

Air Quality Impact Assessment



Report

Air Quality Impact Assessment for Caltex Kurnell Refinery Conversion

28/2/2013

Prepared for
Caltex Refineries (NSW) Pty Ltd
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43177836

URS

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Notes on Text

Notes on Text

Confidential and Sensitive Document – Exempt from disclosure under the Government Information (Public Access) Act 2009 (NSW)

The complete Air Quality Impact Assessment is provided to the NSW Department of Planning & Infrastructure (“DP&I”) by Caltex Refineries (NSW) Pty Ltd (“Caltex”) in confidence for use only within DP&I and the NSW Environment Protection Authority (EPA). It is submitted on the basis that there is an overriding public interest against disclosure pursuant to section 14(2) of the *Government Information (Public Access) Act 2009 (NSW)* (the “Act”). The Report is exempt from disclosure under the Act on the grounds that it contains information associated with the storage of security sensitive petroleum finished product and information that is commercial-in-confidence.

The information which is exempt from disclosure applies specifically to the following parts of the Report:

- The full version of **Table 3-1** and **Figure 5-4**;
- Appendix C Summary of Emission Source Parameters; and
- Appendix D Sample Ausplume List File.

These parts of the Report have been excluded as they must not be copied or distributed outside DP&I or EPA without the express permission of Caltex.

Abbreviations

Abbreviation	Description
AQIA	Air Quality Impact Assessment
API	American Petroleum Institute
ATSDR	Agency for Toxic Substances and Disease Registry (US)
AWS	Automatic Weather Station
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CBD	Central Business District
CLORE	Caltex Lubricating Oil Refinery
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EFRT	External Floating Roof Tank
EIP	Environmental Improvement Plan
EIS	Environmental Impact Statement
EMS	Environmental Management System
EPA	New South Wales Environment Protection Authority
EPL	Environment Protection Licence
EPHC	Environment Protection Heritage Council
IFH	Isolation Flux Hood
IFRT	Internal Floating Roof Tank
JUHI	Joint User Hydrant Installation
kg	kilogram
LBL	Load-Based Licencing
LGA	Local Government Area
AGD	Australian Geodetic Datum
MGA	Map Grid of Australia
NEPM	National Environment Protection Measure
NO _x	Oxides of Nitrogen
NPI	National Pollutant Inventory
OEHS	New South Wales Office of Environment and Heritage
OMC	Oil Movements Centre
ORP	Odour Reduction Program
PAH	Polycyclic Aromatic Hydrocarbon
POEO	Protection of the Environment Operations (Act)
PULP	Premium Unleaded Petrol
PRP	Pollution Reduction Program
RPIP	Refining Performance Improvement Program
SPULP	Super Premium Unleaded Petrol
SVOC	Semi-Volatile Organic Compound
t	tonne
T&I	Turnaround and Inspection
TPH	Total Petroleum Hydrocarbon
ULP	Unleaded Petrol
US EPA	United States Environment Protection Authority
VFRT	Vertical Fixed Roof Tank
VOC	Volatile Organic Compound
VOL	Volatile Organic Liquid
WWTP	Wastewater Treatment Plant

Executive Summary

URS Australia Pty Ltd (URS) was commissioned by Caltex Refineries (NSW) Ltd (Caltex) to undertake an Air Quality Impact Assessment (AQIA) for the proposed conversion of the existing Kurnell Refinery (the Site) into a finished product terminal (the Project).

The Project would involve the ongoing use of parts of the Site for the storage and distribution of petroleum products, whilst refining operations at the Site would be discontinued. The Project would also include modifications to some tankage, pumps, piping and instrumentation, as well as minor modifications to site ancillaries. Under terminal configuration, the Site would continue to import gasoline products, diesel, fuel oil and jet fuel from the existing Kurnell Wharf. These products would be stored on the Site, and transferred via the existing subsea pipelines to either the Caltex Banksmeadow distribution terminal, or (in the case of jet fuel), the Sydney Airport joint user hydrant installation. Fuel oil may also be used to refuel ships at the Kurnell Wharf.

The AQIA was performed in general¹ accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (DEC, 2005), using the Ausplume dispersion model in accordance with a site-specific meteorological dataset prepared with the incorporation of on-site meteorological monitoring data.

URS conducted a review of proposed conversion works, noting that the proposed activities were of minor scale and progressive in nature, and most appropriately managed through the implementation of an Air Quality Management Plan (AQMP) for the conversion works.

A review of terminal configuration was also undertaken, and a range of Volatile Organic Compound (VOC) emission sources were identified, of which storage tanks were noted to be of the greatest significance. URS were provided with estimates of fugitive VOC emissions from the storage tanks in accordance with the proposed site layout and forecasted product volume throughputs. Emissions were estimated for benzene, toluene, ethylbenzene, xylenes, and n-hexane. URS utilised pre-existing National Pollutant Inventory emission estimates of emissions for other sources on the Site, which included fugitive emissions from plant items such as pumps and valves, and a land farm that is used to treat oily sludge that arises from operations on the Site.

A review in the change of the emissions profile for the Site noted a large reduction in the quantity of combustion pollutants emitted, as governed by the retirement of refinery combustion sources. It was also noted that a significant reduction in sulphur emissions was expected due to the retirement of the refinery sources, and that Total VOC emissions would be reduced to around one half of 2010/2011 levels, primarily due to removal of crude oil and intermediate refinery products.

Dispersion modelling was performed using the NSW Office of Environment and Heritage (OEH) approved Ausplume dispersion model. Model results were compared against impact assessment criteria provided in DEC, 2005. With the exception of benzene, the predicted concentrations of all compounds were predicted to be less than 10% of relevant OEH impact assessment criteria. Modelling predictions estimated a 99.9th percentile 1 hour average benzene concentration of 13.5 µg/m³ which was found to be slightly less than half of the OEH impact assessment criterion of 29 µg/m³. Modelling was also performed for annual averages, and compared to criteria for benzene, toluene and xylenes, as provided in the National Environment Protection (Air Toxics) Measure. Given the limitations in addressing short-term fluctuations in tank emissions, and the importance of assessing chronic exposures to compounds such as benzene, these results were considered to be of

¹This is with the exception of reporting standards as provided in the Approved Methods, where in the case of this AQIA, information has been excluded in accordance with the "Notes on Text".

Executive Summary

key interest. Predicted incremental impacts, when added to adopted background concentrations, were found to be within the adopted air toxics criteria, with emissions from the Site making a minor contribution to predicted cumulative concentrations.

It was also noted that the Site has a history of odour complaints, and changes (especially to the refinery component of the Site) would result in a significant reduction in the emission of odorous sulphur and VOC type compounds. Given the change in emissions profile, the odour sensitivity of nearby receptors may also be modified. Whilst a significant reduction in odour emissions is expected, it is not anticipated that odour issues would be completely eliminated as a result of the Project. Hence a summary of air quality management measures was prepared, detailing measures proposed as part of both the conversion works, and operational phases of the Project. These management measures covered mitigation measures for construction activities, odour reduction programs and VOC emissions from fuel storage.

On the basis of the information reviewed, and the analysis undertaken, the potential for the Project to result in adverse air quality impacts is considered to be low, and manageable, with the ongoing implementation of appropriate mitigation strategies. It is also noted that the overall reduction in emissions of VOCs and combustion pollutants would be a beneficial outcome of the Project.

Introduction

1.1 General

URS Australia Pty Ltd (URS) has been commissioned by Caltex Refineries (NSW) Ltd (Caltex) to undertake an Air Quality Impact Assessment (AQIA) for the proposed conversion of the existing Kurnell Refinery (the Site) into a finished product terminal (the Project).

The Project involves the ongoing use of parts of Site for the storage and distribution of petroleum products, whilst refining operations would be discontinued. The Project would also include modifications to some tankage, pumps, piping and instrumentation, as well as minor modifications to site ancillaries. A detailed project description can be found in **Chapter 2** within this AQIA. No demolition or remediation works would be undertaken on the Site as part of this Project. Such work would be subject to separate approvals at a later stage.

The Project is registered with the New South Wales Department of Planning and Infrastructure as a State Significant Development (Ref: SSD-5544) requiring an Environmental Impact Statement (EIS) to be completed and exhibited prior to determination of the project approval. This AQIA has been prepared as part of the EIS for the Project.

1.2 Assessment Scope

The Director General's environmental assessment requirements for the Project contain requirements for air quality and odour. These requirements request that:

The EIS must address... ..Air Quality and Odour – including:

- A quantitative assessment of the air quality and odour impacts of the development on surrounding receivers, including impacts from construction, operation and road transportation; and
- Details of the proposed management and monitoring measures.

In order to address these requirements and facilitate the consideration of the Project in the context of air quality issues, the AQIA has incorporated the following elements:

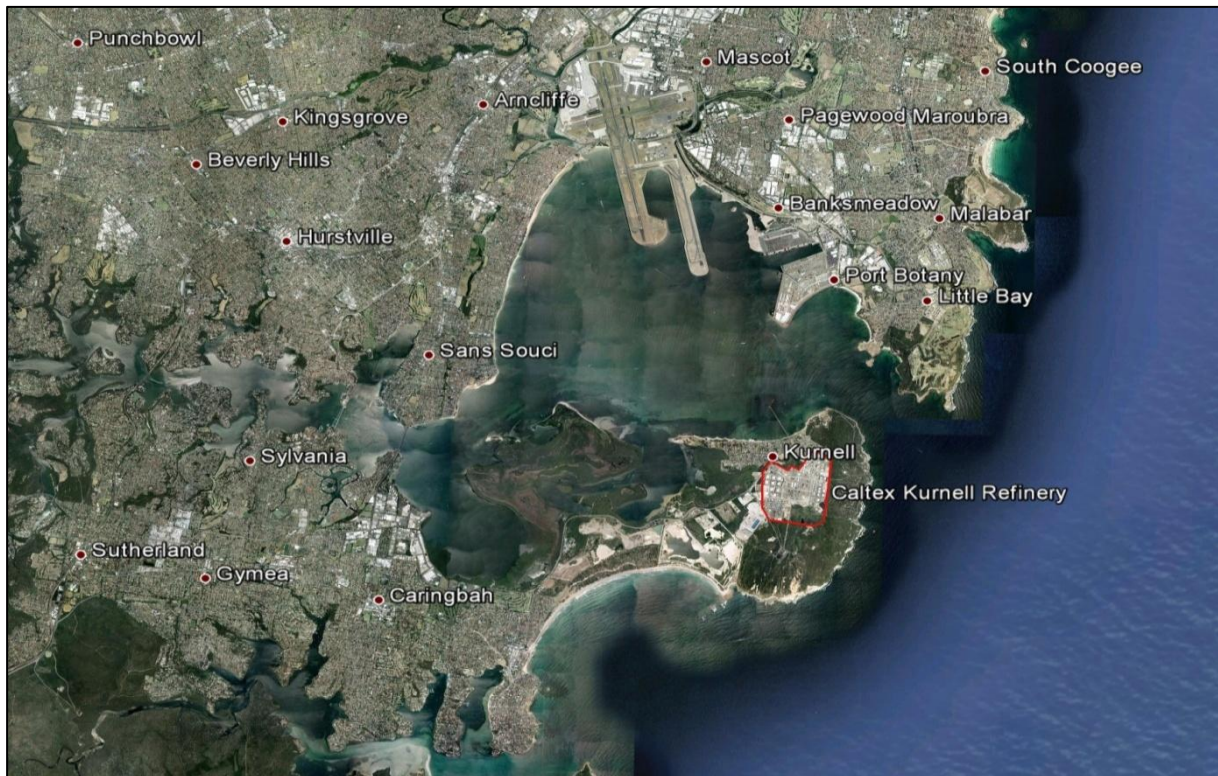
- A review of activities proposed as part of conversion works and terminal operation;
- Identification of key pollutants and emission sources associated with identified activities;
- A review of the regulatory framework for air emissions including impact assessment criteria;
- Preparation of an emissions inventory for the operational phase of the Project;
- Atmospheric dispersion modelling of emissions from the operational phase of the Project;
- Comparison of model predictions against impact assessment criteria; and
- Proposed mitigation and monitoring measures relative to the Project.

1 Introduction

1.3 Project Location

The Project is located at the existing Caltex Kurnell Refinery (the Site²) on the Kurnell Peninsula within Sutherland Shire Local Government Area (LGA), approximately 15 km south of Sydney's CBD. **Figure 1-1** provides an aerial view of the Kurnell Peninsula, showing the Site location relative to the surrounding areas of Sydney.

Figure 1-1 Aerial view of Kurnell Peninsula showing the Site



Site Boundary ———
(Image sourced from Google Earth Pro)

The Site is at present the largest oil refinery in NSW and the second largest of the seven oil refineries in Australia, based on crude oil processing capacity. The refinery currently produces petrol, diesel, and jet fuel, alongside smaller amounts of other petroleum products. The volumes of the different products vary from year to year depending on the type of crude processed in the refinery and changes in product demand.

The Site also currently acts as a terminal, receiving, storing and distributing finished petroleum products that have been refined both at the Site and elsewhere. Under current operations, the facility receives both pre-processed refined product and crude oil.

In addition to the refining and distribution of transport fuels, the Site has historically produced lubricating oils at the now decommissioned Caltex Lubricating Oil Refinery (CLOR) which was located in the south western part of the Site.

² For the purposes of this AQIA, the Site has been defined as Caltex-owned land encompassing the refinery site, and has not included Caltex-owned land outside of the refinery boundary (e.g. areas associated with pipeline right of way areas between the Site and the Kurnell wharf).

Site Operations

2.1 Project Overview

Caltex is seeking development approval for the progressive transition of the existing refinery to a finished product terminal. The conversion would involve the continued use of parts of the Site for the storage and distribution of petroleum products. The majority of terminal operation would take place using existing infrastructure, however the following modifications are proposed as part of the Project:

- A number of existing crude oil tanks would be modified to allow for the storage of refined product;
- A small number of tanks would be converted to store different products; and
- Several new pumps and electrical infrastructure would be installed.

A range of ancillary works would also be undertaken to improve efficiency and to facilitate the conversion of the refinery into a terminal, including upgrades and consolidation of the utilities, transportation and management systems on the Site.

In addition, the refinery plant would be shut down, depressurised, de-inventoried, and left in situ. This process is routine and already completed as part of the existing maintenance program for the Site in line with the EPL, therefore does not form part of the Project.

2.2 Products Handled

The proposed terminal would import, store and distribute the following products:

- Gasoline products including:
 - Unleaded Petrol (ULP);
 - Premium Unleaded Petrol (PULP); and
 - Super Premium Unleaded Petrol (SPULP).
- Diesel;
- Jet fuel; and
- Fuel oil.

The terminal would also manage the following by-products:

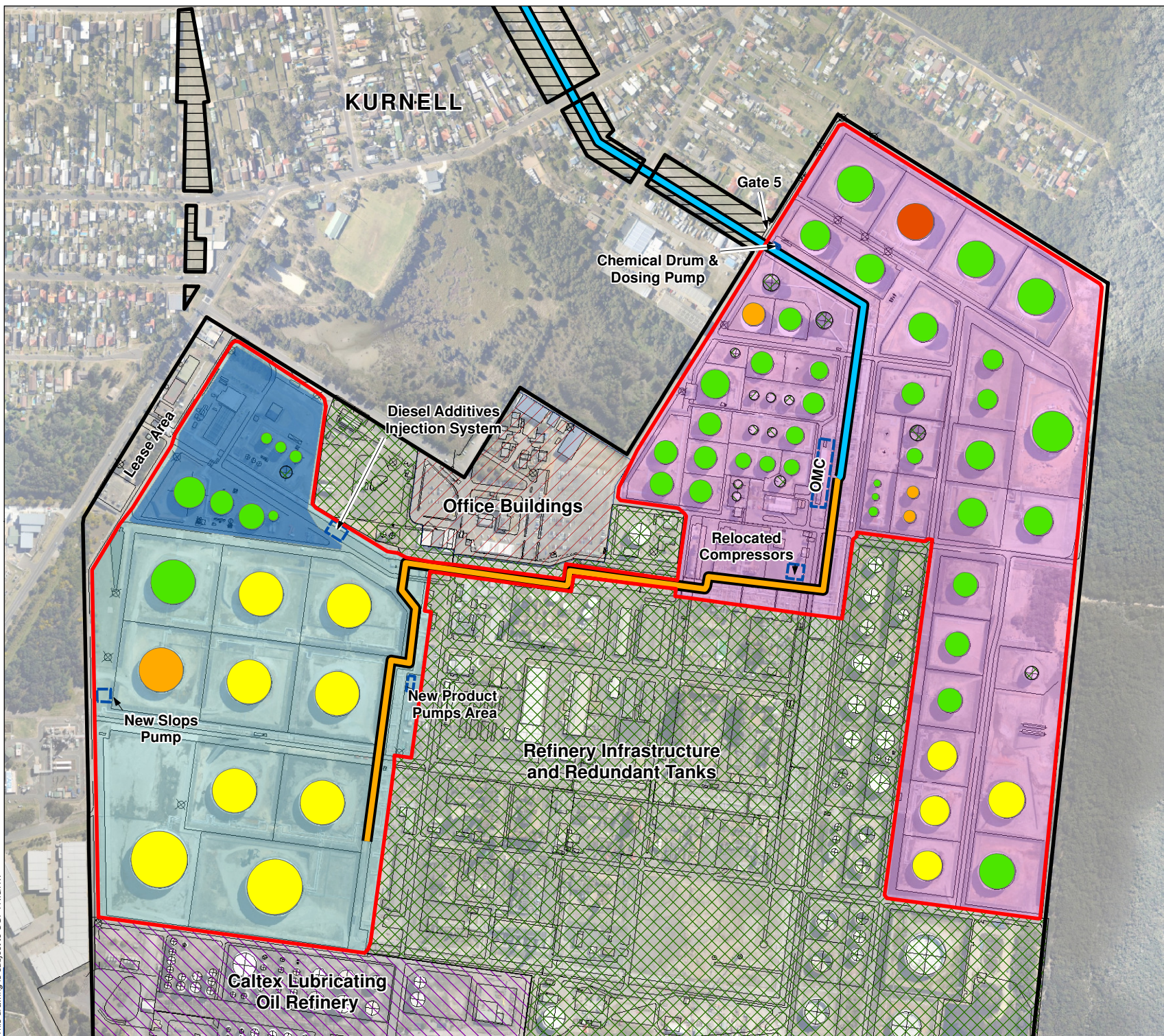
- Slop oil³; and
- Wastewater.

2.3 Terminal Configuration

Given the proposed closure of the refinery, and the previous closure of CLOR operations, activities associated with the Project are confined to the northern portion of the Site. For this reason, an area within the Site has been designated as the “Project Area”. **Figure 2-1** provides the proposed Site layout under terminal configuration, showing the Project Area, the Eastern and Western Tank areas, pipeline easements, and Wastewater Treatment Plant (WWTP). Within the figure, proposed tank conversions are also identified, along with the proposed location of pump and compressor installations.

³ Slop or slop oil is a petrochemical industry term for recovered petroleum hydrocarbons in a refinery or terminal, which requires further processing to make it suitable for sale and use.

This drawing is subject to COPYRIGHT.



Legend

- The Site and Right of Way Areas
- Project Area
- New Infrastructure

Pipeline

- Pipeline Easement 1
- Pipeline Easement 2

Tank Conversion

- Conversion Required
- No Works Required
- Change of Service
- Restore in Kind

Tank Areas

- Eastern Tanks Area
- Western Tanks Area
- Office Buildings
- Refinery Infrastructure and Redundant Tanks
- Caltex Lubricating Oil Refinery (CLOR)
- Pipeline Right of Way
- Waste Water Treatment Plant (WWTP)

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

0 50 100 200 Meters

Source: Aerial Imagery - Nearmap Hypertiles 2012

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NSW PTY LTD

KURNELL REFINERY
CONVERSION

**SITE LAYOUT AND
PROPOSED WORKS**

URS

Figure: **2-1**
Rev. A A4

2 Site Operations

Under terminal configuration, gasoline products would be distributed from the Kurnell Wharf to sixteen existing tanks within the Eastern Tank Area via two existing dedicated pipelines. Twelve of these tanks are currently in gasoline or similar service. Four tanks would be converted to gasoline service.

Diesel would be distributed from the Kurnell Wharf to twelve existing tanks within the Eastern Tank Area via two existing dedicated pipelines. These tanks are currently used to store diesel, with the exception of one tank which is currently used to store fuel oil. In addition, the two existing diesel pipelines would be extended from the Oil Movements Centre (OMC) to supply four large tanks within the Western Tank Area, which would be converted from crude oil to diesel service. These pipelines would be installed along pipe racks in line with the existing pipework on the Site. The existing diesel additives injection system at the OMC manifold would be duplicated at a new location within the Western Tank Area (refer to **Figure 2-1**). This system would be used to dose diesel as it is received into the terminal from the wharf to ensure that the finished product meets the required specification.

Jet fuel would be distributed from the Kurnell Wharf to six existing tanks within the Eastern Tank Area via two existing dedicated pipelines. The two existing jet fuel pipelines would be extended from the OMC to supply four large tanks within the Western Tank Area which would be converted from crude oil to jet fuel service. These pipelines would be installed along pipe racks in line with the existing pipework on the Site. A small chemical drum and dosing pump would be installed at Gate 5 (refer to **Figure 2-1**). This system would be attached to the jet fuel pipeline and used for dosing a static dissipater into the jet fuel as it is received into the Site from the wharf.

Fuel oil would be distributed from the Kurnell Wharf to four existing tanks within the Eastern Tank Area via two existing dedicated pipelines. No proposed conversion works would be associated with these tanks as they are already used for fuel oil storage.

An existing pipeline within Pipeline Easement 1 would be changed from its current usage to transfer slop oil. This would involve flushing the existing pipeline. No intrusive works would occur within Pipeline Easement 1. Slop oil produced from normal terminal transfers would be stored within five existing tanks within the Eastern Tank Area. Two of these tanks require minor piping and tank nozzle modifications to change their service. It is proposed that a tank within the Western Tank Area would be changed from crude oil into slop service. No changes are required to this tank to facilitate this change of service. The existing pipelines that connect this tank to the existing slop tanks would be replaced in kind.

The existing oily water management system at the Site collects process effluent and stormwater from areas of the Site where there is potential for interaction of water flows with petroleum products. Oily water from a range of sources is collected in the Site's oily water sewer system and is transferred to the Wastewater Treatment Plant (WWTP) (refer to **Figure 2-1**).

Oily water is treated within the WWTP using a combination of physical, chemical and biological treatment processes. Treated effluent is subsequently discharged to the Tasman Sea via the Yena Gap outfall under conditions of the Environment Protection Licence (EPL) for the Site. The WWTP would remain in service as part of the Project.

2 Site Operations

2.4 Conversion Works

2.4.1 Tank Modifications and Refurbishment

The existing Site has over 100 tanks used for storing crude oil, refined or finished product, other petroleum intermediate products and effluent water. Some of these tanks would remain in current service, some would change service with no modifications required, some would be modified to contain finished product when the refinery is converted to a terminal and others would not be required.

Tanks that do not require modification in order to change service would have the tank levels drawn down to minimum and, in cases where product specifications would not be compromised, the new product would be added to the tanks. In cases where product specifications could be compromised, the tank would be safely emptied using a vacuum truck. The removed material would be relocated to an appropriate product tank and the tank would be filled with new material.

For tanks which require modification in order to change service or have reached their statutory Turnaround and Inspection (T&I) date, the works may involve some or all the following activities:

- Shutdown of the tanks and associated infrastructure;
- Removal of the existing product from the tanks;
- Drainage of excess product from the pipes connecting to the tanks;
- Isolation and making safe any infrastructure and instrumentation that is no longer required;
- Upgrades to control systems to improve efficiency; and
- Modifications to tanks including upgrades to the tank internals, roofs, nozzles, floors, manifolds and finished product distribution pipework where required.

Other works associated with the tank modifications (where required) include:

- Installation of additional product quality controls; and
- Upgrades to safeguard systems.

The specific works required for those tanks that would be converted to contain gasoline, diesel and jet fuel are outlined below.

Gasoline Tanks

The changes required for the conversion of heavy oil tanks to gasoline tanks involve the following works:

- The water draw-off system for the tank would be evaluated and where required replaced;
- Installation of an internal floating roof (with air scoops, hinged covers and stainless mesh screens) and an external cone roof where required;
- Internal painting would be undertaken for entire floor and shell up to the first strake⁴, unless additional protection is required. The external side of the tank would be painted as required;
- Vent systems would be designed and installed on the gasoline tanks in line with American Petroleum Institute (API) standards API 2000, API 1650 and API 1653;
- Fire systems would be modified to meet fire foam and water volume requirements as required;
- Sleeves would be installed on slotted guide poles on all converted EFRTs; and

⁴ A "strake" is a section of the cylindrical shell of the tank/vessel which is formed by rolling a piece of steel and joining at the seam.

2 Site Operations

- New power and signal cables, cable ladders, switchgear, instrumentation and electrical motors would be installed where required.

No new mixers would be installed in these tanks. Mixers would be made fit for service which could require modification or replacement.

Diesel Tanks

The changes required for the conversion of crude oil tanks to diesel tanks involve the following works:

- The water draw-off system for the tank would be evaluated and replaced as required;
- The tank floor would be evaluated and repaired or replaced as required;
- Vent systems would be installed on the diesel tanks;
- Internal painting would be undertaken for the entire floor up to 600 mm. The external side of the tank would be painted as required;
- New power and signal cables, cable ladders, switchgear, instrumentation and electrical motors would be installed where required; and

No new mixers would be installed in these tanks. The existing mixers would be retained. The roofs of all the tanks would remain as external floating roofs.

Jet Fuel Tanks

The conversion of crude oil tanks to jet fuel tanks would involve the following:

- The tank floor would be replaced with a cone down floor;
- A system would be installed to remove free water from the jet fuel;
- The tanks would be fully painted internally to minimise the possibility of product contaminations due to shell/floor corrosion;
- New power and signal cables, cable ladders, switchgear, instrumentation and electrical motors would be installed as required; and
- Fire systems would be modified to meet foam and water volume requirements as required.

No new mixers would be installed in these tanks. The existing mixers would be retained. The fixed roofs would be retained on all of the tanks.

Summary of Tank Conversions

The tank conversion works described above would commence in advance of recommissioning the tanks to receive imported finished product. These works would be conducted throughout the construction phase. At the end of the conversion works there would be a reduction in the total number of tanks required for the storage of finished product imports and terminal operations when compared to the number currently required for refinery operations. The tanks that are not required for terminal operations are shown on **Figure 2-1**. These tanks would be isolated, emptied cleaned and left with all manhole covers removed. This process already occurs as part of the T&I program on a continuous rotating basis as part of the maintenance program for the Site. The dismantling and remediation of the redundant tanks would be subject to a separate approval process.

2 Site Operations

Table 2-1 provides a summary of the final tankage use within the Project Area.

Table 2-1 Tank conversion numbers

Proposed Service	Conversion and Change of Service*	Change of Service Only
Gasoline	5	-
Diesel	4	1
Jet Fuel	4	-
Fuel Oil	0	-
Waste Water and Slop Oil	0	3
Total	13	4

Note: *One tank in the Eastern Tank Area would be restored in kind.

Where it has been identified that either a change of service or no works are required for a tank, a Turnaround and Inspection (T&I) would be carried out for remaining tanks at a date which complies with statutory requirements for that tank, as per normal operating procedures at the Site.

A T&I event involves the following high level activities:

- Removing the tank from service and removing the stored product;
- Cleaning the tank to allow internal inspection of the tank walls, floor and roof;
- Preparing a scope of works based on the results of the inspection;
- Undertaking repair works as required which may include tank repair, painting or further testing; and
- Returning the tank to service with the proposed finished product.

2.4.2 Pump Installation

Five new product transfer pumps would be installed in the Western Tank Area. These pumps would service the newly converted large diesel and jet fuel product tanks (refer to **Figure 2-1**). The product transfer pumps would consist of three jet fuel product pumps and two diesel pumps. They would be located on the eastern side of the Western Tank Area (refer to **Figure 2-1**).

One new product transfer pump would be located within the Western Tank Area to transfer slop oil. This pump would be located on the western side of the Western Tank Area in a shed (refer to **Figure 2-1**). Two new product transfer pumps would be installed at the OMC to transfer slop oil and jet fuel across the Site. For each set of pumps new concrete foundations would be installed.

2.4.3 Site Utilities

The existing air, potable water, firewater, natural gas and nitrogen utilities would remain in place on the Site. Demand for these utilities would significantly decrease as a result of the Project. Some minor relocation and consolidation of utilities equipment would be required. These relocation works would include moving certain compressors and pipework within the Project Area (refer to **Figure 2-1**).

2.5 Conversion Works Programme

Following Project approval, construction works are proposed to begin in Q3 2013 and progress over approximately 3 years. During the construction phase, the Site would still operate as both a refinery and a terminal. Cessation of refinery operations is planned to occur in the second half of 2014. This would be followed by continued conversion of some tanks and associated piping within the Project Area to hold finished products.

2 Site Operations

A high-level schedule for conversion activities is shown in **Table 2-2** below.

Table 2-2 Proposed construction schedule

Task	Date
Detailed Engineering & Design Start	Mid 2012
Engineering & Design Completed	Q2 2013
Tank Conversions Start	Second half 2013
Installation of Piping, Pumps and Associated Infrastructure	Second half 2013
Construction on Piping Completed	Q2 2014
Kurnell Refinery Shutdown	Second half 2014
Continued Tank Conversions	End 2014 – end 2016
CONVERSION TO TERMINAL COMPLETED	December 2016

2.6 Terminal Operation

Once the conversion is complete, Caltex would continue to import finished products (gasoline, jet fuel, diesel and fuel oil) through the two fixed berths at the existing wharf and the additional sub-berth located in Botany Bay. This product would be stored in existing and converted tanks.

The upgrade to the Port and Berthing Facility (State Significant Development SSD-5353) would improve flexibility in the size of the ships able to berth at the Kurnell Wharf. This flexibility would see a reduction in ships arriving at the facility by approximately 40% in 2020 (compared to 2011 figures). This reduction is anticipated to occur progressively over the life of the Project.

The major product distribution systems would continue to operate in line with current practice, i.e. product would be pumped under Botany Bay to the Banksmeadow Terminal, the Sydney/Newcastle pipeline or the Joint User Hydrant Installation (JUHI) at Sydney Airport for further distribution. Road transport of products during routine operations would cease. However, in exceptional circumstances some road transport of product may be required. This assessment has not included a consideration of road transport.

Ongoing operational activities would be undertaken on the Site. As described in **Section 2.4.1**, these activities would include Tank T&Is and various other maintenance activities.

Emissions to Air

3.1 Conversion Works

The conversion works detailed in **Section 2.4** were reviewed in the context of potential emissions to air, and the following potentially emissive activities were identified:

- Volatile Organic Compound (VOC) emissions from the draining and cleaning of tanks;
- Particulate emissions from metal fabrication: cutting, grinding and welding during tank and piping modifications;
- Combustion emissions from portable plant items (e.g. generators and compressors);
- VOC emissions from painting of tanks and piping; and
- Particulate/VOC emissions from excavations, concrete cutting and concreting (as required for the installation of items such as pump foundations).

The refinery plant would be shut down, depressurised, de-inventoried and left *in situ* in a staged manner. The shut down and depressurisation of the refinery plant is a process that currently occurs on a routine basis as part of the T&I program for the refinery plant. Caltex has extensive documented procedures which are used routinely during T&I activities. These procedures enable air emissions from this process to be monitored and managed in compliance with the EPL. Therefore any air emissions would be managed under the relevant EPL and do not require assessment as part of this Project.

Given the minor scale and progressive nature of the conversion activities, the potential for these operations to adversely impact air quality is considered small, and most appropriately managed through the implementation of an Air Quality Management Plan (AQMP) as incorporated into the Construction Environmental Management Plan (CEMP) for the Project. Hence a quantitative assessment of these activities has not been undertaken, rather mitigation measures suitable for incorporation into the AQMP/CEMP have been provided in **Section 7**.

3.2 Terminal Operation

In the absence of combustion processes at the Site, emission sources are primarily limited to those that arise through fugitive volatilisation of hydrocarbon materials as they are imported to, stored and exported from the Site. Based on the project description detailed in **Section 2**, the following potential emission sources were identified:

- Storage tanks;
- Product transfer infrastructure;
- Land farm;
- Waste water treatment plant; and
- Shipping.

A brief description of each of these emission sources is provided in the following sections.

3.2.1 Storage tanks

The refinery has over 100 tanks used for storing crude oil, refined or finished product, other petroleum intermediate products and effluent water. Approximately half of these tanks would be utilised in the terminal operation. Of the tanks remaining in service, some of them would remain in their current service, some would change service with no modifications required, and some would be modified to contain finished product when the refinery is converted to a terminal. These tanks (as shown in **Figure 2-1**) are of varied construction, and include the following types:

3 Emissions to Air

- External Floating Roof Tank (EFRT);
- Internal Floating Roof Tank (IFRT); and
- Vertical Fixed Roof Tank (VFRT).

Approximately 40 % of the tanks would be EFRTs, 40 % VFRTs and 20 % IFRTs. Due to variations in construction, the way in which VOC emissions (losses) occur varies by tank type. In general, such losses include:

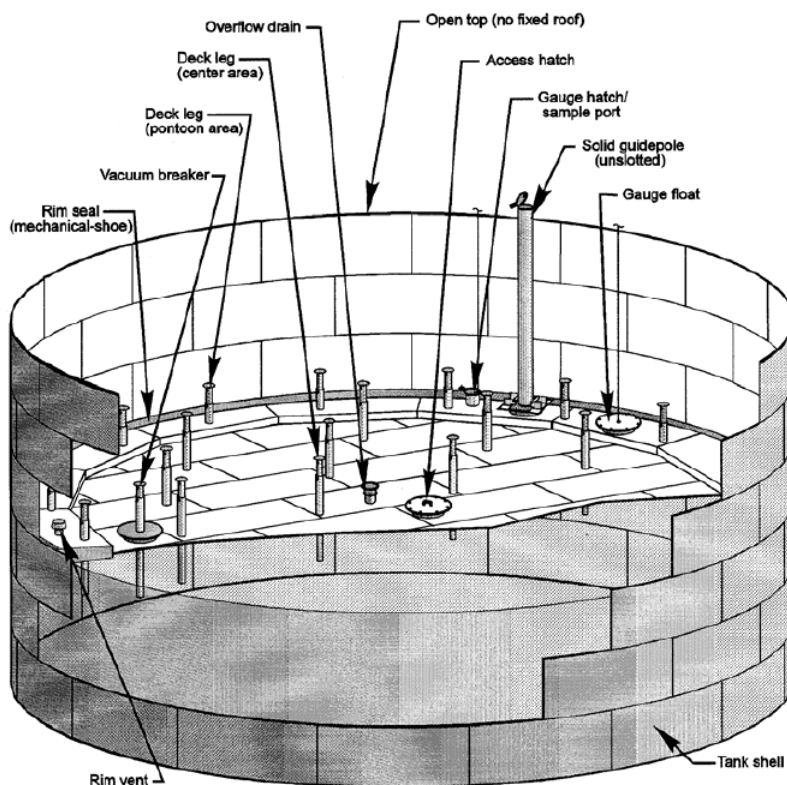
- **Standing losses:** those which occur through volatilisation of material when the tank is idle;
- **Breathing losses:** those which occur through displacement of vapour-laden air from the tank, either through changes in temperature, atmospheric pressure, or filling of the tank; and
- **Withdrawal losses:** those that occur when material is withdrawn from the tank through evaporation of material on the tank shell (clingage).

An overview of construction, fittings and loss modes is provided in the following sections.

EFRT Construction

EFRTs consist of an open-topped cylindrical shell containing a separate floating roof (or deck) that floats directly on the surface of the liquid being stored as shown in **Figure 3-1**. The roof typically contains a range of fittings, and a rim seal that seals the space between the roof and roof shell. Guidepoles are fitted to limit horizontal translation or rotation of the roof and prevent damage to tank fittings, whilst vacuum breakers are used to prevent a build-up of vacuum (and associated roof damage) in the event that the tank is drained to a point in which the roof comes to rest on the internal deck leg supports. Drains and access hatches are also fitted.

Figure 3-1 EFRT construction and fittings



3 Emissions to Air

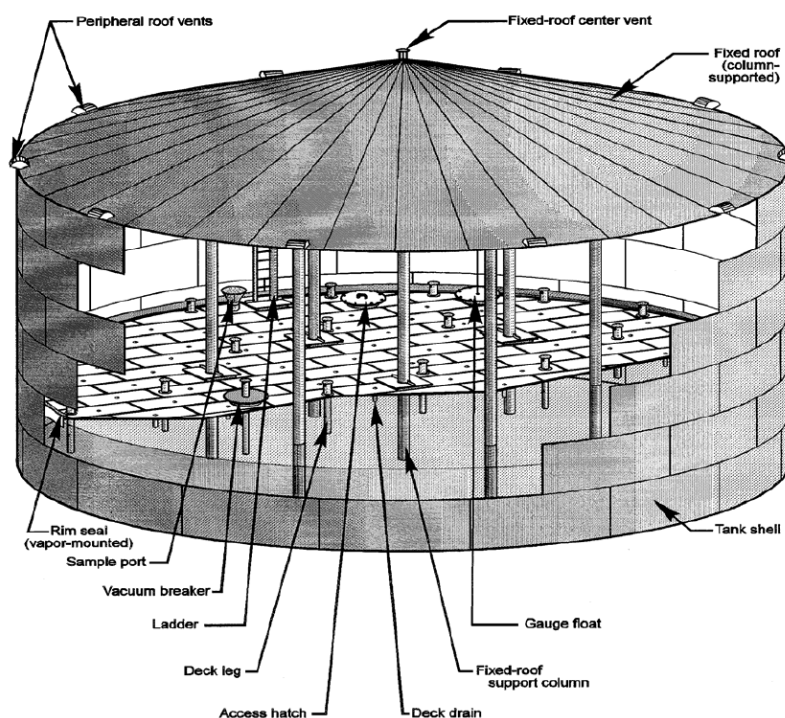
Source: USEPA (2006)

This tank construction reduces the potential standing losses through minimisation of the surface area available for volatilisation; however losses still occur with movement of the roof (i.e. withdrawal losses resulting from evaporation of liquid from the internal surface of the tank shell upon the removal of liquid from the tank), and standing losses through the rim seal and deck fittings. In addition, the action of wind over the open tank top contributes to rim seal losses.

IFRT Construction

IFRTs are similar to EFRTs with the key exception that a fixed roof encloses the outer shell. **Figure 3-2** shows typical IFRT construction, and a range of commonly used fittings.

Figure 3-2 IFRT construction and fittings



Source: USEPA (2006)

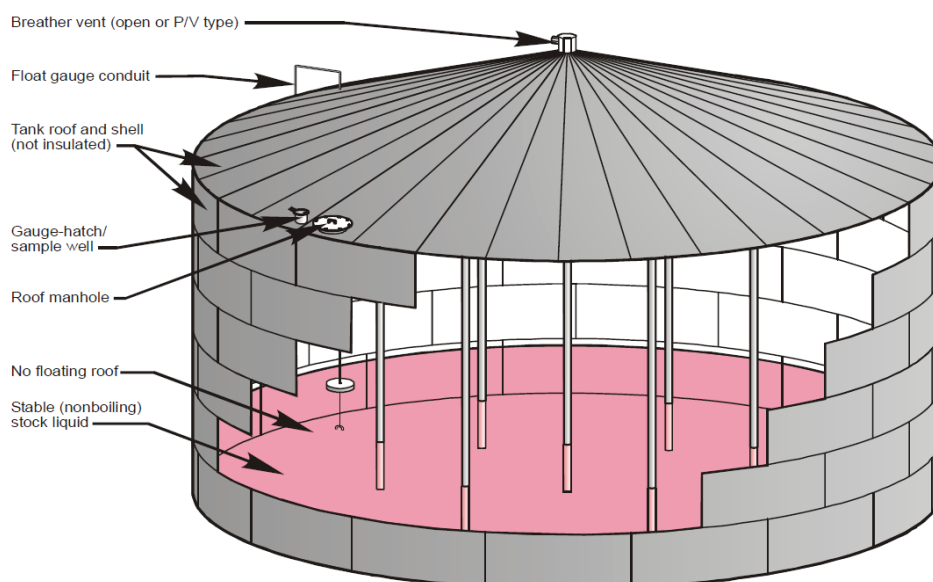
The roof does not act as a vapour barrier, rather it prevents the wind-induced diffusion (and associated rim seal losses) from occurring. Otherwise, loss modes are similar to those for EFRTs, with the addition of those from roof support columns. These losses are considered small in comparison to the benefits associated with the reduction in rim seal losses achieved with the use of a roof (USEPA, 2006).

VFRT Construction

VFRTs consist of a cylindrical shell to which a fixed roof is fitted as shown in **Figure 3-3**. Typical fittings include breather vents, float gauges and access hatches.

3 Emissions to Air

Figure 3-3 VFRT construction and fittings



Source: USEPA (2006)

VFRT losses occur primarily as breathing losses through displacement of vapour-laden air when the tank is filled, or through variations in temperature or atmospheric pressure.

3.2.2 Product Transfer Infrastructure

During terminal operation, fugitive emissions would occur from equipment that is used to move products around the Site. This includes fugitive losses from plant items such as pumps (seals), valve collars and pipe flanges.

3.2.3 Land Farm

Caltex operates a land farm that is used to treat sludges that are generated from operational activities on the Site. The land farm consists of a lined area of approximately 1.4 ha in size on which sludge material is placed. Dozers are used to turn the material on a near daily basis, and material is turned and stored in stockpiles within the land farm. As part of this process, VOCs are released from the land farm material to the atmosphere.

3.2.4 Wastewater Treatment Plant

Caltex operates a Wastewater Treatment Plant (WWTP) which is capable of treating approximately 15 ML/day using physical, chemical and biological processes to treat wastewater prior to ocean discharge.

WWTP emissions are estimated by Caltex for the purposes of National Pollutant Inventory (NPI) and Load-Based Licensing (LBL) reporting. Whilst specific information on the configuration and operation of the WWTP was not reviewed, emission estimates performed by Caltex indicate that VOC emissions from the WWTP are unlikely to be significant in the context of emissions from the Site⁵, hence these emissions have not been incorporated into the quantitative component of this assessment.

⁵ Caltex routinely estimate Total VOC losses based on WWTP biological oxygen demand. Typically, these VOCs are estimated to constitute approximately 0.01% of Total VOCs from storage tanks under terminal operation.

3 Emissions to Air

3.2.5 Shipping Activities

Shipping emissions occur from ship loading activities and emissions associated with the combustion of fuels whilst at berths. Loading emissions arise from the displacement of vapour from within a given tank as it is filled. Unloading emissions are considered negligible given that unloading is undertaken using a sealed system in accordance with the need to manage the atmosphere within the tank against the lower explosive limit. This is achieved through the use of a (ship-fitted) inert gas generator which provides an inert gas mixture to a given tank as it is unloaded.

It is noted that with the loss of refining capacity, shipping activities would be primarily limited to the importation of products. Caltex anticipates that ship loading may be required for ship refuelling (fuel oil), and non-routine redistribution of products that had previously been imported to the terminal by ship.

During the 2010-2011 NPI reporting year, approximately 915 ML of fuels were loaded into tankers at the Kurnell Wharf resulting in approximately 125 tonnes (t) of Total VOC emissions. These emissions were associated with the export of refinery intermediates and gasoline products, with a negligible contribution (< 0.01%) from fuel oil loading, due to its low volatility.

When the minor scale of potential emissions is considered in conjunction with the physical separation of the wharf from on-site sources and nearby receptors, potential cumulative impacts are considered negligible. On this basis, emissions from shipping activities have not been incorporated into the quantitative component of this assessment.

3.3 Key Pollutants

3.3.1 Volatile Organic Compounds (VOCs)

The fuels stored within the Site are composed of a range of mixtures of organic compounds, which include a range of VOCs that have potentially adverse impacts on human health and amenity. In the absence of combustion processes at the Site, emissions are primarily limited to those that arise through fugitive volatilisation of hydrocarbon materials as it is imported to, stored and exported from the Site, hence VOCs are considered of key relevance to this assessment⁶. URS conducted a review of *Toxicological Profile for Total Petroleum Hydrocarbons* (TPH) (ATSDR, 1999a) in which TPH represents the several hundred compounds present in crude oil and the various fuels and solvents which are derived from it. Within the document, a range of chemical compounds are identified as being of typical interest with regard to the consideration of VOC exposure from TPH.

⁶ A consideration of Semi-Volatile Organic Compounds (SVOCs) as Polycyclic Aromatic Hydrocarbons (PAHs) was performed, however release modes from sources at the Site were found to be non-conducive to emissions of PAHs (as B[a]P TEQ). Tank emission calculations were performed for SVOCs as PAHs (B[a]P TEQ) in accordance with the Potency Equivalency Factors [PEFs] provided in the *Approved Methods* in conjunction with product composition, and Total VOC emissions. Raoult's law was used to estimate B[a]P emissions as a fraction of total VOC emissions. As part of this calculation, all non-naphthalene PAHs were conservatively assumed to be present as 7,12 dimethylbenzanthracene (the PAH with the highest product of PEF and vapour pressure). These emissions were found to be in the order of ~1 g B[a]P/year which is considered negligible relative to levels associated with potentially adverse air quality impacts.

3 Emissions to Air

These compounds include:

- BTEX, consisting of:
 - Benzene;
 - Toluene;
 - Ethylbenzene;
 - Xylenes; and
- n-Hexane.

In addition, URS conducted a review of the Site's 2010-2011 tank emissions profile in the context of impact assessment criteria contained in *The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (the Approved Methods) (DEC, 2005). This review provided agreement with the compounds identified in ATSDR (1999a), hence they have been adopted as key pollutants, and indicative of the classes of pollutants emitted from the Site.

3.3.2 Odour

The fugitive volatilisation of hydrocarbon containing materials would result in the emission of odorous substances from the Site. Petroleum hydrocarbons possess a characteristic hydrocarbon odour typically associated with transport fuels.

In addition, sulphurous compounds such as mercaptans and hydrogen sulphide are odorous gases that are present in petroleum hydrocarbons in small quantities. Improvements in Australian fuel standards have resulted in a significant reduction in the amount of sulphur present in transport fuels, hence the potential for sulphur-based odorants to be present at significant levels is expected to be primarily limited to fuel oil which can contain higher concentrations of sulphur than fuels such as gasoline and diesel, which are regulated to contain less than 50 mg/kg and 10 mg/kg of sulphur (respectively).

3.4 Emission Estimation

This section provides an overview of the methodologies used for estimating emissions from the proposed terminal operation. These methodologies have remained consistent with methods used to date by Caltex for the reporting of emissions in accordance with NPI and NSW EPA Load-Based Licencing (LBL) reporting requirements.

3.4.1 Storage Tanks

Caltex have provided URS with estimates of storage tank emissions which were performed using the US EPA TANKS model. The TANKS model has been used to estimate fugitive losses from storage tanks at the Site on a tank by tank basis, and has used a wide range of site-specific information including the following:

- Tank design (EFRT, IFRT, VFRT), construction and finish;
- Product handled and volume throughput;
- Storage conditions (product temperature, and average product level);
- Tank geometry (height, diameter, volume);
- Tank fittings (e.g. access hatches, sample wells, vacuum breakers);
- Seal construction (e.g. mechanical shoe, liquid mounted); and
- Local meteorology (temperature, average wind speed, atmospheric pressure, solar insolation).

3 Emissions to Air

The TANKS emission estimates have been generated for VOC emissions from each tank based on Caltex forecasts of product throughputs. Emissions of key pollutants have subsequently been estimated from the Total VOC emissions using Raoult's law, where the emissions of a given substance (relative to Total VOCs) are proportional to the mole fraction of that substance in the stored liquid, and the vapour pressure of the (pure) substance relative to that of the mixture.

A review of the sensitivity of emission estimates showed a high level of sensitivity to benzene composition. Benzene contents of 0.03% and 0.01% for diesel and fuel oil (respectively) were adopted from (NPI, 2012), *National Pollutant Inventory Emission Estimation Technique Manual for Fuel and Organic Liquid Storage*, whilst other values were provided by Caltex, and were consistent with NPI (2012). This is with the exception of jet fuel, for which Caltex measured a benzene content of 0.02%, in contrast to the value of 0.37% provided in NPI (2012). It is expected that the NPI figure inadvertently represents a "wide-cut" jet kerosene specification, which would be representative of a gasoline blended fuel of "Jet B" classification, and hence is not relevant to the jet fuel handled by Caltex (jet kerosene as required to meet the Jet A-1 specification suitable for use on the JUHI installation). This understanding is consistent with ATSDR (1999) which also notes a benzene content generally less than 0.02% for jet kerosene.

Table 3-1 provides a summary of annual key pollutant emissions estimates for the storage tanks and estimated total VOCs across all storage tanks.

Table 3-1 Summary of terminal storage tank emission estimates

Source	Emissions (kg/year)					Total VOCs
	Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	
Tanks	2,968	6,426	603	2,928	6,450	452,608

3.4.2 Product Transfer Infrastructure

During the proposed terminal operation, fugitive emissions would occur from equipment that is used to move products around the Site. This includes fugitive losses from plant items such as pumps (seals), valve collars and pipe flanges. The quantity of infrastructure on the Site means that the estimation of such losses is a complex exercise. In order to simplify this estimate, the "Yardlines" Total VOC emission estimate from the 2010/2011 NPI reporting year has been used. Yardlines emissions reflect those that occur outside of dedicated plant areas (e.g. refinery or tank farm), which include pipeline easements, the Oil Movements Centre (OMC) and other areas of the Site where pumps and valves are located.

VOC speciation (e.g. Benzene/Total VOC wt%) of these emissions was calculated as a weighted average across all products at the Site, as a function of product composition and leak potential. For each product, the leak potential was defined as being proportional to both the annual volume throughput and the reciprocal of viscosity.

3 Emissions to Air

Yardlines emissions occur in a diffuse manner across the Site. In order to provide a simple and conservative means of incorporating these emissions into the assessment, it has been assumed that they originate entirely from the OMC. This simplification is considered appropriate given that the OMC is the location of the piping manifolds and approximately 30 pumps, and is likely to constitute a significant proportion of the total Yardlines emissions. The OMC is also located close to receptors of interest along the north-eastern boundary of the Site. **Table 3-2** provides a summary of the Yardlines emissions estimates.

Table 3-2 Estimate of Yardlines emission estimates

Source	Emissions (kg/year)					Total VOCs
	Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	
Yardlines	103	1,001	20	1,032	198	11,492

3.4.3 Land Farm

Land farm emissions have been estimated based on Source emission testing performed in 2005 using Isolation Flux Hoods (IFHs) by Coffey Geosciences P/L (Coffey, 2005). IFHs enclose the area of a surface to be sampled. A flow of high-purity nitrogen is ducted through the IFH at a known rate, during which time a sample of pollutant concentrations within the IFH is collected. This subsequently allows the calculation of pollutant emission rates per unit of surface area (e.g. mg/m²/second).

IFH sampling was conducted at three separate locations on the land farm. The estimates detailed in **Table 3-3** were performed assuming surface emission rates equal to the average across all samples, in conjunction with a land farm surface emission area of 1.4 ha.

Table 3-3 Summary of land farm surface emission estimates

Source	Emissions (kg/year)					Total VOCs
	Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	
Land Farm	3.5	1.6	5.3	41	113	4,369

3.4.4 Summary of Emissions

Table 3-4 provides a summary of emission estimates performed for the terminal operation. As can be seen in this table, storage tanks were estimated to be the primary emission source, constituting approximately 97% of annual Total VOC emissions from the Site.

Table 3-4 Summary of emission estimates

Source	Emissions (kg/year)					Total VOCs
	Benzene	Toluene	Ethylbenzene	Xylenes	n-Hexane	
Tanks	2,968	6,426	603	2,928	6,450	452,608
Yardlines	103	1,001	20	1,032	198	11,492
Land Farm	3.5	1.6	5.3	41	113	4,369
Total	3,074	7,429	628	4,002	6,760	468,469

3 Emissions to Air

3.5 Change in Emissions Profile

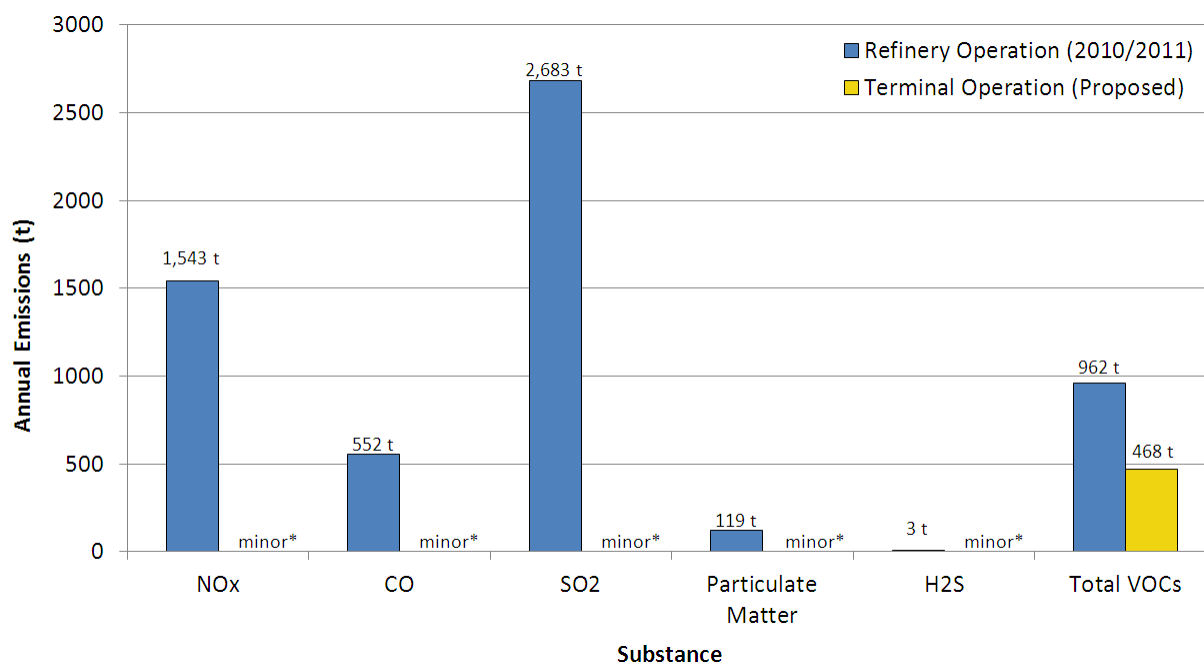
The closure of refining operations would result a significant change in the emissions profile for the facility. Of key significance is the retirement of stationary combustion sources on the Site and associated classes of pollutant emissions, which include oxides of nitrogen (NO_x), carbon monoxide, sulphur dioxide, hydrogen sulphide and particulate matter. **Table 3-5** and **Figure 3-4** show the change in emission profile relative to the 2010/2011 NPI reporting year (the base year). This reporting year is considered to be the most recent year in which the refinery (including CLOR) was operating at near to full capacity. It should be noted that shipping emissions are not shown in **Table 3-5** for either refinery or terminal operation estimates.

Table 3-5 Change in emissions profile associated with conversion of the Site

Pollutant	Site Emissions (t/annum)	
	Refinery Operation (Base Year)	Terminal Operation
Oxides of Nitrogen (NO _x)	1,543	Minor*
Carbon Monoxide	552	
Sulphur Dioxide	2,683	
Particulate Matter	119	
Hydrogen Sulphide	3	
Volatile Organic Compounds (VOCs)	962	468

Note: *Emissions have not been estimated, but would be primarily limited to those from vehicles and other mobile plant on the Site.

Figure 3-4 Change in emissions profile with conversion of the Site



3 Emissions to Air

Relative to refinery operation, total VOC emissions are anticipated to halve in quantity under the proposed terminal operations. These reductions are due to a range of changes proposed as part of the Project. Total VOC emissions from storage tanks were estimated at 705 t in the base year, as compared to 453 t under terminal operation. This is primarily associated with the removal of storage requirements for crude oil and intermediate products. In addition, the closure of the refinery process plant would result in a reduction of 142 t/year of VOCs against the base year. These emissions were from both point sources (86 t) and fugitive sources (55 t).

In addition, it is expected that with the retirement of refinery sources and associated plant, emissions of hydrogen sulphide (which possesses a potent rotten egg-like odour) would be significantly reduced. It is noted that these estimated reductions in emissions of VOCs and combustion pollutants would be a beneficial outcome of the Project.

Approach to Assessment

4.1 Assessment Criteria

There are three types of criteria relevant to air emissions associated with the Project. These are:

- **Air Impact Assessment Criteria** – ambient criteria designed for use in air dispersion modelling and air quality impact assessments for new or modified emission sources;
- **Ambient Air Quality Standards** – regional standards against which ambient air quality monitoring results may be assessed; and
- **Emission Standards** – which specify maximum allowable in-stack pollutant concentrations as specified for particular industrial activities and plant types.

A combination of Emission Standards and Air Impact Assessment Criteria are typically used to evaluate the expected impact of air emissions on local air quality and the effectiveness of plant design and associated emission controls. The wider objective of these criteria is to ensure that the resulting regional ambient air quality meets the relevant Ambient Air Quality Standards.

In addition, Ambient Air Quality Standards constitute an additional range of Criteria which can be used to provide additional context to modelling predictions.

4.1.1 Impact Assessment Criteria

In August 2005, the NSW Office of Environment and Heritage (OEH, formerly DEC) released the *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (the *Approved Methods*). This document provides impact assessment criteria for a range of air pollutants. These criteria are endorsed in New South Wales to be protective against unacceptable (nuisance) odour and health related impacts⁷. The impact assessment criteria relevant to the proposed emission sources are listed in **Table 4-1**.

Table 4-1 OEH impact assessment criteria

Substance	Averaging Period	Impact Assessment Criteria		Criterion Type
		($\mu\text{g}/\text{m}^3$)	(ppb)	
Benzene	1 hour	29	9	Toxic
Toluene	1 hour	360	90	Odorous
Ethylbenzene	1 hour	8,000	1,800	Toxic
Xylenes	1 hour	190	40	Odorous
n-Hexane	1 hour	3,200	900	Toxic

4.1.2 Ambient Air Quality Standards

The National Environment Protection (Air Toxics) Measure (NEPC, 2004) provides health investigation levels for a range of substances. These investigation levels represent numerical values that are

⁷In the *Approved Methods*, where a compound has both toxic and odorous properties, the lower criterion has been adopted, e.g. if a compound is shown to be odorous at levels below which it is established to be an unacceptable health risk, the endorsed criterion is based on odour. The application of these criteria to odorous mixtures is complex, and has not been defined in the quantitative assessment beyond the adoption of the criteria as provided in DEC (2005).

4 Approach to Assessment

protective of human health, and against which ambient monitoring data can be compared, for the purposes of establishing whether additional investigation is required.

Whilst not intended directly for use in impact assessment, nor applicable to the Project in a specific regulatory sense, the sources from which the criteria are developed are considered relevant and useful in the context of this assessment. Specifically, these criteria are available as long-term (annual) averages, and hence offer improved compatibility with the assessment of exposure to pollutants with chronic health effects (e.g. benzene).

It is noted that the 24 hour average NEPM (Air Toxics) criteria contained in NEPC (2004) have not been incorporated into this assessment, as it is understood that these criteria were adapted from short-term criteria in order to provide criteria that were compatible with the 24 hr monitoring duration required by the methods which were proposed as part of the NEPM (Air Toxics) Measure. Noting this, the 24 hour criteria essentially reflect short-term criteria, and are hence considered redundant in the context of the OEH (short-term) impact assessment criteria.

Given that the NEPM (Air Toxics) criteria are for comparison of ambient monitoring data, in the context of this assessment, an allowance for background levels must be made. NEPC (2010) contains a summary of monitoring conducted as part of the NEPM Air Toxics program, and includes two monitoring sites within Sydney at Rozelle and Turrella. Of these two stations, Turrella is the closer to Kurnell, being located on the opposite side of Botany Bay, approximately 12 km north-west of the Site. This area is densely populated, and located on heavy arterial traffic routes including the M5 motorway. Whilst monitoring data from this location is unlikely to be reflective of background air quality in Kurnell, its use is considered appropriate as a representation of background air quality.

Table 4-2 provides a summary of the long-term NEPM monitoring investigation levels and assumed background levels for substances considered in this assessment.

Table 4-2 NEPM monitoring investigation levels and assumed background levels

Substance	Averaging Period	Monitoring Investigation Level		Assumed Background Level	
		($\mu\text{g}/\text{m}^3$)*	(ppb)	($\mu\text{g}/\text{m}^3$)*	(ppb)
Benzene	Annual	9.6	3	1.2	0.38
Toluene	Annual	377	100	6.8	1.8
Xylenes	Annual	870	200	5.2	1.2

Note: *Converted from volumetric units at a temperature of 25°C and a pressure of 1 atmosphere.

4.1.3 Emission Standards

The *Protection of the Environment Operations (Clean Air) Regulation 2010* (NSW, 2010) sets regulatory emission limits for air impurities from stationary plant and equipment which apply throughout New South Wales under the *Protection of the Environment Operations Act 1997*.

Under refinery operation this regulation has historically applied to a wide range of point sources (stacks) at the Site, in the form of pollutant concentration limits not to be exceeded. It is noted that after the closure of the refinery plant, such point sources would not be operational on the Site. Rather emissions would be limited to those identified in **Section 3**, which are fugitive in nature.

4 Approach to Assessment

Hence post conversion, emission standards in NSW (2010) as relevant to the Project are limited to those contained in Part 6, Clause 63 of the document:

Control of Volatile Organic Liquids (VOLs) – Control Equipment for Large Storage Tanks.

This clause of the regulation includes a range of specific definitions, qualifications and exceptions, however a high-level review of the requirements is provided in the context of the Project below. For further detail, the regulation should be consulted directly.

Clause 63 applies to large storage tanks (i.e. >150 kL capacity) which are used to store VOLs, i.e. those liquids with a vapour pressure greater than 25.8 mm Hg (~3.4 kPa) at storage conditions. Of the liquids handled on the Site, at storage conditions gasoline products would be classified as VOLs, whilst fuel oil, jet fuel and diesel would not meet this classification.

In the case of control equipment for large storage tanks containing VOLs, the clause essentially requires that:

- for tanks which are not filled from other tanks situated on the premises, a drainage system comprising a small sump or tundish is fitted under each water draw-off valve and connected to a totally enclosed drain;
- tanks containing VOLs are of EFRT or IFRT construction, unless fitted with emission controls that treat or recover the vapour stream;
- floating roofs or covers must be constructed so as to prevent the escape of vapour so that:
 - vapour beneath the floating roof or cover is contained by skirt plates situated near the edges of the roof or cover and surrounding any openings in the roof or cover or by similar means; and
 - the roof or cover is equipped with one or more closure seals to close the spaces between the roof or cover and the tank walls and between any openings in the roof or cover and any equipment passing through those openings; and
 - seals on floating roofs are shielded from the weather; and
 - weather-shields are moveable to permit proper inspection of seals.
- the level of VOL in a large storage tank that is fitted with a floating roof or cover must be maintained (during normal operating conditions) at a depth sufficient to prevent the supports of the floating roof or cover from resting on the floor of the tank.

Under the proposed terminal operation, all gasoline tanks would be of either EFRT or IFRT construction, and designed to operate at levels such that landing of the tank roof (on the tank floor supports) is avoided. In addition, slop oil with potentially elevated vapour pressures (e.g. a gasoline derived slop) would be stored in slop tanks with appropriate emission controls, e.g. EFRTs. In addition, even though some of the tanks in service would be filled from other tanks on the Site, all these tanks would have a drainage system which is comprised of a small sump or tundish fitted under each water draw-off valve and connected to a totally enclosed drain.

4.2 Assessment of Odour

In recent times, odour has been a key issue of community concern near to the Site. Odour complaints have typically numbered between 50 and 60 complaints per year. As identified in **Section 3.5**, it is expected that the closure of the refinery component of the Site would result in a significant reduction in the emission of odorous sulphur and VOC-based compounds.

4 Approach to Assessment

In addition, with the change in emissions profile, the sensitivity of nearby receptors to odour may also be modified. Whilst a significant reduction in odour emissions is expected, it is not anticipated that odour issues would be completely eliminated as part of the Project.

Given the established understanding of odour matters around the Site, a quantitative assessment of odour has not been undertaken within this AQIA. Noting this, Caltex propose the ongoing management of odour through the odour reduction program that is currently undertaken through the EPL for the Site (EPL #837). A discussion of this program is provided in **Section 7** of this report.

Dispersion Modelling

5.1 Model Selection

Three dispersion models are generally endorsed by OEH for use in AQIAs. These are Ausplume, TAPM and CALPUFF. Historically, assessments at the Site have used the CALPUFF dispersion model. This has been due to the requirement to address emissions from emission sources that are both elevated and buoyant, in the presence of coastal meteorology.

For emission sources proposed under terminal operation, Ausplume is considered capable of representing the key dispersion mechanisms, and hence has been adopted for use. This is due to the following conditions being met:

- Emissions from the Site occur at ground-level and are non-buoyant;
- Receptors of key interest are located in the near-field range; and
- On-site meteorological monitoring data is available, and is sited in an area considered representative of key emission sources and receptors.

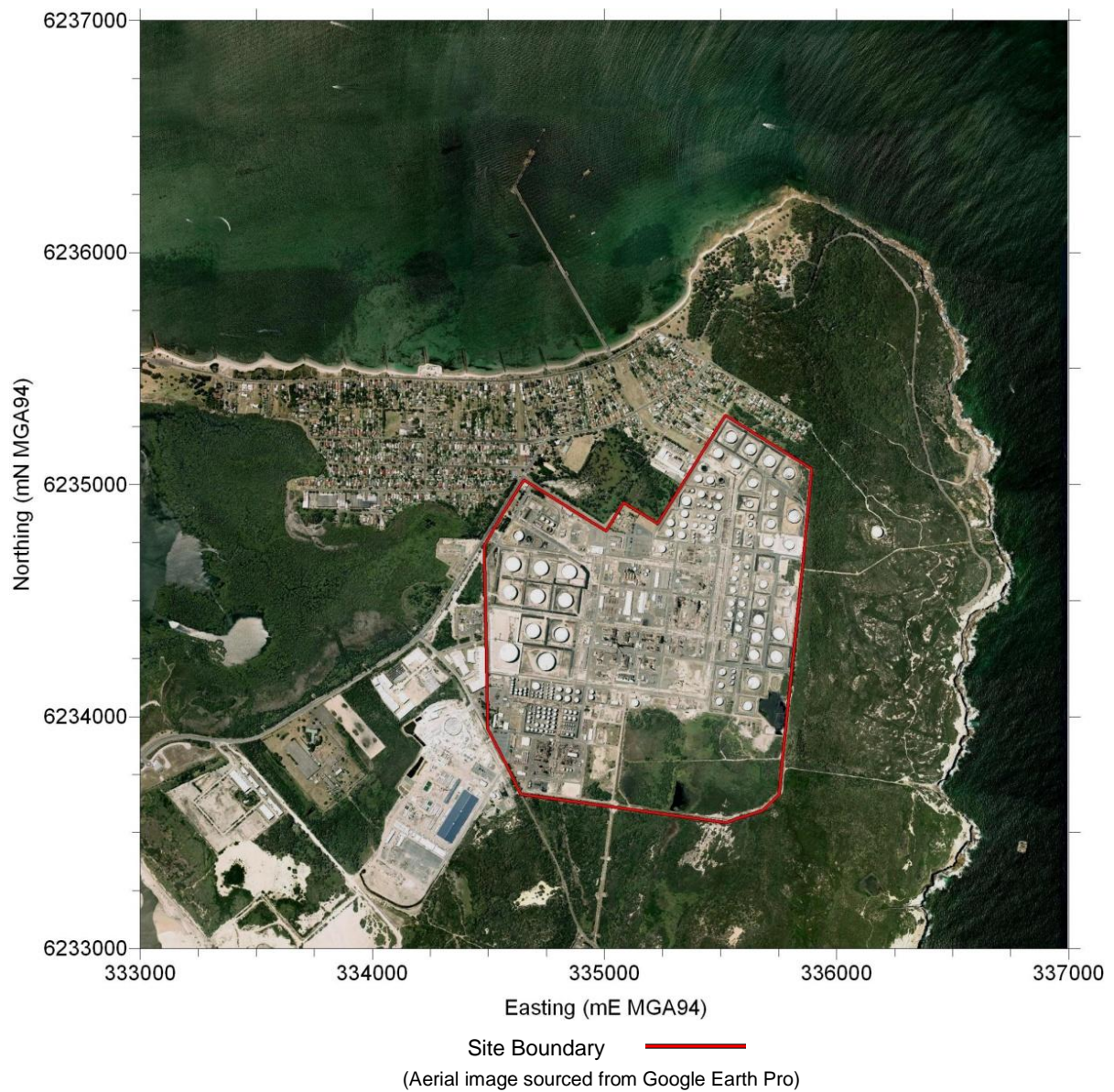
Ausplume is a steady-state Gaussian dispersion model, which was developed by the Victorian Environment Protection Authority, based on the USEPA Industrial Source Complex (ISC) model. The model uses conservation of mass principles to estimate pollutant concentrations downwind of a given emission source. The model is a steady-state model, given that it uses discrete hourly meteorological records to estimate pollutant dispersion. The model assumes that the flux of emissions through a cross section of the plume (at all distances downwind), is equal to the emission rate at the pollutant source. Within this hour, emissions and meteorological conditions are assumed to be constant in time. Within the plume, it is assumed that contaminant concentration follows a Gaussian (normal) profile, where peak concentrations occur at the centreline, and drop away toward the plume boundary. The cross-plume dimensions are assumed to increase downwind of the plume, as a function of distance and atmospheric stability, and initial plume dimensions.

5.2 Modelling Domain

Modelling has been conducted for a receptor grid of 81 x 81 receptor points at 50 m resolution, which equates to a receptor grid of 4 x 4 km. The extent of this modelling domain encompasses the Site and surrounding areas of interest on the Kurnell Peninsula as shown in **Figure 5-1**.

5 Dispersion Modelling

Figure 5-1 Modelling domain extent showing site boundary (red)



Given the varying land uses surrounding the Site, discrete receptors have been included as a simple means for screening the modelling results at areas which are routinely occupied. Eleven discrete receptors have been added around the northern perimeter of the Site. These primarily include residential receptors along the northern and north-eastern boundary of the Site. **Figure 5-2** shows these discrete receptor locations, whilst **Table 5-1** lists the coordinates of these receptors as used in the modelling.

5 Dispersion Modelling

Figure 5-2 Aerial image showing discrete receptor locations



Site Boundary ———
(Aerial image sourced from Google Earth Pro)

Table 5-1 Discrete receptor locations

Receptor	Easting (mE MGA94)	Northing (mN MGA94)	Base Elevation (mAGD)
R1	334 511	6234 929	5.0
R2	334 646	6235 052	6.9
R3	334 752	6235 211	5.5
R4	334 915	6235 240	3.2
R5	335 195	6235 145	5.0
R6	335 385	6235 091	6.0
R7	335 434	6235 171	4.9
R8	335 489	6235 264	5.6
R9	335 570	6235 347	5.9
R10	335 692	6235 271	8.0
R11	335 830	6235 186	13.4

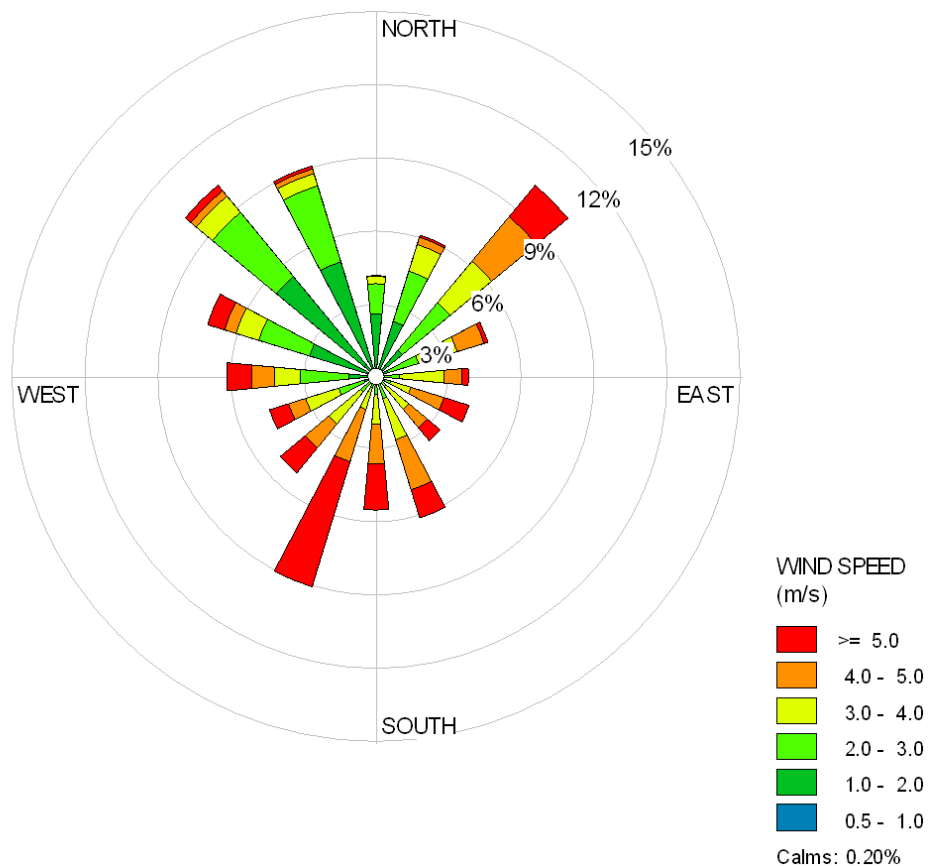
5.3 Dispersion Meteorology

A site-specific meteorological dataset has been prepared using meteorological data that was collected at the Site, in conjunction with synoptic meteorological databases, as required for the calculation of meteorological parameters required by the dispersion model. Five years of meteorological data (2007 to 2011 inclusive) were reviewed, and 2008 was selected as being representative of meteorological patterns across all years. Further detail and analysis of this process is provided in **Appendix A**.

5 Dispersion Modelling

Figure 5-3 shows a wind rose at the Site for the year 2008. Winds are shown to be well distributed in all directions, with the slight accentuation of north easterly sea breezes, south-south westerly and north-westerly winds, as common to the coastal areas of Sydney. Also shown is a low proportion of calm winds, constituting only 0.2% of hourly wind records for the year, as is expected given the location on the Kurnell Peninsula.

Figure 5-3 Wind rose for 2008



5.4 Model Settings

Ausplume was run using the following settings:

- Terrain effects were incorporated using the Egan half-height algorithm. Terrain data was sourced from the Shuttle Radar Topography Mission, at a horizontal resolution of 3 arc-seconds (approximately 90 m);
- Pasquill Gifford dispersion coefficients were used for both horizontal and vertical dispersion;
- Irwin Urban wind profile exponents were used;
- The 'Adjust PG curves for roughness' option was selected; and
- A surface roughness height of 0.1 m was used.

Default parameters were used elsewhere. Further detail of the model configuration has been omitted from this Report as per the 'Notes on Text'.

5 Dispersion Modelling

5.5 Source Parameters

Emissions have been represented in Ausplume as volume sources. Volume sources constitute a generic method of representing fugitive emissions, such as those that are released into an aerodynamic wake, such as fugitive emissions from storage tanks.

Within the model, volume sources are defined by location (i.e. easting, northing and height), and the amount of initial horizontal and vertical dispersion, as defined by two separate parameters, σ_y and σ_z . These represent the standard deviation of pollutant mass from the plume centreline, and have been calculated in this assessment by dividing the source/wake dimensions by 4.3. Within Gaussian dispersion models, this number is used as a general rule to represent the number of standard deviations across a Gaussian curve, within which 90% of the total area under the curve is contained, thus providing a basis to estimate concentrations downwind of each source, as each plume disperses. A summary of source emission parameters and source locations and names has been omitted from this Report as per the 'Notes on Text'.

5.6 Emission Rates

Emission rates have been modelled based on the annual estimates detailed in **Section 3** of this report. In order to generate hourly emission rates, total emission quantities have been divided by 8760 (the number of hours in a year), and treated as a constant emission rate within the model. In addition, summer and winter product emissions have been assigned relevant months (summer: October-March, winter: April-September) using the monthly variable emission rate option within Ausplume. Noting this, the emissions reflect average emissions and are considered generally representative of net emissions across the Site at a given time, and long-term average emissions. These emissions do not reflect short-term localised emission peaks that may arise from a specific tank (e.g. due to product movements). In this sense, long-term average predictions are considered more robust in the estimation of pollutant levels near to a specific tank.

A summary of source emission rates have been omitted from this Report as per the 'Notes on Text'.

Dispersion Modelling Results

This section provides the results of the dispersion modelling undertaken for the Project, with comparison against OEH impact assessment criteria, as well as the NEPM criteria identified in **Section 4**. Results have been presented both in tabulated form, as well as contour isopleths.

6.1 Short Term Model Predictions

Table 6-1 shows a summary of short-term model predictions as the 99.9th percentile 1 hour averages. The 99.9th percentile statistic equates to the 9th highest hour of the year. These criteria are incremental, meaning that they apply to the incremental impact from emissions from the pollutant source alone.

As can be seen in the table, all concentrations at receptors R1 to R11 and at the Site boundary are compliant with the OEH impact assessment criteria. Concentrations for all substances other than benzene were less than 10% of OEH impact assessment criteria. Benzene predictions were less than half of the OEH criterion, with an estimated maximum incremental impact of 13.5 µg/m³ on the eastern boundary of the Site.

Table 6-1 Predicted 99.9th percentile 1 hour average concentrations

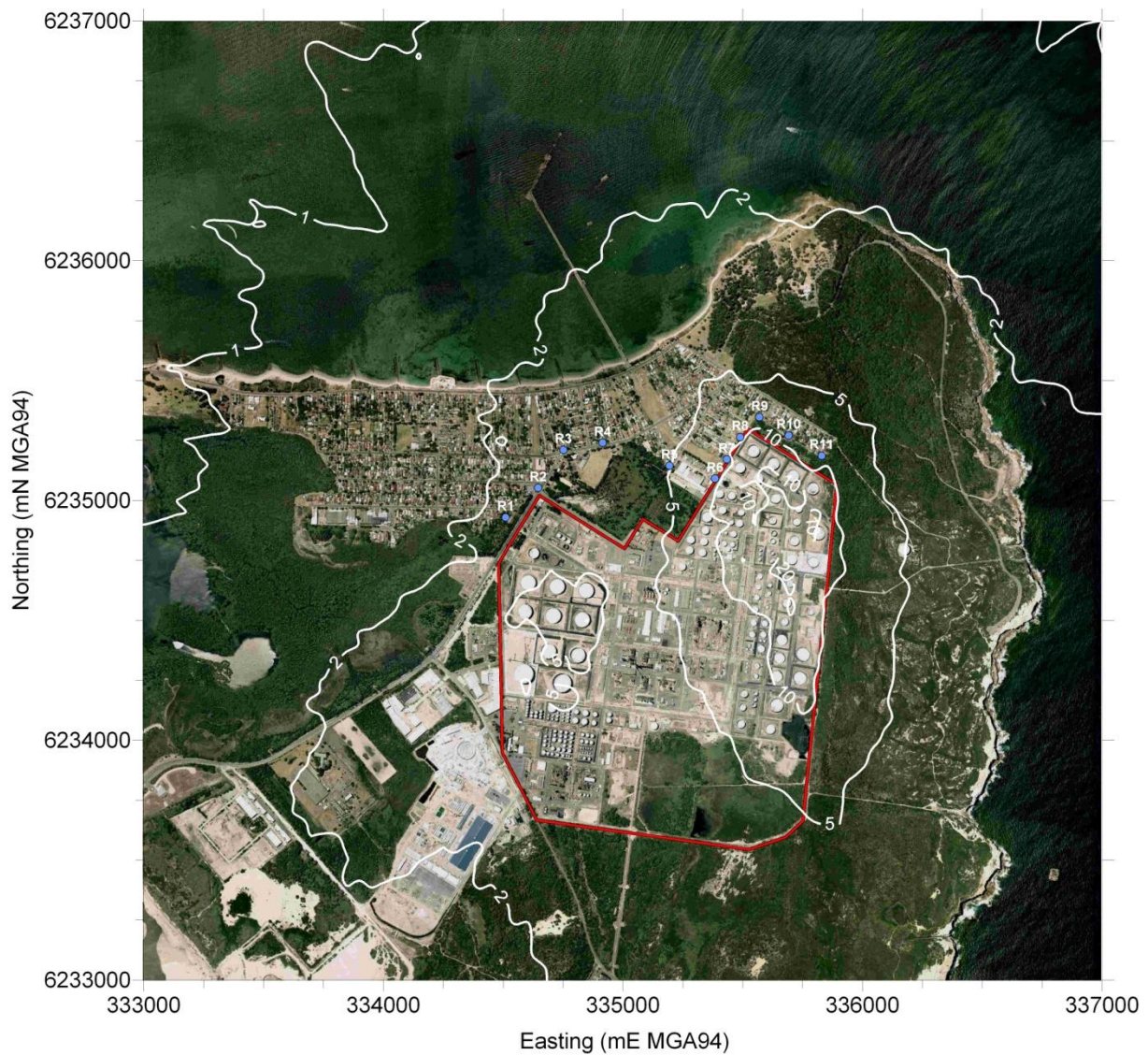
Receptor	Benzene	Model Prediction (µg/m ³)			
		Toluene	Ethylbenzene	Xylenes	n-Hexane
R1	2.2	6.2	0.6	4.1	4.5
R2	2.5	5.9	0.7	4.0	4.2
R3	2.6	6.7	0.7	4.0	4.6
R4	3.0	7.5	0.8	4.2	5.7
R5	4.9	12.5	1.6	8.3	8.2
R6	8.5	20.1	3.9	14.7	12.8
R7	9.6	20.6	4.9	12.0	13.0
R8	9.2	20.5	3.7	10.2	18.0
R9	7.7	18.5	2.1	8.3	15.2
R10	8.5	21.6	2.4	9.3	17.9
R11	8.8	23.3	2.2	11.6	20.2
Maximum (R1-R11)	9.6	23.3	4.9	14.7	20.2
Maximum (off-Site)*	13.5	35	5	19	37
Impact Assessment Criterion	29	360	8,000	190	3,200

Note:*Off-site concentrations estimated using kriging interpolation method.

Contour plots are provided for 99.9th percentile 1 hour average model predictions in **Figure 6-1** through to **Figure 6-5**.

6 Dispersion Modelling Results

Figure 6-1 Predicted 99.9th percentile 1 hour average benzene concentration



Concentration contours shown in $\mu\text{g}/\text{m}^3$

(Aerial image sourced from Google Earth Pro)

6 Dispersion Modelling Results

Figure 6-2 Predicted 99.9th percentile 1 hour average toluene concentration

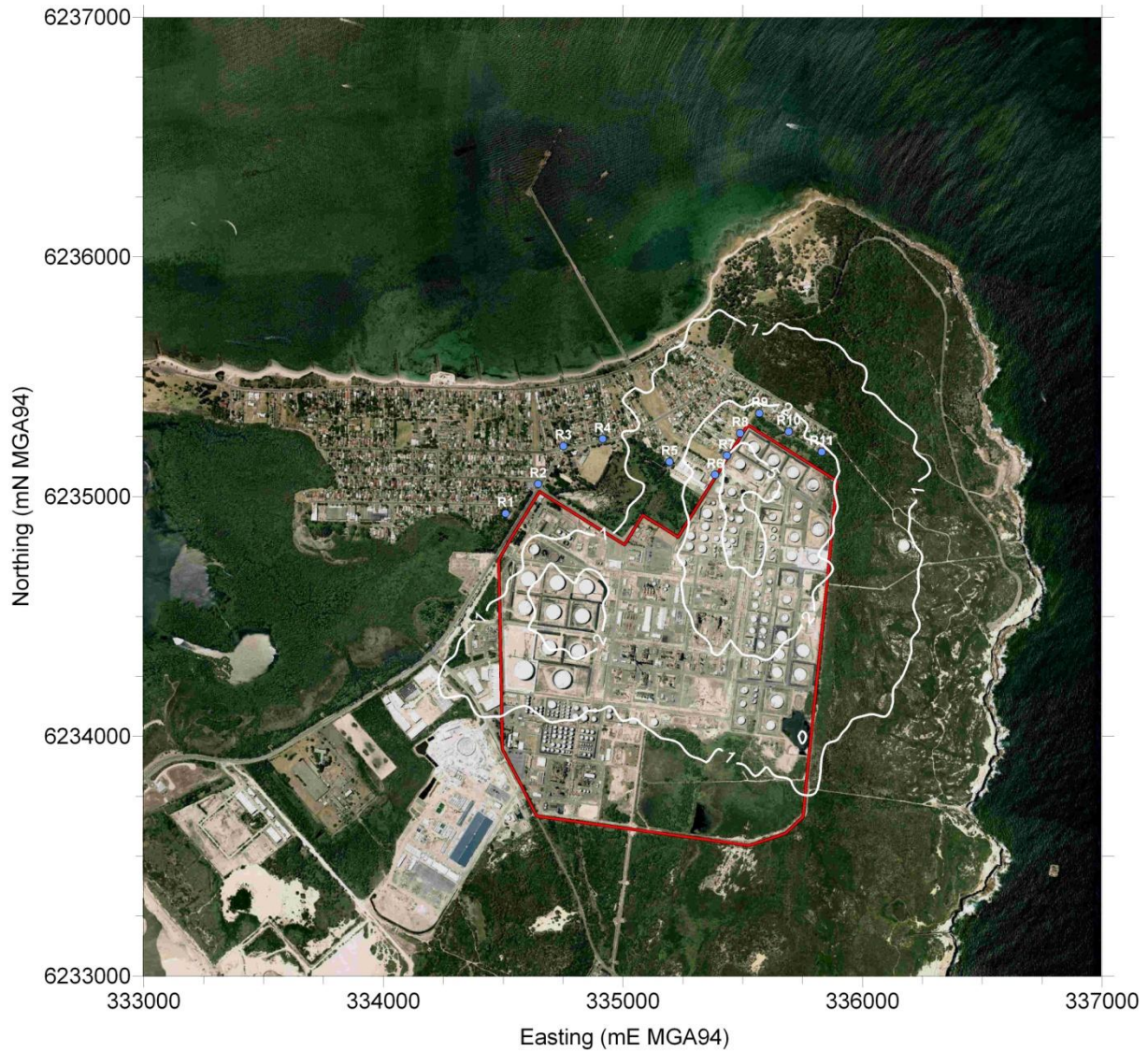


Concentration contours shown in ug/m³

(Aerial image sourced from Google Earth Pro)

6 Dispersion Modelling Results

Figure 6-3 Predicted 99.9th percentile 1 hour average ethylbenzene concentration

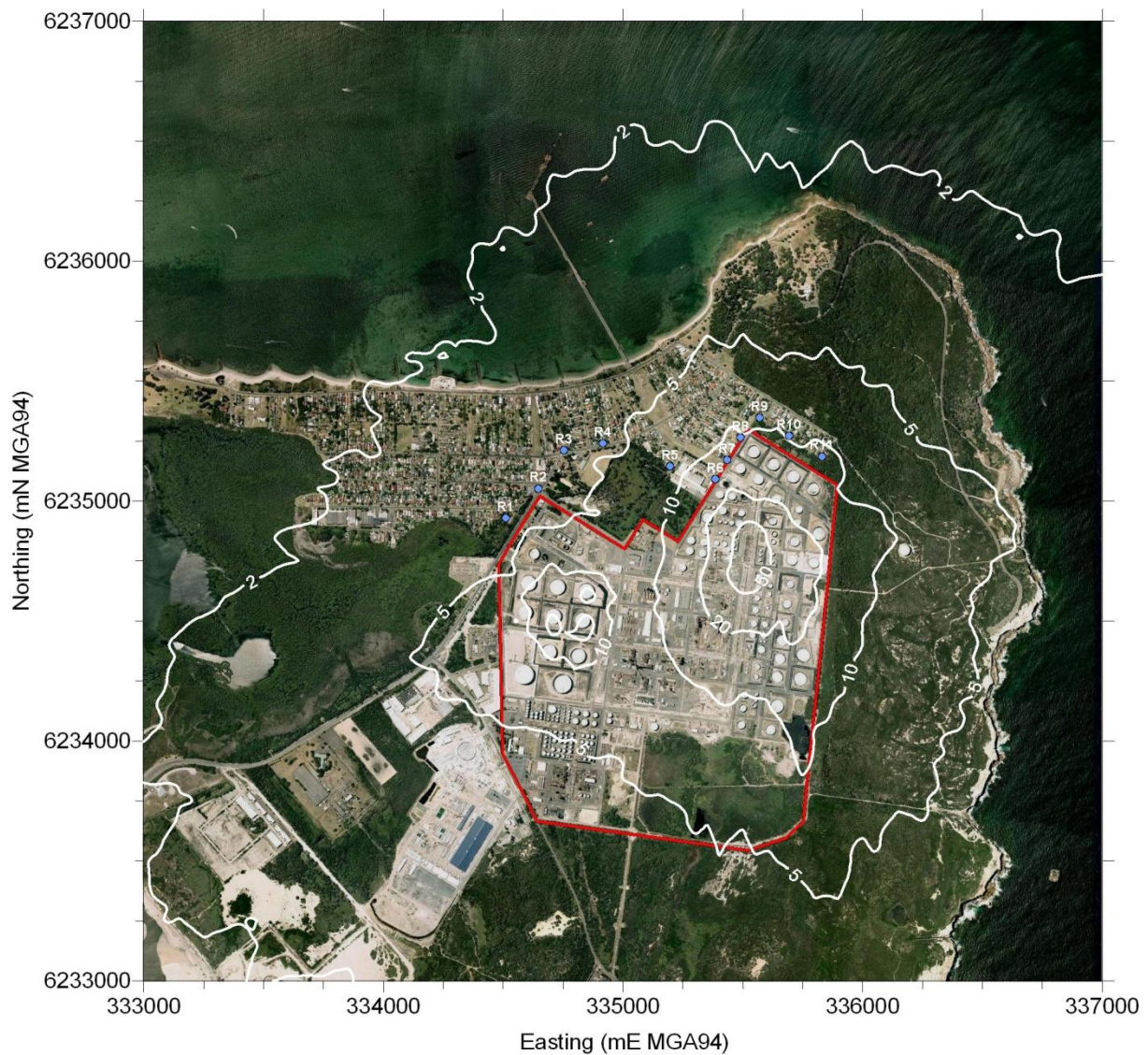


Concentration contours shown in ug/m3

(Aerial image sourced from Google Earth Pro)

6 Dispersion Modelling Results

Figure 6-4 Predicted 99.9th percentile 1 hour average xylenes concentration

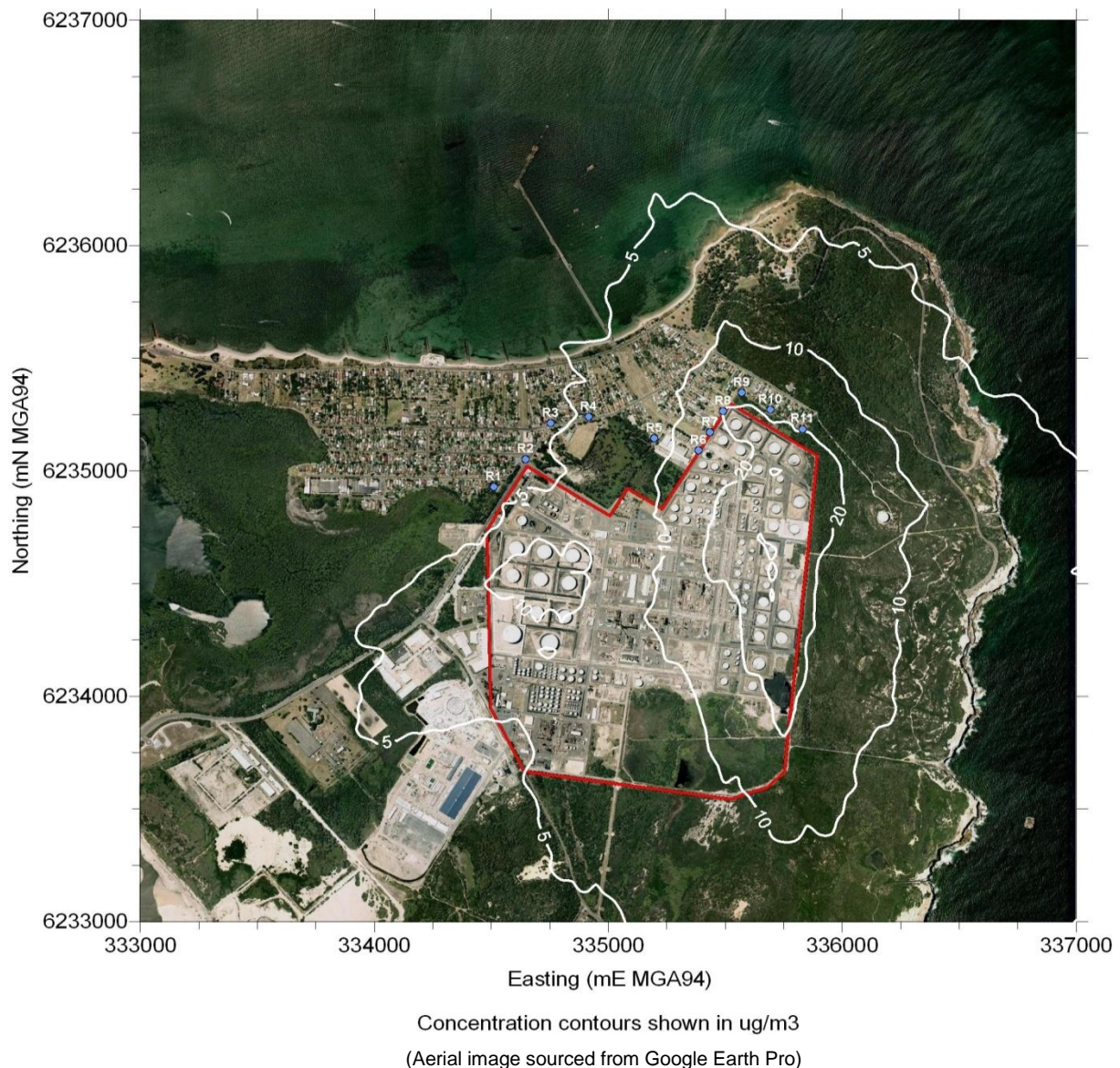


Concentration contours shown in ug/m³

(Aerial image sourced from Google Earth Pro)

6 Dispersion Modelling Results

Figure 6-5 Predicted 99.9th percentile 1 hour average n-Hexane concentration



With regard to these predictions, it is noted that high percentile statistics (in this case, the 99.9th percentile statistic, which equates to the 9th highest hourly result within the modelled dataset of 8,784 hours), are more difficult for dispersion models to predict.

Given the exposed nature of the Kurnell peninsula, the sensitivity of the 99.9th percentile predictions to wind speed is of interest, including the use of vector averaged wind speed in contrast to scalar averaged wind speed⁸, and the potential effects of vector cancellation and associated under-representation of wind speed.

⁸ Scalar average wind speed simply represents the arithmetic average of wind speed measured within a given averaging period. Vector averaged wind speed is reflective of the total translation that would be experienced by a parcel of air within a given averaging period, and hence takes into account wind speed and wind direction for every sample from which the average is calculated. For example, if the wind blows at 3 m/s from the south for 30 minutes, and 3 m/s from the north for the remainder of the hour, the hourly average vector averaged wind speed would be 0 m/s whilst the scalar averaged wind speed would be 3 m/s.

6 Dispersion Modelling Results

The presence of water bodies and low-lying areas around the Site is associated with high wind speeds and a low frequency of calm conditions (refer to **Appendix A** for a review of meteorology in the region). For non-buoyant ground level emission sources such as those considered in this AQIA, calm conditions are typically associated with peak model predictions.

As discussed in **Section 5.1**, dispersion models are based on conservation of mass, where the concentration at a given receptor is proportional to the rate at which a pollutant is emitted divided by the volume of air passing through the cross-section of the plume at the receptor location. Noting this, in isolation of other parameters, a doubling of wind speed will result in a halving of model predictions.

In order to investigate the nature of winds defining the peak model predictions, wind conditions were reviewed for the 9 highest 1 hour average benzene predictions⁹. Specifically, hourly vector averaged wind speed (as used by the model) was compared to arithmetic averages of 5 minute wind speed for that same data. This statistic has been assumed representative of scalar average wind speed for the purposes of this discussion. **Table 6-2** shows a summary of these data.

Table 6-2 Comparison of modelled wind speed against scalar averaged wind speed

Rank	Hour, Date	Model Prediction ($\mu\text{g}/\text{m}^3$) ³	Modelled Wind Speed*	Scalar Wind Speed**
1	02, 04/02/08	16.4	0.5	1.2
2	04, 02/11/08	15.9	0.5	N/A
3	05, 29/11/08	15.0	0.5	0.9
4	20, 13/01/08	12.8	0.5	2.7
5	23, 10/09/08	10.1	0.5	N/A
6	20, 17/06/08	10.0	0.5	1.8
7	24, 16/09/08	9.9	0.6	2.7
8	05, 02/11/08	9.8	0.6	N/A
9	22, 11/05/08	9.6	0.5	1.5

Notes: *Modelled wind speeds were based on vector averages. **Scalar wind speed as calculated from twelve 5 minute vector averages. N/A: Not Available due to missing AWS records.

It is noted that scalar wind speeds were significantly higher than vector average wind speeds for the peak model predictions. This phenomenon occurs due to cancellation effects associated with vector averaging of periods in which a change in wind direction is observed. Whilst the use of scalar averaged wind speed in this AQIA would be considered potentially optimistic (given the presence of near-field receptors and diffuse emission sources with a horizontal extent of approximately 1.5 km), the difference between vector and scalar wind speeds provided in **Table 6-2**, indicates that the representation of winds in 99.9th percentile model results is conservative, yet appropriate for use in this assessment. It is also noted that the sensitivity of long-term (annual) average model predictions to this issue is expected to be significantly lower.

⁹ As relevant to 99.9th percentile predictions. Model predictions were extracted at receptor location R7.

6 Dispersion Modelling Results

6.2 Long Term Model Predictions

Table 6-3 shows a summary of long-term model predictions as annual averages. As adopted in this assessment, these criteria are cumulative, hence they have been compared to cumulative estimates which reflect the sum of background levels and incremental model predictions.

As can be seen in the table, concentrations at receptors R1 to R11 and at the Site boundary are below the NEPM (Air Toxics) criteria, with emissions from the Site making a minor contribution to predicted cumulative (i.e. the Site plus background levels) concentrations.

Table 6-3 Predicted annual average concentrations

Receptor	Model Prediction (µg/m³)		
	Benzene	Toluene	Xylenes
R1	0.1	0.2	0.1
R2	0.1	0.2	0.1
R3	0.1	0.2	0.1
R4	0.1	0.2	0.1
R5	0.2	0.4	0.2
R6	0.5	1.0	0.6
R7	0.5	0.9	0.5
R8	0.4	0.8	0.4
R9	0.3	0.7	0.3
R10	0.4	1.0	0.4
R11	0.5	1.2	0.5
Maximum R1-R11	0.5	1.2	0.6
Background Concentration	1.2	6.8	5.2
Maximum R1-R11 (Including Background)	1.7	8.0	5.8
NEPM (Air Toxics) Criterion	9.6	377	870

In addition, contour plots are provided for incremental annual average model predictions in **Figure 6-6** through to **Figure 6-8**.

6 Dispersion Modelling Results

Figure 6-6 Predicted annual average benzene concentration



Concentration contours shown in $\mu\text{g}/\text{m}^3$

(Aerial image sourced from Google Earth Pro)

6 Dispersion Modelling Results

Figure 6-7 Predicted annual average toluene concentration



Concentration contours shown in $\mu\text{g}/\text{m}^3$

(Aerial image sourced from Google Earth Pro)

6 Dispersion Modelling Results

Figure 6-8 Predicted annual average xylenes concentration



Concentration contours shown in ug/m3

(Aerial image sourced from Google Earth Pro)

Air Quality Management

This section provides a background to environmental management at the Site, as well as an overview of measures that Caltex propose to implement for the management of air quality as part of the the Project.

7.1 Environmental Management System

As part of the current refinery operating procedures, Caltex strives continuously to minimise the creation of air emissions during its operations, both routine and non-routine. Within the ISO 14001 certified Environmental Management System (EMS) for the Site, all routine operations have been assessed with regard to their potential impact on the environment. The mitigation measures that have been implemented have been assessed as well. These mitigation measures can be of an engineering and/or operational nature. Any remaining risks are of concern to Caltex and have been included in the Site's Environmental Improvement Plan (EIP).

For non-routine activities, as documented in the EMS, the environmental impacts, including the potential to create odours, are assessed during the planning phase of that activity and where required mitigating and monitoring actions are implemented during the implementation phase of that activity. This is documented in an Environmental Management Plan (EMP). The EMP is not necessarily a standalone document but can be incorporated in the safety review of the activity. Caltex will continue this approach not only during the conversion works but also into the operation phase of the Project.

With regards to odours this approach is in line with the Site's EPL Pollution Reduction Program (PRP), which Caltex will continue during the terminal operation phase. Where appropriate the PRP will continue, albeit in a modified form. Further details of the ongoing PRP work are provided in **Section 7.3**.

7.2 Conversion Works

As noted in **Section 3.1**, given the minor scale and progressive nature of the conversion activities, the potential for these operations to adversely impact air quality is considered small, and most appropriately managed through the implementation of an Air Quality Management Plan (AQMP).

Hence Caltex propose to perform the conversion works in accordance with an AQMP for the Project. The following mitigation measures have been nominated for incorporation into the AQMP:

- Daily activities would be reviewed in the context of potential air emissions and mitigation measures;
- Workers would maintain a visual awareness of dust emissions, and a general awareness of potential odour emissions. During activities with the potential to create dust emissions, a designated worker would continuously monitor downwind emissions and call a halt to activities if the wind direction is towards the community or other sensitive on-site receiver locations (e.g. offices, car parks);
- Vehicle movements on unsealed areas would be minimised, and vehicles would travel on designated roadways where feasible;
- Where there is the potential for dust or odour generation, trucks carrying spoil loads shall be covered. Tailgates on all trucks would be securely fixed prior to loading and immediately after unloading of materials. Loads would be less than the height of the side and tailboards of the trucks;
- Soil adhering to the undercarriage and wheels of trucks would be removed prior to departure from the works area where there is the potential for sediment to enter drains or for dust generation;

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- Vehicles traveling at speed would avoid generating excessive amounts of dust. The maximum speed of vehicles in construction areas would be 10km/hr, and 25 km/hr elsewhere in the refinery;
- Construction activities would be minimised or ceased during undesirable weather conditions or forecasts (e.g. periods of high winds) near sensitive receptors or when offensive odours are noticed by receptors;
- Plant, equipment and vehicles shall be maintained and operated in accordance with the manufacturers specifications to minimise the emission of air pollutants and offensive odours and minimise the generation of dust;
- Plant or equipment would not to be left/parked with the motors running when not in use;
- Excavated soils would be assessed for odour as/if they are stockpiled, and would be controlled in order to manage potential odour or dust emissions;
- The effectiveness of any dust controls implemented would be visibly assessed and adjustments made accordingly;
- All concrete cutting and coring would to be undertaken using “wet tools”; and
- If excess dust is observed due to extreme weather conditions or construction activities (e.g. high winds, surface dirt accumulation, etc.), work would cease or be phased down while the cause is being actively investigated and suppression measures are implemented.

7.3 Terminal Operation

Caltex currently implements a range of management programs in order to address emissions from the Site under refinery operation. These programs would continue into the operational phase of the Project albeit in a modified form. Details of the programs proposed by Caltex are provided in the sections below.

7.3.1 Odour Reduction Program (ORP)

Caltex is currently in the process of implementing an Odour Reduction Program (ORP) for the Site as part of the current EPL for the operating refinery. Improvements associated with this work include the installation of covers on the oil separator pit bays, which Caltex believe has resulted in a significant reduction of the odour emissions from the Site. An overview of the ORP as relevant to the Project is provided in the following sections.

Odour Assessment Methodology

This part of the ORP involved the preparation of an odour assessment methodology targeted at identifying and managing sources of offensive odour from the premises. The methodology includes:

- Identification of odour sources;
- Development of odour performance criteria for each source;
- Construction of a monitoring and reporting program for odour sources; and
- Identification of a methodology to quantitatively assess the effectiveness of mitigation strategies.

The preparation of this methodology was completed in 2012, and focused on:

- The vent stacks affixed to the covers over the main oily-water separator area;
- Land farm;
- Boiler stacks;
- CO boiler stack;
- #3 Crude distillation unit stack;

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- Common (refinery) stack; and
- Catalytic cracking unit stack.

Odour Assessment and Reduction Program

This component involves a program of odour assessment and the development of an ORP to prevent the emission of offensive odours from the Site. The ORP involves a range of tasks including the following:

- Identification and review of the success of previously implemented odour reduction measures;
- Identification of new or remaining odour sources, with characterisation and review of odour potential;
- A review of technically reasonable and feasible emission controls, with a review of cost and control efficiency; and
- Prioritisation of odour sources and development of an implementation program for reduction measures, and reporting and progress review.

This program was configured with the intent of addressing emission sources present as part of the refinery. In light of the Project, it is proposed that the assessment program will be carried out as designed but that the implementation of any required mitigation measures will be adapted in order to target odour emission sources that are of potential significance for the proposed terminal operation.

7.3.2 VOC Emissions

7.3.2.1 Land Farm

As part of the Environment Protection Licence's Pollution Reduction Program (PRP), Caltex is committed to evaluate alternative options for the sustainable management of oily wastes/sludges that will facilitate Caltex to cease land farming at the premises.

Caltex is in the process of developing a management plan for the landfarm; incorporating options for the long term remediation, in line with and as part of the Site's remediation plan. The land farm management plan will also include a review of terminal related oily wastes/sludges and their management in a sustainable manner.

Land farm management and waste management during the Project would be included in the CEMP for this project.

7.3.2.2 Trial Tank Sleeve Program

Caltex is in the process of implementing a trial program investigating the use of sleeves on the guidepoles on EFRTs. In view of the Project, Caltex has proposed not to carry out a trial program but to start the implementation of tank sleeves on all EFRTs that will be in gasoline service. These works will start during Project construction and will continue during the operational phase.

The guidepoles on EFRTs have been identified as one of the highest sources of VOC emissions from tanks. To reduce these emissions, a sleeve consisting of a transition box and a flexible enclosure that encapsulates the whole guidepole is attached to the floating roof. Preliminary assessments of the effectiveness of these sleeves have indicated that VOC emissions from EFRTs can be reduced by

7 Air Quality Management

50%. It is also noted that in order to maintain a conservative assessment of the impacts of the Project on air quality, modelling within this AQIA has assumed that the tank sleeves would be absent.

7.3.2.3 Leak Detection and Repair Program

Caltex have a well-established Leak Detection and Repair (LDAR) Program at the Site, which is a requirement of the current Site EPL. The LDAR Program is a monitoring program that involves technicians monitoring components such as valves and rotating equipment (e.g. pumps) in order to detect hydrocarbon leaks, which are a source of fugitive VOCs emissions. It is also a repair program, in that those components found to be leaking above the leak thresholds defined in the EPL, are required to be repaired by qualified fitters or the leak stopped/isolated by other means. Since its establishment in 2006, the LDAR Program has resulted in a significant reduction in VOC emissions, including benzene, which is not only beneficial to the environment and community but is beneficial for the occupational safety of refinery workers, reduces process safety risks and increases product utilisation. Caltex propose to continue the LDAR Program for the Project whilst the refinery is in operation. Following the shutdown of refinery operations the LDAR program would be modified to a tanks and lines monitoring program due to the reduction in potentially emissive infrastructure at the Site.

Conclusions

This AQIA has been performed in general¹⁰ accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (DEC, 2005), using the Ausplume dispersion model in conjunction with a site-specific meteorological dataset which has been prepared with the incorporation of on-site meteorological monitoring data.

Dispersion modelling performed using the Ausplume dispersion model has predicted short-term concentrations which are below the impact assessment criteria provided in DEC, 2005. Concentrations for all substances other than benzene were less than 10% of OEH impact assessment criteria. Benzene was less than half of the OEH criterion, with an estimated incremental impact of 13.5 µg/m³ at the eastern boundary of the Site. Modelling has also been performed for annual averages, and compared to criteria for benzene, toluene and xylenes. When the annual average model predictions have been added to the adopted background concentrations, emissions from the Site make a minor contribution to predicted cumulative (the Site and background) concentrations at residential receptor locations near and adjacent to the Site, and are within the adopted criteria.

It is also noted that the Site has a history of odour complaints, and that whilst the Project would result in a significant reduction in the emissions of odour, it is not anticipated that odour issues would be completely eliminated as part of the Project. Hence a summary of proposed air quality management measures has been prepared for the Project.

Based on the information reviewed, and the analysis undertaken, the potential for the Project to result in adverse air quality impacts is considered to be low and manageable with ongoing implementation of appropriate mitigation strategies.

¹⁰ This is with the exception of reporting standards as provided in the Approved Methods, where in the case of this AQIA, information has been excluded in accordance with the "Notes on Text".

References

- ATSDR 1999a, *Toxicological Profile for Total Petroleum Hydrocarbons (TPH)* U.S. Department of Health And Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, September 1999, <http://www.atsdr.cdc.gov/toxprofiles/tp123.pdf> (accessed 12/01/13);
- ATSDR 1999b, *Toxicological Profile for Ethylbenzene*, Agency for Toxic Substances and Disease Registry, U.S. Public Health Service July 1999;
- ATSDR 1999c, *Toxicological Profile for n-Hexane*, Agency for Toxic Substances and Disease Registry, July 1999.
- ATSDR 2000, *Toxicological Profile for Toluene*, Agency for Toxic Substances and Disease Registry, September 2000;
- ATSDR 2007a, *Toxicological Profile for Benzene*, Agency for Toxic Substances and Disease Registry, August 2007;
- ATSDR 2007b, *Toxicological Profile for Xylenes*, Agency for Toxic Substances and Disease Registry, August 2007;
- Coffey 2005, *Flux Hood Sampling, Caltex Refinery Landfarm*, Coffey Geosciences P/L, 10 March 2005;
- DEC 2005, *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*, New South Wales Department of Environment and Conservation, August 2005, <http://www.environment.nsw.gov.au/resources/air/ammodelling05361.pdf> (accessed 14/01/13);
- NEPC 2003, *Impact Statement for the National Environment Protection (AirToxics) Measure*, National Environment Protection Council, May 2003, http://www.ephc.gov.au/sites/default/files/AT_NEPM_Air_Toxics_Impact_Statement_200305.pdf (accessed 12/01/2013);
- NEPC 2004, *National Environment Protection (AirToxics) Measure*, National Environment Protection Council, 3 December 2004, http://www.ephc.gov.au/sites/default/files/AT_NEPM_Air_Toxics_NEPM_20041203.pdf (accessed 12/01/2013);
- NEPC 2010, *National Environment Protection Council Annual Report 2009-2010*, National Environment Protection Council, 2010, <http://www.scew.gov.au/archive/annual-report/pubs/nepc-annual-report-09-10.pdf> (accessed 12/01/2013);
- NPI 2012, *National Pollutant Inventory Emission Estimation Technique Manual for Fuel and Organic Liquid Storage*, Version 3.3, National Pollutant Inventory, Australian Government, Department of the Environment, Water, Heritage and the Arts, May 2012, <http://www.npi.gov.au/publications/emission-estimation-technique/pubs/fols.pdf> (accessed 14/01/13);
- USEPA 2006, *AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors, Section 7.1, Organic Liquid Storage Tanks*, Volume 1 Stationary Point and Area Sources, United States Environment Protection Agency, 2006, <http://www.epa.gov/ttn/chief/ap42/ch07/final/c07s01.pdf> (accessed 14/01/13).
- WHO 1993, *Benzene, Environmental Health Criteria 150*, International Programme on Chemical Safety, World Health Organisation, 1993.

Limitations

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Appendix A Meteorological Data Preparation

Appendix A - Meteorological Data Preparation

A.1 Overview

The dispersion of pollutants in the atmosphere is driven by meteorology. As a representation of atmospheric processes, dispersion models rely on meteorological data a fundamental input for the estimation of pollutant concentrations near to emission sources. For this reason, meteorological data is required to be representative of the setting in which an assessment is conducted. This assessment has incorporated a site-specific meteorological dataset, prepared using meteorological data that were collected at the Site, in conjunction with synoptic meteorological databases, as required for the calculation of a range of meteorological parameters that are relevant to atmospheric dispersion, and cannot be directly measured. This Appendix provides a summary of the methodology applied in preparation, and analysis of the meteorological dataset applied in this assessment.

A.2 Setting and Meteorological Monitoring

The Site is located within the Kurnell peninsula headland, which is bound by Botany Bay to the north, Bate Bay to the south, and the Pacific Ocean to the east. The peninsula is connected to the mainland to the west by an area of low-lying dunes and marshes.

Terrain across the peninsula is generally low-lying, with the exception of eastern-most portion of the headland, where a ridge runs on a north/south alignment. The eastern boundary of the Site is bound by this ridge, where elevations reach approximately 40 m above sea level. In this respect, winds at the Site are expected to be typical coastal winds for the Sydney region, with higher than average wind speeds present due to the exposed nature of the peninsula, and some potential sheltering of easterly winds due to the ridge to the east.

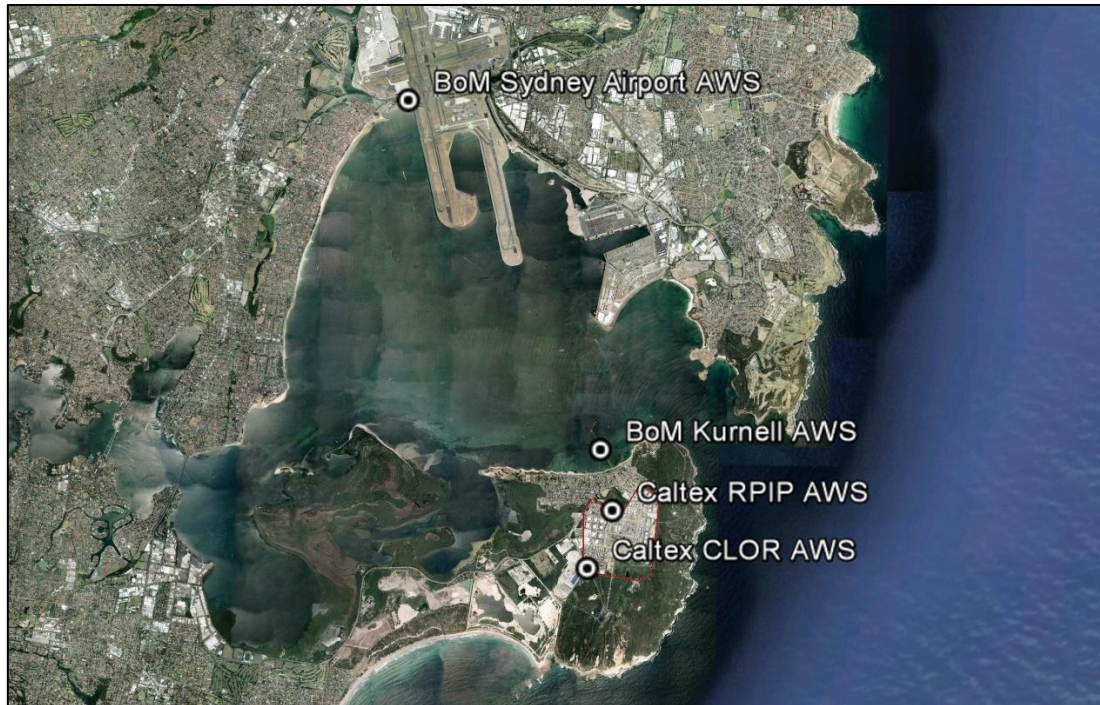
A review of meteorological monitoring on the Kurnell peninsula identified the following Automatic Weather Stations (AWS):

- Bureau of Meteorology (BoM) Kurnell;
- Caltex Kurnell RPIP; and
- Caltex Kurnell CLOR.

In addition, the BoM Sydney Airport AWS was identified as a nearby source of long term meteorological records, relevant to the review of regional meteorological trends. The locations of these AWS are shown in **Figure A-1**, whilst the locations of the Caltex RPIP and CLOR AWS are shown in relation to local terrain features in **Figure A-2**.

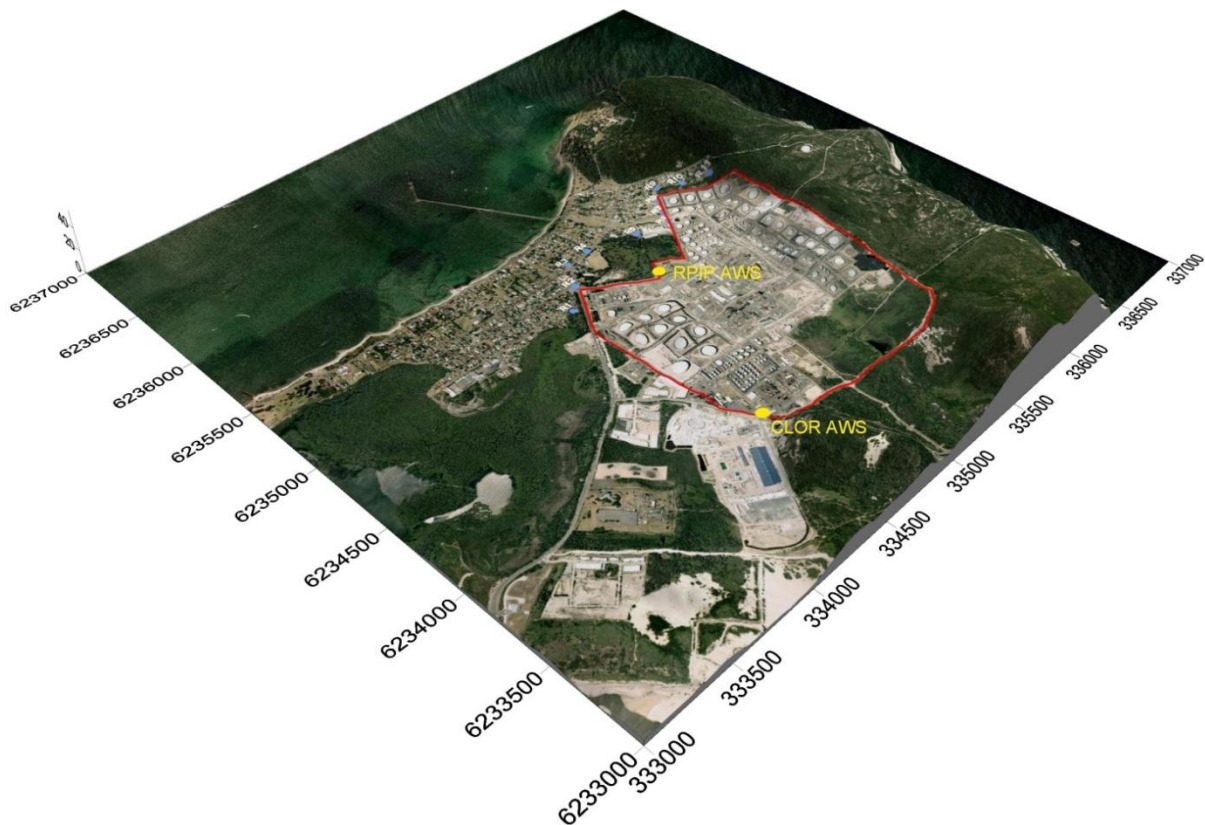
Appendix A - Meteorological Data Preparation

Figure A-1 Aerial image of the Kurnell peninsula and surrounds showing AWS locations



(Image sourced from Google Earth Pro)

Figure A-2 Location of the Caltex RPIP and CLOR AWS relative to surrounding terrain features



Site Boundary
(Aerial image sourced from Google Earth Pro)

Appendix A - Meteorological Data Preparation

A.3 Meteorological Data Selection

The data that is collected at a given AWS is influenced by a range of local siting factors. For a given synoptic (broad-scale) meteorological condition, data from different AWS within a region will contain significant variations, according to siting influences such as proximity to the coast, local terrain, local obstructions such as buildings, and the extent of development of the surrounding land.

Given that this assessment is focused on the dispersion of emissions from non-buoyant ground-level pollutant sources, pollutant concentrations closest to the Site are of most interest. Hence meteorological records that are representative of areas at and immediately surrounding the Site are considered to be of key relevance, as they represent meteorological conditions encountered by pollutants as they are transported between the source and receptor.

Caltex have performed meteorological monitoring at two Automatic Weather Stations (AWS) on the Site since 2006. These stations are located near to the central-northern boundary (RPIP AWS), and south-western boundary (CLOR AWS). These AWS are considered representative of meteorology at areas at and immediately surrounding the Site, and are thus of key relevance to this assessment. Meteorological parameters recorded at these stations include wind speed and wind direction, temperature and humidity.

The BoM Kurnell AWS is located on the Kurnell Wharf which is located overwater approximately 1 km to the north of the Site. The location of this AWS means that it is considered representative of overwater conditions, which are typically associated with higher wind speeds, a lower extent of radiative-forcing, and lower diurnal temperature variation. Given the physical distance, and difference in land use from areas near to the Site, this AWS is considered to be of lower relevance to this assessment than the Caltex Site data.

On this basis, BoM Kurnell data has not been used in the preparation of the meteorological dataset, in preference of the Caltex Site data, whilst BoM Sydney Airport data has been used in conjunction with the Caltex Site data for the consideration of inter-annual variability in regional winds, and compatibility of the Caltex Site data with regional winds.

A.4 Selection of Assessment Year

An objective of the meteorological dataset preparation is to capture a year for which the monitoring dataset is both complete (ideally greater than 90%), and representative of long-term meteorological patterns. This section provides a summary of data availability, and inter-annual variability, as used in the selection of an assessment year.

A.4.1 Data Availability

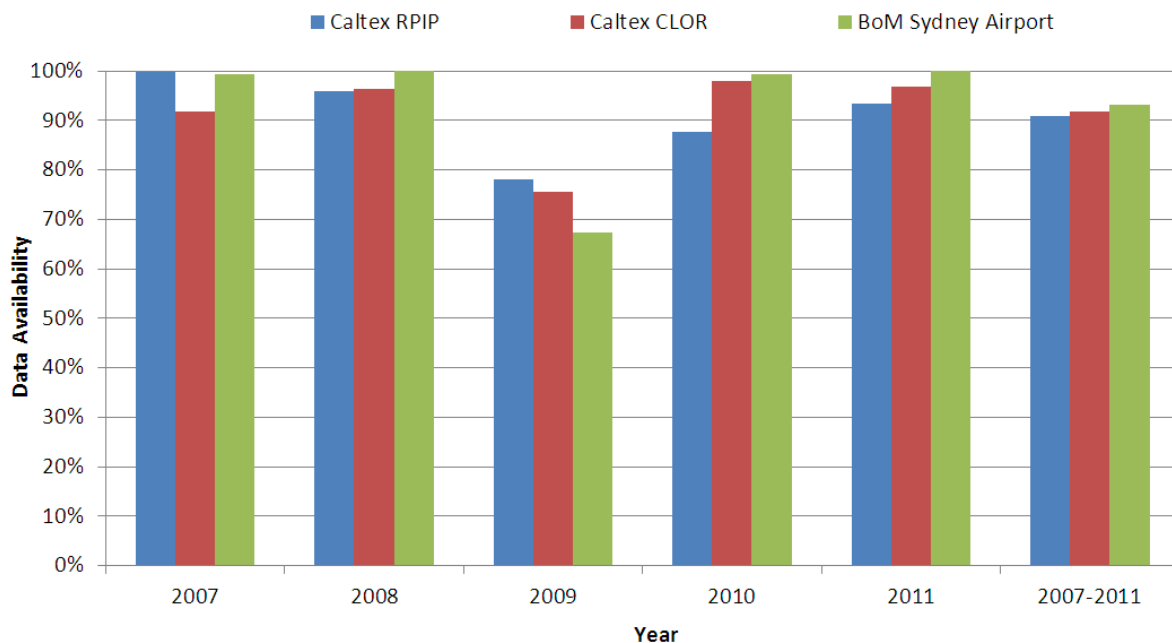
Table A-1 and **Figure A-3** show a summary of the data availability of records from the Caltex and BoM Kurnell AWS. As can be seen in these Figures, records are generally above 90% for all years, with the exception of 2009 where all three reviewed AWS reported data availability below 90%.

Appendix A - Meteorological Data Preparation

Table A-1 Comparison of meteorological data availability (2007-2011)

Period	Caltex RPIP	Caltex CLOR	BoM Kurnell
2007	100%	92%	99%
2008	96%	96%	100%
2009	78%	76%	67%
2010	88%	98%	99%
2011	93%	97%	100%
2007 - 2011	91%	92%	93%

Figure A-3 Comparison of meteorological data availability (2007-2011)



A.4.2 Inter-Annual Variability

The dispersion modelling utilises a full year of meteorological data, equating to 8,760 hourly meteorological records. Whilst this period encompasses all diurnal and seasonal cycles, given the use of a single year, a review of longer term meteorological trends is required to ensure that inter-annual variability is adequately addressed in the assessment. For this purpose, URS review 5 years of wind records from the Caltex, and BoM Sydney Airport AWS, with comparison of the following:

- Annual averaged wind speed;
- Frequency of calm wind conditions;
- Annual wind roses; and
- Wind speed and direction frequency distributions (as wind roses).

Appendix A - Meteorological Data Preparation

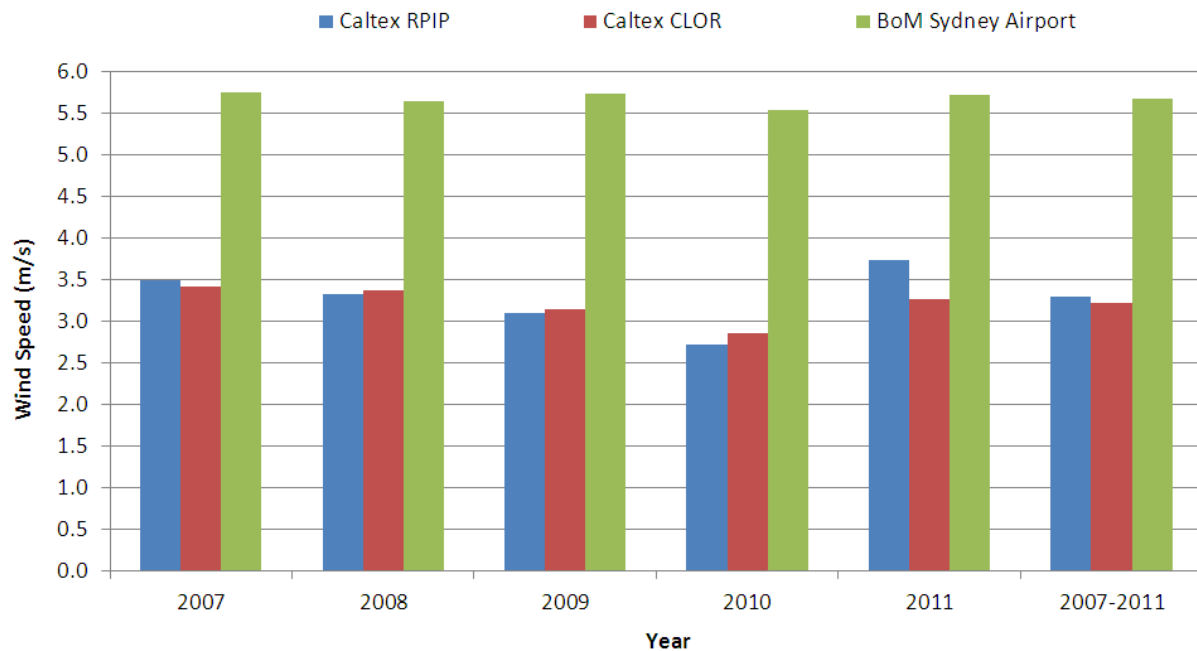
Annual Average Wind Speed

Table A-2 and **Figure A-4** show a comparison of annual average wind speed for the period 2007 to 2011. As can be seen wind speeds are fairly consistent with 2010 possessing the lowest annual average wind speeds at all stations, and 2007 possessing the highest annual average wind speeds at Caltex CLOR and BoM Kurnell, and 2011 possessing the highest annual average wind speeds at Caltex RPIP.

Table A-2 Comparison of annual average wind speed (2007-2011)

Period	Caltex RPIP	Caltex CLOR	BoM Kurnell
2007	3.50	3.41 (<i>max</i>)	5.74 (<i>max</i>)
2008	3.33	3.37	5.64
2009	3.09	3.15	5.73
2010	2.72 (<i>min</i>)	2.86 (<i>min</i>)	5.53 (<i>min</i>)
2011	3.73 (<i>max</i>)	3.27	5.71
2007 - 2011	3.29	3.21	5.67

Figure A-4 Comparison of annual average wind speed (2007-2011)



Frequency of Calm Conditions

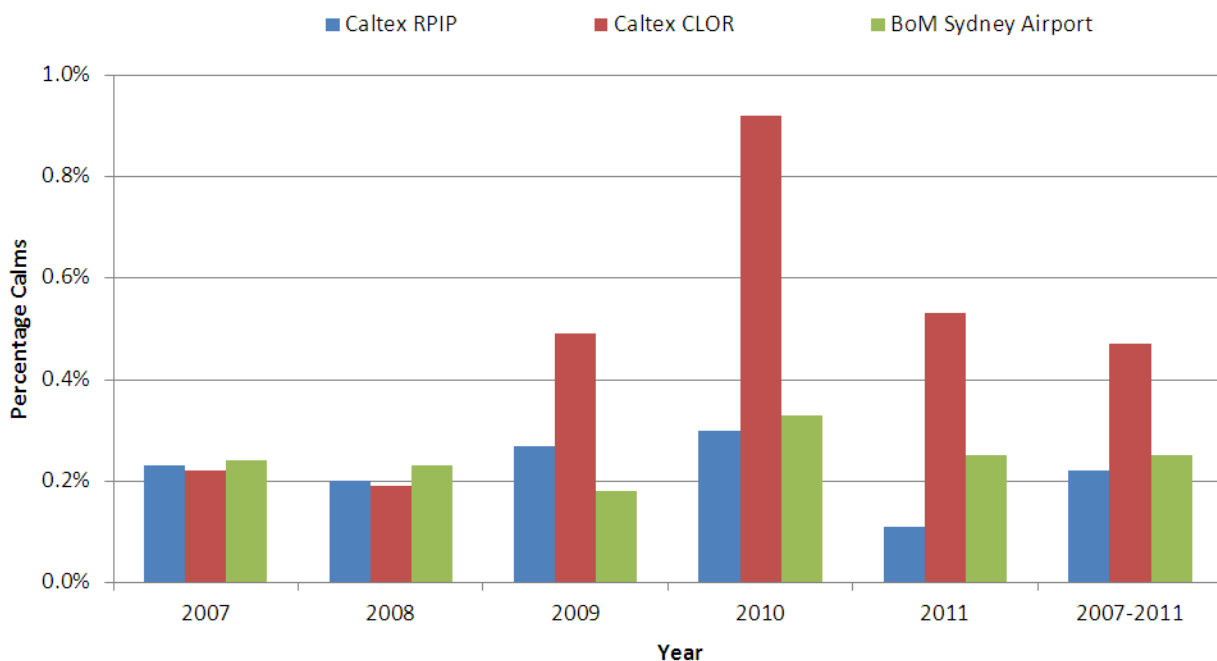
Table A-3 and **Figure A-5** show a comparison of the frequency of calm conditions for the period 2007 to 2011. As can be seen calm frequencies are fairly consistent between years with 2010 possessing the highest frequency of calm winds at all stations, and 2007 possessing the lowest frequency of calm winds at Caltex CLOR and BoM Kurnell.

Appendix A - Meteorological Data Preparation

Table A-3 Comparison of frequency of calm conditions (2007-2011)

Period	Caltex RPIP	Caltex CLOR	BoM Kurnell
2007	0.23%	0.22%	0.24%
2008	0.20%	0.19% (<i>min</i>)	0.23%
2009	0.27%	0.49%	0.18%(<i>min</i>)
2010	0.30% (<i>max</i>)	0.92%(<i>max</i>)	0.33%(<i>max</i>)
2011	0.11% (<i>min</i>)	0.53%	0.25%
2007 - 2011	0.22%	0.47%	0.25%

Figure A-5 Comparison of frequency of calm conditions (2007-2011)

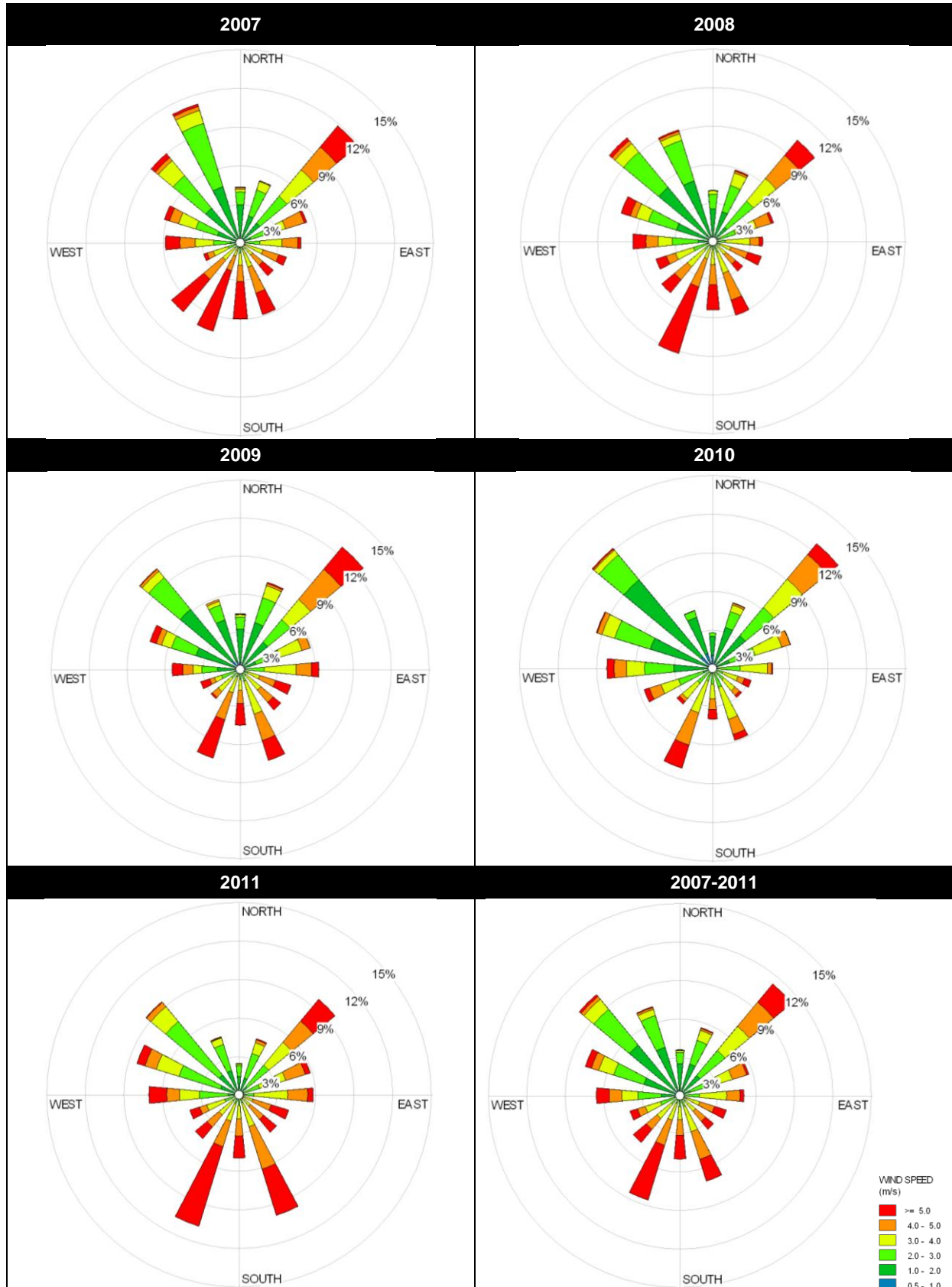


Wind Direction Frequency Distribution

Figure A-6 shows a comparison of annual wind roses for the Caltex RPIP AWS for the period 2007-2011. Winds are shown to be well distributed in all directions, with the slight accentuation of north easterly sea breezes, south-south westerly and north-westerly winds common to the coastal areas of Sydney. Winds appear fairly consistent between years, with 2008 showing the greatest consistency with the 2007-2011 5 year wind rose.

Appendix A - Meteorological Data Preparation

Figure A-6 Comparison annual wind roses at the Caltex RPIP AWS (2007-2011)



Appendix A - Meteorological Data Preparation

A.4.3 Screening of Assessment Year

The representativeness of each year (2007-2011) was reviewed in the context of the 5 years of data. 2009 was not used due to low data availability, whilst 2010 possessed lowest average wind speeds at all reviewed stations, and 2007 possessed higher than average wind speeds at all stations. This leaves 2008 and 2011 as potentially suitable for use. Of these two years, 2011 possessed highest average wind speeds at the Caltex RPIP AWS (the AWS with closest proximity to key receptors). In addition, the Caltex RPIP 2008 wind rose showed a reasonable consistency with the 2007-2011 5 year wind rose. On this basis 2008 was selected for use in the assessment. **Table A-4** provides a summary of this basis.

Table A-4 Screening of Assessment Year (2007-2011)

Year	Consistency with 5 year review period
2007	Higher than average wind speeds.
2008	Consistency with 5 year wind rose and other wind statistics.
2009	Low data availability at all stations.
2010	Lowest average wind speeds.
2011	Highest average wind speed at Caltex RPIP.

A.5 Meteorological Modelling

The meteorological modelling has been performed in order to provide a full dataset of meteorological records as required by Ausplume. This dataset includes parameters of mixing height and atmospheric stability, which cannot be measured directly, and must be derived using empirical methods, or through the numerical modelling of atmospheric processes. In this case, such modelling has been performed using the TAPM model developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

TAPM is a synoptic scale meteorological model that has been identified as a suitable model of choice to simulate meteorological fields in a number of situations¹¹. TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical co-ordinate for three-dimensional simulations. It includes parameterisations for cloud/rain micro-physical processes, turbulence closure, urban/vegetative canopy and soil, and radiative fluxes.

TAPM (Version 4), in conjunction with the input databases provided by CSIRO, was used to generate a comprehensive meteorological file for the RPIP AWS.

The following TAPM settings and input files were used:

- 5 nested model grids (at 30, 10, 3.0, 1.0 and 0.3 km resolution), 25 x 25 grid points, with 25 vertical levels;
- Grid centre coordinates: 151°13'00"E, 34°01'00"S, (MGA94: 335335 mE, 6234562 mN);

¹¹ CSIRO (2005) *The Air Pollution Model (TAPM) Version 3. Part 2: Summary of Some Verification Studies*. CSIRO Atmospheric Research Technical Paper 72, 2005.

Appendix A - Meteorological Data Preparation

- Assimilation of meteorological data (configured to affect the two lowest vertical levels, i.e. 10 and 25 m) from:
 - BoM Sydney Airport AWS, Radius of Influence (ROI): 3 km ;
 - Caltex RPIP AWS, ROI: 1.0 km;
 - Caltex CLOR AWS, ROI: 1.5 km;
- Data exported at RPIP AWS site as an Ausplume compatible meteorological file.

Given the weight of the assimilation data in TAPM, the wind predictions contained in the RPIP output file are nearly identical to those measured at the RPIP AWS. In this assessment, for hours where actual monitoring records were available, wind speed and direction records in the output file have been overwritten with the actual RPIP data. This provides a file with the actual RPIP wind data that has been augmented to provide the full set of meteorological parameters required by the Ausplume dispersion model, for every hour of the year 2008.

A.6 Results

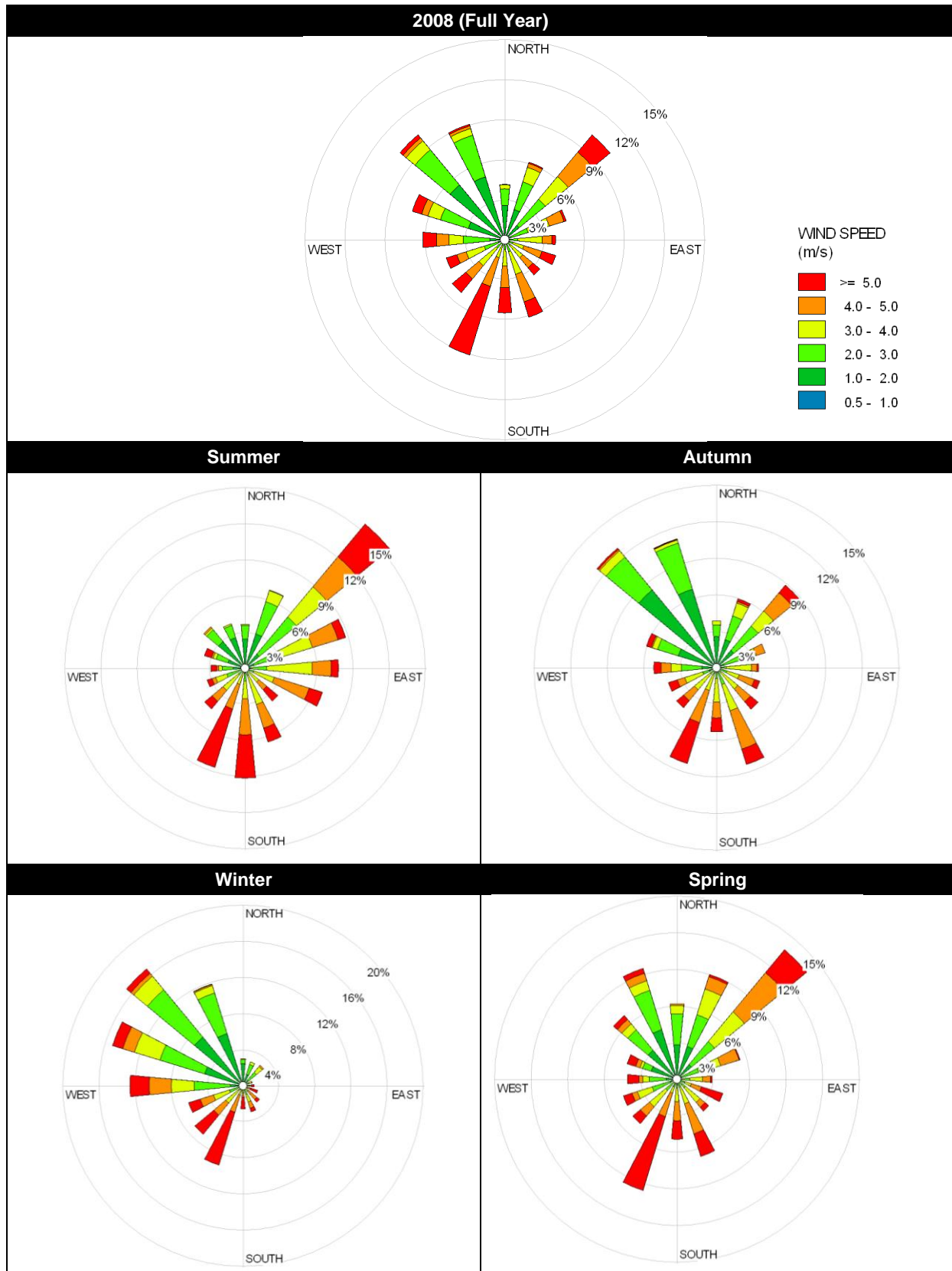
This section provides a summary and analysis of meteorological dataset that was used for the dispersion modelling as part of this assessment.

A.6.1 Winds

Figure A-7 provides annual and seasonal wind roses for the RPIP-based Ausplume meteorological dataset.

Appendix A - Meteorological Data Preparation

Figure A-7 RPIP-based annual and seasonal wind roses (2008)

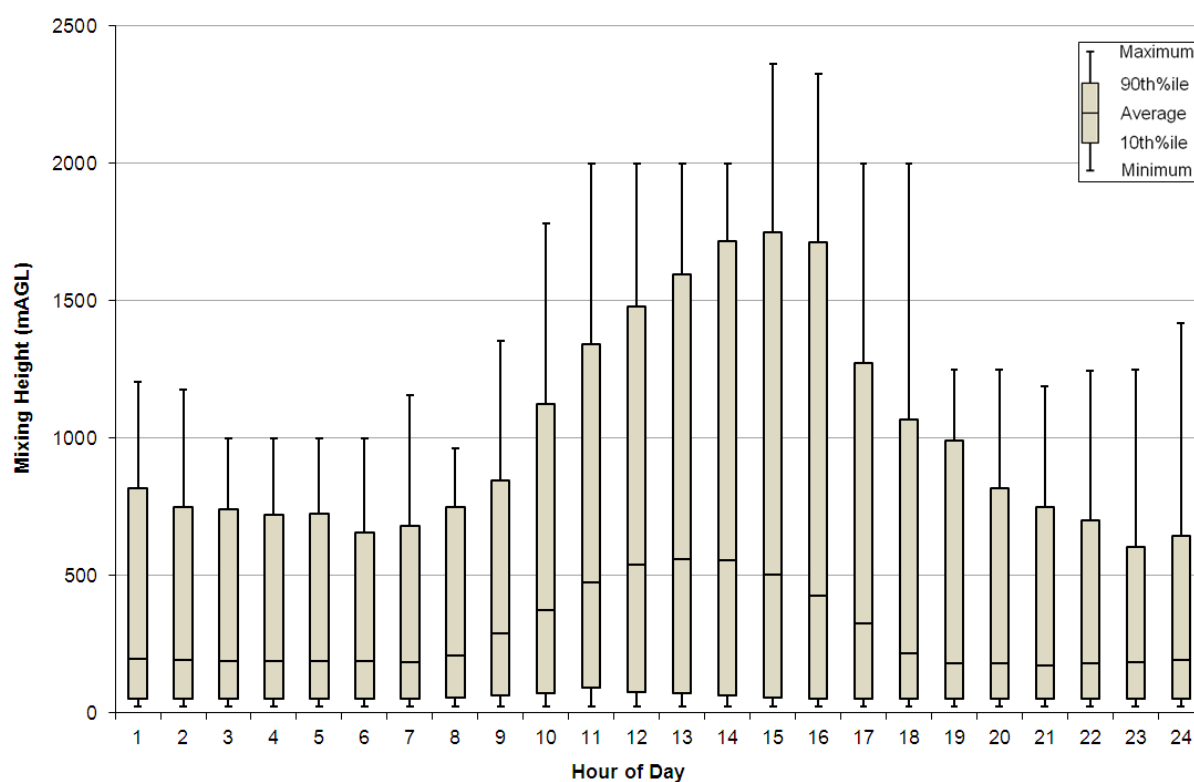


Appendix A - Meteorological Data Preparation

A.6.2 Mixing Height

Figure A-8 shows the mixing height against the hour of the day as generated by TAPM at the RPIP AWS. The figure shows that the predicted mixing height increases with increasing solar radiation as a function of time of day, with peak average mixing heights of approximately 500 m Above Ground Level (AGL). This is consistent with general atmospheric processes that show increased vertical mixing during the daytime, as well lower mixing heights than would be experienced further inland. Night time conditions are cooler, more stable, and as expected, winds are generally lighter thus vertical mixing is reduced, leading to lower mixing heights.

Figure A-8 TAPM predicted mixing height at RPIP AWS by hour of day



A.6.3 Stability Class

Stability class is used as an indicator of atmospheric turbulence for use in meteorological models. The class of atmospheric stability generally used in these types of assessments is based on the Pasquill-Gifford-Turner scheme where six categories are used (A to F) which represent atmospheric stability from extremely unstable to moderately stable conditions. The stability class of the atmosphere is based on three main characteristics, these being:

- Static stability (vertical temperature profile/structure);
- Convective turbulence (caused by radiative heating of the ground); and
- Mechanical turbulence (caused by the motion of wind over irregular surfaces).

The Pasquill Gifford Stability classes are provided in **Table A-5**.

Appendix A - Meteorological Data Preparation

Table A-5 Modified Pasquill-Gifford stability classes (adapted from Turner, 1994¹²)

Surface Wind Speed at 10m (m/s)	Insolation			Night-time cloud (Oktas)	
	Strong	Moderate	Slight	Thinly overcast of > 4/8 low cloud	< 3/8 Cloud
≤ 2	A	A-B	B	-	-
2 - 3	A-B	B	C	E	F
3 - 5	B	B-C	C	D	E
5 - 6	C	C-D	D	D	D
> 6	C	D	D	D	D

The Pasquill Gifford Stability Classes, shown in **Table A-6** shows stability class frequencies that reflect the proximity to the coast, with higher wind speeds, and the absence of surrounding land mass reducing the prevalence of conditions driven by radiative heat transfer, namely A/B and E/F stability classes, as relative to what would be typically expected further inland.

Table A-6 TAPM predicted stability class at RPIP AWS

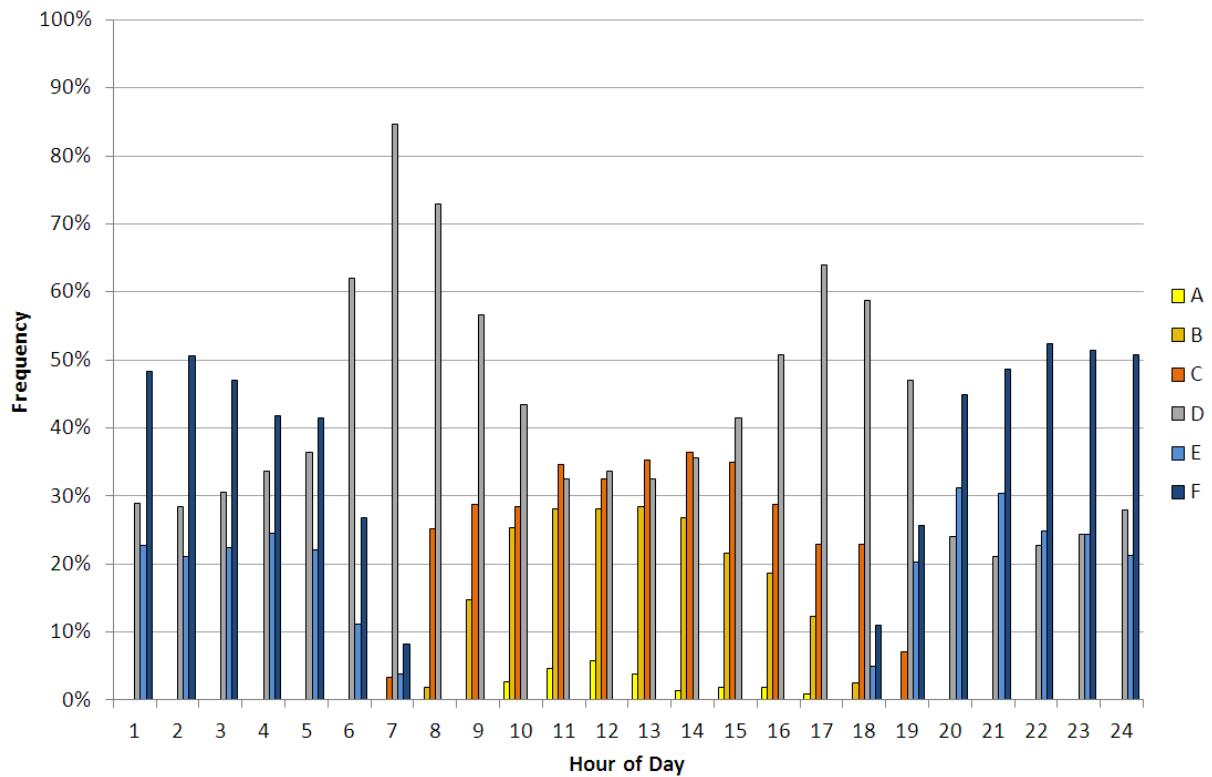
Stability Class	Frequency
A (Extremely Unstable)	1.0%
B (Moderately Unstable)	8.7%
C (Slightly Unstable)	14.2%
D (neutral)	41.4%
E (Slightly Stable)	11.9%
F (Moderately Stable)	22.9%

In addition to their frequency, Stability Classes have also been presented as a function of time of day, as shown in **Figure A-9**. As expected, there is a tendency for the unstable classes (Stability Classes A, B and C) to occur during daytime, whilst stable conditions (Stability Classes E and F) are shown to occur primarily during night time. This distribution of stability class is consistent with the values contained in **Table A-5**.

¹² Turner B (1994) *Workbook of Atmospheric Dispersion Estimates: An Introduction to Dispersion Modelling*. 2nd Edition. CRC Press Inc.

Appendix A - Meteorological Data Preparation

Figure A-9 TAPM RPIP AWS predicted stability class vs hour of day



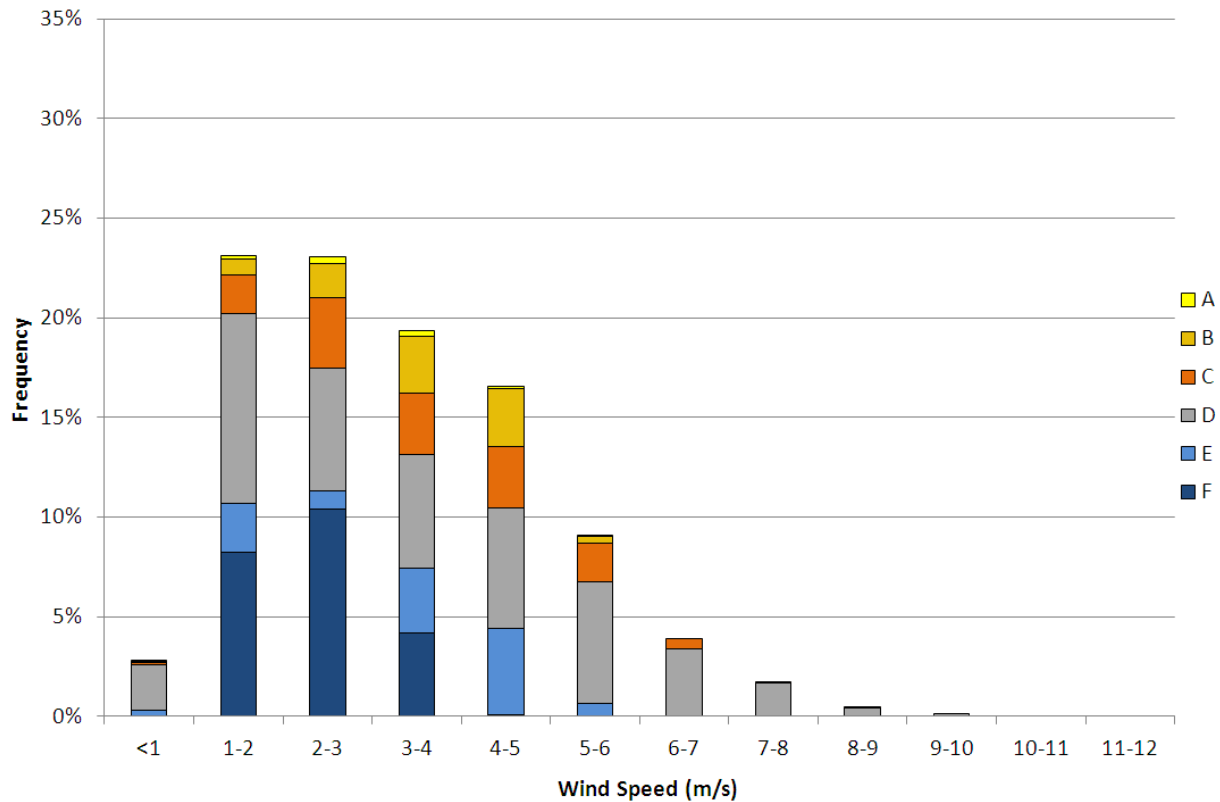
Stability Classes have been presented against wind speed, as shown in **Table A-7** and **Figure A-10**. As expected, the highest wind speeds are associated with neutral stability classes (Stability Classes C and D). The more unstable conditions (Stability Classes A and B) are associated with lower wind speeds, and the more stable conditions (Stability Classes E and F) are also associated with lower wind speeds. These data are consistent with the values contained in **Table A-5**.

Table A-7 TAPM RPIP AWS stability class vs wind speed

Stability Class	Wind Speed (m/s)												All
	<1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
A	4	16	30	24	9	1	0	0	0	0	0	0	84
B	5	68	153	253	256	27	1	0	0	0	0	0	763
C	10	171	307	269	269	173	45	3	1	0	0	0	1248
D	200	837	541	500	532	534	291	146	39	13	0	4	3637
E	24	215	81	285	377	57	4	0	0	0	0	0	1043
F	4	720	911	366	8	0	0	0	0	0	0	0	2009
TOTAL	247	2027	2023	1697	1451	792	341	149	40	13	0	4	8784

Appendix A - Meteorological Data Preparation

Figure A-10 TAPM RPIP AWS generated Stability Class vs wind speed



A.7 Conclusion

A review of meteorology in the region has been performed, and a meteorological dataset prepared incorporating a range of site-specific data. The resulting meteorological dataset has been analysed, and shown to be consistent with expected atmospheric behaviours for the region. It is therefore considered that the meteorological dataset is appropriate for use in this assessment.

Appendix B Background on Key VOC Pollutants

Appendix B - Background on Key VOC Pollutants

This section provides a brief background on the VOC pollutants identified in **Section 3.3.1**.

B.1 Benzene

Benzene found in the environment is generated by both human activities and natural processes. Benzene is a volatile, colourless liquid with a characteristic "aromatic" odour, and was first discovered and isolated from coal tar in the 1800s. Today, most benzene is produced from petroleum sources and because of its wide use, benzene is produced in large volumes in many countries. Various industries use benzene to make other chemicals, such as foam, nylon and synthetic fibres. Benzene is also used for the manufacturing of some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides. Natural sources of benzene, including volcanoes and forest fires, also contribute to the presence of benzene in the environment. Benzene is also a natural part of crude oil, petrol and cigarette smoke (ATSDR, 2007a). Benzene is also known as benzol. Benzene evaporates into air very quickly and dissolves slightly in water. Benzene is highly flammable.

Acute exposure to high levels of benzene produces central nervous system excitation and depression. Acute ingestion of benzene causes gastrointestinal and neurological toxicity (WHO, 1993). Chronic exposure to benzene results primarily in haematotoxicity. Chronic benzene exposure is associated with an increased risk of leukaemia. Benzene is classified as a "known" human carcinogen (Category A) by the USEPA under the Risk Assessment Guidelines of 1986 (and USEPA, 1996) for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies.

B.2 Toluene

Toluene, also known as methylbenzene and phenylmethane, is a colourless liquid with a sweet pungent, benzene-like odour. Toluene occurs naturally in crude oil and in the tolu tree. It is produced in the process of making petrol and other fuels from crude oil, in making coke from coal, and as a by-product in the manufacture of styrene. Toluene is used in making paints, paint thinners, fingernail polish, lacquers, adhesives and rubber and in some printing and leather tanning processes. It is disposed of at hazardous waste sites as used solvent (a substance that can dissolve other substances) or at landfills where it is present in discarded paints, paint thinners and fingernail polish (ATSDR, 2000). Toluene is highly volatile and flammable.

Inhalation is the primary route of toluene exposure for the general population and for occupationally exposed individuals. Evaporation of petrol and vehicle exhaust is the largest source of toluene in the environment, and industries that use toluene as a solvent are the second largest source. Toluene is also a common indoor contaminant due to releases from common household products and from cigarette smoke. Trace amounts are typically found in food and water. Toluene is absorbed via ingestion, inhalation and skin application.

Health effects of Toluene are associated with acute, intermediate and chronic exposures. Chronic occupational exposure to toluene has resulted in headaches, dizziness, and impaired neurobehavioral performance. Effects on the function of liver, kidneys, reproductive system, respiratory system and skin have also been noted.

Appendix B - Background on Key VOC Pollutants

B.3 Ethylbenzene

Ethylbenzene is a colourless liquid that smells like petrol, evaporates at room temperature and burns easily, and possesses an aromatic odour. Ethylbenzene occurs naturally in coal tar and petroleum. It is also found in many products, including paints, inks and insecticides and is also used in the production of styrene. It is also used as a solvent; a component of asphalt and naphtha; and in fuels, and by the chemical industry for the manufacture of a range of organic chemicals. Consumer products containing ethylbenzene include pesticides, carpet glues, varnishes and paints, and tobacco products (ATSDR, 2007b).

Inhalation is the primary route of ethylbenzene exposure for the general population and for occupationally exposed individuals. However, it is also present in trace amounts in some water supplies; hence, ingestion (and dermal contact) may be an important exposure pathway. Exposure of the general population to ethylbenzene may occur through contact with petrol, evaporation of petrol and vehicle exhaust, solvents, pesticides, printing inks, varnishes, coatings and paints. Ethylbenzene is also a common contaminant due to releases from cigarette smoke.

Health effects of Ethylbenzene are associated with particularly associated with acute exposures. The primary target organs following chronic oral and inhalation exposures are likely to be the liver and kidney, with central nervous system depression identified following acute exposures, which are likely to cause irritation of the respiratory tract and effects such as dizziness and vertigo.

B.4 Xylenes

There are three forms of xylene in which the methyl groups vary on the benzene ring: *meta*-xylene, *ortho*-xylene, and *para*-xylene (*m*-, *o*-, and *p*-xylene). These different forms are referred to as isomers. The term total xylenes refer to all three isomers of xylene (*m*-, *o*-, and *p*-xylene). Xylene is a colourless, flammable liquid with a sweet odour which evaporates and burns easily. Chemical industries produce xylene from petroleum. Xylene also occurs naturally in petroleum and coal tar, and is formed during forest fires. It is used as a solvent (a liquid that can dissolve other substances) in the printing, rubber, and leather industries. Along with other solvents, xylene is also used as a cleaning agent, a thinner for paint, and in varnishes. It is found in small amounts in aviation fuel, and is a major component of petrol. Xylene is used as a material in the chemical, plastics, and synthetic fibre industries, and as an ingredient in the coating of fabrics and papers. Isomers of xylene are used in the manufacture of certain polymers (chemical compounds), such as plastics (ATSDR, 2007c).

Inhalation is the primary route of xylene exposure for the general population and for occupationally exposed individuals. However, xylenes are ubiquitously distributed in the environment, and have been detected in air, rainwater, soils, surface waters, sediments, drinking water, aquatic organisms, human blood, urine and expired breath.

Exposure of the general population to xylene may occur through contact with petrol, evaporation of petrol, vehicle exhaust, workplace air, solvents and ingestion of contaminated drinking water. Xylene is also a common contaminant due to releases from cigarette smoke.

Health effects of mixed xylenes, *o*-xylene, *m*-xylene and *p*-xylene appear to be similar, although the individual isomers are not necessarily equal in potency with respect to a particular effect. Studies indicate that the central nervous system is a major and sensitive target of xylene toxicity via inhalation and oral routes. The primary target organs following chronic oral and inhalation exposures are likely to be the central nervous system and its development. Some studies indicate enlargement of the liver

Appendix B - Background on Key VOC Pollutants

and kidneys following oral exposure to mixed xylene. Other target organs identified following inhalation exposure include the respiratory system, altered haematological parameters and nose and throat irritation.

B.5 n-Hexane

n-Hexane (hexane) is a solvent that has many uses in the chemical and food industries, either in pure form or as a component of the commercial hexane mixture. Highly purified n-hexane is primarily used as a reagent for chemical or chromatographic separations. Commercial n-hexane is a mixture that contains approximately 52% n-hexane (with the remaining typically comprising isohexane and cyclohexane). Mixtures containing n-hexane are also used in the extraction of edible fats and oils in the food industry, as cleaning agents in textile and furniture manufacturing, and in the printing industry. n-Hexane is the solvent base for many commercial products, such as glues, cements, paint thinners, and degreasers. The chemical is a minor constituent of crude oil and natural gas and, therefore, represents a variable proportion of different petroleum distillates.

The most probable route of human exposure to n-hexane is by inhalation. Individuals are most likely to be exposed to n-hexane in the workplace; however, monitoring data indicate that n-hexane is a widely occurring atmospheric pollutant. Exposure from contact with vapours or emissions from heating and motor fuels refined from petroleum products is the most widespread form of low-level exposure for the general population. Most n-hexane in these fuels is oxidized, or destroyed, as part of the combustion process to provide heat or drive internal combustion engines. Small amounts of n-hexane, along with other petroleum compounds, volatilise to the atmosphere during handling, storage in fuel tanks, or through incomplete combustion. Research suggests that certain fungi may be able to produce n-hexane.

The acute toxicity of n-hexane is low. Effects of acute exposure to n-hexane in humans include irritation to the eyes, nose, and throat, blurred vision, and neurotoxicity at relatively high concentrations. Single exposures to n-hexane can cause vertigo, giddiness, and drowsiness. n-Hexane is also a mild skin irritant and can also irritate the eyes. Case studies of occupational exposure to n-hexane show that exposure for intermediate (15 to 365 days) and long (over one year) periods of time results in peripheral neuropathy (degeneration of nerve endings) in humans.

Appendix C Summary of Emission Source Parameters

Confidential and Sensitive Document – Exempt from disclosure under the Government Information (Public Access) Act 2009 (NSW)

The complete Air Quality Impact Assessment is provided to the NSW Department of Planning & Infrastructure (“DP&I”) by Caltex Refineries (NSW) Pty Ltd (“Caltex”) in confidence for use only within DP&I and the NSW Environment Protection Authority (EPA). It is submitted on the basis that there is an overriding public interest against disclosure pursuant to section 14(2) of the *Government Information (Public Access) Act 2009 (NSW)* (the “Act”). The Report is exempt from disclosure under the Act on the grounds that it contains information associated with the storage of security sensitive petroleum finished product and information that is commercial-in-confidence.

The information which is exempt from disclosure applies specifically to the following parts of the Report:

- The full version of **Table 3-1** and **Figure 5-4**;
- Appendix C Summary of Emission Source Parameters; and
- Appendix D Sample Ausplume List File.

These parts of the Report have been excluded as they must not be copied or distributed outside DP&I or EPA without the express permission of Caltex.

Appendix D Sample Ausplume List File

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- Appendix D Sample Ausplume List File.

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