Vopak Terminal B4
Vopak Terminals Pty Ltd
27-May-2016

Air Quality Impact Assessment

Vopak Terminal B4 - State Significant Development

27-May-2016
Prepared for – Vopak Terminals Pty Ltd – ABN: 67 004 754 750

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1.0 Introduction

1.1 Project Overview

This Air Quality Impact Assessment (AQIA) was prepared by AECOM Australia Pty Ltd (AECOM) to support the Environmental Impact Statement (EIS) prepared on behalf of Vopak Terminals Pty Ltd (Vopak) for a State Significant Development (SSD) application for the Stage B4 Expansion Project. The expansion project consists of the construction and operation of a petroleum tank farm at Port Botany, NSW, which would consist of seven storage tanks with a total nominal capacity of 200 ML (the Project).

The main potential sources of air emissions associated with the proposed development are vapour emissions (volatile organic compounds, or VOCs) from the storage and transfer of fuels. The purpose of this assessment was to estimate the emissions of VOCs from the facility and the resultant concentrations of these pollutants at sensitive receptor locations. This report provides details of the methodology and results of the dispersion modelling of VOC emissions.

The assessment has been undertaken with consideration of the cumulative impacts of other Vopak operated facilities in Port Botany, and also addresses the emissions and impacts from the existing Site B Terminal as proposed under their current Section 75W Development Modification 2650515. The 75W Modification proposes an increase in site throughout from 3,950ML per year to 7,800ML.

1.2 Scope of Work

The assessment was undertaken in accordance with the NSW Environment Protection Authority (NSW EPA) *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (The Approved Methods) (DEC 2005). Impacts from the operation of the B4 terminal have been included in the dispersion model CALPUFF, together with the emissions from the adjacent Vopak Site B (as modified under 75W Modification 2650515), Bulk Liquid Berths and the nearby Vopak Bitumen facility. These sites have been included in the one air dispersion model as they are all integral to the operation of Vopak B4. In addition, the Vopak Bitumen facility has also been included in the dispersion model as the site is also operated by Vopak. Emissions from other nearby facilities, such as the Terminals liquid storage facility, have been included as background values and not specifically modelled.

The assessment considered the following pertinent information from the stated facilities:

<u>Vopak Site B4:</u>

- Storage tank emissions from working and standing losses due to operation of seven new storage tanks (nominally three combustible and four flammable).

<u>Vopak Site B:</u>

- An increase in storage tank emissions due to an increase in throughput from 3,950Mlpa to the proposed 7,800Mlpa, with a mixture of petroleum, diesel, biodiesel, ethanol and jet fuel stored on-site.
- The continued operation of the existing vapour recovery system on the truck loading gantry, accommodating for the proposed increase in throughput.

<u>Bulk Liquid Berths:</u>

- Emissions from the Bulk Liquid Berths due to fugitive emissions from pipework, flanges and other fittings.

<u>Vopak Bitumen:</u>

- Operation of the vapour combustion unit.
- Bitumen storage tank breathing losses.

1.3 Secretary's Environmental Assessment Requirements

In preparing this AQIA, consideration has been given to the NSW Planning and Environment (P&E) Secretary's Environmental Assessment Requirements (SEARs) issued for the project (SSD 7000) on 30 April 2015. The key matters raised by the Secretary, and where this report addresses them, are outlined in **Table 1**.

Table 1 Secretary's Environmental Assessment Requirements

Secretary's Environmental Assessment Requirement	Section Addressed
A quantitative assessment of the air quality and odour impacts of the development on surrounding receivers	**Section 7.0**
Details of mitigation, management and monitoring measures for preventing and/or minimising emissions	**Section 10.0**
An assessment of the potential greenhouse gas emissions of the proposed development	Addressed in the Site B4 AQIA.

1.4 Structure of Report

The structure of the remainder of the report is provided in **Table 2**.

Table 2 Structure of Report

Section	Brief
Section 1	Assessment overview
Section 2	Provides a description of the Project
Section 3	Describes the existing environment, including a review of existing air quality and local climate conditions
Section 4	Outlines the impact assessment criteria used in this assessment
Section 5	Detailed description of the air quality assessment methodology, specifically emissions and dispersion models applied
Section 6	Identifies the inputs required for the dispersion model and includes meteorology, terrain, source characteristics and emission rate
Section 7	Assessment of the potential air quality impacts of the Project on the local air shed and provides assessment of relevant criteria against identified sensitive receptors
Section 8	Assessment of the ozone generation and potential impacts as a result of the Project
Section 9	Describes the mitigation measures that are currently used at the Facility or that are recommended to be implemented as part of the Project
Section 10	Provides the study conclusions

2.0 Project Description

The following sections provides a brief background to the primary facility being assessed, Vopak site B4, and secondly those facilities that have been included in the air dispersion model.

2.1 Proposed Vopak Site B4

The Project consists of the construction and operation of a liquid fuels (finished or refined petroleum) storage depot. This would involve the construction of seven storage tanks with a total nominal capacity of 200 ML. Vopak proposes to undertake the Project in two stages:

- Stage 1 (B4A):
  - Construction of three storage tanks and bunding dedicated to ADO (diesel fuel with a nominal total capacity of 105,000 m^3);
  - Construction of new pipelines/culverts to inter-connect with the Site B (B1) manifold;
  - Installation of manifold/transfer pumps and connections to utilities; and
  - Extension of existing Site B fire protection system to the B4A site.
- Stage 2 (B4B):
  - Construction of four storage tanks (nominal combined total capacity of 95,000 m^3) capable of storing any Class 3 combustible product;
  - Construction of additional transfer pipelines to Site B manifold systems; and
  - New fire protection system complying with AS 1940 requirements.

2.1.1 Development Location

The existing Site is located on part of the former Qenos Hydrocarbon Terminal at 39 Friendship Road, Port Botany, which protrudes into Botany Bay. The site is approximately 12 km south-east of the Sydney Central Business District. Vopak currently operates the Site B Terminal in Port Botany located at 20 Friendship Road.

The site is surrounded by industrial properties, including operations handling containers, bulk liquids and petrochemicals. Sydney Airport is located to the northwest of the site. Closest residential areas are located approximately 1.4 km to the east of the site, across Yarra Bay.

2.1.2 Infrastructure

The dimensions of the proposed Site B4 tanks are summarised in **Table 3**.

Table 3 Proposed Tanks

Area	Tank No.	Diameter (m)	Height (m)	Shell Volume (m^3)	Safe Fill Volume (m^3)	Operating Volume (m^3)	Product
B4A	110-01	43.5	24.7	36,700	35,200	33,700	Diesel
	110-02	43.5	24.7	36,700	35,200	33,700	
	110-03	43.5	24.7	36,700	35,200	33,700	
B4B	110-04	41	24	31,600	30,300	29,000	Gasoline/ petroleum
	110-05	41	24	31,600	30,300	29,000	
	110-06	29	24	15,800	15,000	14,500	
	110-07	29	24	15,800	15,000	14,500	

Area B4A tanks would be made from carbon steel, each with an aluminium geodesic dome roof (no internal floating roof). Area B4B tanks would be carbon steel floating roof tanks with aluminium geodesic dome roofs. All tanks would be painted white.

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AECOM

SITE LOCATION

Environmental Impact Statement
Vopak Terminals, Port Botany, New South Wales

FIGURE 1

2.1.3 Project Construction

The proposed construction timetable is for work to commence in Quarter 4, 2016 and be completed by early 2018. An indicative program of works for the construction phase, relative to the main construction activities, is shown in **Table 4**.

Table 4 Proposed Timeline for Each Stage of Construction Activities

Item	Description	Start (Week)	Finish (Week)
Mobilisation	- Initial mobilisation of construction team to the site and establishment of construction infrastructure such as construction office, car parking laydown areas. - Establish construction site fencing and security measures.	1	9
Civil works	- Modify site drainage to isolate and control runoff from the construction site; - Bund wall sub base preparation; - Construct vertical bund walls; - Prepare for and construct tank foundation; and - Apply asphalt to remaining hardstand areas.	10	14
Tank works	- Fabrication and installation of tanks in Site B4 - Hydrostatic testing of tanks	15	54
Fire and safety systems installation	- Piping installation for connection to fire ring main. - Installation of fire water sprays systems. - Installation of fire detection system.	23	54
Electrical works	- Installation of electrical control systems - Connection to existing Vopak terminal management systems. - Connection to utility electrical supplies.	25	56
Commissioning	- Testing and commissioning of fuel movement and storage systems. - Testing and commissioning of fire management systems.	57	70

Activities that have the potential to result in airborne pollutants during the construction phase include earthmoving during site preparation and handling of any excavated material. Prior to construction activities taking place, a Construction Environmental Management Plan (CEMP) would be prepared to address the management of potential environmental impacts associated with construction activities. The CEMP would include measures to manage and mitigate air quality and odour emissions. As the works would be intermittent in nature, the implementation of an appropriate CEMP is expected to adequately mitigate any construction emissions from the Site as discussed in **Section 9.1**. As such, Construction emissions were not assessed quantitatively in the AQIA.

2.1.4 Project Operations

The Project would facilitate the following operations:

- Ship unloading to Site B4 directly from Bulk Liquid Berth 1 and 2 via Site B;
- Tank to tank transfers with Site B; and
- Tank recirculation.

The Project will be connected to the existing Site B Vopak Terminal truck load-out gantry. Vopak recently lodged a modification application for the Site B consent, which sought approval for the increase in throughput of the gantry.

The main emissions of interest for fuel storage activities are VOCs. VOCs are organic compounds with a vapour pressure exceeding 0.13 kPa at a temperature of 20^{o}C. VOCs have been implicated as a precursor in the production of photochemical smog, which causes atmospheric haze, eye irritation and respiratory problems. VOCs can be emitted from storage tanks, filling stations vents, pipelines and process equipment leaks at plant associated with fuel storage. The primary emission sources are storage tank and pipeline losses.

2.2 Vopak Site B 75W Modification

The following section provides a brief description of the Vopak Site B 75W Modification, with the full details of the Modification provided in the following report:

- PlanCom May (2015) *Section 75W Modification – MP 06_0089 – Modification 2 – Environmental Assessment, Vopak Terminals Sydney Pty Ltd, Site B Bulk Liquids Storage Terminal.*

The existing Site B Terminal is adjacent to the Bulk Liquids Berths (BLB). At present the total annual approved product throughput is 3,950,000 m3 (3,950 ML) and it is proposed to increase the total approved product throughput to 7,800,000 m3 (7,800 ML).

The proposed changes to the Site B Facility as part of the 75W modification include the following:

- West Entry Northern Approach Roadways - requiring the need to lease an additional 2,870 m2 of land from NSW Ports to the north and west of Site B plus the modification to the Simblist Road intersection with Friendship Road;
- Construction of Three New Road Tanker Loading Bays (Bays 7 & 8 and Bay 9);
- Installation of additional transfer pumps and product supply pipelines to existing RT Pump Manifolds;
- Construction of One Road Tanker Unloading Bay for Biofuels, Additives and other ancillary products together with RT unloading pumps;
- Construction of a New Drivers' Amenities Building at Fishburn Road entrance;
- Ship Import debottlenecking of inlet manifolds, tank import pipelines and tank inlets, inclusive of tank-to-tank and tank recirculation piping and pump facilities as well as instrumentation for quantity and quality control to increase flowrates;
- Ship debottlenecking of tank outlets, pipelines and transfer pumps as well as instrumentation for quantity and quality control to increase flowrates;
- Additional Ship connection Marine Loading Arm complete with berth and terminal import line and manifold extensions to increase the number of simultaneous shipping operations;
- Civil, Structural, Piping, Electrical and Instrumentation Works for the above; and
- Increase in the size of the approved Warehouse (8m x 12m) near the Fire Pump House. The proposal is to extend the Warehouse to be 12m x 20m.

2.3 Bulk Liquid Berths

The below provides a brief description of the Bulk Liquids Berths, with full details provided in the following report:

- SKM (2007) *Bulk Liquids Berth No. 2 – Port Botany – Air Quality Impact Assessment*.

Two Bulk Liquids Berths (BLB) at Port Botany, No's 1 and 2 (BLB 1 and BLB 2), service the discharge and load requirements of the petrochemical industry in New South Wales. The BLB is a shared common user facility operated by NSW Ports. Hazardous and non-hazardous bulk liquids, petrochemicals and gases are transferred by pipeline to nearby industry storage facilities which are operated by private companies, including Vopak. Bulk liquids (which include VOC containing liquids such as petroleum) are discharged from the BLBs to the liquid storage terminals via MLA connected to the Ship Manifold pipework.

2.4 Vopak Bitumen

The below provides a brief description of the Vopak Bitumen facility, with full details provided in the following report:

- Pacific Environment Limited (2015) *Vopak Terminals Sydney Pty Ltd – Air Quality Assessment For Vopak Bitumen Storage Facility - Vopak Terminals Sydney Pty Ltd.*

The Vopak bitumen facility includes three 7,300 m3 tanks for the storage of bitumen products, gantry facilities for loading and in-line blending bitumen road tankers, a thermal oil and heating system and furnace and a dedicated pipeline for bitumen unloading from ships. A vapour combustion unit treats large tank vapours during ship unloading operations and truck venting during filling.

The source characteristics, emission rates and other details of the Vopak Bitumen facility have been sourced directly from PEL 2015 (as provided in **Appendix D**). The source details have not been reproduced in this B4 report.

3.0 Existing Environment

3.1 Air Quality

The pollutants of prime interest in NSW are ozone and particulates, with levels of these pollutants approaching or exceeding the national standards prescribed in the National Environment Protection Measure for Ambient Air Quality (NEPM) on occasion. The Vopak facility is not expected to generate significant levels of ozone or particulates.

Port Botany is the major NSW port for the handling of containers, bulk liquids and petrochemicals. The international and domestic airport terminals are located nearby, as are major arterial roads and the botany Freight Rail line. Industrial uses dominate the surrounding area, including the sections of Banksmeadow and Matraville abutting Port Botany.

No local monitoring of VOCs was identified at the time of preparation of this report. Despite this lack of relevant monitoring data, a cumulative assessment utilising predicted local VOC concentrations (including adjacent VOC sources) has been undertaken (refer to **Section 5.1**).

3.2 Regional Meteorology

The Bureau of Meteorology (BOM) records long-term meteorological data at a number of automatic weather stations around the country. The station that best represents the site is located at Sydney Airport, approximately 4.5 kilometres northwest of the Vopak B4 site, across Botany Bay. A summary of the long-term data recorded at this station is provided below; more data are provided in **Appendix B**.

The warmest temperatures occur between November and March, with the warmest average maximum temperatures occurring in January (26.5ºC). The coldest temperatures are recorded in the winter months, with the lowest average minimum temperature occurring in July (7.2ºC).

The highest average rainfall is recorded in June (122.8 mm), while September is the driest month (60.2 mm). Humidity in the area is typically between 50 and 74 %. Average wind speeds range from 12.6 – 25.3 kilometres per hour, and are typically higher at 3 pm compared to 9 am. Winds are predominantly from the northwest at 9 am, with also frequent winds from the western direction. At 3 pm, the winds swing around to predominantly blow from the northeast and southeast. Southerly winds are common both in the morning and afternoon.

4.0 Assessment Criteria

The EPA specifies impact assessment criteria for a range of pollutants (DEC, 2005). The criteria and associated averaging periods for the pollutants considered in this assessment are shown in **Table 5**.The pollutants represent those included in the National Pollutant Inventory (NPI) TANKS database as being constituents of diesel and gasoline fuel for which the EPA has impact assessment criteria.

Table 5 NSW EPA Assessment Criteria

Pollutant	Criteria (µg/m^3)	Averaging Period	Percentile	Applicable location
Benzene	29	1 hour	99.9th	At and beyond the boundary of the facility
Cumene	21	1 hour	99.9th	At the nearest existing or likely off-site sensitive receptor
Cyclohexane	19,000	1 hour	99.9th	At and beyond the boundary of the facility
Ethylbenzene	8,000	1 hour	99.9th	At and beyond the boundary of the facility
n-Hexane	3,200	1 hour	99.9th	At and beyond the boundary of the facility
Toluene	360	1 hour	99.9th	At the nearest existing or likely off-site sensitive receptor
Xylenes	190	1 hour	99.9th	At the nearest existing or likely off-site sensitive receptor

Due to the proximity of local industrial receptors, all pollutant concentrations were assessed at the site boundary of Site B and B4and beyond (with the exclusion of areas over water).

A level 2 assessment has been applied. The tank fuel throughputs and tank design data are site specific and the meteorological data was created specific for the project site. The meteorological data used included a combination of prognostic TAPM data and surface station data from the local area in accordance with the guidance document "*Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*" Barclay & Scire (2011). The data included surface information from Sydney Airport BoM station approximately 5km to the northwest of the site and is considered appropriate for use in the assessment.

The VOC speciation data used were based on the Australian Government provided NPI default values. It is AECOMs experience that these values are considered to be conservative and would likely result in an overestimation of actual emissions. Recent work on a similar tank farm showed a diesel liquid benzene percentage composition of closer to 0.004% rather than the default NPI value of 0.03%, and a cumene value of 0.02% compared to the default 0.96%.

Given the above information, the application of a level 2 assessment for the Project is considered a reasonable approach.

5.0 Assessment Methodology

5.1 Cumulative Assessment Methodology

In areas where significant pollutant levels may be expected due to emissions beyond that contributed by the project seeking approval, a cumulative assessment may be required. The primary pollutants of concern in relation to the Project are VOCs. A review of operations in Port Botany identified that Vopak is likely to be a primary contributor of VOCs in the immediate area. The operators in the adjacent area are identified on **Figure 1**.

In order to look at the cumulative impact of the entire Vopak Petroleum Site B facility and associated infrastructure, emissions from the BLB pipe loses, storage tanks from Site B (at the proposed 75W throughput), tanker loading gantry emissions from the existing Site B gantry (at the proposed 75W modification design), and storage tanks from the proposed site B4 have been included in the dispersion model. In addition, the Vopak Bitumen emissions have been included in the model as it is also operated by Vopak. Vopak Site A was decommissioned in March 2014 and has therefore been assumed to have no contribution to the cumulative impact.

In addition to the modelled sources provided above, the assessment has also taken into consideration the potential impacts from the following nearby notable emitters of VOCs, with a brief summary of each facility provided below:

- Terminals Pty Ltd Bulk Liquid Services; and
- Terminals Pty Ltd Bitumen Facility.

The identified facilities have undertaken air quality impact assessments in order to gain planning approval or in response to EPA directives for their current operational designs. The most recent reports prepared for the sites, and those that were used to estimate the background values for this Vopak assessment, are as follows with a brief summary of each facility provided below:

- Terminals Pty Ltd – Botany Stage 5B Expansion - Air Quality Impact Assessment, August 2013 GHD;
- Terminals Pty Ltd – Report for Port Botany Terminal Upgrade – Air Assessment, July 2008, GHD; and
- Terminals Pty Ltd – Report for Bitumen Import and Dispatch Facility, Port Botany – Air Assessment, April 2011, GHD.

Terminals have owned and operated the existing bulk liquid storage and handling facility for hazardous and non-hazardous bulk liquids at Port Botany since 1979. The original facility has undergone three subsequent expansions, each involving the construction of additional storage capacity. Terminals Pty Ltd provides bulk liquid storage, handling and repackaging services, import shipping of hazardous and non-hazardous liquid chemicals. The facility is located at 45 Friendship Road Port Botany, and is adjacent to the B4 site to the north east. The site includes 65 tanks ranging in size from 200m^3 to 8,000m^3, with a total capacity of 53,000m^3.

Terminals Bitumen is located on Simblist Road, Port Botany, and is adjacent to the Terminals liquid facility. It covers approximately 6,000m2 leased from Sydney Ports. The site has a storage capacity of 24,000m3 including nine storage tanks and associated infrastructure, as well as a two bay truck loading gantry.

Each of the above facilities air assessments predicted VOC impacts in the area adjacent to their site, although the data is often very limited. The data provided in the reports has been modified in order to be applicable to the B4 assessment in the following ways.

<u>Terminals Liquid Storage:</u>

- The most recent air modelling for the Terminals Liquid Storage site was reported in GHD 2008 and assessed a total capacity of 72,780m^3. Benzene emissions and impacts were reported primarily at four residential receptors, as well as reporting one ground level concentration (GLC) at or beyond the boundary. The maximum GLC reported was 15 ug/m^3, however the provided contours show this to be over water. The approximate GLC at the boundary of the B4 site is shown as 5 ug/m^3;
- In 2013 a qualitative assessment was undertaken to assess the increase in VOC emissions from the addition of 12 new tanks on the site. The assessment reported an increase in VOC emissions from the site of 0.7%. The GLC at the B4 boundary reported in GHD 2008 has therefore been factored up by 0.7% to gain a final background benzene value for the Terminals liquid storage facility of 5.04 ug/m^3; and

- Neither report provided speciated VOC impacts. The estimation of pollutants other than benzene has been undertaken in accordance with the speciation profile provided in **Section 6.4.3**.

Terminals Bitumen Facility:

- The most recent air modelling for the Terminals Bitumen Facility was reported in GHD 2011 and assessed the current approved operations. GLCs were estimated for several VOCs at the residential receptors and reported a maximum benzene value of 0.0077 ug/m^3 at a residential receptor. GLC contours were provided for benzene in the area adjacent to the site and showed a maximum value at the B4 boundary of approximately 0.002 ug/m^3; and
- GLC contours were not provided for VOCs other than benzene. The ratio of each VOC to benzene from the reported residential GLCs were calculated and applied to the benzene B4 boundary GLC to gain the speciated VOC concentrations. The estimation of pollutants other than benzene has been undertaken in accordance with the speciation profile provided in **Section 6.4.3**.

A summary of the background values at the boundary of the Site B4 to be applied in the assessment are provided in **Table 6**.

Table 6 Background Data Summary

Pollutant	Criteria (µg/m^3)	Predicted Maximum Ground Level Concentration (ug/m^3)		
		Terminals Liquid Storage	Terminals Bitumen	Total Background
Benzene	29	5.04	0.0020	5.04
Cumene	21	0.081	0.000032	0.081
Cyclohexane	19,000	4.25	0.0017	4.25
Ethylbenzene	8,000	0.46	0.0000086	0.46
n-Hexane	3,200	10.14	0.0040	10.14
Toluene	360	6.43	0.0022	6.43
Xylenes	190	1.99	0.0025	1.99

Given the reasonably low GLCs of the pollutants in **Table 6,** with the exception of benzene, these levels have been applied to all receptor locations at or beyond the boundary of the Vopak sites, including residential receptors. Benzene values were estimated at several sensitive receptors for the Terminals Liquid Storage Facility and have been applied as the background for each. Where a sensitive receptor identified in this B4 assessment was not modelled, the value at the nearest sensitive receptor was applied. The Terminals Bitumen Facility only reported one maximum residential GLC. This GLC has been applied to all residential receptors. A summary of benzene background values for each residential receptor identified is provided in **Table 7**; details of the receptors are provided in **Section 5.6**.

Table 7 **Benzene Residential Receptor Background Data**

Receptor ID	Receptor Description	Ground Level Concentration (ug/m^3)		
		Terminals Liquid Storage	Terminals Bitumen	Total Background
1	Matraville Public School, Matraville	2.62	0.0077	2.63
2	St Agnes Primary School, Matraville	2.62	0.0077	2.63
3	Matraville High School, Chifley	2.62	0.0077	2.63
4	St Andrews Primary School, Malabar	2.62	0.0077	2.63
5	Malabar Public School, Malabar	2.62	0.0077	2.63
6	23 Adina Avenue, Phillip Bay	4.63	0.0077	4.64
7	61 Yarra Road, Phillip Bay	4.63	0.0077	4.64
8	52 Eyre Street, Chifley	2.62	0.0077	2.63
9	26 Moorina Avenue, Matraville	2.62	0.0077	2.63
10	5 Clonard Way, Little Bay	4.63	0.0077	4.64
11	Botany Golf Club, Banksmeadow	1.91	0.0077	1.92
12	Elaroo Avenue, Yarra Point	4.63	0.0077	4.64
13	La Perouse Point, ANZAC Parade	3.83	0.0077	3.83

5.2 Sources Assessed in the Dispersion Model

In order to look at the cumulative impact of the entire Vopak Petroleum Site B facility, directly associated infrastructure, and Vopak Bitumen Facility, the following operations were included in the air dispersion model:

- Proposed Site B4 storage tank emissions;
- Bulk Liquids Berth 1 and 2 fugitive emissions;
- Existing Site B storage tank emissions (inclusive of B1, B2 & B3) and the proposed 75W modification design and throughput of 7,800ML per year;
- Existing Site B tanker loading gantry emissions with the modifications as proposed in the 75W modification, specifically the operation of 9 loading bays with the existing VRU system;
- Vopak Bitumen vapour combustor unit; and
- Vopak Bitumen storage tank breathing losses.

The source characteristics, emission rates and other details of the Vopak Bitumen facility have been sourced directly from PEL 2015 (as provided in **Appendix D**). Scenario 6 was chosen as it best represents typical operations; operating the Vapour Control Unit (VCU) only during transfers from a ship, the emissions from two road tanker loading activities via the VCU and fugitive emissions. It was assumed that bypass of the VCU would not occur under typical operations. The source details have not been reproduced in this B4 report. The 2015 report was prepared for the EPA and have therefore been assumed to be valid and fit for purpose. As such, no efforts have been made to review or validate the information provided in the report.

5.3 Emission and Dispersion Models

5.3.1 TANKS Emission Model

Emission rates for the fuel storage tanks were generated using the TANKS program. TANKS is a Windows-based computer software program that estimates VOC and hazardous air pollutant (HAP) emissions from fixed- and floating-roof storage tanks. TANKS is based on the emission estimation procedures from Chapter 7 of EPA's Compilation Of Air Pollutant Emission Factors (AP-42). TANKS uses chemical, meteorological, roof fitting, and rim seal data to generate emissions estimates for several types of storage tanks including:

- Vertical and horizontal fixed roof tanks;
- Internal and external floating roof tanks;
- Domed external floating roof tanks; and
- Underground tanks.

5.3.2 TAPM Meteorological Model

TAPM predicts three-dimensional meteorology, including terrain-induced circulations. TAPM is a PC-based interface that is connected to databases of terrain, vegetation and soil type, leaf area index, sea-surface temperature, and synoptic-scale meteorological analyses for various regions around the world. TAPM is used to predict meteorological parameters at both ground level and at heights of up to 8,000 m above the surface; these data are required by the CALPUFF model. The TAPM output file requires processing through a program such as CALTAPM to generate a file that is used within CALMET to generate the three-dimensional wind fields required by the CALPUFF dispersion model.

The NSW EPA has released guidance documentation (Barclay and Scire, 2011) on the optimum settings for the use of the CALPUFF modelling system. One modelling approach provided in the document is the use of a ‘Hybrid Mode’ whereby numerical prognostic three-dimensional meteorological model data, in a 3D.DAT file, along with surface observation data gained from a representative nearby surface monitoring station, are combined. The CALTAPM program converts the TAPM data into a 3D.DAT file, which can be input directly into the CALMET meteorological processer.

5.3.3 CALPUFF Air Dispersion Model Suite

Various air dispersion models are required for the successful modelling of air quality impacts from the Site. These are: The Air Pollution Model (TAPM), which is used to generate prognostic meteorological data; CALTAPM, which is used to process the TAPM output into a format suitable for input into the CALMET model; CALMET, which generates three-dimensional wind fields used in the dispersion modelling; CALPUFF, which predicts the movement and concentration of pollutants; and CALPOST, which is used to process the CALPUFF output files.

CALPUFF is the NSW EPA model of choice for areas that are affected by coastal breezes, coastal fumigation or complex terrain. The Project site is located in a coastal area and, hence, the CALPUFF model was chosen for use in the AQIA. The CALPUFF modelling system consists of three main components and a set of pre-processing and post-processing programs. The main components of the modelling system are CALMET (a diagnostic three-dimensional meteorological model), CALPUFF (an air quality dispersion model), and CALPOST (a post-processing package). The main CALPUFF related software package programs are described in the following sections.

5.3.3.1 CALMET

CALMET is a meteorological model that develops hourly wind and temperature fields on a three-dimensional gridded modelling domain. Associated two-dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. CALMET produces a meteorological file that is used within the CALPUFF model to predict the movement of pollution.

5.3.3.2 CALPUFF

CALPUFF is a non-steady-state three-dimensional Gaussian puff model developed for the US Environmental Protection Agency (US EPA) and approved by the NSW EPA for use in situations where basic Gaussian plume models are not effective, such as areas with complex meteorological or topographical conditions, including coastal areas with re-circulating sea breezes. The CALPUFF model substantially overcomes the basic limitations of the steady-state Gaussian plume models, and as such, was chosen as the most suitable dispersion model for the AQIA and Site Model. Some examples of applications for which CALPUFF may be suitable include:

- Near-field impacts in complex flow or dispersion situations:
  - Complex terrain;
  - Stagnation, inversion, recirculation, and fumigation conditions;
  - Overwater transport and coastal conditions; and
  - Light wind speed and calm wind conditions.

- Long range transport;
- Visibility assessments and Class I area impact studies;
- Criteria pollutant modelling, including application to development applications;
- Secondary pollutant formation and particulate matter modelling; and
- Buoyant area and line sources (e.g. forest fires and aluminium reduction facilities).

5.3.3.3 CALPOST

The CALPOST program is used to process the outputs of the CALPUFF program into a format defined by the user. Results can be tabulated for selected options including percentiles, selected days, gridded results or discrete locations, and can be adjusted to account for chemical transformation and background values.

The program default settings were used for the CALPOST program, ensuring that the correct averaging periods, percentiles and receptors were selected to meet the NSW EPA ambient pollutant criteria assessed (DEC, 2005).

5.4 Model Setup

A summary of the data and parameters used as inputs to TAPM, CALMET and CALPUFF is shown in **Table 8**. Details of the TANKS inputs (and outputs) are provided in **Appendix B**. The CALMET and CALPUFF settings have been chosen in accordance with the following documents:

- Barclay & Scire (2011). Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales; and
- DEC (2005). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.

Table 8 Summary of Model Input Parameters

Parameter	Input
TAPM	
Horizontal resolution	40 x 40 grid points; outer grid spacing 30,000 m x 30,000 m with an inner grid spacing of 1,000 metres.
Grid centre coordinates	33 deg 59 min E, 151 deg 13 min S
Vertical levels	Defaults
Land use data	Default TAPM database
Simulation length	1 January – 31 December 2014
CALMET (v6.42)	
Meteorological grid domain	35 km x 35 km
Meteorological grid resolution	250 metre resolution (140 x 140 grid cells)
Reference grid coordinate (centre)	335182 E, 6238801 S
Cell face heights in vertical grid	0, 20, 40, 80, 160, 320, 640, 1200, 2000 and 3000 m
Simulation length	1 year (2014)
Surface meteorological stations	Sydney Airport (BoM) 2014
Upper air meteorological station	No upper air stations. The 3-dimensional gridded prognostic data from TAPM (M3d) were used as the initial guess wind-field for CALMET
Terrain and land use data	Terrain elevations were extracted from the NASA Shuttle Radar Topography Mission Version 3 data set (SRTM1 30 metre resolution). Land use data taken from GLCC Australia Pacific (~1 km resolution)
TERRAD (Terrain radius of influence)	10km

Parameter	Input
RMAX1 (Radius of influence of meteorological stations: surface)	1km
RMAX2 (Radius of influence of meteorological stations: aloft)	10km
R1 (Observation weighting: surface)	5
R2 (Observation weighting: aloft)	20
IEXTRP (Vertical extrapolation of surface wind observation)	- 4 (extrapolate using similarity theory, exclude upper air observations from layer 1)
BIAS (NZ) (Layer dependent weighting factor for initial guess field)	0 (default)
CALPUFF (v7.2.1)	
Computational grid	10 km x 10 km approximately centred on the site
Sampling grid	4 km x 4 km with a nesting factor of 5 (~49 metres spacing), approximately centred on the site; converted to discrete receptors
Number of sensitive receptors	The sampling grid was converted to discrete receptor locations. An additional 13 residential receptors have been included as discussed previously.
Dispersion option	Dispersion coefficient. use turbulence computed from micrometeorology
Meteorological modelling period	1 January 2014 – 31 December 2014

The CALMET settings have been selected in accordance with Barclay & Scire 2011. A review of the prepared CALMET meteorological data using the above settings, as provided in **Appendix B**, shows a strong correlation between measured surface patterns and predicted data. It is therefore concluded that the meteorological data used in the assessment is fit for purpose.

Note that the CALMET meteorological file has been updated since the initial Vopak B4 assessment in order to accommodate the release of the 30m SRTM data and to further align with Barclay & Scire 2011.

5.5 Assessment Scenarios

The dispersion modelling was undertaken for maximum typical operating conditions. The scenario has been created by selecting a representative number of fuel loading arms for the tankers per hour, together with the expected loading time of a tanker and the selection of representative residual tanker fuels (resulting in remnant vapours in the empty tankers). Combustible refers to diesel while flammable refers to petroleum.

The details of the operational parameters adopted for the modelling scenario are as follows (further details are provided in **Section 6.4**):

- Continuous operation of the Facility (24 hours per day, 7 days per week, 365 days per year);
- A VRU with an efficiency of 93.57 percent as identified in site testing (Ektimo 2015, **Appendix D**);
- Storage tank emissions calculated using TANKS based on the tank designations in **Section 6.4.2**;
- A total of 9 gantry bays (6 existing and 3 proposed), loading 3.5 tankers per hour per bay, with an average truck loaded volume of $36m^3$, with a calculated total flow of $1,134m^3/hr$; and
- Residual fuel in tankers ratio of 1/3 combustible (diesel) to 2/3 flammable (petroleum).

Advice from Vopak suggests that 3.5 tankers per bay per hour is a conservative normal operating maximum, and that generally there is likely to be less than this value resulting in lower emissions.

Further details of the calculation method are provided in **Section 6.4.3**. It is envisaged that by looking at hourly tanker loading information that the best hourly emissions assessment would be achieved, avoiding the possible removal of peak emissions if an annual averaged mass calculation was applied.

5.6 Sensitive Receptors

As indicated in **Section 4.0**, the impact assessment criteria for the pollutants assessed are applied either at the site boundary and beyond or at the closest existing or future sensitive receptor, depending on the pollutant. In order to provide a thorough assessment of pollutant concentrations surrounding the facility, a grid 4 km x 4 km with a 50 metre spacing, centred approximately on the site, was assessed. Additionally, receptors were placed along the approximate boundary of the Project. Concentrations predicted at on-site locations were excluded from the results. The receptors are shown in **Figure 2** indicated as blue crosses.

Sensitive receptors are generally defined as residential areas, hospitals, schools and similar facilities. In addition to the above gridded receptors and boundary receptors, sensitive receptors have been selected and identified in accordance with previous assessments for consistency. The sensitive receptors assessed are summarised in **Table 9** and shown in **Figure 2.**

Table 9 Residential Sensitive Receptors

Receptor #	Receptor Description	X Coordinate	Y Coordinate
		m	m
1	Matraville Public School, Matraville	336377	6241348
2	St Agnes Primary School, Matraville	336628	6241013
3	Matraville High School, Chifley	337889	6240355
4	St Andrews Primary School, Malabar	338106	6240430
5	Malabar Public School, Malabar	338156	6240701
6	23 Adina Avenue, Phillip Bay	337019	6238494
7	61 Yarra Road, Phillip Bay	336641	6238493
8	52 Eyre Street, Chifley	337049	6239809
9	26 Moorina Avenue, Matraville	336345	6240209
10	5 Clonard Way, Little Bay	337171	6239080
11	Botany Golf Club, Banksmeadow	334852	6240659
12	Elaroo Avenue, Yarra Point	336468	6238404
13	La Perouse Point, ANZAC Parade	336621	6237803

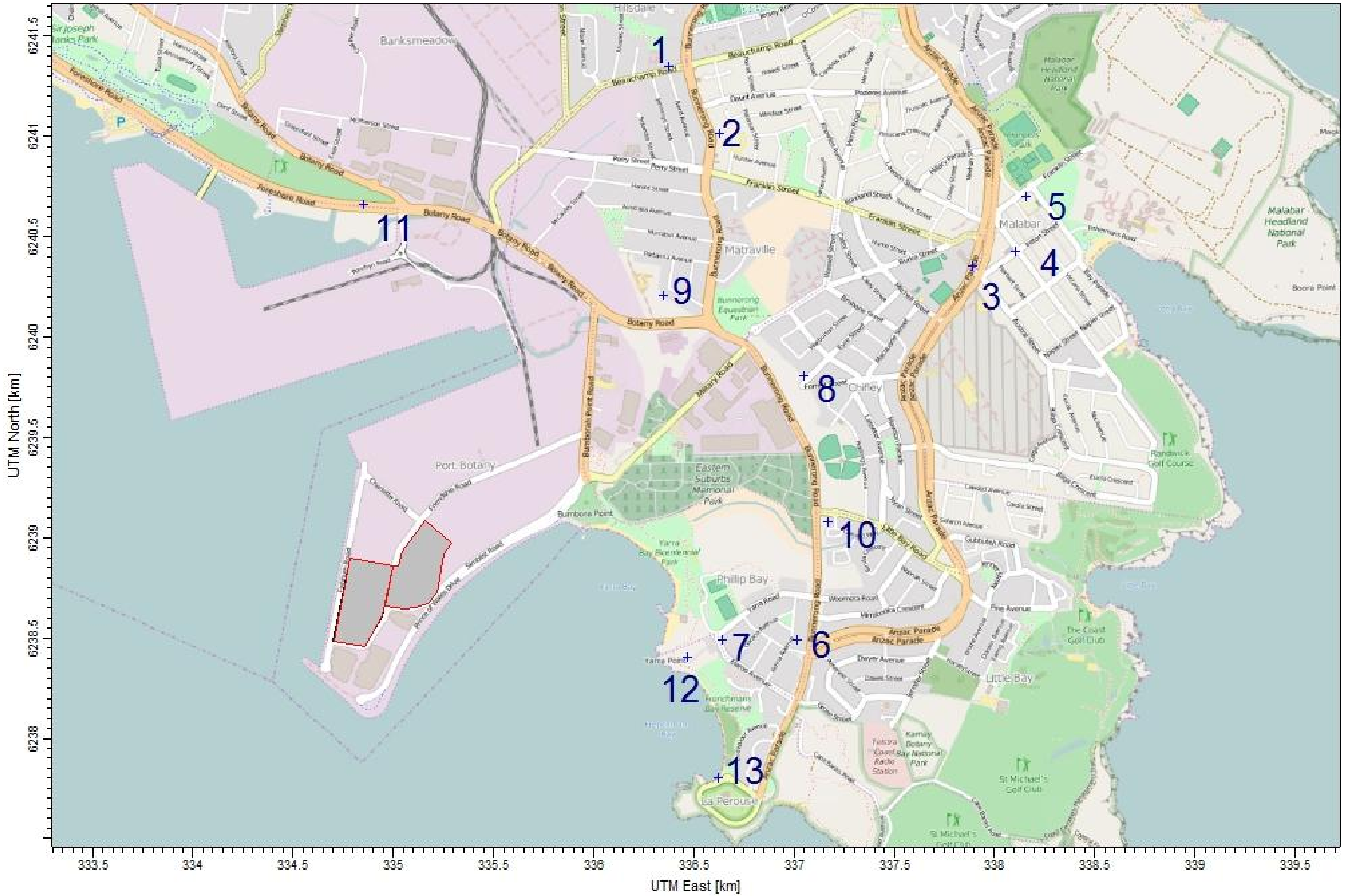

Figure 2 Sensitive Receptor Locations

6.0 Dispersion Model Inputs

The inputs used in the modelling are described in the following sections.

6.1 Meteorology

The meteorological data are used by the CALPUFF model in different ways to estimate the dispersion of air pollutants:

- Ambient temperature is used to incorporate thermal buoyancy effects when calculating the rise and dispersion of pollutant plumes;
- Wind direction determines the direction in which pollutants will be carried;
- Wind speed influences the dilution and entrainment of the plume into the air continuum;
- Atmospheric stability class is a measure of atmospheric turbulence and the dispersive properties of the atmosphere. Most dispersion models utilise six stability classes, ranging from A (very unstable) to F (stable/very stable); and
- Vertical mixing height is the height at which vertical mixing occurs in the atmosphere.

Meteorological data for the period January – December 2014 were used in this assessment. Prognostic meteorological data were generated using TAPM for upper air conditions for a 40 km x 40 km grid with a 1 km grid spacing centred close to the Vopak site. The TAPM output (processed using CALTAPM) was then used, with surface station data from the Bureau of Meteorology monitoring station at Sydney Airport, as input into the CALMET meteorological module to compute the wind fields used by CALPUFF. Sydney Airport is approximately 5 kilometres northwest of the Vopak site, across Botany Bay. Analyses of the meteorological data used in the modelling are provided in **Appendix B**. The analysis concluded that the data were considered to be representative of meteorological conditions around the site.

For the TANKS model, the Australian database was used. The database contains meteorological data for Sydney Airport, which were selected for this assessment.

6.2 Terrain

Digital terrain data used to generate the upper air prognostic meteorological data were obtained from the TAPM 9 second DEM database covering an area of 40 km by 40 km on a 1 km grid, roughly centred on the Vopak facility. For the CALMET model, the geophysical processor was used to convert land use and terrain data from WebGIS (SRTM1 for terrain at approximately a 30 metre resolution) and GLCC Australia Pacific (approximate 1 kilometre resolution) throughout the meteorological domain.

6.3 Building Wake Effects

The dispersion of pollutants emitted from stack sources may be affected by aerodynamic wakes generated by winds having to flow around buildings. Building wakes generally decrease the distance downwind at which stack plumes comes into contact with the ground, which may result in higher ground level pollutant concentrations closer to the emission source.

The Site B VRU is a point source, while the storage tank emissions have also been assessed as point sources in order to adequately assess potential building wake affects. The Prime building wake algorithm was used in the assessment as per EPA guidance (DEC 2005). All storage tanks and dominant structures have been included in the model.

6.4 Source Characteristics

Fuel storage tanks are sources of fugitive emissions. Details of the tank parameters and emission rates are provided in the following sections.

6.4.1 Bulk Liquid Berths

There are now two Bulks Liquids Berths, No's 1 and 2 (BLB 1 and BLB 2). BLB 2 was approved by the NSW Department of Planning in 2008 and NSW Ports officially opened on 21 February 2014 to cater for growing demand in this industry sector. The Bulk Liquids Berth at Port Botany services the discharge and load requirements of the petrochemical industry in New South Wales. Hazardous and non-hazardous bulk liquids, petrochemicals and gases are transferred by pipeline to nearby industry storage facilities which are operated by private companies.

Bulk liquids (which include VOC containing liquids such as petroleum) will be discharged from the BLBs to the liquid storage terminals via flexible hoses or marine loading arms (MLA) for petroleum products connected to the Ship Manifold discharge pipework. VOC emissions have been estimated for the valves and flanges associated with BLB operations. Emissions were estimated using the *Emission Estimation Technique Manual for Petroleum Refining* (Commonwealth Government, 1999). Screening information was not available, and as such average emission factors were used together with the number of fittings for the berth. The parameters applied in the assessment are consistent with those in the approved document *Bulk Liquids Berth No. 2 – Port Botany – Air Quality Impact Assessment (SKM 2007).*

6.4.2 Storage Tanks

The storage tanks would be designed to AP1650 and operated in accordance with the requirements of *AS 1940; The storage and handling of flammable and combustible liquids*. In complying with these standards, the following safety features would be installed:

- Tank level instruments (high and low) with independent high/low alarms;
- Tank vents with anti-flash gauze to prevent potential for sparking and ignition from external sources;
- Multi-level temperature measurements; and
- Water draining facilities to prevent water build up in the tank and potential corrosion in the tank base.

The TANKS emissions estimation model was used to calculate the predicted total VOC emissions from the storage tanks using the parameters provided in **Table 10.** Input and output data from the TANKS model is provided in **Appendix C.** The tanks types listed are defined as Vertical Fixed Roof Tank (VFR) and Domed External Floating Roof (DEFR).

Table 10 Storage Tank Details

Tank ID No.	Product	Tank Type	Tank Diameter (ft)	Volume(gal)	Throughput (gal/yr)
Site B					
101	Jet	DEFR	118.1	4650462	68899241
102	Jet	DEFR	118.1	4650462	68899241
103	Jet	DEFR	118.1	4650462	68899241
104	Avcat (Jet)	DEFR	65.6	1433554	21238909
105	98	DEFR	65.6	1434610	41949872
206	95	DEFR	91.9	2822457	77208946
207	95	DEFR	91.9	2812682	77208946
208	98	DEFR	91.9	2818230	82593160
309	98	DEFR	39.4	511229	14960008
310	Bio Diesel	DEFR	39.4	510964	8011640
311	98	DEFR	39.4	510700	14960008
312	91	DEFR	39.4	510964	13007287
621	Diesel	DEFR	120	6393659	155206146
622	Diesel	DEFR	120	6393659	155206146

Tank ID No.	Product	Tank Type	Tank Diameter (ft)	Volume(gal)	Throughput (gal/yr)
623	Jet	DEFR	120	6393659	94725691
624	Ethanol	DEFR	62.6	1741083	18369752
625	Ethanol	DEFR	49.2	800624	8443396
726	91	DEFR	123.8	6801321	173047328
727	91	DEFR	88.6	3479260	88523493
728	98	DEFR	88.6	3479260	101813098
729	91	DEFR	123.8	6801321	173047328
730	98	DEFR	54.1	1299339	38022387
940	Diesel	DEFR	114.8	5846499	141923835
941	ULP	DEFR	65.6	1909115	48567259
942	91	DEFR	117.8	6150859	156497489
943	Diesel	DEFR	117.8	6150859	149312160
Site B4					
110-01	Diesel	VFR	142.71	9246020	221904480
110-02	Diesel	VFR	142.71	9246020	221904480
110-03	Diesel	VFR	142.71	9246020	221904480
110-04	ULP	DEFR	134.51	8221033	197304792
110-05	ULP	DEFR	134.51	8221033	197304792
110-06	ULP	DEFR	95.14	4247886	101949264
110-07	ULP	DEFR	95.14	4247886	101949264

VFR - Vertical Fixed Roof Tank
DEFR - Domed External Floating Roof

Site operations also encompass the use of additive and slops tanks. These tanks are small in size and have an extremely low turnover when compared to the large storage tanks. The additives used on site are not volatile organic liquids due to their low vapour pressure. Any emissions from this source would be negligible and have not been quantitatively reviewed in this assessment.

The product component databases prepared for Australian fuel for the NPI were used for the TANKS modelling. The default values of the fuel type compositions were compared against the values in the current NPI Emission Estimation Technique Manual. The diesel values were found to be the same, and were used for the TANKS emission estimations. The database did not contain default values for gasoline; as such, the unleaded petrol values published in the NPI EET (DSEWPC, 2012) were entered manually into the TANKS program and used to calculate emissions from the proposed gasoline tanks. A copy of the TANKS output is provided in **Appendix C**.

Site B and B4 Storage tank emission rates were calculated using the TANKS emission estimation model. The fuel throughput of each tank was evenly allocated to each month of the year within TANKS and the outputs provided in monthly emission rates to account for seasonal atmospheric influences. The monthly emission rates were estimated in kilograms per month and calculated back to grams per second (g/s) for each month for use in the dispersion model and are provided in **Appendix C**.

Table 11 Fuel Composition – Substance Proportions (NPI)

Substance	Typical Liquid Composition (%)				
	Diesel (ADO)	Unleaded Petrol (ULP)	95	98	Jet Kerosene
Benzene	0.03	0.933	1.003	1.007	0.367
Cumene	0.975	0.100	0.120	0.170	2.830
Cyclohexane	0.010	0.765	0.990	1.100	1.200
Ethylbenzene	0.110	1.533	1.763	1.805	0.517
n-Hexane	0.010	1.830	1.520	2.025	4.650
Toluene	0.100	5.603	7.093	19.650	0.180
Xylenes	0.345	7.747	8.980	9.730	1.880

Source: Table 2: Minimum amount of individual substances in fuel stored to trip the Category 1 reporting threshold (10 tonnes), DSEWPC (2012).

The monthly emissions of the above pollutants in pounds were converted to an emission rate for each tank in grams per second assuming constant emissions (24/7/365). These were used as the emission rates in CALPUFF as an hourly varying emissions file. Each tank was modelled as a point source at the peak of the tank in order to adequately account for building wake influences. The model was set with no vertical momentum as the pipes generally exhaust in a down facing position.

6.4.3 Site B Gantry Vapour Emissions

Emissions from the truck filling gantries are generated when tankers are filled with fuel on site; as the tankers are loaded residual vapours from the empty tankers are expelled and captured by the gantry system. The composition of the expelled vapours is dependent on the previous contents of the tanker. The tanker being filled at the Facility may have previously contained either combustibles (i.e. diesel) or flammables (i.e. petroleum), resulting in residual vapours from either of these fuels. Flammable fuels generally have higher concentrations of VOCs than combustible fuels.

After the vapour within the empty tanker is displaced and collected by the gantry vapour collection system (VCS), it is directed to the VRU. The volumetric flow rate of the gantry VRU emissions is dependent on the road tanker filling activities at that time, that is, the rate at which the air is displaced in the road tanker, tank compartment is the driver of the air flow through the VRU. The typical operational scenario modelled assumes a flow rate of 1,134m^3/hr and together with the diameter was used to calculate the velocity. The VRU stack emission characteristics are provided in **Table 12**.

Table 12 Vopak Site B VRU Stack Emission Parameters

Parameter	Units	Value
Temperature	ºC	Assumed ambient
Height above ground	m	10
Internal exhaust diameter	m	0.2
Velocity	m/s	10.03

The modelling has assumed a stack venting 10m above ground level with vertical momentum i.e. no witches' hat, T-junctions or other units that may limit the stacks vertical velocity. Vopak has confirmed that the approved and built Site B 75W modification design would meet this stack height and orientation requirement.

The volumetric flow rate of the displaced tanker vapour is used to calculate the emission rate for the pollutants of concern using sample vapour concentration data collected for a similar facility (AECOM 2015b). The study collected samples directly from the tanker vapour outlet lines in June 2015; sampling was undertaken before any mitigation measures. Two samples were collected from combustible tankers and four from flammable tankers using Summa Canisters and sent to the NATA-certified ALS laboratories (accreditation number 825) for analysis of VOC composition in accordance with USEPA method TO-15.

The sampling results are summarised in **Table 13**. The maximum combustible value was applied, while the upper quartile value from flammables was used in the assessment and presented in the table.

Table 13 Gantry Sample Concentration Summary (pre- VRU) (AECOM 2015b)

Fuel Type*	Concentration (mg/m^3)						
	Benzene	Cumene	Cyclo-hexane	Ethyl-benzene	Hexane	Xylenes	Toluene
Combustible	26	4	78	27	143	114	90
Flammable	613	44	650	473	2625	7440	2060

*denotes the fuel type that was previously carried by the road tanker prior to entering the measured bay

The concentrations shown in **Table 13** were used with the source parameters provided in this AQIA to estimate emissions of individual VOCs from the gantry, together with a VRU efficiency of 93.57 per cent (Ektimo 2015).

6.4.4 Fugitive Emissions

Fugitive emissions from Site B and B4 storage tank pipe networks were estimated using the *Emission Estimation Technique Manual for Petroleum Refining* (Commonwealth Government, 1999). Screening information was not available, and as such average emission factors were used together with the estimated number of fittings. The emission factor and number of fittings applied are summarised in **Table 14** and were used to estimate the TVOC emission rate in g/s, which was then speciated to individual compound emission rates. Fugitive emissions were modelled as volume sources located at various locations on each site.

Table 14 Pipeline Parameters – Site B and B4

Pipe Loss Source	Emission Factor (kg/hr)	Count of sources			
		B1	B2	B3	B4
Connections / flanges	0.00006	600	250	450	439
Valves	0.0017	120	50	90	285
Pump seals	0.012	1.2	0.5	0.9	4
Compressors	0.0894	0	0	0	0
Pressure relief valves	0.0447	0	0	0	0
Open ended lines	0.0015	0	0	0	0

6.5 Emission Rates

The storage tank monthly emission rates were estimated in kilograms per month and calculated back to grams per second (g/s) for each month for use in the dispersion model. The emission rates for the assessed project Site B4 are provided in **Appendix C**. Due to the number of tanks on Site B, the monthly emission rates are not provided in this report. The estimated emission rates for all other sources are provided in **Table 15**.

Table 15 Modelled Emission Rates

Facility Source	Emission	Benzene	Cumene	Cyclohexane	Ethylbenzene	n-Hexane	Toluene	Xylenes
		g/s	g/s	g/s	g/s	g/s	g/s	g/s
VOPAK Site B	Gantry VRU	8.46E-03	3.20E-04	9.31E-03	6.57E-03	3.64E-02	1.01E-01	2.84E-02
	Pipe losses	4.81E-09	3.02E-10	4.65E-09	3.76E-09	1.53E-08	4.60E-08	9.80E-09
	Tank Venting	Varying TANKS output						
VOPAK Site B4	Pipe losses	4.87E-09	3.07E-10	4.71E-09	3.81E-09	1.55E-08	4.66E-08	9.94E-09
	Tank Venting	Varying TANKS output						
BLB1	Pipe losses	5.43E-03	3.42E-04	5.26E-03	4.25E-03	1.73E-02	5.20E-02	1.11E-02
BLB2	Pipe losses	5.43E-03	3.42E-04	5.26E-03	4.25E-03	1.73E-02	5.20E-02	1.11E-02
VOPAK Bitumen	Vapour Combustion Unit	1.37E-05	8.62E-07	1.33E-05	1.07E-05	4.37E-05	1.31E-04	2.79E-05
	Tank 1	7.07E-06	4.45E-07	6.84E-06	5.53E-06	2.25E-05	6.76E-05	1.44E-05
	Tank 2	9.19E-08	5.78E-09	8.89E-08	7.19E-08	2.93E-07	8.79E-07	1.87E-07
	Tank 3	2.91E-06	1.83E-07	2.81E-06	2.28E-06	9.28E-06	2.78E-05	5.93E-06
	Gantry Fugitive	9.13E-06	5.75E-07	8.83E-06	7.15E-06	2.91E-05	8.74E-05	1.86E-05

6.6 Limitations and Conservatism of Dispersion Modelling

The atmosphere is a complex, physical system, and the movement of air in a given location is dependent on a number of variables, including temperature, topography and land use, as well as larger-scale synoptic processes. Dispersion modelling is a method of simulating the movement of air pollutants in the atmosphere using mathematical equations. The model equations necessarily involve the current understanding of the complex environmental interactions and chemical reaction processes involved, available input data, processing time and data storage limitations. The model configuration particularly affects model predictions during certain meteorological conditions and source emission types. For example, the prediction of pollutant dispersion under low wind speed conditions (typically defined as those less than 1 m/s) or for low-level, non-buoyant sources, is problematic for most dispersion models. To accommodate these effects, the model is configured to provide conservative estimates of pollutant concentrations at particular locations.

The results of dispersion modelling, therefore, provide an overly conservative indication of the worst likely level of pollutants within the modelling domain. While the models, when used appropriately and with high quality input data, can provide very good indications of the scale of pollutant concentrations and the likely locations of the maximum concentrations occurring, their outputs should not be considered to be representative of exact pollutant concentrations at any given location or point in time.

Information from literature sources have been used in this assessment, specifically adjacent facility air quality assessments. These reports were prepared for the EPA for the purposes of Development Applications or responding to a Pollution Reduction Program notice and have therefore been assumed to be valid and fit for purpose. As such, no further validation of the information provided in these reports has been undertaken for this assessment.

7.0 Dispersion Modelling Results

The NSW EPA's assessment criteria for the assessed pollutants apply to the 99.9th percentile for site-specific assessments, such as this AQIA. The data are presented for principle air toxics, individual air toxics and individual odorous air pollutants assessed at or beyond the plant boundary. Although individual odorous air pollutants are generally assessed at the nearest sensitive receptor, given the proximity of industrial receptors, at or beyond the boundary was conservatively assessed.

An additional assessment of the residential sensitive receptors has been provided to clarify any impact the Project may have on the local residential community.

7.1 Typical Maximum Operational Assessment

The predicted maximum cumulative ground level concentrations for typical maximum operations at or beyond the site boundary, including residential receptors, resulting from the dispersion model are summarised in **Table 16**. The data is provided for the maximum cumulative impact at any modelled receptor, with predicted concentration isopleths for all pollutants provided in **Appendix E**. The maximum cumulative value has been further broken up into its source contributions from Site B4, Site B, Vopak Bitumen & BLB pipe losses, and the background values as identified in **Section 5.1**.

Table 16 Maximum Cumulative Predicted Ground Level Concentrations At or Beyond the Site Boundary 99.9th Percentile (µg/m³)

Pollutant	Criteria (µg/m³)	Maximum Predicted 99.9th Percentile Concentration (µg/m³)					Cumulative % of Criteria
		Cumulative*	Contribution to Cumulative				
			Site B4	Site B	Vopak bitumen & BLB1/2	Background	
Benzene	29	25.41	0.414	19.96	<0.0001	5.04	88%
Cumene	21	15.7	0.0005	0.0003	0.08	15.81	75%
Cyclohexane	19,000	23.06	0.197	18.61	<0.0001	4.25	<1%
Ethylbenzene	8,000	15.66	<0.0001	15.20	<0.0001	0.46	<1%
n-Hexane	3,200	73.53	0.496	62.89	0.0081	10.14	2%
Toluene	360	197.92	0.537	190.95	<0.0001	6.43	55%
Xylenes	190	42.19	0.452	39.75	<0.0001	1.99	22%

* Cumulative concentrations are the sum of contemporaneous impacts from Site B4, Site B, Vopak bitumen & BLB1/2 and background.

As shown, the predicted maximum cumulative pollutant concentrations were all below their respective assessment criteria. The following observations can be made:

- The cumulative contribution predicts that benzene would have the highest contribution of the EPA criteria representing 88%. The predicted benzene isopleth for the area dajcent to the site is provided in **Figure 3**;
- The Site B4 contribution to this maximum cumulative benzene value is 1.4% of the EPA criterion, with the Site B contributing the highest proportion; and
- As shown in the figures provided, the maximum cumulative impact for all pollutants except cumene was located at the boundary of Site B adjacent to the VECS; and
- The maximum cumene impact occurred at the boundary of Site B4. Cumene is present at higher levels in diesel than gasoline, resulting in the highest cumene emissions occurring adjacent to the cumene storage tanks at site B4.

The assessment predicts that no adverse impacts are likely to occur as a result of the Vopak B4 facilities typical operations at and beyond the site boundary or at residential receptors. The assessment also suggests that the facilities contribution to the maximum cumulative VOC level is low.

Figure 3 **Maximum Cumulative Benzene Isopleth 99.9th Percentile (Criterion 29 ug/m^3)**

In order to gain a better picture of the maximum influence that the assessed project, Site B4, may have on the local area, **Table 17** has been provided which shows the values for the location with the maximum impact from Site B4 and the contribution from the other sources at this time.

Table 17 Maximum Site B4 Predicted Ground Level Concentrations At or Beyond the Site Boundary 99.9th Percentile (µg/m³)

Pollutant	Criteria (µg/m³)	Maximum Predicted 99.9th Percentile Concentration (µg/m³)					Cumulative % of Criteria
		Site B4	Site B*	Vopak bitumen & BLB1/2*	Background*	Cumulative*	
Benzene	29	9.7	0.0036	0.0049	5.04	14.76	51%
Cumene	21	15.7	0.0005	0.0003	0.08	15.81	75%
Cyclohexane	19,000	3.3	0.0040	0.0048	4.25	7.59	<1%
Ethylbenzene	8,000	3.6	0.0020	0.0039	0.46	4.10	<1%
n-Hexane	3,200	5.2	0.0159	0.0158	10.14	15.36	<1%
Toluene	360	9.6	0.0236	0.0473	6.43	16.08	4%
Xylenes	190	9.5	0.0062	0.0101	1.99	11.54	6%

* Contemporaneous value at the time and location of the maximum Site B4 impact. Cumulative concentrations are the sum of contemporaneous impacts from Site B4, Site B, Vopak bitumen & BLB1/2 and background.

As shown, the predicted pollutant concentrations were all below their respective assessment criteria. The following observations are made:

- The cumulative contribution, when sorted by the maximum Site B4 contribution, predicts that cumene would have the highest contribution of the EPA criteria representing 75%. This is the same result as the maximum gridded due to the contribution of the diesel tanks as previously discussed. The maximum cumulative cumene isopleth is provided in **Figure 4**;
- The maximum contribution of Site B4 to the EPA criteria is for cumene with 75%, representing the dominant source of the cumulative impact;
- The maximum impacts occurred at the boundary of Site B4 for all pollutants.

The assessment predicts that no adverse impacts are likely to occur as a result of the Vopak B4 facilities typical operations at and beyond the site boundary or at residential receptors.

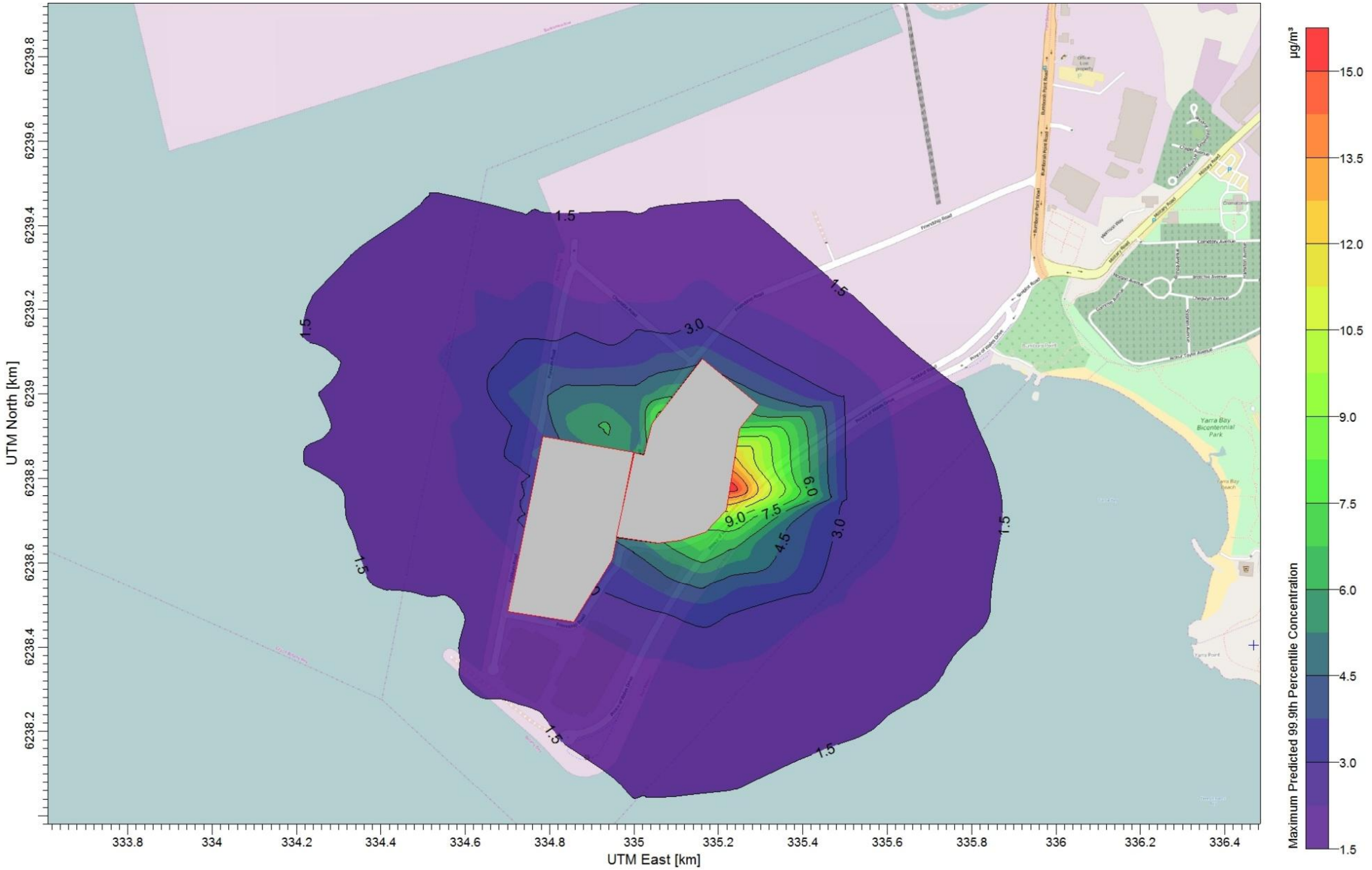

Figure 4 Maximum Cumulative Cumene Isopleth 99.9th Percentile

7.2 Specific Residential Receptor Assessment

The predicted maximum cumulative impacts provided include the selected residential receptors, and as the maximum cumulative values met the EPA criteria, subsequently the EPA criteria are also expected to be met at all residential receptors.

In order the further clarify the predicted cumulative impacts at the residential receptors, the cumulative maximum 99.9th percentile GLC values have been provided **Table 18**. As shown, the predicted pollutant concentrations were all well below the assessment criteria. The maximum cumulative contribution to the EPA criteria was for benzene at Receptor 12 (Elaroo Avenue, Yarra Point) at 20%. Note that of this 5.3 ug.m3 maximum, 4.6ug/m3 is from background emissions not related to Vopak operations. Subsequently, the modelled Vopak impacts at this maximum residential receptor location represent 2% of the benzene criterion

The data show that the GLCs met the relevant assessment criteria at all residential receptors for all pollutants. Figures showing the predicted maximum cumulative concentrations are provided in **Appendix E**.

Table 18 **Benzene Residential Receptor Predicted Maximum Ground Level Concentrations 99.9th Percentile ($\mu g/m^3$)**

#	Receptor Description	Cumulative Ground Level Concentration (ug/m^3)						
		Benzene	Cumene	Cyclohexane	Ethylbenzene	n-Hexane	Toluene	Xylenes
EPA Criterion (ug/m^3)		29	21	19,000	8,000	3,200	360	190
1	Matraville Public School, Matraville	2.9	0.3	4.5	0.6	10.8	7.9	2.4
2	St Agnes Primary School, Matraville	2.9	0.3	4.5	0.6	10.8	7.9	2.4
3	Matraville High School, Chifley	2.9	0.4	4.5	0.6	10.9	8.2	2.4
4	St Andrews Primary School, Malabar	2.9	0.3	4.5	0.6	10.8	8.1	2.4
5	Malabar Public School, Malabar	2.9	0.3	4.4	0.6	10.7	7.7	2.3
6	23 Adina Avenue, Phillip Bay	5.1	0.5	4.6	0.7	11.1	8.6	2.6
7	61 Yarra Road, Phillip Bay	5.2	0.7	4.6	0.8	11.4	9.2	2.8
8	52 Eyre Street, Chifley	3.1	0.5	4.6	0.7	11.2	8.8	2.6
9	26 Moorina Avenue, Matraville	3.0	0.5	4.5	0.7	11.1	8.7	2.6
10	5 Clonard Way, Little Bay	5.1	0.5	4.6	0.7	11.1	8.4	2.6
11	Botany Golf Club, Banksmeadow	2.4	0.5	4.7	0.8	11.7	10.5	2.9
12	Elaroo Avenue, Yarra Point	5.3	0.9	4.6	0.8	11.4	9.5	2.8
13	La Perouse Point, ANZAC Parade	4.4	0.7	4.6	0.8	11.4	9.4	2.8

8.0 Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources – Site B4

Assessment of the air quality impacts from stationary sources of oxides of nitrogen (NO_x) and VOCs needs to consider the potential generation of ground-level ozone. The NSW EPA have developed a tiered approach to ozone impact assessment for this purpose (ENVIRON 2011). The assessment framework includes:

- Guidance on the application of a level 1 assessment – screening procedure; and
- Guidance on the application of a level 2 assessment – refined procedure.

The steps required under the tiered procedure, as they apply to the assessment, are provided in the following sections in accordance and with reference to the tiered procedure document (ENVIRON 2011).

8.1 Region Classification

The initial step involves the classification of the region within which the source is to be located as either an ozone "attainment area" or "non-attainment area" based 1 hour and 4 hour average ozone concentrations recorded over a five year period. The different categories have varying assessment criteria for triggering the need for an ozone assessment; non-attainment areas have stricter thresholds. The assessment document identified that for 2006-2010 the Sydney region is defined as a non-attainment area, a result that is highly likely should the most recent 5 year period be assessed. This report assumes that the Vopak B4 site is located in a non-attainment area.

8.2 Threshold Assessment

The second step in the procedure involves the evaluation of the source's emissions against the new or modified source thresholds for NOx and VOC emissions. Total emissions from the new or modified source, from all individual emission units, are compared to the emission thresholds.

For a source with emissions below the relevant emission threshold, an ozone impact assessment is not required. Where source emissions are above the relevant emission threshold, a Level 1 assessment should be undertaken using the Level 1 screening procedure tool.

To be consistent with the cumulative assessment of Vopak emissions in Port Botany, the total tonnes per year of VOCs emitted for Vopak sites B1, B2, B3 (GHD 2006) and B4 (current assessment; **Appendix D**) have been calculated and compared against the thresholds.

The reported tonnes per annum (tpa) from B1, B2 and B3, including emissions from storage tanks and truck loading (gantry) was 68 tpa VOC. The estimated tpa from the B4 facility, as calculated from the TANKS data provided in **Appendix D**, is 26 tpa VOC. No significant stationary NOx sources are expected from the Vopak sites. The total cumulative VOC emission from the Vopak sites is 86 tpa (0.236 t/day).

The non-attainment threshold applicable for a modified source (applicable as the review is cumulatively assessing the Vopak sites) for the application of a Level 1 Screening Assessment is >35 tpa. The assessment triggers this threshold and hence a Level 1 Screening Assessment is required.

8.3 Level 1 Screening Assessment

Criteria for determining the significance of predicted incremental increase in ambient ozone concentrations for non-attainment areas comprise the evaluation of sources against a screening impact level (SIL) of 0.5 ppb and against the maximum allowable increment of 1 ppb.

In cases where the maximum ozone increment is below the SIL and/or below the relevant maximum allowable increment, further ozone impact assessment is not required but a best management practice (BMP) determination should be undertaken for the source.

In the event the impacts are greater than the maximum allowable increment, the EPA may consider the impact of the source on local and regional air quality and may require that a Level 2 refined assessment be undertaken for the source.

To undertake the Level 1 Screening Assessment the EPA (with ENVIRON 2011) has created a Level 1 Screening Tool and is available on the EPA website (http://www.epa.nsw.gov.au/air/appmethods.htm). Specific data is entered into the tool, including source region and the tonnes per day of VOC and NOx, and the ozone impacts are calculated. In the case of this assessment, the calculated Vopak cumulative tonnes/day (previously provided as 0.236 t/day VOC) was entered into the model and the incremental and cumulative ozone values calculated by the tool. The results of the tool calculation are provided below:

- Maximum 1-hr Ozone Increment = 0.080 ppb (threshold is 1 ppb); and
- Maximum 4-hr Ozone Increment = 0.054 ppb (threshold is 1 ppb).

The results of the tool show that the designated thresholds are not exceeded and therefore no further ozone assessment is required. A review of BMP is provided in **Section 8.4**.

Note that there are no significant stationary sources of NOx at the Vopak sites, although mobile vehicle NOx emissions from the truck loading are notable at 23 tpa NOx. VOC emissions from mobile vehicles is also notable at 7 tpa. The EPA assessment applies to stationary sources only. However, should the mobile vehicle NOx and VOC emissions be included in the assessment (totalling 117tpa, 0.320 t/day) the threshold would still not be exceeded (0.11 ppb 1 hour increment and 0.073 ppb 4 hour increment).

8.4 Best Management Practice (BMP) Review

The operations for the Vopak B4 site are relative simple, being an arrangement of liquid storage tanks. The gasoline tanks are designed with with a geodesic dome with full contact aluminium internal floating roof, while the diesel allocated tanks have a fixed geodesic domed roof. The design of the tanks relevant to the type of fuel stored is industry standard (API 650).

With respect to the adjacent Vopak sites, the truck loading gantry emissions are filtered through a vapour recovery unit (VRU). The use of a VRU for truck loading emissions is industry standard and regulated by the NSW POEO Act and regulations.

9.0 Recommended Mitigation Measures

9.1 Construction Mitigation Measures

Mitigation of air quality impacts relating to construction works essentially relates to management such works. For any construction activity, the focus should be on implementing a strict dust and air quality management regime. Mitigation measures for the Project are to be detailed in the Construction Environmental Management Plan (CEMP). All reasonable and feasible management measures should be documented and employed where practicable to do so. Management plans and monitoring programs should be suitably documented for easy reference throughout the process.

Vopak has prepared CEMPs as part of the construction of the existing neighbouring facilities and for subsequent modifications, which provide the framework for the implementation of environmental management requirements necessary for the construction phase of the Project. Prior to each construction phase the CEMP was updated and reviewed by the relevant agency stakeholders as nominated by the Project Approval. Subject to approval, the Project will also be subject to a specific CEMP that incorporates the outcomes and recommendations of the EIS.

A key objective of the CEMP is to clearly outline the procedures to address and manage potential environmental impacts associated with the activities. As a minimum, the plan should outline the following aspects related to the works:

- Environmental Policy;
- Environmental Management Structure, Communication and Responsibility;
- Approval and Licensing Requirements;
- Reporting;
- Emergency Contacts and Response;
- Environmental Management Activities and Controls;
- Environmental Monitoring;
- Complaints;
- Corrective Action; and
- Environmental Management Plan Review.

The mitigation measures recommended for inclusion for the construction period are as follows:

- All vehicles and plant/equipment should be fitted with appropriate emission control equipment and be serviced and maintained in accordance with the manufacturers' specifications. Smoke from vehicles/plant should not be visible for more than ten seconds;
- Trucks entering and leaving the premises that are carrying loads of dust-generating materials must have their loads covered at all times, except during loading and unloading;
- Hard surfaces or paving should be used where possible, as unpaved routes can account for a significant proportion of fugitive dust emissions, particularly during dry/windy conditions. Routes should be inspected regularly and repaired when necessary, and roads should be swept and watered as required to limit dirt/dust build up and potential dust generation during windy conditions;
- Any areas on site that are not covered with hard surfaces should be vegetated wherever possible to minimise wind erosion and associated dust generation;
- All vehicles should be switched off when not in use for extended periods;
- Use of water carts and/or road sweeping to minimise dust generation. The frequency of operation is to be increased during dry windy conditions which create a higher potential for dust generation;
- Wetting and covering of stockpiles where hazardous material has been encountered;
- Active excavation area works are wet down with hoses; and
- Housekeeping is maintained to keep exposed areas to a minimum.

9.2 Operational Mitigation Measures

Operational mitigation measures are those implemented after operations have commenced in accordance with its development consent. Operational mitigation measures focus on undertaking of specific activities in a manner designed to minimise environmental impacts.

An Air Quality Management Plan (AQMP) should be prepared in accordance with conditions of consent and the Environment Protection Licence for Project. The following information should be included:

- Sensitive receptors in proximity to the site;
- The legislative framework and standards applicable to the operation;
- Potential contributors to off-site pollutant impacts, including the pollutants that are of concern;
- Mitigation measures required to minimise the operation's effects on local air quality;
- Contingency plans for complaints and pollution incidents; and
- Review and reporting protocols.

The modelling has assumed a stack venting 10m above ground level with vertical momentum i.e. no witches' hat, T-junctions or other units that may limit the stacks vertical velocity. Vopak has confirmed that the approved and built Site B 75W modification design would meet this stack height and orientation requirement.

10.0 Conclusion

AECOM conducted an assessment of the potential effects on air quality associated with the operation of the proposed Vopak Site B4, which consists of bulk liquid fuel storage at Port Botany, NSW. Vopak proposes to import approximately 2,520 ML of diesel and 2,266 ML of gasoline per annum by ship, which would be stored in tanks prior to dispatch via truck. The site would have a total storage capacity of around 200 ML. This assessment has also incorporated the operation of the existing Vopak Site B facility and amendments to Site B as proposed in their current S75 W modification Environmental Assessment. In addition to potential emissions from Vopak operations this assessment undertook a review of other potential VOC sources in proximity to the project and incorporated this into a cumulative assessment to cover the major VOC emissions sources in Port Botany.

This assessment investigated the effects of the proposed operations on the air quality of the surrounding environment. The assessment of air emissions was limited to VOCs during operation of the proposed facility. VOC concentrations at sensitive receptor locations were estimated through dispersion modelling using the CALPUFF program. A cumulative assessment including local VOC emissions was included.

The results of the modelling predicted that all assessed VOC concentrations would be less than the relevant EPA guideline criteria at all sensitive receptor locations assessed at and beyond the site boundary and at residential areas.

In accordance with EPA requirements, a tiered approach to ozone impact assessment was undertaken for the Project. The assessment identified that the site triggered the requirements to undertake a level 1 assessment based on total annual VOC emissions. The Tier 1 assessment confirmed that the Project emissions do not trigger further thresholds and as such no further assessment beyond the Tier 1 assessment undertaken was required.

The air quality impact assessment predicts that the operation of the proposed Vopak B4 is not expected to adversely affect the air environment or the amenity of sensitive receptors.

11.0 References

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Appendix A

Meteorological Data Analyses

Appendix A Meteorological Data Analyses

Wind roses were prepared to compare the data used in the modelling to data recorded at Sydney Airport over the longer term. The BoM website provides historical wind roses for 9am and 3pm only, so in order to analyse the CALMET data wind roses for the combined years 2013, 2014 and 2015 have been prepared for annual and seasonal time periods. The wind rose comparison is provided over page, comparing the CALMET data centred on the airport against the BoM Sydney Airport data.

The annual wind roses were similar, showing strong components from the north-easterly, north-westerly and south directions, with lesser winds present from all other directions. The annual percentage of calms were similar with 0.7 % for CALMET versus 0.2 % for BoM. A review of the seasonal wind roses shows a strong correlation between CALMET and BoM.

The wind directions at 9 am showed similar data, with a large proportion of winds from the northwest and south. The 3 pm wind roses both showed a strong north-easterly component for both datasets, however the Sydney Airport data did show a larger southerly and easterly component. The wind speeds recorded at BoM were generally stronger than those predicted by CALMET.

A review of the CALMET wind speed categories is provided below. The data show that winds are typically mild to high with 85% of the winds between 2.1 and 8.8 m/s. Given the coastal location of the Airport this is considered a reasonable representation. This is further justified by the three year (2013-2015) data from the below wind roses reporting a calm percentage of 0.2%, meaning high winds are expected.

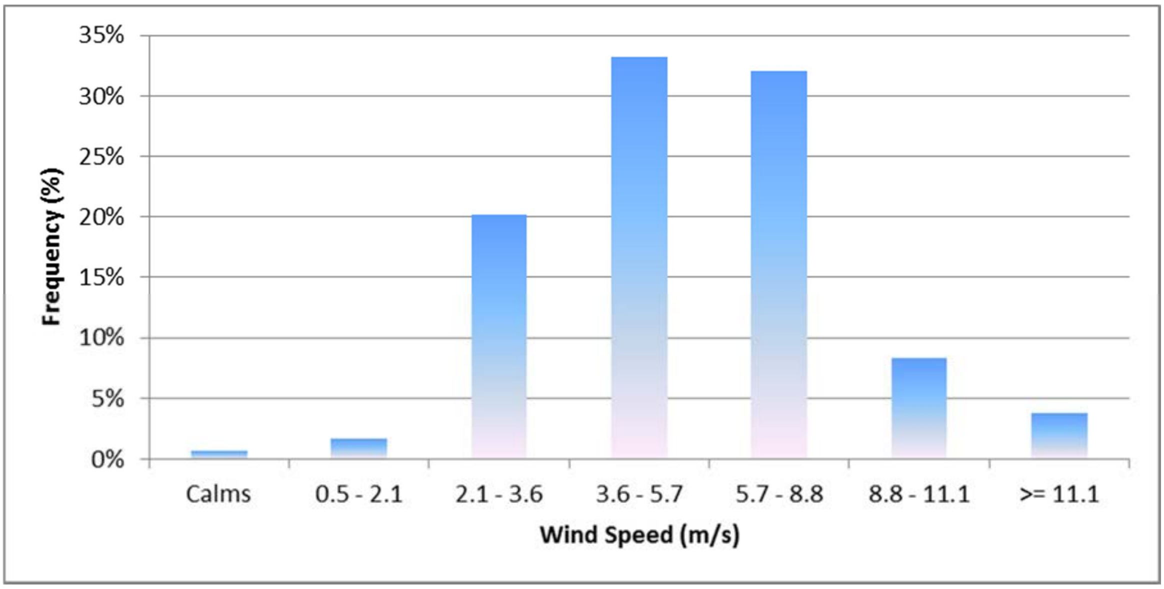


Figure Wind Speed Frequency Distribution

A review of the wind speeds by hour of day has been provided over page. The data show typical trends, with the average strongest winds in the daytime hours and lowest at nigh time. There is a notable range between the maximum and minimum, however the 10th percentile to 90th percentile data shows a balanced range.

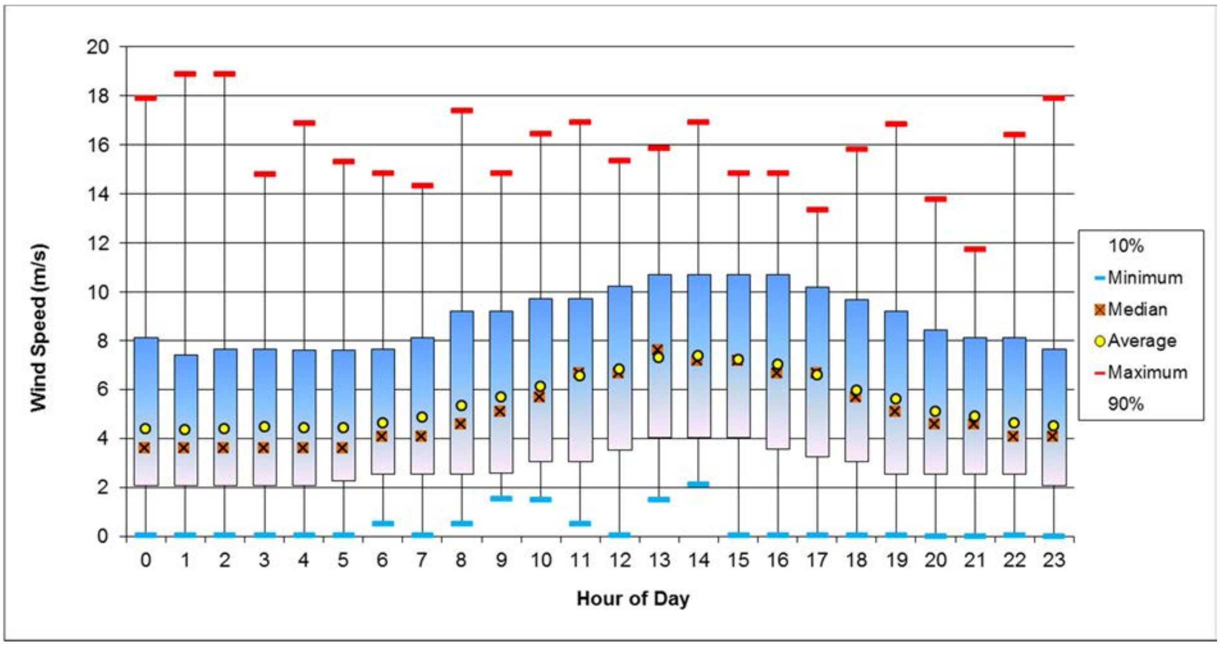


Figure Wind Speed Distribution by Hour of Day

A review of the stability classes for CALMET centred on the airport and on the Vopak B4 site. The data show mostly neutral conditions (condition D) at both locations, with slightly more variability at the Vopak B4 site.

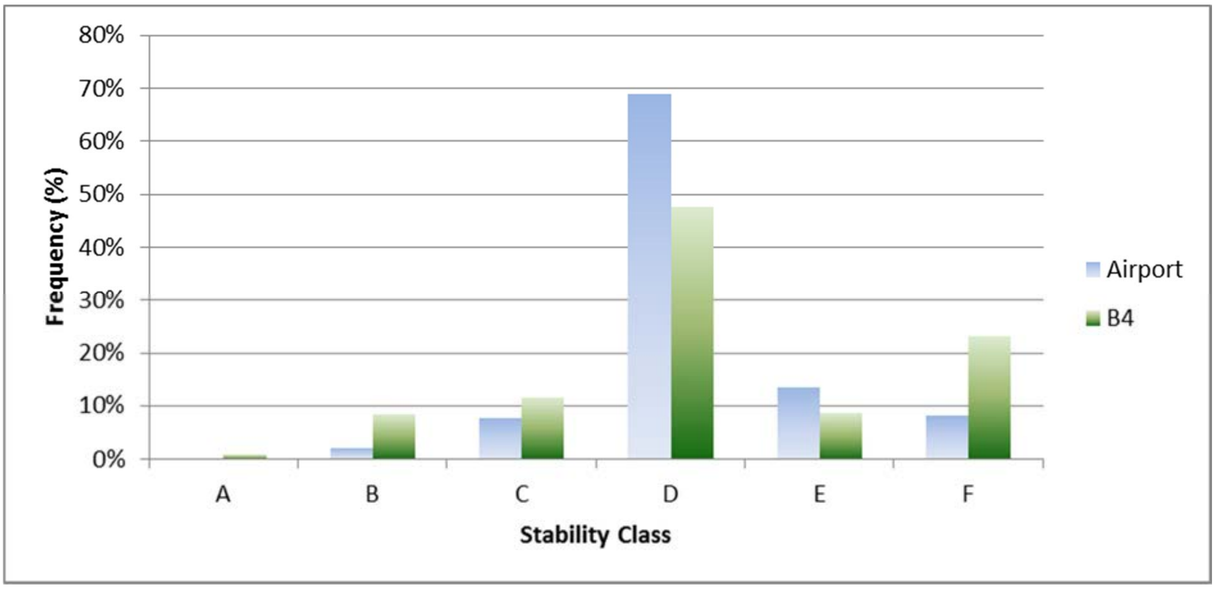
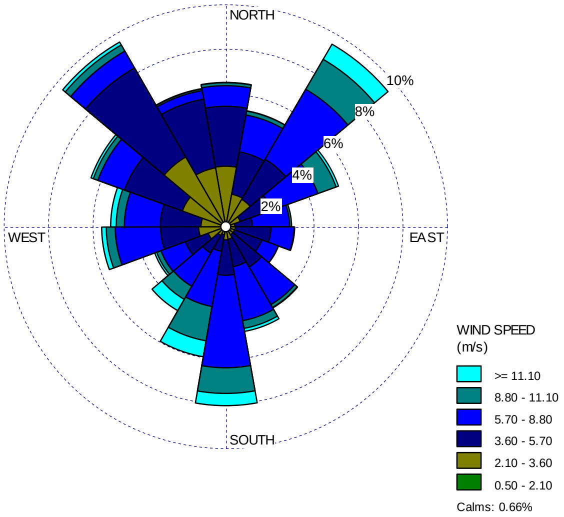


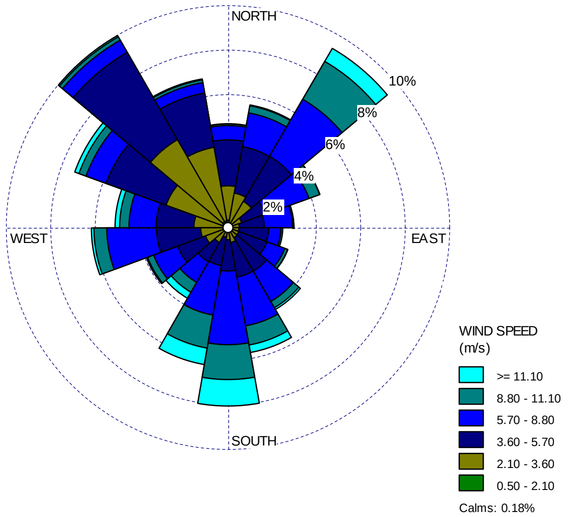
Figure Stability Class Frequency

A summary of the Sydney Airport long term Climatic data is provided at the end of this section.

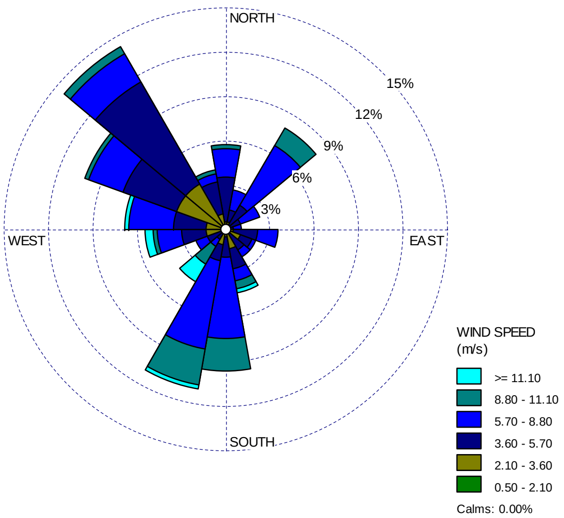
CALMET Airport 2014 vs BoM Sydney Airport Long Term



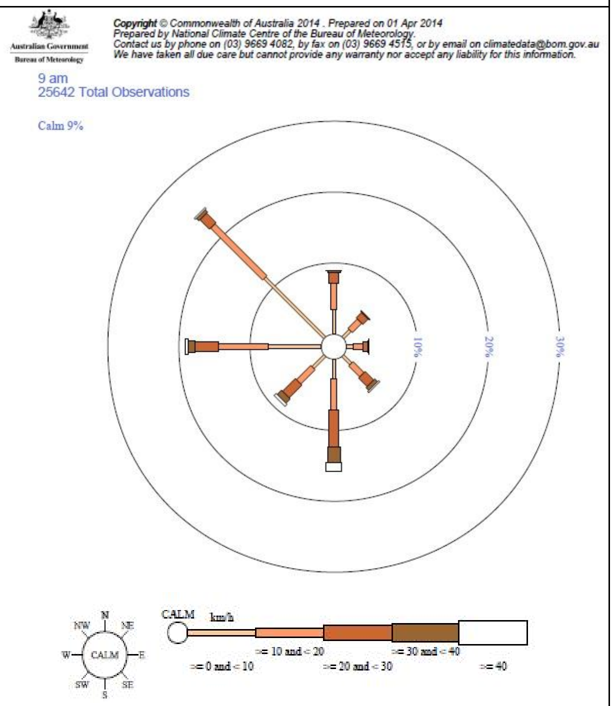
CALMET Airport – Annual, all hours 2014



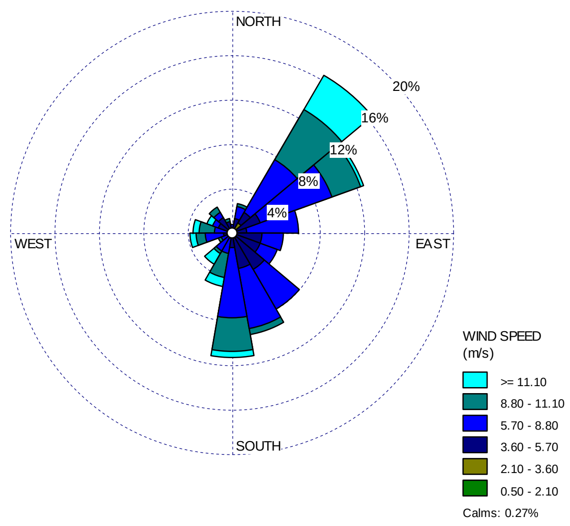
BoM Sydney Airport – Annual, 2013-2015



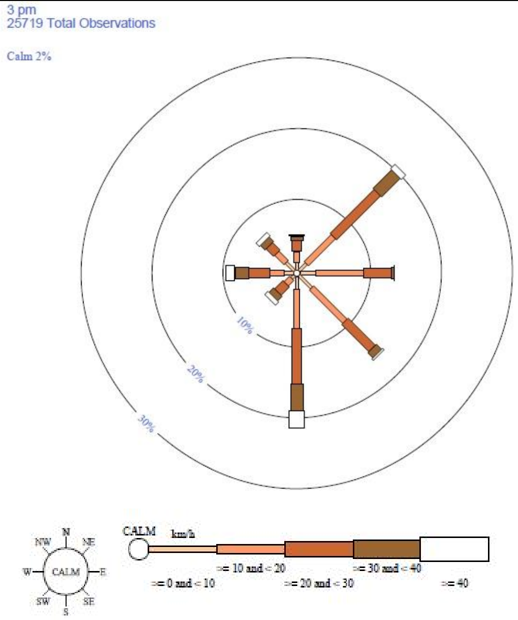
CALMET Airport – Annual, 9 am, 2014



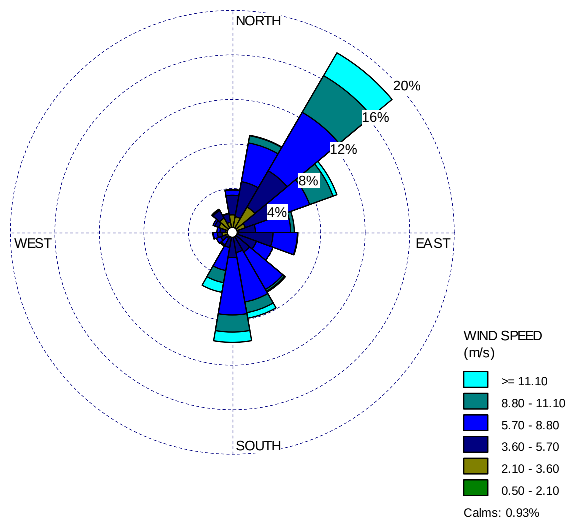
BoM Sydney Airport – Annual, 9 am, 1939 – 2010



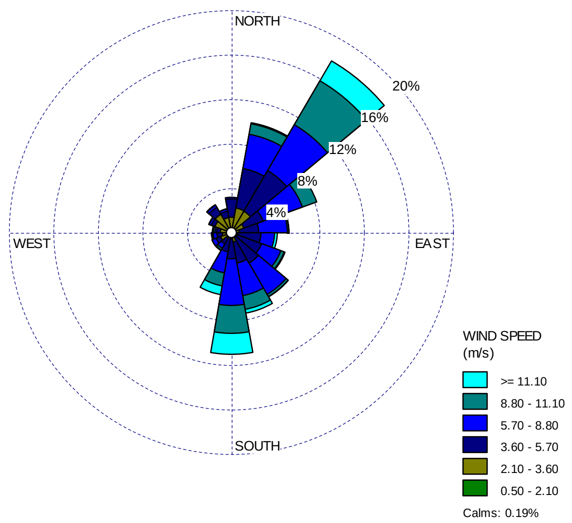
CALMET Airport – Annual, 3 pm, 2014



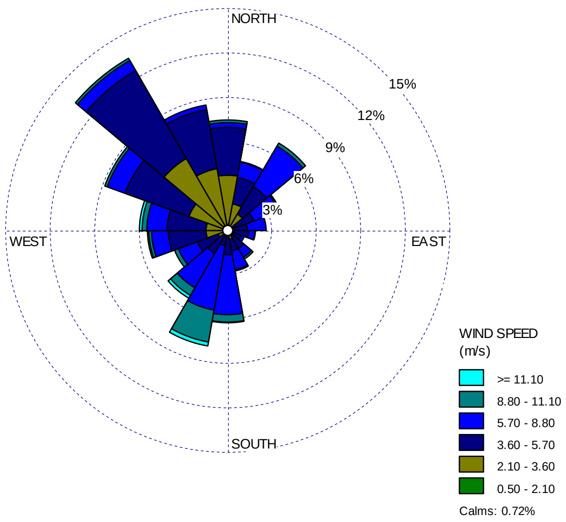
BoM Sydney Airport – Annual, 3 pm, 1939 - 2010



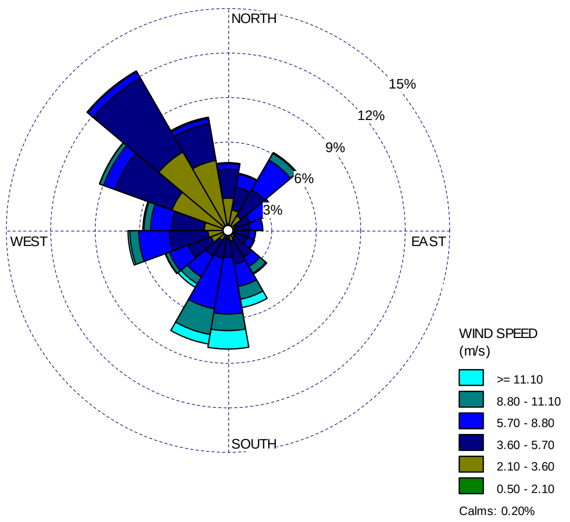
CALMET Airport – Summer, 2014



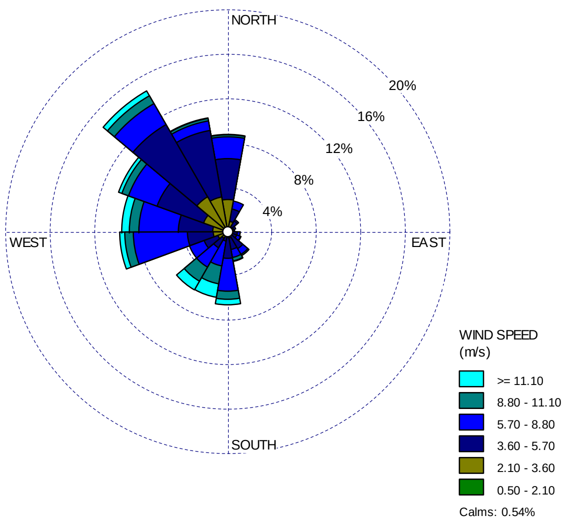
BoM Sydney Airport – Summer, 2013-2015



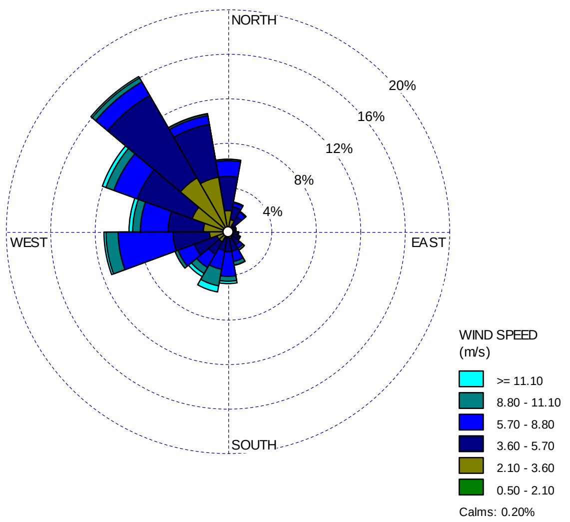
CALMET Airport – Autumn, 2014



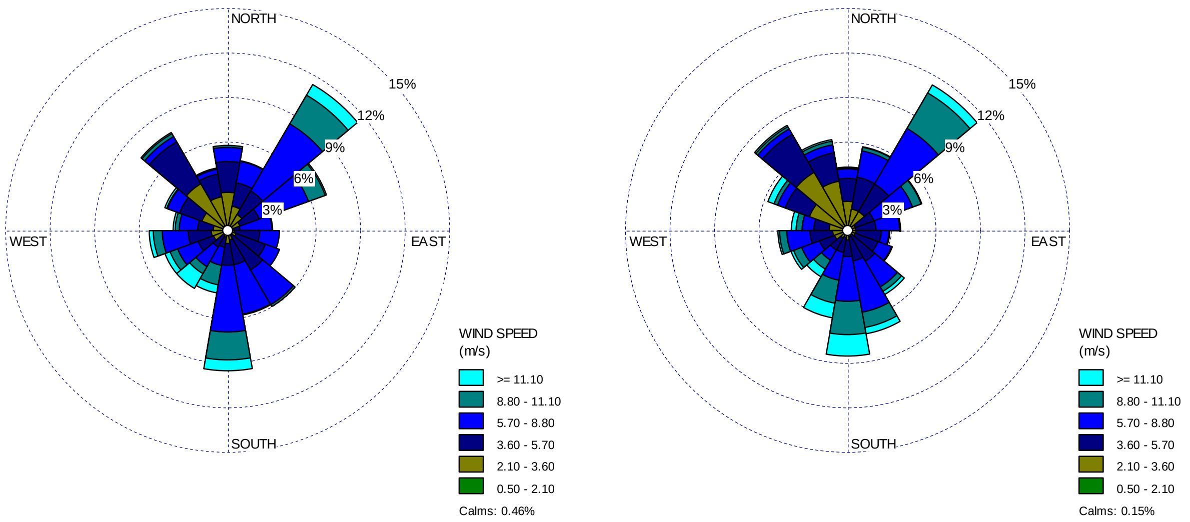
BoM Sydney Airport – Autumn, 2013-2015



CALMET Airport – Winter, 2014



BoM Sydney Airport – Winter, 2013-2015



CALMET Airport – Spring, 2014 **BoM Sydney Airport – Spring, 2013-2015**

Climate Averages: Sydney Airport AMO (Site Number 066037) – 1939 - 2015

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years		
Average temperature (^{o}C)																
Maximum	26.5	26.4	25.3	22.9	20	17.6	17	18.3	20.6	22.6	24.1	25.8	22.3	76	1939	2015
Minimum	18.9	19.1	17.6	14.2	10.9	8.7	7.2	8.2	10.5	13.2	15.4	17.5	13.5	76	1939	2015
Average rainfall																
Rainfall (mm)	94	111.9	115.4	109.3	98.7	122.8	69.9	77	60.2	70.7	81.5	74.1	1085.4	86	1929	2015
Number of days of rain ≥ 1 mm	8	8.6	9.2	8.6	8.5	8.8	6.6	6.9	6.8	7.8	8.4	7.8	96	86	1929	2015
Average 9 am conditions																
Temperature (°C)	22.4	22.3	21.1	18.2	14.6	11.9	10.8	12.5	15.7	18.4	19.9	21.6	17.4	71	1939	2010
9 am relative humidity (%)	70	73	73	71	73	74	71	65	62	61	64	66	69	60	1939	2010
9 am wind speed (km/h)	14.4	13.8	12.9	12.9	12.6	13.4	13.3	14.4	15.5	16.3	16	14.8	14.2	70	1939	2010
Average 3 pm conditions																
Temperature (°C)	24.8	24.8	23.9	21.7	19	16.6	16.1	17.2	19	20.7	22.1	23.9	20.8	71	1939	2010
3 pm relative humidity (%)	60	63	61	59	58	57	52	49	51	54	56	58	57	60	1939	2010
3 pm wind speed (km/h)	24.1	23	21	19.3	17.1	17.8	18.2	20.8	23.1	24.6	25.3	25.2	21.6	70	1939	2010
Source: http://www.bom.gov.au/climate/averages/tables/cw_066037.shtml; accessed 14 May 2015																

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Appendix B

TANKS Details

Appendix B TANKS Details

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	VOPAK 110-04 & 110-05
City:	Sydney Airport Amo
State:	NSW
Company:	VOPAK
Type of Tank:	Domed External Floating Roof Tank
Description:	Domed extrenal floating roof tanks for gasoline (assumed ULP)

Tank Dimensions

Diameter (ft):	134.51
Volume (gallons):	8,221,033.00
Turnovers:	24.00

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	Aluminum/Specular
Shell Condition	Good

Roof Characteristics

Type:	Double Deck
Fitting Category	Typical

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	None

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Unbolted Cover, Ungasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	2
Unslotted Guide-Pole Well/Ungasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Drain (3-in. Diameter)/Open	2
Roof Leg (3-in. Diameter)/Adjustable, Double-Deck Roofs	40
Rim Vent (6-in. Diameter)/Weighted Mech. Actuation, Gask.	1

Meterological Data used in Emissions Calculations: Sydney Airport Amo, NSW (Avg Atmospheric Pressure = 14.74 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

VOPAK 110-04 & 110-05 - Domed External Floating Roof Tank
Sydney Airport Amo, NSW

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 10)	Jan	74.38	66.31	82.45	64.84	5.7233	N/A	N/A	66.4970			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.7176	N/A	N/A	78.1100	0.0093	0.0039	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0861	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.7659	N/A	N/A	84.1600	0.0077	0.0033	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1760	N/A	N/A	106.1700	0.0153	0.0007	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.8023	N/A	N/A	66.0000	0.8149	0.9701	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.7482	N/A	N/A	86.1700	0.0183	0.0123	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.5091	N/A	N/A	92.1300	0.0560	0.0070	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1473	N/A	N/A	106.1700	0.0775	0.0028	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Feb	73.73	66.39	81.07	64.84	5.6548	N/A	N/A	66.4942			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.6889	N/A	N/A	78.1100	0.0093	0.0039	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0842	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.7371	N/A	N/A	84.1600	0.0077	0.0033	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1724	N/A	N/A	106.1700	0.0153	0.0007	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.7217	N/A	N/A	66.0000	0.8149	0.9703	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.7051	N/A	N/A	86.1700	0.0183	0.0122	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4995	N/A	N/A	92.1300	0.0560	0.0069	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1442	N/A	N/A	106.1700	0.0775	0.0028	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Mar	72.23	65.18	79.29	64.84	5.4992	N/A	N/A	66.4877			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.6242	N/A	N/A	78.1100	0.0093	0.0038	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0799	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.6720	N/A	N/A	84.1600	0.0077	0.0032	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1641	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.5386	N/A	N/A	66.0000	0.8149	0.9706	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.6076	N/A	N/A	86.1700	0.0183	0.0121	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4781	N/A	N/A	92.1300	0.0560	0.0068	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1372	N/A	N/A	106.1700	0.0775	0.0027	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Apr	68.85	62.48	75.22	64.84	5.1600	N/A	N/A	66.4732			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.4853	N/A	N/A	78.1100	0.0093	0.0038	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0708	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.5322	N/A	N/A	84.1600	0.0077	0.0032	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1467	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.1391	N/A	N/A	66.0000	0.8149	0.9714	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.3978	N/A	N/A	86.1700	0.0183	0.0119	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4325	N/A	N/A	92.1300	0.0560	0.0066	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1226	N/A	N/A	106.1700	0.0775	0.0026	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	May	65.20	59.77	70.62	64.84	4.8130	N/A	N/A	66.4576			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.3466	N/A	N/A	78.1100	0.0093	0.0036	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0620	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.3922	N/A	N/A	84.1600	0.0077	0.0031	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1298	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21

Gasoline (RVP 10)						5.7300	N/A	N/A	66.0000	0.8149	0.9723	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.1870	N/A	N/A	86.1700	0.0183	0.0116	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3874	N/A	N/A	92.1300	0.0560	0.0063	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1083	N/A	N/A	106.1700	0.0775	0.0024	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Jun	62.86	57.86	67.85	64.84	4.6008	N/A	N/A	66.4478			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.2636	N/A	N/A	78.1100	0.0093	0.0036	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0569	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.3083	N/A	N/A	84.1600	0.0077	0.0030	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1198	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						5.4797	N/A	N/A	66.0000	0.8149	0.9729	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.0602	N/A	N/A	86.1700	0.0183	0.0114	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3607	N/A	N/A	92.1300	0.0560	0.0061	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.0999	N/A	N/A	106.1700	0.0775	0.0023	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Jul	62.18	56.76	67.59	64.84	4.5404	N/A	N/A	66.4450			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.2402	N/A	N/A	78.1100	0.0093	0.0036	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0555	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.2847	N/A	N/A	84.1600	0.0077	0.0030	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1170	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						5.4085	N/A	N/A	66.0000	0.8149	0.9730	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.0244	N/A	N/A	86.1700	0.0183	0.0114	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3532	N/A	N/A	92.1300	0.0560	0.0061	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.0975	N/A	N/A	106.1700	0.0775	0.0023	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Aug	64.27	57.71	70.84	64.84	4.7283	N/A	N/A	66.4538			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.3133	N/A	N/A	78.1100	0.0093	0.0036	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0600	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.3586	N/A	N/A	84.1600	0.0077	0.0031	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1258	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						5.6302	N/A	N/A	66.0000	0.8149	0.9725	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.1362	N/A	N/A	86.1700	0.0183	0.0116	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3766	N/A	N/A	92.1300	0.0560	0.0062	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1049	N/A	N/A	106.1700	0.0775	0.0024	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Sep	66.99	59.50	74.48	64.84	4.9806	N/A	N/A	66.4652			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.4132	N/A	N/A	78.1100	0.0093	0.0037	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0662	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.4594	N/A	N/A	84.1600	0.0077	0.0031	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1379	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						5.9277	N/A	N/A	66.0000	0.8149	0.9719	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.2883	N/A	N/A	86.1700	0.0183	0.0117	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4090	N/A	N/A	92.1300	0.0560	0.0064	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1151	N/A	N/A	106.1700	0.0775	0.0025	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Oct	70.02	61.92	78.11	64.84	5.2749	N/A	N/A	66.4781			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.5320	N/A	N/A	78.1100	0.0093	0.0038	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0738	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.5792	N/A	N/A	84.1600	0.0077	0.0032	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1525	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.2744	N/A	N/A	66.0000	0.8149	0.9712	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.4684	N/A	N/A	86.1700	0.0183	0.0120	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4477	N/A	N/A	92.1300	0.0560	0.0066	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1275	N/A	N/A	106.1700	0.0775	0.0026	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Nov	72.12	63.71	80.53	64.84	5.4871	N/A	N/A	66.4872			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.6192	N/A	N/A	78.1100	0.0093	0.0038	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0795	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.6669	N/A	N/A	84.1600	0.0077	0.0032	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1635	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.5243	N/A	N/A	66.0000	0.8149	0.9707	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.6001	N/A	N/A	86.1700	0.0183	0.0121	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4764	N/A	N/A	92.1300	0.0560	0.0068	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1367	N/A	N/A	106.1700	0.0775	0.0027	106.17	Option 2: A=7.009, B=1462.266, C=215.11

Gasoline (RVP 10)	Dec	73.77	65.37	82.18	64.84	5.6592	N/A	N/A	66.4944			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.6908	N/A	N/A	78.1100	0.0093	0.0039	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0843	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.7389	N/A	N/A	84.1600	0.0077	0.0033	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1726	N/A	N/A	106.1700	0.0153	0.0007	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.7269	N/A	N/A	66.0000	0.8149	0.9703	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.7079	N/A	N/A	86.1700	0.0183	0.0122	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.5001	N/A	N/A	92.1300	0.0560	0.0069	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1444	N/A	N/A	106.1700	0.0775	0.0028	106.17	Option 2: A=7.009, B=1462.266, C=215.11

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

VOPAK 110-04 & 110-05 - Domed External Floating Roof Tank
Sydney Airport Amo, NSW

Month:	January	February	March	April	May	June	July	August	September	October	November	December
Rim Seal Losses (lb):	528.5384											
Seal Factor A (lb-mole/ft-yr):	5.8000											
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.3000											
Average Wind Speed (mph):	0.0000											
Seal-related Wind Speed Exponent:	2.1000											
Value of Vapor Pressure Function:	0.1223											
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	5.7233											
Tank Diameter (ft):	134.5100											
Vapor Molecular Weight (lb/lb-mole):	66.4970											
Product Factor:	1.0000											
Withdrawal Losses (lb):	23.9433											
Net Throughput (gal/mo.):	16,442,066.0000											
Shell Clingage Factor (bbl/1000 sqft):	0.0015											
Average Organic Liquid Density (lb/gal):	5.8161											
Tank Diameter (ft):	134.5100											
Roof Fitting Losses (lb):	65.0242											
Value of Vapor Pressure Function:	0.1223											
Vapor Molecular Weight (lb/lb-mole):	66.4970											
Product Factor:	1.0000											
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	95.9800											
Average Wind Speed (mph):	0.0000											
Total Losses (lb):	617.5059											

		Roof Fitting Loss Factors			
Roof Fitting/Status	Quantity	KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	1.1048
Automatic Gauge Float Well/Unbolted Cover, Ungasketed	1	14.00	5.40	1.10	9.6666
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	2	6.20	1.20	0.94	8.5618
Unslotted Guide-Pole Well/Ungasketed Sliding Cover	1	31.00	150.00	1.40	21.4045
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	0.3245
Roof Drain (3-in. Diameter)/Open	2	1.50	0.21	1.70	2.0714
Roof Leg (3-in. Diameter)/Adjustable, Double-Deck Roofs	40	0.82	0.53	0.14	22.6474
Rim Vent (6-in. Diameter)/Weighted Mech. Actuation, Gask.	1	0.71	0.10	1.00	0.4902

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: January, February, March, April, May, June, July, August, September, October, November, December

VOPAK 110-04 & 110-05 - Domed External Floating Roof Tank
Sydney Airport Amo, NSW

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Gasoline (RVP 10)	5,599.02	287.32	688.83	0.00	6,575.17
Benzene	21.08	2.68	2.59	0.00	26.35
Cumene (Isopropyl benzene)	0.11	0.29	0.01	0.00	0.41
Cyclohexane	17.82	2.20	2.19	0.00	22.21
Ethyl benzene	3.44	4.40	0.42	0.00	8.26
Gasoline (RVP 10)	5,438.47	234.13	669.08	0.00	6,341.68
Hexane (-n)	66.68	5.26	8.20	0.00	80.14
Toluene	36.92	16.10	4.54	0.00	57.56
Xylene (-m)	14.50	22.26	1.78	0.00	38.55

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	VOPAK 110-01, -02, -03
City:	Sydney Airport Amo
State:	NSW
Company:	VOPAK
Type of Tank:	Vertical Fixed Roof Tank
Description:	VOPAK vertical fixed roof free venting tanks for B4A - diesel

Tank Dimensions

Shell Height (ft):	79.89
Diameter (ft):	142.71
Liquid Height (ft) :	77.26
Avg. Liquid Height (ft):	49.21
Volume (gallons):	9,246,020.00
Turnovers:	24.00
Net Throughput(gal/yr):	221,904,480.00
Is Tank Heated (y/n):	N

Paint Characteristics

Shell Color/Shade:	Aluminum/Specular
Shell Condition	Good
Roof Color/Shade:	Aluminum/Specular
Roof Condition:	Good

Roof Characteristics

Type:	Dome
Height (ft)	13.78
Radius (ft) (Dome Roof)	142.71

Breather Vent Settings

Vacuum Settings (psig):	0.00
Pressure Settings (psig)	0.00

Meterological Data used in Emissions Calculations: Sydney Airport Amo, NSW (Avg Atmospheric Pressure = 14.74 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

VOPAK 110-01, -02, -03 - Vertical Fixed Roof Tank
Sydney Airport Amo, NSW

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Distillate fuel oil no. 2	Jan	74.38	66.31	82.45	64.84	0.0158	0.0124	0.0199	118.0761			186.01	Option 1: VP70 = .009 VP80 = .012
Benzene						1.7176	1.3878	2.1095	78.1100	0.0003	0.0513	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0861	0.0646	0.1135	120.2000	0.0098	0.0837	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.7659	1.4338	2.1588	84.1600	0.0001	0.0176	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0103	0.0081	0.0130	130.0000	0.9842	0.6994	188.00	Option 1: VP70 = .009 VP80 = .012
Ethyl benzene						0.1760	0.1348	0.2277	106.1700	0.0011	0.0193	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.7482	2.2497	3.3335	86.1700	0.0001	0.0274	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.5091	0.4007	0.6412	92.1300	0.0010	0.0507	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1473	0.1125	0.1911	106.1700	0.0035	0.0506	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	Feb	73.73	66.39	81.07	64.84	0.0155	0.0124	0.0191	118.0645			186.01	Option 1: VP70 = .009 VP80 = .012
Benzene						1.6889	1.3906	2.0381	78.1100	0.0003	0.0515	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0842	0.0648	0.1084	120.2000	0.0098	0.0834	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.7371	1.4367	2.0873	84.1600	0.0001	0.0176	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0101	0.0081	0.0124	130.0000	0.9842	0.6995	188.00	Option 1: VP70 = .009 VP80 = .012
Ethyl benzene						0.1724	0.1351	0.2181	106.1700	0.0011	0.0193	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.7051	2.2540	3.2273	86.1700	0.0001	0.0275	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4995	0.4016	0.6168	92.1300	0.0010	0.0507	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1442	0.1128	0.1829	106.1700	0.0035	0.0505	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	Mar	72.23	65.18	79.29	64.84	0.0148	0.0120	0.0181	118.0282			186.01	Option 1: VP70 = .009 VP80 = .012
Benzene						1.6242	1.3459	1.9484	78.1100	0.0003	0.0518	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0799	0.0620	0.1020	120.2000	0.0098	0.0828	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.6720	1.3915	1.9975	84.1600	0.0001	0.0178	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0097	0.0078	0.0118	130.0000	0.9842	0.6996	188.00	Option 1: VP70 = .009 VP80 = .012
Ethyl benzene						0.1641	0.1297	0.2062	106.1700	0.0011	0.0192	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.6076	2.1858	3.0937	86.1700	0.0001	0.0277	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4781	0.3871	0.5865	92.1300	0.0010	0.0508	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1372	0.1082	0.1728	106.1700	0.0035	0.0503	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	Apr	68.85	62.48	75.22	64.84	0.0134	0.0109	0.0162	117.9402			186.01	Option 1: VP60 = .0065 VP70 = .009
Benzene						1.4853	1.2505	1.7555	78.1100	0.0003	0.0526	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0708	0.0561	0.0887	120.2000	0.0098	0.0815	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.5322	1.2951	1.8040	84.1600	0.0001	0.0181	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0087	0.0071	0.0106	130.0000	0.9842	0.6996	188.00	Option 1: VP60 = .0065 VP70 = .009
Ethyl benzene						0.1467	0.1183	0.1809	106.1700	0.0011	0.0190	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.3978	2.0402	2.8052	86.1700	0.0001	0.0283	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4325	0.3565	0.5217	92.1300	0.0010	0.0510	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1226	0.0986	0.1514	106.1700	0.0035	0.0499	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	May	65.20	59.77	70.62	64.84	0.0120	0.0100	0.0141	117.8705			186.01	Option 1: VP60 = .0065 VP70 = .009
Benzene						1.3466	1.1605	1.5568	78.1100	0.0003	0.0533	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0620	0.0508	0.0754	120.2000	0.0098	0.0798	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.3922	1.2040	1.6041	84.1600	0.0001	0.0184	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0078	0.0065	0.0092	130.0000	0.9842	0.7004	188.00	Option 1: VP60 = .0065 VP70 = .009

Ethyl benzene						0.1298	0.1077	0.1556	106.1700	0.0011	0.0188	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.1870	1.9022	2.5059	86.1700	0.0001	0.0289	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3874	0.3278	0.4559	92.1300	0.0010	0.0511	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1083	0.0897	0.1301	106.1700	0.0035	0.0493	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	Jun	62.86	57.86	67.85	64.84	0.0111	0.0094	0.0130	117.7778			186.01	Option 1: VP60 = .0065 VP70 = .009
Benzene						1.2636	1.1004	1.4463	78.1100	0.0003	0.0540	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0569	0.0472	0.0683	120.2000	0.0098	0.0791	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.3083	1.1430	1.4929	84.1600	0.0001	0.0186	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0072	0.0061	0.0085	130.0000	0.9842	0.6996	188.00	Option 1: VP60 = .0065 VP70 = .009
Ethyl benzene						0.1198	0.1007	0.1419	106.1700	0.0011	0.0188	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.0602	1.8095	2.3386	86.1700	0.0001	0.0294	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3607	0.3088	0.4197	92.1300	0.0010	0.0514	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.0999	0.0838	0.1185	106.1700	0.0035	0.0491	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	Jul	62.18	56.76	67.59	64.84	0.0108	0.0090	0.0129	117.7424			186.01	Option 1: VP60 = .0065 VP70 = .009
Benzene						1.2402	1.0668	1.4363	78.1100	0.0003	0.0543	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0555	0.0453	0.0677	120.2000	0.0098	0.0789	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.2847	1.1089	1.4828	84.1600	0.0001	0.0187	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0070	0.0059	0.0084	130.0000	0.9842	0.6992	188.00	Option 1: VP60 = .0065 VP70 = .009
Ethyl benzene						0.1170	0.0969	0.1407	106.1700	0.0011	0.0188	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.0244	1.7577	2.3235	86.1700	0.0001	0.0295	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3532	0.2982	0.4165	92.1300	0.0010	0.0515	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.0975	0.0806	0.1175	106.1700	0.0035	0.0491	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	Aug	64.27	57.71	70.84	64.84	0.0116	0.0093	0.0142	117.8389			186.01	Option 1: VP60 = .0065 VP70 = .009
Benzene						1.3133	1.0956	1.5658	78.1100	0.0003	0.0536	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0600	0.0470	0.0760	120.2000	0.0098	0.0795	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.3586	1.1381	1.6132	84.1600	0.0001	0.0185	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0076	0.0060	0.0093	130.0000	0.9842	0.7002	188.00	Option 1: VP60 = .0065 VP70 = .009
Ethyl benzene						0.1258	0.1002	0.1568	106.1700	0.0011	0.0188	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.1362	1.8021	2.5195	86.1700	0.0001	0.0290	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3766	0.3073	0.4588	92.1300	0.0010	0.0512	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1049	0.0833	0.1310	106.1700	0.0035	0.0492	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	Sep	66.99	59.50	74.48	64.84	0.0126	0.0099	0.0159	117.9149			186.01	Option 1: VP60 = .0065 VP70 = .009
Benzene						1.4132	1.1517	1.7220	78.1100	0.0003	0.0529	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0662	0.0502	0.0864	120.2000	0.0098	0.0806	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.4594	1.1951	1.7703	84.1600	0.0001	0.0182	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0082	0.0064	0.0103	130.0000	0.9842	0.7003	188.00	Option 1: VP60 = .0065 VP70 = .009
Ethyl benzene						0.1379	0.1067	0.1766	106.1700	0.0011	0.0189	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.2883	1.8886	2.7548	86.1700	0.0001	0.0286	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4090	0.3250	0.5105	92.1300	0.0010	0.0510	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1151	0.0888	0.1478	106.1700	0.0035	0.0495	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	Oct	70.02	61.92	78.11	64.84	0.0138	0.0107	0.0176	117.9470			186.01	Option 1: VP70 = .009 VP80 = .012
Benzene						1.5320	1.2316	1.8906	78.1100	0.0003	0.0524	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0738	0.0550	0.0980	120.2000	0.0098	0.0821	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.5792	1.2759	1.9395	84.1600	0.0001	0.0180	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0090	0.0070	0.0114	130.0000	0.9842	0.6990	188.00	Option 1: VP70 = .009 VP80 = .012
Ethyl benzene						0.1525	0.1160	0.1985	106.1700	0.0011	0.0191	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.4684	2.0112	3.0074	86.1700	0.0001	0.0282	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4477	0.3504	0.5670	92.1300	0.0010	0.0511	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1275	0.0967	0.1663	106.1700	0.0035	0.0502	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Distillate fuel oil no. 2	Nov	72.12	63.71	80.53	64.84	0.0148	0.0114	0.0188	118.0247			186.01	Option 1: VP70 = .009 VP80 = .012
Benzene						1.6192	1.2931	2.0102	78.1100	0.0003	0.0518	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0795	0.0587	0.1064	120.2000	0.0098	0.0827	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.6669	1.3382	2.0594	84.1600	0.0001	0.0178	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0096	0.0074	0.0122	130.0000	0.9842	0.6996	188.00	Option 1: VP70 = .009 VP80 = .012
Ethyl benzene						0.1635	0.1233	0.2144	106.1700	0.0011	0.0192	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.6001	2.1054	3.1859	86.1700	0.0001	0.0277	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4764	0.3702	0.6074	92.1300	0.0010	0.0508	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1367	0.1028	0.1798	106.1700	0.0035	0.0503	106.17	Option 2: A=7.009, B=1462.266, C=215.11

Distillate fuel oil no. 2	Dec	73.77	65.37	82.18	64.84	0.0155	0.0120	0.0198	118.0653			186.01	Option 1: VP70 = .009 VP80 = .012
Benzene						1.6908	1.3527	2.0956	78.1100	0.0003	0.0515	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0843	0.0624	0.1125	120.2000	0.0098	0.0834	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.7389	1.3984	2.1448	84.1600	0.0001	0.0176	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Distillate fuel oil no. 2						0.0101	0.0078	0.0129	130.0000	0.9842	0.6995	188.00	Option 1: VP70 = .009 VP80 = .012
Ethyl benzene						0.1726	0.1305	0.2258	106.1700	0.0011	0.0193	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Hexane (-n)						2.7079	2.1963	3.3128	86.1700	0.0001	0.0275	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.5001	0.3894	0.6364	92.1300	0.0010	0.0507	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1444	0.1089	0.1895	106.1700	0.0035	0.0505	106.17	Option 2: A=7.009, B=1462.266, C=215.11

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

VOPAK 110-01, -02, -03 - Vertical Fixed Roof Tank
Sydney Airport Amo, NSW

Month:	January	February	March	April	May	June	July	August	September	October	November	December
Standing Losses (lb):	359.2188											
Vapor Space Volume (cu ft):	602,281.9370											
Vapor Density (lb/cu ft):	0.0003											
Vapor Space Expansion Factor:	0.0609											
Vented Vapor Saturation Factor:	0.9694											
Tank Vapor Space Volume:												
Vapor Space Volume (cu ft):	602,281.9370											
Tank Diameter (ft):	142.7100											
Vapor Space Outage (ft):	37.6531											
Tank Shell Height (ft):	79.8900											
Average Liquid Height (ft):	49.2120											
Roof Outage (ft):	6.9751											
Roof Outage (Dome Roof)												
Roof Outage (ft):	6.9751											
Dome Radius (ft):	142.7100											
Shell Radius (ft):	71.3550											
Vapor Density												
Vapor Density (lb/cu ft):	0.0003											
Vapor Molecular Weight (lb/lb-mole):	118.0761											
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0158											
Daily Avg. Liquid Surface Temp. (deg. R):	534.0495											
Daily Average Ambient Temp. (deg. F):	72.2500											
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731											
Liquid Bulk Temperature (deg. R):	524.5100											
Tank Paint Solar Absorptance (Shell):	0.3900											
Tank Paint Solar Absorptance (Roof):	0.3900											
Daily Total Solar Insulation Factor (Btu/sqft day):	2,038.0000											
Vapor Space Expansion Factor												
Vapor Space Expansion Factor:	0.0609											
Daily Vapor Temperature Range (deg. R):	32.2630											
Daily Vapor Pressure Range (psia):	0.0076											
Breather Vent Press. Setting Range(psia):	0.0000											
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0158											
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0124											
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0199											
Daily Avg. Liquid Surface Temp. (deg R):	534.0495											
Daily Min. Liquid Surface Temp. (deg R):	525.9837											
Daily Max. Liquid Surface Temp. (deg R):	542.1152											
Daily Ambient Temp. Range (deg. R):	13.9000											
Vented Vapor Saturation Factor												
Vented Vapor Saturation Factor:	0.9694											
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	0.0158											

Vapor Space Outage (ft):	37.6531
Working Losses (lb):	821.9557
Vapor Molecular Weight (lb/lb-mole):	118.0761
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0158
Net Throughput (gal/mo.):	18,492,040.0000
Annual Turnovers:	24.0000
Turnover Factor:	1.0000
Maximum Liquid Volume (gal):	9,246,020.0000
Maximum Liquid Height (ft):	77.2600
Tank Diameter (ft):	142.7100
Working Loss Product Factor:	1.0000
Total Losses (lb):	1,181.1745

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: January, February, March, April, May, June, July, August, September, October, November, December

VOPAK 110-01, -02, -03 - Vertical Fixed Roof Tank
Sydney Airport Amo, NSW

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Distillate fuel oil no. 2	8,401.54	3,229.04	11,630.59
Benzene	440.64	169.02	609.66
Cumene (Isopropyl benzene)	686.17	264.32	950.48
Cyclohexane	151.47	58.08	209.56
Distillate fuel oil no. 2	5,878.07	2,259.11	8,137.18
Ethyl benzene	160.19	61.64	221.83
Hexane (-n)	236.94	90.81	327.75
Toluene	428.35	164.55	592.90
Xylene (-m)	419.72	161.52	581.24

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	VOPAK 110-06 & 110-07
City:	Sydney Airport Amo
State:	NSW
Company:	VOPAK
Type of Tank:	Domed External Floating Roof Tank
Description:	Domed External Floating Roof Tanks - gasoline - B4B

Tank Dimensions

Diameter (ft):	95.14
Volume (gallons):	4,247,886.00
Turnovers:	24.00

Paint Characteristics

Internal Shell Condition:	Light Rust
Shell Color/Shade:	Aluminum/Specular
Shell Condition	Good

Roof Characteristics

Type:	Double Deck
Fitting Category	Typical

Tank Construction and Rim-Seal System

Construction:	Welded
Primary Seal:	Mechanical Shoe
Secondary Seal	None

Deck Fitting/Status	Quantity
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1
Automatic Gauge Float Well/Unbolted Cover, Ungasketed	1
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Unslotted Guide-Pole Well/Ungasketed Sliding Cover	1
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1
Roof Drain (3-in. Diameter)/Open	1
Roof Leg (3-in. Diameter)/Adjustable, Double-Deck Roofs	25
Rim Vent (6-in. Diameter)/Weighted Mech. Actuation, Gask.	1

Meterological Data used in Emissions Calculations: Sydney Airport Amo, NSW (Avg Atmospheric Pressure = 14.74 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

VOPAK 110-06 & 110-07 - Domed External Floating Roof Tank
Sydney Airport Amo, NSW

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Gasoline (RVP 10)	Jan	74.38	66.31	82.45	64.84	5.7233	N/A	N/A	66.4970			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.7176	N/A	N/A	78.1100	0.0093	0.0039	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0861	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.7659	N/A	N/A	84.1600	0.0077	0.0033	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1760	N/A	N/A	106.1700	0.0153	0.0007	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.8023	N/A	N/A	66.0000	0.8149	0.9701	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.7482	N/A	N/A	86.1700	0.0183	0.0123	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.5091	N/A	N/A	92.1300	0.0560	0.0070	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1473	N/A	N/A	106.1700	0.0775	0.0028	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Feb	73.73	66.39	81.07	64.84	5.6548	N/A	N/A	66.4942			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.6889	N/A	N/A	78.1100	0.0093	0.0039	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0842	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.7371	N/A	N/A	84.1600	0.0077	0.0033	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1724	N/A	N/A	106.1700	0.0153	0.0007	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.7217	N/A	N/A	66.0000	0.8149	0.9703	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.7051	N/A	N/A	86.1700	0.0183	0.0122	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4995	N/A	N/A	92.1300	0.0560	0.0069	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1442	N/A	N/A	106.1700	0.0775	0.0028	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Mar	72.23	65.18	79.29	64.84	5.4992	N/A	N/A	66.4877			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.6242	N/A	N/A	78.1100	0.0093	0.0038	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0799	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.6720	N/A	N/A	84.1600	0.0077	0.0032	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1641	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.5386	N/A	N/A	66.0000	0.8149	0.9706	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.6076	N/A	N/A	86.1700	0.0183	0.0121	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4781	N/A	N/A	92.1300	0.0560	0.0068	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1372	N/A	N/A	106.1700	0.0775	0.0027	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Apr	68.85	62.48	75.22	64.84	5.1600	N/A	N/A	66.4732			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.4853	N/A	N/A	78.1100	0.0093	0.0038	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0708	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.5322	N/A	N/A	84.1600	0.0077	0.0032	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1467	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.1391	N/A	N/A	66.0000	0.8149	0.9714	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.3978	N/A	N/A	86.1700	0.0183	0.0119	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4325	N/A	N/A	92.1300	0.0560	0.0066	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1226	N/A	N/A	106.1700	0.0775	0.0026	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	May	65.20	59.77	70.62	64.84	4.8130	N/A	N/A	66.4576			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.3466	N/A	N/A	78.1100	0.0093	0.0036	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0620	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.3922	N/A	N/A	84.1600	0.0077	0.0031	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1298	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21

Gasoline (RVP 10)						5.7300	N/A	N/A	66.0000	0.8149	0.9723	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.1870	N/A	N/A	86.1700	0.0183	0.0116	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3874	N/A	N/A	92.1300	0.0560	0.0063	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1083	N/A	N/A	106.1700	0.0775	0.0024	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Jun	62.86	57.86	67.85	64.84	4.6008	N/A	N/A	66.4478			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.2636	N/A	N/A	78.1100	0.0093	0.0036	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0569	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.3083	N/A	N/A	84.1600	0.0077	0.0030	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1198	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						5.4797	N/A	N/A	66.0000	0.8149	0.9729	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.0602	N/A	N/A	86.1700	0.0183	0.0114	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3607	N/A	N/A	92.1300	0.0560	0.0061	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.0999	N/A	N/A	106.1700	0.0775	0.0023	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Jul	62.18	56.76	67.59	64.84	4.5404	N/A	N/A	66.4450			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.2402	N/A	N/A	78.1100	0.0093	0.0036	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0555	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.2847	N/A	N/A	84.1600	0.0077	0.0030	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1170	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						5.4085	N/A	N/A	66.0000	0.8149	0.9730	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.0244	N/A	N/A	86.1700	0.0183	0.0114	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3532	N/A	N/A	92.1300	0.0560	0.0061	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.0975	N/A	N/A	106.1700	0.0775	0.0023	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Aug	64.27	57.71	70.84	64.84	4.7283	N/A	N/A	66.4538			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.3133	N/A	N/A	78.1100	0.0093	0.0036	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0600	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.3586	N/A	N/A	84.1600	0.0077	0.0031	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1258	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						5.6302	N/A	N/A	66.0000	0.8149	0.9725	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.1362	N/A	N/A	86.1700	0.0183	0.0116	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.3766	N/A	N/A	92.1300	0.0560	0.0062	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1049	N/A	N/A	106.1700	0.0775	0.0024	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Sep	66.99	59.50	74.48	64.84	4.9806	N/A	N/A	66.4652			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.4132	N/A	N/A	78.1100	0.0093	0.0037	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0662	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.4594	N/A	N/A	84.1600	0.0077	0.0031	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1379	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						5.9277	N/A	N/A	66.0000	0.8149	0.9719	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.2883	N/A	N/A	86.1700	0.0183	0.0117	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4090	N/A	N/A	92.1300	0.0560	0.0064	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1151	N/A	N/A	106.1700	0.0775	0.0025	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Oct	70.02	61.92	78.11	64.84	5.2749	N/A	N/A	66.4781			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.5320	N/A	N/A	78.1100	0.0093	0.0038	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0738	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.5792	N/A	N/A	84.1600	0.0077	0.0032	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1525	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.2744	N/A	N/A	66.0000	0.8149	0.9712	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.4684	N/A	N/A	86.1700	0.0183	0.0120	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4477	N/A	N/A	92.1300	0.0560	0.0066	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1275	N/A	N/A	106.1700	0.0775	0.0026	106.17	Option 2: A=7.009, B=1462.266, C=215.11
Gasoline (RVP 10)	Nov	72.12	63.71	80.53	64.84	5.4871	N/A	N/A	66.4872			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.6192	N/A	N/A	78.1100	0.0093	0.0038	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0795	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.6669	N/A	N/A	84.1600	0.0077	0.0032	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1635	N/A	N/A	106.1700	0.0153	0.0006	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.5243	N/A	N/A	66.0000	0.8149	0.9707	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.6001	N/A	N/A	86.1700	0.0183	0.0121	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.4764	N/A	N/A	92.1300	0.0560	0.0068	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1367	N/A	N/A	106.1700	0.0775	0.0027	106.17	Option 2: A=7.009, B=1462.266, C=215.11

Gasoline (RVP 10)	Dec	73.77	65.37	82.18	64.84	5.6592	N/A	N/A	66.4944			92.84	Option 4: RVP=10, ASTM Slope=3
Benzene						1.6908	N/A	N/A	78.1100	0.0093	0.0039	78.11	Option 2: A=6.905, B=1211.033, C=220.79
Cumene (Isopropyl benzene)						0.0843	N/A	N/A	120.2000	0.0010	0.0000	120.20	Option 2: A=6.9636, B=1460.793, C=207.78
Cyclohexane						1.7389	N/A	N/A	84.1600	0.0077	0.0033	84.16	Option 2: A=6.841, B=1201.53, C=222.65
Ethyl benzene						0.1726	N/A	N/A	106.1700	0.0153	0.0007	106.17	Option 2: A=6.975, B=1424.255, C=213.21
Gasoline (RVP 10)						6.7269	N/A	N/A	66.0000	0.8149	0.9703	92.00	Option 4: RVP=10, ASTM Slope=3
Hexane (-n)						2.7079	N/A	N/A	86.1700	0.0183	0.0122	86.17	Option 2: A=6.876, B=1171.17, C=224.41
Toluene						0.5001	N/A	N/A	92.1300	0.0560	0.0069	92.13	Option 2: A=6.954, B=1344.8, C=219.48
Xylene (-m)						0.1444	N/A	N/A	106.1700	0.0775	0.0028	106.17	Option 2: A=7.009, B=1462.266, C=215.11

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

VOPAK 110-06 & 110-07 - Domed External Floating Roof Tank
Sydney Airport Amo, NSW

Month:	January	February	March	April	May	June	July	August	September	October	November	December
Rim Seal Losses (lb):	373.8395											
Seal Factor A (lb-mole/ft-yr):	5.8000											
Seal Factor B (lb-mole/ft-yr (mph)^n):	0.3000											
Average Wind Speed (mph):	0.0000											
Seal-related Wind Speed Exponent:	2.1000											
Value of Vapor Pressure Function:	0.1223											
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	5.7233											
Tank Diameter (ft):	95.1400											
Vapor Molecular Weight (lb/lb-mole):	66.4970											
Product Factor:	1.0000											
Withdrawal Losses (lb):	17.4913											
Net Throughput (gal/mo.):	8,495,772.0000											
Shell Clingage Factor (bbl/1000 sqft):	0.0015											
Average Organic Liquid Density (lb/gal):	5.8161											
Tank Diameter (ft):	95.1400											
Roof Fitting Losses (lb):	51.4746											
Value of Vapor Pressure Function:	0.1223											
Vapor Molecular Weight (lb/lb-mole):	66.4970											
Product Factor:	1.0000											
Tot. Roof Fitting Loss Fact.(lb-mole/yr):	75.9800											
Average Wind Speed (mph):	0.0000											
Total Losses (lb):	442.8054											

Roof Fitting/Status	Quantity	Roof Fitting Loss Factors KFa(lb-mole/yr)	KFb(lb-mole/(yr mph^n))	m	Losses(lb)
Access Hatch (24-in. Diam.)/Bolted Cover, Gasketed	1	1.60	0.00	0.00	1.1048
Automatic Gauge Float Well/Unbolted Cover, Ungasketed	1	14.00	5.40	1.10	9.6666
Vacuum Breaker (10-in. Diam.)/Weighted Mech. Actuation, Gask.	1	6.20	1.20	0.94	4.2809
Unslotted Guide-Pole Well/Ungasketed Sliding Cover	1	31.00	150.00	1.40	21.4045
Gauge-Hatch/Sample Well (8-in. Diam.)/Weighted Mech. Actuation, Gask.	1	0.47	0.02	0.97	0.3245
Roof Drain (3-in. Diameter)/Open	1	1.50	0.21	1.70	1.0357
Roof Leg (3-in. Diameter)/Adjustable, Double-Deck Roofs	25	0.82	0.53	0.14	14.1546
Rim Vent (6-in. Diameter)/Weighted Mech. Actuation, Gask.	1	0.71	0.10	1.00	0.4902

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: January, February, March, April, May, June, July, August, September, October, November, December

VOPAK 110-06 & 110-07 - Domed External Floating Roof Tank
Sydney Airport Amo, NSW

	Losses(lbs)				
Components	Rim Seal Loss	Withdrawl Loss	Deck Fitting Loss	Deck Seam Loss	Total Emissions
Gasoline (RVP 10)	3,960.23	209.90	545.29	0.00	4,715.42
Benzene	14.91	1.96	2.05	0.00	18.92
Cumene (Isopropyl benzene)	0.08	0.21	0.01	0.00	0.30
Cyclohexane	12.61	1.61	1.74	0.00	15.95
Ethyl benzene	2.43	3.22	0.33	0.00	5.98
Gasoline (RVP 10)	3,846.67	171.04	529.66	0.00	4,547.37
Hexane (-n)	47.16	3.84	6.49	0.00	57.50
Toluene	26.12	11.76	3.60	0.00	41.47
Xylene (-m)	10.26	16.26	1.41	0.00	27.93

Appendix C

Emission Rates

Appendix C Emission Rates

TANK	Month	Monthly Emission Rate g/s						
		Benzene	Cumene	Cyclohexane	Ethylbenzene	Hexane	Toluene	Xylene
DT01	January	1.03E-02	1.67E-02	3.52E-03	3.86E-03	5.48E-03	1.01E-02	1.01E-02
	February	1.06E-02	1.71E-02	3.63E-03	3.96E-03	5.65E-03	1.04E-02	1.04E-02
	March	9.37E-03	1.50E-02	3.21E-03	3.47E-03	5.01E-03	9.19E-03	9.10E-03
	April	8.57E-03	1.33E-02	2.95E-03	3.11E-03	4.61E-03	8.32E-03	8.14E-03
	May	7.32E-03	1.10E-02	2.52E-03	2.59E-03	3.96E-03	7.02E-03	6.77E-03
	June	6.93E-03	1.01E-02	2.39E-03	2.41E-03	3.77E-03	6.59E-03	6.30E-03
	July	6.76E-03	9.83E-03	2.33E-03	2.34E-03	3.68E-03	6.42E-03	6.11E-03
	August	7.50E-03	1.11E-02	2.59E-03	2.63E-03	4.06E-03	7.17E-03	6.88E-03
	September	8.54E-03	1.30E-02	2.94E-03	3.06E-03	4.61E-03	8.24E-03	8.00E-03
	October	9.22E-03	1.44E-02	3.17E-03	3.37E-03	4.95E-03	8.99E-03	8.83E-03
	November	1.01E-02	1.61E-02	3.45E-03	3.73E-03	5.39E-03	9.87E-03	9.77E-03
	December	1.02E-02	1.66E-02	3.51E-03	3.84E-03	5.47E-03	1.01E-02	1.01E-02
DT02	January	1.03E-02	1.67E-02	3.52E-03	3.86E-03	5.48E-03	1.01E-02	1.01E-02
	February	1.06E-02	1.71E-02	3.63E-03	3.96E-03	5.65E-03	1.04E-02	1.04E-02
	March	9.37E-03	1.50E-02	3.21E-03	3.47E-03	5.01E-03	9.19E-03	9.10E-03
	April	8.57E-03	1.33E-02	2.95E-03	3.11E-03	4.61E-03	8.32E-03	8.14E-03
	May	7.32E-03	1.10E-02	2.52E-03	2.59E-03	3.96E-03	7.02E-03	6.77E-03
	June	6.93E-03	1.01E-02	2.39E-03	2.41E-03	3.77E-03	6.59E-03	6.30E-03
	July	6.76E-03	9.83E-03	2.33E-03	2.34E-03	3.68E-03	6.42E-03	6.11E-03
	August	7.50E-03	1.11E-02	2.59E-03	2.63E-03	4.06E-03	7.17E-03	6.88E-03
	September	8.54E-03	1.30E-02	2.94E-03	3.06E-03	4.61E-03	8.24E-03	8.00E-03
	October	9.22E-03	1.44E-02	3.17E-03	3.37E-03	4.95E-03	8.99E-03	8.83E-03
	November	1.01E-02	1.61E-02	3.45E-03	3.73E-03	5.39E-03	9.87E-03	9.77E-03
	December	1.02E-02	1.66E-02	3.51E-03	3.84E-03	5.47E-03	1.01E-02	1.01E-02
DT03	January	1.03E-02	1.67E-02	3.52E-03	3.86E-03	5.48E-03	1.01E-02	1.01E-02
	February	1.06E-02	1.71E-02	3.63E-03	3.96E-03	5.65E-03	1.04E-02	1.04E-02
	March	9.37E-03	1.50E-02	3.21E-03	3.47E-03	5.01E-03	9.19E-03	9.10E-03
	April	8.57E-03	1.33E-02	2.95E-03	3.11E-03	4.61E-03	8.32E-03	8.14E-03
	May	7.32E-03	1.10E-02	2.52E-03	2.59E-03	3.96E-03	7.02E-03	6.77E-03
	June	6.93E-03	1.01E-02	2.39E-03	2.41E-03	3.77E-03	6.59E-03	6.30E-03
	July	6.76E-03	9.83E-03	2.33E-03	2.34E-03	3.68E-03	6.42E-03	6.11E-03
	August	7.50E-03	1.11E-02	2.59E-03	2.63E-03	4.06E-03	7.17E-03	6.88E-03

TANK	Month	Monthly Emission Rate g/s						
		Benzene	Cumene	Cyclohexane	Ethylbenzene	Hexane	Toluene	Xylene
	September	8.54E-03	1.30E-02	2.94E-03	3.06E-03	4.61E-03	8.24E-03	8.00E-03
	October	9.22E-03	1.44E-02	3.17E-03	3.37E-03	4.95E-03	8.99E-03	8.83E-03
	November	1.01E-02	1.61E-02	3.45E-03	3.73E-03	5.39E-03	9.87E-03	9.77E-03
	December	1.02E-02	1.66E-02	3.51E-03	3.84E-03	5.47E-03	1.01E-02	1.01E-02
GT04	January	4.31E-04	6.17E-06	3.62E-04	1.28E-04	1.31E-03	9.27E-04	5.94E-04
	February	4.68E-04	6.77E-06	3.94E-04	1.40E-04	1.42E-03	1.01E-03	6.50E-04
	March	4.05E-04	5.99E-06	3.41E-04	1.23E-04	1.23E-03	8.77E-04	5.72E-04
	April	3.81E-04	5.94E-06	3.21E-04	1.20E-04	1.16E-03	8.33E-04	5.59E-04
	May	3.33E-04	5.51E-06	2.81E-04	1.09E-04	1.01E-03	7.37E-04	5.11E-04
	June	3.23E-04	5.56E-06	2.73E-04	1.08E-04	9.83E-04	7.21E-04	5.11E-04
	July	3.06E-04	5.34E-06	2.59E-04	1.04E-04	9.34E-04	6.86E-04	4.89E-04
	August	3.25E-04	5.46E-06	2.74E-04	1.07E-04	9.89E-04	7.21E-04	5.04E-04
	September	3.62E-04	5.81E-06	3.05E-04	1.16E-04	1.10E-03	7.95E-04	5.43E-04
	October	3.81E-04	5.83E-06	3.21E-04	1.18E-04	1.16E-03	8.29E-04	5.51E-04
	November	4.18E-04	6.18E-06	3.52E-04	1.27E-04	1.27E-03	9.04E-04	5.90E-04
	December	4.23E-04	6.12E-06	3.56E-04	1.27E-04	1.29E-03	9.12E-04	5.88E-04
GT05	January	4.31E-04	6.17E-06	3.62E-04	1.28E-04	1.31E-03	9.27E-04	5.94E-04
	February	4.68E-04	6.77E-06	3.94E-04	1.40E-04	1.42E-03	1.01E-03	6.50E-04
	March	4.05E-04	5.99E-06	3.41E-04	1.23E-04	1.23E-03	8.77E-04	5.72E-04
	April	3.81E-04	5.94E-06	3.21E-04	1.20E-04	1.16E-03	8.33E-04	5.59E-04
	May	3.33E-04	5.51E-06	2.81E-04	1.09E-04	1.01E-03	7.37E-04	5.11E-04
	June	3.23E-04	5.56E-06	2.73E-04	1.08E-04	9.83E-04	7.21E-04	5.11E-04
	July	3.06E-04	5.34E-06	2.59E-04	1.04E-04	9.34E-04	6.86E-04	4.89E-04
	August	3.25E-04	5.46E-06	2.74E-04	1.07E-04	9.89E-04	7.21E-04	5.04E-04
	September	3.62E-04	5.81E-06	3.05E-04	1.16E-04	1.10E-03	7.95E-04	5.43E-04
	October	3.81E-04	5.83E-06	3.21E-04	1.18E-04	1.16E-03	8.29E-04	5.51E-04
	November	4.18E-04	6.18E-06	3.52E-04	1.27E-04	1.27E-03	9.04E-04	5.90E-04
	December	4.23E-04	6.12E-06	3.56E-04	1.27E-04	1.29E-03	9.12E-04	5.88E-04
GT06	January	3.09E-04	4.48E-06	2.60E-04	9.28E-05	9.38E-04	6.67E-04	4.30E-04
	February	3.36E-04	4.91E-06	2.83E-04	1.02E-04	1.02E-03	7.26E-04	4.71E-04
	March	2.91E-04	4.35E-06	2.45E-04	8.91E-05	8.84E-04	6.32E-04	4.14E-04
	April	2.74E-04	4.31E-06	2.31E-04	8.67E-05	8.32E-04	6.00E-04	4.05E-04
	May	2.39E-04	4.01E-06	2.02E-04	7.89E-05	7.28E-04	5.31E-04	3.71E-04

TANK	Month	Monthly Emission Rate g/s						
		Benzene	Cumene	Cyclohexane	Ethylbenzene	Hexane	Toluene	Xylene
	June	2.32E-04	4.04E-06	1.96E-04	7.86E-05	7.06E-04	5.20E-04	3.70E-04
	July	2.20E-04	3.88E-06	1.86E-04	7.52E-05	6.70E-04	4.95E-04	3.55E-04
	August	2.33E-04	3.97E-06	1.97E-04	7.77E-05	7.10E-04	5.20E-04	3.66E-04
	September	2.60E-04	4.22E-06	2.19E-04	8.40E-05	7.90E-04	5.73E-04	3.93E-04
	October	2.73E-04	4.23E-06	2.30E-04	8.56E-05	8.31E-04	5.97E-04	3.99E-04
	November	3.00E-04	4.49E-06	2.52E-04	9.19E-05	9.10E-04	6.51E-04	4.27E-04
	December	3.04E-04	4.44E-06	2.56E-04	9.18E-05	9.22E-04	6.57E-04	4.25E-04
GT07	January	3.09E-04	4.48E-06	2.60E-04	9.28E-05	9.38E-04	6.67E-04	4.30E-04
	February	3.36E-04	4.91E-06	2.83E-04	1.02E-04	1.02E-03	7.26E-04	4.71E-04
	March	2.91E-04	4.35E-06	2.45E-04	8.91E-05	8.84E-04	6.32E-04	4.14E-04
	April	2.74E-04	4.31E-06	2.31E-04	8.67E-05	8.32E-04	6.00E-04	4.05E-04
	May	2.39E-04	4.01E-06	2.02E-04	7.89E-05	7.28E-04	5.31E-04	3.71E-04
	June	2.32E-04	4.04E-06	1.96E-04	7.86E-05	7.06E-04	5.20E-04	3.70E-04
	July	2.20E-04	3.88E-06	1.86E-04	7.52E-05	6.70E-04	4.95E-04	3.55E-04
	August	2.33E-04	3.97E-06	1.97E-04	7.77E-05	7.10E-04	5.20E-04	3.66E-04
	September	2.60E-04	4.22E-06	2.19E-04	8.40E-05	7.90E-04	5.73E-04	3.93E-04
	October	2.73E-04	4.23E-06	2.30E-04	8.56E-05	8.31E-04	5.97E-04	3.99E-04
	November	3.00E-04	4.49E-06	2.52E-04	9.19E-05	9.10E-04	6.51E-04	4.27E-04
	December	3.04E-04	4.44E-06	2.56E-04	9.18E-05	9.22E-04	6.57E-04	4.25E-04

Appendix D

Literature and Documentation

Appendix D Literature and Documentation

Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

Report

AIR QUALITY ASSESSMENT FOR VOPAK BITUMEN STORAGE FACILITY

VOPAK TERMINALS SYDNEY PTY LTD

Job ID. 20528B

13 October 2015

PROJECT NAME:	Air Quality Assessment For Vopak Bitumen Storage Facility
JOB ID:	20528B
DOCUMENT CONTROL NUMBER	AQU-NW-001-20528
PREPARED FOR:	Vopak Terminals Sydney Pty Ltd
APPROVED FOR RELEASE BY:	Damon Roddis
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DOCUMENT CONTROL				
VERSION	**DATE**	**COMMENT**	**PREPARED BY**	**REVIEWED BY**
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EXECUTIVE SUMMARY

Overview

Pacific Environment has been commissioned by Vopak Terminals Sydney Pty Ltd (Vopak) to prepare an Air Quality Assessment for the 'as built' bitumen import, storage and distribution facility (the Vopak bitumen facility) located at Lot 12, 49 Friendship Road, Port Botany, NSW.

The Vopak bitumen facility includes three 7,300 m^3 tanks for the storage of bitumen products, gantry facilities for loading and in-line blending bitumen road tankers, a thermal oil and heating system and furnace and a dedicated pipeline for bitumen unloading from ships. A vapour combustion unit treats large tank vapours during ship unloading operations and truck venting during filling.

This Air Quality Assessment has been prepared to address an EPA Prevention Notice, in addition to providing information as to potential odour emissions and effective odour management. A summary of where the requirements of the EPA Prevention Notice comments have been addressed within this document is provided below:

EPA Prevention Notice Comments	Relevant Section of AQIA
1, 2, 3 and 7	N/A
4. (a) Potential odour sources including but not limited to vents from Product Tanks 1, 2 and 3; truck loading; and fugitive emission from pipe work and other sources;	Section 7
(b) Potential for variability in the amount of odour generated due to variability in the odour emission rate of products stored; and	Section 8
(c) Different mitigation and/or management strategies including but not limited to:	
• Running the Vapor Combustor Unit (VCU) continuously, with vapours from only one of the three product tanks directed to the VCU at any one time;	Section 7, Section 8
• Running the VCU continuously, with vapours from all the three product tanks directed to the VCU at any time when transfers of bitumen from a ship to the premises are not taking place; and;	Section 7, Section 8
• Running the VCU only during transfers of bitumen from a ship to the premises (as currently stated in *Odour Management Procedures* prepared by Vopak Terminals Sydney Pty Limited dated 20 November 2014).	Section 7, Section 8
5. The AQIA must include recommendations to ensure the bitumen plant can be operated without offensive odours occurring beyond the premises boundary, including whether any future mitigation measures are required in order for the bitumen plant to be operated in an environmentally satisfactory matter.	Section 10
6. The AQIA must, if applicable, include proposed updates to Vopak's bitumen odour management procedures based on the findings of the AQIA.	Section 10

Emissions

The main potential sources of emissions to air are associated with the operation of the vapour combustion unit (VCU), bypass stack, road tanker loading (RTL) and storage tank breathing losses from product tanks 1, 2 and 3.

Information provided on the 'as built' plant design, along with source testing of tank headspace, has been used to develop an odour emission inventory. This was subsequently applied within a quantitative air dispersion modelling study to evaluate the potential impacts on local air quality due to Vopak's bitumen handling operations.

Conservatively estimated odour emission rates were used as input data for atmospheric dispersion modelling. The CALPUFF model was chosen to perform dispersion modelling for this assessment.

In addition to odour, potential impacts of the criteria air pollutants benzene and hydrogen sulfide have been assessed using data from tank headspace sampling completed at the Vopak facility.

Dispersion Modelling

The atmospheric dispersion modelling results have been assessed against the NSW Environment Protection Authority (EPA) assessment criteria to provide an air quality impact assessment for the Vopak bitumen facility.

Based on the results of the modelling study, the emissions are predicted to be minor and air quality goals are not expected to be compromised.

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1 INTRODUCTION

Pacific Environment (PE; formerly PAEHolmes) completed an air quality / odour impact assessment of the (then proposed) facility in November 2011, *Air Quality Assessment – Port Botany Bitumen Storage Facility*. This assessment was completed as part of the development application process for Vopak Terminals Sydney Pty Ltd (Vopak).

In late 2012, PE evaluated various options for the pollution control at the bitumen facility as part of the facility's detailed design. This was in light of both a proposed change in specification of bitumen to be handled at the site (potential H_2S concentrations and %LEL in tank head space) as well as the site's energy efficiency.

Additional air emission scenarios were then evaluated in early 2013 based on a new design point for normal operation (100% LEL and 300ppm H_2S in the tank head vapour space, air dilution of 3:1 for ship discharge and Road Tanker Loading (RTL) emissions).

The original intent of the air quality assessment, based on discussions with Vopak on 3 July 2015, was to complete an update of the PE air quality / odour assessment (AQIA) using the 'as built' design / geometry, combined with updated meteorology and emission data.

However, in the interim, Vopak received a Notice of Preventative Action from NSW Environment Protection Authority (EPA; Prevention Notice Number 1531474). This Prevention Notice includes a prescriptive requirement for completion of an AQIA, as follows:

Air Quality Impact Assessment

1. *On or before* ***Thursday, 23 July 2015****, Vopak must engage a suitably qualified and experienced consultant ("the consultant") that is capable of fulfilling the requirements of this Prevention Notice relating to the Air Quality Impact Assessment.*
2. *The consultant must prepare an Air Quality Impact Assessment (AQIA) of the premises.*
3. *The AQIA must:*
    - *be prepared in accordance with the requirements of the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2005).*
    - *make appropriate reference to the Assessment and Management of Odour from Stationary Sources in NSW: Technical Framework (2006) and Management of Odour from Stationary Sources in NSW: Technical Notes (2006); and*
    - *consider the requirements of the Protection of the Environment Operations (Clean Air) Regulation 2010 as applicable.*
4. *The AQIA must include an assessment of:*
    a) *Potential odour sources including but not limited to vents from Product Tanks 1, 2 and 3; truck loading; and fugitive emission from pipe work and other sources;*
    b) *Potential for variability in the amount of odour generated due to variability in the odour emission rate of products stored; and*
    c) *Different mitigation and/or management strategies including but not limited to:*
        i. *Running the Vapor Combustor Unit (VCU) continuously, with vapours from only one of the three product tanks directed to the VCU at any one time;*
        ii. *Running the VCU continuously, with vapours from all the three product tanks directed to the VCU at any time when transfers of bitumen from a ship to the premises are not taking place; and;*
        iii. *Running the VCU only during transfers of bitumen from a ship to the premises (as currently stated in Odour Management Procedures prepared by Vopak Terminals Sydney Pty Limited dated 20 November 2014).*
5. *The AQIA must include recommendations to ensure the bitumen plant can be operated without offensive odours occurring beyond the premises boundary, including whether any future mitigation measures are required in order for the bitumen plant to be operated in an environmentally satisfactory matter.*

6. *The AQIA must, if applicable, include proposed updates to Vopak's bitumen odour management procedures based on the findings of the AQIA.*

The current document has therefore been designed to meet the requirements of the Prevention Notice while capturing the requirements of Vopak's original brief.

In addition to odour, potential impacts of the criteria air pollutants benzene and hydrogen sulfide have been assessed using data from tank headspace sampling completed at the Vopak facility.

1.1 Scope of Work

Based on the above understanding, the scope of work, to meet the requirements of the Prevention Notice is as follows:

- Evaluation of potential odour sources including but not limited to vents from Product Tanks 1, 2 and 3; truck loading

NB: it is understood that Vopak have provided feedback to the EPA and that fugitive emissions from pipe work and other sources (outside of RTL emissions) will not be quantitatively assessed at this stage.

- Evaluate the potential for variability in the amount of odour generated due to variability in the odour emission rate of products stored
- Quantify the effect of different mitigation and/or management strategies including but not limited to:
  - Running the Vapour Combustor Unit (VCU) continuously, with vapours from only one of the three product tanks directed to the VCU at any one time;
  - Running the VCU continuously, with vapours from all the three product tanks directed to the VCU at any time when transfers of bitumen from a ship to the premises are not taking place; and
  - Running the VCU only during transfers of bitumen from a ship to the premises (as currently stated in Odour Management Procedures prepared by Vopak Terminals Sydney Pty Limited dated 20 November 2014).
- Provide recommendations to ensure the bitumen plant can be operated without offensive odours occurring beyond the premises boundary, including whether any future mitigation measures are required to achieve this.
- Provide proposed updates to Vopak's bitumen odour management procedures, as required, based on the findings of the AQIA.

2 PROJECT DESCRIPTION AND LOCAL SETTING

2.1 Introduction

The facility receives products (approximately 100,000 tonnes per year) via ship from the Bulk Liquids Berth (BLB1) in Port Botany. Bitumen products are imported into three tanks of up to 7,300 m^3 each and the typical parcel size would be 5-10 kt per shipment. There are approximately 8-16 shipments per annum.

The bitumen is stored at approximately 140-150°C and loaded out at approximately 180°C. The facility stores up to three imported bitumen grades. Various grades may be generated by blending the stored grades through an inline blending system during Road Tanker loading (RTL). The facility operates 24 hours a day, 365 days a year.

The bitumen facility consists of the construction and operation of:

- Three tanks each with a capacity of 7,300 m^3. The tanks are 22m in diameter and have an overall height of 23 m. Each tank has four vents for tank breathing losses to atmosphere. However during normal operation only one of these will be open. These tanks will be used to store the three grades of bitumen;
- A Vapour Combustion Unit (VCU) located near the Friendship Road boundary for treating large tank vapours during ship unloading operations and truck venting during filling;
- A two Bay Road Tanker Loading Gantry for driver self-loading of bitumen products. Operations occur 24 hours per day, 365 days a year;
- A pipeline dedicated to bitumen unloading from BLB1. The unloading capacity minimum rate is 100 m^3/hour with electric heat tracing and insulation/cladding; and
- A thermal oil system and incinerator operating on natural gas to fulfil the following heating applications:
  - Heating of bulk storage tanks using hot oil coils;
  - Heating of bitumen loading line heat exchangers (loading lines x 3);

The 'As Built' plant layout is presented in **Figure 2.1** showing emission points and the layout of the site.

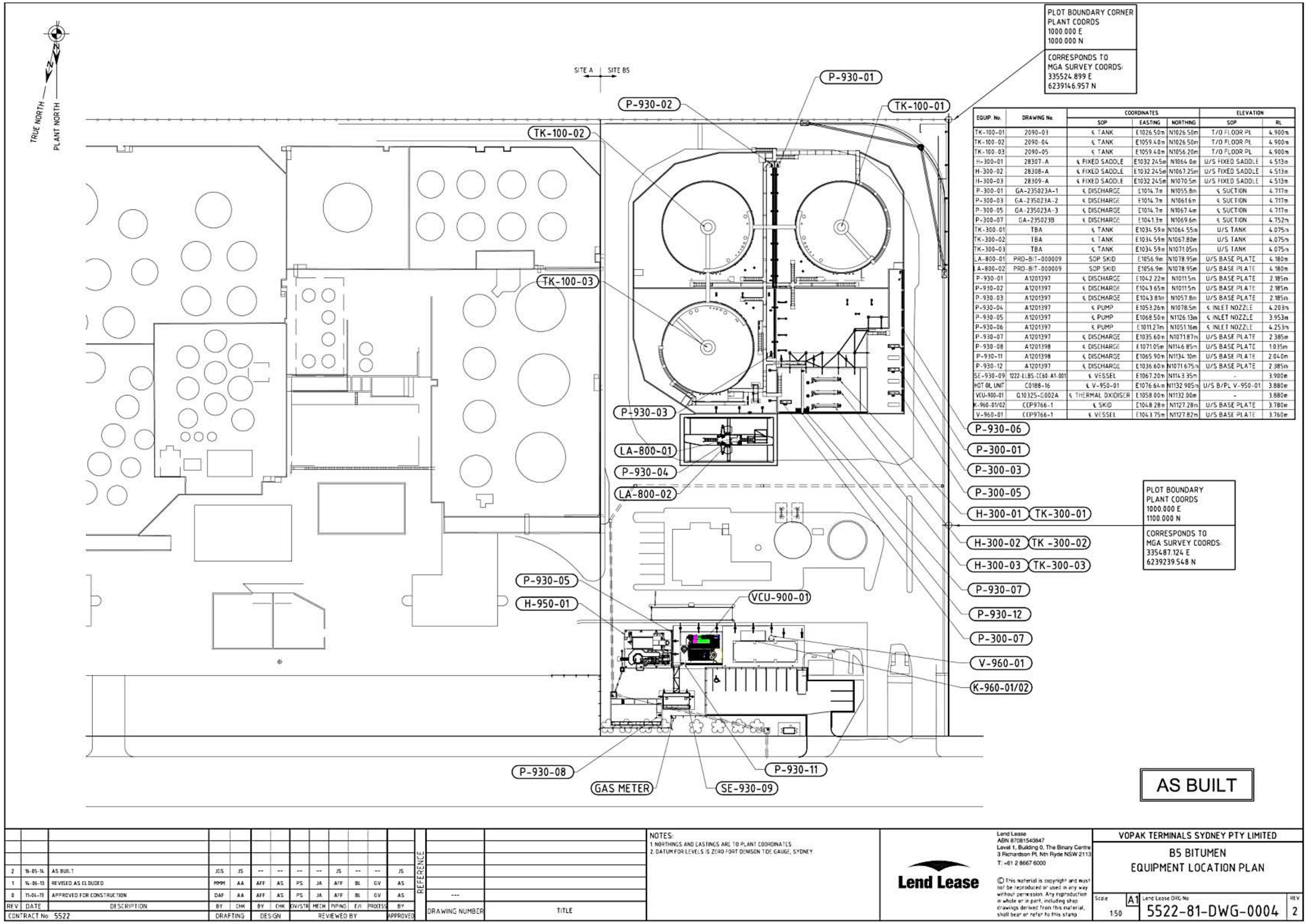


Figure 2.1: Site Layout

2.2 Local Setting

The Vopak bitumen facility is located on Lot 103 DP 1182871, 49 Friendship Road, Port Botany, NSW. The site is located in an industrial area and is approximately 5 km southeast of the Sydney Airport.

There are several suburbs located within a 3 km radius of the site including Banksmeadow (north-northwest), Matraville (north-northeast), Chifley (east-northeast), Little Bay (east-southeast) and Phillip Bay (south-southeast). A number of child care facilities, schools and aged care facilities are located within these townships. **Figure 2.2** shows the key components, the local setting and selected sensitive receptor locations.

The discrete receptor locations presented in **Table 2.1** were chosen for the purposes of assessing impacts from the facility. These locations are the closest potentially affected residential and sensitive locations to the site. A discrete receptor is placed at the entry/exit to the site to evaluate impacts to truck drivers lining up at the gate for potentially long periods of time.

Table 2.1: Selected Discrete Closest Receptor Locations

ID	Location	Easting (m)	Northing (m)	Elevation (m)	Approximate Distance from Site (m) and Direction
1	Matraville Public School	336821	6240701	17.9	1.9 km NE
2	St Agnes School	336628	6241013	26.0	2.1 km NNE
3	Matraville High School	337889	6240355	39.4	2.6 km ENE
4	St Andrews Primary School	338106	6240430	36.9	2.8 km ENE
5	Malabar Public School	338156	6240701	20.9	3.0 km NE
6	23 Adina Avenue, Phillip Bay	337019	6238494	29.3	1.7 km SE
7	61 Yarra Rd, Philip Bay	336641	6238493	19.0	1.3 km SE
8	52 Eyre St, Chifley	337049	6239809	28.8	1.6 km ENE
9	26 Moorina Av, Matraville	336345	6240209	16.2	1.3 km NE
10	5 Clonard Way, Little Bay	337171	6239080	18.1	1.6 km ESE
11	Botany Golf Course	334852	6240659	4.7	1.6 km WNW
12	Friendship Road	335476	6239298	4.0	Entry/exit to site

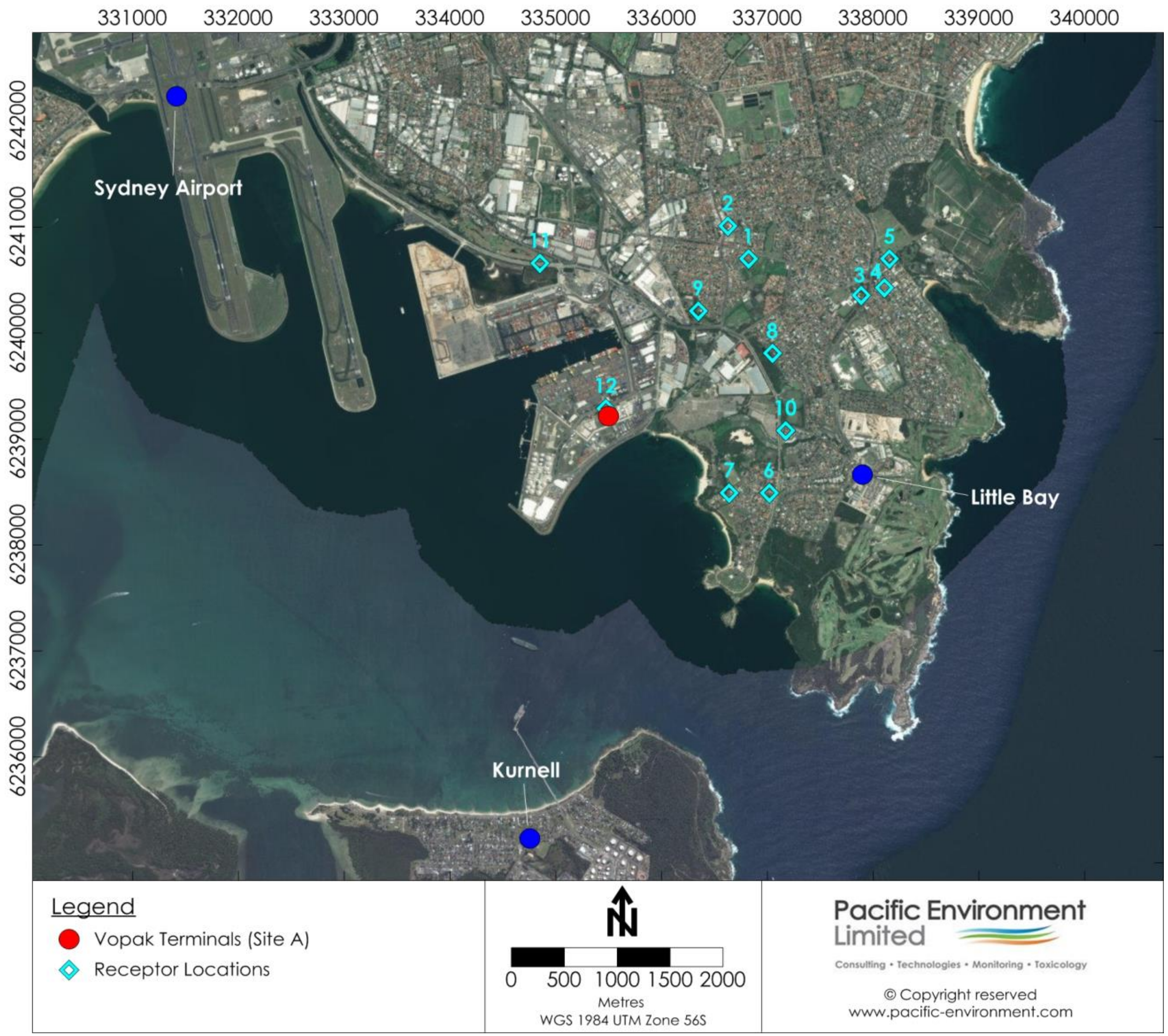


Figure 2.2: Local Setting and Selected Sensitive Receptors

2.3 Topography

A three-dimensional representation of the regional topography is shown in **Figure 2.3** reflecting the terrain used in the dispersion modelling for this assessment. The proposed site is located in a low lying region with Botany Bay to the west and south. There is some elevation to the east that could influence the general diurnal wind patterns that can be expected in a coastal environment.

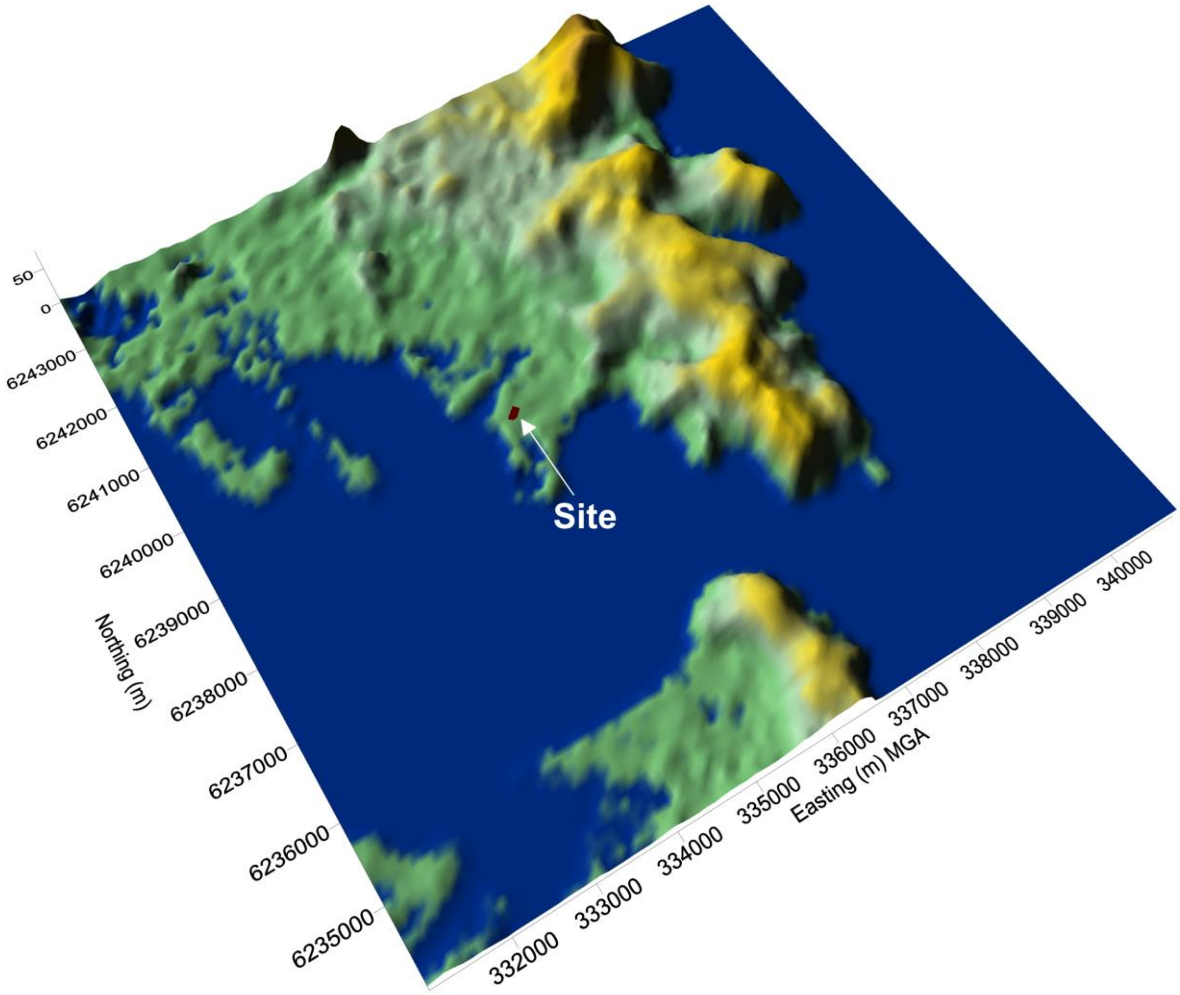


Figure 2.3 Three-Dimensional Representation of Regional Topography

3 AIR QUALITY PARAMETERS

3.1 Expected Emissions from the Vopak Bitumen Facility

Odorous emissions are the primary air quality emissions of concern from the Vopak bitumen facility. The key odour producing sources at the facility include:

- Operation of the vapour combustion unit (VCU) during both ship unloading to the storage tanks and truck loading within the gantry;
- Emissions leaving through the bypass stack;
- Fugitive emissions resulting from RTL within the gantry;
- Bitumen storage tank breathing losses.

The displaced vapour headspace that occurs during ship unloading and RTL operations is typically treated by the VCU. Further descriptions of the proposed scenarios and the anticipated emissions are outlined in **Section 7.3**.

It is acknowledged that the VCU is not running continuously. The VCU was principally designed to capture emissions from tank tops during ship discharges. When the tank inlet valve opens ready for a ship import, the fan / VCU starts up and the ductwork leading from the tank roof is opened by a remotely controlled valve on the tank roof. Hence, the air within the tank roof space is displaced and drawn by the fan to the VCU whilst the tank is filling. Similarly, for the RTL operations the fan / VCU starts up when a road tanker is connected and ready to fill.

When there are no transfer operations occurring, the fan / VCU is shut-down and the tanks sit in a static state at approximately 150 °C and vent to atmosphere. Accordingly, these tank breathing losses need to be evaluated in terms of their emissions to air.

3.2 Odour

The determination of air quality goals for odour and their use in assessing odour impacts is recognised as a difficult topic in air pollution science. The topic has received considerable attention in recent years and the procedures for assessing odour impacts using dispersion models have been refined considerably. There is still considerable debate in the scientific community about appropriate odour goals.

The **NSW EPA (2005)** has developed odour goals used to assess the likelihood of nuisance impact arising from the emission of odour.

There are two factors that need to be considered:

- what "level of exposure" to odour is considered acceptable to meet current community standards in NSW; and
- how can dispersion models be used to determine if a source of odour meets the goals which are based on this acceptable level of exposure.

The term "level of exposure" has been used to reflect the fact that odour impacts are determined by several factors the most important of which are:

- the **F**requency of the exposure;
- the **I**ntensity of the odour;
- the **D**uration of the odour episodes; and
- the **O**ffensiveness of the odour (the so-called FIDO factors).

In determining the offensiveness of an odour it needs to be recognised that for most odours the context in which an odour is perceived is also relevant. Some odours, for example the smell of sewage, hydrogen sulfide, butyric acid, landfill gas etc., are likely to be judged offensive regardless of the context in which they occur. Other odours such as the smell of jet fuel may be acceptable at an airport, but not in a house, and diesel exhaust may be acceptable near a busy road, but not in a restaurant.

In summary, whether or not an individual considers an odour to be a nuisance will depend on the FIDO factors outlined above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

The difference between odour goals is based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area.

3.3 Volatile Organic Compounds

Organic hydrocarbons are comprised of a collection of various volatile organic compounds (VOCs), and several of these compounds may be toxic. Of the primary VOCs, benzene is being assessed in this air quality assessment.

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

4 AIR QUALITY CRITERIA

The tanks holding organic hydrocarbons (finished fuel products) have the potential to release a collection of various fugitive emissions, several of which may be toxic at high concentrations.

Organic hydrocarbons may be present in the air in low concentrations, however characteristics such as toxicity or persistence means they can be potentially hazardous to human, plant or animal life. There is evidence that cancer, birth defects, genetic damage, immuno-deficiency, respiratory and nervous system disorders can be linked to exposure to occupational levels of such air toxics.

Organic hydrocarbons also include reactive organic compounds, which play a role in the formation of photochemical smog. There are no impact assessment criteria specified for total VOCs, however modelling predictions can be compared to the impact assessment criteria for individual organic pollutants that may be present in the fugitive headspace gases.

For this assessment, the predicted concentration of benzene has been compared against the NSW EPA's 1-hour average criteria outlined in their "Approved Methods for Modelling and Assessment of Air Pollutants in NSW" (the Approved Methods)(**NSW EPA, 2005**). Section 7.2.2 of the Approved Methods allows for this pollutant to be assessed at the 99.9th percentile for Level 2 impact assessments.

Table 4.1 summarises the benzene criteria relevant for the site.

Table 4.1: Benzene Assessment Criterion, 99.9th Percentile of 1 hour average Concentrations

Pollutant	Standards	Averaging Period	Source
Benzene	0.029 mg/m^3	1-Hour	NSW EPA (2005)(assessment criteria)

In addition to health impacts, the NSW OEH lists impact assessment criteria for complex mixtures of odorous air pollutants. **Table 4.2** lists the odour glc criterion to be exceeded not more than 1% of the time, for different population densities. For adjacent industrial lots a less stringent criterion should be applicable as these areas would not be expected to be populated for long continuous periods of time. However, for residential areas further away the more stringent criterion of 2 OU would apply.

Table 4.2: Odour Assessment Criteria, 99th Percentile of 1-second average Concentrations

Population of Affected Community	Impact Assessment Criteria for Complex Mixtures of Odourous Air Pollutants (OU)
Urban (2000) and/or schools and hospitals	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
≤ ~2	7.0

Hydrogen sulfide, like odour, is an assessment criteria based on a function of population density as per **Table 4.3**. This odorous pollutant is assessed at the 1.38 µg/m³ criterion.

Table 4.3: Hydrogen Sulfide Assessment Criteria, 99th Percentile of 1-second average Concentrations

Population of Affected Community	Impact Assessment Criteria (µg/m²)
Urban (2000) and/or schools and hospitals	1.38
~500	2.07
~125	2.76
~30	3.45
~10	4.14
≤ ~2	4.83

It is a common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because Gaussian dispersion models are only able to directly predict concentrations over an averaging period of 3-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a 3-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

To determine more rigorously the ratio between the one-second peak concentrations and 3-minute and longer period average concentrations (referred to as peak-to-mean ratio) that might be predicted by a Gaussian dispersion model, EPA commissioned a study by **Katestone Scientific Pty Ltd (1995, 1998)**. The peak-to-mean ratio for a range of circumstances are listed in **Table 4.4**. The ratio is also dependent on atmospheric stability and the distance from the source.

Table 4.4: Factors for estimating peak concentration

Source Type	Pasquill-Gifford stability class	Near field P/M60*	Far field P/M60
Area	A, B, C, D	2.5	2.3
	E, F	2.3	1.9
Line	A – F	6	6
Surface point	A, B, C	12	4
	D, E, F	25	7
Tall wake-free point	A, B, C	17	3
	D, E, F	35	6
Wake-affected point	A – F	2.3	2.3
Volume	A – F	2.3	2.3

*Ratio of peak 1-second average concentrations to mean 1-hour average concentrations

The EPA Approved Methods take account of this peaking factor and the goals shown in **Table 4.2** and **Table 4.3** are based on nose response time.

5 EXISTING AMBIENT AIR QUALITY

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

Existing industrial odour sources in the vicinity of the site include the nearby Qenos, Origin Energy, Australian Container Freight Services as well as Vopak's other operations.

A bitumen import and dispatch facility similar to the Vopak Bitumen Terminal is operating on the land adjacent south west of the Vopak facility site by Terminals Pty Ltd (Terminals). An air quality assessment (AQA) was undertaken for the Terminals facility in April 2011 (**GHD, 2011**). The Terminals AQA included assessment of odour, VOCs and products of combustion.

5.1 Odour

There is no measured odour data for the Port Botany area. However, the Air Quality Assessment for the Terminals facility (**GHD, 2011**) modelled odour concentrations associated with the site. The predicted peak odour concentration at ground level was 0.1 OU along Simblist Road. This concentration will be used as the respective background level for odour.

5.2 Volatile Organic Compounds

The Air Quality Assessment for the Terminals facility (**GHD, 2011**) also predicted potential impacts for VOCs (speciated) as a result of the proposed Terminals facility. The maximum predicted ground level concentrations are well below the relevant OEH Impact Assessment Criteria.

The predicted ground level concentration for benzene is summarised in **Table 5.1**.

Table 5.1: Predicted Ground Level Concentrations at Terminals Facility

Pollutant	99.9th Percentile Predicted glc [mg/m^3]	OEH Impact Assessment Criterion [mg/m^3]
Benzene	7.7 E-06	0.029

6 METEOROLOGY

6.1 Long Term Meteorological Data Analysis

Table 6.1 presents the temperature, humidity and rainfall data for the closest Bureau of Meteorology site located at Sydney Airport (Site number 0660371), approximately 5.3 km north-east of the site. Relative humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures recorded at the Sydney Airport station are 22.3°C and 13.5 °C, respectively. On average, December is the hottest month with average maximum temperatures of 25.8°C. July is the coldest month, with an average minimum temperature of 7.2°C. The annual average relative humidity reading collected at 9am is 69% and at 3pm the annual average is 57%. The month with the highest relative humidity on average is June with 9am averages of 74% and August has with the lowest relative humidity with 3pm averages of 49%.

Rainfall data collected at the Sydney Airport station show that June is the wettest month, with an average rainfall of 122.5 mm over an average of 8.8 rain days. The average annual rainfall is 1084.5 mm with an average of 96.0 rain days per year.

Table 6.1: Monthly Climate Statistics for Sydney Airport

Heading	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean maximum temperature (°C)	26.5	26.4	25.3	22.9	20.0	17.6	17.0	18.3	20.6	22.6	24.1	25.8
Mean minimum temperature (°C)	18.9	19.1	17.6	14.2	11.0	8.7	7.2	8.2	10.5	13.2	15.4	17.5
Mean rainfall (mm)	94.0	111.9	115.4	109.3	98.6	122.5	69.6	76.7	60.2	70.7	81.5	74.1
Mean 9am temperature (°C)	22.4	22.3	21.1	18.2	14.6	11.9	10.8	12.5	15.7	18.4	19.9	21.6
Mean 9am relative humidity (%)	70	73	73	71	73	74	71	65	62	61	64	66
Mean 9am wind speed (km/h)	14.4	13.8	12.9	12.9	12.6	13.4	13.3	14.4	15.5	16.3	16.0	14.8
Mean 3 pm temperature (°C)	24.8	24.8	23.9	21.7	19.0	16.6	16.1	17.2	19.0	20.7	22.1	23.9
Mean 3pm relative humidity (%)	60	63	61	59	58	57	52	49	51	54	56	58
Mean 3pm wind speed (km/h)	24.1	23.0	21.0	19.3	17.1	17.8	18.2	20.8	23.1	24.6	25.3	25.2

Site name: SYDNEY AIRPORT AMO, Site number: 066037, Latitude: 33.95 °S Longitude: 151.17 °E

6.2 Meteorological Modelling

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

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

6.2.1 TAPM

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

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

For the Assessment, TAPM was setup with 4 domains, composed of 25 grids along both the x and the y axes, centred on -33˚58.5' Latitude and 151˚13.5' Longitude. Each nested domain had a grid resolution of 20 km, 10 km, 3 km and 1 km respectively. The 3D output for innermost domain was used to drive CALMET as an initial guess field, in combination with observed surface data.

Default TAPM terrain values are based on a global 30-second resolution (approximately 1 km) dataset provided by the US Geological Survey, Earth Resources Observation Systems (EROS). Default land use and soils data sets for TAPM were used (**Hurley, 2002a**).

TAPM was used to generate gridded prognostic data (3D.dat) for the CALMET modelling domain.

6.2.2 Onsite Meteorological Data Analysis (CALMET)

Figure 6.1 presents CALMET generated on-site annual and seasonal windroses for the modelling year (July 2014 – June 2015). CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region.

On an annual basis, the most common winds are from the northeast, south and northwest. Very few winds originate from the east quadrant. During summer and spring, winds from the northeast are predominant and during autumn and winter, winds are predominantly from the south to northwest.

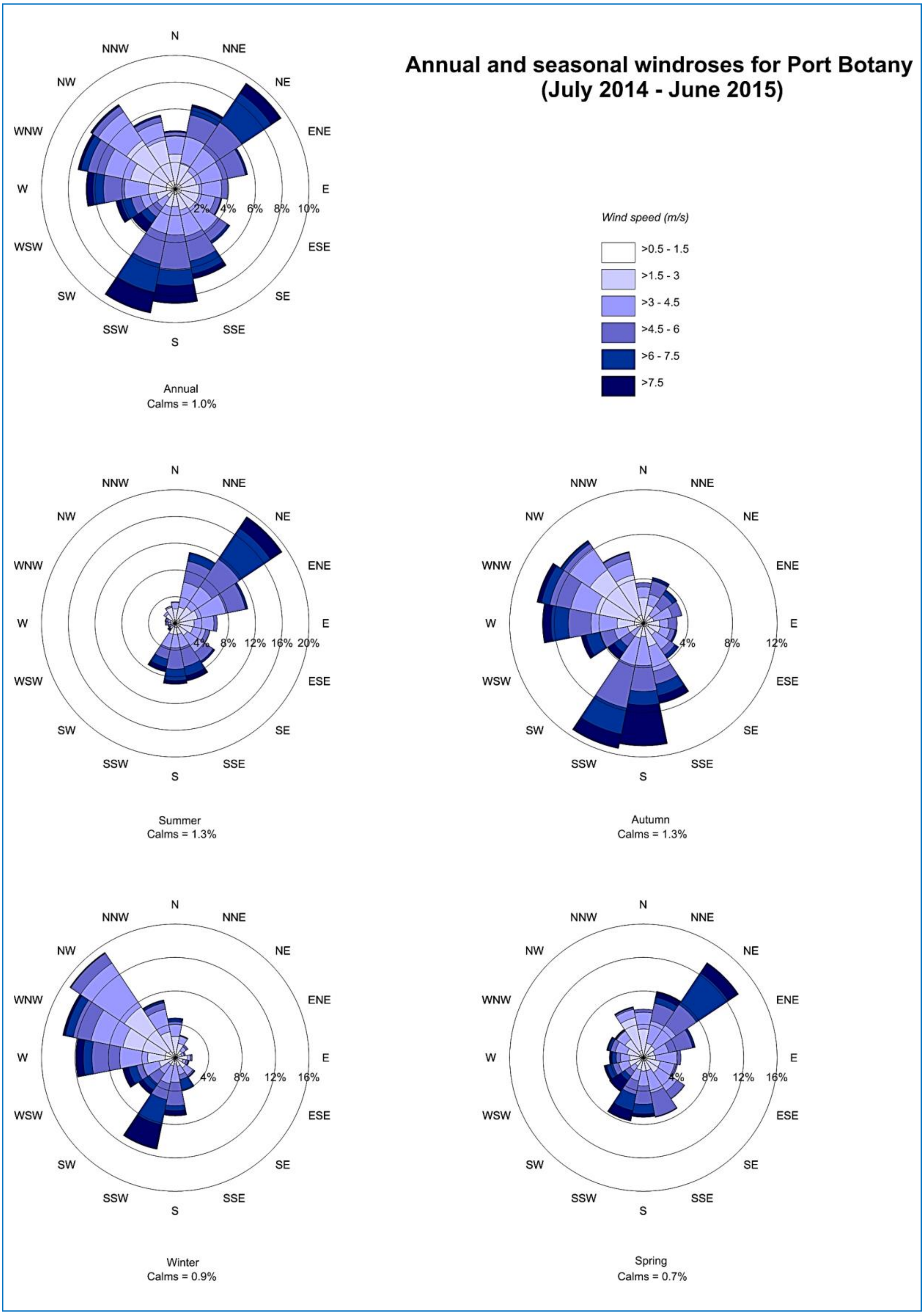


Figure 6.1: Annual and Seasonal Windroses for Port Botany, July 2014 – June 2015 (CALMET generated)

6.3 Atmospheric Stability

An important aspect of pollutant dispersion is the level of turbulence in the lowest 1 km of the atmosphere, known as the planetary boundary layer (PBL). Turbulence controls how effectively a plume is diffused into the surrounding air and hence diluted. It acts by increasing the cross-sectional area of the plume due to random motions. With stronger turbulence, the rate of plume diffusion increases. Weak turbulence limits diffusion and contributes to high plume concentrations downwind of a source.

Turbulence is generated by both thermal and mechanical effects to varying degrees. Thermally driven turbulence occurs when the surface is being heated, in turn transferring heat to the air above by convection. Mechanical turbulence is caused by the frictional effects of wind moving over the earth's surface, and depends on the roughness of the surface as well as the flow characteristics.

Turbulence in the boundary layer is influenced by the vertical temperature gradient, which is one of several indicators of stability. Plume models use indicators of atmospheric stability in conjunction with other meteorological data to estimate the dispersion conditions in the atmosphere.

Stability can be described across a spectrum ranging from highly unstable through neutral to highly stable. A highly unstable boundary layer is characterised by strong surface heating and relatively light winds, leading to intense convective turbulence and enhanced plume diffusion. At the other extreme, very stable conditions are often associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Neutral conditions are linked to windy and/or cloudy weather, and short periods around sunset and sunrise, when surface rates of heating or cooling are very low.

The stability of the atmosphere plays a large role in determining the dispersion of a plume and it is important to have it correctly represented in dispersion models. Current air quality dispersion models (such as AERMOD and CALPUFF) use the Monin-Obukhov Similarity Theory (MOST) to characterise turbulence and other processes in the PBL. One of the measures of the PBL is the Monin-Obukhov length (L), which approximates the height at which turbulence is generated equally by thermal and mechanical effects (Seinfeld and Pandis, 2006). It is a measure of the relative importance of mechanical and thermal forcing on atmospheric turbulence.

Because values of L diverge to + and - infinity as stability approaches neutral from the stable and unstable sides, respectively, it is often more convenient to use the inverse of L (i.e., 1/L) when describing stability.

Figure 6.2 shows the hourly averaged 1/L for the bitumen site computed from all data in the CALMET extract file. Based on **Table 6.2** this plot indicates that, as to be expected, the PBL is stable overnight and becomes unstable as radiation from the sun heats the surface layer of the atmosphere and drives convection. The changes from positive to negative occur at the shifts between day and night. This indicates that the diurnal patterns of stability are realistic.

Table 6.2: Inverse of the Monin-Obukhov length L with respect to Atmospheric Stability

1/L	Atmospheric Stability
Negative	Unstable
Zero	Neutral
Positive	Stable

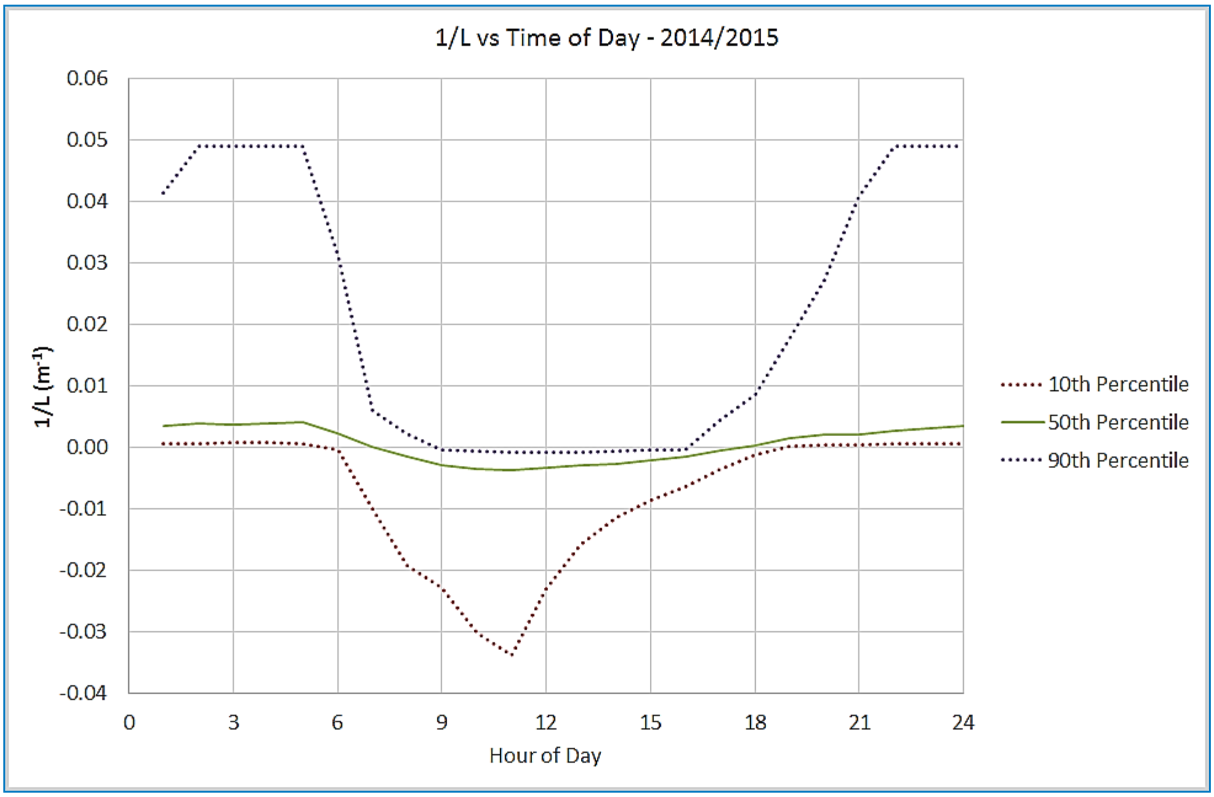


Figure 6.2: Annual statistics of 1/L by hour of the day

Figure 6.3 shows the variations in stability over the year by hour of the day, with reference to the widely known Pasquill-Gifford classes of stability. The relationship between L and stability classes is based on values derived by **Golder (1972)** set out in **NSW EPA (2005)**. Note that the reference to stability categories here is only for convenience in describing stability. The CALMET/CALPUFF modelling system uses calculated values of L across a continuum.

Figure 6.3 shows that stable and very stable conditions occur for about 40-50% of the time, which is the expected typical conditions for on-shore locations that experience temperature inversions at night. Atmospheric instability increases during the day and reaches a peak at around 11 am. A stable atmosphere is prevalent during the night. These profiles indicate that pollutant dispersion is most effective during the daytime and least effective at night.

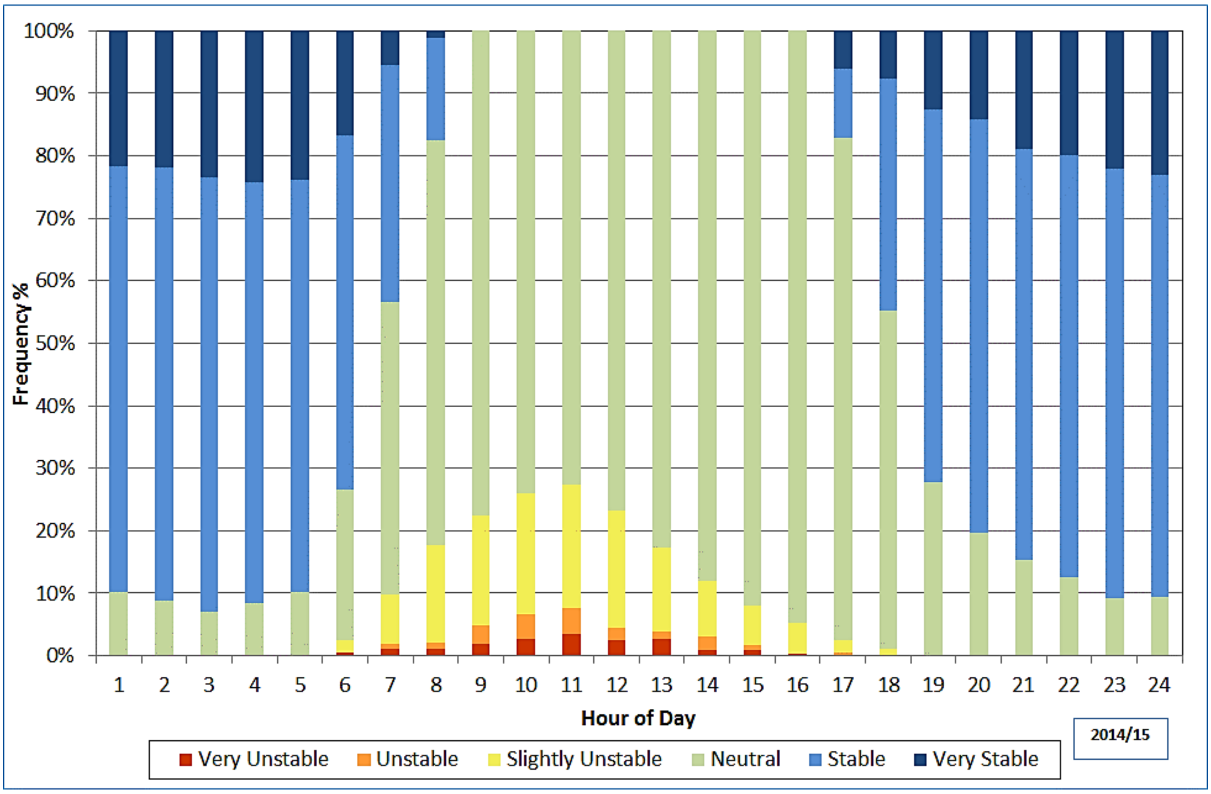


Figure 6.3: Annual distribution of stability type by hour of the day

7 EMISSIONS ESTIMATION

7.1 Assessment Approach

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

An estimate of the existing background air quality has been made based on the Air Quality Assessment for Terminals facility (**GHD, 2011**). This was assumed to include existing sources within the airshed.

The Air Quality Impact Assessment (AQIA) will fulfil the requirements of the Prevention Notice (No: 1531474) issued by the EPA to Vopak Terminals.

In addition to these requirements, a sensitivity analysis as to the likely proportion of fugitive emissions from the RTL has been completed.

Further, the potential impacts of emissions diverted to the bypass stack as opposed to through the VCU were modelled.

A detailed summary of all the emission scenarios modelled is provided in **Section 7.3**.

The results obtained for each new source are added to the existing background concentrations and compared to the appropriate impact assessment criteria. The cumulative impacts are discussed in **Section 8.3**.

7.2 Pollutant Dispersion Modelling

7.2.1 CALPUFF

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

In March 2011 the NSW EPA published generic guidance and optional settings for the CALPUFF modelling system for inclusion in the Approved Methods (**TRC, 2011**). The model set up for this study has been completed in consideration of these guidelines.

7.3 Model Scenarios

Nine scenarios have been modelled as part of this air quality assessment. Scenarios 1, 2 and 3 are detailed from the EPA Prevention Notice, with the remaining scenarios assessed to develop options for future odour control within the Vopak bitumen facility. The scenarios evaluated are as follows:

- Scenario 1: running the VCU continuously, with vapours from only one of the three product tanks directed to the VCU at any one time;
- Scenario 2: running the VCU continuously, with vapours from all three tanks directed to the VCU at any time when transfers of bitumen from a ship to the premises are not taking place;
- Scenario 3: running the VCU only during transfers of bitumen from a ship to the premises;
- Scenario 4: Scenario 1 plus the emissions from 2 RTLs via the VCU and the fugitive emissions from RTL;
- Scenario 5: Scenario 2 plus the emissions from 2 RTL activities via the VCU and fugitive emissions from the RTLs;
- Scenario 6: Scenario 3 plus the emissions from 2 RTL activities via the VCU and fugitive emissions from the RTLs;
- Scenario 7: Scenario 1, but with discharge via the Bypass stack;
- Scenario 8: Scenario 2, but with discharge via the Bypass stack;
- Scenario 9: Scenario 3, but with discharge via the Bypass stack;

The primary odour producing sources at the Vopak bitumen facility include tank venting, the bypass stack, the VCU and RTL. These emission sources are discussed further in **Section 7.4**.

Table 7.1 presents a summary of the emission source statuses for each of the modelled scenarios.

Table 7.1: Summary of Model Scenarios

Scenario	VCU Status	Bypass Status	Tank 1	Tank 2	Tank 3	Ship Status	RTL Status
1	Active	Inactive	Tank Breathing	Emissions to VCU	Tank Breathing	Inactive	Inactive
2	Active	Inactive	Emissions to VCU	Emissions to VCU	Emissions to VCU	Inactive	Inactive
3	Active	Inactive	Tank Breathing	Emissions to VCU	Tank Breathing	Unloading	Inactive
4	Active	Inactive	Tank Breathing	Emissions to VCU	Tank Breathing	Inactive	Loading
5	Active	Inactive	Emissions to VCU	Emissions to VCU	Emissions to VCU	Inactive	Loading
6	Active	Inactive	Tank Breathing	Emissions to VCU	Tank Breathing	Unloading	Loading
7	Inactive	Active	Tank Breathing	Emissions to Bypass	Tank Breathing	Inactive	Inactive
8	Inactive	Active	Emissions to Bypass	Emissions to Bypass	Emissions to Bypass	Inactive	Inactive
9	Inactive	Active	Tank Breathing	Emissions to Bypass	Tank Breathing	Unloading	Inactive

7.4 Model Inputs

7.4.1 Vapour Combustion Unit

Uncontrolled emissions from ship unloading were estimated based on the volumetric flow rate of approximately 350 m^3/hr. For modelling purposes, the emissions from ship unloading were calculated by multiplying the maximum[a] measured pollutant concentrations (within the tank headspace) by the volumetric flow rate of ship unloading.

The efficiency of the VCU was assumed to be 99%. This assumption as the efficiency of the VCU has been confirmed as valid by the manufacturer (Pers. Comm., Gasco, 17 August 2015).

For modelling scenarios involving the VCU, emissions were assumed to occur 24 hours a day, 365 days per year. In reality, the VCU is designed to capture emissions from tank vents during ship discharges and RTL operations. There are anticipated to be 8-16 ship discharges per annum, dependent upon vessel size.

The modelled parameters for the VCU are presented in **Table 7.2**.

Table 7.2: Modelling Emission Parameters from Vapour Combustion Unit

Parameters	VCU
Stack Diameter (m)	0.53
Stack Height (m)	12
Temperature (K)	1158
Velocity (m/s)	23
Odour / hydrocarbon destruction efficiency	99%
x coordinate (UTM)	335536
y coordinate (UTM)	6239293
z coordinate	4

7.4.2 Road Tanker Loadout

Potential emissions from RTL at the gantry were estimated using the same method described in **Section 7.4.1**. The volumetric flow rate for one bay is up to 90 m^3/hr, a conservative estimation of two bays operating at the same time was assumed.

The percentage of fugitive emissions leaving the RTL gantry was determined using a sensitivity analysis exercises. This involved varying the emissions to determine a reasonable (likely) partitioning between emissions leaving the gantry as (near ground level) fugitive emissions and the emission collected and reticulated to / treated by the VCU. This ratio was then used for scenarios 4, 5 and 6. The results of the sensitivity analysis are presented in **Section 8**.

7.4.3 Bypass Stack

The bypass stack is used to disperse emissions at the bitumen facility. The emission rates from the ship load-out and RTL are the same as stated above. Further (unlike the VCU), there is no emission control applied to this source. That is, the emissions from tank venting, ship load-out and the gantry are emitted as per the modelled parameters presented in **Table 7.3**.

[a] The maximum odour unit measurement recorded in the Stephensons Report (**2015**) was used in the emission estimation of ship unloading and RTL load out.

Table 7.3: Modelling Emission Parameters from Bypass Stack

Parameters	Bypass
Stack Diameter (m)	0.3
Stack Height (m)	25
Temperature (K)	338
Velocity (m/s)	11
Odour / hydrocarbon destruction efficiency	N/A
x coordinate (UTM)	335529
y coordinate (UTM)	6239290
z coordinate	4

7.4.4 Tank Breathing

The three storage tanks on site have a ratio of bitumen product to headspace equivalent to 7.3:1. The headspace in these tanks results in tank outbreathing loss emissions. For modelling purposes, it has been assumed that these emissions occur 24 hours a day, 365 days per year.

A volumetric flowrate of 0.006 (m^3/s) was used in the assessment. This value was referenced from the report issued in 2011 by Pacific Environment for the Vopak site, "Air Quality Assessment – Port Botany Bitumen Storage Facility". The original flow rate was estimated through use of the US EPA program TANKS, and it was concluded that the tank inputs used are comparable to the as built specifications.

The modelled parameters for tank venting are presented in **Table 7.4**.

Table 7.4: Modelling Emission Parameters from Tank Venting (Breathing Losses)

Parameters	Tank Vent
Vent Diameter (m)	0.3
Vent Height (m)	23
Temperature (K)	313
Velocity (m/s)	0.1
Tank 1	
x coordinate (UTM)	335540
y coordinate (UTM)	6239179
z coordinate	4.9
Tank 2	
x coordinate (UTM)	335570
y coordinate (UTM)	6239191
z coordinate	4.9
Tank 3	
x coordinate (UTM)	335559
y coordinate (UTM)	6239219
z coordinate	4.9

7.5 Source Locations

Emission sources were represented by a series of point sources and a ground-level volume source (fugitive RTL emissions) situated according to the location of those activities. These locations were derived from the site layout (**Figure 2.1**) and the proposed scenarios outlined in **Section 7.3**.

7.6 Peak-to-Mean Ratio

As discussed in **Section 4**, peak-to-mean ratios have been applied to the measured emission rates. The peak-to-mean ratios are used to cover a range of atmospheric conditions. The emissions were modelled for all stability classes and a range of wind speeds. For conditions where the odour sources are considered as volume sources or point sources with building wake effect, a peak-to-mean ratio of 2.3 is applied for both the near field and far field. Therefore, a peak-to-mean ratio of 2.3 was applied to odorous emissions.

7.7 Source Sampling

Sampling of the constituents of the tank headspace was completed by **Stephenson (2015)**, at the Vopak bitumen facility on 30 July 2015. The results obtained are detailed in **Table 7.5**, with the relevant extracts from the Stephenson report presented in **Appendix A**.

Table 7.5: Sampling Results from Stephensons Report (2015)

Emission Source	Odour (OU)	Benzene (mg/m^3)	Hydrogen Sulfide (ppm)
Tank 1	36,000	1.00	46
Tank 2	33,000	0.013	14
Tank 3[1]	39,000	0.22	25
	30,000		

[1] The average of the Odour Unit concentrations for Tank 3 was used in the dispersion modelling.

7.8 Building Wake Effects

Building wake effects were included in the modelling simulations and were incorporated into the CALPUFF modelling using the PRIME downwash algorithm.

7.9 Modelled Emission Rates

The specific emission rates for point and volume sources were determined using the analysis results from **Stephenson (2015)**.

A listed summary of the emissions inventory adopted for each modelling scenario is provided in **Appendix B**. Note that a peak-to-mean ratio of 2.3 was applied to all odour and hydrogen sulfide sources within the dispersion modelling.

8 MODELLING RESULTS

8.1 Fugitive Emissions from RTL Gantry Sensitivity Analysis

The likely ratio of fugitive to VCU emissions leaving the RTL gantry during loadout activities was estimated through a sensitivity analysis based on emission scenario 6, presented in **Table 8.1**. For example, if an assumption of 50% fugitive odours and 50% of emissions to the VCU presented odour dispersion results showing exceedances of odour criteria in the wider community on a regular basis, this is clearly too conservative an assumption to adopt.

Scenario 6 was selected as it represents the highest odour emission inventory involving the RTL activities.

Table 8.1 shows the results of this sensitivity analysis, based on assumed partitioning of fugitive emission to VCU emission.

Table 8.1: Odour Sensitivity Analysis: Scenario 6

Discrete Receptor ID	Odour (OU)					
	Fugitive Emissions : VCU Emissions					
	100 : 0	80 : 20	60 : 40	40 : 60	20 : 80	0: 100
1	0.03	0.02	0.02	0.01	0.01	0.00
2	0.03	0.02	0.02	0.01	0.01	0.01
3	0.02	0.02	0.02	0.01	0.01	0.01
4	0.02	0.02	0.01	0.01	0.01	0.00
5	0.02	0.01	0.01	0.01	0.01	0.00
6	0.10	0.08	0.07	0.05	0.04	0.02
7	0.2	0.1	0.1	0.09	0.06	0.04
8	0.06	0.05	0.04	0.03	0.02	0.01
9	0.06	0.05	0.04	0.03	0.02	0.01
10	0.08	0.07	0.06	0.04	0.03	0.01
11	0.06	0.05	0.04	0.03	0.02	0.01
12	3.8	3.1	2.4	1.7	0.9	0.3

The results in **Table 8.1** indicate that under all of the potential fugitive release scenarios (including 100% fugitive emissions, and no emission captured by the VCU) there was no predicted exceedance of the 2 OU odour goal from this source alone at any of the residential receptor locations.

Thus, for modelling purposes, a 40:60 split of fugitive to VCU emissions from the gantry was selected. This partitioning is considered conservative since air extraction at the gantry exceeds the potential air displaced during tanker filling. Air is extracted at the RTL gantry at a rate of 100 m^3/hr/RTL. Conversely, road tankers are loaded at a rate up to 90 m^3/hr.

Further, under the 40:60 scenario, it was also deemed that odour predictions were not unrealistically high.

This ratio has been adopted in the modelling of scenarios 4, 5 and 6.

8.2 Assessment of Impacts

Modelling results for the maximum predicted odour, benzene and hydrogen sulfide concentrations at each discrete receptor are presented in **Table 8.2** and **Table 8.3**, referencing the relevant NSW EPA criteria.

Table 8.2: Maximum Predicted Odour Concentrations (99th Percentile 1-second average) Scenarios 1-9

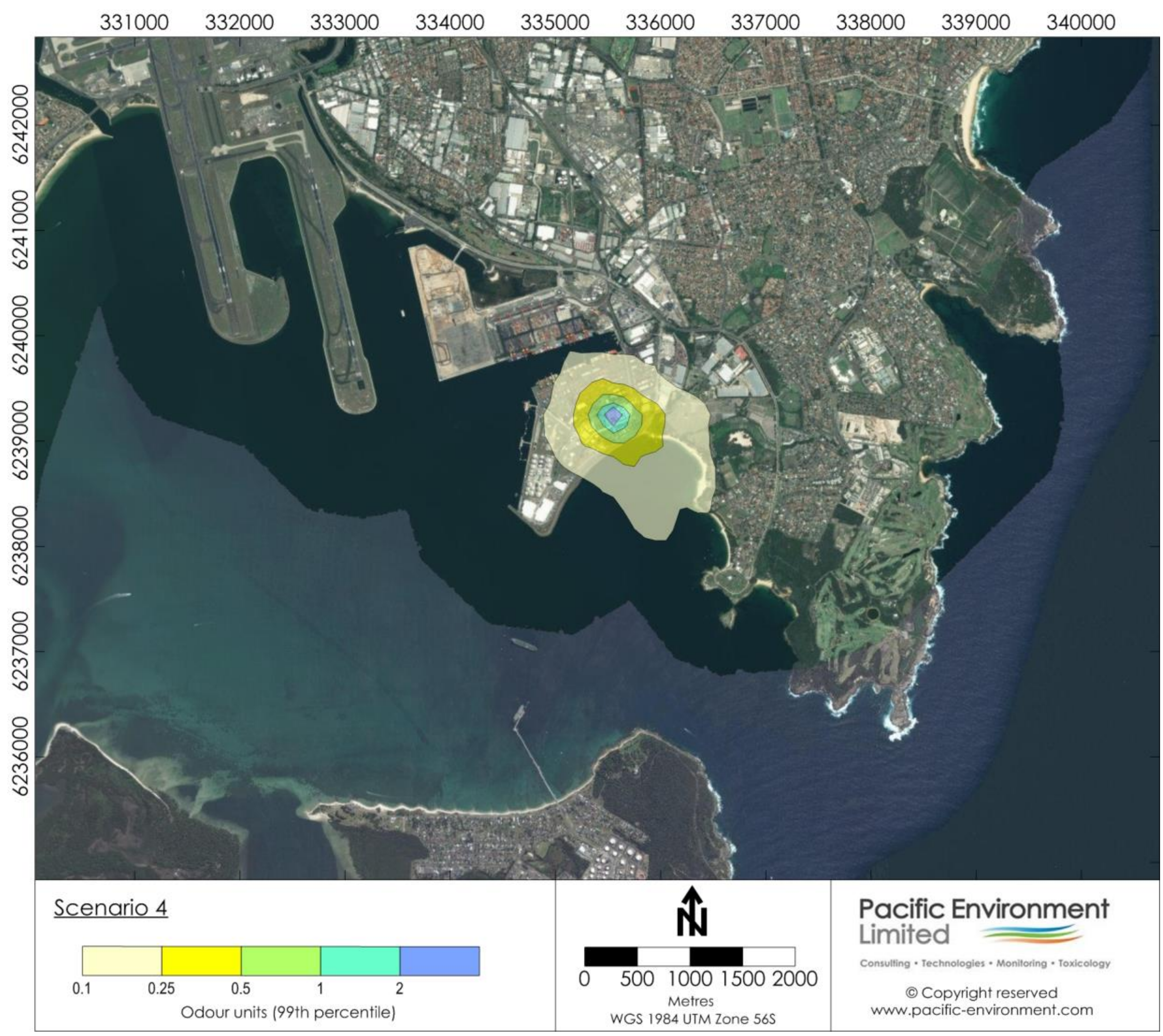
Discrete Receptor ID	Odour (OU)								
	1-second average (nose response)								
	Assessment Criterion: 2 OU								
	Scenario								
	1	2	3	4	5	6	7	8	9
1	0.003	0.0004	0.004	0.01	0.01	0.01	0.03	0.08	0.02
2	0.003	0.001	0.005	0.01	0.01	0.01	0.03	0.09	0.02
3	0.004	0.0005	0.01	0.01	0.01	0.01	0.03	0.1	0.02
4	0.003	0.0004	0.005	0.01	0.01	0.01	0.03	0.08	0.02
5	0.002	0.0003	0.003	0.01	0.01	0.01	0.02	0.05	0.01
6	0.01	0.002	0.02	0.04	0.03	0.05	0.1	0.3	0.08
7	0.02	0.002	0.04	0.08	0.06	0.09	0.1	0.4	0.09
8	0.01	0.001	0.01	0.03	0.02	0.03	0.06	0.2	0.04
9	0.01	0.001	0.01	0.03	0.02	0.03	0.05	0.1	0.04
10	0.01	0.001	0.01	0.04	0.03	0.04	0.08	0.2	0.05
11	0.01	0.001	0.01	0.03	0.02	0.03	0.05	0.2	0.04
12	0.2	0.01	0.3	1.6	1.5	1.7	0.5	1.7	0.4

Table 8.2 indicates that the worst-case impact of odour from the facility at the nearest residential sensitive receptor locations is predicted to be well below the odour performance goal of 2 OU.

The maximum odour concentration of 1.7 OU for scenarios 6 and 8 is predicted at the site entrance (Receptor 12). At the closest residential receptor (Receptor 6) for the same scenarios, it is predicted that in maximum odour concentrations would be well below the odour criterion.

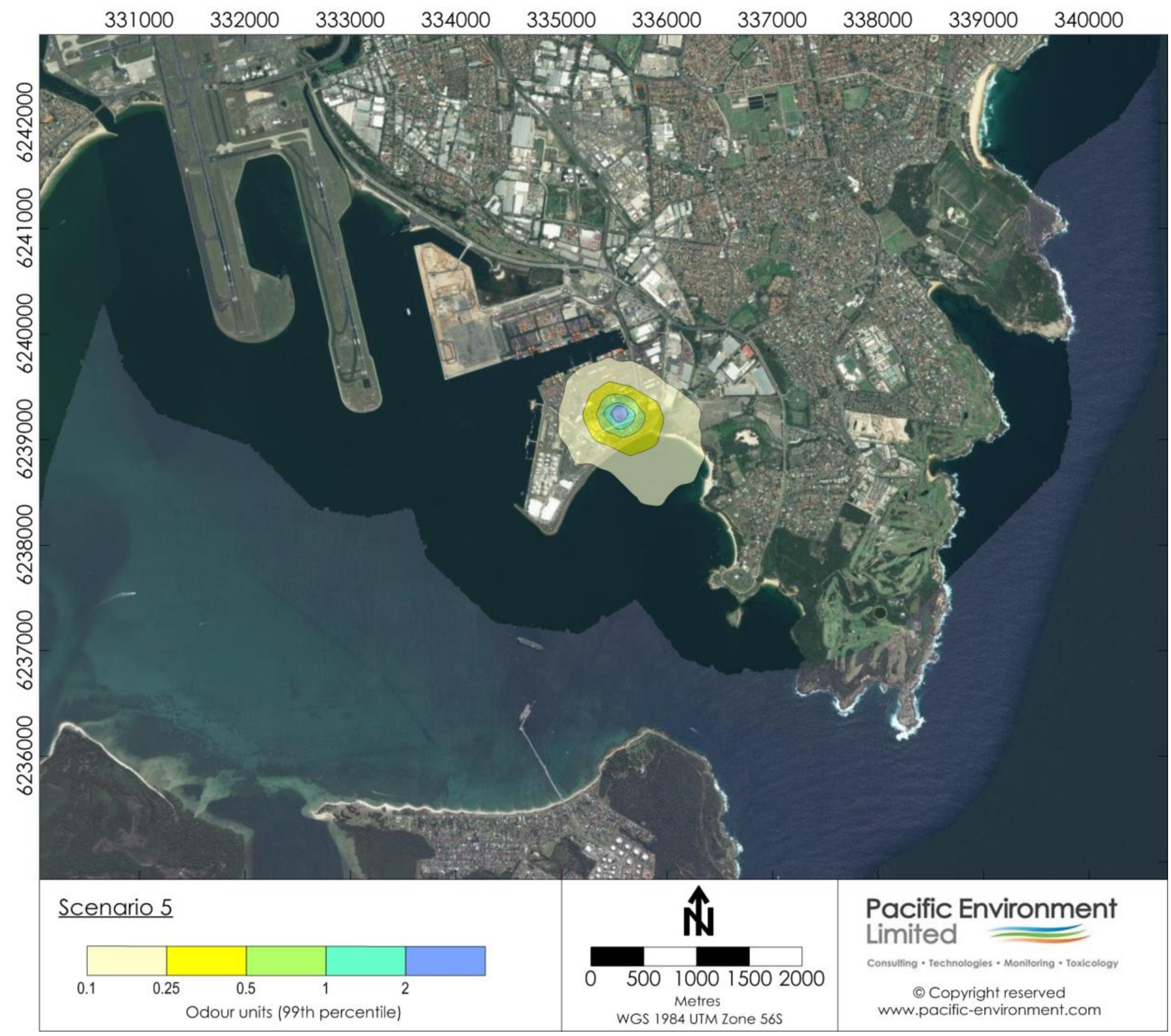
Scenarios 4, 5, 6 and 8 produce the highest odour concentration predictions of those modelled. These have been presented as contour plots shown in **Figure 8.1** to **Figure 8.4**.

It is noted that it is not meaningful to describe odour impacts in less than whole numbers, however odour units have been reported as fractions of odour units to show the reduction in predicted odour spatially around the site.



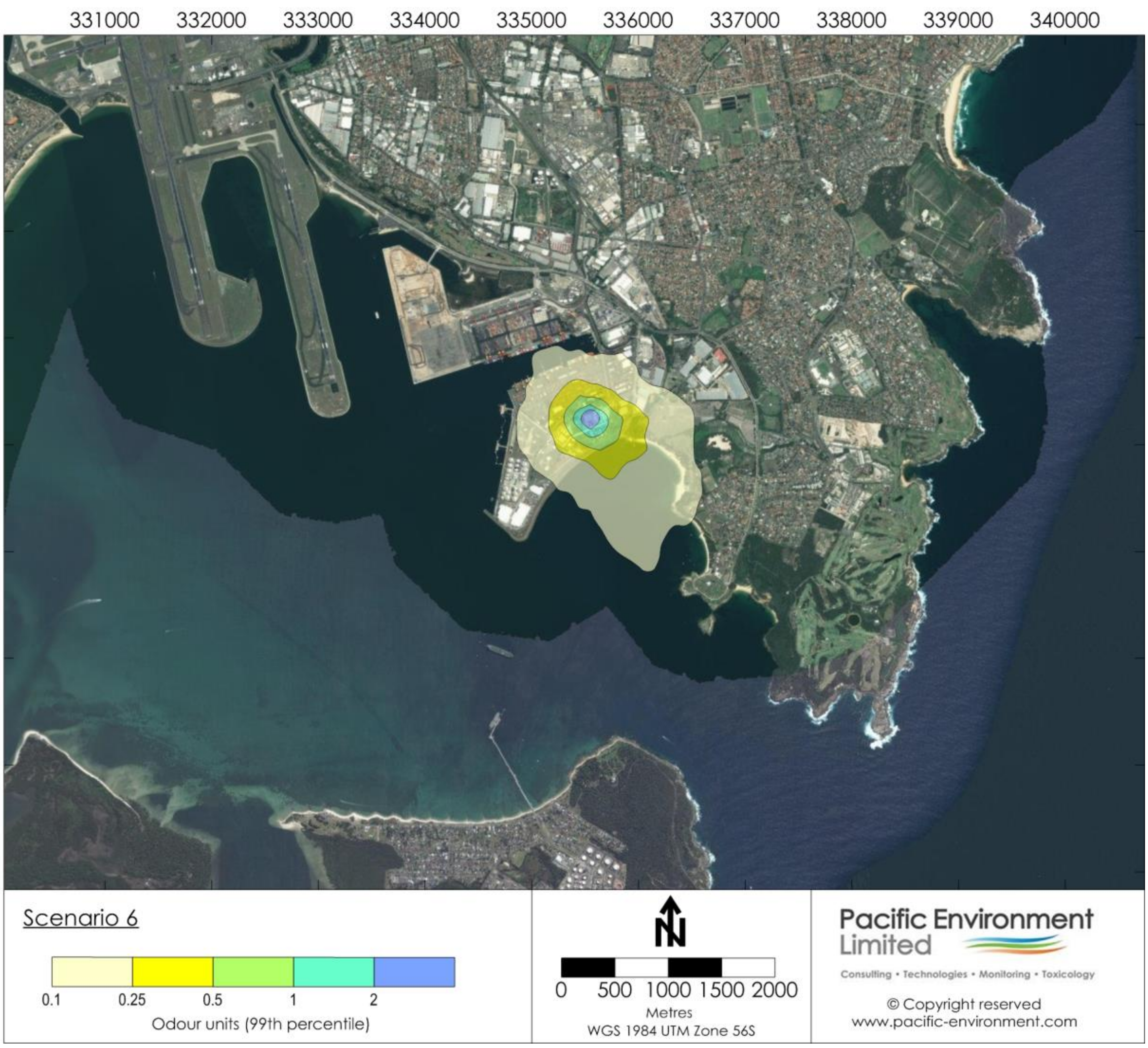
Species: Odour	**Averaging Time:** 1-second	**Percentile:** 99th	**Scenario:** 4	**Location:** Vopak Terminals
Model Used: CALPUFF v6.42	**Units:** OU	**Criterion:** 2	**Met Data:** July 2014 – June 2015 (CALMET)	**Plot:** A Rouggos

Figure 8.1: Predicted 99th Percentile 1-second Odour Concentrations – Scenario 4



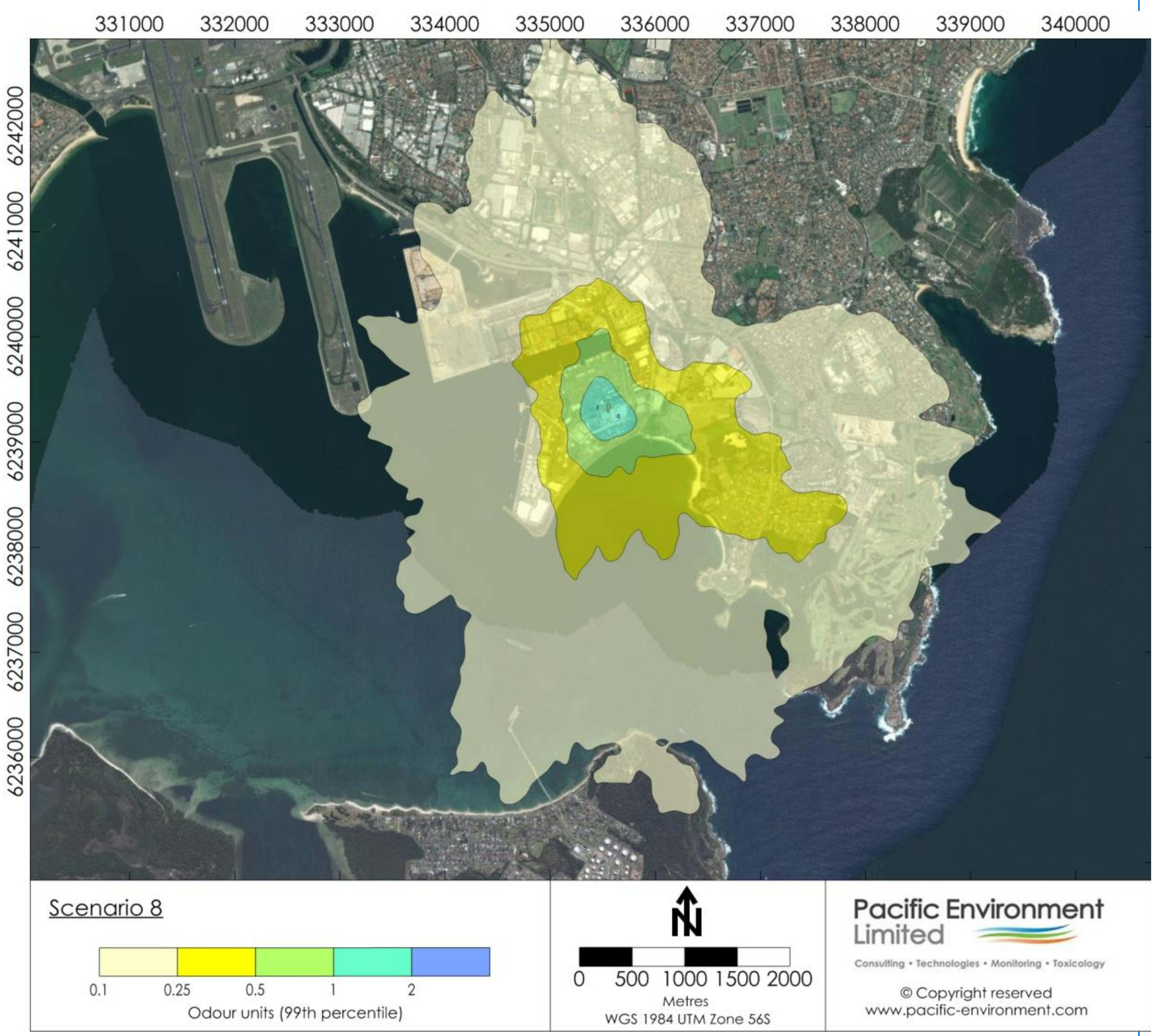
Species: Odour	**Averaging Time:** 1-second	**Percentile:** 99th	**Scenario:** 5	**Location:** Vopak Terminals
Model Used: CALPUFF v6.42	**Units:** OU	**Criterion:** 2	**Met Data:** July 2014 – June 2015 (CALMET)	**Plot:** A Rouggos

Figure 8.2: Predicted 99th Percentile 1-second Odour Concentrations – Scenario 5



Species: Odour	**Averaging Time:** 1-second	**Percentile:** 99^{th}	**Scenario:** 6	**Location:** Vopak Terminals
Model Used: CALPUFF v6.42	**Units:** OU	**Criterion:** 2	**Met Data:** July 2014 – June 2015 (CALMET)	**Plot:** A Rouggos

Figure 8.3: Predicted 99^{th} Percentile 1-second Odour Concentrations – Scenario 6



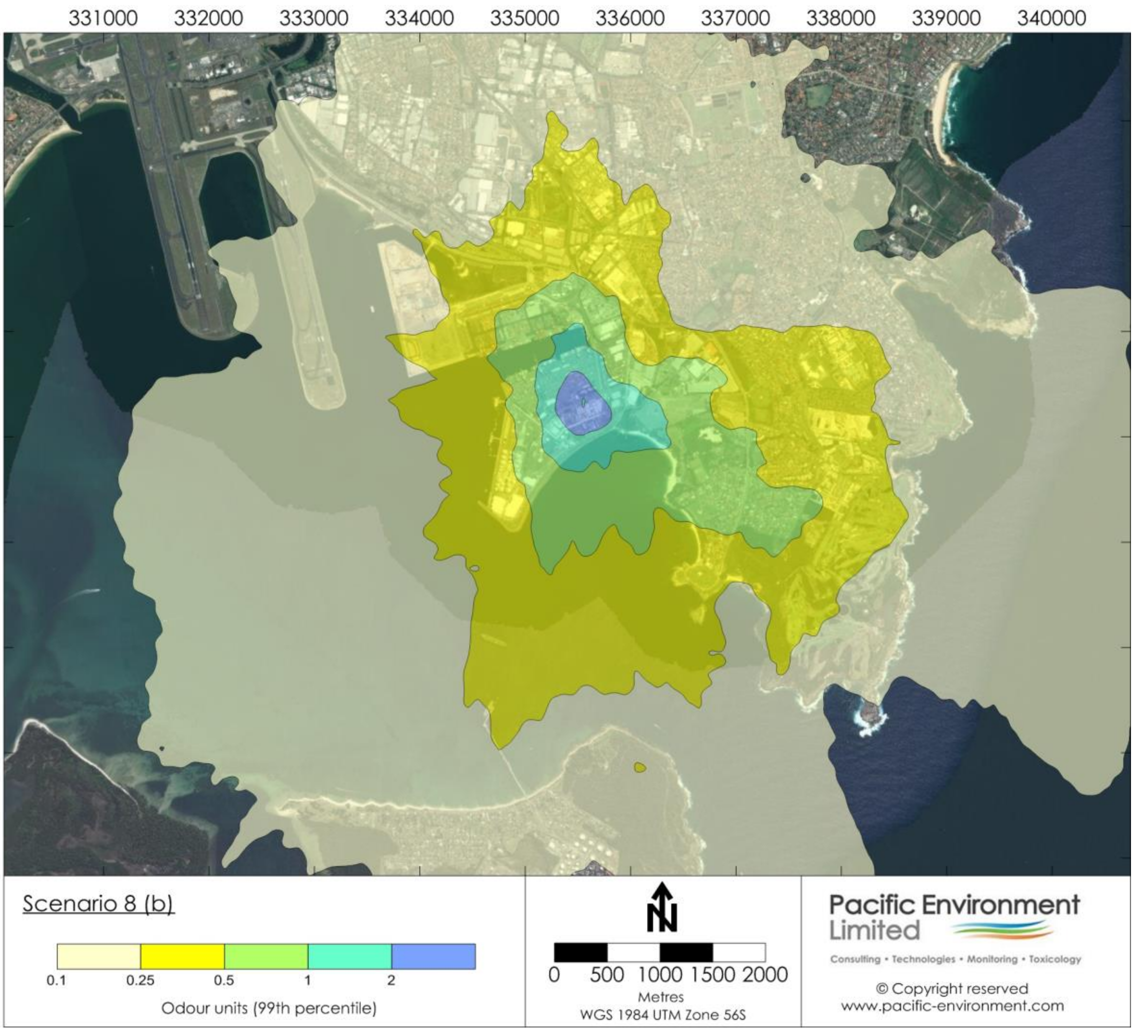
Species: Odour	Averaging Time: 1-second	Percentile: 99th	Scenario: 8	Location: Vopak Terminals
Model Used: CALPUFF v6.42	**Units:** OU	**Criterion:** 2	**Met Data:** July 2014 – June 2015 (CALMET)	**Plot:** A Rouggos

Figure 8.4: Predicted 99th Percentile 1-second Odour Concentrations – Scenario 8

As seen above, of the scenarios modelled, scenario 8 produces the highest spatial distribution of odour around the site. To account for product, and associated odour, variability, along with the potential for additional odour due to higher temperature load-out, a further scenario was assessed.

This comprised of a conservative sensitivity analysis, whereby the odour emission rates for scenario 8 were doubled (scenario 8 (b)).

Figure 8.5 presents the contour plot for scenario 8 (b), which represents a worst case scenario referencing odour emission rates double those observed at the site.



Species: Odour	**Averaging Time:** 1-second	**Percentile:** 99th	**Scenario:** 8 (b)	**Location:** Vopak Terminals
Model Used: CALPUFF v6.42	**Units:** OU	**Criterion:** 2	**Met Data:** July 2014 – June 2015 (CALMET)	**Plot:** A Rouggos

Figure 8.5: Predicted 99th Percentile 1-second Odour Concentrations – Scenario 8 (b)

The results from **Figure 8.5** indicate that, even under the worst-case assumptions adopted, the odour concentrations for Scenario 8 (b) would be below the odour criterion at the sensitive receptors.

To provide a screening evaluation of benzene and hydrogen sulfide concentrations off-site, the emission scenario 8 was also modelled for these parameters. Scenario 8 was selected as this represents the maximum anticipated emission scenario from the site. The results in **Table 8.3** indicate that the concentration of benzene is predicted to be well below the EPA criterion under a worst case emission scenario. There is anticipated to be a small exceedance of the hydrogen sulfide criterion at the boundary of the site under the same scenario, however at all residential receptors, concentrations are predicted to be well below the criterion.

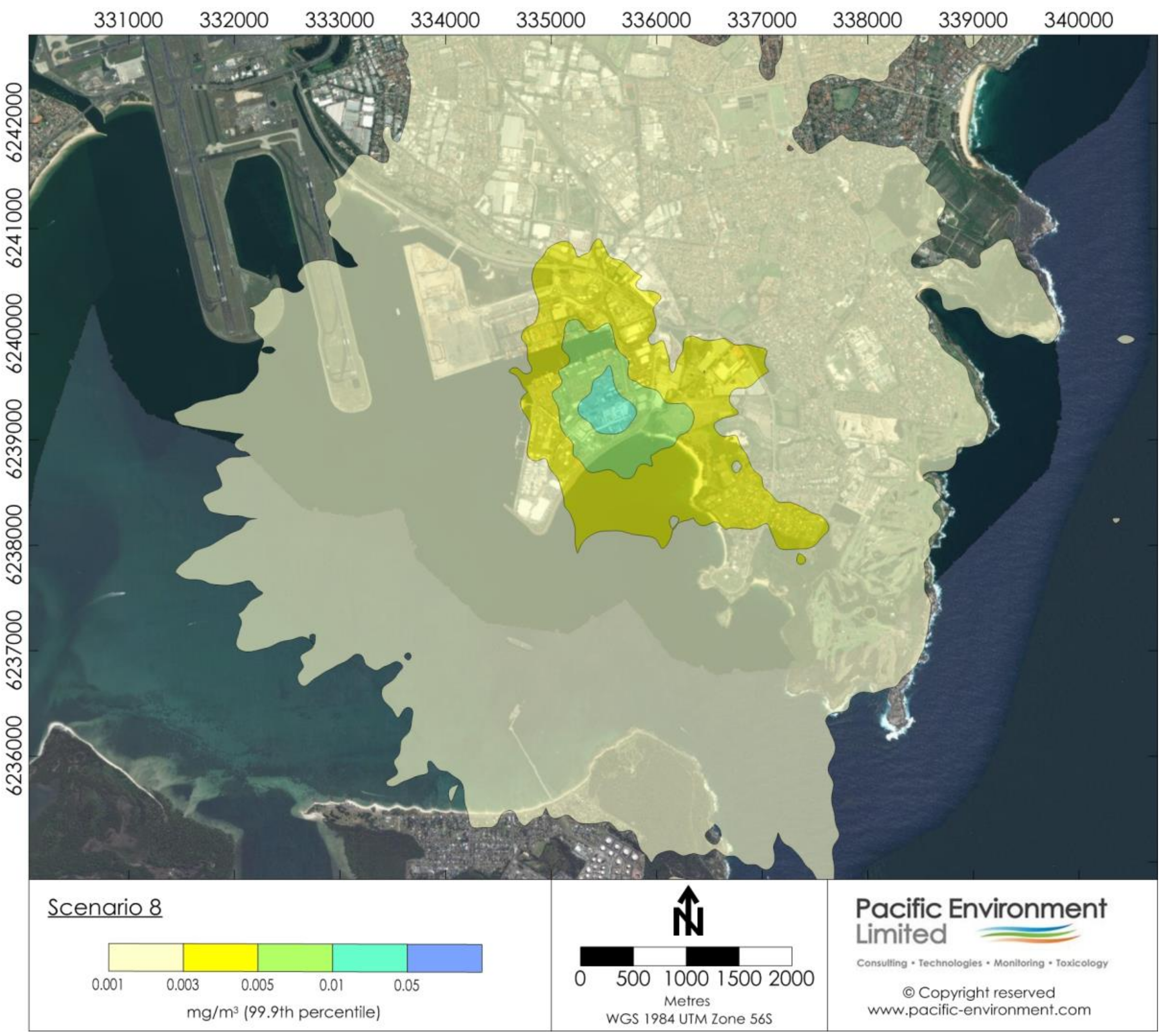
Further, Scenario 8 does not represent an operational scenario at the site. This is supported by Vopak's Bitumen Odour Management Procedures (**Section 9.2**). Therefore, the maximum predicted concentrations of benzene and hydrogen sulfide in the vicinity of the site are expected to be lower than presented in **Table 8.3** in reality.

Given the low predicted concentrations at a reasonable worst-case emission scenario, modelling of lesser emission scenarios have not been completed for these air quality metrics.

Table 8.3: Scenario 8: Benzene and Hydrogen Sulfide

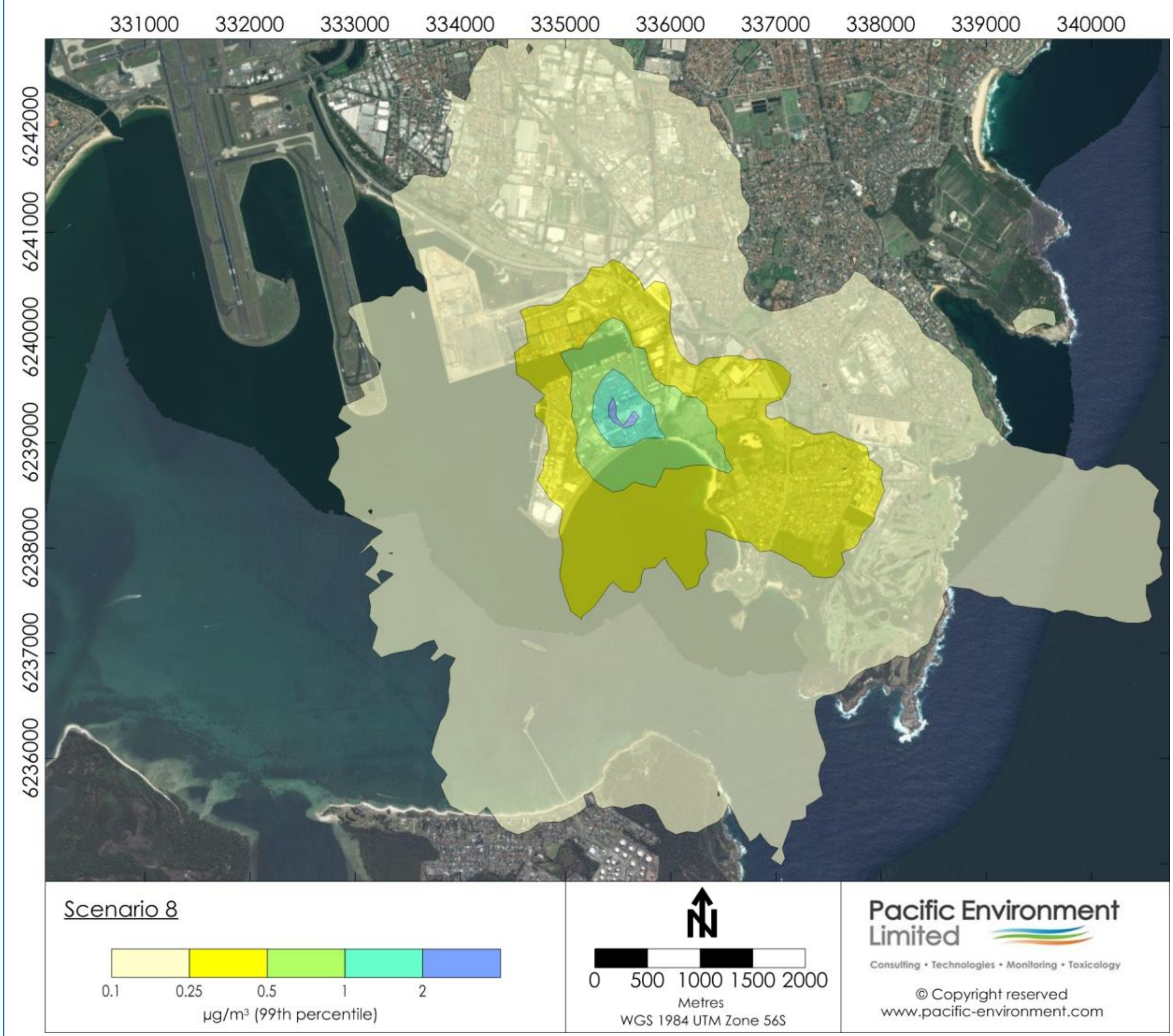
Discrete Receptor ID	Benzene (mg/m^3)	Hydrogen Sulfide (µg/m^3)
	99.9th Percentile 1- hour	99th Percentile 1- second
	Assessment Criteria	
	0.029	1.38
1	0.0016	0.09
2	0.0018	0.1
3	0.0018	0.1
4	0.0016	0.1
5	0.0012	0.06
6	0.004	0.4
7	0.004	0.4
8	0.002	0.2
9	0.002	0.2
10	0.002	0.3
11	0.004	0.2
12	0.02	2.0

The concentration predictions presented in **Table 8.3** are shown spatially as contour plots in **Figure 8.6** and **Figure 8.7**.



Species: Benzene	Averaging Time: 1-hour	Percentile: 99.9th	Scenario: 8	Location: Vopak Terminals
Model Used: CALPUFF v6.42	**Units:** mg/m³	**Criterion:** 0.029	**Met Data:** July 2014 – June 2015 (CALMET)	**Plot:** A Rouggos

Figure 8.6: Predicted 99.9th Percentile 1-hour Benzene Concentrations – Scenario 8



Species: Hydrogen Sulfide	**Averaging Time:** 1-seond	**Percentile:** 99th	**Scenario:** 8	**Location:** Vopak Terminals
Model Used: CALPUFF v6.42	**Units:** µg/m³	**Criterion:** 1.38	**Met Data:** July 2014 – June 2015 (CALMET)	**Plot:** A Rouggos

Figure 8.7: Predicted 99th Percentile 1-second Hydrogen Sulfide Concentrations – Scenario 8

8.3 Cumulative Impacts

To assess impacts against the relevant air quality standards and goals, it is necessary to have information on the background concentrations to which the site is likely to contribute. The existing background environment is described in **Section 5**.

The predicted maximum odour concentration at the closest sensitive receptor (excluding the entry/exit) as a result of activities on site is 0.3 OU (scenario 8). When this is added to the predicted maximum odour concentration of 0.1 OU in the Terminals Air Quality Assessment (**GHD, 2011**), the cumulative odour concentration of 0.4 OU is still well below the odour criterion of 2 OU.

The predicted benzene concentration is an order of magnitude or more below its respective ground level criterion. The predicted benzene concentration in the Terminals Air Quality Assessment (**GHD, 2011**) is also well below the EPA criterion. Therefore, the cumulative emissions of benzene are expected to be in compliance with the air quality goals.

Ambient concentrations of hydrogen sulfide, in the absence of the Vopak bitumen terminal activities, are also anticipated to be negligible.

9 RECOMMENDATIONS

9.1 Odour Emission Control

The results of the dispersion modelling indicate that the air quality impact from current operations in the vicinity of the Vopak bitumen facility are predicted to be minimal.

However, to attain a more thorough understanding of the operations and potential sources of odour impact, a source apportionment exercise has been completed on scenarios 3, 6, and 9. This has been completed to determine which potential odour emission sources may have the greatest off-site impact. The outputs of this exercise are shown in **Table 9.1** and **Table 9.2**. The receptors selected are representative of the closest residential receptor and the entry/exit to the site respectively (receptors 6 and 12).

Table 9.1: Odour Emission Source Percentage Contribution: Receptor 6

	Scenario		
Source	**3**	**6**	**9**
Tank 1	33%	16%	4%
Tank 2	31%	15%	5%
Tank 3	35%	18%	6%
VCU	1%	N/A	N/A
Bypass	N/A	N/A	85%
Gantry Fugitive	N/A	51%	N/A
Total	**100**	**100**	**100**

Table 9.2: Emission Source Percentage Contribution: Receptor 12

	Scenario		
Source	**3**	**6**	**9**
Tank 1	6%	8%	N/A
Tank 2	34%	9%	0%
Tank 3	60%	10%	3%
VCU	N/A	N/A	N/A
Bypass	N/A	N/A	97%
Gantry Fugitive	N/A	73%	N/A
Total	**100**	**100**	**100**

Table 9.1 and **Table 9.2** indicates that the emission from the bypass stack and tank venting have the highest potential contribution to off-site odour impacts. Further, the bypass and gantry emissions have an increased potential for contribution in the region closest to the site.

While the dispersion modelling scenarios presented above indicate that compliance with odour goals should be easily achieved, in the event of differing emission scenarios (i.e. handling of off-spec / odorous bitumen batches) that odour management should concentrate on the above sources (i.e. use of VCU in favour of the bypass, extraction to VCU during tank breathing) in the first instance. By prioritising these odour management activities, it is considered that the potential for off-site odour impacts can be tangibly reduced.

9.2 Bitumen Odour Management Procedures

The existing bitumen odour management procedures (**BOMP, 2014**) for the Vopak bitumen facility have been reviewed by Pacific Environment. The results of the dispersion modelling indicate that current procedures followed by Vopak Terminals are appropriate to manage adverse off-site odour impacts.

Section 6.1 of the BOMP describes the recommended operation of the vapour combustion unit. As identified in the dispersion modelling results, fugitive emissions from the RTL gantry have the potential to significantly contribute to total site odour emissions without adequate capture and control.

To ensure that high levels of odour management are maintained, it is recommended that Vopak operate the VCU as per the current conditions provided in their management procedures, namely;

1. On individual tank mode during tank ship receipt and wharfline blowing;
2. On road tanker filling mode during road tanker filling;
3. On individual tank mode to receiving tank during receipt from tank transfer or road tanker unloading;
4. On individual tank mode during tank top maintenance;
5. On individual tank or multi-tank cycling modes when tank storage temperature is elevated above 160°C;
6. On individual tank or multi-tank cycling modes when high odours are detected during odour monitoring;
7. On individual tank or multi-tank cycling modes when an odour complaint is received as long as conclusion of the internal investigation determines any link with the operation of the bitumen tanks.

10 CONCLUSIONS

The potential air quality impacts from the operation of the Vopak bitumen facility has been assessed, including operation of the vapour combustion unit, bypass stack, free tank venting and product loading.

Modelling results indicate that, under all normal operational scenarios, off-site odour impacts from the Vopak bitumen facility anticipated to be minor. This same conclusion applies to the air quality metrics benzene and hydrogen sulfide when compared to their respective impact assessment criteria.

An assessment of cumulative air quality impacts indicates that the site is not resulting in any additional exceedances of air quality goals.

While the dispersion modelling scenarios presented above indicate that compliance with odour goals should be easily achieved, in the event of differing emission scenarios (i.e. handling of off-spec / odorous bitumen batches), odour management may be prioritised. Dispersion modelling indicates that under such conditions, the use of VCU in favour of the bypass, along with extraction to VCU during tank breathing may be used to reduce the potential for off-site odour impacts.

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

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Appendix A STEPHENSONS 2015 REPORT EXTRACT

Table A.1: Stephensons (2015) Report Table Extract 1

Parameters	Units	Location			
		Tank No.1 Headspace	Tank No.2 Headspace	Tank No.3 Headspace	
Condition		Venting	VCS	Venting	VCS
Temperature	°C	33	21	38	
Velocity	m/s	0.03	-1.1	0.06	
Total Flow	m^3/s	0.000020	-0.0086	0.00036	
Odour	ou	36,000	33,000	39,000	30,000
Oxygen	%	20.5	20.9	20.6	
Hydrogen Sulphide	ppm	46	14	25	
Sum of *Reported* VOCs	mg/m^3	58*	0.8	14*	
Sum of *Reported* VOCs (as n-propane equivalent)	mg/m^3	28*	0.3	6*	
Total VOCs by PID (as isobutylene) – Average^	ppm	42	17	22	
PAH	mg/m^3	0.4	0.01	1.4	

Table A.2: Stephensons (2015) Report Table Extract 2

TABLE A-2 DETAILED VOC EMISSION TEST RESULTS - ACTUAL

Project Number	5545	5545	5545
Project Name	Vopak	Vopak	Vopak
Test Location	Tank 1	Tank 2	Tank 3
Date	30-Jul-15	30-Jul-15	30-Jul-15
Method	VOCs / USEPA method TO-17	VOCs / USEPA method TO-17	VOCs / USEPA method TO-17
Sample Start Time (hrs)	11:54	12:25	12:23
Sample Stop Time (hrs)	12:24	12:55	12:53
Inlet/Exhaust	Exhaust	Exhaust	Exhaust
SEMA Sample No.:	724943	724944	724945
Sample Period (min):	30	30	30
Pump Sample Rate (ml/min):	17	17	17
Oxygen (O2):	20.5	20.9	20.6
VOC Compound	Concentration (Actual) (mg/m3)		
Freon 114	< 0.028	< 0.028	< 0.028
Vinyl Chloride	< 0.005	< 0.005	< 0.005
1,3-Butadiene	< 0.004	< 0.004	< 0.004
Isopentane	9.40	< 0.012	0.58
Freon 11	< 0.022	< 0.022	< 0.022
1,1-Dichloroethene	< 0.008	< 0.008	< 0.008
Methylene Chloride	< 0.042	< 0.042	< 0.042
Freon 113	< 0.015	< 0.015	< 0.015
trans-1,2-Dichloroethene	< 0.008	< 0.008	< 0.008
1,1-Dichloroethane	< 0.008	< 0.008	< 0.008
cis-1,2-Dichloroethene	< 0.008	< 0.008	< 0.008
Hexane	7.90	< 0.070	2.20
Chloroform	< 0.010	< 0.010	< 0.010
1,2-Dichloroethane	< 0.008	< 0.008	< 0.008
1,1,1-Trichloroethane	< 0.011	< 0.011	< 0.011
Benzene	1.00	< 0.013	0.22
Carbon Tetrachloride	0.01	< 0.012	< 0.012
Cyclohexane	6.80	< 0.014	0.24
1,2-Dichloropropane	< 0.009	< 0.009	< 0.009
Trichloroethene	< 0.011	< 0.011	< 0.011
1,4-Dioxane	< 0.022	< 0.022	0.04
2,2,4-Trimethylpentane	< 0.019	< 0.019	< 0.019
Heptane	10.00	0.06	3.90
Methylcyclohexane	3.90	< 0.016	0.39
1,1,2-Trichloroethane	< 0.011	< 0.011	< 0.011
4-Methyl-2-pentanone	< 0.016	< 0.016	0.06
Toluene	1.60	0.03	0.82
2-Hexanone	0.84	< 0.016	0.31

Appendix B EMISSION ESTIMATES

Table B.1: Scenario 1

Emission Source	Odour (OUV/s)	Benzene (g/s)	Hydrogen Sulfide (g/s)
Vapour Combustion Unit	127	2.17E-08	8.05E-05
Tank 1	585	7.07E-06	1.12E-03
Tank 3	561	2.91E-06	6.91E-04

Table B.2: Scenario 2

Emission Source	Odour (OUV/s)	Benzene (g/s)	Hydrogen Sulfide (g/s)
Vapour Combustion Unit	414	2.06E-06	4.89E-04

Table B.3: Scenario 3

Emission Source	Odour (OUV/s)	Benzene (g/s)	Hydrogen Sulfide (g/s)
Vapour Combustion Unit	81	4.00E-07	9.50E-05
Tank 1	585	7.07E-06	1.12E-03
Tank 2	537	9.19E-08	3.41E-04
Tank 3	561	2.91E-06	6.91E-04

Table B.4: Scenario 4

Emission Source	Odour (OUV/s)	Benzene (g/s)	Hydrogen Sulfide (g/s)
Vapour Combustion Unit	2760	1.37E-05	3.26E-03
Tank 1	585	7.07E-06	1.12E-03
Tank 3	561	2.91E-06	6.91E-04
Gantry Fugitive	1840	9.13E-06	2.17E-03

Table B.5: Scenario 5

Emission Source	Odour (OUV/s)	Benzene (g/s)	Hydrogen Sulfide (g/s)
Vapour Combustion Unit	2760	1.37E-05	3.26E-03
Gantry Fugitive	1840	9.13E-06	2.17E-03

Table B.6: Scenario 6

Emission Source	Odour (OUV/s)	Benzene (g/s)	Hydrogen Sulfide (g/s)
Vapour Combustion Unit	2760	1.37E-05	3.26E-03
Tank 1	585	7.07E-06	1.12E-03
Tank 2	537	9.19E-08	3.41E-04
Tank 3	561	2.91E-06	6.91E-04
Gantry Fugitive	1840	9.13E-06	2.17E-03

Table B.7: Scenario 7

Emission Source	Odour (OUV/s)	Benzene (g/s)	Hydrogen Sulfide (g/s)
Bypass Stack	1260	2.17E-06	8.05E-03
Tank 1	585	7.07E-06	1.12E-03
Tank 3	561	2.91E-06	6.91E-04

Table B.8: Scenario 8

Emission Source	Odour (OUV/s)	Benzene (g/s)	Hydrogen Sulfide (g/s)
Bypass Stack	41400	2.06E-04	4.89E-02

Table B.9: Scenario 9

Emission Source	Odour (OUV/s)	Benzene (g/s)	Hydrogen Sulfide (g/s)
Bypass Stack	8050	4.00E-05	9.50E-03
Tank 1	585	7.07E-06	1.12E-03
Tank 2	537	9.19E-08	3.41E-04
Tank 3	561	2.91E-06	6.91E-04

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Report Number R000484-1

Vapour Recovery Unit

Hydrocarbon Recovery Assessment
Vopak Terminals Australia, Sydney Terminal Site B

Document Information

Client Name:	Vopak Terminals Australia
Report Number:	R000484-1
Report Title:	Vapour Recovery Unit – Hydrocabon Recovery Assessment
Date of Issue:	17 March 2015
Attention:	Keyhan Nouriafshar
Address:	Gate B47, 20 Friendship Rd Port Botany NSW 2036

Sampling Information

Sampling Date:	18 February 2015
Sampling Team:	SC/SW
Testing Laboratory:	Ektimo (ETC) ABN 74 474 273 172

Report Status

Format	Document Number	Report Date	Prepared By	Reviewed By (1)	Reviewed By (2)
Preliminary Report	-	-	-	-	-
Draft Report	R000484-1 [DRAFT]	27 February 2015	SC	AD	-
Draft Report	R000484-1 [DRAFT2]	6 March 2015	SC	-	-
Final Report	R000484-1	17 March 2015	SC	-	-
Amend Report	-	-	-	-	-

Amendment Record

Document Number	Initiator	Report Date	Section	Reason
Nil	-	-	-	-

Report Authorisation

Steven Cooper
Client Manager

NATA Accredited Laboratory
No. 14601

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Appendices

1 EXECUTIVE SUMMARY

Ektimo was engaged by Vopak Terminals Australia to perform simultaneous sampling at the inlet and outlet of the Vapour Recovery Unit (VRU) at their Sydney terminal site B. This testing enables the efficiency of the VRU as well as the amount of petroleum product recovered to be calculated. This testing was conducted on 18 February 2015.

This testing was performed in compliance with a directive by the Australian Taxation Office (ATO) to use a formulae derived method to determine the total amount of liquid hydrocarbon recovered from vapours by the VRU. This calculation will be used to determine the duty paid on the petroleum products loaded at the site B terminal.

The testing methods and formulae approach are described in the technical paper, written by Professor D L Trimm, entitled *Vapour Recovery in the Petroleum Industry,* July 1998. This report will henceforth by referred to as The Trimm Report.

Two Flame Ionization Detectors (FID's) were calibrated and verified on-site at the start and end of the sample duration. Zero and span drift were observed to be less than 2% for both analysers. The inlet gas stream was diluted by a factor of 10 to ensure all envisaged concentrations could be captured by the instrument.

Plant operating conditions have been noted in the report. Tanker loading data is contained in Appendix 1. A total of 683,079 litres (corrected to 15 degrees celcius and 1 atmosphere) were loaded during the four hours of sampling.

2 TESTING SUMMARY

Test Summary Table

Parameter	Value
Terminal Description	Vopak Terminals Australia Pty Ltd Sydney Terminal Site B
Vapour Control Unit, type	John Zink
Test Date	18th February 2015
Test Period	11:30 - 15:30
Average Ambient Temperature	24 ^{o}C
Average Barometric Pressure	1018 hPa
Average Outlet Concentration (Y_{out})	0.8459%
Average Inlet Concentration (Y_{in})	11.7105%
Total Petroleum Products Loaded ($V_{gin\ test}$ corrected)	683079 L
Total Motor Spirit Loaded $V_{motor\ spirit}$ (corrected)	413139 L
Total Distillate Loaded $V_{distillate}$ (corrected)	269940 L
Distillate / Motor Spirit Ratio	39.52% / 60.48%
Unit Efficiency E	93.57 %
Vapour Volume Recovered $V_{ads\ test}$	74846 L
Vapour Recovered (% of Total Throughput)	10.96%
Liquid Volume Recovered $V_{liq\ test}$	345.8 L
Liquid Recovered (% of Total Throughput)	0.051%
Liquid Recovered (% of Motor Spirit Throughput)	0.084%

3 RESULTS – VRU OUTLET SAMPLING PLANE & GAS PARAMETERS

Date	18/02/2015	**Client**	Vopak Terminals Australia Pty Ltd		
Report	R000484	**Stack ID**	VRU Outlet		
Licence No.	6007	**Location**	Sydney Terminal site B	**State**	NSW
EML Staff	SC/SW				
Process Conditions	Please refer to appended records.				
Reason for testing:	To determine VRU efficiency				

Sampling Plane Details		
Sampling plane dimensions (mm) & area	200	0.0314 m²
Sampling port size, number & depth	4" BSP (x1)	
Access & height of ports	Fixed ladder	8 m
Duct orientation & shape	Horizontal	Circular
Downstream disturbance	Exit	> 8 D
Upstream disturbance	Bend	> 10 D
No. traverses & points sampled	1	2
Traverse method & compliance	AS4323.1	Ideal

Stack Parameters		
Moisture content, %v/v	1.03	
Gas molecular weight, g/g mole	28.9 (wet)	29.1 (dry)
Gas density at NTP, kg/m³	1.29 (wet)	1.30 (dry)
	Test 1	
Gas Flow Parameters		
Temperature, °C	31	
Velocity at sampling plane, m/s	4.4	
Volumetric flow rate, discharge, m³/s	0.14	
Volumetric flow rate (wet NTP), m³/s	0.12	
Volumetric flow rate (dry NTP), m³/s	0.12	
Mass flow rate (wet basis), kg/hour	580	
Velocity difference, %	<1	

4 RESULTS – VRU INLET SAMPLING PLANE & GAS PARAMETERS

Date	18/02/2015	**Client**	Vopak Terminals Australia Pty Ltd		
Report	R000484	**Stack ID**	VRU Inlet		
Licence No.	6007	**Location**	Sydney Terminal site B	**State**	NSW
EML Staff	SC/SW				
Process Conditions	Please refer to appended records.				
Reason for testing:	To determine VRU efficiency				

Sampling Plane Details

Sampling plane dimensions (mm) & area	220	0.038 m²
Sampling port size, number & depth	1" BSP (x1)	
Access & height of ports	Ground level	1.5 m
Duct orientation & shape	Vertical	Circular
Downstream disturbance	Junction	1 D
Upstream disturbance	Bend	> 10 D
No. traverses & points sampled	1	4
Traverse method & compliance	AS4323.1	Non-compliant

Comments

Non-compliant sampling plane; the testing precision will be reduced
The gas velocity at some or all sampling points is less than 3 m/s
The stack or duct does not have the required number of access holes (ports)
The sampling plane is too near to the downstream disturbance but is greater than or equal to 1D
The number of traverses sampled is less than the requirement
The number of points sampled is less than the requirement
All results reported on a dry basis at NTP

Stack Parameters

Moisture content, %v/v	2.1	
Gas molecular weight, g/g mole	28.7 (wet)	28.9 (dry)
Gas density at NTP, kg/m³	1.28 (wet)	1.29 (dry)

Gas Flow Parameters	Test 1
Temperature, °C	30
Velocity at sampling plane, m/s	2.4
Volumetric flow rate, discharge, m³/s	0.09
Volumetric flow rate (wet NTP), m³/s	0.082
Volumetric flow rate (dry NTP), m³/s	0.08
Mass flow rate (wet basis), kg/hour	380
Velocity difference, %	-3

5 TEST INSTRUMENTATION & CALIBRATION

Two JUM Total organic compound (FID) analysers was used to measure hydrocarbon concentrations with data logged every 10 seconds for the entire 4 hour sampling duration.

Due to an increasing inability to source the gas mix as recommended in the Trimm report the decision was taken, in consultation with the Australian Taxation Office, to substitute propane as a calibration gas. A mathematical conversion factor has been applied to the average final result to produce equivalency with the calibration gas as described in the Trimm report.

The conversion factor has been calculated by averaging the molecular weight of the Trimm mix and propane of the same concentration and calculating the multiplication factor required to achieve equivalency. The calculated conversion factor (CF), as outlined below, has been determined to be 1.37 which has been applied to the averages measured.

Conversion Factor Calculation

Compound	MW (g/mol)	MW in 30% Trimm mixture		MW in proposed Cal Gas		
Propane	44.11	0.03 x 44.11 =	1.32	0.309 x 44.11	13.63	
Butane	58.12	0.15 x 58.12 =	8.72			
Pentane	72.15	0.12 x 72.15 =	8.66			
		Total	18.70			
				Conversion Factor (CF)	18.70/13.63 =	**1.37**

The inlet analyser was calibrated on site, at the start and end of the sampling period using medical air for zero calibration and a 30.9% Propane in Nitrogen mix for span adjustment. This analyser has a range of 0 – 10% (100,000 ppm) so the calibration gas and subsequently the sample gas was passed through a dilution system to achieve a dilution factor of 10. This analyser was thus calibrated to a 3.09% (30900ppm).

The outlet analyser was calibrated on site, at the start and end of the sampling period using medical air for zero calibration and a 9019ppm Propane in Nitrogen mix for span adjustment.

Calibration Summary

	%	ppm
Inlet Zero Drift	1.3	1300
Inlet Span Drift	1.9	1900
Outlet Zero Drift	1.3	130
Outlet Span Drift	-1.6	-160

6 METHOD CALCULATIONS

Measured Average Inlet Vapour Concentration $\mathbf{Y_{inm}}$ =	160433.1	ppm
Calculated Average Inlet Vapour Concentration $\mathbf{Y_{in}}$ =	117104.5	ppm
By Definition $\mathbf{Y_{in}}$ (volume fraction hydrocarbon) =	0.117104	
Measured Average Outlet Vapour Concentration $\mathbf{Y_{outm}}$ =	11589.2	ppm
Calculated Average Outlet Vapour Concentration $\mathbf{Y_{out}}$ =	8459.267	ppm
By Definition $\mathbf{Y_{out}}$ (volume fraction hydrocarbon) =	0.008459	
Volume of Motor Spirit Loaded During Test $\mathbf{V_{motor\ spirit}}$ (corrected to 15oC and 101.3kPa) =	413139	
Volume of Distillate Produce Loaded During Test $\mathbf{V_{distillate}}$ (corrected to 15oC and 101.3kPa) =	269940	
Total Liquid Volume Loaded During Test $\mathbf{V_{gin\ test\ (corrected)}}$ =	683079	
Calibration gas MW conversion Factor **CF** =	1.37	

Calculated Y_{in} and Y_{out}

$Y_{in} = Y_{inm}/$**CF**

Y_{in} = 16.04331/1.37

Y_{in} = 11.71044711

$Y_{out} = Y_{outm}/$**CF**

Y_{out} = 1.15892/1.37

Y_{out} = 0.845927

Calculate VRU Recovery Efficiency

E = Vapour Recovery Efficiency

$E = 1-((1-Y_{in})/Y_{in})*(Y_{out}/(1-Y_{out}))*100$ — Trimm equation 9

E = 93.56782242

Calculate vapour Volume Recovered During Test Period

$V_{ads\ test} = V_{gin\ test}$ (corrected) * E * Y_{in} — NB E = 0.935678 — Trimm equation 10

$V_{ads\ test}$ = 74846.40294

Calculate Liquid Volume Recovered During Test Period

By Definition F = Molecular Weight/Density = 0.10925

By Definition Gas Constant = (22.414 liter/mole / 273^{o}K) x 288^{o}K = 23.6455

$V_{liq\ test} = (V_{ads\ test} * F) / (23.6455)$ — Trimm equation 17

$V_{liq\ test}$ = 345.8150397 litres of liquid hydrocarbon

$V_{liq\ gain}$ = 0.050625922 of total throughput

0.083704283 of motor spirit throughput

8 PLANT OPERATING CONDITIONS

Unless otherwise stated, the plant operating conditions were normal at the time of testing.

Motor spirit (gasoline) and Distillate (Diesel) volumes loaded during the test period are recorded and appended to this report. This information was supplied by Vopak Terminals Australia's terminal inventory control system.

The volume of motor spirit loaded over the sample duration was 269,940L (adjusted to 15 °C and 1 atm).

The volume of distillate loaded over the sample duration was 413,139L (adjusted to 15 °C and 1 atm).

9 TEST METHODS

All sampling and analysis was performed by Ektimo unless otherwise specified. Specific details of the methods are available upon request

Test Method Table

Parameter	Test Method	Method Detection Limit	Uncertainty*	NATA Accredited	
				Sampling	Analysis
Velocity	NSW TM-2	$2ms^{-1}$	7%	✓	NA
Moisture content	NSW TM-22	0.40%	19%	✓	✓
Sample plane criteria	NSW TM-1	NA	-	✓	NA
Temperature	NSW TM-2	0°C	2%		NA
Flow rate	NSW TM-2	Location	8%		NA
Carbon dioxide	NSW TM-24	0.10%	13%	✓	✓
Oxygen	NSW TM-25	0.10%	13%	✓	✓
Determination of total amount of liquid hydrocarbon recovered from vapour recovery units	*Vapour Recovery in the Petroleum Industry,* July 1998	3.9 mg/m³	2%	X	X

* Uncertainty values cited in this table are calculated at the 95% confidence level (coverage factor = 2)

10 QUALITY ASSURANCE/ QUALITY CONTROL INFORMATION

Ektimo is accredited by the National Association of Testing Authorities (NATA) for the sampling and analysis of air pollutants from industrial sources. Unless otherwise stated test methods used are accredited with the National Association of Testing Authorities. For full details, search for Ektimo at NATA's website www.nata.asn.au.

Ektimo is accredited by NATA (National Association of Testing Authorities) to Australian Standard 17025 – General Requirements for the Competence of Testing and Calibration Laboratories. Australian Standard 17025 requires that a laboratory have a quality system similar to ISO 9002. More importantly it also requires that a laboratory have adequate equipment to perform the testing, as well as laboratory personnel with the competence to perform the testing. This quality assurance system is administered and maintained by the Compliance Manager.

NATA is a member of APLAC (Asia Pacific Laboratory Accreditation Co-operation) and of ILAC (International Laboratory Accreditation Co-operation). Through the mutual recognition arrangements with both of these organisations, NATA accreditation is recognised world –wide.

A formal Quality Control program is in place at Ektimo to monitor analyses performed in the laboratory and sampling conducted in the field. The program is designed to check where appropriate; the sampling reproducibility, analytical method, accuracy, precision and the performance of the analyst. The Laboratory Manager is responsible for the administration and maintenance of this program.

11 DEFINITIONS

The following symbols and abbreviations may be used in this test report:

NTP	Normal temperature and pressure. Gas volumes and concentrations are expressed on a dry basis at 0°C, at discharge oxygen concentration and an absolute pressure of 101.325 kPa, unless otherwise specified.
Disturbance	A flow obstruction or instability in the direction of the flow which may impede accurate flow determination. This includes centrifugal fans, axial fans, partially closed or closed dampers, louvres, bends, connections, junctions, direction changes or changes in pipe diameter.
TOC	The sum of all compounds of carbon which contain at least one carbon to carbon bond, plus methane and its derivatives.
BSP	British standard pipe
NA	Not applicable
D	Duct diameter or equivalent duct diameter for rectangular ducts
<	Less than
>	Greater than
≥	Greater than or equal to
~	Approximately
EPA	Environment Protection Authority
NATA	National Association of Testing Authorities
AS	Australian Standard
USEPA	United States Environmental Protection Agency
TM	Test Method
OM	Other approved method
CTM	Conditional test method

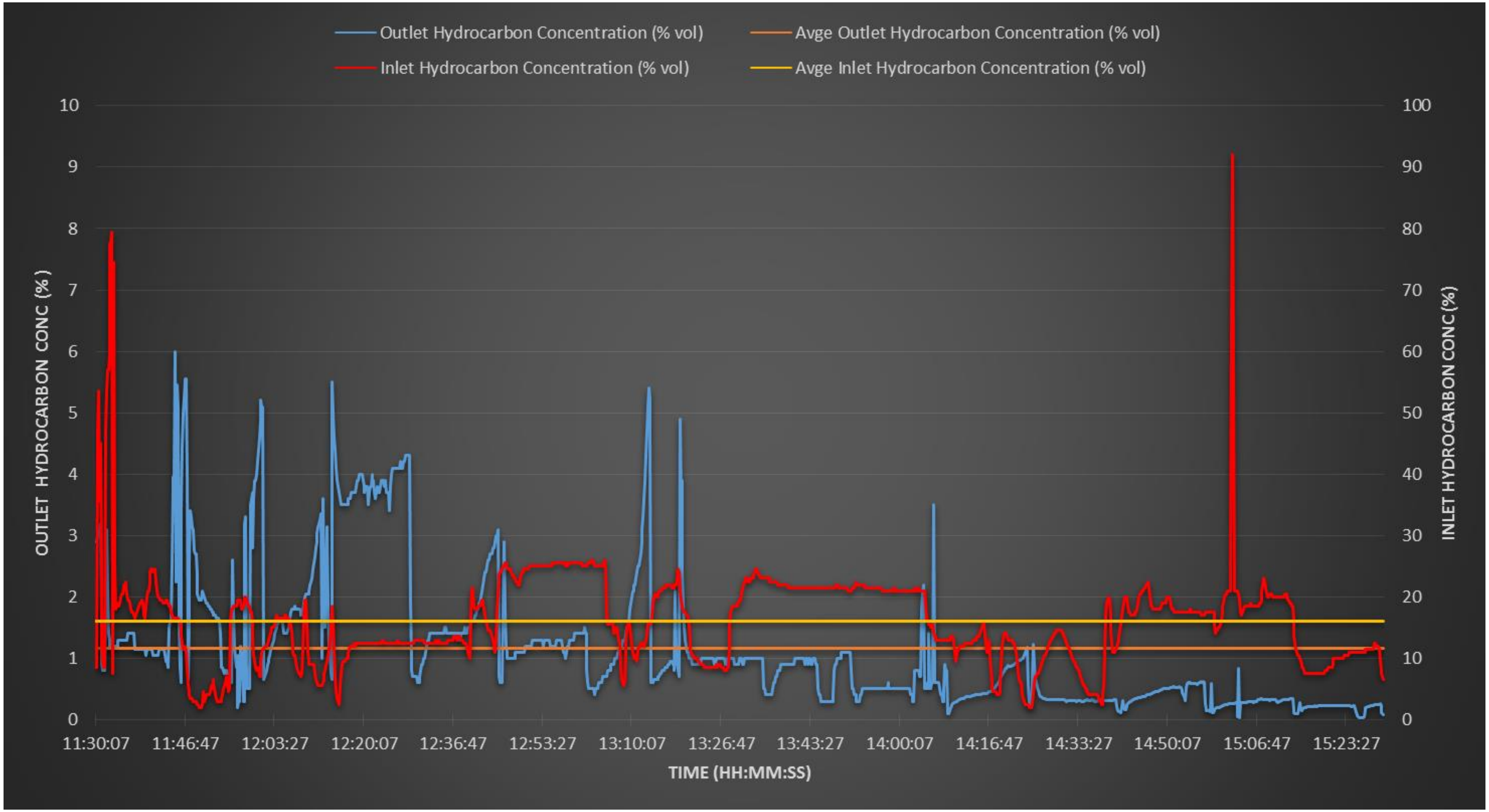
APPENDIX 1

Tank Truck Loading Data

Order Number	Load Date	Load Time	Product Code	Product Name	Gross	Temp	Dens	Net @ 15 degrees
77812	18/02/2015	11:34:02	9881	Diesel	29,966	30.5	844.6	29,577
77814	18/02/2015	12:19:26	2000	Gasoline	16,299	27.5	741.8	16,049
77814	18/02/2015	12:19:26	3000	Gasoline	35,185	27.9	746.9	34,636
77815	18/02/2015	12:08:46	1050	Diesel	21,508	30.2	837.8	21,229
77815	18/02/2015	12:08:46	2500	Gasoline	14,621	26.7	742.3	14,412
77815	18/02/2015	12:08:46	3000	Gasoline	7,261	25.1	747.1	7,175
77816	18/02/2015	12:04:03	9862	Gasoline	8,238	25.4	746.8	8,135
77816	18/02/2015	12:04:03	9885	Gasoline	21,612	27.4	741.8	21,281
77816	18/02/2015	12:04:03	9886	Gasoline	8,280	26.3	741.8	8,165
77819	18/02/2015	14:25:26	97	Gasoline	5,001	28.0	741.8	4,922
77819	18/02/2015	14:25:26	152	Gasoline	14,200	27.9	741.8	13,977
77819	18/02/2015	14:25:26	262	Diesel	16,992	27.3	835.4	16,813
77821	18/02/2015	14:38:29	97	Gasoline	1,799	28.1	741.8	1,770
77821	18/02/2015	14:38:29	262	Diesel	1,795	27.0	835.4	1,776
77822	18/02/2015	15:15:48	1050	Diesel	22,579	30.3	837.8	22,285
77822	18/02/2015	15:15:48	2500	Gasoline	13,992	27.2	742.3	13,784
77822	18/02/2015	15:15:48	3000	Gasoline	11,192	25.5	747.1	11,052
830871	18/02/2015	14:52:05	1050	Diesel	7,190	29.7	837.8	7,101
830871	18/02/2015	14:52:05	2500	Gasoline	4,991	27.9	742.3	4,913
830871	18/02/2015	14:52:05	3000	Gasoline	7,194	25.8	747.1	7,102
830871	18/02/2015	14:52:05	4018	Gasoline	7,180	29.0	739.8	7,056
830871	18/02/2015	14:52:05	4850	Gasoline	11,919	161.5	786.6	11,775
538327	18/02/2015	13:13:18	1000	Diesel	3,995	29.6	835.4	3,945
538327	18/02/2015	13:13:18	2000	Gasoline	19,998	27.8	741.8	19,685
538327	18/02/2015	13:13:18	4018	Gasoline	4,001	28.2	739.8	3,936
130281	18/02/2015	11:44:42	7256	Gasoline	13,334	27.2	741.8	13,134
130281	18/02/2015	11:44:42	7257	Gasoline	8,327	25.3	746.8	8,226
130281	18/02/2015	11:44:42	7259	Gasoline	8,388	27.4	756.1	8,264
130281	18/02/2015	11:44:42	7261	Diesel	18,117	29.9	837.6	17,886
870859	18/02/2015	11:43:53	97	Gasoline	8,805	26.0	741.8	8,685
870859	18/02/2015	11:43:53	210	Gasoline	7,299	27.5	756.1	7,191
870859	18/02/2015	11:43:53	254	Gasoline	14,191	25.1	746.9	14,020
870859	18/02/2015	11:43:53	264	Diesel	7,299	30.7	835.4	7,201
870870	18/02/2015	12:51:41	210	Gasoline	20,003	28.2	756.1	19,689
870870	18/02/2015	12:51:41	262	Diesel	15,795	30.5	835.4	15,587
538347	18/02/2015	12:03:29	1000	Diesel	31,996	30.3	835.4	31,578
870873	18/02/2015	13:36:44	210	Gasoline	8,800	28.2	756.1	8,664
339555	18/02/2015	12:11:34	210	Gasoline	14,992	27.7	756.1	14,766
870891	18/02/2015	13:16:53	152	Gasoline	16,243	27.5	741.8	15,994
870891	18/02/2015	13:16:53	262	Diesel	19,793	30.4	835.4	19,531
870892	18/02/2015	12:16:49	269	Diesel	50,546	30.4	837.8	49,885
870894	18/02/2015	11:39:13	210	Gasoline	30,025	27.5	756.1	29,577
870894	18/02/2015	11:39:13	264	Diesel	6,760	30.4	835.4	6,670
870898	18/02/2015	13:23:05	210	Gasoline	20,999	28.0	756.1	20,673
870898	18/02/2015	13:23:05	264	Diesel	16,190	27.7	835.4	16,014
870909	18/02/2015	13:10:36	210	Gasoline	9,792	28.1	756.1	9,639
870909	18/02/2015	13:10:36	254	Gasoline	6,096	28.2	746.9	6,000
870909	18/02/2015	13:10:36	264	Diesel	2,899	29.8	835.4	2,862
870910	18/02/2015	15:05:33	97	Gasoline	2,499	27.9	741.8	2,460
870910	18/02/2015	15:05:33	210	Gasoline	10,791	28.6	756.1	10,616
870910	18/02/2015	15:05:33	254	Gasoline	5,801	27.2	746.9	5,716

APPENDIX 2

Chart Recording of Measured VRU TOC Emissions



Outlet Hydrocarbon Concentration (% vol)
Avge Outlet Hydrocarbon Concentration (% vol)
Inlet Hydrocarbon Concentration (% vol)
Avge Inlet Hydrocarbon Concentration (% vol)
OUTLET HYDROCARBON CONC (%)
INLET HYDROCARBON CONC (%)
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
80
90
100
11:30:07
11:46:47
12:03:27
12:20:07
12:36:47
12:53:27
13:10:07
13:26:47
13:43:27
14:00:07
14:16:47
14:33:27
14:50:07
15:06:47
15:23:27
TIME (HH:MM:SS)

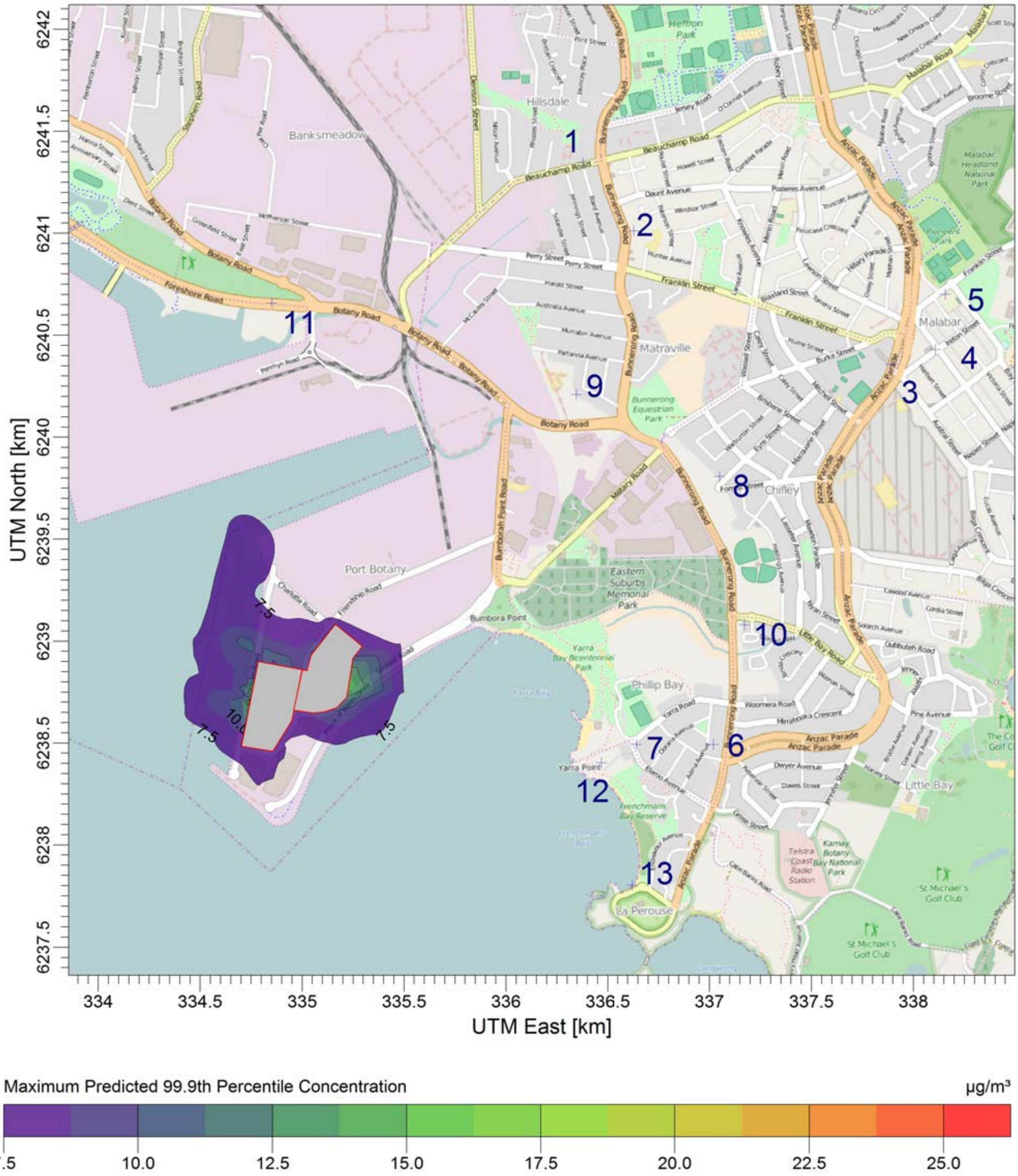
Appendix E

Predicted Concentration Isopleths

Appendix E Predicted Concentration Isopleths

PROJECT TITLE:

Predicted Cumulative Benzene Concentrations (μg/m³)



COMMENTS:

Criteria
29 μg/m³

CLIENT:

Vopak Terminals Pty Ltd

MODELER:

DC

SCALE: 1:30,000

0 1 km

AECOM

DATE:

25/05/2016

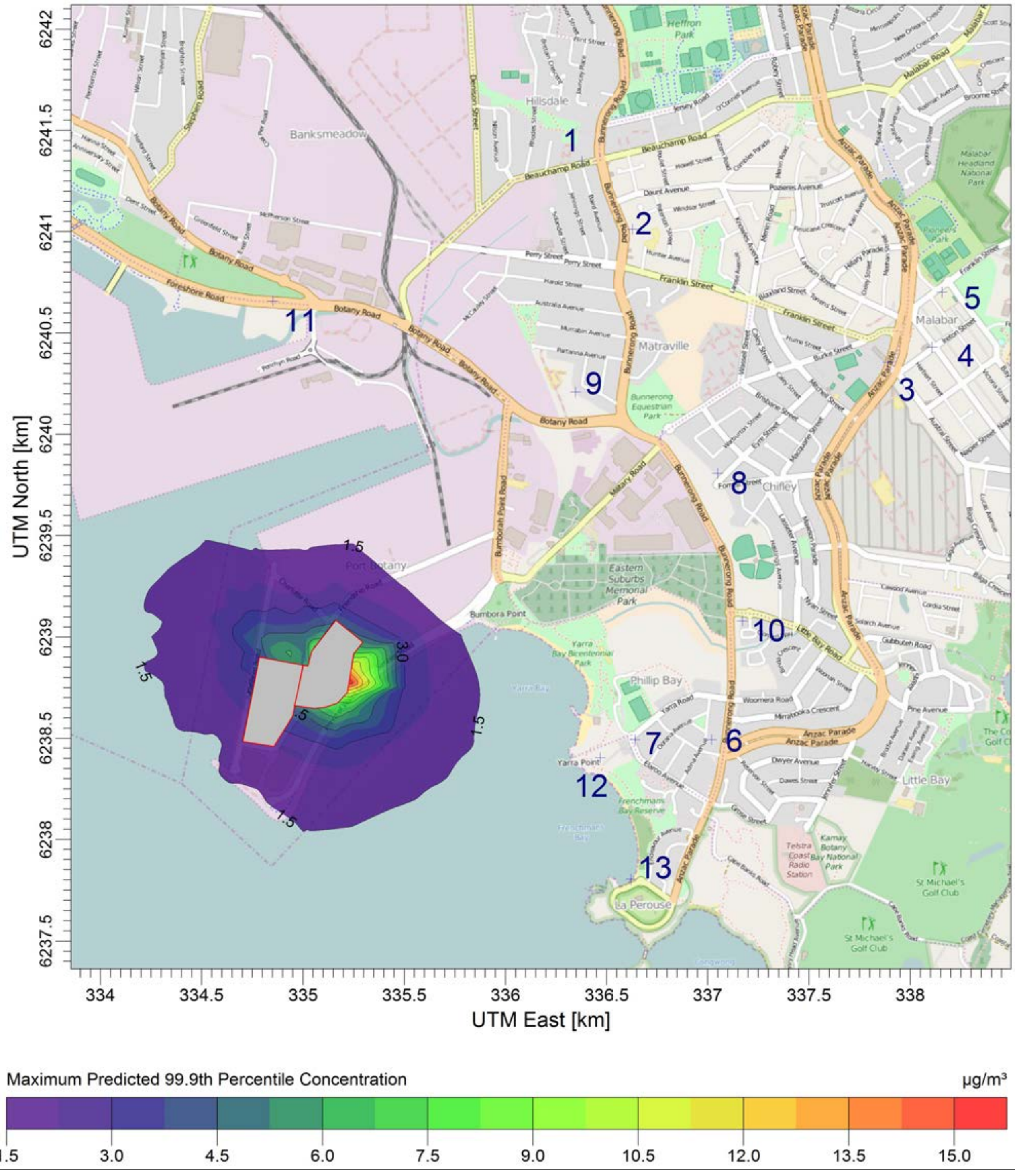
PROJECT NO.:

60344169

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Predicted Cumulative Cumene Concentrations (μg/m³)



COMMENTS:

Criteria
21 μg/m³

CLIENT:

Vopak Terminals Pty Ltd

MODELER:

DC

SCALE: 1:30,000

0 — 1 km

AECOM

DATE:

25/05/2016

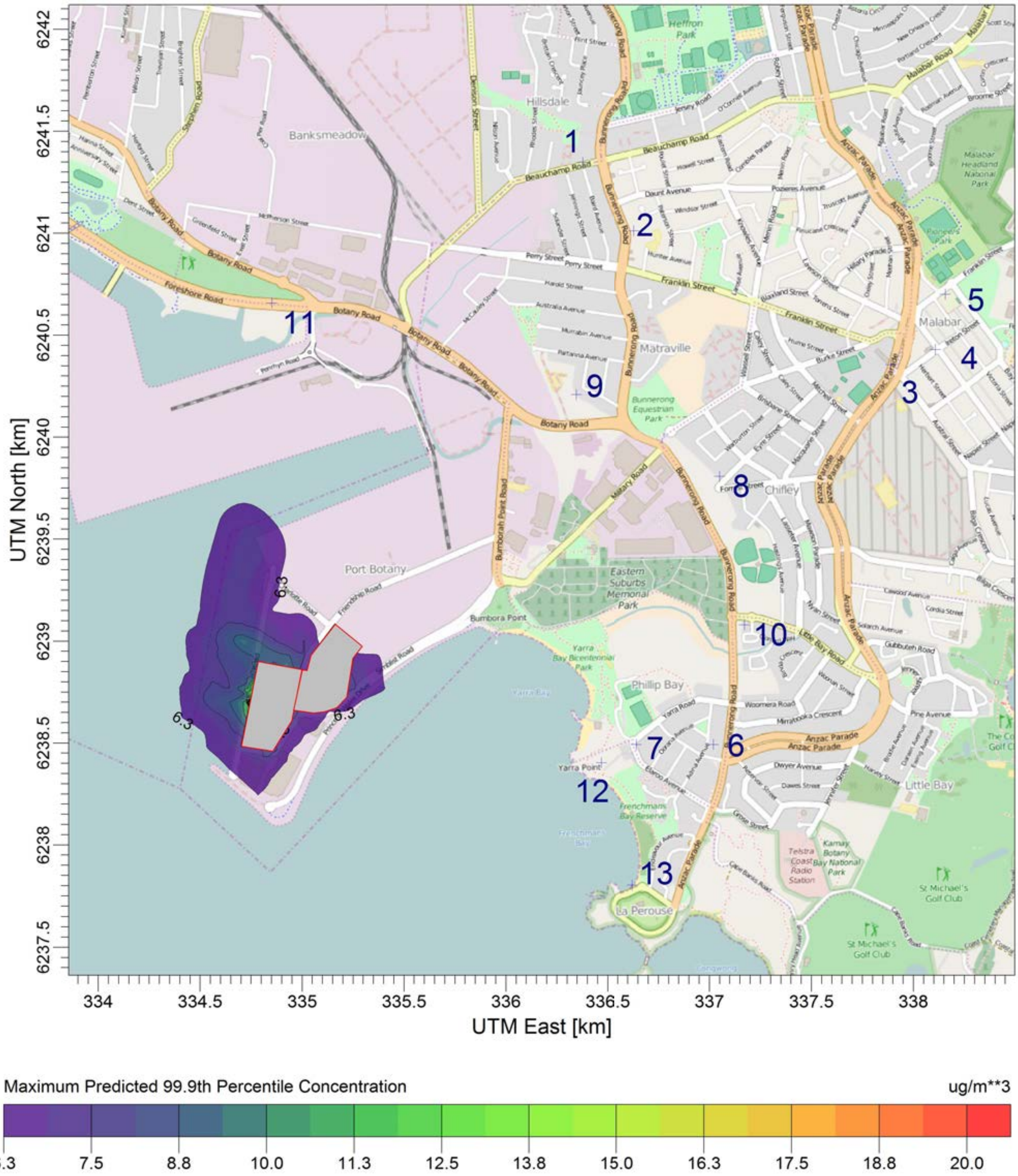
PROJECT NO.:

60344169

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Predicted Cumulative Cyclohexane Concentrations (μg/m³)



COMMENTS:

Criteria
19,000 μg/m³

CLIENT:

Vopak Terminals Pty Ltd

MODELER:

DC

SCALE: 1:30,000

0 — 1 km

AECOM

DATE:

25/05/2016

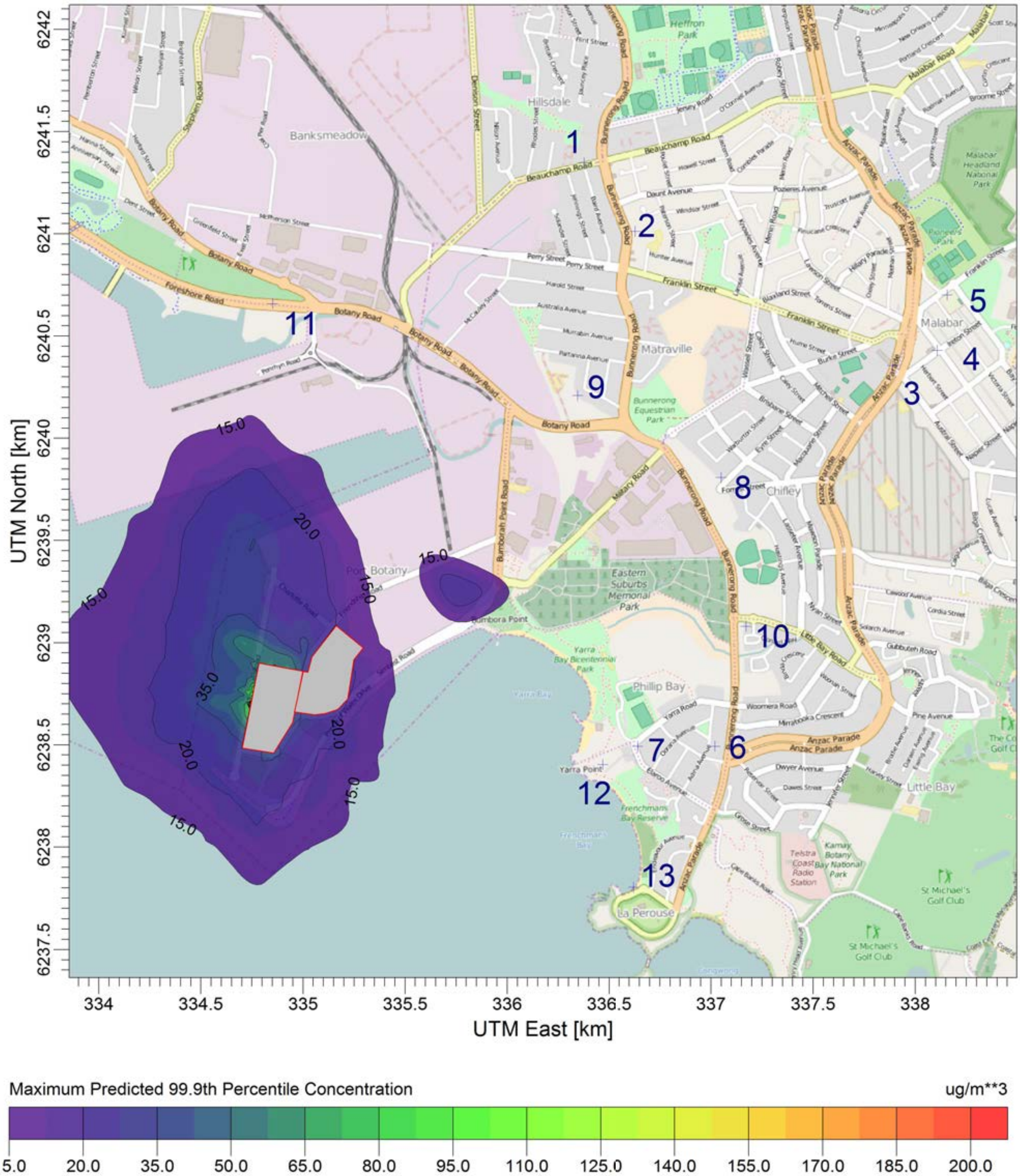
PROJECT NO.:

60344169

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Predicted Cumulative Toluene Concentrations (µg/m³)

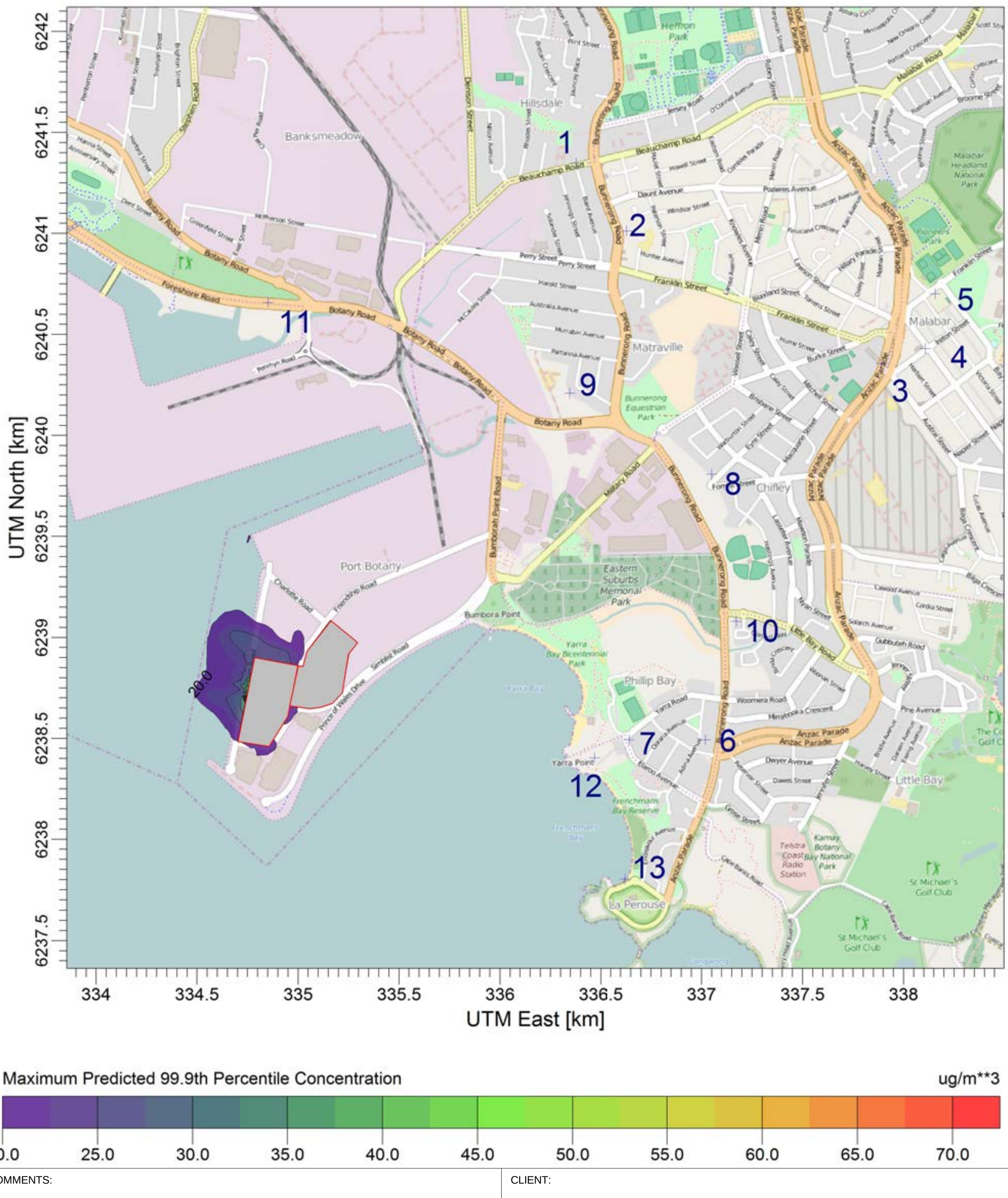


COMMENTS:	CLIENT:	
Criteria 360 µg/m³	**Vopak Terminals Pty Ltd**	
	MODELER: **DC**	AECOM
	SCALE: 1:30,000 (0 — 1 km)	
	DATE: **25/05/2016**	PROJECT NO.: **60344169**

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Predicted Cumulative n-Hexane Concentrations (µg/m³)



COMMENTS:

Criteria
3,200 µg/m³

CLIENT:

Vopak Terminals Pty Ltd

MODELER:

DC

SCALE: 1:30,000

0 — 1 km

DATE:

25/05/2016

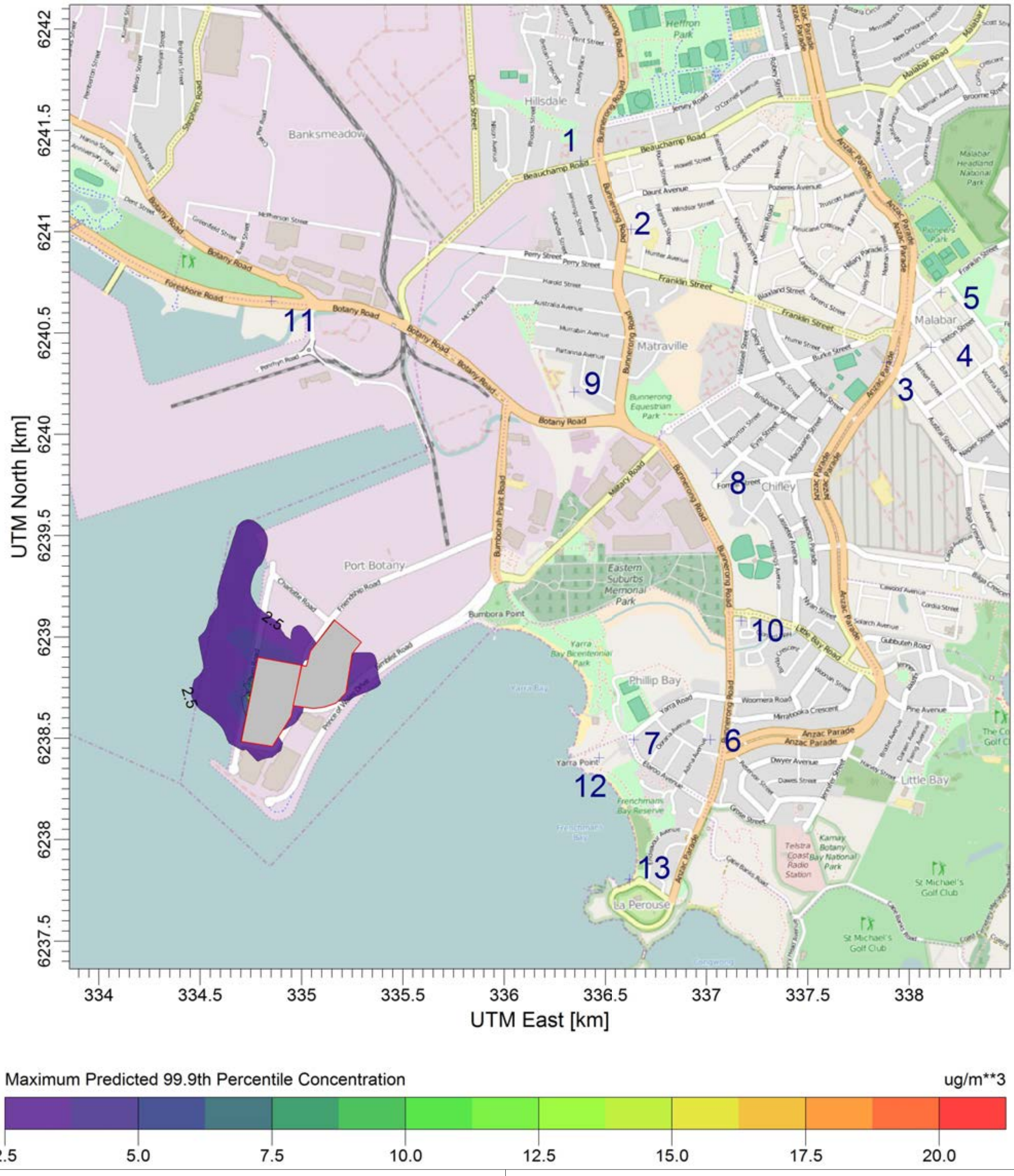
PROJECT NO.:

60344169

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Predicted Cumulative Ethylbenzene Concentrations (µg/m³)



COMMENTS:

Criteria
8,000 µg/m³

CLIENT:

Vopak Terminals Pty Ltd

MODELER:

DC

SCALE: 1:30,000

0 — 1 km

AECOM

DATE:

25/05/2016

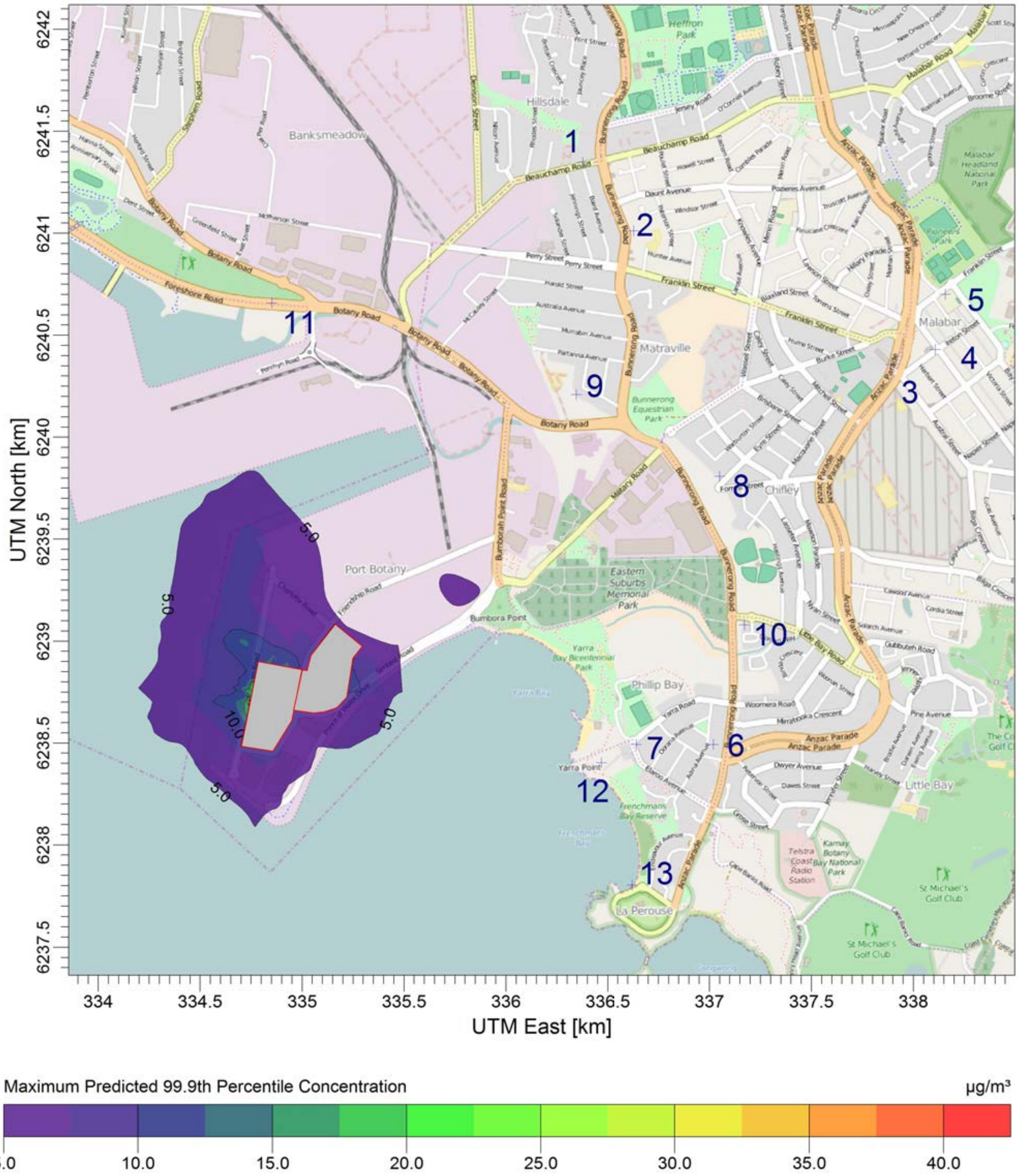
PROJECT NO.:

60344169

CALPUFF View - Lakes Environmental Software

PROJECT TITLE:

Predicted Cumulative Xylenes Concentrations (µg/m³)



COMMENTS:

Criteria
190 µg/m³

CLIENT:

Vopak Terminals Pty Ltd

MODELER:

DC

SCALE: 1:30,000

0 — 1 km

AECOM

DATE:

25/05/2016

PROJECT NO.:

60344169

CALPUFF View - Lakes Environmental Software

AECOM Australia Pty Ltd

ABN 20 093 846 925