By-product from the Anaerobic Digester Plant (decanted sludge) will be discharged into raw material hoppers in one of the four Thermal Drying Plants. Rock phosphate will be added. Exhaust gases from the Thermal Drying Plants will be ducted via a knock out drum to biofilters, where final odour, particulate and inorganic gas treatment occurs. Moisture from the discharge air will be condensed and returned to the digester for reprocessing. Each Thermal Drying Plant is anticipated to operate six and a half days per week to allow for maintenance. Fertiliser ingredient produced by the drying system will be conveyed to the blending shed where bulk ingredients are blended.

2.3 Main Operating Issues relating to Air Quality

Below are specific operational and technical details relating to the proposed bio-refinery, which have relevance to its potential air quality impacts on the surrounding area.

These details have been obtained from Umwelt (Australia) Pty Ltd, TFA Project Engineering Group and Flo-Dry Engineering Group (manufacturers of the biofilters to be installed at the plant). Certain assumptions have had to be made regarding some components/aspects of the plant and its operation. Where these assumptions have been made, they are fully documented such that this air quality impact assessment is fully transparent and reproducible. For clarity, a process flow diagram of the whole bio-refinery operations is included in **Appendix C**.

In terms of air quality, it is the atmospheric emissions from the CHPP and the steam generation process within the ethanol plant which have the greatest potential for impact. Therefore, the sections below concentrate on the atmospheric emissions associated with operation of these elements. Full emissions inventories for both normal operation and maintenance scenarios are provided in **Appendix D**. These have been fully annotated to show the sources of all data.

2.3.1 Normal Plant Operation Scenario

Eleven 2 MW CAT G3520C gas engines will be used to generate heat and power for the proposed bio-refinery. Technical data sheets have been obtained for these engines and from these atmospheric emission rate data has been derived. The exhaust from these engines will flow through 4 Thermal Dryer Units. Exhaust gas from the CAT engines is at 450ºC. Temperature required in the Thermal dryer Units is 600ºC and therefore a natural gas fired burner is used to supplement this shortfall. 900 GJ/week of natural gas is consumed within each Thermal Dryer Unit. This natural gas has a calorific value of 38 MJ/m^3. After passing through the Thermal Dryer Units, exhaust gas (at 600ºC) passed through cyclones and is cooled to 50ºC via a condenser unit (refer **Appendix C**). After being cooled and condensed, the exhaust gas is passed through a knock out drum where residual liquid is removed, including any dissolved NOx. The gas stream is then passed onto the biofilters where exit temperature to atmosphere will be 40ºC. The knock out drum and biofilters remove a substantial amount of the atmospheric emissions (refer **Section 2.3.3**).

In total there are six steam generating boilers, however only four of which will be operational at any one time. Each boiler has its own dedicated stack to atmosphere with the following dimensions: 12 m height, 600 mm diameter, 15 m/s exit velocity, and a 250ºC exit temperature. The boiler tender specification (received from TFA Project Engineers) states that the boiler burning system will be a low NO_X burner, designed to burn natural gas.

2.3.2 Thermal Dryer Unit Maintenance Scenario

There will be occasions when the Thermal Dryer Units will need to be maintained. From discussions with the project engineers, it is understood that each dryer will be offline for approximately 10 hours each week.

On such occasions, the exhaust from three of the CAT G3520C engines will bypass the offline Thermal Dryer Unit and biofilter, and will be redirected through one of the four operational steam generating boilers, with the additional thermal energy used to assist in steam production. Addition of this exhaust flow will reduce the quantity of natural gas required in that boiler for the period of maintenance. The exhaust of these three CAT G3520C engine will then be vented to atmosphere at 250ºC through this boiler stack.

The remaining eight CAT G3520C engine exhausts will pass through the remaining three online Thermal Dryer Units and be treated within the biofilters as per the normal operation scenario described above.

2.3.3 Biofilters

The biofilters are designed to remove odour and volatile organic compound (VOC) emissions from the exhaust gas exiting the thermal driers. The biofilters also significantly reduce the emissions of inorganic gases (CO, SO_2 and NOx) through both biofilter activity and also through the condensate of the gas stream from the condenser being removed (i.e. the knock out drum). Data from the biofilter manufacturers has been sourced as to the minimum removal efficiencies associated with well operated biofilters. This data is presented as shown in **Table 1** (Pers. Comm., Flo-Dry Engineering Group). Peer reviewed studies have also been examined which confirm that biofilters are an effective method of NOx removal (Jin et al (2005), Okuno et al, (2000))

Table 1 Minimum Removal Efficiencies using Flo-Dry Biofilters / Knock Out Drum

Pollutant	Emission reduction expected through Biofilter / Knock Out Drum
Carbon Monoxide (CO)	90%
Sulphur Dioxide (SO_2)	98%
Oxides of Nitrogen (NO_X)	95%
Odour	99%

The above emissions reductions have been applied to all emissions exiting via the biofilters, assuming that they will be operated as per the manufacturer's specifications.

2.3.4 Best Practice in Emission Control

It is proposed that best management practices be employed across the site. Examples of best management practice to be employed on site include:

- The ethanol tanks will incorporate a floating blanket system, preventing contact with the ambient air, reducing evaporative emissions and VOC emissions to the atmosphere;

- Biofilters are to be employed which will reduce emissions to air of NO_2, SO_2, CO and Odour (see **Table 1**).
- A redundancy factor has been designed into the biofilter capacity. It is proposed the biofilters will be capable of treating 40,000 m^3/hour. Processes at the plant will only require the biofilters to treat a total of 25,000 m^3/hour;
- At least one of the steam generating boilers are to be configured to burn biogas and natural gas to negate the need for flaring of methane;
- Steam generating boilers are to be low NOx (as per the tenderers quotation specifying Dunphy low NOx modulating packaged burner);
- CAT G3520C engines are low NOx;
- Thermal Dryer Units have a direct burner gas preheating system which will reduce hydrocarbon emissions substantially prior to emission. Although this is unquantified, the biofilters are expected to further reduce hydrocarbon emissions by 95% (see **Table 1**);
- A CO_2 scrubber is to be installed on the fermentation stack to reduce VOC and Ethanol emissions;
- The hammer mill is enclosed to reduce dust emissions;
- The fertiliser plant is enclosed to reduce dust emissions; and
- Bag filters are to be employed on the hammer mill.
- The fertiliser plant will be fitted with strip curtains in order to keep as enclosed as possible when vehicles are entering.

2.3.5 Biogas Flaring

A biogas flaring device will be constructed at the site. However, the flare is not to be used during either normal operating mode or during maintenance for the plant and is only to be used in emergencies to avoid venting methane to the atmosphere.

Under normal operating conditions all biogas will be used by the CHPP CAT G3520C gas engines. There is an additional engine provided as a spare to allow for additional biogas to be consumed should one engine be offline for maintenance. In addition, at least one steam generating boiler will be configured with a dual fuel option to burn either biogas or natural gas. This will cater for rare occasions where multiple gas engines are offline. Only in an emergency when all of the above measures fail to utilise all the biogas, will the flares be used. In view of the contingency built into the design, the emergency flaring of biogas has not been modelled as an atmospheric emission source within this assessment.

2.3.6 Atmospheric Dispersion Modelling Scenarios

Taking into account all of the information outlined above, two scenarios have been identified for air quality modelling, based on the activities described in **Section 2.3.1** and **Section 2.3.2**;

1. Normal Operation
    - Eleven CAT G3520C engines exhausting through four natural gas fired Thermal Dryer Units which then exhaust through 4 biofilters
    - Four natural gas fired steam generating boilers exhausting through four stacks
2. Thermal Dryer Maintenance (Conservatively, 10 hours per day, 365 days per annum)
    - Eight CAT G3520C engines exhausting through three natural gas fired Thermal Dryer Units which then exhaust through 4 biofilters
    - Three natural gas fired steam generating boilers exhausting through three stacks

- One natural gas fired steam generating boiler operating on a mixture of exhaust gas from 3 CAT G3520C engines and a lower amount of natural gas (29.5 GJ/hour as opposed to 45 GJ/hour during normal operation).

The emissions inventories for each scenario can be seen in **Appendix D.** Further details of the derivation of the Emission Inventory are given in **Section 5.5**.

Note: The particulate emissions in each scenario remain constant as the maintenance of the thermal driers does not affect the Grain Feed Conveyor Vents, the Grain Reclaim Bucket Elevator nor the Grain Surge Bin.

3 EXISTING AMBIENT AIR QUALITY ENVIRONMENT

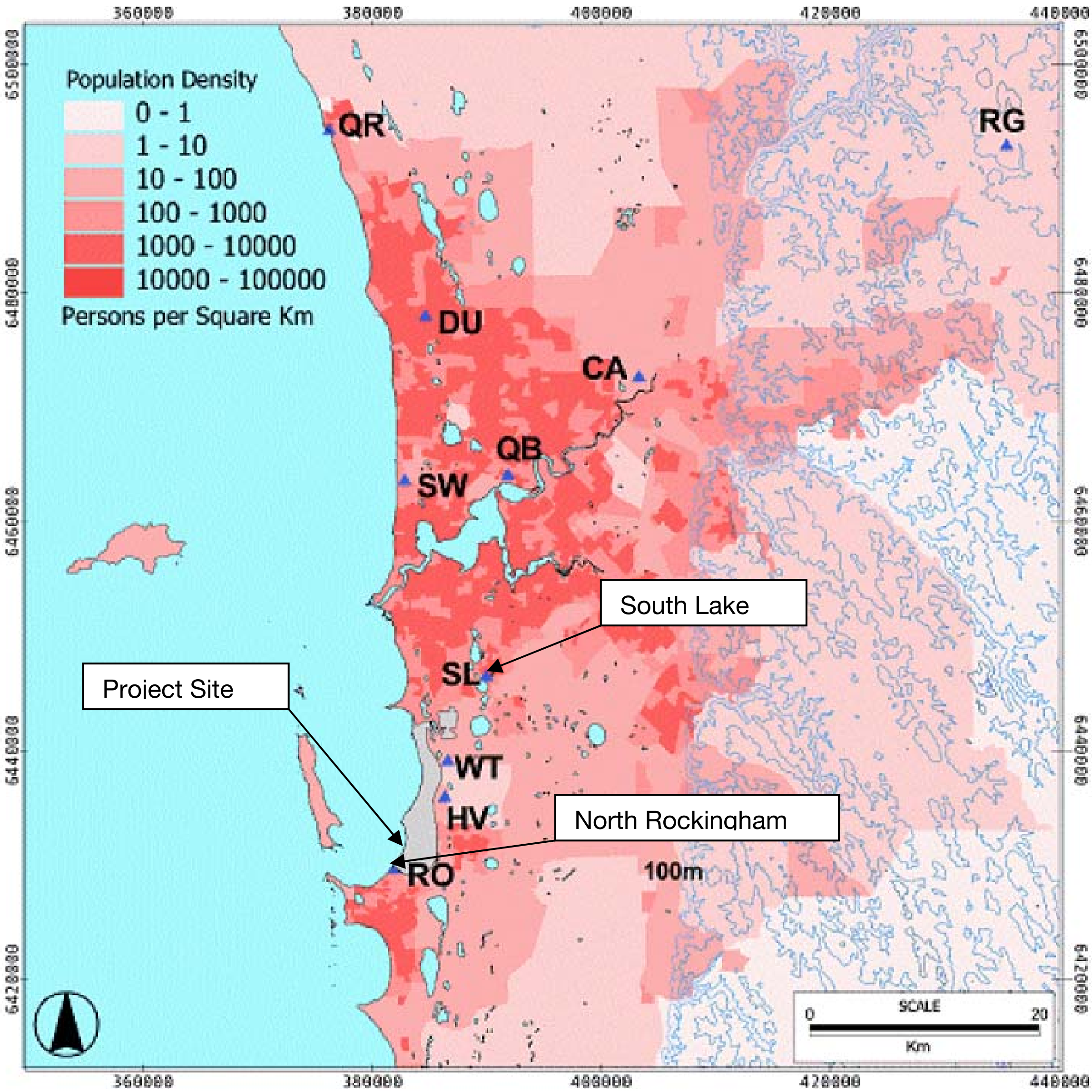
The WA DEC currently maintains an air quality monitoring station at North Rockingham, approximately 1 km south of the project site. The North Rockingham monitoring station measures the following pollutants:

- Ozone;
- Nitrogen Dioxide; and
- Sulphur Dioxide.

The WA DEC also currently maintains an air quality monitoring station at South Lake, approximately 17 km northeast of the project site. The South Lake monitoring station measures the following pollutants:

- Carbon Dioxide;
- Carbon Monoxide
- Ozone;
- Nitrogen Dioxide;
- Sulphur Dioxide;
- PM_{10}; and
- Visibility.

Figure 3 WA DEC Air Quality Monitoring Sites nearest to the Project Site



Source: DEC *"Western Australia Air Monitoring Report 2004"* Technical Series 122, April 2005.

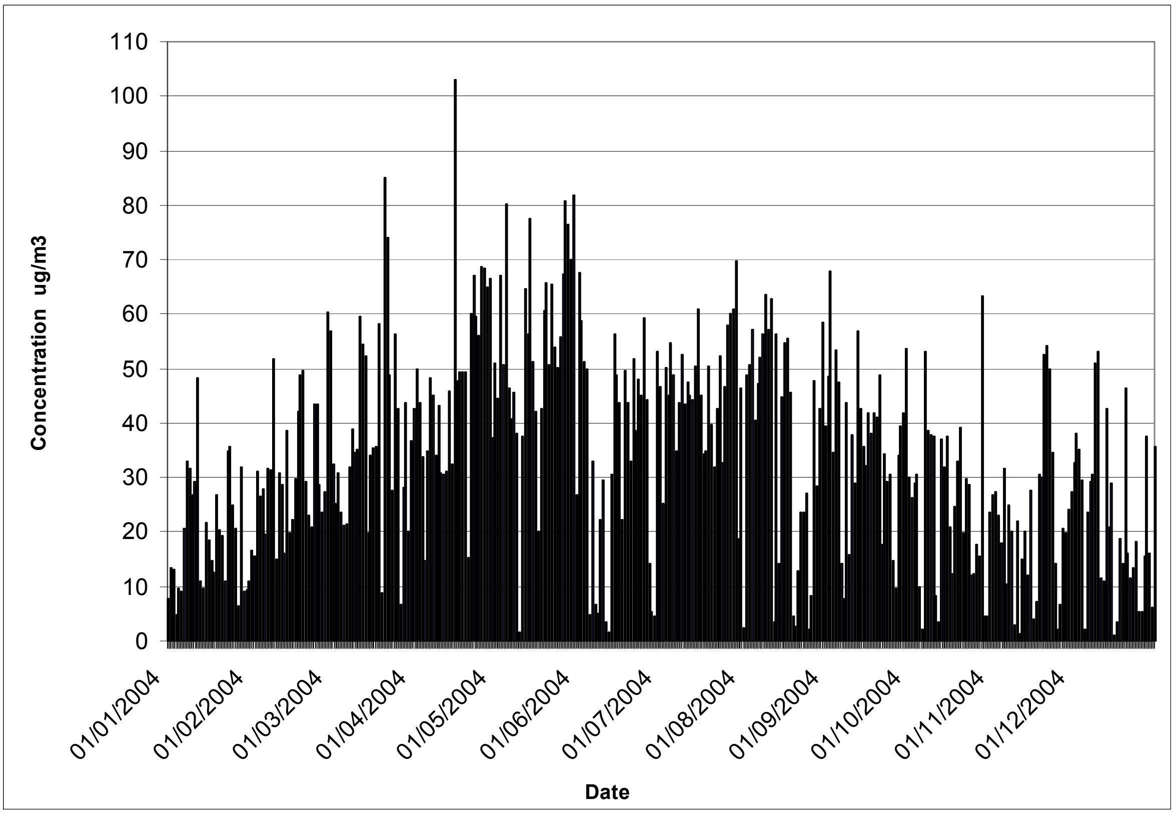
For the purpose of this background assessment, hourly average NO_2 and SO_2 data from the North Rockingham monitoring station as well as 24-hour average PM_{10} data from South Lake monitoring station was obtained from the WA DEC for the year 2004. Ozone data has also been extracted for 2004 from the North Rockingham monitoring site for use in the calculation of NO_2 concentrations. This is detailed further in **Section 5.8**. Data for 2004 has been selected because this calendar year represents the most recent validated data set available from the WA DEC at the time of writing. In addition, WA DEC ambient air quality reports for the years 2002 and 2003 were studied and 2004 was deemed to be representative of the ambient air quality environment. It should be noted that the PM_{10} data for 2004 contains a bush fire event.

3.1 Existing Ambient Nitrogen Dioxide

The majority of nitrogen dioxide (NO_2) in the atmosphere is attributable to anthropogenic sources. The project site is surrounded by heavy industrial activities; as such it is important to consider pollutant concentrations of NO_2.

The WA DEC's 2004 North Rockingham pollutant monitoring of NO_2 is considered a representative background data set for the project site. The verified data for 2004 showing the highest daily 1-hour averages of NO_2 at North Rockingham is presented in **Figure 4**.

Figure 4 WA DEC NO_2 Monitoring Results for North Rockingham, 2004 – Maximum Daily 1-hour Average Concentration



Note: The NEPM standard for NO_2 (1-hour average) is 0.120 ppm (226 µg/m^3 at 25°C and 1 atmosphere pressure) with one exceedance per year permitted. For the Year 2004 at North Rockingham there were no exceedances of this value.

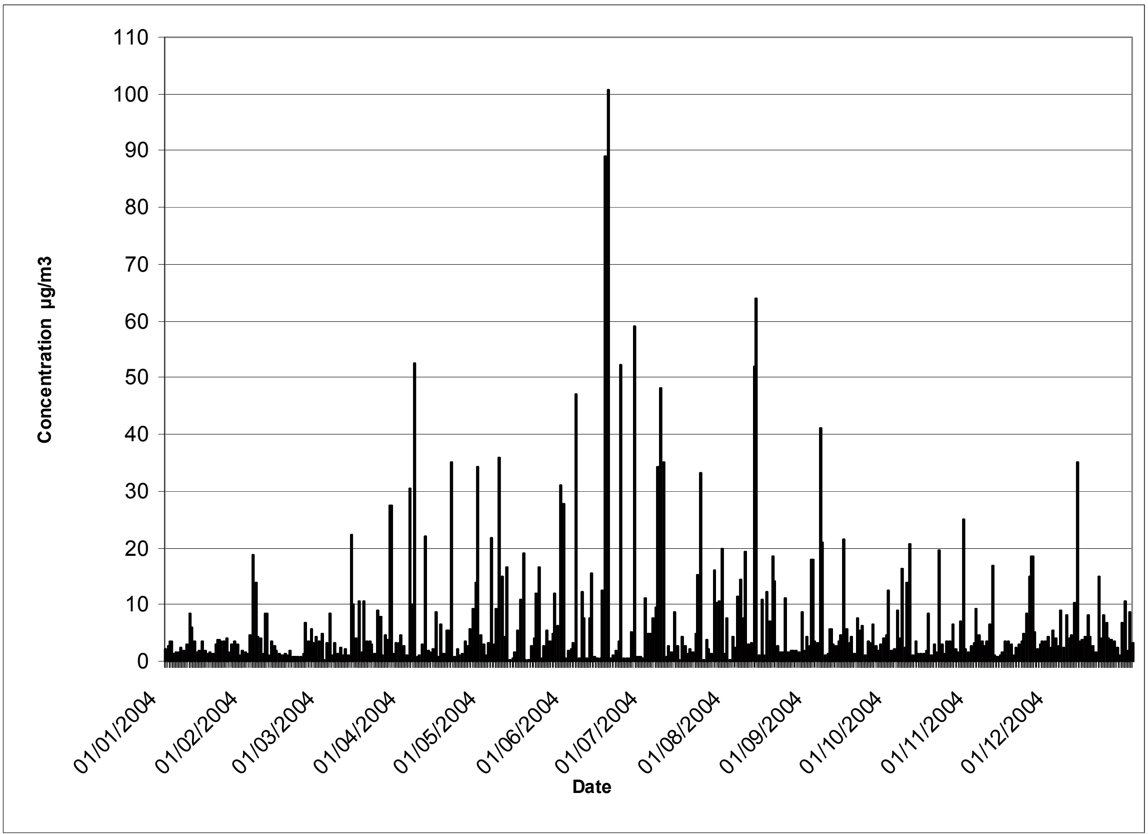
The maximum daily 1-hour NO_2 background concentration at North Rockingham during 2004 was 106 µg/m^3 (0.055 ppm) on the 16 April 2004 at 8:00pm and the second highest was 85.05 µg/m^3 (0.045 ppm) on the 21 March 2004 at 9:00pm.

Section 9 of the WA DEC document *Air Quality Modelling Guidance Notes* 2006 states that when using a conventional model (such as Ausplume), ambient monitoring data for at least one year of continuous measurements should be used in dispersion modelling. The above background 1-hour average NO_2 data set for North Rockingham 2004 has been utilised coupled with a 2004 meteorological file (refer to **Section 5**).

3.2 Existing Ambient Sulphur Dioxide

According to the *Revised Draft Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999,* sulphur dioxide has been identified as a key pollutant within the Kwinana heavy industrial region. The WA DEC's 2004 North Rockingham SO_2 monitoring data is considered a representative background for the project site. The verified data for 2004 showing the highest daily 1-hour averages of SO_2 at North Rockingham is presented in **Figure 5**.

Figure 5 WA DEC SO_2 Monitoring Results for North Rockingham, 2004 – Maximum Daily 1-hour Average Concentration



Note: The NEPM standard for SO_2 (1-hour average) is 0.20 ppm (520 µg/m^3 at 25°C and 1 atmosphere pressure) with one exceedance per year permitted. For the Year 2004 at North Rockingham there were no exceedances of this value.

The maximum daily 1-hour SO_2 background concentration at North Rockingham during 2004 was 101 µg/m^3 (0.039 ppm) on the 16 June 2004 at 1:00pm and the second highest was 89 µg/m^3 (0.034 ppm) on the 15 June 2004 at 11:00 am.

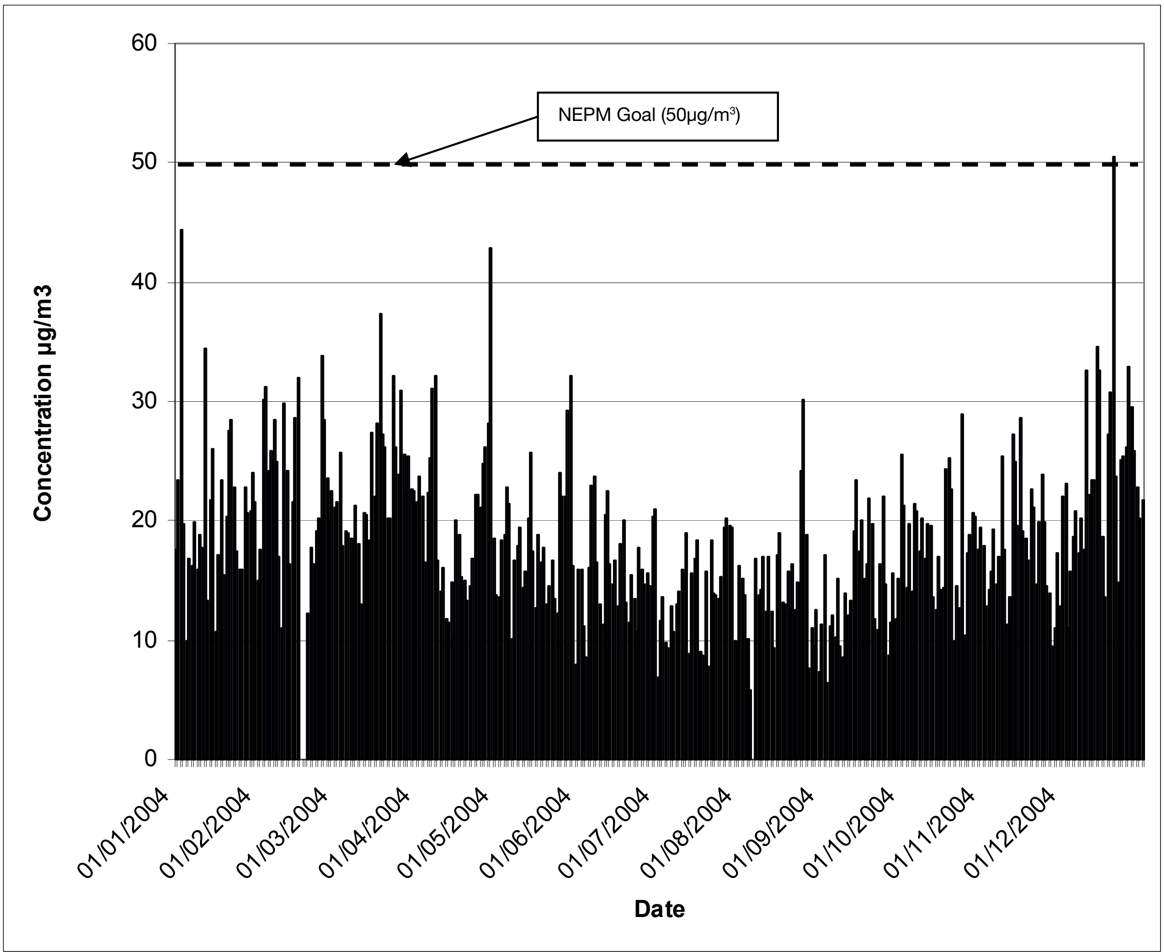
The above background 1-hour average SO_2 data set for North Rockingham 2004 has been utilised coupled with a 2004 meteorological file (refer to **Section 5**).

3.3 Existing Ambient Particulate Matter

The term "particulate matter" refers to a category of airborne particles typically less than 50 µm in aerodynamic diameter and ranging down to 0.1 µm in size. Particles less than 10 µm and 2.5 µm are referred to in this report as PM_{10} and $PM_{2.5}$ particles respectively.

The WA DEC's 2004 South Lake PM_{10} monitoring data is considered a representative background data set for the Kwinana Bio-Refinery project site. The verified data for 2004 showing 24-hour average PM_{10} concentrations at the South Lake air quality monitoring site obtained from the WA DEC is presented in **Figure 6.**

Figure 6 WA DEC PM_{10} (24-hour average) Monitoring Results for South Lake, 2004



The data set indicates that the highest 24-hour average PM_{10} concentration at the South Lake monitoring site was 50.5 µg/m^3, recorded on 20 December 2004.

The WA DEC document *Western Australia Air Monitoring Report 2004* Technical Series 122 and the *Western Australia Air Monitoring Report (Supplementary) 2004* Technical Series 123, note that the one exceedance of the 24-hour PM_{10} goal at South Lake during 2004 was attributable to bushfire events recorded within the Perth metropolitan region on the 20 December 2004. This exceedance has not been replaced in the daily varying background file used in the dispersion modelling exercise as the NEPM is designed to allow for natural particulate events such as this. The annual average PM_{10} concentration for 2004 was 18.5 µg/m^3.

The above background 24-hour average PM_{10} data set for South Lake 2004 has been utilised coupled with a 2004 meteorological file (refer to **Section 5**).

The nearest WA DEC monitoring station which currently assesses $PM_{2.5}$ is located at Caversham, approximately 45 kilometres northeast of the project site. The WA DEC on an annual basis summarises the data for all monitoring locations within an Air Monitoring report. As outlined within the *2004 Western Australia Air Monitoring Report* (Department of Environment 2005) the 6th highest (the maximum is not provided) 24-hour average $PM_{2.5}$ concentration for 2004 was 9.0 µg/m^3. In the absence of more appropriate monitoring data, this has been adopted as the background 24-hour average $PM_{2.5}$ concentration in the vicinity of the project site.

3.4 Existing Ambient Carbon Monoxide

The nearest WA DEC monitoring station at South Lake is considered adequate for the approximation of background carbon monoxide concentrations within the region of the project site. In the absence of a contemporaneous daily varying background concentration file for CO, a conservatively high constant background concentration of CO has been applied to the atmospheric dispersion modelling exercise.

The CO background concentration has been nominated as the maximum observed 8-hour average CO concentration from the South Lake 2004 data set. This was 4.025 mg/m^3 (3.5 ppm) as documented within the *2004 Western Australia Air Monitoring Report, Technical Series 122, April 2005, Department of Environment Table C1*.

3.5 Existing Ambient Odour

It is recognised that there are a number of potential odour sources in the vicinity of the project site. However, standard odour assessment procedure does not typically account for background odour, due in part to the complexity of this process. Further, the odour emissions from the proposed bio-refinery are considered to be distinctive. Therefore, for the purpose of this air quality assessment, background odour concentrations have not been considered.

3.6 Existing Ambient Ethanol

There is no available data for background ethanol concentrations in the vicinity of the project site. A search of the National Pollutant Inventory for reporting facilities within the region of Kwinana indicates that Coogee Chemicals Pty Ltd, located on the corner of Patterson and Kwinana Beach Road report emissions of ethanol to atmosphere. However, the quantity reported is not considered significant (370 kg/year). Therefore it is assumed that background ethanol concentrations are negligible.

3.7 Existing Ambient Air Quality Environment for Assessment Purposes

For the purposes of assessing the potential air quality impacts of the proposed Kwinana Bio-Refinery, an estimate of background air quality parameters is required.

Based on the data and discussion above, the site-specific background air quality concentrations adopted for this assessment are presented in **Table 2.**

Table 2 Background Air Quality Environment for Assessment Purposes

Air Quality Parameter	Averaging Period	Assumed Background Level
PM_{10}	24-Hour	Varying [1]
	Annual	18 $\mu g/m^3$
$PM_{2.5}$	24-Hour	9 $\mu g/m^3$
NO_2	1-hour	Varying [1]
SO_2	1-hour	Varying [1]
CO	8-hour	4.025 mg/m^3
Odour	3-minute	Negligible
Ethanol	1-hour	Negligible

Note 1 Daily-varying 1-hour average NO_2 and SO_2 and 24-hour average PM_{10} concentrations have been used within the atmospheric dispersion modelling.

Finally, it is acknowledged that the addition of the measured background concentrations from a site distant is only appropriate if the “background” concentrations do not vary across the area. It is anticipated that this is the case for oxides of nitrogen and PM_{10} as peak concentrations are principally governed by the wide-reaching influence of bushfire events. The use of a varying background concentration seeks to represent reality more effectively than using a single figure which does not take into account the fluctuations in ambient air quality due to, for example, bushfire events.

However, in the case of sulphur dioxide, (SO_2), peak concentrations are likely to be influenced by impacts of local industry such as power stations and the BP refinery. While SO_2 concentrations in this area are possibly higher than those measured at South Lake, modelling has utilised the best available data and it is considered that these data are sufficiently conservative.

The approximation of background air quality, particularly in relation to SO_2, should be acknowledged when incremental impacts of the proposed facility are considered.

4 AIR QUALITY CRITERIA

4.1 National Environmental Protection Measure (Air Quality)

The WA DEC routinely adopt (where necessary) ambient air quality guideline values in the assessment of new proposals and in the management of both local and regional ambient air quality. As a matter of policy the WA DEC have adopted the National Environment Protection Measure (NEPM) standards for ambient air quality. Ambient air quality guideline values are intended to be met at all sensitive receivers.

Table 3 outlines the NEPM Air Quality Standards for criteria pollutants.

Table 3 NEPM Air Quality Standards

Pollutant	Averaging Time	Maximum Concentration [1]	Maximum Allowable Exceedances
Nitrogen dioxide (NO_2)	1 Hour Annual	0.120 ppm (226 µg/m^3) 0.03 ppm (56 µg/m^3)	1 day a year none
Particulate matter <10 µm (PM_{10})	24 Hours	50 µg/m^3	5 days a year
Particulate matter <2.5 µm ($PM_{2.5}$)	24 Hours Annual	25 µg/m^3 8 µg/m^3	Not Applicable
Sulphur Dioxide (SO_2)	1 Hour	0.20 ppm (520 µg/m^3)	1 day a year
	1 Day	0.08 ppm (210 µg/m^3)	1 day a year
	1 Year	0.02 ppm (52 µg/m^3)	none
Carbon monoxide	8 Hour	9 ppm (10 mg/ m^3)	1 day a year

Note 1 Gravimetric concentrations have been derived at 25°C and 1 atmosphere pressure.

In December 2000, the NEPC initiated a review to determine whether a new ambient air quality goal for particulates of 2.5 microns or less in aerodynamic diameter ($PM_{2.5}$) was needed in Australia, and the feasibility of developing such a goal. The review found that:

- there are health effects associated with fine particles;
- the health effects observed overseas are supported by Australian studies; and
- fine particle standards have been set in Canada and the USA, and an interim goal proposed for New Zealand.

The review concluded that there is sufficient community concern regarding $PM_{2.5}$ to consider it an entity separate from PM_{10}.

As such, in July 2003 a variation to the Ambient Air Quality NEPM was made to extend its coverage to $PM_{2.5.}$ This document references the following goals for $PM_{2.5.}$

- A 24-hour maximum of 25 µg/m^3.
- An annual average of 8 µg/m^3.

4.2 Environmental Protection (Kwinana) (Atmospheric Wastes) Policy and Regulations 1999

The bio-refinery project site is within the southern section of the Kwinana major heavy industrial area. Historically, SO_2 from industries caused significant pollution in nearby residential areas. As such the Environmental Protection Authority established an Environmental Protection Policy (EPP) for Sulphur Dioxide and Particulate Matter at Kwinana in 1992 to maintain acceptable air quality. Upon subsequent review, the *Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999,* is now enacted. The bio-refinery lies within Area A, and ambient air quality standards and limits are shown in **Table 4**.

It is recognised that Kwinana is an area which requires protection; as the criterion within Area A is not as stringent as the NEPM standards, the NEPM for SO_2 has been adopted as the project air quality goal.

Table 4 Ambient Air Quality Standards and Limits - Environmental Protection (Kwinana) (Atmospheric Wastes) Policy and Regulations 1999

Pollutant	Item	Area	Standard (μg/m3)	Limit (μg/m3)	Averaging period
Sulphur Dioxide	1	Area A	700	1400	1 hour
	2	Area A	200	365	24 hours
	3	Area A	60	80	1 year

4.3 World Health Organisation Vegetation Criteria for NOx

Due to the proximity of this proposed plant to the recreational reserve to the west, and the inapplicability of the NEPM standards in this area (due to their intended applicability to human health), it is prudent to assess the air quality impact of the proposed Kwinana plant on the vegetation within the reserve. The World Health Organisation (WHO) adopted in 2000, a standard for the protection of vegetation from impacts of NOx. This standard is as follows:

- 30 $\mu g/m^3$ as an annual average; and
- 75 $\mu g/m^3$ as a 24hour mean.

The potential exceedances of this vegetation based standard at the 5 receptors in the recreational reserve have been assessed.

4.4 Odour

The WA Environmental Protection Authority (EPA) is currently reviewing the assessment of odour impacts from new developments. The following interim guidance is to be followed while an updated guidance statement is prepared.

- If generic buffer distances are met and the proposed facility is designed for "best practice" emission control (*EPA Guidance statement No 55*), then no further assessment of odour is required.
- If the generic buffer distance is not met, it may nevertheless be possible for the proponent to demonstrate acceptability by undertaking a conservative but relatively simple screening procedure which assesses odour impact against a two-part "green-light" criterion, as follows:

Computer modelling must be undertaken using either a measurement or reliable estimate of odour emission rate (in odour unit volumes per second, OUV/s) in order to demonstrate that the ambient odour concentration does not exceed the following two-part "green-light" criterion at existing or proposed sensitive premises:

a. 2 OU, 3 minute average, 99.5th percentile;

and

b. 4 OU, 3 minute average, 99.9th percentile.

If the above two-part criterion is met, no further assessment of odour is needed.

Proposals which do not meet the two-part "green-light" criterion above will be assessed on a case-by-case basis, including a determination as to the form of odour impact study required.

Guidelines for odour sampling and modelling methodology entitled *Odour Methodology Guideline* (DEP 2002) should be read in conjunction with this Interim Guidance.

4.5 Ethanol and Methanol

Ethanol is emitted from breathing losses across the site from tanks and load-out operations. According to the National Pollution Inventory (NPI) Ethanol has a pleasant alcoholic odour detectable at 49 to 716 ppm. Once ethanol is released to the atmosphere, it will usually oxidise quickly.

There are no national or WA environmental guidelines for ethanol. However the NSW *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (2005) identifies ethanol within a list of impact assessment criteria for individual odourous air pollutants. The 1-hour average 99.9th percentile NSW impact assessment criteria for ethanol is 2.1 mg/m^3. In the absence of a WA guideline for ethanol, the NSW impact assessment criterion of 2.1 mg/m^3 has been adopted for this project.

As ethanol will constitute well in excess of 90% of fugitive emissions of alcohols from the site, and in view of the equivalent NSW impact assessment criterion for methanol being not as stringent (3.0 mg/m^3), impacts of methanol have not been quantitatively assessed and are not considered further within this assessment.

5 DISPERSION MODELLING

5.1 Methodology

The atmospheric dispersion modelling carried out in the present assessment utilises the Ausplume Gaussian Plume Dispersion Model software developed by EPA Victoria, Version 6.0.

Ausplume is a frequently used model for industrial emissions assessment within WA. Default options specified in the Technical Users Manual (EPA Victoria, 2000) have been used, although the dispersion scheme used for stacks less than 100 m (all in this study), the Pasquill Gifford dispersion curve has been selected in preference to the Sigma-theta dispersion scheme. It is understood that the use of this dispersion scheme is a preference of the WA DEC and is employed for reasons of conservatism.

5.2 Dispersion Meteorology

Meteorological data for the Woodman Point Waste Water Treatment Plant is considered adequate to represent the meteorological conditions of the project site within this assessment. The Woodman Point Waste water treatment plant is located approximately 12 km to the north of the project site within 400 m of the WA coastline. A representative Ausplume modelling file developed by Ian Wallis of CEE for Water Corporation has been used. This file is based on the following:

- Two years of meteorological measurements collected at the Woodman Point Waste Water Treatment Plant. Wind measurements were undertaken with sensors that met the Australian standard for Class 1 Air Quality wind sensors (*Ambient air - Guide for measurement of horizontal wind for air quality applications AS 2923-1987*) with a reasonable siting though slightly shielded for southeast winds;
- Stability estimates derived using the USEPA method using solar radiation and the temperature difference measurements between 2 and 10 metres; and
- Mixing heights were determined using the NSW DEC screening approach. It is noted this is an approximate method, but should have negligible affect on predicted ground level concentrations for surface or near surface releases with low buoyancy and for receptors within 1 km. It is noted that for taller stacks, the mixing height method is not a rigorous approach and may lead to errors.

A summary of the 2004 annual wind behaviour presented as a wind rose is included in **Appendix A**. This wind rose is representative of the meteorological input file collated from data collected at the weather station at the Woodman Point Waste Water Treatment Plant representing the project site and displays occurrences of winds from all quadrants.

The annual wind rose indicates the prevailing wind direction is from the southwest and northeast quadrants. Calms are infrequent, occurring approximately 2% of the time. Winds for both quadrants are mild in nature, having an average wind speed of between 1.5 m/s and 5.5 m/s.

The seasonal variation in wind behaviour at the Woodman Point Waste Water Treatment Plant (representing the project site) is also presented in **Appendix A**. The seasonal wind roses indicate the following.

- In winter, moderate winds are present from the west (8% of the time) and east-northeast (10% of the time).
- In spring, moderate winds are present from the southwest (14% of the time) and east (9% of the time).
- In summer, moderate winds are present from the south (17% of the time) and the east (13% of the time).

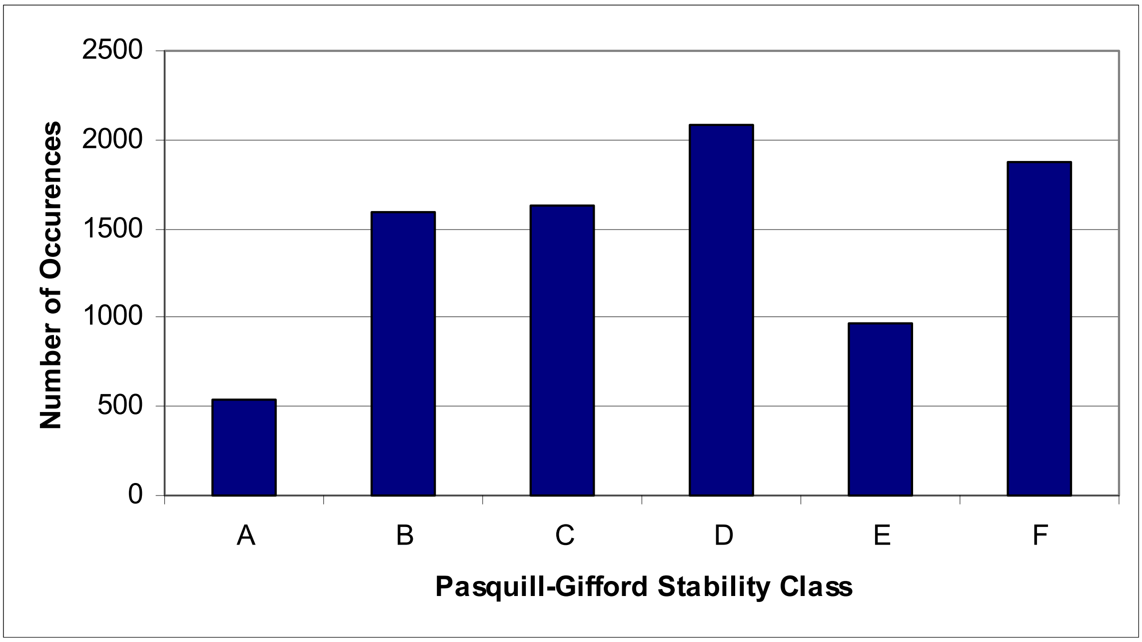
- In autumn, moderate winds are present from the north-northeast (13% of the time) and the south (10% of the time).

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Turner assignment scheme identifies six Stability Classes, "A" to "F", to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions.

Stability Class "A" represents highly unstable conditions that are typically found during summer, and are categorised by strong winds and convective conditions. Conversely, stability class "F" relates to highly stable conditions, typically associated with clear skies, light winds and the presence of a temperature inversion. Classes "B" through to "E" represent conditions intermediate to these extremes.

Measurements of incoming solar radiation and wind speed were used to assign atmospheric stability to the records for each hour of the year. The resulting annual distribution of atmospheric stability categories for the project site (2004) is shown in **Figure 7.**

Figure 7 Annual Stability Class Frequency Distribution for the Woodman Point Waste water treatment plant – representing the Project site for 2004



The results indicate a high frequency of conditions typical of Stability Class "D" and "F" throughout the year. This is indicative of neutral conditions, conducive to a moderate level of pollutant dispersion due to mechanical mixing.

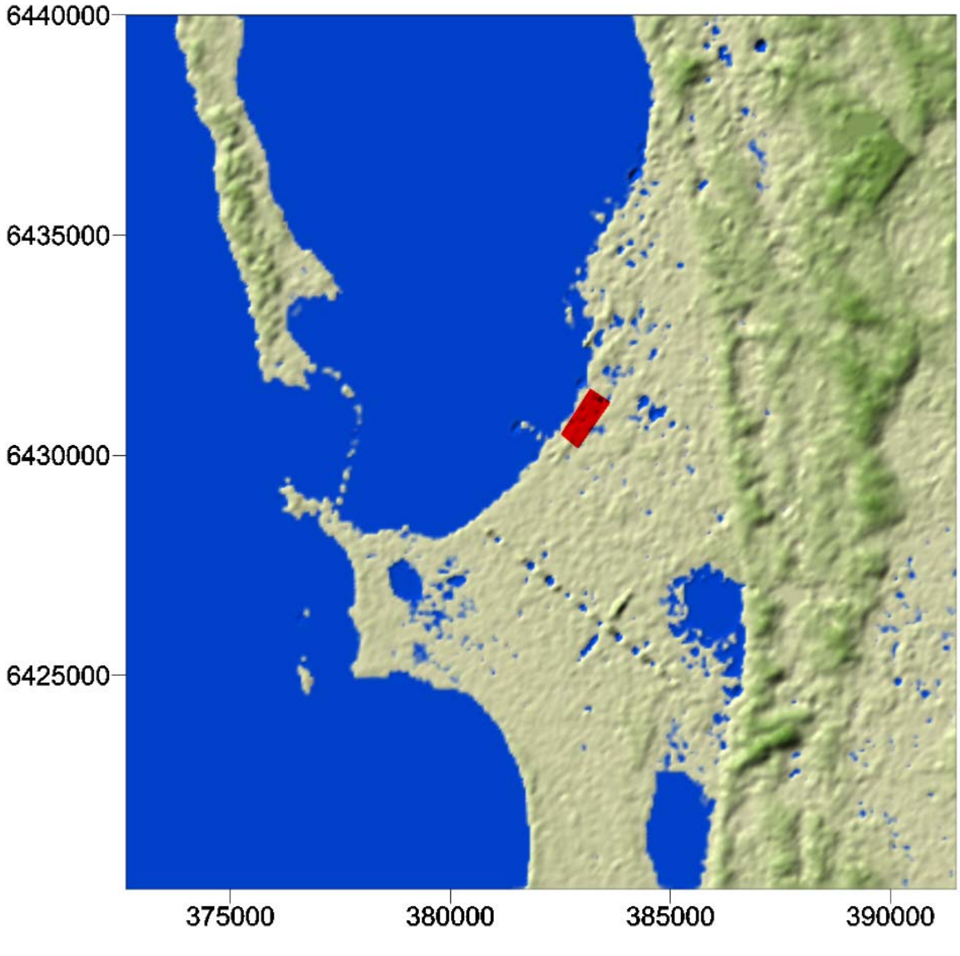
Appendix B illustrates the seasonal variation in atmospheric stability class for the Woodman Point Waste Water Treatment Plant. The frequency distribution of stability class varies relatively little with season, with Stability Class "D" dominating for spring, summer and winter and Stability Class "F" dominating for autumn.

5.3 Site Topography

The Kwinana Bio-Refinery project site is situated at an elevation of approximately 3 m to 5 m AHD surrounded by flat, uncomplicated terrain (see **Figure 8**). It is close (approximately 250 m) to the WA coast line encompassing Cockburn Sound. It is located between the North Rockingham township to the south and uncomplicated terrain, encompassing heavy industrial premises and Kwinana township to the north.

In view of the foregoing, the topography of the area has not been considered in the atmospheric dispersion model, as significant impacts on modelled concentrations at the sensitive receivers identified will not be seen with the inclusion of such uncomplicated near-field topography.

Figure 8 Regional Topography and Proposed Project Location



5.4 Nearest Sensitive Receivers/Areas of Interest

The impact of pollutant emissions from the proposed plant has been assessed at the following representative sensitive receivers and areas of interest surrounding the subject site. These locations are:

- Sensitive Receivers
  - The caravan park at North Rockingham – located approximately 650 m southwest of the project site;
  - Kwinana Township – located approximately 3,700 m northeast of the project site; and
  - Wells Park (WP) – located approximately 180 m northwest of the project site.
- Areas of Interest
  - Pollutant concentrations have been predicted at 5 locations along the western boundary of the project site, within the adjacent recreational reserve.

The areas of interest along the western boundary of the project have been modelled for instructive purposes only and modelling at these locations have not been directly compared to the project air quality goals.

5.5 Emissions Inventory

The potential emissions for Kwinana are based on an existing 160 ML name plate Bio-Refinery. Illustrated in **Appendix C** is a plan outlining the location of all air emission sources.

Following a review of the anticipated emissions to air, the following pollutants have been considered within the air quality assessment model:

- PM_{10};
- NO_2;
- SO_2;
- CO;
- Odour; and
- Ethanol.

The PM_{10}, SO_2, NOx and CO emissions inventory is presented in **Appendix D.** The major emission sources include:

- Grain reclaim bucket elevator (PM_{10});
- Grain surge bin (PM_{10});
- Steam generation boilers (PM_{10}, SO_2, NO_2 and CO);
- CAT G3520C Low NOx gas engines (NO_2 and CO) and
- Thermal Dryer Units (NO_2, SO_2. and CO).

Odour from the biofilters is considered a potential air pollutant resulting from the Kwinana Bio-Refinery activities. It is proposed the biofilters will be capable of treating 40,000 m^3/hour. Processes at the plant will only require the biofilters to treat a total of 25,000 m^3/hour whilst producing a 99% or greater reduction in odour at the surface of the biofilter in accordance with the biofilter manufacturer's specifications.

Four biofilters will be in operation during normal plant operations, with each having an active area of 1,185m^2.

The anticipated operational odour concentration associated with the biofilter as specified by Flo-Dry (the manufacturer), and the one adopted for this assessment is 250 OU. Considering the volumetric flow rate of the biofilter, **Table 5** outlines the odour emission rate from the biofilter and the associated inputs.

Table 5 Odour Emission Rate Calculations – 4 Biofilters

biofilter height	2.5 m
biofilter dimensions	67 x 71 m (including gaps between biofilters)
Odour Concentration	250 OU
Volumetric Flow Rate	27.8 m^3/s
Area of biofilter	4,740 m^2
Exit velocity	0.006 m/s
Odour Emission Rate	**6,950 OU.m^3/s (based on a worst case 100'000 m^3/hour flow rate)**

Biofilter emissions have been modelled as a volume source (refer **Section 5.9**).

The majority of Volatile Organic Compounds (VOCs) emitted from the bio-refinery will be ethanol. For the purpose of this assessment, it is assumed that 100% of the VOCs emitted from the site are ethanol.

The technologies proposed to be used at the project site are proven and in use in existing bio-refinery plants worldwide. As a result of this experience, VOC emissions rates for identified activities across the proposed Kwinana site have been provided by Delta T (the ethanol plant providers). The activities across the site considered to be sources of VOCs (as ethanol) include:

- Fermentation stack;
- Ethanol Load-out;
- Ethanol day storage tanks;
- Denaturant tank;
- Ethanol storage tank; and
- Equipment leaks.

Appendix E presents the emissions data for ethanol.

It is noted that the proposed configuration for aqueous ammonia load-out is to operate as a closed system with vapour return from truck to storage tank vapour space. Storage tanks will have a water loot – a water scrubber, with vapours removed and returned to the process during production. Hence no significant fugitive emissions of ammonia are expected. Ammonia has therefore not been considered further within this assessment.

5.6 Building Wake Effects

It is noted that the on-site stacks are not of a significant height to exclude the influence of building wake effects on plume dispersion.

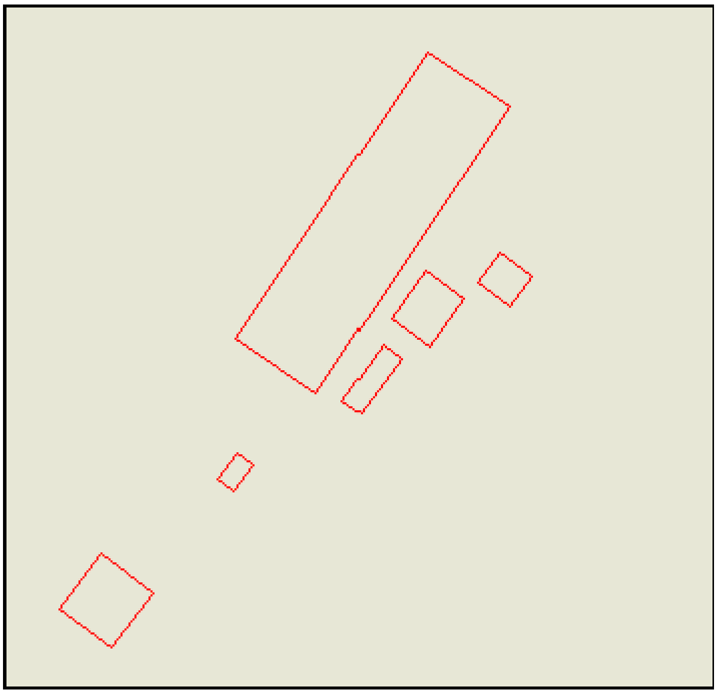
Plumes trapped in building wakes can either be recirculated in the cavity region immediately downwind of a building or subjected to plume downwash and enhanced horizontal or vertical spreading due to the turbulent zone that exists further downwind.

Buildings generate downwind wake effects up to 5 times the lesser of the building height or projected building width. If there are stacks less than approximately 2.5 times the building height within this zone, then the effect of building wakes should be considered.

Ausplume v6.0 allows the user to enter wind direction dependent building wake characteristics at 10 degree intervals. The software has an integrated utility referred to as the Building Profile Input Program (BPIP) which can be used to estimate projected impacts of building dimensions for these 36 wind directions. By running the BPIP, this information is automatically entered into Ausplume's stack building wake fields.

The buildings wake effects considered the building outlined in **Figure 9**.

Figure 9 Building wakes considered within the assessment



5.7 Modelling Assumptions

In order that this air quality assessment withstand the rigours of both legislative and scientific appraisal, assumptions as to plant configuration have been minimised within all atmospheric dispersion modelling. Where possible, emission rates and exhaust parameters have been sourced directly from items of plant operational internationally. However, as the plant configuration has not yet undergone its detailed design phase, it is inevitable that some assumptions have been used. The assumptions have been outlined below.

- In accordance with The National Pollutant Inventory (NPI) *Emission Estimation Technique Manual for Mining, Version 2.3* (2001), an 83% PM_{10} reduction can be applied for crushing and grinding activities, if fabric filters are applied and if hooding is undertaken.
- It is proposed the Hammer Mill be enclosed and that bag filters are to be used in this process. It is anticipated therefore, that by using good dust management techniques (visual inspections be carried out to ensure this operation as enclosed), then no significant fugitive emissions will result from this source.
- In accordance with the NPI *Emission Estimation Technique Manual for Mining, Version 2.3* (2001), a 70% PM_{10} reduction can be applied for miscellaneous transfer and conveying, if enclosed. It is proposed the Grain Feed Conveyor, the Grain Reclaim Bucket Elevator and the Grain Surge Bin be enclosed, and therefore it is assumed that a 70% reduction in dust emissions will applied to the emission rate from this source. This enclosure must be maintained by site officials in order for this reduction to be applicable.

- In accordance with the NPI *Emission Estimation Technique Manual for Mining, Version 2.3* (2001), a 99% PM_{10} reduction can be applied for handling, conveying and transferring activities, if the use of fabric filters is employed. It is proposed that bag filters be in operation within this process and therefore it is assumed that 99% of the dust emissions will be reduced from this source. Further particulate emissions reductions may be achievable if enclosure (ie, doors shut, windows closed) is observed by site officials.
- The US EPA document *AP42 Vol 1, 5th edition Chapter 9 - Food and Agricultural Industry Emission Factors, 9.9.1 – Grain Elevators and Processes (2005)* has been used to calculate PM_{10} emission factors for the Grain Feed Conveyor, Grain Reclaim Bucket Elevator and Grain Surge Bin. The emission source *Headhouse and Grain Handling* is considered applicable for each of these sources.
- The NPI *Emission Estimation Technique Manual for Combustion in Boilers, Version 1.2 - Table 25 and 26* (2003) has been used to derive boiler PM_{10}, SO_2 and NO_2 emission factors in the absence of emission rate data from existing boilers. The emission factors for low NOx boilers were used.
- The energy content for natural gas is taken as 38.9 MJ/m^3 (NPI 2000).
- It is anticipated that an average of up to approximately 17 to 22 heavy vehicle movements would be generated per day. Given this magnitude of heavy vehicle traffic, it is not anticipated that this would impact significantly on the local air shed's capability to achieve the air quality goals associated with vehicle emissions (principally PM_{10} and NO_2). Additionally, since all roads within the project site would be sealed, wheel-generated dust emissions would also be negligible. Therefore trucks have not been considered within the modelling.
- The fermentation stack parameters will be finalised following completion and interpretation of this assessment. To provide guidance as to minimum stack exit parameters applicable to the project, and to demonstrate the stack will not have a detrimental impact upon the local Kwinana air quality, the following conservative parameters were selected and modelled:
  - Stack height – 10 metres;
  - Stack Velocity – 10 metres per second;
  - Stack Diameter – 1 metre; and
  - Stack temperature – 180 degrees C.
- The ethanol load-out, ethanol day storage tanks, the denaturant tank, the ethanol storage tank and equipment leaks have been assessed as volume sources. These sources result from ethanol breathing losses and therefore the simulation of these fugitive losses as a volume source is considered appropriate.
- The VOC (as ethanol) emissions from ethanol load-out are generated due to the displacement of air within the tanker being loaded. It is assumed the tanker was previously loaded with ethanol and therefore the emissions contain ethanol vapour.
- The denaturant tank does not contain ethanol, and is anticipated to contain methanol. However, due to the low VOC emission rate and the lack of similar pollutant sources, it is considered a conservative assumption to assume 100% of the vapour is ethanol.
- The biofilter is designed to operate at a maximum temperature of 50 - 60°C. It has been confirmed by Flo-Dry Engineering Ltd that a suitable temperature reduction across the biofilter be in the order of 10°C. The exit temperature of pollutants from the biofilter has therefore been taken as 40°C.
- Ethanol load-out will occur between the hours of 6:00 am to 6:00 pm Monday to Saturday and has been modelled for these hours.

- Total Particulate Matter has not been considered within this assessment. The nature of the plant design has reduced larger dust particle generation due to best management practises as described in **Section 5.5**. The majority of dust emissions are associated with combustion processes, which generate finer particulate typified by PM_{10}. Further, it is considered that if predicted PM_{10} concentrations are below the project goals, total particulate matter would also satisfy any relevant criteria.
- The biofilter has been modelled as a volume source rather than a stack source. Sensitivity analyses in **Section 5.9** show that ground level pollutant concentrations are higher when modelling the biofilter in this way. This is a more conservative assumption.
- A definitive surface roughness input to the air quality model was not possible due to the unique nature of the area in which the proposed plant is to be built (industrial/rural mix). The air quality modelling has been undertaken using 0.3 m as the default surface roughness length after sensitivity analyses were carried out examining model output with the use of 0.3 m and 0.4 m as surface roughness parameters. These two surface roughness parameters were identified as the most suitable for use within this study. The surface roughness resulting in higher predicted ground level concentrations within the atmospheric dispersion modelling (0.3 m) was chosen to provide conservatively high model outputs.
- The adopted NO/NO_2 ratio for NOx emitted from the site has been calculated using an empirical relationship described by Janssen (1988) in which the NO to NO_2 conversion is a function of distance from the pollutant source, season, ambient ozone concentration and wind speed. This method is described fully in **Section 5.8**. It has been employed within this study as it is a more realistic assessment than assuming that 100% of the NOx emitted is in the form of NO_2.
- Emissions data for the 11 Caterpillar CAT G3520C engines has been obtained, negating the need for assumptions to be made.
- The stack parameters for the steam generation boilers have been confirmed following communications with TFA Project Engineers. The following parameters were modelled:
  - Stack height – 12 m;
  - Stack Velocity – 15 m/s;
  - Stack Diameter – 0.6 m; and
  - Stack temperature – 250 degrees C.

  NOTE: There are six stacks associated with the steam generation boilers although only up to four will be emitting at any one time.
- Emissions reductions associated with the biofilters are as shown in **Table 1**. These have been obtained from Flo-Dry Engineering Ltd, the manufacturers of the biofilters.
- Schematic diagrams of the plant received from TFA Project Engineers (**Appendix C**) show that potable water is to be used in the cooling process at this plant. Therefore, due to the absence of salts within this water, it has been assumed that no particulate matter will arise from the cooling process, and therefore this has not been modelled.

5.8 NO to NO_2 Modelling Approach

Emission rates of the oxides of nitrogen (NOx) are modelled as the total of NO_2, NO and small amounts of N_2O (nitrous oxide). In terms of human health, the NEPM and vegetation criteria, it is the concentrations of NO_2 which are of most concern and therefore it is of paramount importance that this pollutant is modelled accurately.

Ground level concentrations of NO_2 can be modelled using several methods. Two of three methods approved by the NSW DEC are used in this report for comparative purposes. A summary of each of the three methods is given here. The information below has been taken from the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW DEC, 2005).

5.8.1 Method 1: 100% conversion of NO to NO2

This approach is the most precautionary, making the assumption that all of the NOx emitted from the plant is converted to NO_2. This method is generally used to show that even in the most extreme case, prescribed NO_2 levels will not be breached at sensitive receptors. However, when predicted ground level concentrations of NO_2 are close to or above the prescribed levels, then a more accurate representation of the NO to NO_2 conversion is required.

5.8.2 Method 2: NO to NO_2 conversion limited by ambient ozone concentration (Ozone Limiting Method)

The US EPA's ozone limiting method (OLM) provides an equation which gives predicted NO_2 concentrations when predicted NO_X and background ozone and NO_2 are provided. Hourly varying background concentrations of NO_2 and ozone were obtained for the North Rockingham monitoring site for 2004. The Equation used to calculate NO_2 concentrations from predicted NO_X, background NO_2 and background O_3 concentrations is as follows;

$$[NO_2]_{TOTAL}=\{0.1 \text{ x } [NO_x]_{PRED}\} + MIN\{(0.9) \text{ x } [NO_x]_{PRED} \text{ or } (46/48) \text{ x } [O_3]_{BKGD}\} + [NO_2]_{BKGD}$$

Where:

$[NO_2]_{TOTAL}$ = The predicted concentration of NO_2

$[NO_x]_{PRED}$ = The Ausplume prediction of ground level NO_X concentrations (increment due to plant)

MIN = The minimum of the two quantities within the braces

$[O_3]_{BKGD}$ = The background ambient O_3 concentration at North Rockingham

46/48 = the molecular weight of NO_2 divided by the molecular weight of O_3

$[NO_2]_{BKGD}$ = The background ambient NO_2 concentration at North Rockingham

The US EPA's OLM assumes that all of the available ozone in the atmosphere will react with NO until either all of the ozone, or all of the NO has reacted. A major assumption of this method is that the reaction is instant. In reality, this reaction takes place over a number of hours and over distance. Further to this, the method assumes that the complete mixing of the plume NO and ambient ozone, down to the level of molecular contact will have occurred by the time the plume reaches the ground level receptor of maximum ground level NOx concentration.

The OLM method also ignores the photodissociation of NO_2 and the conversion of NO to NO_2 by organic radicals is neglected.

The NSW DEC *Approved Methods for the Modelling and Assessment of Air Pollutants* provides two levels of assessment which should be carried out. The Level 1 assessment uses the maximum predictions and maximum background concentrations within the Equation, (that is, non-contemporaneous predictions and background concentrations are used; only the maxima modelled and monitored for the whole year are entered into the Equation).

A more refined approach has also been undertaken using the Level 2 assessment in which hour-by-hour contemporaneous NO_X predictions and NO_2 and O_3 background concentrations have been used in the Equation.

Predicted NO_X concentrations using Ausplume for Scenario 1 (Normal Running) were identical to those for Scenario 2 (Maintenance schedule) and therefore only results for Scenario 1 have been examined here.

Annual average NO_2 has not been assessed using the OLM method as the annual average NEPM criteria for NO_2 (56 µg/m^3) is met even when 100% NO_X to NO_2 conversion is assumed.

5.8.3 Method 3: NO to NO_2 conversion using empirical relationship

Janssen et al (1988) describe a method for estimating the oxidation rate of NO in power plant plumes. The derived equation is dependent on the distance downwind from the source and also on O_3 concentration, wind speed and season. It is this method which has been used in this air quality assessment as it is deemed that it represents reality greater than the previous 2 methods. The equation can be seen below;

$$NO_2 / NOx = A(1 - \exp(-\alpha x)$$

A and α are a function of ambient ozone concentration and wind speed and were derived using the method in Janssen et al (1988). Hourly average ambient ozone data from North Rockingham for 2004 was obtained, along with hourly wind speed from Woodman Point for 2004 (used in all air quality modelling within this report).

The percentages of NOx as NO_2 at each receptor calculated using the method above show that at those receptors closest to the source, very low percentages (e.g. 1.3% at Receptor 5) are experienced. Janssen et al (1988) states that NOx from the combustion of fossil fuels for power generation consists for the large part (>95%) of nitric oxide (NO) and for the smaller part (<5%) of nitrogen dioxide (NO_2). Further, a study by Bland et al (2000) examined the formation of NO_2 in gas fired combustion systems. The study found that generally NO_2 accounts for between 5 and 10 percent of total NOx emissions due to direct thermal conversion at the source. The implications for this assessment are that the NOx as NO_2 percentage at source (i.e. at the biofilters) may be of the order of 5 to 10 percent. To be conservative, it has been assumed that at the point of emission, and subsequently at sensitive receptors, no less than 10% of the NOx is present as NO_2.

Thus, at each receptor, an additional 10% baseline NO_2 has been added to the calculated NO_2 percentage (from Janssen et al (1988)), i.e. at Receptor 5, the percentage NO_2 is conservatively reported as 11.3% of total NOx.

Hourly average and 1-hour maximum NOx was calculated at each of the 8 sensitive receptors and the equation above was applied to identify the appropriate percentage of the NOx present as NO_2. These data (both raw and adjusted) can be seen in **Section 6**.

5.9 Sensitivity Analyses

Sensitivity analyses have been undertaken to provide additional information as to the effect on ground level pollutant concentrations when certain model input parameters are varied. This is desirable in cases where there is uncertainty of which parameter should be used in the model. After sensitivity analysis, the absolute difference in output due solely to the varying input parameters can be assessed. In air quality assessments such as this, typically the assessment will err on the side of caution and input which results in the greater ground level pollution impacts is selected for conservatism.

5.9.1 Surface Roughness Height

A sensitivity analysis was undertaken to assess how varying the surface roughness height in the Ausplume model would affect ground level concentrations of the criteria pollutants. This sensitivity analysis was carried out as the study area is a unique mixture of industrial development and rural area and the surface roughness is not readily quantified within the Ausplume model for an area of this kind. Two values have been assessed, 0.3 m and 0.4 m, with the surface roughness parameter resulting in the greatest ground level concentrations being taken forward for use throughout this assessment. The results can be seen in **Table 6** for NOx (Note: no derivation of the oxidation of NO to NO_2 has been undertaken here, and thus this table is for indicative purposes only).

Table 6 Sensitivity Analysis of Surface Roughness Height used in Ausplume Modelling

Sensitive Receptor	Maximum 1-hour NOx concentration (μg/m³) at Receptor	
	0.3 m Surface Roughness Height Modelled	**0.4 m Surface Roughness Height Modelled**
Caravan park at North Rockingham	124	122
Wells Park	259	244
Kwinana Township	103	103
Areas of Interest		
Recreational Reserve 1	347	324
Recreational Reserve 2	992	927
Recreational Reserve 3	992	928
Recreational Reserve 4	455	427
Recreational Reserve 5	207	190

It can be seen that the predicted maximum hourly NOx concentration is greater when a surface roughness parameter of 0.3 is used. Therefore, for precautionary reasons, all subsequent model runs have been carried out using a surface roughness parameter of 0.3 m.

5.9.2 Modelling of the Biofilter as a Stack and a Volume Source

Emissions from the biofilter are not easily defined as either a stack, volume or area source within the Ausplume model.

While modelling the biofilters as stack sources allows bouyancy to be taken into account within the modelling as temperature is an input parameter to this source, due to the wide area covered by the biofilters and their low exit height they cannot be said to behave as conventional stack sources.

To investigate the sensitivity of the model to the clasification of the biofilters source, the biofilters were modelled as both a stack source and as a volume source. The detailed stack and volume source parameters used can be seen in the emissions inventory in **Appendix D**. The results can be seen in **Table 7** for NOx (Note: no derivation of the oxidation of NO to NO_2 has been undertaken here, and thus this table is for indicative purposes only).

Table 7 Sensitivity Analysis of Modelling Biofilter as a Stack and Volume Source

Sensitive Receptor	Maximum 1-hour NOx concentration ($\mu g/m^3$) at Receptor	
	Biofilter Modelled as a Volume Source	**Biofilter Modelled as a Stack Source**
Caravan park at North Rockingham	124	111
Wells Park	259	153
Kwinana Township	103	103
Areas of Interest		
Recreational Reserve 1	347	114
Recreational Reserve 2	992	166
Recreational Reserve 3	992	186
Recreational Reserve 4	455	120
Recreational Reserve 5	207	121

It can be seen that the predicted maximum hourly NOx concentration is greater when the biofilter is modelled as a volume source rather than a stack source.

It is recognised that accounting for buoyancy effects (as with the stack source configuration) may provide results closer to reality. However, for precautionary reasons, all subsequent model runs have been carried out modelling the biofilter as a volume source.

6 ATMOSPHERIC DISPERSION MODELLING RESULTS

6.1 Odour

Ausplume predictions for the 99.5th percentile and 99.9th percentile odour concentration at each of the nearest sensitive receivers, using the emission rates detailed in **Section 5.5** are shown in **Table 8**. The 99.9th percentile concentration isopleth is presented in **Appendix F**.

Table 8 Predicted 99.9th and 99.5th Percentile Odour Concentrations at the Identified Sensitive Receivers and Areas of Interest

Receiver	Predicted Odour Concentration (OU)		
	Background	Increment	Total (Background + Increment)
99.9th Percentile (limit of 4 OU)			
Sensitive Receivers			
Caravan park at North Rockingham	0.00	0.033	0.033
Wells Park	0.00	0.167	0.167
Kwinana Township	0.00	0.003	0.003
Areas of Interest			
Recreational Reserve 1	0.00	0.123	0.123
Recreational Reserve 2	0.00	0.519	0.519
Recreational Reserve 3	0.00	0.423	0.423
Recreational Reserve 4	0.00	0.122	0.122
Recreational Reserve 5	0.00	0.08	0.08
99.5th Percentile (limit of 2 OU)			
Sensitive Receivers			
Caravan park at North Rockingham	0.00	0.008	0.008
Wells Park	0.00	0.098	0.098
Kwinana Township	0.00	0.001	0.001
Areas of Interest			
Recreational Reserve 1	0.00	0.077	0.077
Recreational Reserve 2	0.00	0.336	0.336
Recreational Reserve 3	0.00	0.313	0.313
Recreational Reserve 4	0.00	0.064	0.064
Recreational Reserve 5	0.00	0.031	0.031

The modelling results indicate that the predicted odour concentrations are anticipated to be below the project odour goals at all sensitive receivers. The odour concentrations are below 2 OU for a 3 minute average at the 99.5th percentile and are below 4 OU for a 3 minute average at the 99.9th percentile. This satisfies the two-part “green-light” criteria, as set out in the EPA Guidance Statement No 55. Scenario 2 has not been modelled for odour as the maintenance schedule will only reduce emissions of odour as one of 4 Thermal Dryer Units will be offline.

6.2 PM_{10}

Ausplume has predicted the 6th highest PM_{10} concentrations at each of the sensitive receptors using the emission rates outlined in **Appendix D**. These results show the maximum predicted increment due to the plant operation (normal and maintenance operation), and the maximum total PM_{10} concentrations (background plus increment).

The results for all 8 receptors can be seen in **Appendix I**. The results for the receptor with the highest incremental concentrations and the 6th highest total (background plus increment) 24-hour PM_{10} are shown in **Table 9** and **Table 10** respectively for Scenario 1. The receptor with the maximum predicted PM_{10} impact was Receptor 5 (Recreational Reserve).

Scenario 2 has not been modelled for PM_{10} as PM_{10} emissions are anticipated to decrease during Scenario 2 due to the lower quantity of natural gas being consumed in maintenance. Therefore Scenario 1 is a representation of "worst case".

Table 9 Maximum 24 hour Incremental PM_{10} Predicted for Receptor 5 (Normal Plant Operation - Scenario 1)

Date	Background PM_{10}	Predicted Incremental PM_{10} due to proposed plant ($\mu g/m^3$)	Total PM_{10}
28-08-2004	11.0	**6.3**	17.3
22-09-2004	10.9	**5.6**	16.5
01-06-2004	16.0	**4.7**	20.7
30-03-2004	22.6	**4.7**	27.3
07-03-2004	18.5	**4.4**	22.9
03-03-2004	25.8	**4.4**	30.1

Note: The 6 highest increments are shown here as the 6th highest maximum PM_{10} concentration criteria relates to total PM_{10}, not the incremental contributions.

Table 10 6th Highest Maximum Total (Background + Increment) 24-hour PM_{10} predicted for Receptor 5, Receptor 2 (Wells Park) and Receptor 1 (Caravan Park at North Rockingham) (Normal Plant Operation - Scenario 1)

Receptor	Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant ($\mu g/m^3$)	Total PM_{10}
5 – Recreation Reserve	25-02-2004	33.8	2.1	**35.9**
2 - Wells Park	14-12-2004	34.6	0.0	**34.6**
1 - Caravan Park at North Rockingham	12-01-2004	34.5	0.0	**34.5**

The maximum predicted PM_{10} concentration due to the bio-reactor alone (no background) at receptor 5 is 6.3 $\mu g/m^3$. The 6th highest total PM_{10} at receptor 5 is 35.9 $\mu g/m^3$ (comprising a background concentration of 33.8 $\mu g/m^3$ and an incremental concentration of 2.1 $\mu g/m^3$). The modelling results indicate that the predicted 24-hour average PM_{10} concentrations are anticipated to be below the NEPM air quality goal of 50 $\mu g/m^3$ (not to be exceeded more than 5 times per year), at all sensitive receptors modelled (including those within the recreational reserve).

The 6th maximum 24 hour average PM_{10} concentration isopleth is presented in **Appendix G** for total PM_{10} (background plus increment due to the proposed plant) and for the increment due to the proposed plant only.

For purposes of reporting performance against the NEPM standard, the 6th highest 24-hour PM_{10} isopleth is additionally presented in **Appendix G** for total PM_{10} (background plus increment due to the proposed plant) and for the increment due to the proposed plant only.

6.3 $PM_{2.5}$ Assessment

As there is little data available regarding $PM_{2.5}$ emission factors, $PM_{2.5}$ has not been quantitatively assessed. It is possible however to qualitatively assess $PM_{2.5}$ concentrations attributable to the proposed bio-reactor, based on the modelling of PM_{10} concentrations.

For the purpose of this qualitative assessment, the highly conservative assumption that 100% of the maximum predicted 24-hour average PM_{10} concentration constitutes the $PM_{2.5}$ size fraction has been adopted. **Table 11** thus outlines the (conservatively high) worst-case 24-hour average $PM_{2.5}$ concentrations at the nearest sensitive receivers.

The *National Ambient Air Quality Status and Trends Report 1991 – 2001* (2004) examined the relationship between $PM_{2.5}$ and PM_{10} across 14 monitoring sites across Australia. Although there are site specific, yearly and seasonal fluctuations in the relationship between these two size fractions, the ratio has been generally found to be between 0.2 and 1.

Table 11 Maximum 24-hour Average $PM_{2.5}$ Concentrations at the nearest Sensitive Receivers

Receiver	Maximum 24-hour Average $PM_{2.5}$ Concentration ($\mu g/m^3$)		
	Background	**Increment**	**Total (Background + Increment)**
Sensitive Receivers			
Caravan park at North Rockingham	9.0	0.9	9.9
Kwinana Township	9.0	0.1	9.1
Wells Park	9.0	1.7	10.7

The qualitative results shown in **Table 11** indicate that the $PM_{2.5}$ concentrations are anticipated to be below the project goal of 25 $\mu g/m^3$ at all sensitive receivers.

6.4 Nitrogen Dioxide

As detailed in **Section 5.8,** ground level nitrogen dioxide concentrations have been calculated based on both the NO to NO_2 empirical relationship described by Janssen et al (1988) and the USEPA's Ozone Limiting Method (OLM).

6.4.1 Janssen Method

Table 12 and **Table 13** show the results of the Ausplume predictions for the 1-hour maximum and annual average NO_x (and derived NO_2) concentrations at each of the 8 identified receptors, using the emission rates detailed in **Appendix D**.

The 1-hour maximum NO_x concentration isopleth is presented in **Appendix H** for Scenario 1 for incremental plus background concentrations. Scenario 2 shows identical maximum hourly concentrations and therefore has not been included.

This appendix has been provided for indicative purposes only, to show the percentage of NO_X which should be expected to be NO_2 at the distances shown in the figure. A linear regression was performed on the NO to NO_2 data derived from the results below in order to identify a percentage NO_X as NO_2 at distance from source.

Table 12 Ausplume predictions for total NOx and calculated NO_2 concentrations (maximum hour) using the Janssen method at identified receptors (Normal Operating Conditions - Scenario 1)

Receptor	Distance from source (km)	Hourly Background NO_2 ($\mu g/m^3$)	Maximum hourly NOx ($\mu g/m^3$) Increment only	Percentage NOx as NO2 (plus conservative 10% baseline)	Maximum hourly NO_2 concentration ($\mu g/m^3$) Increment only	Maximum hourly NO_2 concentration ($\mu g/m^3$)
1	1.4	82	42	18.1	8	90
2	0.5	59	200	12.5	25	84
3	4.2	103	0.08	38.9	0	103
4	0.6	55	292	12.8	38	93
5	0.2	20	525	11.3	59	79
6	0.2	9	701	11.2	79	88
7	0.5	70	385	13.3	51	121
8	0.7	1	206	14.3	29	30

Table 13 Ausplume predictions for total NOx and calculated NO_2 Concentrations (Annual Average) using the Janssen method at identified receptors (Normal Operating Conditions - Scenario 1)

Receptor	Distance from source (km)	Annual Average NO_2 ($\mu g/m^3$)	Annual Average NOx ($\mu g/m^3$) Increment only	Percentage NOx as NO2 (plus conservative 10% baseline)	Annual Average NO_2 concentration ($\mu g/m^3$) Increment only	Annual Average NO_2 concentration ($\mu g/m^3$)
1	1.4	12	0.8	18.1	0	12
2	0.5	12	4.5	12.5	1	13
3	4.2	12	0.08	38.9	0	12
4	0.6	12	4.4	12.8	1	13
5	0.2	12	21.5	11.3	2	14
6	0.2	12	18.5	11.2	2	14
7	0.5	12	3.5	13.3	0	12
8	0.7	12	2.2	14.3	0	12

The results indicate that the predicted NO_2 concentrations are anticipated to be well below the project goal of 226 $\mu g/m^3$ (1 hour maximum) and 56 $\mu g/m^3$ (annual average) at all identified receptors.

6.4.2 Ozone Limiting Method (OLM)

Predicted hourly maximum NO_2 concentrations at each of the sensitive receptors, calculated using the US EPA Ozone Limiting Method are shown in **Table 14.**

Table 14 Ausplume predictions for total NOx and calculated NO_2 Concentrations (maximum hour) using the OLM method at identified receptors (Normal Operating Conditions - Scenario 1)

Receptor	Maximum hourly NOx (µg/m^3) predicted using Ausplume - Increment only	Background NO_2 concentration (µg/m^3)	Background O_3 concentration (µg/m^3)	Maximum hourly NO_2 concentration (µg/m^3) calculated using the OLM method (Level 2)
1	42	82	3	89
2	200	59	1	80
3	0	103	11	103
4	292	55	4	86
5	525	20	5	77
6	701	9	22	101
7	385	70	4	112
8	206	1	61	80

The results indicate that the predicted NO_2 concentrations are anticipated to be well below the project goal of 226 µg/m^3 (1 hour maximum). As discussed previously, annual average NO_2 has not been assessed using the OLM method as the annual average NEPM criteria for NO_2 (56 µg/m^3) is met even when 100% NO_X to NO_2 conversion is assumed.

The maximum hourly NO_2 concentrations calculated using the Janssen method and the OLM method show similar results for receptors 1-5 and 7. Discrepancies in the predictions using the two methodologies are observed at receptors 8 and 6, with the OLM method predicting higher values of 50 µg/m^3 and 13 µg/m^3 respectively. Overall, the OLM may therefore be seen to be slightly more conservative in its predictive approach.

6.4.3 WHO Vegetation Criteria

Ground level NOx concentrations have been modelled to compare against World Health Organisation vegetation criteria as discussed in **Section 4.3**. Ausplume predictions for the maximum 24 hour mean and annual average NOx concentrations can be seen in **Table 15**.

Table 15 WHO Vegetation Criteria Assessment –Biofilter Modelled as Volume and Stack Source

Receptor[1]	Volume Source		Stack Source	
	Maximum 24 hour average NOx (µg/m3)	Annual Average NOx (µg/m3)	Maximum 24 hour average NOx (µg/m3)	Annual Average NOx (µg/m3)
1	44.6	12.9	44.6	12.7
2	52.8	16.7	45.9	14.1
3	44.2	12.2	44.2	12.2
4	**70.1**	16.6	55.2	15.0
5	**158.0**	**33.7**	56.8	20.1
6	**156.0**	**30.7**	48.1	16.6
7	53.7	15.7	44.6	14.2
8	54.5	14.4	47.9	13.7

Note 1: Predicted exceedances of the WHO Vegetation criteria are shown in bold

As discussed in **Section 5.9**, sensitivity analyses have been undertaken which show that significant differences in the 1-hour maximum NOx concentration are observed when the biofilter is modelled as either a stack or volume source within the Ausplume model. A conservative approach has been undertaken for the air quality assessment as a whole in that the biofilter has been modelled as a volume source as the highest concentrations of NOx and NO_2 were obtained in this way.

However, as can be seen from **Table 14**, exceedances of the WHO vegetation criteria for NOx (75 $\mu g/m^3$ as a 24-hour average, 30 $\mu g/m^3$ annual average) are experienced at Receptors 5 and 6 within the Recreation Reserve when modelling the biofilter as a volume source. When modelling the biofilter as a stack source, no exceedences of the WHO 24 hour or annual average criteria are experienced at any of the receptors.

It is considered that in reality, the true ground level concentrations of NOx within the Recreation Reserve may be somewhere between those predicted in **Table 14**. Studies have suggested that Ausplume is considered to give conservative predictions of NOx (WA DEC, 2004) and therefore it might be expected that the concentrations actually associated with the proposed site may be closer to those predicted modelling the biofilter as a stack source (no exceedances of the WHO vegetation based criteria are predicted when this method is used).

As a comparison, Hope Valley (approximately 5km north of Kwinana) experienced, in 2002, maximum 24-hour average NOx concentrations of approximately 60 $\mu g/m^3$ and an annual average of approximately 13.16 $\mu g/m^3$. At Queens Building in central Perth, where vehicle emissions and not industrial emissions are the main factor in high NOx concentrations, maximum 24-hour average NOx concentrations of approximately 336 $\mu g/m^3$ and an annual average of approximately 142 $\mu g/m^3$ were observed. The concentrations predicted at Kwinana due to the proposed Bio-Refinery are significantly lower than those observed at Perth and of greater similarity to those monitored at Hope Valley.

Primary Energy is committed to carrying out ambient NOx monitoring within the Recreation Reserve adjacent to the proposed Bio-Refinery to better quantify the ambient NOx concentrations. If, after further modelling and monitoring it is identified that NOx concentrations will be of sufficient concentration to exceed the WHO vegetation criteria, then retrofit mitigation measures will be added to the plant (for example catalytic converters). As a first step, monitoring will be undertaken to examine the status of the vegetation within the Recreation Reserve and ground level NOx concentrations. If impacts on this vegetation by the proposed plant are observed, then contingency measures will be implemented and additional vegetation will be encouraged within the Recreation Reserve to offset any potential air quality impacts on vegetation.

The maximum 24-hour NO_x concentration isopleth is presented in **Appendix H** for Scenario 1 for incremental plus background concentrations. Also shown is the annual average NOx concentration Isopleth. These are shown for modelling of the biofilter as a volume source and as a stack source for information.

6.5 Sulphur Dioxide

Table 16 shows the results of the Ausplume predictions for the maximum SO_2 concentration at each of the nearest receivers and areas of interest, using the emission rates detailed in **Appendix D.**

Table 16 Predicted Maximum SO_2 Concentrations at the nearest Sensitive Receivers and Areas of Interest (Normal Operations - Scenario 1)

Receiver	Maximum Predicted 1-hour average SO_2 Concentration (μg/m³)			Maximum Predicted 24-hour average SO_2 Concentration (μg/m³)			Annual Average SO_2 Concentration (μg/m³)		
	Bg [1]	Inc	Total (Bg + Inc)	Bg [1]	Inc	Total (Bg + Inc)	Bg [1]	Inc	Total (Bg + Inc)
Sensitive Receivers									
Caravan park at North Rockingham	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73
Wells Park	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73
Kwinana Township	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73
Areas of Interest									
Recreational Reserve 1	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.01	1.74
Recreational Reserve 2	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.02	1.75
Recreational Reserve 3	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.01	1.74
Recreational Reserve 4	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73
Recreational Reserve 5	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73

Note 1: WA DEC *"Air Quality Modelling Guidance Notes"* 2006 require consideration of background concentrations to show the cumulative predicted pollutant levels. As described in **Section 3.2,** varying hourly SO_2 concentrations were included within the model for the year 2004. The SO_2 background reflects the background which occurred during the highest 1-hour period for each location.

Bg = Background

Inc = Increment

Table 17 Predicted Maximum SO_2 Concentrations at the nearest Sensitive Receivers and Areas of Interest (Maintenance Activities - Scenario 2)

Receiver	Maximum Predicted 1-hour average SO_2 Concentration (μg/m³)			Maximum Predicted 24-hour average SO_2 Concentration (μg/m³)			Annual Average SO_2 Concentration (μg/m³)		
	Bg [1]	Inc	Total (Bg + Inc)	Bg [1]	Inc	Total (Bg + Inc)	Bg [1]	Inc	Total (Bg + Inc)
Sensitive Receivers									
Caravan park at North Rockingham	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73
Wells Park	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73
Kwinana Township	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73
Areas of Interest									
Recreational Reserve 1	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.01	1.74
Recreational Reserve 2	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.02	1.75
Recreational Reserve 3	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.01	1.74
Recreational Reserve 4	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73
Recreational Reserve 5	100.9	0.0	100.9	15.28	0.02	15.30	1.73	0.00	1.73

Note 1: WA DEC *"Air Quality Modelling Guidance Notes"* 2006 require consideration of background concentrations to show the cumulative predicted pollutant levels. As described in **Section 3.2,** varying hourly SO_2 concentrations were included within the model for the year 2004. The SO_2 background reflects the background which occurred during the highest 1-hour period for each location.

Bg = Background

Inc = Increment

The modelling results indicate that the predicted SO_2 concentrations are anticipated to be below the project goals of 520 μg/m³ (Maximum 1 hour average), 210 μg/m³ (maximum 24 hour average) and 52 μg/m³ (Annual average) at all sensitive receivers.

1-hour SO_2 concentrations for the Kwinana Ethanol project site are also below the ambient air quality standards and limits within the WA DEC's *Revised Draft Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999* at all sensitive receivers .

6.6 Carbon Monoxide

Table 18 and **Table 19** show the results of the Ausplume model predictions for the maximum 8 hour average CO concentrations at each of the nearest receivers and areas of interest, using the emission rates detailed in **Appendix D** for both scenarios (Normal and maintenance operations).

Table 18 Predicted Maximum 8 hour average CO Concentrations at the nearest Sensitive Receivers and Areas of Interest (Normal Operations - Scenario 1)

Receiver	Maximum Predicted 8-hour average CO Concentration (mg/m³)		
	Background [1]	Increment	Total (Background + Increment)
Sensitive Receivers			
Caravan park at North Rockingham	4.025	0.075	4.1
Wells Park	4.025	0.315	4.34
Kwinana Township	4.025	0.015	4.04
Areas of Interest			
Recreational Reserve 1	4.025	0.365	4.39
Recreational Reserve 2	4.025	1.305	5.33
Recreational Reserve 3	4.025	1.055	5.08
Recreational Reserve 4	4.025	0.275	4.30
Recreational Reserve 5	4.025	0.225	4.25

[1]A constant, worst case 4.025 mg/m³ background was used.

Table 19 Predicted Maximum 8 hour average CO Concentrations at the nearest Sensitive Receivers and Areas of Interest (Maintenance Activities - Scenario 2)

Receiver	Maximum Predicted 8-hour average CO Concentration (mg/m³)		
	Background [1]	Increment	Total (Background + Increment)
Sensitive Receivers			
Caravan park at North Rockingham	4.025	0.075	4.1
Wells Park	4.025	0.315	4.34
Kwinana Township	4.025	0.015	4.04
Areas of Interest			
Recreational Reserve 1	4.025	0.375	4.40
Recreational Reserve 2	4.025	1.305	5.33
Recreational Reserve 3	4.025	1.075	5.10
Recreational Reserve 4	4.025	0.275	4.30
Recreational Reserve 5	4.025	0.225	4.25

[1]A constant, worst case 4.025 mg/m³ background was used.

The modelling results indicate that the predicted 8 hour average CO concentrations are anticipated to be below the project goal of 10 mg/m³ at all sensitive receivers and Areas of Interest for both operating scenarios. The use of a constant (and conservatively high) background value has resulted in some receptors being close to the criterion, although this gives confidence that even though such a high background has been used, the impact of the plant does not breach the NEPM criterion at any of the sensitive receivers or Areas of Interest. **Appendix J** shows contour plots of 8 hour average CO concentrations.

6.7 VOCs (as Ethanol)

Table 20 shows the results of the Ausplume predictions for the 99.9th percentile ethanol concentrations at each of the nearest receivers, using the emission rates detailed in **Appendix D** The 1-hour average 99.9th percentile ethanol concentration isopleth is presented in **Appendix K**.

Table 20 Predicted 99.9th Percentile 1-hour average Ethanol Concentrations at the nearest Sensitive Receivers and Areas of Interest

Receiver	Predicted 99.9th percentile 1-hour Average VOC (as ethanol) Concentration (mg/m^3)		
	Background	Increment	Total (Background + Increment)
Sensitive Receivers			
Caravan park at North Rockingham	0	0.06	0.06
Wells Park	0	0.08	0.08
Kwinana Township	0	0.01	0.01
Areas of Interest			
Recreational Reserve 1	0	1.15	1.15
Recreational Reserve 2	0	0.33	0.33
Recreational Reserve 3	0	0.12	0.12
Recreational Reserve 4	0	0.07	0.07
Recreational Reserve 5	0	0.32	0.32

The modelling results indicate that the predicted 99.9th percentile 1-hour average ethanol concentrations are anticipated to be below the project goal of 2.1 mg/m^3 at all sensitive receivers or Areas of Interest. Scenario 2 was not modelled for Ethanol as the maintenance operation does not change.

7 CONCLUSION

Heggies Pty Ltd (Heggies) has been commissioned by Umwelt Australia Pty Ltd (Umwelt) to conduct an air quality impact assessment for the proposed bio-refinery, located at Kwinana Beach Road, Kwinana WA.

The atmospheric dispersion modelling carried out in the present assessment utilises the Ausplume Gaussian Plume Dispersion Model software developed by EPA Victoria, Version 6.0.

The impact of pollutant emissions from the proposed plant has been assessed at the following representative sensitive receivers surrounding the subject site. These locations are:

- Caravan park at North Rockingham – located approximately 650 m southwest of the project site;
- Wells Park – located approximately 180 m northwest of the project site; and
- Kwinana Township – located approximately 3,700 m northeast of the project site.

The results of the modelling indicate that:

- The predicted odour concentrations are anticipated to be below the project odour goals at all sensitive receivers. The odour concentrations are below 2 OU for a 3 minute average in the 99.5^{th} percentile and are below 4 OU for a 3 minute average in the 99.9^{th} percentile. This satisfies the two-part "green-light" criteria, as set out in the *EPA Guidance Statement No 55*. At the closest receptor to the project site, Wells Park, the 99.9^{th} and 99.5^{th} percentile odour concentrations are predicted to be 0.167 OU and 0.098 OU respectively. At the Caravan Park at North Rockingham, the 99.9^{th} and 99.5^{th} percentile odour concentrations are also predicted to be 0.033 OU and 0.008 OU respectively
- The predicted 24-hour average PM_{10} concentrations are anticipated to be within the NEPM air quality goal of 50 $\mu g/m^3$ at the sensitive receivers (not to be exceeded more than 5 times per year).
  - At Wells Park, the contribution of the Bio-Refinery to maximum 24-hour average PM_{10} concentrations is predicted to be 0.1 $\mu g/m^3$ resulting in a total maximum 24-hour average PM_{10} concentration of 50.6 $\mu g/m^3$. The 6^{th} highest 24-hour average concentration is predicted to be 34.6 $\mu g/m^3$ with a contribution from the Bio-Refinery of 0 $\mu g/m^3$.
  - At the Caravan Park at North Rockingham, the contribution of the Bio-Refinery to maximum 24-hour average PM_{10} concentrations is predicted to be 0 $\mu g/m^3$, the maximum 24 hour PM^{10} concentration being caused by a bushfire event on the 20^{th} December 2004 (50.5 $\mu g/m^3$). The 6^{th} highest 24-hour average concentration is predicted to be 34.5 $\mu g/m^3$ with a contribution from the Bio-Refinery of 0 $\mu g/m^3$.
- The predicted NO2 concentrations are anticipated to be below the health based project goals of 226 $\mu g/m^3$ 1 hour maximum and 56 $\mu g/m^3$ annual average at all sensitive receivers. At Wells Park, NO_2 concentrations are predicted to be 84 $\mu g/m^3$ as a 1 hour maximum and 12.8 $\mu g/m^3$ as an annual average. At the Caravan Park at North Rockingham, NO_2 concentrations are predicted to be 89.6 $\mu g/m^3$ as a 1 hour maximum and 12.3 $\mu g/m^3$ as an annual average. A detailed discussion of the possible exceedances of vegetation based NOx standards is included within this report.

- The predicted SO_2 concentrations are anticipated to be below the project goal of 520 $\mu g/m^3$ as a 1 hour maximum (within the DEC's *Revised Draft Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999*), 210 $\mu g/m^3$ as a 24 hour mean and 52 $\mu g/m^3$ as an annual average at all sensitive receivers. Predicted concentrations at Wells Park are 100.9 $\mu g/m^3$ as a 1 hour maximum, 15.3 $\mu g/m^3$ as a 24-hour mean and 1.73 $\mu g/m^3$ as an annual average. At the Caravan Park at North Rockingham, predicted concentrations are 100.9 $\mu g/m^3$ as a 1 hour maximum, 15.3 $\mu g/m^3$ as a 24-hour mean and 1.73 $\mu g/m^3$ as an annual average. The values are the same for many locations as the increments due to the Bio-Refinery are predicted to be so low. The maximum hourly, 24-hour mean and the annual average are driven by background concentrations of SO_2 rather than that which is generated by the Bio-Refinery itself.
- The predicted 8-hour average CO concentrations are anticipated to be below the project goal of 10 mg/m^3 at all sensitive receivers. At Wells Park concentrations are predicted to be 4.34 mg/m^3, and at the Caravan Park at North Rockingham, concentrations are predicted to be 4.1 mg/m^3.
- The predicted 1-hour average ethanol concentrations are anticipated to be below the project goal of 2.1 mg/m^3 at all sensitive receivers. At Wells Park the 99.9th percentile concentration is predicted to be 0.08 mg/m^3 and at the Caravan Park at North Rockingham concentrations are predicted to be 0.06 mg/m^3.

Considering the above air quality modelling results, it is concluded that the proposed Kwinana Bio-Refinery will not have a detrimental health impact upon the surrounding sensitive receivers. Additional monitoring is required and will be undertaken by the proponent to confirm that vegetation standards are not exceeded within the Recreation Reserve.

8 GLOSSARY OF TERMS

CBH	Cooperating Bulk Handling
CHPP	Combine Heat and Power Plant
EPA	Environmental Protection Authority
mg	Milligram (g x 10^{-3})
µg	Microgram (g x 10^{-6})
µm	Micrometre or micron (metre x 10^{-6})
m^3	Cubic metre
MW	Megawatt
NEPM	National Environment Protection Measure
NO_2	Nitrogen Dioxide
NO	Nitric Oxide
NO_X	Oxides of nitrogen
NPI	National Pollutant Inventory
NSW DEC	NSW Department of Environment and Conservation
OU	Odour Units
$OU.m^3$	Odour Unit Volumes
$OU.m^3/s$	Odour Unit Volumes per second
PM_{10}	Particulate matter less than 10 microns in aerodynamic diameter
$PM_{2.5}$	Particulate matter less than 2.5 microns in aerodynamic diameter
ppb	Parts per billion (volumetric concentration)
ppm	Parts per million (volumetric concentration)
SO_2	Sulphur Dioxide
USEPA	United States Environmental Protection Agency
WA DEC	WA Department of Environment and Conservation
VOCs	Volatile Organic Compounds

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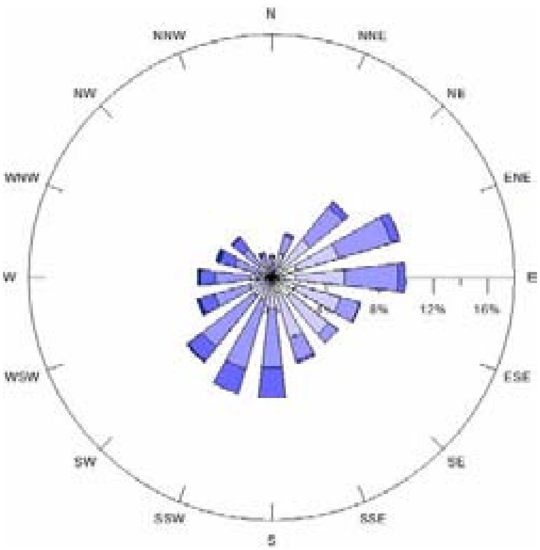
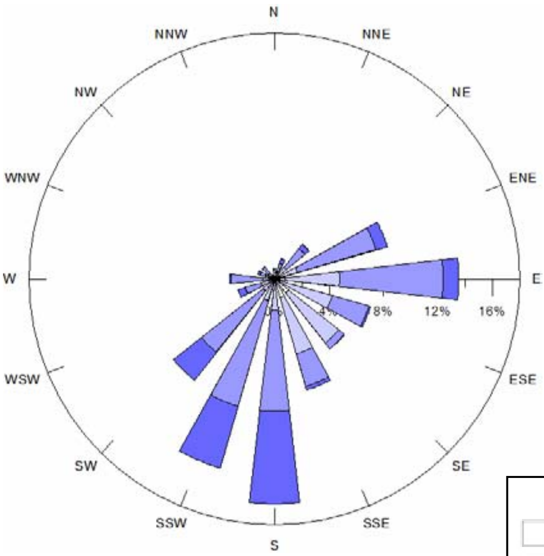
Wind Roses

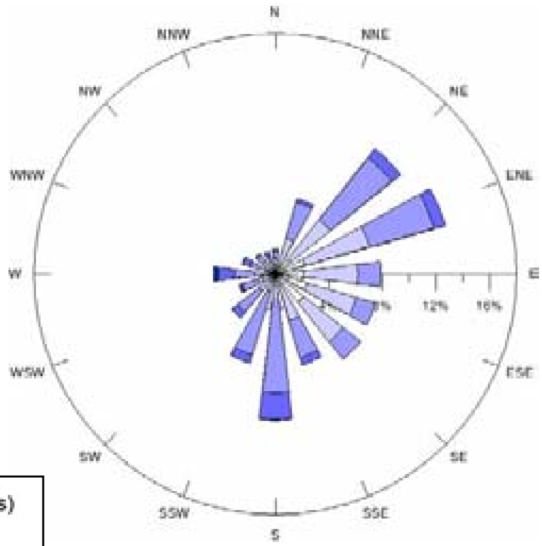
Annual Wind Rose



Summer Wind Rose

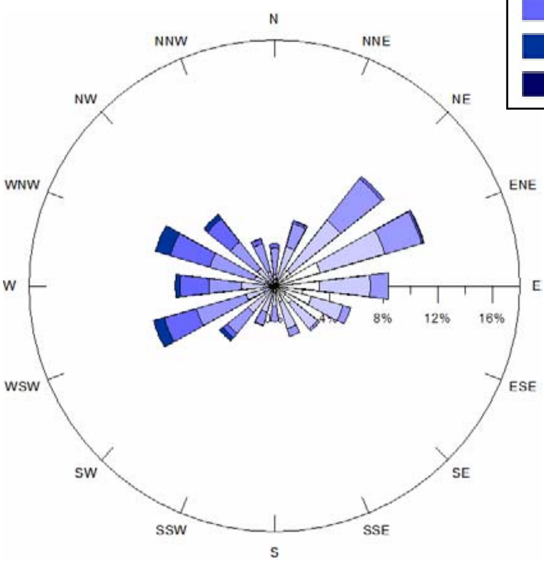


Autumn Wind Rose

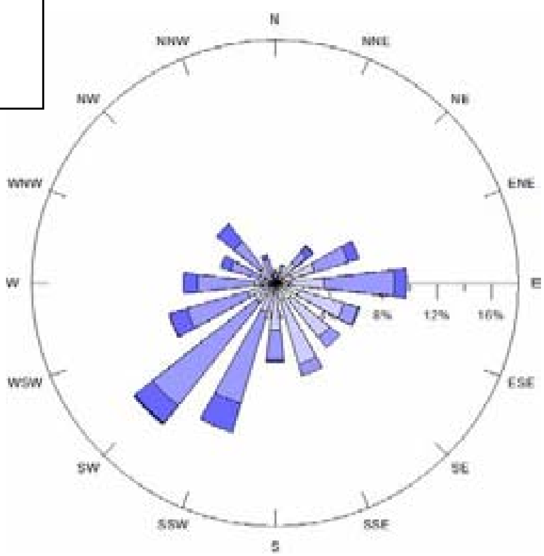


Wind Speed (m/s)
- >0.5 - 1.5
- >1.5 - 3
- >3 - 5.5
- >5.5 - 8
- >8 - 10.5
- >10.5

Winter Wind Rose



Spring Wind Rose



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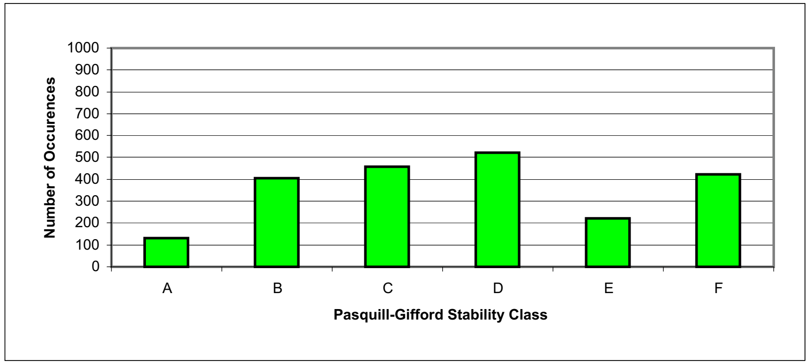
Designed by	Checked by	Approved by - date	Filename	Dated
KT	JW	26/10/06	30-1540	26/10/06

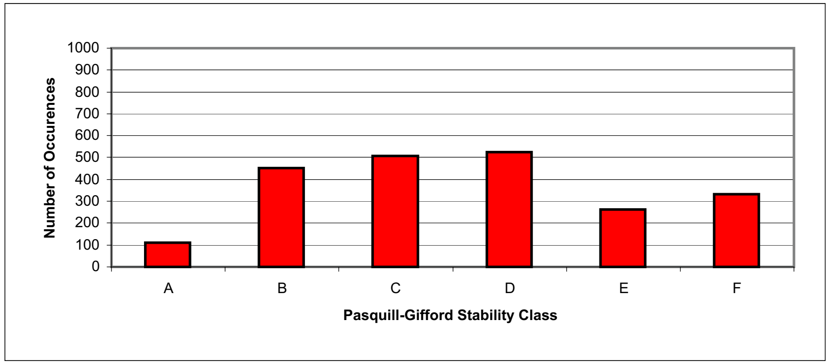
Appendix A: Seasonal Wind Roses for Kwinana Ethanol Plant (2004)

Appendix B

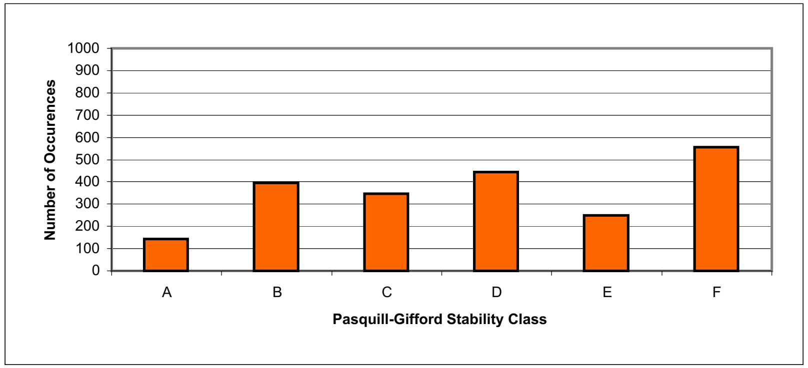
Seasonal Stability Class



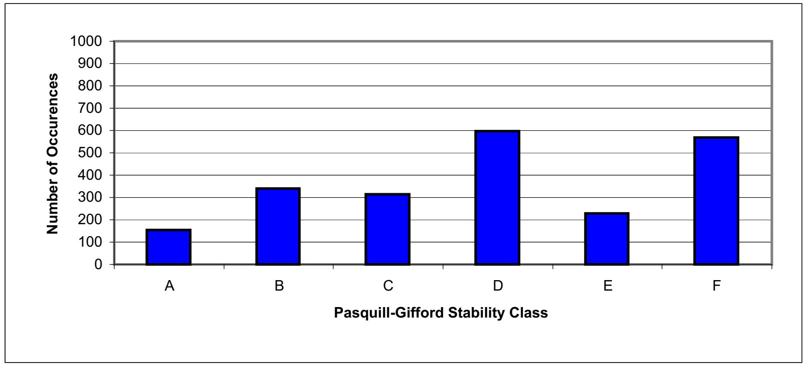
Spring



Summer



Autumn



Winter

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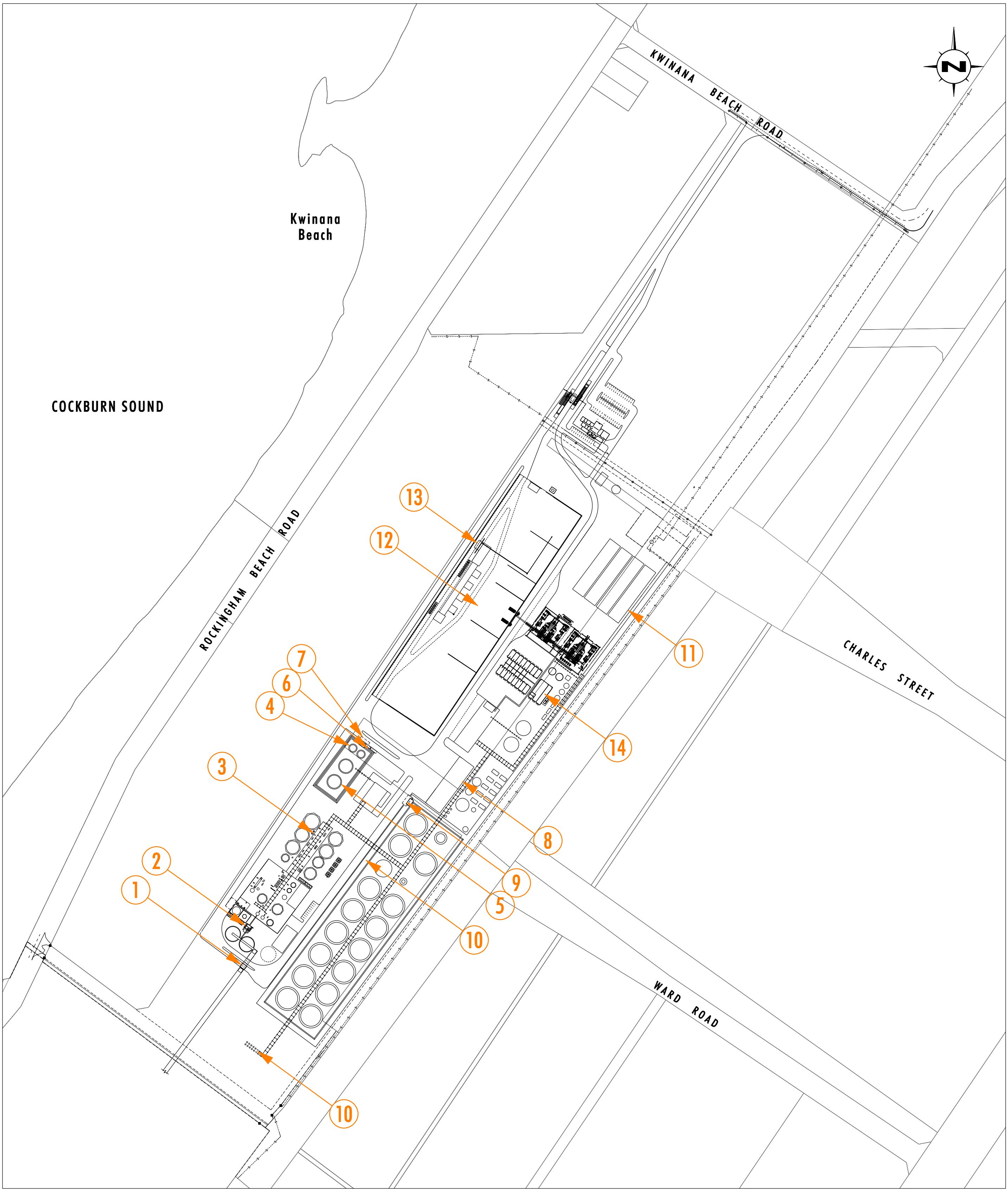
Designed by	Checked by	Approved by - date	Filename	Dated
KT	JW	26-10-2006	30-1540	26-10-2006

Appendix B

Seasonal Stability Class Frequency Distribution for Kwinana Ethanol Plant (2004)

Umwelt
Environmental Consultants



Source: TFA Project Group 2006

0 100 200 300m
1:6000

Legend

1 Grain Dump
2 Hammer Mills
3 Carbon Dioxide Scrubber
4 Ethanol Day Tank Vents (2)
5 Ethanol Storage Tank Vents (2)
6 Denaturant Tank Vent
7 Ethanol Loadout
8 Boiler Flue Gas - 6 Stacks
9 Aqueous Ammonia Loadout
10 Flares (12)
11 Dryer Exhaust via Bio Filter Stack
12 Phos Rock Truck Unloading
13 Fertiliser Loadout
14 Power Generation Engine Exhaust

APPENDIX C

Proposed Bio-Refinery Gaseous Emission Points

File Name (A4): R01_V2/2120_027.dgn

Appendix D - Emissions Inventory

Normal Running – Scenario 1

	PM_{10} Emission Factor	NOx Emission Factor	SO_2 Emission Factor	CO Emission Factor	Emission Factor Units	Throughput	Throuhput units	Working days available	Working hours per day	PM_{10} Emission Rate (g/s)	NOx Emission Rate (g/s)	SO_2 Emission Factor (g/s)	CO Emission Factor (g/s)	Source width (m)	Source Length (m)	Base Height (m)	Stack Height (m)	Stack Velocity (m/s)	Stack Diameter (m)	Stack Temperature (deg/C)	Notes
Grain Feed conveyor vent #1 (kg/t)	0.015	N/A	N/A	N/A	kg/t	16	t/hr	365	24	0	N/A	N/A	N/A	0.5	0.5	6.0	N/A	N/A	N/A	N/A	99% particulate emission reduction in grain handling due to the fitting of bag filters (Umwelt personal communication). Also depends of the successful operation of mitigation measures detailed within the main report
Grain Feed conveyor vent #2 (kg/t)	0.015	N/A	N/A	N/A	kg/t	16	t/hr	365	1	0	N/A	N/A	N/A	0.5	0.5	6.0	N/A	N/A	N/A	N/A	
Grain Feed conveyor vent #3 (kg/t)	0.015	N/A	N/A	N/A	kg/t	16	t/hr	365	24	0	N/A	N/A	N/A	0.5	0.5	6.0	N/A	N/A	N/A	N/A	
Grain reclaim bucket elevator (kg/t)	0.015	N/A	N/A	N/A	kg/t	48	t/hr	365	24	0	N/A	N/A	N/A	0.5	0.5	17.6	N/A	N/A	N/A	N/A	
Grain surge bin (kg/t)	0.015	N/A	N/A	N/A	kg/t	48	t/hr	365	24	0	N/A	N/A	N/A	1	1	17.6	N/A	N/A	N/A	N/A	
Steam Generation Boiler # 1	121.6	800	2.09	1344	mg of substance emitted per m^3 of gas burned	0.26	m^3/s	365	24	0.0316	0.208	0.0005	0.349	N/A	N/A	0	12	15	0.6	250	Stack parameters obtained from TFA Project Engineers. Details of emission rates based on natural gas consumption in low NOx burners (NPI EET Combustion in Boilers, v1.2, 2003)
Steam Generation Boiler # 2	121.6	800	2.09	1344	mg of substance emitted per m^3 of gas burned	0.26	m^3/s	365	24	0.0316	0.208	0.0005	0.349	N/A	N/A	0	12	15	0.6	250	
Steam Generation Boiler # 3	121.6	800	2.09	1344	mg of substance emitted per m^3 of gas burned	0.26	m^3/s	365	24	0.0316	0.208	0.0005	0.349	N/A	N/A	0	12	15	0.6	250	
Steam Generation Boiler # 4	121.6	800	2.09	1344	mg of substance emitted per m^3 of gas burned	0.26	m^3/s	365	24	0.0316	0.208	0.0005	0.349	N/A	N/A	0	12	15	0.6	250	
11 x Caterpillar 2MW low heating value gas engines (CATG3520C) exhausted through 4 thermal dryers, cooled, condensed and emitted via 4 Biofilters	N/A	32.0	N/A	79.2	kg/hr	24	hrs	365	24	N/A	0.445	N/A	2.20	67	71	0	2.5	0.006	71	40	Emissions data obtained from CAT G3520C Technical Data Sheet running through biofilters
4x Thermal Dryers running on Natural Gas (900 GJ/wk), ignited to increase temperature of thermal dryers from 450 to 600ºC, cooled, condensed and emitted through 4 Biofilters	121.6	800	2.09	1344	mg of substance emitted per m^3 of natural gas burned	0.16	m^3/s	365	24	0.00	0.0064	0.000007	0.0215	67	71	0	2.5	0.006	71	40	Biofilter details obtained from Flo-Dry Engineering and TFA Project Engineers

Maintenance Running Scenario 2

	PM_{10} Emission Factor	NOx Emission Factor	SO_2 Emission Factor	CO Emission Factor	Emission Factor Units	Throughput	Throuhput units	Working days available	Working hours per day	PM_{10} Emission Rate (g/s)	NOx Emission Rate (g/s)	SO_2 Emission Factor (g/s)	CO Emission Factor (g/s)	Source width (m)	Source Length (m)	Base Height (m)	Stack Height (m)	Stack Velocity (m/s)	Stack Diameter (m)	Stack Temperature (deg/C)	Notes
Grain Feed conveyor vent #1 (kg/t)	0.015	N/A	N/A	N/A	kg/t	16	t/hr	365	24	1	N/A	N/A	N/A	0.5	0.5	6.0	N/A	N/A	N/A	N/A	99% particulate emission reduction in grain handling due to the fitting of bag filters (Umwelt personal communication). Also depends of the successful operation of mitigation measures detailed within the main report
Grain Feed conveyor vent #2 (kg/t)	0.015	N/A	N/A	N/A	kg/t	16	t/hr	365	1	1	N/A	N/A	N/A	0.5	0.5	6.0	N/A	N/A	N/A	N/A	
Grain Feed conveyor vent #3 (kg/t)	0.015	N/A	N/A	N/A	kg/t	16	t/hr	365	24	1	N/A	N/A	N/A	0.5	0.5	6.0	N/A	N/A	N/A	N/A	
Grain reclaim bucket elevator (kg/t)	0.015	N/A	N/A	N/A	kg/t	48	t/hr	365	24	2	N/A	N/A	N/A	0.5	0.5	17.6	N/A	N/A	N/A	N/A	
Grain surge bin (kg/t)	0.015	N/A	N/A	N/A	kg/t	48	t/hr	365	24	2	N/A	N/A	N/A	1	1	17.6	N/A	N/A	N/A	N/A	
Steam Generation Boiler # 1	121.6	800	2.09	1344	mg of substance emitted per m^3 of gas burned	0.26	m^3/s	365	24	0.03	0.208	0.00054	0.349	N/A	N/A	0	12	15	0.6	250	Stack parameters obtained from TFA Project Engineers. Details of emission rates based on natural gas consumption in low NOx burners (NPI EET Combustion in Boilers, v1.2, 2003)
Steam Generation Boiler # 2	121.6	800	2.09	1344	mg of substance emitted per m^3 of gas burned	0.26	m^3/s	365	24	0.03	0.208	0.00054	0.349	N/A	N/A	0	12	15	0.6	250	
Steam Generation Boiler # 3	121.6	800	2.09	1344	mg of substance emitted per m^3 of gas burned	0.26	m^3/s	365	24	0.03	0.208	0.00054	0.349	N/A	N/A	0	12	15	0.6	250	
Steam Generation Boiler # 4 (Creating Steam from 3 x CAT engine exhaust and a lower quantity of natural gas (29.5GJ/hr)) The exhaust emission from the 3 x CAT engines is detailed below	121.6	800	2.09	1344	mg of substance emitted per m^3 of gas burned	0.21	m^3/s	365	24	0	0.168	0.00001	0.282	60	65	0	12	15	0.6	250	
3 x Caterpillar 2MW low heating value gas engines exhausted through 1 boiler	N/A	8.73	N/A	21.60	kg/hr	10	hrs	365	24	N/A	2.43	N/A	6.00	60	65	0	12	15	0.6	250	Emissions data obtained from CAT G3520C Technical Data Sheet running through biofilters
8 x Caterpillar 2MW low heating value gas engines exhausted through 4 dryers, condensed and emitted via 4 Biofilters	N/A	23.28	N/A	57.60	kg/hr	24	hrs	208	10	N/A	0.32	N/A	1.6	67	71	0	2.5	0.006	71	40	Biofilter details obtained from Flo-Dry Engineering and TFA Project Engineers
3x Thermal Dryers running on Natural Gas (900 GJ/wk), ignited to increase temperature of thermal dryers from 450 to 600ºC, cooled, condensed and emitted through 4 Biofilters	121.6	800	2.09	1344	mg of substance emitted per m^3 of natural gas burned	0.12	m^3/s	208	10	0	0.0048	0.00001	0.016	60	65	0	2.5	0.006	71	40	Stack diameter used only in sensitivity runs

Ethanol Emissions Inventory

Source	Source Type	Days available	Hours per day	Ethanol Emission Rate (g/s)	Height (m)	Width/diameter (m)	Length (m)	Stack Velocity (m/s)	Stack Temperature (deg C)
Fermentation Stack	Stack	365	24	1.1	10	1	N/A	10	180
Ethanol Load Out	Volume	365	2.5	0.8	2	2.5	6 - not used in modelling	N/A	N/A
Ethanol Day Storage Tank #1	Volume	365	24	0.01	16.2	0.2	0.2	N/A	N/A
Ethanol Day Storage Tank #2	Volume	365	24	0.01	16.2	0.2	0.2	N/A	N/A
Denaturant Storage Tank	Volume	365	24	0.05	1	0.2	0.2	N/A	N/A
Ethanol Storage tank #1	Volume	365	24	0.02	11	0.2	0.2	N/A	N/A
Ethanol Storage tank #2	Volume	365	24	0.02	11	0.2	0.2	N/A	N/A
Equipment Leaks	Volume	365	24	0.2	2	5	5	N/A	N/A

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	22/11/06		SF	MD

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Telephone 02 9427 8100 Facsimilie 02 9427 8200

APPENDIX F
99.9th Percentile 1-hour Average Odour Concentration Isopleth (OU)
- no background -

FILE NAME: Kwinana Contour Plots.dwg

DRAWING No. ----

REVISION 0

50 mm ON ORIGINAL 0 10 20 30 40 50

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	22/11/06		SF	MD

Heggies Pty Ltd
2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
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Telephone 02 9427 8100 Facsimilie 02 9427 8200

APPENDIX G1
6th Highest 24-hour Average PM_{10}
Concentration Isopleth (µg/m³)
- daily varying background -

FILE NAME: Kwinana Contour Plots.dwg

DRAWING No. ----

REVISION 0

50 mm ON ORIGINAL

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	22/11/06		SF	MD

50 mm ON ORIGINAL

Heggies Pty Ltd
2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Email address sydney@heggies.com.au
Telephone 02 9427 8100 Facsimilie 02 9427 8200

APPENDIX G2

Maximum 24-hour Average PM_{10} Concentration Isopleth (µg/m³)

- no background -

FILE NAME: Kwinana Contour Plots.dwg

DRAWING No. ----

REVISION 0

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	22/11/06		SF	MD

Heggies Pty Ltd
2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Email address sydney@heggies.com.au
Telephone 02 9427 8100 Facsimilie 02 9427 8200

APPENDIX G3

6th Highest 24-hour Average PM_{10}

Concentration Isopleth (µg/m³)

- no background -

FILE NAME: Kwinana Contour Plots.dwg

DRAWING No. ----

REVISION 0

50 mm ON ORIGINAL

REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
0	22/11/06		SF	MD

Heggies Pty Ltd
2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Email address sydney@heggies.com.au
Telephone 02 9427 8100 Facsimilie 02 9427 8200

APPENDIX H1
Maximum 1-hour Average
NOx Concentration Isopleths (µg/m³)
Volume Source - daily varying background -

FILE NAME: Kwinana Contour Plots.dwg
DRAWING No. ----
REVISION 0

50 mm ON ORIGINAL

0	22/11/06		SF	MD
REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED

Heggies Pty Ltd
2 Lincoln Street
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APPENDIX H2

Maximum 24-hour Average

NOx Concentration Isopleths (µg/m³)

Volume Source - daily varying background -

FILE NAME: Kwinana Contour Plots.dwg

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APPENDIX H3

Annual Average

NOx Concentration Isopleths (µg/m³)

Volume Source - daily varying background -

FILE NAME: Kwinana Contour Plots.dwg

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APPENDIX H4

Maximum 1-hour Average

NOx Concentration Isopleths (µg/m³)

Stack Source - daily varying background -

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APPENDIX H5

Maximum 24-hour Average

NOx Concentration Isopleths (µg/m³)

Stack Source - daily varying background -

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APPENDIX H6

Annual Average

NOx Concentration Isopleths (µg/m³)

Stack Source - daily varying background -

FILE NAME: Kwinana Contour Plots.dwg

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Maximum Total 24 Hour and Incremental Predicted PM10 Concentrations

Table I1 Maximum 24 hour Incremental PM_{10} predicted for Receptor 1 (North Rockingham Caravan Park) showing background and total PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant (μg/m³)	Total PM_{10}
04-07-2004	9.9	**0.9**	10.8
05-07-2004	9.4	**0.8**	10.2
11-07-2004	15.6	**0.7**	16.3
17-04-2004	18.9	**0.6**	19.5
22-03-2004	20.2	**0.6**	20.8
12-07-2004	19.0	**0.5**	19.5

Table I2 Maximum 24 hour PM_{10} predicted for Receptor 1 (North Rockingham Caravan Park) showing background and Incremental PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant (μg/m³)	Total PM_{10}
20-12-2004	50.5	0.0	**50.5**
03-01-2004	44.4	0.0	**44.4**
29-04-2004	42.9	0.0	**42.9**
18-03-2004	37.4	0.0	**37.4**
14-12-2004	34.6	0.0	**34.6**
12-01-2004	34.5	0.0	**34.5**

Table I3 Maximum 24 hour Incremental PM_{10} predicted for Receptor 2 (Wells Park) showing background and total PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant (μg/m³)	Total PM_{10}
15-03-2004	27.3	**1.7**	29.0
27-03-2004	25.6	**1.4**	27.0
16-03-2004	22.0	**1.3**	23.3
23-03-2004	32.2	**1.2**	33.4
04-02-2004	31.3	**1.2**	32.5
30-01-2004	24.0	**1.0**	25.0

Table I4 Maximum 24 hour PM_{10} predicted for Receptor 2 (Wells Park) showing background and Incremental PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant (μg/m³)	Total PM_{10}
20-12-2004	50.5	0.1	**50.6**
03-01-2004	44.4	0.6	**45.0**
29-04-2004	42.9	0.6	**43.5**
18-03-2004	37.4	0.6	**38.0**
12-01-2004	34.5	0.6	**35.1**
14-12-2004	34.6	0.0	**34.6**

Table I5 Maximum 24 hour Incremental PM_{10} predicted for Receptor 3 (Kwinana Township) showing background and total PM_{10} (Normal running Scenario 1)

Date	**Background PM10**	**Predicted Incremental PM_{10} due to proposed plant (μg/m³)**	**Total PM_{10}**
07-10-2004	20.8	**0.1**	20.9
01-07-2004	6.9	**0.1**	7.0
26-08-2004	18.9	**0.1**	19.0
16-10-2004	14.2	**0.1**	14.3
24-01-2004	17.5	**0.1**	17.6
08-06-2004	16.5	**0.1**	16.6

Table I6 Maximum 24 hour PM_{10} predicted for Receptor 3 (Kwinana Township) showing background and Incremental PM_{10} (Normal running Scenario 1)

Date	**Background PM10**	**Predicted Incremental PM_{10} due to proposed plant (μg/m³)**	**Total PM_{10}**
20-12-2004	50.5	0.0	**50.5**
03-01-2004	44.4	0.0	**44.4**
29-04-2004	42.9	0.0	**42.9**
18-03-2004	37.4	0.0	**37.4**
14-12-2004	34.6	0.0	**34.6**
12-01-2004	34.5	0.0	**34.5**

Table I7 Maximum 24 hour Incremental PM_{10} predicted for Receptor 4 (Nature Reserve) showing background and total PM_{10} (Normal running Scenario 1)

Date	**Background PM10**	**Predicted Incremental PM_{10} due to proposed plant (μg/m³)**	**Total PM_{10}**
20-03-2004	26.2	**2.6**	28.8
04-05-2004	18.8	**2.6**	21.4
03-06-2004	11.3	**2.3**	13.5
23-04-2004	22.2	**2.2**	24.4
26-04-2004	24.9	**2.2**	27.0
10-08-2004	17.0	**1.9**	18.9

Table I8 Maximum 24 hour PM_{10} predicted for Receptor 4 (Nature Reserve) showing background and Incremental PM_{10} (Normal running Scenario 1)

Date	**Background PM10**	**Predicted Incremental PM_{10} due to proposed plant (μg/m³)**	**Total PM_{10}**
20-12-2004	50.5	0.2	**50.7**
03-01-2004	44.4	0.2	**44.6**
29-04-2004	42.9	0.5	**43.4**
18-03-2004	37.4	1.0	**38.4**
12-01-2004	34.5	0.8	**35.2**
14-12-2004	34.6	0.3	**34.9**

Maximum Total 24 Hour and Incremental Predicted PM10 Concentrations

Table I9 Maximum 24 hour Incremental PM_{10} predicted for Receptor 5 (Nature Reserve) showing background and total PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant ($\mu g/m^3$)	Total PM_{10}
28-08-2004	11.0	**6.3**	17.3
22-09-2004	10.9	**5.6**	16.5
01-06-2004	16.0	**4.7**	20.7
30-03-2004	22.6	**4.7**	27.3
07-03-2004	18.5	**4.4**	22.9
03-03-2004	25.8	**4.4**	30.1

Table I10 Maximum 24 hour PM_{10} predicted for Receptor 5 (Nature Reserve) showing background and Incremental PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant ($\mu g/m^3$)	Total PM_{10}
20-12-2004	50.5	1.2	**51.7**
29-04-2004	42.9	2.7	**45.6**
03-01-2004	44.4	0.8	**45.2**
18-03-2004	37.4	1.7	**39.1**
12-01-2004	34.5	1.8	**36.2**
25-02-2004	33.8	2.1	**35.9**

Table I11 Maximum 24 hour Incremental PM_{10} predicted for Receptor 6 (Nature Reserve) showing background and total PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant ($\mu g/m^3$)	Total PM_{10}
23-03-2004	32.2	**3.2**	35.4
15-03-2004	27.3	**3.1**	30.4
27-03-2004	25.6	**2.9**	28.5
30-01-2004	24.0	**2.7**	26.7
13-02-2004	16.3	**2.7**	19.0
14-02-2004	21.5	**2.7**	24.2

Table I12 Maximum 24 hour PM_{10} predicted for Receptor 6 (Nature Reserve) showing background and Incremental PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant ($\mu g/m^3$)	Total PM_{10}
20-12-2004	50.5	1.1	**51.6**
03-01-2004	44.4	1.1	**45.5**
29-04-2004	42.9	1.0	**43.9**
18-03-2004	37.4	1.2	**38.6**
12-01-2004	34.5	1.6	**36.0**
25-02-2004	33.8	1.7	**35.5**

Maximum Total 24 Hour and Incremental Predicted PM10 Concentrations

Table I13 Maximum 24 hour Incremental PM_{10} predicted for Receptor 7 (Nature Reserve) showing background and total PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant (μg/m³)	Total PM_{10}
23-03-2004	32.2	**1.3**	33.5
23-01-2004	22.9	**1.1**	24.0
13-02-2004	16.3	**1.0**	17.3
08-02-2004	24.9	**1.0**	25.9
17-05-2004	18.8	**1.0**	19.8
03-11-2004	14.2	**0.9**	15.1

Table I14 Maximum 24 hour PM_{10} predicted for Receptor 7 (Nature Reserve) showing background and Incremental PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant (μg/m³)	Total PM_{10}
20-12-2004	50.5	0.9	**51.4**
03-01-2004	44.4	0.2	**44.6**
29-04-2004	42.9	0.2	**43.1**
18-03-2004	37.4	0.1	**37.5**
14-12-2004	34.6	0.4	**35.0**
12-01-2004	34.5	0.3	**34.7**

Table I15 Maximum 24 hour Incremental PM_{10} predicted for Receptor 8 (Nature Reserve) showing background and total PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant (μg/m³)	Total PM_{10}
17-04-2004	18.9	**2.1**	21.0
05-07-2004	9.4	**2.0**	11.4
20-06-2004	11.5	**1.8**	13.3
11-07-2004	15.6	**1.7**	17.3
22-03-2004	20.2	**1.7**	21.9
04-05-2004	18.8	**1.6**	20.4

Table I16 Maximum 24 hour PM_{10} predicted for Receptor 8 (Nature Reserve) showing background and Incremental PM_{10} (Normal running Scenario 1)

Date	Background PM10	Predicted Incremental PM_{10} due to proposed plant (μg/m³)	Total PM_{10}
20-12-2004	50.5	0.1	**50.6**
03-01-2004	44.4	0.2	**44.6**
29-04-2004	42.9	0.4	**43.3**
18-03-2004	37.4	0.4	**37.8**
12-01-2004	34.5	0.5	**35.0**
14-12-2004	34.6	0.3	**34.9**

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APPENDIX J1 - SCENARIO 1
Maximum 8-hour Average CO
Concentration Isopleth (mg/m³)
- background = 4.025 mg/m³ -

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APPENDIX J2 - SCENARIO 2
Maximum 8-hour Average CO Concentration Isopleth (mg/m^3)
- background = 4.025 mg/m^3 -

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APPENDIX K

99.9th Percentile 1-hour Average Ethanol Concentration Isopleth (mg/m^3)

- no background -

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