Appendix E

Air Quality & Odour Assessment

E

Weston Aluminium Pty Ltd
26-Aug-2016

Weston Aluminium Thermal Waste Processing Project

Air Quality Impact Assessment

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Air Quality Impact Assessment

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Quality Information

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Acronyms

Term	Description
Airshed	Part of the atmosphere that shares a common flow of air and to similar influences.
Ambient	Ambient/background pollutant concentrations refer to the concentrations of pollutants in the air, which are generated by all local pollutant sources.
As	Arsenic
Be	Beryllium
BRF	Battery recycling facility
BOM	Bureau of Meteorology
Cd	Cadmium
Co	Cobalt
CO	Carbon monoxide
Cr	Chromium
Cu	Copper
Cumulative assessment	The cumulative assessment was undertaken by summing the project contributions with the ambient pollutant concentrations where relevant.
EPA	Environment Protection Authority
H_2SO_4	Sulphuric acid mist
HCl	Hydrogen chloride
HF	Hydrogen fluoride
Hg	Mercury
Mn	Manganese
Ni	Nickel
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen, including nitric oxide (NO) and NO_2
OEH	Office of Environment and Heritage
Particulate matter	Very small solid particles or liquid droplets, which may become suspended in air.
Pb	Lead
PM_{10}	Particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less.
$PM_{2.5}$	Particulate matter with an equivalent aerodynamic diameter of 2.5 micrometres or less.
Receivers	Discrete receivers are identified by the EPA as anywhere someone works or resides or may work or reside
Sb	Antimony
Se	Selenium
Sn	Tin
TSP	Total suspended particulates; a type of particulate matter.
VOCs	Volatile organic compounds with a high vapour pressure at room temperature.
WA	Weston Aluminium
V	Vanadium

Executive Summary

AECOM was commissioned by Weston Aluminium (WA) to prepare an air quality impact assessment for inclusion in an environmental assessment of a proposed medical and other waste thermal processing project (the Project). The proposed thermal destruction/processing equipment would be incorporated into the existing facility footprint, using existing access and emission control systems. A Level 2 Air Quality Impact Assessment was conducted in accordance with the *NSW Approved Methods for Modelling and Assessment OF Air Pollutants in NSW* (DEC 2005). This report provides an assessment of the potential ground level air quality impacts from particulates, sulphur dioxide, oxides of nitrogen, hydrogen fluoride, acid gases, volatile organic compounds, heavy metals and dioxins and furans from the proposed thermal waste processing plant. WA is also seeking changes to the Environmental Protection Licence (EPL) limit for Point 13 (Stack 5) during operation of the proposed thermal equipment and would also require a variation to the existing load limit for oxides of nitrogen.

Dispersion modelling was undertaken for the AQIA using the Lagrangian model CALPUFF. One primary modelling scenario was assessed and is described as follows:

- **Scenario 1 (Normal Operating Conditions)**: A worst case modelling scenario based on standard operating conditions, with the proposed thermal processing plant operating at a maximum operational capacity of 800kg/h.

In addition to the above primary scenario, two additional modelling scenarios were assessed to look at the below theoretical situations:

- **Scenario 2 (EPL Limits**: A theoretical modelling scenario whereby the point source for the proposed thermal processing plant would be operating at the maximum stack concentration for each pollutant set by the EPL; and
- **Scenario 3 (Kurri Kurri Battery Recycling Facility (BRF))**: A modelling scenario was undertaken to account for the air quality impacts associated with the proposed BRF, and these results were added to the predicted incremental impacts associated with WA.

Additionally, background air quality was also examined from the nearest OEH monitoring station in Beresfield to assess the cumulative impacts associated with the Project.

Results of the modelling showed no exceedances of the relevant air quality criteria for all examined pollutants under Scenario 1 or 2. The particulate data predicts that there are no additional exceedances of the criteria, beyond those already attributed to the background data, once the potential impacts from both the WA and BRF sites are cumulatively assessed with the background. The Project contribution from WA was found to be relatively small in all cases, and similarly contributions from the adjacent BRF were also considered small. Furthermore, estimates were considered conservative under 'normal operating conditions' with the modelling showing the thermal treatment plant operating continuously instead of intermittently in conjunction with reverb furnace operations and at the maximum operational capacity of 800kg/h.

In addition to the above mentioned exceedances, it should be noted that the EPL Scenario (Scenario 2) has been used to determine upper emission rate limits for beryllium and dioxins and furans using the maximum stack concentrations described in Schedule 4 of the POEO (Clear Air) Regulation 2010 that would result in no exceedances of the ground level concentration criteria. Models of offsite impacts for beryllium and dioxins and furans resulted in the maximum offsite 99.9th percentile concentrations being equal to the ambient air quality criteria and lower concentrations were observed at nearby sensitive receptors. Scenario 2 modelling reflects highly conservative, worst-case conditions, which are considered unrepresentative of typical operating conditions.

In conclusion, the results of the modelling indicate that there would be no substantial air quality impacts from the operation of the proposed thermal processing plant at WA, and the proposed emission concentrations associated with operation of the plant would unlikely result in any additional exceedances of local air quality, for all pollutants examined.

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1.0 Introduction

1.1 Weston Aluminium Thermal Waste Processing Project

This section provides an introduction to Weston Aluminium (WA), the proposal to install and operate medical and other waste processing equipment at the WA facility (the Project), and the purpose and content of this report.

1.1.1 Overview

WA proposes to install and operate new thermal waste processing equipment at their existing aluminium recycling and refining facility at 129 Mitchell Avenue, Kurri Kurri in the Hunter Valley, NSW. Refer **Figure 1**. The purpose of this report is to characterise the proposal and to provide an overview of its potential effects on local air quality.

In response to the ongoing decline in traditional focus areas within the aluminium and steel sectors, and identified growth opportunities in other and emerging markets, WA proposes to further adapt and diversify its plant, equipment and processes to enable the thermal processing of other wastes. This Project promotes development of the Kurri Kurri region, providing employment opportunities and contributes to the growth of industrial development in an environmentally sustainable manner.

The WA facility is ideally positioned in the Lower Hunter to cater for the ever-increasing generation of wastes and the resulting increasing demand for regional specialist waste management. Currently, such wastes must be transported significant distances, often interstate for disposal. As part of the Project, WA propose to construct and operate purpose-built infrastructure for the safe receipt, storage and processing of medical and other wastes. WA has a strong demonstrated history of planning approval and environmental license compliance with stringent environmental requirements currently enforced through a comprehensive environmental management system.

1.1.2 Proposed Development

Proposed thermal destruction/processing equipment is to be incorporated into the existing WA facility footprint, using existing access and emission control systems. Proposed plant and equipment would be located within the northern end of the site with the northern fence line to be extended further north to accommodate the new development (still remaining within WA property boundaries). The location of the Project Area is shown in **Figure 2**.

The kiln is proposed to be established in an east-west orientation, with enclosed input storage facilities and a dedicated feeding system. The existing Baghouse 5 is to be utilised for emission capture and treatment of process emissions from the proposed plant and equipment before discharge to atmosphere via the existing Stack 5. This emission control system currently services Reverberatory Furnace process emissions, typically operated during one shift per day. A dry-lime scrubber system currently operates in conjunction with Baghouse 5 to treat acid gases and adsorb pollutants (e.g. PAHs and Dioxins/Furans). It is proposed that this scrubber system be upgraded to incorporate an activated carbon dosing system, with the activated carbon injected at the baghouse entry point.

WA is also seeking changes to the Environmental Protection Licence (EPL) limit for Point 13 (Stack 5) during operation of the proposed thermal construction equipment and would also require a variation to the existing load limit for oxides of nitrogen. WA is not seeking to vary/increase air emission concentration or load limits associated the current operation of the Reverberatory Furnace for this discharge point. This is further discussed in detail under **Section 2.1.2**.

1.2 Proposed Operations

The proposed thermal processing plant (rotary kiln) would primarily be used to thermally treat a mixture of medical wastes including general refuse, laboratory and pharmaceutical chemicals and containers, pathological wastes and cytotoxic materials. The plant would also be used to thermally treat smaller quantities of quarantine and other wastes including pitch sludge residues, solvents and paints, oily rags and documents and hard drives.

The proposed processing equipment would include (Airlabs Environmental 2015):

- Solid waste loader and bin tipper to deliver solid waste materials directly into the primary chamber of the thermal processing plant;
- Primary combustion chamber, consisting of a rotary kiln equipped with a final ash burn out zone;
- Ash discharge system, whereby ash is removed by means of a water seal pit and drag conveyor;

- Secondary combustion chamber, equipped with two natural gas fired burners used to ensure virtually complete breakdown of combustible gases generated in the plants primary chamber and minimise emissions of dioxins and other products of incomplete combustion;
- Emergency bypass for hot combustion gases to be directly vented from the plant to atmosphere during incidents, power failure or other emergency situations. This application would use a separate stack equipped with a fail-safe pneumatically assisted counterweighted insulated stack cap and would be 12.5 metres (m) in height; and
- Waste bin washing machine.

Potential air quality emissions from the proposed operations would include emissions from Stack 5 and may potentially include the following pollutants:

- Total Suspended Particulates (TSP)
- Particulates ≤10µm in diameter (PM_{10})
- Particulates ≤2.5µm in diameter ($PM_{2.5}$)
- Carbon Monoxide (CO)
- Sulphur Dioxide (SO_2)
- Sulphur Trioxide (SO_3)
- Sulphuric Acid Mist (H_2SO_4)
- Oxides of Nitrogen (NO_x)
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- Volatile Organic Compounds (VOCs)
- Antimony (Sb)
- Arsenic (As)
- Cadmium (Cd)
- Lead (Pb)
- Mercury (Hg)
- Beryllium (Be)
- Chromium (Cr)
- Cobalt (Co)
- Manganese (Mn)
- Nickel (Ni)
- Selenium (Se)
- Tin (Sn)
- Vanadium (V)
- Copper (Cu)
- Dioxins and Furans

The proposed thermal waste processing plant would operate interchangeably with the operation of the existing reverb furnace. As such emissions from Stack 5 would either be attributed to the thermal waste processing plant or reverb furnace at any one time.

1.3 Purpose of the Report

1.3.1 Secretary's Environmental Assessment Requirements

The WA Medical and other waste thermal processing facility Project Environmental Impact Statement has been prepared in accordance with Division 4.1, Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) which ensures that the potential environmental effects of a proposal are properly assessed and considered in the decision-making process.

In preparing this Air Quality Impact Assessment, the Secretary's Environmental Assessment Requirements (SEARs) issued for the Project (SSD_7349) on 16 December 2015 have been addressed as required by Clause 75F of the EP&A Act. The key matters raised by the Secretary for consideration in the Air Quality Impact Assessment are outlined in **Table 1** along with a reference to where the requirements are addressed in the report. **Table 1** also lists the requirements detailed in the NSW Environment Protection Authority (EPA) submission to the SEAR's.

Table 1 Secretary's Environmental Assessment Requirements – Air Quality

Secretary's Environmental Assessment Requirement		Section Addressed
Air Quality	Quantitative assessment of the air quality, dust and odour impacts of the development in accordance with the relevant Environment Protection Authority Guidelines	**Section 5.0**. and EIS Report
	The details of buildings and air handling systems and strong justification for any handling, processing and monitoring measures	**Section 1.1.2** and **Section 5.0**
	A greenhouse gas assessment	EIS Report
	Details of proposed mitigation, management and monitoring measures	**Section 5.0**
NSW Environment Protection Authority Requirement		**Section Addressed**
Air Quality	Assess the risk associated with potential discharges of fugitive and point source emissions for all stages of the proposal. Assessment of risk relates to environmental harm, risk to human health and amenity	**Section 4.0**. and Health Risk Assessment Report
	Justify the level of assessment undertaken on the basis of risk factors, including but not limited to: - Proposal location; - Characteristics of the receiving environment; and - Type and Quantity of pollutants emitted	**Section 2.0**
	Describe the receiving environment in detail. The proposal must be contextualised within the receiving environment (local, regional and inter-regional as appropriate). The description must include but not be limited to: - Meteorology; - Topography; - Surrounding land-use; receptors; and - Ambient Air Quality	**Section 3.0**
	Include a detailed description of the proposal. All processes that could result in air emissions must be identified and described. Sufficient detail to accurately communicate the characteristics	**Section 1.0**
	Include a consideration of 'worst case' emissions scenarios as well as any currently approved developments linked to the receiving environment	**Section 2.3.1**, **Section 2.4.1** and **Section 4.0**
	Include air dispersion modelling where there is a risk of adverse air quality impacts, or where there is sufficient uncertainty to warrant a rigorous numerical impact assessment. Air dispersion modelling must be conducted in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2005)*	**Section 2.0** and **Section 4.0**.
	Demonstrate the proposal's ability to comply with the relevant regulatory framework, specifically the *Protection of the Environment (POEO) Act (1997)* and the *POEO (Clean Air Regulation (2010)*	**Section 2.1.2** and **Section 4.0**.
	Provide an assessment of the project in terms of the priorities and targets adopted under the NSW State Plan 2010 and its implementation plan Action for Air	The Project aligns with the socioeconomic goals of the NSW government in unlocking the Hunter Valleys productive potential as a key contributor to the state's economy. The predicted impacts from the Project meet the Actions for Air goal to maintain national air quality standards identified in the Air NEPM
	Detail monitoring that will be conducted to assess impacts of the proposal.	**Section 5.0**

1.3.2 Air Quality Impact Assessment Objectives

The Purpose of this report is to undertake an Air Quality Impact Assessment (AQIA) for the proposed installation and operation of medical waste thermal destruction equipment at the WA facility for inclusion into the EA. This report aims to address the SEARs described in **Section 1.3.1** for the Project and has been prepared in accordance with the following guidelines:

- Air quality and odour impact assessment guidelines:
  - *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (DEC 2005);
  - *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into Approved Methods for Modeling (sic) and Assessments of Air Pollutants in NSW, Australia* (TRC 2011);
  - *Technical Framework, Assessment and management of odour from stationary sources in NSW* (DEC 2006); and
  - *Technical Notes, Assessment and management of odour from stationary sources in NSW* (DEC 2006).
- The AQIA includes air dispersion modelling using the Lagrangian puff model CALPUFF to assess the air quality impacts from the Project. In summary the scope of this report includes:
  - Description of the proposed modification;
  - Description of the existing environment including local meteorology, climatic conditions, terrain, land use and sensitive receptors; and
  - Preparation of an AQIA including:
    - Identification of relevant ambient air quality criteria;
    - Description of methodology used to develop emissions inventory;
    - Description of modelling methodology;
    - Assessment of potential air quality and odour impacts; and
    - Discussion and recommendations.

1.4 Report Structure

This report is structured as follows:

Section 1.0 Introduction – outlines the Project and presents the purpose of the report.

Section 2.0 Methodology – describes the methodology employed for the air quality impact assessment.

Section 3.0 Existing environment – describes the receiving environment.

Section 4.0 Potential impacts – describes the potential impacts to air quality resulting from the proposed Project.

Section 5.0 Safeguards and management - provides a summary of environmental mitigation, management and monitoring responsibilities in relation to air quality management for the Project.

Section 6.0 Conclusion.

Appendix A EPL Pollutant Limit Assessment.

Appendix B Model Inputs and Results for Bypass Stack for input into Health Risk Assessment.

Appendix C Meteorological Analysis.

Appendix D Discreet Receptor Locations.

2.0 Methodology

The following subsections provide a description of the relevant EPA criteria for ambient air quality and stack concentrations, a description of the study area, a review of relevant background information used in this assessment and the modelling methodology.

2.1 Legislation, Policy, Criteria and/or Guidelines

2.1.1 Ambient Air Quality Criteria

As discussed in **Section 1.2** potentially major contributing air pollutants from the existing and proposed operations may include particulates, CO, SO_2, H_2SO_4, NO_2, HCl, HF, VOCs, heavy metals and dioxins and furans. **Table 2** summarises the NSW EPA's impact assessment criteria as detailed in the *NSW Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales* (DEC 2005) for the pollutants included in the assessment. In general, these criteria relate to the total burden of air pollutants in the air and not just the air pollutants from Project-specific sources. Therefore, some consideration of background levels needs to be made when using these criteria to assess impacts. A discussion of background levels in the study area is provided in **Section 3.3**.

No ambient air quality criterion is administered for heavy metals cobalt, selenium, tin and vanadium under the NSW Approved Methods, NEPM or relevant authorities for other states. As such for the purpose of this assessment, 1 hour short term exposure limits listed by the Texas Commission on Environmental Quality (TCEQ) under the *Effects Screening Level* (ESL) *List* (TCEQ 2015) used in the review of air permitting data have been adopted for the purpose of this assessment.

Table 2 NSW EPA Air Quality Impact Assessment Criteria

Pollutant	Averaging Period	Criteria (µg/m^3)	Reference
TSP	Annual Average	90	NSW EPA
PM_{10}	24 Hour Maximum	50	NSW EPA
	Annual Average	30	NSW EPA
$PM_{2.5}$	24 Hour Maximum	8	NEPM
	Annual Average	25	NEPM
CO	1 Hour Maximum	30,000	NSW EPA
	8 hour Maximum	10,000	NSW EPA
SO_2	1 Hour Maximum	570	NSW EPA
	24 Hour Maximum	228	NSW EPA
	Annual Average	60	NSW EPA
H_2SO_4	1 Hour (99.9th Percentile)	18	NSW EPA
NO_2	1 Hour Maximum	246	NSW EPA
	Annual Average	62	NSW EPA
HCl	1 Hour (99.9th Percentile)	140	NSW EPA
HF (General land use)	90 days	0.5	NSW EPA
	30 days	0.84	NSW EPA
	7 days	1.7	NSW EPA
	24 hours	2.9	NSW EPA

Pollutant	Averaging Period	Criteria (µg/m^3)	Reference
TVOCs (as benzene)[1]	1 Hour (99.9th Percentile)	29	NSW EPA
Sb	1 Hour (99.9th Percentile)	9	NSW EPA
As	1 Hour (99.9th Percentile)	0.09	NSW EPA
Cd	1 Hour (99.9th Percentile)	0.018	NSW EPA
Pb	Annual Average	0.5	NSW EPA
Hg (as organic mercury)	1 Hour (99.9th Percentile)	0.18	NSW EPA
Be	1 Hour (99.9th Percentile)	0.004	NSW EPA
Cr (as Chromium VI compounds)	1 Hour (99.9th Percentile)	0.09	NSW EPA
Co	1 Hour maximum	0.2	TCEQ
Mn	1 Hour (99.9th Percentile)	18	NSW EPA
Ni	1 Hour (99.9th Percentile)	0.18	NSW EPA
Se	1 Hour maximum	2	TCEQ
Sn (as organic compounds)	1 Hour maximum	1	TCEQ
V	1 Hour maximum	2	TCEQ
Cu (as copper fumes)	1 Hour (99.9th Percentile)	3.7	NSW EPA
Dioxins and Furans	1 Hour (99.9th Percentile)	$2x10^{-9}$	NSW EPA

2.1.2 Environment Protection Licence

2.1.2.1 Stack Concentration Limits

Under the *Protection of the Environment Operations Act 1997 (NSW)* (POEO Act), Western Aluminium) WA holds an EPL (No. 6423) administered by the NSW EPA. Section 3, Condition 3.3 of the EPL details the stack concentration limits for the existing plant for Point 1, Point 2, Point 3, Point 4, Point 13, Point 14 and Point 15.

Existing stack limits for Point 13 (Stack 5) are based on both the original conditions of consent and standard concentrations listed for secondary aluminium production under Schedule 3 of the *Protection of the Environment Operations (Clean Air) Regulation 2010 (NSW)* (POEO (Clear Air) Regulation 2010)). Whilst these values still remain appropriate for the operation of the reverb furnace, emissions from Point 13, during the proposed thermal destruction of medical and other waste do not fall under the description of emissions for secondary aluminium production. As such, WA proposes to vary the EPL limits for Point 13 applicable during the operation of the thermal destruction equipment. The proposed emission limits would be consistent with the Group 6 standards of concentration listed under Schedule 4 of the POEO (Clear Air) Regulation 2010).

The existing and proposed EPL limits for Point 13 (Stack 5) are presented in **Table 3**. The proposed limits are either lower than or equal to the standards of concentration listed under Schedule 4 of the POEO (Clear Air) Regulation 2010. The standards of concentration listed under Schedule 4 of the POEO (Clear Air) Regulation 2010 are also provided in **Table 3** as a reference point. No changes are proposed to EPL stack concentration limits for all other point sources. EPL stack limits for all other existing sources are presented in **Table 4**.

[1] Under the Approved Methods (DEC 2005) there is no ambient air quality criteria for TVOCs as such the EPA criterion for benzene has been adopted for this assessment.

Table 3 EPL Stack 13 (Stack 5) Existing EPL Stack Concentration limits during Reverb Furnace Operations and Proposed Rotary Furnace Operations

Operations	TSP (mg/m^3)	NOx (mg/m^3)	H_2SO_4 and SO_3 (mg/m^3)	CO (mg/m^3)	HCl (mg/m^3)	Type 1 & Type 2 Substances (mg/m^3)	VOCs (mg/m^3)	Dioxins and Furans (ng/m^3)
Reverb Furnace	10	100	100	125	10	5	77	0.1 [2]
Proposed Thermal Waste Processing[1]	20	200	100	125	30	1	40	0.1
Group 6 General Activities[2]	50	350	100	125	100	1	40	0.1

1 – Stack concentrations limits for the proposed project operating from Stack 5.

2 – Taken from the *Protection of the Environment Operations (Clean Air) Regulation 2010.*

[2] Limit value is a rolling annual average.

Table 4 Existing EPL Stack Concentration Limits for All Stacks

EPL Point ID	WA Site ID	TSP (mg/m^3)	NOx (g/m^3)	H_2SO_4 and SO_3 (mg/m^3)	CO (ppm)	Gaseous Fluoride (mg/m^3)	HCl (mg/m^3)	Cyanide (mg/m^3)	Type 1 & Type 2 Substances (mg/m^3)
Point 1	Stack 1 Rotary furnace	25	2.5	100	100	2	400	0.5	10
Point 2	Stack 2 Materials Storage	35	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit
Point 3	Stack 3 2nd MRM-Cooler	50	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit
Point 4	Stack 4 MRM-Cooler	24	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit
Point 13	Stack 5 Reverbatory furnace	10	0.1	100	100*	No Limit	10	No Limit	5
Point 14	Stack 6 Gas combustion of Reverbatory furnace	10	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit
Point 15	Stack 7 Pre-processing plant and briquetting plant	15	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit

* provided in EPL as 125 mg/m3, Dry, 273K, 101.3kPa, as a rolling 10hour average.

2.1.2.2 Load Limits

Section 2 Condition 2.2 of WA's EPL (No. 6423) details the load limit for assessable pollutants discharged from the premises that must not be exceeded, during the annual reporting period. **Table 5** provides a list of the assessable pollutants and the existing load limits.

Table 5 Load Limits

Assessable Pollutant	Load Limit (kg)
Coarse Particulates	6,538
Fine Particulates	11,622
Fluoride	1,894
Nitrogen Oxides	22,803
Sulphur Oxides	14,935
Volatile Organic Compounds	3,984

To conservatively estimate the pollutant contribution from the Project, pollutant loads were calculated using the emission rates described in **Section 2.4.4** based on a maximum throughput capacity of 800kg/hr from the thermal processing plant operating for approximately 75 percent (%) of the year. The Project contribution was then added to the existing pollutant load reported in the facility's 2012-13 and 2013-14 Annual Returns to determine the predicted total pollutant load.

Predicted total pollutant loads are presented in **Table 6**. It can be seen from **Table 6** that there is an exceedance of the predicted total pollutant load for NO_x, when the Project contribution of 12,877 kg/y is added to the pollutant load of 14,148kg reported for 2013-14. Predicted total pollutant loads for all other pollutants were found to be below the EPL (No. 6423) load limit for both years.

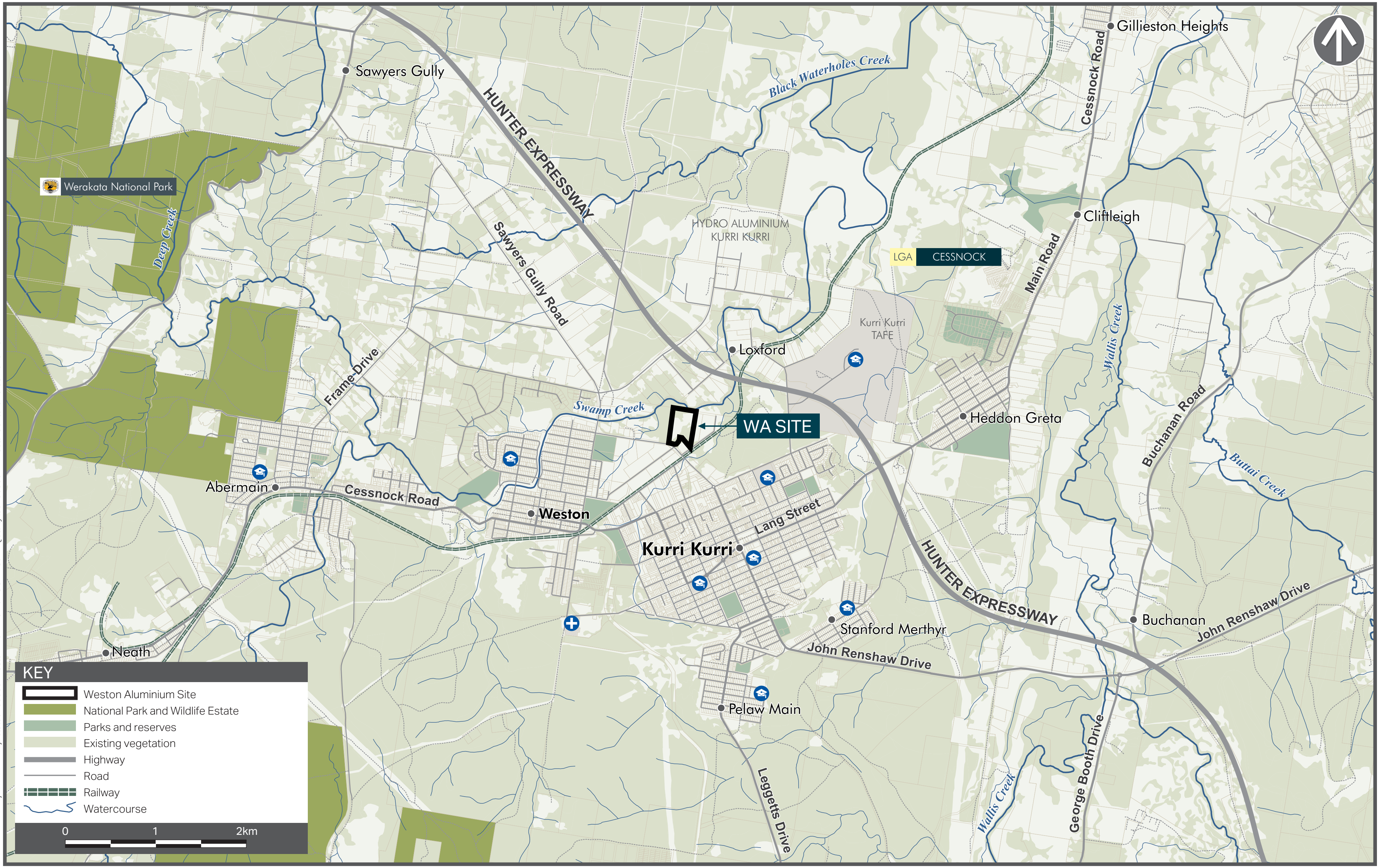
Although the estimates provided are considered to be conservative, WA would need to seek a variation to the existing load limit under EPL No. 6423 for NO_x as part of the approval process which, which should be discussed with the EPA at the appropriate stage.

Table 6 Predicted Total Pollutant Load

Assessable Pollutant	Project Contribution (kg/y)	Existing Pollutant Load (kg/y)		Predicted Pollutant Load (kg/y)		Load Limit (kg)
		2012-13	2013-14	2012-13	2013-14	
Coarse Particulates	199	1,178	2,121	1,377	2,320	6,538
Fine Particulates	143	618	2,237	761	2,380	11,622
Fluoride	79	387	1122	466	1,201	1,894
Nitrogen Oxides	12,877	4,384	14,148	17,261	**27,025**	22,803
Sulphur Oxides	788	7,243	10,472	8,031	11,260	14,935
Volatile Organic Compounds	No data	549	322	-	-	3984

2.2 Study Area

The Weston Aluminium facility is located on Lot 796, Mitchell Avenue, within the Kurri Kurri industrial area of NSW. Residences are located approximately 600 metres to the south (Kurri Kurri) and southwest (Weston) of the site. Dispersion modelling undertaken for the AQIA covered an area of 13km by 13 km surrounding the WA facility. **Figure 1** shows the location of the study area.



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Weston Aluminium Recycling Facility

FIGURE 1

2.3 Background Information Review

2.3.1 Review of Surrounding Developments

A review of Cessnock City Council and NSW Department of Planning and Environment (DP&E) databases was conducted on 4 March 2016. No nearby developments of significance to this assessment were listed on Cessnock City Councils website. Three projects were listed on the DP&E Major Project website may have a cumulative influence on air quality within the regional air shed.

Kurri Kurri Battery Recycling Facility

Pymore Recyclers International Pty Ltd (Pymore) lodged a Request for SEARs for the proposed development of a battery recycling facility with the DP&E in February 2016. The facility would be located at 129 Mitchell Avenue, Kurri Kurri, and would occupy approximately 3.4ha of the lot on which WA is sited.

The proposed facility would recycle approximately 60,000 tpa of used-lead-acid batteries (ULABs) using a CX Integrated System which uses a combination of hydrometallurgical and pyro metallurgical process for the recovery of lead and associated by-products. ULAB recycling at the facility would be comprised of four main processes: crushing screening and separation; desulphurisation; crystallisation; and lead smelting (EMM 2016). As a result, the main pollutants of concern from the facility would be particulates, SO_2, NO_x and lead. Cumulative impacts of the proposed facility have been assessed in this report and are addressed in **Section 2.4.1**, **Section 2.4.4** and **Section 4.0**.

Hydro Aluminium

At the Hydro Aluminium plant at Kurri Kurri metal production and cast house product production ceased in 2012 and the plant was permanently closed in 2014. This closure would have resulted in a reduction in ambient air quality concentrations of some pollutants within the local air shed. SEARs have currently been issued by DP&E for the proposed demolition and remediation of the site including demolition of buildings and structures, soil and ground water remediation and design and construction of a waste management facility. The demolition and construction works would potentially result in temporary air quality impacts to the local area, particular regarding particulate concentrations.

Hunter Resource Recovery Centre and Energy from Waste (EFW) plant

Omega Energy is proposing to construct and operate the Hunter Resource Recovery Centre and Energy from Waste (EFW) plant to be located adjacently west of WA's facility within the broader Hunter Industrial Ecology Park. A Preliminary Environmental Assessment (PEA) was undertaken for the facility and SEARs issued by DP&E. The proposed facility would receive residue waste from existing contractors and landfills for thermal conversion and generation of gas and/or electricity. Construction and operation of the proposed EFW plant would result in potential air quality impacts within the local area. Primary emissions from the EFW facility are likely to be particulates, HCl, HF, CO, SO_2, NO_x, heavy metals, VOCs and dioxins and furans.

In 2015, the proposed development fell prone to setbacks with thermal waste treatment technologies currently under review. Omega Energy is expected to relodge a development application with the DP&E in 2016 (Sustainable Materials Media 2015). At the time of writing no new development application has been lodged.

2.3.2 Review of Baseline Data

The following subsections provide an outline of the baseline data used in this report.

Meteorological and Climatic Data

Local meteorological and climatic data has been sourced from the Bureau of Meteorology (BoM). Meteorological data used in this report is discussed in **Section 2.4.3.1** and **Section 3.1** of this report. Local climate data is also discussed in **Section 3.2**.

Ambient Air Quality Data

Ambient air quality data sourced from the NSW Office of Environment and Heritage (OEH) database, and is further described in **Section 3.3**.

Emissions Testing Data

Site specific emissions testing data has been used for existing pollutant sources including Stack 5 (EPA Point 13) for the reverb furnace. Three years of stack data has been used in this report dating from 2013 to 2015. Emissions testing data is also further described in **Section 2.4.4.**

2.3.3 Assumptions

Assumptions used in the development of estimated air emissions for the dispersion modelling undertaken as part of this assessment are discussed in **Section 2.4**.

2.4 Method of Impact Assessment

2.4.1 Modelling Scenarios

Three modelling scenarios were undertaken for this assessment and are described in **Table 7**. Modelling Scenario 1 is representative of typical operating conditions, while Scenario 2 is representative of theoretical worst case impacts using the proposed emission limits described in **Section 2.1.2**. Scenario 3 includes predicted background concentrations from the proposed battery recycling plant (see **Section 2.3.1**).

A fourth operational modelling scenario for the scenarios (Scenario 4) was also assessed to determine the impact of the operation of the emergency bypass stack, should this be activated during the operation of the Project Scenario 4 used the results of Scenarios 1 and 2 and added the bypass stack as an emission source.

Results of Scenario 4 were used to review health implications during upset (emergency) conditions at the plant and are discussed in the Health Risk Assessment report. As upset conditions do not represent long term (or even expected short term) operating conditions, the assessment did not compare the predictions during the bypass with EPA criteria. Further details are also provided in **Appendix B**.

Table 7 Modelled Scenarios

Scenario ID	Scenario Name	Description
Primary Operational Scenario for EPA Impact Assessment Purposes		
1	Normal Operating Conditions	- Proposed thermal processing plant operating continuously at maximum operational capacity of 800kg/h. - All existing point sources modelled using average source emission data
Theoretical Scenarios		
2	Stack Emission Limits	- Proposed thermal processing plant operating continuously using proposed stack concentration EPL limits detailed in **Table 3** (worst case). - All existing point sources modelled using average source emission data.
3	Battery Recycling Plant (Cumulative Impacts)	- Modelling of emissions from the proposed adjacent battery recycling facility (refer to **Section 2.3.1**), using design limit emission concentrations (see **Section 2.4.4**.) and assumes the battery recycling facility would be operating continuously. - Results of Scenario 3 were then added to the predicted maximum impacts in Scenario 1 and Scenario 2 to determine the cumulative impacts from operation of the WA plant including the thermal processing plant and the battery recycling facility.
4	Emergency Bypass Operations	- This scenario utilises maximum discharge emission concentrations based on design limits for the operation of the emergency bypass stack during upset plant conditions. - The results of this scenario are not discussed in detail within this report but have been presented in **Appendix B**. Assessment of predicted air quality impacts in relation to acute health impacts are discussed in detail in the Health Risk Assessment Report.

2.4.2 Dispersion Models

This assessment made use of TAPM, the CALMET meteorological processor and the CALPUFF dispersion model. A brief description of each model is provided in **Section 2.4.2.1** to **Section 2.4.2.3**. A summary of the data and parameters used for both the meteorological and air dispersion modelling is described in **Table 8**.

2.4.2.1 TAPM

The Air Pollution Model (TAPM) is a prognostic meteorological and air pollution model developed by CSIRO. The model can be used to predict threx10-dimensional meteorology, including terrain-induced circulations and 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 was used in this assessment to generate a gridded three dimensional meteorological file for input into the CALMET model.

2.4.2.2 CALMET

CALMET is a meteorological model that develops hourly wind and temperature fields on a threx10-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 air pollution.

TAPM prognostic threx10-dimensional meteorological data were used to simulate the threx10-dimensional complex meteorological patterns that exist within the modelling domain, accounting for the effects of local topography and changes in land surface characteristics. Gridded threx10-dimensional TAPM data were input into the CALMET model to generate the initial guess wind field[3] in CALMET and to generate the final threx10-dimensional wind fields for use in CALPUFF. The dispersion modelling was undertaken using one year of meteorological data (January 2014 – December 2014).

2.4.2.3 CALPUFF

CALPUFF is a non steady-state, threx10-dimensional Gaussian puff model developed for the US Environmental Protection Agency (USEPA) for use in situations where basic Gaussian plume models are not effective. These situations include areas where stagnation conditions occur, which are characterised by calm or very low wind speeds with variable wind direction. The CALPUFF modelling system (and associated CALMET program) has the ability to model spatially varying winds and turbulence fields that are important in complex terrain, long range transport and near calm conditions. As such, CALPUFF was selected as the appropriate dispersion model for this assessment.

A summary of the data and parameters used for both the meteorological and air dispersion modelling is described in **Table 8** while additional information regarding meteorology, local terrain and land use, building wake effects and air emissions are described in **Section 2.4.3.1, Section 2.4.3.2, Section 2.4.3.3** and **Section 2.4.4** respectively.

The CALPUFF suite of programs, including meteorological (CALMET), dispersion (CALPUFF) and post processing modules (CALPOST), is an advanced non-steady state modelling system designed for meteorological and air quality modelling. CALPUFF is approved for use in NSW by the EPA, particularly in applications involving complex terrain, non-steady-state conditions, in areas where coastal effects may occur, and/ or when there are high frequencies of stable or calm meteorological conditions. CALPUFF was selected for use in this assessment based on the modelling system's ability to model low wind speeds and calm hours by simulating stagnant puffs and puff transport caused by divergence or slope flow.

2.4.3 Model Input Parameters

A summary of the data and parameters used as inputs to TAPM, CALMET and CALPUFF is provided in **Table 8**.

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[3] CALMET uses a two step procedure in developing final wind fields. The "initial guess" wind field is developed based on a domain-average wind profile, and this domain-average profile of winds is adjusted for terrain effects and divergence minimisation to produce a 'Step 1' wind field. The second step in the processing of the wind field is the introduction of observational data into the terrain adjusted Step 1 field.

Table 8 Summary of Model Input Parameters

Parameter	Input
TAPM	
TAPM Version	v4.04
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1km)
Number of grid points	40 x 40 x 30
Simulation period	2014
Terrain information	AUSLIG 9 second (horizontal resolution 9")
Centre of analysis	32°81 S, 151°46 E
Local data assimilation	None
Mode	Meteorology mode only
CALMET (v6.42)	
Meteorological grid domain	37.5 km x 37.5 km
Meteorological grid resolution	250 metre resolution (150 x 150 grid cells)
Reference grid coordinate of SW corner	338600 E, 6350552 S
Cell face heights in vertical grid	0, 20, 50, 100, 150, 300, 600, 1000, 1500 and 3000 m
Simulation length	1 year (2014)
Surface meteorological stations	N/A
Upper air meteorological station	The threx10-dimensional gridded prognostic data from TAPM (M3d) were used as the initial guess wind-field for CALMET.
Terrain data	Terrain elevations were extracted from the NASA Shuttle Radar Topography Mission data set (SRTM 90 metre, 3-arc sec).
CALPUFF (v7.02)	
Modelling domain	**Computation grid**: 23 km x 23 km **Sampling Grid**: 13 km x 13 km *MGA SW Coordinates (km)*: 347.100 E, 6357.800 S *MGA NE Coordinates (km)*: 360.100 E, 6270.800 S **Nested Grid:** 1.5 km x 1.5 km *MGA SW Coordinates (km)*: 356.500 E, 6268.550 S *MGA NE Coordinates (km)*: 338.000 E, 6270.050 S
Modelling grid resolution	Sampling grid resolution of 250m. Nesting grid resolution of 50m.
Number of sensitive receptors	184 Discrete receptors and 12 boundary receptors
Dispersion algorithm	PG coeff. (Rural, ISC curves) and MP coeff. (Urban)
Meteorological modelling period	1 January 2014 – 31 December 2014

2.4.3.1 Meteorology

Meteorology in the area surrounding WA is affected by several factors, such as terrain and land use. Wind speed and direction are largely affected by topography at a small scale, while factors such as synoptic scale winds and complex valley drainage flows that develop during night hours, affect wind speed and direction on the larger scale.

The CALMET meteorological model uses actual or prognostic meteorological observations to generate three - dimensional wind fields on an hourly time step at a grid of points covering the area under investigation.

Topographical features and land use factors are then used to further refine the wind fields, which are subsequently used in the CALPUFF dispersion model.

Meteorological data for the period January – December 2014 were used in this assessment. Prognostic meteorological data were generated using TAPM for surface and upper air conditions for a grid roughly centred on the WA facility. The TAPM output (processed using CALTAPM) was then used as input into the CALMET meteorological module to compute the wind fields used by CALPUFF. Analyses of the meteorological data used in the modelling are provided in **Appendix C**.

2.4.3.2 Terrain

Digital terrain data used to generate the upper air prognostic meteorological data were obtained from the TAPM 9 second DEM database covering the meteorological domain. For the CALMET model, the geophysical processor was used to convert land use and terrain data from WebGIS (SRTM3 for terrain at approximately a 90 metre resolution) and GLCC Australia Pacific (approximate 1 kilometre resolution).

2.4.3.3 Building Wake Effects

The dispersion of pollutants around WA is likely to be affected by aerodynamic wakes generated by winds having to flow around the production and storage buildings. Building wakes generally decrease the distance downwind at which the plume comes into contact with the ground. This may result in higher ground level pollutant concentrations closer to the emission source. The Building Profile Input Program (BPIP) was used to assess building wake effects from the plant and ALDEX buildings on site.

2.4.4 Emissions Estimation

Stack parameters for each of the seven modelled point sources are presented in **Table 9** and modelled emission rates for Scenario 1 and Scenario 2 as described in **Section 2.4.1** are presented in **Table 10**. Stack parameters and modelled emission rates for the battery recycling facility (BRF) as described in **Section 2.4.1** are presented in **Table 11** and **Table 12.**

Stack temperature and velocity for Stack 5 emissions shown in **Table 9** have been based on existing stack data and design parameters provided by Advanced Combustion Engineering Pty Ltd. For all other stacks, temperature and velocity data have been derived from stack testing reports obtained from sample data collected between 2013 and 2015 at the WA Facility (AECOM 2013, AECOM 2014 and AECOM 2015a).

The bypass stack (Stack 8) has been excluded from the AQIA, as this source would only be operational in emergencies, and as such its contribution to local air emissions is limited. Stack parameters and emission rates for the bypass stack used to access acute health impacts as part of the health risk assessment have been presented in **Appendix B**.

Table 9 Stack Parameters for Weston Aluminium

Stack ID	Diameter (m)	Flow Rate (Nm^3/s)	Velocity (m/s)	Temp (K)	Height AGL (m)	MGA 56 Coordinates (m)	
						X	Y
Stack 1	1.65	24.4	26.0	349.3	15	357265	6369322
Stack 2	1.265	13.7	22.9	302.4	15	357310	6369262
Stack 3	1.0	8.9	23.9	305.2	15	357310	6369272
Stack 4	1.395	22.7	31.8	312.4	15	357314	6369296
Stack 5	1.49	21.4	18.8	423.2	30	357347	6369347
Stack 6	0.58	1.9	21.9	557.6	18	357302	6369325
Stack 7	1.5	29.5	35.1	301.4	15	357325	6369226

A conservative estimate of emission rates presented in **Table 10** has been assumed for Scenario 1 and Scenario 2 whereby all plant operations, including operation of the thermal processing plant, would be operating continuously 24 hours a day seven days per week. The following methodology was used to estimate emission rates from Stack 5 during operation of the thermal processing plant:

Scenario 1 (normal operations) emission estimates were:

- Largely derived from the *AP 42 Compilation of Air pollutant Emission Factors* (US EPA 1995) emission factors for thermal processing medical waste.
  - Where possible emission factors for rotary kiln waste thermal waste processors were used and where available, emission factors for pollutants where lime/carbon injection and fabric filters were also adopted; and
  - Particulate emissions for PM_{10} and $PM_{2.5}$ were calculated from TSP using particulate size distribution ratios for controlled air thermal waste processors.
- Calculated from AP-42 (US EPA 1995) emission factors using the maximum operating capacity for the thermal processing plant of 800kg/h;
- Where able to be calculated for most pollutants of concern from AP-42 emission factors, however suitable publically available emission data was available for dioxins and furans and heavy metals Co, Se, Sn and V:
  - An emission concentration for dioxins and furans was estimated based on a stack concentration of 10 percent of the maximum stack concentration for dioxins and furans under the Group 6 standards of concentration listed under Schedule 4 of the POEO (Clear Air) Regulation 2010[4]; and
  - While information gaps exist for heavy metals Co, Se, Sn and V under the normal operating scenario, these are covered by the emission limit scenario (Scenario 2). Predicted impacts in Scenario 2 would be considered worst case impacts and predicted ground level concentrations during operation of the plant at maximum capacity are likely to be less than the proposed limit.

Scenario 2 (EPL limits) emission estimates were:

- Calculated using proposed stack concentration EPL limits detailed in **Table 3**, and based on the proposed thermal processing plant operating continuously;
- Calculated for pollutants associated with a proposed EPL limit (refer to **Table 3**) in accordance with the Group 6 standards of concentration listed under Schedule 4 of the POEO (Clear Air) Regulation 2010. An exception to this emission rates were derived for PM_{10} and $PM_{2.5}$ by scaling the proposed emission concentration for TSP using the particulate size distribution ratios table for controlled air thermal medical waste processors in AP-42 (US EPA); and
- An appropriate emission rate (and associated EPL stack concentration limit) to ensure there would be no exceedances of ground level dioxin and furan emissions was determined for dioxins and furans based on the results of Scenario 1 (**Section 4.0**) whereby:

$$ER_{S2} = \frac{C}{GLC_{S1}} \times ER_{S1}$$

Where:

ER_{S2}	=	Emission rate for Scenario 2
C	=	EPA ground level concentration criteria
GLC_{S1}	=	Predicted maximum ground level concentration for Scenario 1
ER_{S1}	=	Emission rate for Scenario 2

- Stack concentrations for heavy metals included in the proposed Type 1 and Type 2 Substances EPL stack concentration limit of $1mg/m^3$ were calculated by dividing the total stack concentration by the total number of heavy metals (13). These values were then used to calculate the relevant stack emission rate based on stack emission data (AECOM 2013, AECOM 2014 and AECOM 2015a). It should be noted that this methodology resulted in some particularly high emission rates when compared to emission rates used in Scenario 1 (see **Table 10**). In the case of Beryllium this resulted in a gross over estimation of the ground level impacts, and as such, the emission rate for Scenario 2 has been based on the emission rate and

[4] Publically available stack emission data from other similar sources was limited to the Daniels Health Pty Ltd (formerly SteriHealth Pty Ltd) plant located in Silverwater, NSW. The Daniels Health plant would likely have higher emissions (SteriHealth 2015) than the proposed WA Plant attributed to both the size of the plant and control measures employed, which is limited to a wet scrubber installed in 1994 (DoE 2015).

associated predicted ground level concentration in Scenario 1 (refer to **Section 4.0**); whereby the emission rate for Scenario 1 has been scaled up to result in the maximum emission rate possible without causing an exceedance of the EPA ground level criteria for Beryllium (see above formula used for methodology).

Stack emissions for all other stacks for both Scenario 1 and Scenario 2 have been based on average stack emission data collected between 2013 and 2015 at the WA Facility (AECOM 2013, AECOM 2014 and AECOM 2015a). Gaseous fluoride, emissions from stacks have been determined from total fluoride concentrations based on previous testing undertaken in January to March 2012 to determine the ratio of particulate to gaseous fluoride at WA.

Table 10 Pollutant Emission Rates for Weston Aluminium

Pollutant (grams / second)	Stack 1	Stack 2	Stack 3	Stack 4	Stack 5		Stack 6	Stack 7
					Scenario 1	Scenario 2		
TSP	0.1021	0.0054	0.0064	0.0331	0.0084	1.0723	0.0139	0.1023
PM_{10}	0.0134	0.0029	0.0037	0.0146	0.0060	0.3084*	0.0010	0.0644
$PM_{2.5}$					0.0008	0.0429*		
CO	0.2566				0.0056	2.6807	0.0018	
SO_2	0.1340				0.0333	No Limit	0.0421	0.1967
H_2SO_4	0.0273				0.3311	2.1446	0.0025	0.0393
NO_x	0.2769				0.5444	4.2891	0.1020	0.0718
HCl	0.0281				0.0398	0.6434		
HF	0.0014	0.0066	0.0028	0.0135	0.0033	No Limit	0.0083	0.0062
VOCs	0.0040				No Data	0.8578	0.0002	0.0718
Sb	$8.6x10^{-6}$				$1.6x10^{-5}$	$1.6x10^{-3}$		
As	$7.5x10^{-6}$				$1.6x10^{-6}$	$1.6x10^{-3}$		
Cd	$1.0x10^{-4}$				$2.7x10^{-6}$	$1.6x10^{-3}$		
Pb	$4.3x10^{-4}$				$8.2x10^{-6}$	$1.6x10^{-3}$		
Hg	$7.8x10^{-6}$				$8.7x10^{-4}$	$1.6x10^{-3}$		
Be	$1.3x10^{-6}$				$6.5x10^{-7}$	$1.5x10^{-4}$#		
Cr	$1.2x10^{-4}$				$8.6x10^{-6}$	$1.6x10^{-3}$		
Co	$2.4x10^{-6}$				No Data	$1.6x10^{-3}$		
Mn	$3.7x10^{-4}$				$1.4x10^{-4}$	$1.6x10^{-3}$		
Ni	$1.4x10^{-4}$				$4.0x10^{-6}$	$1.6x10^{-3}$		
Se	$1.9x10^{-5}$				No Data	$1.6x10^{-3}$		
Sn	$5.5x10^{-6}$				No Data	$1.6x10^{-3}$		
V	$1.3x10^{-5}$				No Data	$1.6x10^{-3}$		
Cu	$8.7x10^{-5}$				$4.6x10^{-5}$	No Limit		
Dioxins and Furans					$2.1x10^{-10}$	$2.7x10^{-10}$#		

* No EPL limit however ER has been scaled from US EPA AP-42 emission rate for TSP.
# Emission rate has been based on the maximum emission rate calculated without resulting in an offsite ground level concentration exceedance based on the modelling results from Scenario 1.

For the proposed Kurri Kurri BRF, stack temperatures, velocities and flowrates have been based on design parameters for the development and are shown in **Table 11**. Stack diameters for the proposed plant were calculated based on the flow rate, velocity and temperature data provided by Engitec Technologies.

Stack emission rates were based on maximum stack concentration design rates proposed for the plant and are shown in **Table 12**. Emission rates for PM_{10} and $PM_{2.5}$ were estimated conservatively, assuming PM_{10} and $PM_{2.5}$ were equal to the emission rate for TSP.

Table 11 Stack Parameters for Kurri Kurri Battery Recycling Facility

Stack ID	Description	Diameter (m)	Flow Rate (Nm^3/s)	Velocity (m/s)	Temp (K)	Height AGL (m)	MGA 56 Coordinates (m)	
							X	Y
Stack 1	RF-1 Common Stack	2.6	36.11	15.0	313.2	15	357462	6369262
Stack 2	RF-2 Common Stack	1.6	13.89	15.0	353.2	15	357467	6369295
Stack 3	Battery Breaker	0.9	4.44	15.0	298.2	15	357448	6369181
Stack 4	Steam Boiler	0.3	0.28	15.0	453.2	15	357446	6369212

Table 12 Pollutant Emission Rates for Kurri Kurri Battery Recycling Facility

Pollutant	Stack Concentration (mg/m^3)				Emission Rate (g/s)			
	Stack 1	Stack 2	Stack 3	Stack 4	Stack 1	Stack 2	Stack 3	Stack 4
TSP	5.0	5.0	5.0		0.1806	0.0694	0.0222	
PM_{10}	5.0	5.0	5.0		0.1806	0.0694	0.0222	
$PM_{2.5}$	5.0	5.0	5.0		0.1806	0.0694	0.0222	
SO_2		125.0				1.74		
NO_x		250.0		250.0		3.47		0.07
Pb	0.5	0.5	0.5		0.0181	0.0069	0.0022	

2.4.5 Limitations

The atmosphere is a complex, physical system, and the movement of air in a given location is dependent on a number of different 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 some level of simplification of these very complex processes based on our understanding of the processes involved and their interactions, available input data, and processing time and data storage limitations.

These simplifications come at the expense of accuracy, which 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 wind speeds less than 1 m/s) or for low-level, non-buoyant sources, is problematic for most dispersion models. To accommodate these known deficiencies, the model outputs tend to provide conservative estimates of pollutant concentrations at particular locations.

While the models contain a large number of variables that can be modified to increase the accuracy of the predictions under any given circumstances, the constraints of model use in a commercial setting, as well as the lack of data against which to compare the results in most instances, typically precludes extensive testing of the impacts of modification of these variables. With this in mind, model developers typically specify a range of default values for model variables that are applicable under most modelling circumstances. These default values are recommended for use unless there is sufficient evidence to support their modification.

As a result, the findings of dispersion modelling provide an indication of the 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. As stated above, however, the model predictions are typically conservative, and tend to over predict maximum pollutant concentrations at receiver locations.

This assessment was undertaken with the data available at the time of the assessment. Should changes to the Project be made, further assessment may be required to determine if the findings of this assessment are still applicable.

3.0 Existing Environment

3.1 Dispersion Meteorology

3.1.1 Wind Speed and Direction

Meteorology in the area surrounding the resource recovery centre is affected by several factors such as terrain and land use. Wind speed and direction are largely affected by topography at the small scale, while factors such as synoptic scale winds affect wind speed and direction on the larger scale. Wind speed and direction are important variables in assessing potential air quality impacts, as they dictate the direction and distance air pollutant plumes travel. The CALMET meteorological model has been used to generate meteorological data for the WA Facility for the year 2014. Prognostic meteorological data for the site and surrounding area were generated using TAPM for surface and upper air conditions for a grid roughly centred on the WA facility. This methodology is further detailed in **Section 2.4.3.1**.

A wind speed frequency distribution table for the 2014 CALMET data is presented in **Table 13**, while annual and seasonal wind roses are presented in **Figure 2**. It can be seen from **Table 13** and **Figure 2** that on an annual basis the dominant wind direction is from the south west, occurring for 12 percent of the time, with winds also frequenting from the east and west northwest. The annual average wind speed was found to be 2.35 metres per second (m/s) a light to moderate wind speed. Calms (<0.5m/s) were found to occur for just over two percent of the year.

Seasonally, the highest average wind speed during 2014 was observed during the winter months (2.55 m/s) and the lowest average wind speed occurring in autumn (1.91 m/s). The occurrence of easterly winds is frequent from spring through to autumn, while south westerlies are common from autumn through to spring. During the winter months there is also a predominance of west north-westerly winds. A comparison of the CALMET 2014 meteorological data with data collected from the Hydro Aluminium meteorological station for January to September 2014 (the available data from Hydro Aluminium) is presented in **Appendix C**.

Table 13 Wind Speed Frequency Distribution of CALMET 2014 data (%)

Wind Direction	Wind Speed Class (m/s)						
	0.5-2.1	2.1-3.6	3.6-5.7	5.7-8.8	8.8-11.1	≥11.1	Total
N	3.58	0.39	0.14	0.00	0.00	0.00	4.11
NNE	1.96	0.34	0.14	0.00	0.00	0.00	2.44
NE	2.35	0.92	0.65	0.00	0.00	0.00	3.91
ENE	3.71	2.03	1.45	0.10	0.00	0.00	7.29
E	5.19	3.64	1.45	0.05	0.00	0.00	10.33
ESE	3.47	3.07	1.00	0.02	0.00	0.00	7.55
SE	2.90	2.69	1.42	0.15	0.00	0.00	7.15
SSE	2.94	2.29	1.12	0.08	0.00	0.00	6.43
S	1.36	1.74	1.25	0.05	0.00	0.00	4.40
SSW	3.11	1.29	0.60	0.10	0.00	0.00	5.11
SW	8.85	2.16	0.78	0.14	0.00	0.00	11.93
WSW	2.11	1.85	0.85	0.17	0.02	0.00	5.00
W	1.60	1.50	0.78	0.40	0.05	0.00	4.33
WNW	1.82	3.85	2.42	0.84	0.07	0.00	8.99
NW	2.85	1.66	1.75	0.48	0.00	0.00	6.74
NNW	1.39	0.45	0.26	0.02	0.00	0.00	2.12
Sub-Total	49.18	29.86	16.05	2.60	0.14	0.00	97.83
Annual (Jan to Dec, 2014). Total periods = 8,736; Valid periods = 8,735; Calm wind periods = 189; Calm winds: 2.16 %							

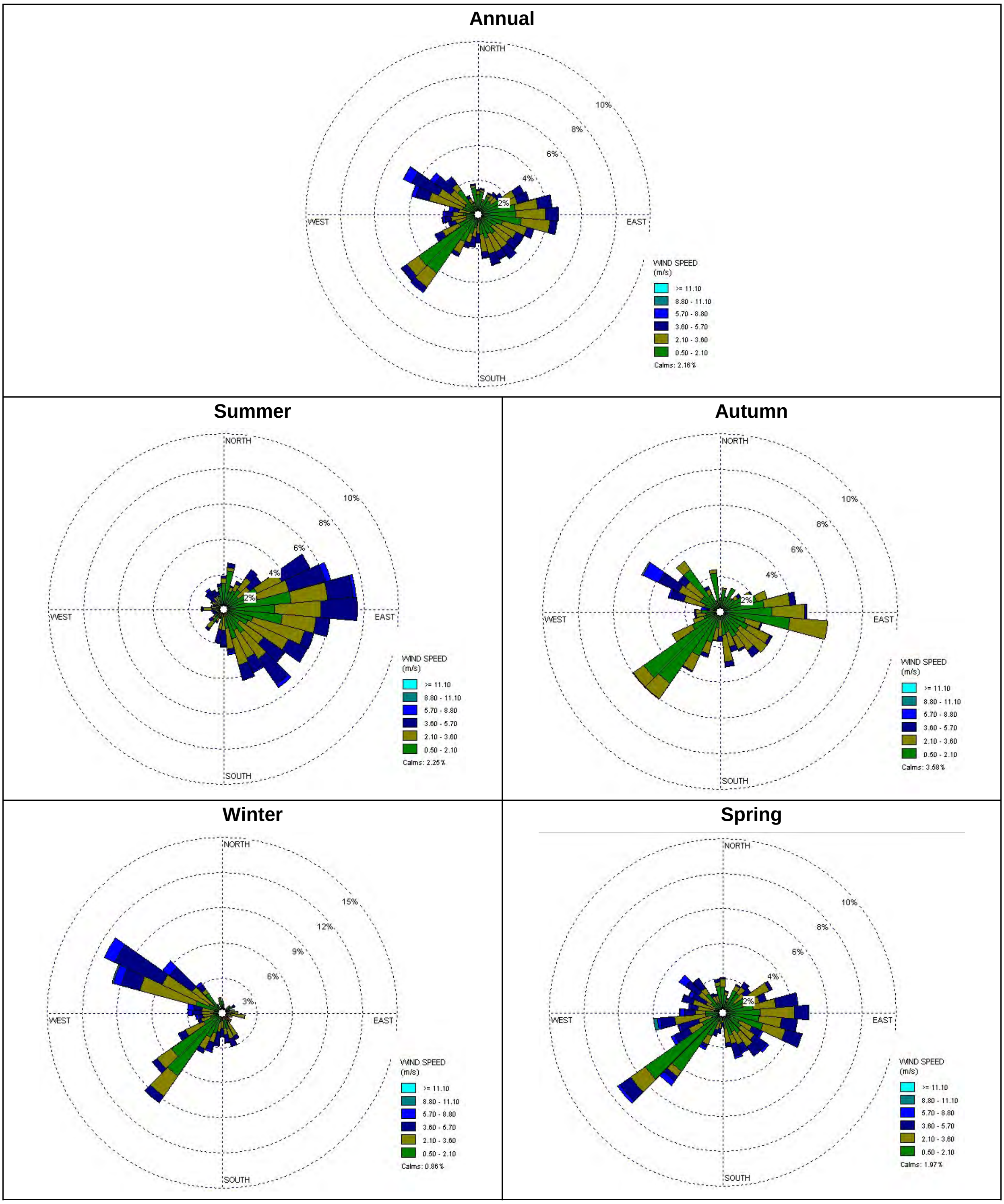


Figure 2 **Annual and Seasonal Wind Roses at Weston Aluminium, Kurri Kurri. Generated by CALMET 2014**

3.1.2 Atmospheric Stability

In dispersion modelling, atmospheric stability describes the rate at which a plume will disperse, represented by typically six classes; A to F (that is, unstable through to very stable conditions). For the WA site, stability class was calculated by CALMET for each hour in the 2014 calendar year. **Table 14** shows the frequency of occurrence of the stability categories expected in the area.

Table 14 Frequency of Occurrence of Stability Categories at Kurri Kurri (2014)

Stability Class	Frequency of Occurrence (%)
A	3
B	16
C	19
D	13
E	5
F	44
Total	100

The most common stability class was determined to be F class. This suggests that the dispersion conditions are such that air emissions will disperse slowly for a significant proportion of the time.

3.2 Local Climate

The BoM meteorological station located at Cessnock Airport (Station Number 061260) approximately 12.5 km west of the site records climate data for a range of meteorological parameters including, temperature, humidity, rainfall, wind speed and wind direction. A summary of the long-term data recorded at this station between 1968 and 2016 is shown in **Table 15.** The data provides an indication of the regional climate of the area.

Table 15 Climate Summary, BOM Monitoring Station at Paterson (Tocal AWS), 1967 to 2015 (BoM 2015)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (°C)	30.0	29.0	27.3	24.1	20.6	17.8	17.3	19.4	22.5	25.3	26.8	28.8	24.1
Mean minimum temperature (°C)	16.8	16.8	14.6	10.5	7.5	5.7	4.0	4.5	7.0	9.7	13.1	14.9	10.4
Mean rainfall (mm)	82	100	70	58	43	57	29	35	44	51	76	81	742
Decile 5 (median) rainfall (mm)	59	106	55	45	43	36	19	24	32	43	63	74	748
Mean number of days of rain ≥ 1 mm	6	8	7	6	5	5	4	4	6	6	8	7	73
Mean 9am temperature (°C)	23.2	22.2	20.2	17.8	14.1	11.0	10.1	12.2	16.2	19.1	20.2	22.2	17.4
Mean 9am relative humidity (%)	68	76	80	76	79	80	76	69	63	60	65	65	71
Mean 9am wind speed (km/h)	11.5	10.2	8.7	10.1	10.4	11.5	11.5	13.0	14.0	13.7	12.7	11.8	11.6
Mean 3pm temperature (°C)	28.7	27.3	25.7	23.0	19.6	16.8	16.4	18.6	21.2	23.4	25.0	27.3	22.8
Mean 3pm relative humidity (%)	46	53	53	52	54	55	49	42	42	44	47	46	49
Mean 3pm wind speed (km/h)	18.5	17.3	15.7	14.6	14.2	15.1	15.3	17.3	19.1	18.7	18.6	18.3	16.9
Station Number: 061260, Latitude: 32.79 °S, **Longitude:** 151.34 °E, **Elevation**: 61 m, Latest available data**:** 12 May 2016													

As shown in **Table 15** the study area experiences a warm to moderate climate. The warmest temperatures occur during the summer months, with the highest average maximum temperature (30.0^{o}C) occurring in January. July is the coldest month, with a recorded average minimum temperature of 4.0^{o}C.

The annual average rainfall for the area is 743 millimetres (mm) over 73 days a year. February is the wettest month, with an average rainfall of 100 mm, while August is driest month with an average rainfall of just 29mm. Humidity follows a diurnal cycle, with higher humidity in the morning compared to the afternoon.

Daytime wind speeds were found to be moderate, with higher wind speeds occurring in the afternoon compared to the morning. The annual average 9am wind speed recorded is 11.6 kilometres per hour (km/h) and the annual average 3pm wind speed was 16.9 km/h. Seasonally, wind speeds are higher during the warmer months with the highest average wind speed occurring in September at 19.1 km/h.

3.3 Existing Air Quality

The EPA operates a number of air quality monitoring stations in the Lower Hunter. The closest monitoring station sites to the proposed development are located at Beresfield (17km east of the site). This station records hourly PM_{10} and $PM_{2.5}$ concentrations using a Tapered Element Oscillating Microbalance (TEOM), NO_2 and SO_2. Ambient air quality monitoring data for 2015 at Beresfield is presented in **Table 16** as sourced from the Office of Environment and Heritage (OEH) website[5]. All other pollutants assessed in the AQIA are not measured and as such no background data is available for use in the cumulative assessment. Notable nearby emission sources, however, have been included in the assessment.

The maximum PM_{10} 24-hour concentration measured at Beresfield in 2015 (the most recent year for which data are available) was 64.9µg/m^3 which is above the EPA 24 hour maximum criterion of 50µg/m^3 (DEC 2005). There was one additional exceedance of the 24 hour EPA criterion recorded at 57.5µg/m^3. The third highest record for the reporting year was below the criterion at 43.3µg/m^3. When background levels exceed a criteria the NSW EPA (DEC 2005) allows for the identification of 'additional exceedances', that is, you remove those above the criterion, then add your project contribution and calculate if there are any further exceedances. As stated, the highest background value that meets the criterion is 43.3µg/m^3 and as such this value has been applied as the PM_{10} 24-hour background in the assessment in order to identify additional exceedances.

The annual average PM_{10} concentration recorded at 18.7µg/m^3 for 2015 is under the EPA annual average criterion of 30µg/m^3 (DEC 2005).

Similarly to PM_{10}, the maximum $PM_{2.5}$ 24-hour concentration measured at Beresfield in 2015 recorded at 25.9µg/m^3 was also found to be above the NEPM standard of 25µg/m^3. There were no additional exceedances of the EPA criterion, with the second highest 24 hour concentration recorded for 2015 at 20.2µg/m^3. As applied for PM_{10}, the highest value that does not exceed the criterion has been applied as the $PM_{2.5}$ 24-hour background in the assessment in order to identify additional exceedances, being 20.2µg/m^3.

The $PM_{2.5}$ annual average recorded for 2015 was found to be slightly below the NEPM annual average criterion of 8µg/m^3 with a concentration of 7.4 µg/m^3 recorded for the reporting year.

In 2015 the maximum 1 hour NO_2 concentration was 100.5µg/m^3 approximately 40 percent of the EPA criterion. The annual average NO_2 concentration was also well below the criterion recorded at 18.5µg/m^3. Similarly recorded background concentrations for SO_2 for all averaging periods were well below the relevant criteria.

Ground level concentrations for CO are not recorded at the Beresfield EPA monitoring station, however 8-hour averages for CO are recorded at the EPA monitoring station in the more populated area of Newcastle located approximately 31km southeast of the site. The maximum 8-hour average for CO recorded at Newcastle for 2015 was found to be 1,900µg/m^3 which is just under a fifth of the EPA criterion of 10,000µg/m^3.

No measurements of local TSP ambient air quality concentrations were available. In the absence of existing annual TSP concentration data, the annual PM_{10} concentration can be assumed to be 40% of the annual TSP concentration. This is a conservative approach as reported by the NSW Minerals Council (2000) for the measurement of PM_{10} in TSP in the Hunter Valley and is considered to be applicable in Kurri Kurri. This equates to an annual average TSP concentration of 46.7µg/m^3, which is below the NSW EPA criterion of 90 µg/m^3.

[5] http://www.environment.nsw.gov.au/AQMS/search.htm accessed May 2016

OEH does not currently undertake ambient air quality monitoring for air toxics (such as HCl, H_2SO_4 etc). Previous ambient air quality monitoring for air toxics undertaken between 1996 and 2001 indicated low levels of pollutants within the Greater Metropolitan Region (GMR) and as such background concentrations of air toxics are not considered to be a primary issue of concern.

Table 16 Ambient Air Monitoring in Beresfield, NSW for 2015 (OEH website, accessed May 2016)

Pollutant	Averaging Period	Concentration (µg/m^3)	EPA Criteria (µg/m^3)
PM_{10}	24 Hour Maximum	**64.9**	50
	Highest 24 hour that meets criterion	43.3**	
	Annual Average	18.7	30
$PM_{2.5}$	24 Hour Maximum	**25.9**	25*
	Highest 24 hour that meets criterion	20.2**	
	Annual Average	7.4	8*
NO_2	1 Hour Maximum	100.5	246
	Annual Average	18.5	62
SO_2	1 Hour Maximum	234.5	570
	24 Hour Maximum	22.9	228
	Annual Average	2.9	60

* NEPM Standard
** Used in the AQIA as background in order to identify additional exceedances as per DEC 2005.

Table 17 presents ambient hydrogen fluoride ground level concentrations within the study area recorded between the cessation of Hydro Aluminium smelter operation in October 2012 and 2014. Since the shutdown of Hydro Aluminium, the highest HF concentrations have been recorded at McLeod Road. The McLeod Road station is located in proximity to the WA site, and Hydro Aluminium staff indicated that the concentrations recorded at this station were influenced by WA's emissions. As such, if ambient data from this station were used in the cumulative HF concentration calculations, the contribution from WA would likely be substantially overestimated. To avoid that overconservative situation, the ambient data used to calculate the total cumulative HF concentrations at receptors were the highest measured HF concentrations at any monitoring station other than McLeod Road.

Table 17 Maximum Ambient Fluoride Concentrations; October 2012 – 2014 (Hydro Aluminium)

Site	7 days (μg/m^3)	30 days (μg/m^3)	90 days (μg/m^3)
Yawarra	0.20	0.16	0.11
Heddon Greta	0.16	0.12	0.11
Lot 103	0.16	0.11	0.08
Wangara	0.13	0.09	0.07
Bish Bridge	0.13	0.10	0.07
Kurri Kurri	0.13	0.10	0.08
Wandin Valley	0.13	0.09	0.06
Janannie	0.14	0.10	0.08
Allandale	0.14	0.08	0.06
Hope Estate	0.13	0.09	0.07
McWilliams	0.09	0.07	0.05
Wyndham Estate	0.12	0.09	0.07
Maximum	**0.20**	**0.16**	**0.11**
General land use criteria	***1.7***	***0.84***	***0.5***

3.4 Terrain and Land Use

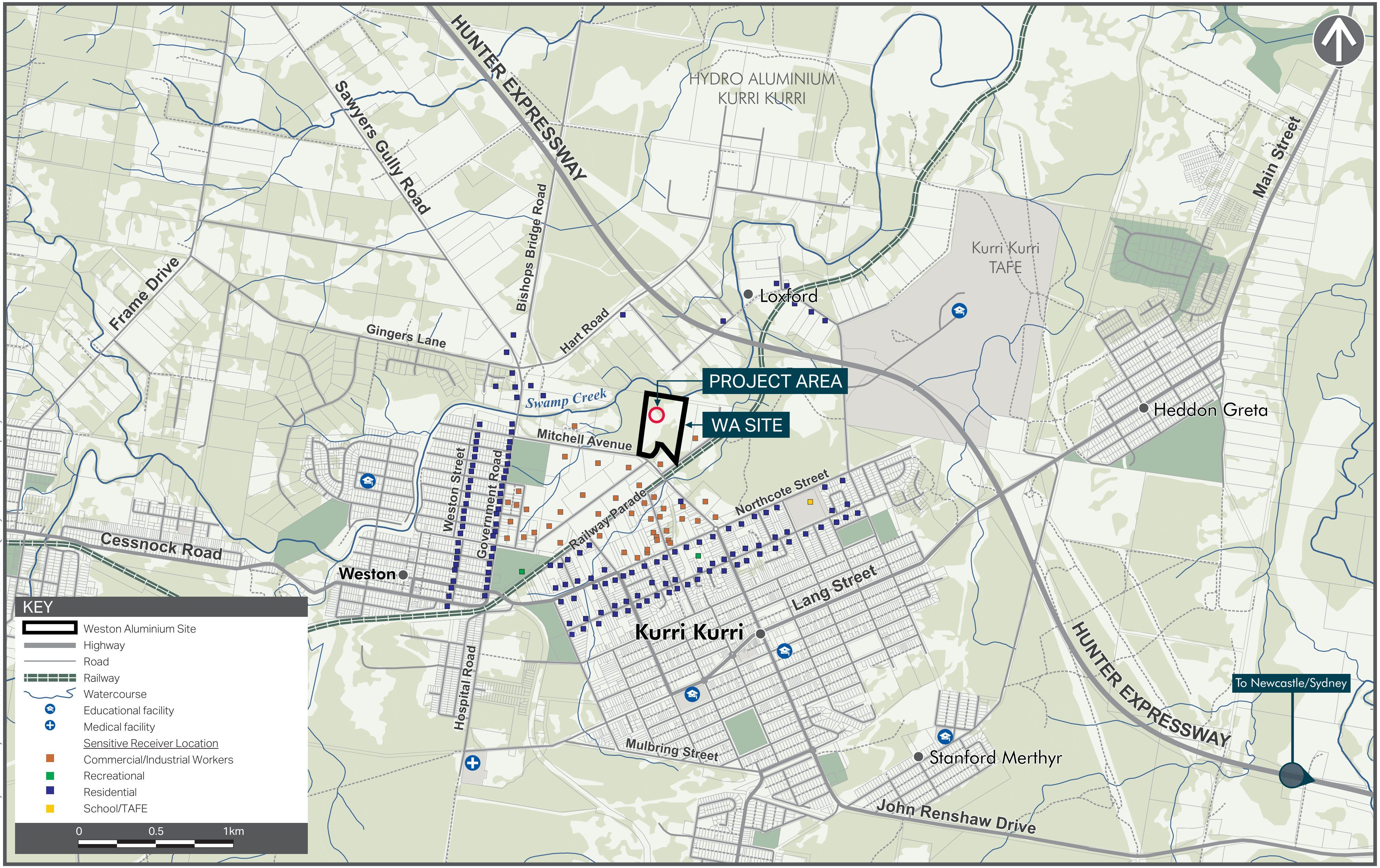
3.4.1 Terrain

Terrain data were captured from NASA's Shuttle Radar Topography Mission (SRTM), which produces terrain information for the entire globe. For Australia, terrain data are available at approximately 90 m resolution (3-arc seconds).

The site lies approximately 17m above MSL and the immediate terrain surrounding the area is relatively flat. In the wider context, the study area lies approximately 30km to the northwest of the East Australian coastline and terrain height within the study area range from between 0 and 520 metres with higher elevations to the southwest.

3.4.2 Land Use and Sensitive Receptors

The WA facility is located within the Kurri Kurri industrial area of NSW. Land use surrounding the WA facility is largely comprised of small to medium industrial premises (predominantly to the south of the site) and native vegetation. Residences are located approximately 600 metres to the south (Kurri Kurri) and west (Weston) of the site. A total of 184 sensitive receptors were included in the dispersion modelling and their location is shown in **Figure 3**. A description and coordinates for all sensitive receptors are tabulated in **Appendix D**.



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LOCATION OF AIR QUALITY SENSITIVE RECEIVERS
Environmental Impact Statement
Weston Aluminium Recycling Facility

FIGURE 3

4.0 Impact Assessment

The following subsections of the report provide a Level 2 quantitative air quality impact assessment of the proposed thermal processing plant under normal operating conditions at maximum capacity (Scenario 1; **Section 4.2**), which includes the impacts from the BRF (Scenario 3). The impact assessment for the theoretical scenarios are provided in **Appendix A** (EPL limits; Scenario 2) and **Appendix B** (Emergency bypass; Scenario 4).

4.1 Construction Impacts

Construction activities related to the established to the Project have the potential to generate dust due to exposed soils, and generate emissions from plant, machinery and vehicles. With Civil works expected to take several months and be restricted to a relative small area within the confirmed of the WA site, potential construction air quality impacts would be minor. Standard construction air quality management measures would provide a suitable level of management and should be incorporated into the Project Construction Environmental Management Plan (CEMP).

4.2 Scenario 1: Normal Operating Conditions Impacts

Results of the dispersion modelling for Scenario 1 (proposed normal operation conditions impacts) are presented in **Table 18** for particulates, CO, SO_2, NO_2, HF and Pb and in **Table 19**. Values in **Table 18** are reported maximum ground-level concentrations reported at sensitive receptor locations (refer to **Figure 3**) in accordance with the Approved Methods (DEC 2005). Maximum predicted concentrations from the WA facility have been added to the maximum predicted concentrations at each receptor location for the proposed Kurri Kurri BRF to determine the combined impact from the two proposals. This has then been added to the existing background concentration to determine the cumulative impacts.

Table 18 Scenario 1 Modelling Results for Predicted TSP, PM_{10}, $PM_{2.5}$, CO, SO_2,, NO_2, HF and Pb Ground Level Concentrations

Pollutant	Averaging Period	Concentration ($µg/m^3$)				Criteria ($µg/m^3$)
		WA Incremental Impact	Cumulative Assessment			
			WA + BRF Impact[2]	Background	Cumulative	
TSP	Annual Average	0.1	0.3	46.8	47.1	**90**
PM_{10}	24 Hour Maximum	0.5	2.5	43.3[1]	45.8	**50**
	Annual Average	0.04	0.20	18.7	18.9	**30**
$PM_{2.5}$	24 Hour Maximum	0.0019	2.02	20.2[1]	22.2	**25**
	Annual Average	0.00017	0.16	7.4	7.6	**8**
CO	1 Hour Maximum	5.3	NA	-	5.3	**30,000**
	8 hour Maximum	1.4	NA	1,900	1,901	**10,000**
SO_2	1 Hour Maximum	23.1	94.0	234.5	328.5	**570**
	24 Hour Maximum	1.5	14.3	22.9	37.2	**228**
	Annual Average	0.1	1.1	2.9	4.0	**60**
NO_2	1 Hour Maximum	15.7	15.7	100.5	116.2	**246**
	Annual Average	0.3	0.3	18.5	18.8	**62**

Pollutant	Averaging Period	Concentration (µg/m^3)				Criteria (µg/m^3)
		WA Incremental Impact	Cumulative Assessment			
			WA + BRF Impact[2]	Background	Cumulative	
HF	90 days	0.05	NA	0.11	0.16	**0.5**
	30 days	0.07	NA	0.16	0.23	**0.84**
	7 days	0.1	NA	0.20	0.31	**1.7**
	24 hours	0.3	NA	-	0.3	**2.9**
Pb	Annual Average	0.00011	0.16	-	0.16	**0.5**

1 Applied the highest background value that met the criterion in order to identify any additional exceedances. Refer to **Section 3.3** for full discussion of method.
2 The WA and BRF data could not be presented in separate columns as the maximum receptor may be different for each. Presenting the maximum for both in columns may lead to readers inadvertently adding the two and over predicting the actual cumulative value.
3 Conservatively assumed total conversion of NOx to NO_2

The air dispersion modelling predicts that all assessed pollutants would meet their respective EPA criterion for all average periods both incrementally (WA alone) and cumulatively (WA+BRF+background). A summary of the modelling results for Scenario 1 and the findings of a comparison with EPA criteria are as follows:

- The predicted annual average TSP incremental and cumulative concentrations were below the EPA criteria (90µg/m^3) with a maximum cumulative annual average concentration of 47.1 µg/m^3 at nearby sensitive receptors;
- Predicted maximum 24-hour (0.5µg/m^3) and annual average (0.04µg/m^3) PM_{10} concentrations attributed to WA were found to be relatively small when compared to the maximum 24 hour criterion of 50µg/m^3 and annual average criterion of 30µg/m^3. When accounting for the proposed BRF and background concentrations:
  - Combined maximum 24 hour incremental contribution from WA and the BRF were low, at approximately 2.5µg/m^3;
  - The PM_{10} 24 hour data predicts that there are no additional exceedances of the criteria, beyond those already identified in the background data (see **Section 3.3**), once the potential impacts from both the WA and BRF sites are cumulatively assessed with the background;
  - The combined predicted annual average from the WA and proposed BRF facilities were found to be 0.2µg/m^3 and when added to the annual background concentration of 18.7 µg/m^3 resulted in a cumulative concentration of 18.9µg/m^3 which is below the annual average criterion of 30µg/m^3; and
  - Predicted incremental contribution from both the WA and the BRF are conservative based on continuous operations at maximum capacity and at proposed design limits respectively and thus while not considered significant are likely to be lower than reported.
- Predicted maximum 24-hour (0.0019µg/m^3) and annual average (0.00017µg/m^3) $PM_{2.5}$ concentrations attributed to WA were found to be negligible compared to the maximum 24 hour (25µg/m^3) and annual average (8µg/m^3) criteria. When accounting for the proposed BRF and background concentrations:
  - Combined maximum 24 hour incremental contribution from WA and the BRF were low, at approximately 2µg/m^3;
  - The $PM_{2.5}$ 24 hour data predicts that there are no additional exceedances of the criteria, beyond those already identified in the background data (see **Section 3.3**), once the potential impacts from both the WA and BRF sites are cumulatively assessed with the background;
  - The combined predicted annual average from the WA and proposed BRF was relatively small at 0.16µg/m^3 and when added to the background concentration of 7.4µg/m^3 was below the EPA criteria of 8 µg/m^3; and

- Predicted incremental contributions from both the WA and the BRF are conservative based on continuous operations at maximum capacity and at proposed design limits respectively and thus while not considered significant are likely to be lower than reported.

- Predicted maximum 1-hour and 8-hour CO contribution from the WA plant are well below the criterion. Cumulative impacts for the maximum 8-hour CO concentration at nearby sensitive receptors were also found to be well below the criterion. No data on the 1-hour CO background was available however based on the low 8-hour background concentration recorded at Beresfield, cumulative 1-hour CO impacts are also likely to be relatively low;
- Modelled incremental SO_2 concentrations under normal operations for all averaging periods were well below the relevant EPA criterion. When added to the predicted incremental impacts of the adjacent BRF and recorded background concentrations, cumulative maximum 1 hour, 24 hour and annual average concentrations at nearby sensitive receptors were still well below the criteria;
- As a conservative assumption, all NOx emissions were assumed to be NO_2. The predicted maximum 1-hour and annual average incremental impacts and cumulative impacts inclusive of both the background concentration and predicted impacts from the BRF were well below the EPA criteria;
- Predicted incremental contributions from HF from WA were relatively small when compared to existing background concentrations. Cumulative impacts for 30, 70 and 90 day averaging periods were below the criteria. No background concentration was available to cumulatively assess maximum 24-hour concentrations, however the incremental impacts from the facility were found to be only 10 percent of the EPA criterion; and
- Predicted incremental annual average lead impacts from WA were found to be negligible at 1.1x10-4µg/m^3 when compared to the EPA criterion of 0.5µg/m3 (<1% of criterion). When added to the maximum incremental impact from the BRF, the cumulative impact equated to 0.16µg/m^3 or, 32 percent of the EPA criterion.

Predicted modelled impacts for air toxics are listed in **Table 19**. In accordance with the Approved Methods these are the 99.9th percentile concentrations at the highest point at or beyond the site boundary.

Table 19 Scenario 1 Modelling Results for Air Toxic 1 hour (99.9th percentile) Ground Level Concentrations

Pollutant	Predicted Incremental Contribution (µg/m^3)	Criteria (µg/m^3)
H_2SO_4	3.2	**18**
HCl	0.5	**140**
Sb	0.00019	**9**
As	0.00023	**0.09**
Cd	0.000079	**0.018**
Hg (as organic mercury)	0.0066	**0.18**
Be	0.000017	**0.004**
Cr (as Chromium VI compounds)	0.0010	**0.09**
Mn	0.0043	**18**
Ni	0.00099	**0.18**
Cu (as copper fumes)	0.0011	**3.7**
Dioxins and Furans	$1.6x10^{-9}$	**$2x10^{-9}$**

The air dispersion modelling predicts that all assessed pollutants would meet their respective EPA criterion. A summary of the modelling results in **Table 19** is as follows:

- Predicted 1-hour 99.9th percentile incremental impacts for H_2SO_4 were below EPA criterion at 3.2µg/m^3 equating to 17.8 percent of the criteria of 18µg/m^3;
- Predicted 1-hour 99.9th percentile incremental impacts for HCl were below EPA criterion at 0.5µg/m^3 equating to less than one percent of the criteria of 140µg/m^3;
- Predicted 1-hour 99.9th percentile incremental impacts for all modelled Type 1 and Type 2 heavy metals were below the relevant EPA criterion; with predicted impacts generally less than one percent of the EPA criterion with the exception to Hg and Cr which were found to be only 3.6 and 1.1 percent of the criteria;
- Predicted 1-hour 99.9th percentile incremental impacts for Cu was found to be less than one percent of the EPA criterion of 3.7µg/m^3; and
- The predicted 99.9th percentile 1-hour offsite concentration for dioxins and furans was 1.6×10^{-9}µg/m^3, which is below the EPA criterion of 2.0×10^{-9}µg/m^3. Predicted offsite 99.9th percentile 1-hour offsite concentrations for dioxins and furans at nearby sensitive receptors was found to be lower than the EPA criterion, with a predicted 1 hour 99th percentile of 1.6×10^{-9}µg/m^3 occurring at the worst effected sensitive receptor.

5.0 Mitigation, Management and Monitoring

The WA facility already includes a number of existing safeguards designed to manage air quality impacts, including the existing fabric filter and lime injection system which would service both the proposed thermal waste treatment facility and the existing reverb furnace. Additionally the proposed facility would include real time monitoring and activated carbon injection.

The Project would be equipped with an extractive emission monitoring system comprised of oxygen, carbon monoxide and carbon dioxide analysers. Analogue signals from these analysers would be used for monitoring combustion efficiency calculations and alarm generation. The Project would also include the installation with an obscurity monitor.

Exhaust gases from the secondary chamber (once cooled) would receive an injection of both activated carbon and lime into the fabric filter exhaust inlet duct. Here, exhaust gases would undergo filtration with activated carbon and lime for particulate, acid gas, heavy metals and dioxin control within the plants existing fabric filter. Treated exhaust gases would then be discharged to the atmosphere from the existing stack.

The thermal waste processor would also include the provision of a bypass stack in which hot combustion gases would be vented directly from the plant to the atmosphere during emergency situations or power failure. The proposed bypass stack would be equipped with a fail-safe pneumatically-assisted and counterweighted insulated stack cap. During normal operations this cap would be closed allowing combustion products to pass through the air pollution control plant. Further details regarding the emergency bypass stack are presented in **Appendix B** and discussed in detail within the Health Risk Assessment Report.

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6.0 Conclusion

AECOM was commissioned by WA to prepare an air quality impact assessment for inclusion into an environmental assessment as part of the Project. A Level 2 Air Quality Impact Assessment was conducted in accordance with the *NSW Approved Methods for Modelling and Assessment of Air Pollutants in NSW* (DEC 2005). The report provides an assessment of the potential ground level air quality impacts associated with the operation of the Project.

Dispersion modelling was undertaken for the AQIA using the Lagrangian model CALPUFF. One primary modelling scenario was assessed as part of the modelling to consider the normal operating emissions at maximum capacity (Scenario 1). Two additional theoretical scenarios were also assessed: emissions assuming the emission points were emitting at concentrations equal to the expected EPL licence limits (Scenario 2), and air quality impacts associated with the proposed Kurri Kurri BRF (Scenario 3). The BRF results were added to the predicted incremental impacts associated with WA.

Background air quality was also examined from the nearest OEH monitoring station in Beresfield to assess the cumulative impacts associated with the Project.

Results of the modelling showed no exceedances of the relevant air quality criteria for all examined pollutants under Scenario 1 or 2. The particulate data predicts that there are no additional exceedances of the criteria, beyond those already attributed to the background data, once the potential impacts from both the WA and BRF sites are cumulatively assessed with the background. The Project contribution from WA was found to be relatively small in all cases, and similarly contributions from the adjacent BRF were also considered small. Furthermore, estimates were considered conservative under ‘normal operating conditions’ with the modelling showing the thermal treatment plant operating continuously instead of intermittently in conjunction with reverb furnace operations and at the maximum operational capacity of 800kg/h.

In addition to the above mentioned exceedances, it should be noted that the EPL Scenario (Scenario 2) has been used to determine upper emission rate limits for beryllium and dioxins and furans using the maximum stack concentrations described in Schedule 4 of the POEO (Clear Air) Regulation 2010 that would result in no exceedances of the ground level concentration criteria. Models of offsite impacts for beryllium and dioxins and furans resulted in the maximum offsite 99.9th percentile concentrations being equal to the ambient air quality criteria and lower concentrations were observed at nearby sensitive receptors. Scenario 2 modelling reflects highly conservative, worst-case conditions, which are considered unrepresentative of typical operating conditions.

In conclusion, the results of the assessment indicate there would be no substantial air quality impacts from the operation of the proposed thermal processing plant at WA, and the proposed emission concentrations associated with operation of the plant are unlikely to result in any additional exceedances of local air criteria for all pollutants examined.

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Appendix A

EPL Pollutant Limit Assessment

Appendix A EPL Pollutant Limit Assessment

Results of the dispersion modelling for Scenario 2 for pollutants associated with a proposed emission limit as discussed in **Section 2.1.2.1** are presented in **Table 20** for particulates, CO, NO_2, and Pb. **Table 21** presents results for air toxics. Results in this section are based on continuous operation of the WA plant with emissions from the thermal treatment plant equal to the proposed emission limit, thus Scenario 2 is model findings are considered worst case and not representative of normal operating conditions.

Results in **Table 20** are maximum predicted concentrations reported at the nearest sensitive receptor. Similarly to Scenario 1, the maximum predicted concentrations from the WA facility for Scenario 2 have been added to the maximum predicted concentrations at each receptor location for the proposed Kurri Kurri BRF to assess the combined potential impact from the two proposals. This has then been added to the existing background concentration to determine the potential worst-case cumulative impacts.

Table 20 shows results only for pollutants with a proposed EPL limit (refer to **Table 3**), with the exception of PM_{10} and $PM_{2.5}$ concentrations (refer to **Section 2.4.4**). Results for SO_2 and HF reported in **Table 18** for Scenario 1 should be considered worst case under normal operating conditions should the thermal operating plant be operating at maximum capacity and continuously (not alternatively with the reverb furnace).

Table 20 Scenario 2 Modelling Results for Predicted TSP, PM_{10}, $PM_{2.5}$, CO, NO_2, and Pb Ground Level Concentrations

Pollutant	Averaging Period	Concentration (µg/m^3)				Criteria (µg/m^3)
		WA Incremental Impact	Cumulative Assessment			
			WA + BRF Impact[2]	Background	Cumulative	
TSP	Annual Average	0.2	0.3	46.8	47.2	**90**
PM_{10}	24 Hour Maximum	1.0	3.1	43.3[1]	46.4	**50**
	Annual Average	0.11	0.26	18.7	19.0	**30**
$PM_{2.5}$	24 Hour Maximum	0.1	2.1	20.2[1]	22.3	**25**
	Annual Average	0.0093	0.17	7.4	7.6	**8**
CO	1 Hour Maximum	46.0	NA	-	-	**30,000**
	8 hour Maximum	10.7	NA	1,900	1,911	**10,000**
NO_2	1 Hour Maximum	74.6	74.6	100.5	175.1	**246**
	Annual Average	1.1	1.1	18.5	19.6	**62**
Pb	Annual Average	0.00045	0.16	-	-	**0.5**

1 Applied the highest background value that met the criterion in order to identify any additional exceedances. Refer to **Section 3.3** for full discussion of method.
2 The WA and BRF data could not be presented in separate columns as the maximum receptor may be different for each. Presenting the maximum for both in columns may lead to readers inadvertently adding the two and over predicting the actual cumulative value.
3 Conservatively assumed total conversion of NOx to NO_2.

The air dispersion modelling predicts that all assessed pollutants would meet their respective EPA criterion for all average periods both incrementally (WA alone) and cumulatively (WA+BRF+background). A summary of the modelling results in is as follows:

- The predicted TSP annual average incremental and cumulative concentrations were below the EPA criteria (90µg/m^3). Due to the small incremental impact associated with WA and the BRF a maximum cumulative annual average concentration of 47.1 µg/m^3 at nearby sensitive receptors is similar to Scenario 1;
- Predicted PM_{10} incremental impacts for WA for maximum 24-hour (1.0µg/m^3) and annual average (0.11µg/m^3) concentrations were found to be relatively small when compared to the maximum 24 hour criterion of 50µg/m^3 and annual average criterion, of 30µg/m^3. When accounting for the proposed BRF and background concentrations:
    - Combined maximum 24 hour incremental contributions from WA and the BRF were low, at approximately 3.1µg/m^3.
    - The PM_{10} 24 hour data predicts that there are no additional exceedances of the criteria, beyond those already identified in the background data (see **Section 3.3**), once the potential impacts from both the WA and BRF sites are cumulatively assessed with the background.
    - The combined predicted annual average from the WA and proposed BRF were found to be 0.26µg/m^3 and when added to the annual background concentration of 18.7 µg/m^{3,} resulted in a cumulative concentration of 19.0µg/m^3 which is below the annual average criterion of 30µg/m^3.
    - Predicted incremental contribution from both the WA and the BRF are conservative based on continuous operations at maximum capacity and at proposed design limits respectively and thus while not considered significant are likely to be lower than reported.
- Predicted $PM_{2.5}$ maximum 24-hour (0.1µg/m^3) and annual average (9.3x10^{-3}µg/m^3) concentrations attributed to WA were found to be negligible compared to the maximum 24 hour (25µg/m^3) and annual average (8µg/m^3) criteria. When accounting for the proposed BRF and background concentrations:
    - Combined maximum 24 hour incremental contributions from WA and the BRF were low, at approximately 2.1µg/m^3.
    - The $PM_{2.5}$ 24 hour data predicts that there are no additional exceedances of the criteria, beyond those already identified in the background data (see **Section 3.3**), once the potential impacts from both the WA and BRF sites are cumulatively assessed with the background.
    - The combined predicted annual average from the WA and proposed BRF was relatively small at 0.17µg/m^3 and when added to the background concentration of 7.4µg/m^3 resulted in a predicted cumulative concentration of 7.6µg/m^3, which is below the annual average criterion.
    - Predicted incremental contribution from both the WA and the BRF are conservative based on continuous operations at maximum capacity and at proposed design limits respectively and thus while not considered significant are likely to be lower than reported.
- Predicted maximum 1-hour and 8-hour CO contributions from the WA plant are well below the criterion. Cumulative impacts for the maximum 8-hour CO concentration at sensitive receptors were also found to be below the criterion. No data on the 1-hour CO background was available, however based on the low 8-hour background concentration recorded at the Beresfield monitoring station, cumulative, 1-hour CO impacts are also likely to be relatively low;
- As a conservative assumption, all NOx emissions were assumed to be $NO_{2.}$ The predicted maximum 1-hour and annual average incremental impacts and cumulative impacts inclusive of both the background concentration and predicted impacts from the BRF were well below the EPA criteria; and
- Predicted incremental annual average lead impacts from WA were found to be very small at 4.5x10^{-4}µg/m^3 when compared to the EPA criterion of 0.5µg/m^3 (<1% of criterion). When added to the maximum incremental impact from the BRF, the cumulative impact equated to 0.16µg/m^3 which equates to 32 percent of the EPA criterion.

Predicted offsite modelled impacts for air toxics in **Table 21** are reported 99.9th percentile concentrations in accordance with the Approved Methods. In exception to this are concentrations for Co, Se, Sn and V which do not have a ground level concentration criteria set by the EPA and are reported as the maximum 1-hour concentration offsite in accordance with the TCEQ 2015 (refer to **Section 2.1.1**).

Table 21 shows results only for pollutants with a proposed EPL limit (refer to **Table 3**) and results for Cu reported in **Table 18** for Scenario 1 should be considered worst case under normal operating conditions should the thermal processing plant be operating at maximum capacity and continuously (not alternatively with the reverb furnace). **Table 21** also includes predicted pollutant concentrations for VOCs (as benzene), Co, Se, Sn and V, not reported in Scenario 1 due to data limitations. Predicted ground level concentrations for these pollutants are assumed to be lower than reported under normal operating conditions.

Table 21 Scenario 2 Modelling Results for Air Toxic 1 hour (99.9th percentile) Ground Level Concentrations

Pollutant	Predicted Incremental Impact (µg/m^3)	Criteria (µg/m^3)
H_2SO_4	16.5	**18**
HCl	10.4	**140**
TVOCs (as benzene)#	6.9	**29**
Sb	0.012	**9**
As	0.027	**0.09**
Cd	0.013	**0.018**
Hg (as organic mercury)	0.012	**0.18**
Be	0.00399	**0.004**
Cr (as Chromium VI compounds)	0.013	**0.09**
Co*	0.027	**0.2**
Mn	0.016	**18**
Ni	0.013	**0.18**
Se*	0.027	**2**
Sn (as organic compounds)*	0.027	**1**
V*	0.027	**2**
Dioxins and Furans	2.0 x10^{-9}	**2x10^{-9}**

EPA criterion for benzene has been adopted for this assessment for TVOCs
* Predicted 1 hour maximum concentration based on 1 hour TCEQ short term exposure limits

The air dispersion modelling predicts that all assessed pollutants would meet their respective EPA criterion. A summary of the modelling results is as follows:

- Predicted 1-hour 99.9th percentile incremental impacts for H_2SO_4 is notably higher than predicted in Scenario 1 at 16.5µg/m^3 but still below the EPA criteria of 18µg/m^3;
- Predicted 1-hour 99.9th percentile incremental impacts for HCl were below EPA criterion at 10.4µg/m^3 equating to seven percent of the criteria of 140µg/m^3;
- The modelled 1-hour 99.9th percentile incremental total VOC concentration was found to be 6.9 µg/m^3 which is well below the most stringent VOC criterion of benzene at 29µg/m^3. As such all VOC emissions would be below the applicable ground level concentration criteria under the proposed EPL limit. NSW EPA criteria for

individual toxic air pollutants are based on EPA Victoria design criteria (Victorian Government Gazette 2001). These criteria are set at the lower of their toxicity and odour impact levels and as such compliance with the criteria infers compliance from both a toxicity and odour perspective. On this basis odour impacts are not expected to be a cause for concern from the facility;

- Emission rates for Type 1 and Type 2 heavy metals derived from the proposed EPL limit (refer to **Table 3**) in accordance with Schedule 4 of the POEO (Clear Air) Regulation 2010 are notably higher than those predicted under normal operating conditions (refer to **Section 2.4.4**). As such predicted ground level concentrations for heavy metals were found to be notably higher than in Scenario 1. However all pollutants were found to have a ground level concentration below the relevant EPA criteria, with the exception to beryllium which was equal to the ground level criteria which was set with a lower emission rate to limit offsite impacts[6]. Again, Scenario 2 modelling is designed to reflect highly conservative worst-case conditions, which are considered unrepresentative of typical operating conditions; and
- The maximum dioxin and furan stack concentration under Schedule 4 of the POEO (Clear Air) Regulation 2010 would have resulted in predicted ground level exceedances for Scenario 2. As such a lower EPL limit (refer to **Table 3**) was set at a level to equal the maximum allowable offsite concentration without exceeding the EPA criterion (refer to **Section 2.4.4**). As such the highest predicted 1-hour 99th percentile concentration was predicted to be equal to the EPA criteria of 2.0×10^{-9}µg/m^3. Predicted offsite 99.9th percentile 1-hour offsite concentrations for dioxins and furans at nearby sensitive receptors was found to be lower, with a predicted 1 hour 99th percentile of 1.8×10^{-9}µg/m^3 occurring at the worst effected sensitive receptor. As above, Scenario 2 modelling is designed to reflect highly conservative worst-case conditions, which are considered unrepresentative of typical operating conditions.

[6] The emission rate for Scenario 2 has been based on the emission rate and associated predicted ground level concentration in Scenario 1; whereby the emission rate for Scenario 1 has been scaled up to result in the maximum emission rate possible without causing an exceedance of the EPA ground level criteria for Beryllium (see **Section 2.4.4**)

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Appendix B

Emergency Bypass Operation Modelling Results

Appendix B Emergency Bypass Operation Modelling Results

The bypass stack (Stack 8) has been excluded from the AQIA as this source would only be operational in emergencies. As such, its contribution to local air emissions is limited. Stack parameters and emission rates for the bypass stack used to access acute health impacts as part of the health risk assessment are discussed below.

Stack parameters for the proposed bypass stack are presented in **Table 22**. Data in **Table 23** have been based on design parameters provided by Advanced Combustion Engineering Pty Ltd.

Table 22 Emergency Bypass Stack Parameters

Stack ID	Diameter (m)	Flow Rate (Nm^3/s)	Velocity (m/s)	Temp (K)	Height AGL (m)	MGA 56 Coordinates (m)	
						X	Y
Stack 8	1.1	4.2	19.2	1173.2	12.5	357326	6369358

The modelled emission rate for Scenario 4 as described in **Section 2.4.1** is presented in **Table 23**. Emission rates used for the emergency bypass stack operation scenario are based on maximum stack concentration design limits provide by Advanced Combustion Engineering Pty Ltd.

Table 23 Pollutant Emission Rates for Emergency Bypass Stack

Pollutant	Maximum Discharge Mass Rate (g/s)
Total Suspended Particulates	0.3100
Sulphur Dioxide	0.2580
Oxides of Nitrogen	0.5170
Hydrogen Chloride	2.5830
Hydrogen Fluoride	0.0260
Antimony	0.0014
Arsenic	0.0014
Cadmium	0.0006
Lead	0.0014
Mercury	0.0026
Chromium	0.0014
Cobalt	0.0014
Manganese	0.0014
Nickel	0.0014
Tin	0.0014
Copper	0.0014
Dioxins & Furans	$3.9x10^{-6}$+00

Predicted incremental 1-hour maximum impacts and annual average dust deposition impacts at sensitive receptors for Scenario 4 are presented in the table below. For a detailed assessment on impacts associated with ground level concentrations associated with operation of the emergency bypass stack, refer to the Health Risk Assessment Report.

ID	TSP (µg/m^3)	SO_2 (µg/m^3)	NO_x (µg/m^3)	HCl (µg/m^3)	HF (µg/m^3)	Sb (µg/m^3)	As (µg/m^3)	Cd (µg/m^3)	Pb (µg/m^3)	Hg (µg/m^3)	Cr (µg/m^3)	Co (µg/m^3)	Mn (µg/m^3)	Ni (µg/m^3)	Sn (µg/m^3)	Cu (µg/m^3)	Dioxins & Furans (µg/m^3)	Dry Deposition (g/m^2/s)
	1 hour	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**Annual**
1	5.65	6.37	9.07	24.24	0.69	1.3X10-02	1.3X10-02	6.5X10-03	1.7X10-02	2.4X10-02	1.4X10-02	1.3X10-02	1.7X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.6E+01	5.42X10-12
2	6.96	7.45	11.94	36.64	0.63	2.0X10-02	2.0X10-02	9.7X10-03	2.5X10-02	3.7X10-02	2.1X10-02	2.0X10-02	2.5X10-02	2.1X10-02	2.0X10-02	2.1X10-02	5.4E+01	5.92X10-12
3	4.28	5.17	7.92	21.65	0.93	1.2X10-02	1.2X10-02	5.9X10-03	1.5X10-02	2.2X10-02	1.3X10-02	1.2X10-02	1.5X10-02	1.3X10-02	1.2X10-02	1.2X10-02	3.2E+01	4.92X10-12
4	9.09	7.70	15.51	74.40	0.91	4.0X10-02	4.0X10-02	1.7X10-02	4.1X10-02	7.5X10-02	4.0X10-02	4.0X10-02	4.1X10-02	4.0X10-02	4.0X10-02	4.0X10-02	1.1E+02	1.26X10-11
5	3.30	5.56	4.84	11.78	0.65	6.4X10-03	6.3X10-03	3.3X10-03	8.6X10-03	1.2X10-02	6.8X10-03	6.3X10-03	8.6X10-03	6.8X10-03	6.3X10-03	6.8X10-03	1.7E+01	7.22X10-12
6	4.44	6.79	7.10	19.63	1.08	1.1X10-02	1.1X10-02	4.7X10-03	1.1X10-02	2.0X10-02	1.1X10-02	1.1X10-02	1.1X10-02	1.1X10-02	1.1X10-02	1.1X10-02	2.9E+01	3.56X10-12
7	7.19	7.57	12.73	33.90	1.30	1.8X10-02	1.8X10-02	9.2X10-03	2.4X10-02	3.4X10-02	2.0X10-02	1.8X10-02	2.4X10-02	2.0X10-02	1.8X10-02	1.9X10-02	5.0E+01	5.47X10-12
8	8.95	11.14	13.13	25.35	1.55	1.4X10-02	1.4X10-02	6.9X10-03	1.8X10-02	2.5X10-02	1.5X10-02	1.4X10-02	1.8X10-02	1.5X10-02	1.4X10-02	1.5X10-02	3.8E+01	6.70X10-12
9	6.99	8.49	11.09	26.27	1.14	1.4X10-02	1.4X10-02	7.0X10-03	1.8X10-02	2.6X10-02	1.5X10-02	1.4X10-02	1.8X10-02	1.5X10-02	1.4X10-02	1.5X10-02	3.9E+01	6.94X10-12
10	4.23	4.92	7.33	18.95	0.75	1.0X10-02	1.0X10-02	5.2X10-03	1.3X10-02	1.9X10-02	1.1X10-02	1.0X10-02	1.3X10-02	1.1X10-02	1.0X10-02	1.1X10-02	2.8E+01	7.03X10-12
11	5.31	5.58	9.93	22.51	1.16	1.2X10-02	1.2X10-02	6.3X10-03	1.7X10-02	2.2X10-02	1.3X10-02	1.2X10-02	1.7X10-02	1.3X10-02	1.2X10-02	1.3X10-02	3.3E+01	4.91X10-12
12	5.66	7.50	11.20	27.67	0.87	1.5X10-02	1.5X10-02	7.8X10-03	2.1X10-02	2.8X10-02	1.6X10-02	1.5X10-02	2.1X10-02	1.6X10-02	1.5X10-02	1.6X10-02	4.1E+01	8.20X10-12
13	7.69	11.31	9.71	23.28	1.22	1.3X10-02	1.3X10-02	5.6X10-03	1.4X10-02	2.3X10-02	1.3X10-02	1.3X10-02	1.4X10-02	1.3X10-02	1.3X10-02	1.3X10-02	3.5E+01	8.25X10-12
14	9.21	12.92	13.33	26.92	1.19	1.5X10-02	1.5X10-02	6.4X10-03	1.5X10-02	2.7X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	4.0E+01	8.23X10-12
15	8.84	12.29	13.52	19.07	1.25	1.0X10-02	1.0X10-02	5.0X10-03	1.5X10-02	1.9X10-02	1.0X10-02	1.0X10-02	1.5X10-02	1.0X10-02	1.0X10-02	1.0X10-02	2.9E+01	8.21X10-12
16	8.11	11.30	11.88	21.24	1.21	1.2X10-02	1.2X10-02	4.9X10-03	1.2X10-02	2.1X10-02	1.2X10-02	1.2X10-02	1.2X10-02	1.2X10-02	1.2X10-02	1.2X10-02	3.2E+01	8.00X10-12
17	5.04	7.02	6.14	25.57	1.08	1.4X10-02	1.4X10-02	5.9X10-03	1.4X10-02	2.6X10-02	1.4X10-02	1.4X10-02	1.4X10-02	1.4X10-02	1.4X10-02	1.4X10-02	3.8E+01	8.17X10-12
18	3.70	5.07	4.52	10.98	1.09	5.9X10-03	5.9X10-03	3.0X10-03	7.7X10-03	1.1X10-02	6.3X10-03	5.9X10-03	7.7X10-03	6.3X10-03	5.9X10-03	6.3X10-03	1.6E+01	9.02X10-12
19	3.04	4.50	5.32	11.86	0.89	6.4X10-03	6.4X10-03	3.3X10-03	8.5X10-03	1.2X10-02	6.9X10-03	6.4X10-03	8.5X10-03	6.9X10-03	6.4X10-03	6.8X10-03	1.8E+01	8.57X10-12
20	3.48	5.72	5.56	13.56	0.60	7.3X10-03	7.3X10-03	3.7X10-03	9.6X10-03	1.4X10-02	7.8X10-03	7.3X10-03	9.6X10-03	7.8X10-03	7.3X10-03	7.8X10-03	2.0E+01	8.32X10-12
21	3.45	5.48	4.44	11.20	0.74	6.0X10-03	6.0X10-03	3.1X10-03	8.0X10-03	1.1X10-02	6.5X10-03	6.0X10-03	8.0X10-03	6.5X10-03	6.0X10-03	6.4X10-03	1.7E+01	8.00X10-12
22	3.72	4.12	6.91	14.87	0.78	8.0X10-03	8.0X10-03	4.3X10-03	1.1X10-02	1.5X10-02	8.8X10-03	8.0X10-03	1.1X10-02	8.8X10-03	8.0X10-03	8.7X10-03	2.2E+01	7.82X10-12
23	5.28	9.14	6.41	14.20	0.84	7.7X10-03	7.7X10-03	3.8X10-03	1.0X10-02	1.4X10-02	8.2X10-03	7.6X10-03	1.0X10-02	8.2X10-03	7.6X10-03	8.1X10-03	2.1E+01	7.66X10-12
24	2.94	3.50	5.05	12.67	0.69	6.8X10-03	6.8X10-03	3.5X10-03	9.1X10-03	1.3X10-02	7.4X10-03	6.8X10-03	9.1X10-03	7.4X10-03	6.8X10-03	7.3X10-03	1.9E+01	8.54X10-12
25	6.46	8.10	9.34	16.77	1.02	9.1X10-03	9.1X10-03	4.8X10-03	1.3X10-02	1.7X10-02	9.8X10-03	9.0X10-03	1.3X10-02	9.8X10-03	9.1X10-03	9.7X10-03	2.5E+01	6.00X10-12
26	7.52	8.41	12.69	31.69	0.92	1.7X10-02	1.7X10-02	8.8X10-03	2.3X10-02	3.2X10-02	1.8X10-02	1.7X10-02	2.3X10-02	1.8X10-02	1.7X10-02	1.8X10-02	4.7E+01	5.02X10-12
27	7.98	8.91	13.06	34.87	0.97	1.9X10-02	1.9X10-02	9.4X10-03	2.4X10-02	3.5X10-02	2.0X10-02	1.9X10-02	2.4X10-02	2.0X10-02	1.9X10-02	2.0X10-02	5.2E+01	4.89X10-12
28	7.40	8.21	11.94	33.42	0.95	1.8X10-02	1.8X10-02	8.8X10-03	2.2X10-02	3.4X10-02	1.9X10-02	1.8X10-02	2.2X10-02	1.9X10-02	1.8X10-02	1.9X10-02	5.0E+01	5.11X10-12
29	8.44	9.23	14.61	37.37	1.04	2.0X10-02	2.0X10-02	1.0X10-02	2.7X10-02	3.7X10-02	2.2X10-02	2.0X10-02	2.7X10-02	2.2X10-02	2.0X10-02	2.1X10-02	5.5E+01	6.02X10-12
30	9.53	11.40	15.72	44.89	1.62	2.4X10-02	2.4X10-02	1.2X10-02	3.0X10-02	4.5X10-02	2.6X10-02	2.4X10-02	3.0X10-02	2.6X10-02	2.4X10-02	2.5X10-02	6.7E+01	6.09X10-12
31	8.50	11.65	13.80	41.29	1.64	2.2X10-02	2.2X10-02	1.1X10-02	2.7X10-02	4.1X10-02	2.3X10-02	2.2X10-02	2.7X10-02	2.3X10-02	2.2X10-02	2.3X10-02	6.1E+01	6.10X10-12
32	7.27	9.12	11.64	34.40	1.40	1.9X10-02	1.9X10-02	8.9X10-03	2.2X10-02	3.5X10-02	1.9X10-02	1.9X10-02	2.2X10-02	1.9X10-02	1.9X10-02	1.9X10-02	5.1E+01	5.77X10-12
33	6.31	8.70	10.05	30.28	1.36	1.6X10-02	1.6X10-02	7.8X10-03	1.9X10-02	3.0X10-02	1.7X10-02	1.6X10-02	1.9X10-02	1.7X10-02	1.6X10-02	1.7X10-02	4.5E+01	5.66X10-12
34	6.08	8.23	9.68	29.17	1.30	1.6X10-02	1.6X10-02	7.5X10-03	1.9X10-02	2.9X10-02	1.6X10-02	1.6X10-02	1.9X10-02	1.6X10-02	1.6X10-02	1.6X10-02	4.3E+01	5.56X10-12

35	7.58	8.41	12.24	34.31	1.00	1.9X10-02	1.9X10-02	9.0X10-03	2.3X10-02	3.4X10-02	2.0X10-02	1.9X10-02	2.3X10-02	2.0X10-02	1.9X10-02	1.9X10-02	5.1E+01	5.22X10-12
36	14.07	23.05	11.68	38.23	2.81	2.1X10-02	2.1X10-02	9.6X10-03	2.4X10-02	3.8X10-02	2.1X10-02	2.1X10-02	2.4X10-02	2.1X10-02	2.1X10-02	2.1X10-02	5.7E+01	6.15X10-12
37	10.67	16.74	10.26	23.46	2.26	1.3X10-02	1.3X10-02	5.8X10-03	1.4X10-02	2.4X10-02	1.3X10-02	1.3X10-02	1.4X10-02	1.3X10-02	1.3X10-02	1.3X10-02	3.5E+01	6.35X10-12
38	8.98	13.85	9.12	29.94	1.95	1.6X10-02	1.6X10-02	7.5X10-03	1.8X10-02	3.0X10-02	1.7X10-02	1.6X10-02	1.8X10-02	1.7X10-02	1.6X10-02	1.7X10-02	4.5E+01	6.22X10-12
39	6.24	9.07	8.76	20.02	1.50	1.1X10-02	1.1X10-02	5.4X10-03	1.4X10-02	2.0X10-02	1.2X10-02	1.1X10-02	1.4X10-02	1.2X10-02	1.1X10-02	1.1X10-02	3.0E+01	5.87X10-12
40	5.29	7.52	8.66	19.55	1.29	1.1X10-02	1.1X10-02	5.3X10-03	1.4X10-02	2.0X10-02	1.1X10-02	1.1X10-02	1.4X10-02	1.1X10-02	1.1X10-02	1.1X10-02	2.9E+01	5.58X10-12
41	5.27	6.96	8.57	19.43	1.21	1.1X10-02	1.0X10-02	5.3X10-03	1.4X10-02	1.9X10-02	1.1X10-02	1.0X10-02	1.4X10-02	1.1X10-02	1.0X10-02	1.1X10-02	2.9E+01	5.49X10-12
42	7.27	8.31	11.82	30.23	1.03	1.6X10-02	1.6X10-02	8.2X10-03	2.1X10-02	3.0X10-02	1.8X10-02	1.6X10-02	2.1X10-02	1.8X10-02	1.6X10-02	1.7X10-02	4.5E+01	7.17X10-12
43	6.15	7.00	10.08	26.07	1.05	1.4X10-02	1.4X10-02	7.1X10-03	1.8X10-02	2.6X10-02	1.5X10-02	1.4X10-02	1.8X10-02	1.5X10-02	1.4X10-02	1.5X10-02	3.9E+01	6.61X10-12
44	7.57	8.56	12.24	32.47	0.92	1.8X10-02	1.8X10-02	8.7X10-03	2.2X10-02	3.3X10-02	1.9X10-02	1.8X10-02	2.2X10-02	1.9X10-02	1.8X10-02	1.9X10-02	4.8E+01	7.83X10-12
45	8.05	9.94	13.05	35.91	1.24	1.9X10-02	1.9X10-02	9.5X10-03	2.4X10-02	3.6X10-02	2.1X10-02	1.9X10-02	2.4X10-02	2.1X10-02	1.9X10-02	2.0X10-02	5.3E+01	1.30X10-11
46	7.18	7.86	11.85	32.30	0.89	1.8X10-02	1.8X10-02	8.6X10-03	2.2X10-02	3.2X10-02	1.9X10-02	1.7X10-02	2.2X10-02	1.9X10-02	1.8X10-02	1.8X10-02	4.8E+01	1.24X10-11
47	8.42	9.80	13.88	30.62	1.06	1.7X10-02	1.7X10-02	8.8X10-03	2.3X10-02	3.1X10-02	1.8X10-02	1.6X10-02	2.3X10-02	1.8X10-02	1.6X10-02	1.8X10-02	4.5E+01	4.77X10-11
48	5.95	6.84	9.71	24.27	0.84	1.3X10-02	1.3X10-02	6.4X10-03	1.6X10-02	2.4X10-02	1.4X10-02	1.3X10-02	1.6X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.6E+01	2.16X10-11
49	8.30	9.41	13.75	32.47	1.13	1.8X10-02	1.8X10-02	8.9X10-03	2.3X10-02	3.3X10-02	1.9X10-02	1.7X10-02	2.3X10-02	1.9X10-02	1.8X10-02	1.9X10-02	4.8E+01	3.60X10-11
50	7.95	9.46	12.91	27.90	1.08	1.5X10-02	1.5X10-02	7.9X10-03	2.1X10-02	2.8X10-02	1.6X10-02	1.5X10-02	2.1X10-02	1.6X10-02	1.5X10-02	1.6X10-02	4.1E+01	4.61X10-11
51	5.97	7.38	9.51	22.72	0.83	1.2X10-02	1.2X10-02	6.3X10-03	1.7X10-02	2.3X10-02	1.3X10-02	1.2X10-02	1.7X10-02	1.3X10-02	1.2X10-02	1.3X10-02	3.4E+01	3.69X10-11
52	4.76	5.67	7.76	20.01	0.63	1.1X10-02	1.1X10-02	5.4X10-03	1.4X10-02	2.0X10-02	1.2X10-02	1.1X10-02	1.4X10-02	1.2X10-02	1.1X10-02	1.1X10-02	3.0E+01	2.89X10-11
53	4.80	5.12	8.28	22.93	0.64	1.2X10-02	1.2X10-02	6.1X10-03	1.6X10-02	2.3X10-02	1.3X10-02	1.2X10-02	1.6X10-02	1.3X10-02	1.2X10-02	1.3X10-02	3.4E+01	1.86X10-11
54	6.18	6.75	10.29	28.61	0.76	1.5X10-02	1.5X10-02	7.5X10-03	1.9X10-02	2.9X10-02	1.6X10-02	1.5X10-02	1.9X10-02	1.6X10-02	1.5X10-02	1.6X10-02	4.3E+01	1.25X10-11
55	6.99	7.84	11.27	30.07	0.86	1.6X10-02	1.6X10-02	8.1X10-03	2.1X10-02	3.0X10-02	1.7X10-02	1.6X10-02	2.1X10-02	1.7X10-02	1.6X10-02	1.7X10-02	4.5E+01	7.88X10-12
56	6.43	7.27	10.33	27.34	0.77	1.5X10-02	1.5X10-02	7.4X10-03	1.9X10-02	2.8X10-02	1.6X10-02	1.5X10-02	1.9X10-02	1.6X10-02	1.5X10-02	1.6X10-02	4.1E+01	6.32X10-12
57	5.05	5.69	8.21	21.82	0.72	1.2X10-02	1.2X10-02	5.9X10-03	1.5X10-02	2.2X10-02	1.3X10-02	1.2X10-02	1.5X10-02	1.3X10-02	1.2X10-02	1.3X10-02	3.2E+01	5.53X10-12
58	4.94	5.73	8.00	19.08	0.99	1.0X10-02	1.0X10-02	5.3X10-03	1.4X10-02	1.9X10-02	1.1X10-02	1.0X10-02	1.4X10-02	1.1X10-02	1.0X10-02	1.1X10-02	2.8E+01	5.18X10-12
59	4.80	5.73	7.86	18.15	1.03	9.8X10-03	9.8X10-03	4.8X10-03	1.3X10-02	1.8X10-02	1.0X10-02	9.8X10-03	1.3X10-02	1.0X10-02	9.8X10-03	1.0X10-02	2.7E+01	4.99X10-12
60	5.16	5.69	8.22	24.25	0.95	1.3X10-02	1.3X10-02	6.3X10-03	1.6X10-02	2.4X10-02	1.4X10-02	1.3X10-02	1.6X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.6E+01	4.81X10-12
61	6.91	7.69	11.16	30.90	0.84	1.7X10-02	1.7X10-02	8.2X10-03	2.1X10-02	3.1X10-02	1.8X10-02	1.7X10-02	2.1X10-02	1.8X10-02	1.7X10-02	1.8X10-02	4.6E+01	4.62X10-12
62	7.23	8.08	11.89	31.32	0.88	1.7X10-02	1.7X10-02	8.5X10-03	2.2X10-02	3.1X10-02	1.8X10-02	1.7X10-02	2.2X10-02	1.8X10-02	1.7X10-02	1.8X10-02	4.6E+01	4.39X10-12
63	6.87	7.67	11.41	29.28	0.83	1.6X10-02	1.6X10-02	8.0X10-03	2.1X10-02	2.9X10-02	1.7X10-02	1.6X10-02	2.1X10-02	1.7X10-02	1.6X10-02	1.7X10-02	4.3E+01	4.27X10-12
64	6.17	6.89	10.31	25.87	0.75	1.4X10-02	1.4X10-02	7.2X10-03	1.9X10-02	2.6X10-02	1.5X10-02	1.4X10-02	1.9X10-02	1.5X10-02	1.4X10-02	1.5X10-02	3.8E+01	4.12X10-12
65	5.35	6.80	8.66	21.04	0.69	1.1X10-02	1.1X10-02	5.9X10-03	1.5X10-02	2.1X10-02	1.2X10-02	1.1X10-02	1.5X10-02	1.2X10-02	1.1X10-02	1.2X10-02	3.1E+01	4.02X10-12
66	6.29	7.95	9.16	18.09	0.91	9.8X10-03	9.7X10-03	5.1X10-03	1.3X10-02	1.8X10-02	1.1X10-02	9.7X10-03	1.3X10-02	1.1X10-02	9.7X10-03	1.0X10-02	2.7E+01	3.98X10-12
67	4.28	5.75	6.56	17.56	0.76	9.5X10-03	9.5X10-03	4.6X10-03	1.2X10-02	1.8X10-02	1.0X10-02	9.5X10-03	1.2X10-02	1.0X10-02	9.5X10-03	9.9X10-03	2.6E+01	3.90X10-12
68	4.09	5.19	6.40	12.69	0.63	6.8X10-03	6.8X10-03	3.6X10-03	9.4X10-03	1.3X10-02	7.4X10-03	6.8X10-03	9.4X10-03	7.4X10-03	6.8X10-03	7.4X10-03	1.9E+01	3.95X10-12
69	4.77	5.94	7.37	18.55	0.70	1.0X10-02	1.0X10-02	4.6X10-03	1.1X10-02	1.9X10-02	1.0X10-02	1.0X10-02	1.1X10-02	1.0X10-02	1.0X10-02	1.0X10-02	2.8E+01	3.26X10-12
70	4.96	6.02	7.61	17.25	0.62	9.3X10-03	9.3X10-03	4.7X10-03	1.2X10-02	1.7X10-02	1.0X10-02	9.3X10-03	1.2X10-02	1.0X10-02	9.3X10-03	9.9X10-03	2.6E+01	3.25X10-12
71	4.83	5.37	7.97	20.01	0.59	1.1X10-02	1.1X10-02	5.6X10-03	1.4X10-02	2.0X10-02	1.2X10-02	1.1X10-02	1.4X10-02	1.2X10-02	1.1X10-02	1.2X10-02	3.0E+01	3.34X10-12
72	5.64	6.25	9.26	24.00	0.69	1.3X10-02	1.3X10-02	6.6X10-03	1.7X10-02	2.4X10-02	1.4X10-02	1.3X10-02	1.7X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.6E+01	3.52X10-12

73	5.90	6.55	9.63	25.55	0.71	1.4X10-02	1.4X10-02	6.9X10-03	1.8X10-02	2.6X10-02	1.5X10-02	1.4X10-02	1.8X10-02	1.5X10-02	1.4X10-02	1.5X10-02	3.8E+01	3.65X10-12
74	5.71	6.33	9.24	25.25	0.69	1.4X10-02	1.4X10-02	6.8X10-03	1.7X10-02	2.5X10-02	1.5X10-02	1.4X10-02	1.7X10-02	1.5X10-02	1.4X10-02	1.4X10-02	3.8E+01	3.78X10-12
75	4.92	5.46	7.86	22.56	0.73	1.2X10-02	1.2X10-02	5.9X10-03	1.5X10-02	2.3X10-02	1.3X10-02	1.2X10-02	1.5X10-02	1.3X10-02	1.2X10-02	1.3X10-02	3.4E+01	4.13X10-12
76	4.35	5.80	7.49	16.68	0.74	9.0X10-03	9.0X10-03	4.6X10-03	1.2X10-02	1.7X10-02	9.7X10-03	8.9X10-03	1.2X10-02	9.7X10-03	9.0X10-03	9.6X10-03	2.5E+01	4.11X10-12
77	4.28	5.12	7.01	17.03	0.71	9.2X10-03	9.2X10-03	4.7X10-03	1.2X10-02	1.7X10-02	9.9X10-03	9.2X10-03	1.2X10-02	9.9X10-03	9.2X10-03	9.8X10-03	2.5E+01	4.20X10-12
78	5.09	5.70	8.13	22.06	0.69	1.2X10-02	1.2X10-02	5.9X10-03	1.5X10-02	2.2X10-02	1.3X10-02	1.2X10-02	1.5X10-02	1.3X10-02	1.2X10-02	1.3X10-02	3.3E+01	4.75X10-12
79	5.97	6.70	9.51	25.51	0.72	1.4X10-02	1.4X10-02	6.9X10-03	1.8X10-02	2.6X10-02	1.5X10-02	1.4X10-02	1.8X10-02	1.5X10-02	1.4X10-02	1.5X10-02	3.8E+01	5.40X10-12
80	6.18	6.90	9.94	26.51	0.76	1.4X10-02	1.4X10-02	7.1X10-03	1.8X10-02	2.7X10-02	1.5X10-02	1.4X10-02	1.8X10-02	1.5X10-02	1.4X10-02	1.5X10-02	3.9E+01	6.21X10-12
81	6.03	6.68	9.83	26.96	0.77	1.5X10-02	1.5X10-02	7.2X10-03	1.8X10-02	2.7X10-02	1.5X10-02	1.5X10-02	1.8X10-02	1.5X10-02	1.5X10-02	1.5X10-02	4.0E+01	7.55X10-12
82	5.32	5.81	8.93	24.11	0.76	1.3X10-02	1.3X10-02	6.4X10-03	1.7X10-02	2.4X10-02	1.4X10-02	1.3X10-02	1.7X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.6E+01	1.03X10-11
83	4.29	4.61	7.38	19.25	0.63	1.1X10-02	1.1X10-02	5.3X10-03	1.4X10-02	1.9X10-02	1.1X10-02	1.0X10-02	1.4X10-02	1.1X10-02	1.0X10-02	1.1X10-02	2.9E+01	1.35X10-11
84	4.10	4.76	6.83	17.56	0.57	9.5X10-03	9.5X10-03	4.7X10-03	1.2X10-02	1.8X10-02	1.0X10-02	9.4X10-03	1.2X10-02	1.0X10-02	9.5X10-03	1.0X10-02	2.6E+01	2.06X10-11
85	4.98	6.12	8.13	20.33	0.70	1.1X10-02	1.1X10-02	5.6X10-03	1.5X10-02	2.0X10-02	1.2X10-02	1.1X10-02	1.5X10-02	1.2X10-02	1.1X10-02	1.2X10-02	3.0E+01	2.62X10-11
86	7.75	8.83	13.07	29.72	0.98	1.6X10-02	1.6X10-02	8.4X10-03	2.2X10-02	3.0X10-02	1.8X10-02	1.6X10-02	2.2X10-02	1.8X10-02	1.6X10-02	1.7X10-02	4.4E+01	3.34X10-11
87	7.54	8.51	12.61	29.30	1.02	1.6X10-02	1.6X10-02	8.1X10-03	2.1X10-02	2.9X10-02	1.7X10-02	1.6X10-02	2.1X10-02	1.7X10-02	1.6X10-02	1.7X10-02	4.3E+01	2.42X10-11
88	7.13	8.06	11.95	27.43	0.96	1.5X10-02	1.5X10-02	7.7X10-03	2.0X10-02	2.8X10-02	1.6X10-02	1.5X10-02	2.0X10-02	1.6X10-02	1.5X10-02	1.6X10-02	4.1E+01	1.89X10-11
89	7.30	8.28	12.29	28.08	0.93	1.5X10-02	1.5X10-02	7.9X10-03	2.1X10-02	2.8X10-02	1.7X10-02	1.5X10-02	2.1X10-02	1.7X10-02	1.5X10-02	1.6X10-02	4.2E+01	2.49X10-11
90	6.79	7.77	11.46	25.72	0.83	1.4X10-02	1.4X10-02	7.4X10-03	2.0X10-02	2.6X10-02	1.5X10-02	1.4X10-02	2.0X10-02	1.5X10-02	1.4X10-02	1.5X10-02	3.8E+01	2.79X10-11
91	5.95	6.94	9.79	23.40	0.81	1.3X10-02	1.3X10-02	6.5X10-03	1.7X10-02	2.3X10-02	1.4X10-02	1.3X10-02	1.7X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.5E+01	3.01X10-11
92	5.55	6.60	8.96	22.31	0.77	1.2X10-02	1.2X10-02	6.0X10-03	1.5X10-02	2.2X10-02	1.3X10-02	1.2X10-02	1.5X10-02	1.3X10-02	1.2X10-02	1.3X10-02	3.3E+01	2.70X10-11
93	4.30	4.92	7.23	17.47	0.60	9.5X10-03	9.5X10-03	4.9X10-03	1.3X10-02	1.8X10-02	1.0X10-02	9.4X10-03	1.3X10-02	1.0X10-02	9.5X10-03	1.0X10-02	2.6E+01	2.06X10-11
94	3.45	4.59	6.48	16.58	0.61	9.0X10-03	8.9X10-03	4.4X10-03	1.1X10-02	1.7X10-02	9.5X10-03	8.9X10-03	1.1X10-02	9.5X10-03	8.9X10-03	9.4X10-03	2.5E+01	1.54X10-11
95	4.51	4.88	7.69	19.90	0.72	1.1X10-02	1.1X10-02	5.5X10-03	1.4X10-02	2.0X10-02	1.2X10-02	1.1X10-02	1.4X10-02	1.2X10-02	1.1X10-02	1.2X10-02	2.9E+01	1.11X10-11
96	5.40	6.50	8.94	24.13	0.85	1.3X10-02	1.3X10-02	6.4X10-03	1.7X10-02	2.4X10-02	1.4X10-02	1.3X10-02	1.7X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.6E+01	7.96X10-12
97	5.78	6.39	9.40	25.70	0.74	1.4X10-02	1.4X10-02	6.8X10-03	1.7X10-02	2.6X10-02	1.5X10-02	1.4X10-02	1.7X10-02	1.5X10-02	1.4X10-02	1.5X10-02	3.8E+01	6.53X10-12
98	5.86	6.54	9.38	25.17	0.71	1.4X10-02	1.4X10-02	6.8X10-03	1.7X10-02	2.5X10-02	1.5X10-02	1.4X10-02	1.7X10-02	1.5X10-02	1.4X10-02	1.4X10-02	3.7E+01	5.29X10-12
99	5.54	6.21	8.82	23.83	0.67	1.3X10-02	1.3X10-02	6.4X10-03	1.6X10-02	2.4X10-02	1.4X10-02	1.3X10-02	1.6X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.5E+01	4.90X10-12
100	4.54	5.05	7.27	20.00	0.67	1.1X10-02	1.1X10-02	5.4X10-03	1.4X10-02	2.0X10-02	1.2X10-02	1.1X10-02	1.4X10-02	1.2X10-02	1.1X10-02	1.1X10-02	3.0E+01	4.33X10-12
101	3.77	5.27	5.93	16.66	0.64	9.1X10-03	9.1X10-03	4.5X10-03	1.1X10-02	1.7X10-02	9.6X10-03	9.1X10-03	1.1X10-02	9.6X10-03	9.1X10-03	9.6X10-03	2.5E+01	4.07X10-12
102	3.98	4.84	6.50	16.31	0.71	8.9X10-03	8.8X10-03	4.5X10-03	1.2X10-02	1.6X10-02	9.5X10-03	8.8X10-03	1.2X10-02	9.5X10-03	8.8X10-03	9.4X10-03	2.4E+01	3.95X10-12
103	4.15	5.75	7.20	16.99	0.63	9.2X10-03	9.2X10-03	4.6X10-03	1.2X10-02	1.7X10-02	9.8X10-03	9.1X10-03	1.2X10-02	9.8X10-03	9.1X10-03	9.7X10-03	2.5E+01	3.86X10-12
104	3.99	5.58	6.72	17.13	0.69	9.3X10-03	9.3X10-03	4.5X10-03	1.1X10-02	1.7X10-02	9.8X10-03	9.3X10-03	1.1X10-02	9.8X10-03	9.3X10-03	9.7X10-03	2.5E+01	3.80X10-12
105	4.58	5.49	7.34	20.69	0.60	1.1X10-02	1.1X10-02	5.5X10-03	1.4X10-02	2.1X10-02	1.2X10-02	1.1X10-02	1.4X10-02	1.2X10-02	1.1X10-02	1.2X10-02	3.1E+01	3.64X10-12
106	5.08	5.60	8.18	22.52	0.61	1.2X10-02	1.2X10-02	6.0X10-03	1.5X10-02	2.3X10-02	1.3X10-02	1.2X10-02	1.5X10-02	1.3X10-02	1.2X10-02	1.3X10-02	3.3E+01	3.54X10-12
107	5.45	6.03	8.84	23.74	0.65	1.3X10-02	1.3X10-02	6.4X10-03	1.6X10-02	2.4X10-02	1.4X10-02	1.3X10-02	1.6X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.5E+01	3.44X10-12
108	5.42	6.00	8.86	23.13	0.65	1.3X10-02	1.3X10-02	6.3X10-03	1.6X10-02	2.3X10-02	1.4X10-02	1.3X10-02	1.6X10-02	1.4X10-02	1.3X10-02	1.3X10-02	3.4E+01	3.35X10-12
109	4.63	5.14	7.58	19.19	0.58	1.1X10-02	1.1X10-02	5.3X10-03	1.4X10-02	1.9X10-02	1.1X10-02	1.0X10-02	1.4X10-02	1.1X10-02	1.0X10-02	1.1X10-02	2.8E+01	3.13X10-12
110	4.49	5.38	6.99	16.58	0.54	8.9X10-03	8.9X10-03	4.5X10-03	1.2X10-02	1.7X10-02	9.6X10-03	8.9X10-03	1.2X10-02	9.6X10-03	8.9X10-03	9.5X10-03	2.5E+01	3.05X10-12

111	4.73	5.76	7.37	16.65	0.62	9.0X10-03	9.0X10-03	4.4X10-03	1.2X10-02	1.7X10-02	9.2X10-03	9.0X10-03	1.2X10-02	9.2X10-03	9.0X10-03	9.2X10-03	2.5E+01	2.99X10-12
112	6.63	8.62	9.21	19.24	0.95	1.0X10-02	1.0X10-02	5.5X10-03	1.4X10-02	1.9X10-02	1.1X10-02	1.0X10-02	1.4X10-02	1.1X10-02	1.0X10-02	1.1X10-02	2.8E+01	4.43X10-12
113	6.12	7.71	8.99	17.27	1.03	9.3X10-03	9.3X10-03	4.5X10-03	1.2X10-02	1.7X10-02	9.6X10-03	9.3X10-03	1.2X10-02	9.6X10-03	9.3X10-03	9.6X10-03	2.6E+01	4.31X10-12
114	4.48	5.87	6.74	13.96	0.80	7.5X10-03	7.5X10-03	3.9X10-03	1.0X10-02	1.4X10-02	8.2X10-03	7.5X10-03	1.0X10-02	8.2X10-03	7.5X10-03	8.1X10-03	2.1E+01	4.43X10-12
115	4.47	6.07	6.73	13.21	0.66	7.2X10-03	7.2X10-03	3.7X10-03	9.6X10-03	1.3X10-02	7.8X10-03	7.2X10-03	9.6X10-03	7.8X10-03	7.2X10-03	7.7X10-03	2.0E+01	4.48X10-12
116	4.00	5.58	5.99	12.96	0.67	7.1X10-03	7.1X10-03	3.6X10-03	9.3X10-03	1.3X10-02	7.6X10-03	7.1X10-03	9.3X10-03	7.6X10-03	7.1X10-03	7.5X10-03	1.9E+01	4.49X10-12
117	3.69	5.20	5.92	15.31	0.64	8.3X10-03	8.3X10-03	4.2X10-03	1.1X10-02	1.5X10-02	8.9X10-03	8.2X10-03	1.1X10-02	8.9X10-03	8.3X10-03	8.8X10-03	2.3E+01	5.76X10-12
118	4.06	5.20	5.90	13.96	0.75	7.6X10-03	7.5X10-03	3.8X10-03	9.8X10-03	1.4X10-02	8.1X10-03	7.5X10-03	9.8X10-03	8.1X10-03	7.5X10-03	8.0X10-03	2.1E+01	5.49X10-12
119	4.10	5.39	6.07	14.53	0.85	7.9X10-03	7.9X10-03	3.9X10-03	1.0X10-02	1.5X10-02	8.4X10-03	7.9X10-03	1.0X10-02	8.4X10-03	7.9X10-03	8.3X10-03	2.2E+01	5.65X10-12
120	4.98	6.85	7.39	15.34	0.92	8.3X10-03	8.3X10-03	4.2X10-03	1.1X10-02	1.5X10-02	8.8X10-03	8.3X10-03	1.1X10-02	8.8X10-03	8.3X10-03	8.8X10-03	2.3E+01	5.65X10-12
121	5.73	7.22	8.44	15.97	0.93	8.7X10-03	8.7X10-03	4.4X10-03	1.2X10-02	1.6X10-02	9.2X10-03	8.6X10-03	1.2X10-02	9.2X10-03	8.6X10-03	9.1X10-03	2.4E+01	5.79X10-12
122	7.34	8.33	12.10	30.76	1.19	1.7X10-02	1.7X10-02	8.4X10-03	2.2X10-02	3.1X10-02	1.8X10-02	1.7X10-02	2.2X10-02	1.8X10-02	1.7X10-02	1.8X10-02	4.6E+01	7.12X10-12
123	3.42	4.10	5.50	14.81	0.77	8.0X10-03	8.0X10-03	3.7X10-03	9.5X10-03	1.5X10-02	8.3X10-03	8.0X10-03	9.5X10-03	8.3X10-03	8.0X10-03	8.2X10-03	2.2E+01	6.57X10-12
124	3.91	4.54	6.49	16.83	0.99	9.1X10-03	9.1X10-03	4.7X10-03	1.2X10-02	1.7X10-02	9.8X10-03	9.0X10-03	1.2X10-02	9.8X10-03	9.1X10-03	9.7X10-03	2.5E+01	3.78X10-12
125	4.21	5.13	7.49	20.98	0.79	1.1X10-02	1.1X10-02	5.6X10-03	1.4X10-02	2.1X10-02	1.2X10-02	1.1X10-02	1.4X10-02	1.2X10-02	1.1X10-02	1.2X10-02	3.1E+01	3.21X10-12
126	3.65	4.08	6.63	18.37	0.78	9.9X10-03	9.9X10-03	4.9X10-03	1.3X10-02	1.8X10-02	1.1X10-02	9.9X10-03	1.3X10-02	1.1X10-02	9.9X10-03	1.0X10-02	2.7E+01	3.21X10-12
127	3.77	5.48	5.24	13.33	0.85	7.2X10-03	7.2X10-03	3.6X10-03	9.1X10-03	1.3X10-02	7.6X10-03	7.2X10-03	9.1X10-03	7.6X10-03	7.2X10-03	7.6X10-03	2.0E+01	3.55X10-12
128	4.22	6.11	5.79	14.82	0.60	8.0X10-03	8.0X10-03	4.0X10-03	1.0X10-02	1.5X10-02	8.5X10-03	8.0X10-03	1.0X10-02	8.5X10-03	8.0X10-03	8.5X10-03	2.2E+01	3.96X10-12
129	3.99	4.87	6.86	18.29	0.50	9.9X10-03	9.9X10-03	4.9X10-03	1.3X10-02	1.8X10-02	1.1X10-02	9.8X10-03	1.3X10-02	1.1X10-02	9.9X10-03	1.0X10-02	2.7E+01	4.10X10-12
130	3.44	3.94	6.06	14.44	0.73	7.8X10-03	7.8X10-03	3.9X10-03	1.0X10-02	1.4X10-02	8.3X10-03	7.8X10-03	1.0X10-02	8.3X10-03	7.8X10-03	8.3X10-03	2.1E+01	7.43X10-12
131	3.63	4.21	6.54	14.05	0.72	7.6X10-03	7.6X10-03	4.0X10-03	1.1X10-02	1.4X10-02	8.3X10-03	7.5X10-03	1.1X10-02	8.3X10-03	7.5X10-03	8.2X10-03	2.1E+01	8.01X10-12
132	4.02	4.68	6.93	13.85	0.68	7.5X10-03	7.4X10-03	4.0X10-03	1.1X10-02	1.4X10-02	8.2X10-03	7.4X10-03	1.1X10-02	8.2X10-03	7.4X10-03	8.1X10-03	2.0E+01	6.67X10-12
133	3.51	4.09	5.69	14.26	0.73	7.7X10-03	7.7X10-03	3.8X10-03	9.6X10-03	1.4X10-02	8.2X10-03	7.7X10-03	9.6X10-03	8.2X10-03	7.7X10-03	8.1X10-03	2.1E+01	6.45X10-12
134	3.70	4.45	6.10	13.20	0.75	7.1X10-03	7.1X10-03	3.7X10-03	1.0X10-02	1.3X10-02	7.7X10-03	7.1X10-03	1.0X10-02	7.7X10-03	7.1X10-03	7.6X10-03	2.0E+01	6.90X10-12
135	3.47	4.20	5.76	14.13	0.70	7.6X10-03	7.6X10-03	3.9X10-03	1.0X10-02	1.4X10-02	8.2X10-03	7.6X10-03	1.0X10-02	8.2X10-03	7.6X10-03	8.1X10-03	2.1E+01	7.34X10-12
136	3.19	4.16	5.81	14.06	0.69	7.6X10-03	7.6X10-03	3.7X10-03	9.7X10-03	1.4X10-02	8.0X10-03	7.6X10-03	9.7X10-03	8.0X10-03	7.6X10-03	7.9X10-03	2.1E+01	7.72X10-12
137	3.20	3.44	5.99	12.21	0.67	6.6X10-03	6.6X10-03	3.4X10-03	9.1X10-03	1.2X10-02	7.1X10-03	6.5X10-03	9.1X10-03	7.1X10-03	6.6X10-03	7.0X10-03	1.8E+01	8.08X10-12
138	3.27	3.33	6.26	14.19	0.94	7.6X10-03	7.6X10-03	4.0X10-03	1.1X10-02	1.4X10-02	8.3X10-03	7.6X10-03	1.1X10-02	8.3X10-03	7.6X10-03	8.2X10-03	2.1E+01	7.86X10-12
139	3.15	3.40	5.90	14.69	0.65	7.9X10-03	7.9X10-03	3.9X10-03	1.0X10-02	1.5X10-02	8.4X10-03	7.9X10-03	1.0X10-02	8.4X10-03	7.9X10-03	8.3X10-03	2.2E+01	7.43X10-12
140	3.53	3.60	6.42	15.45	0.62	8.3X10-03	8.3X10-03	4.1X10-03	1.0X10-02	1.5X10-02	8.8X10-03	8.3X10-03	1.0X10-02	8.8X10-03	8.3X10-03	8.8X10-03	2.3E+01	7.26X10-12
141	3.44	3.61	5.85	15.63	0.66	8.4X10-03	8.4X10-03	4.2X10-03	1.1X10-02	1.6X10-02	9.0X10-03	8.4X10-03	1.1X10-02	9.0X10-03	8.4X10-03	8.9X10-03	2.3E+01	7.12X10-12
142	3.66	4.85	5.77	15.29	0.68	8.3X10-03	8.3X10-03	4.1X10-03	1.0X10-02	1.5X10-02	8.8X10-03	8.2X10-03	1.0X10-02	8.8X10-03	8.2X10-03	8.7X10-03	2.3E+01	6.99X10-12
143	3.59	4.74	6.54	15.06	0.61	8.1X10-03	8.1X10-03	4.2X10-03	1.1X10-02	1.5X10-02	8.7X10-03	8.1X10-03	1.1X10-02	8.7X10-03	8.1X10-03	8.6X10-03	2.2E+01	6.92X10-12
144	3.51	5.64	6.10	14.83	0.64	8.0X10-03	8.0X10-03	3.9X10-03	1.0X10-02	1.5X10-02	8.5X10-03	8.0X10-03	1.0X10-02	8.5X10-03	8.0X10-03	8.4X10-03	2.2E+01	6.88X10-12
145	3.34	5.05	5.60	14.34	0.59	7.8X10-03	7.8X10-03	3.8X10-03	9.7X10-03	1.4X10-02	8.2X10-03	7.7X10-03	9.7X10-03	8.2X10-03	7.7X10-03	8.2X10-03	2.1E+01	6.95X10-12
146	3.14	5.17	4.84	13.46	0.59	7.3X10-03	7.3X10-03	3.6X10-03	9.1X10-03	1.3X10-02	7.7X10-03	7.3X10-03	9.1X10-03	7.7X10-03	7.3X10-03	7.7X10-03	2.0E+01	7.26X10-12
147	3.36	5.21	4.41	12.05	0.80	6.5X10-03	6.5X10-03	3.2X10-03	8.2X10-03	1.2X10-02	6.9X10-03	6.5X10-03	8.2X10-03	6.9X10-03	6.5X10-03	6.9X10-03	1.8E+01	7.89X10-12
148	3.57	5.68	4.32	11.14	0.70	6.0X10-03	6.0X10-03	3.0X10-03	7.9X10-03	1.1X10-02	6.5X10-03	6.0X10-03	7.9X10-03	6.5X10-03	6.0X10-03	6.4X10-03	1.7E+01	8.69X10-12

149	3.16	4.95	4.62	11.83	0.61	6.4X10-03	6.4X10-03	3.2X10-03	8.4X10-03	1.2X10-02	6.9X10-03	6.3X10-03	8.4X10-03	6.9X10-03	6.4X10-03	6.8X10-03	1.8E+01	9.14X10-12
150	4.00	5.48	5.12	11.39	0.84	6.1X10-03	6.1X10-03	3.1X10-03	8.2X10-03	1.1X10-02	6.6X10-03	6.1X10-03	8.2X10-03	6.6X10-03	6.1X10-03	6.6X10-03	1.7E+01	9.39X10-12
151	4.02	5.23	5.67	16.36	0.99	8.9X10-03	8.9X10-03	3.8X10-03	8.9X10-03	1.6X10-02	8.9X10-03	8.9X10-03	8.9X10-03	8.9X10-03	8.9X10-03	8.9X10-03	2.5E+01	8.99X10-12
152	3.78	4.78	5.54	19.88	0.98	1.1X10-02	1.1X10-02	4.6X10-03	1.1X10-02	2.0X10-02	1.1X10-02	1.1X10-02	1.1X10-02	1.1X10-02	1.1X10-02	1.1X10-02	3.0E+01	8.67X10-12
153	4.84	6.84	6.32	27.36	0.93	1.5X10-02	1.5X10-02	6.4X10-03	1.5X10-02	2.8X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	4.1E+01	7.52X10-12
154	6.06	8.42	8.93	25.96	0.94	1.4X10-02	1.4X10-02	6.0X10-03	1.4X10-02	2.6X10-02	1.4X10-02	1.4X10-02	1.4X10-02	1.4X10-02	1.4X10-02	1.4X10-02	3.9E+01	6.88X10-12
155	7.12	9.48	11.27	21.85	0.95	1.2X10-02	1.2X10-02	5.2X10-03	1.4X10-02	2.2X10-02	1.2X10-02	1.2X10-02	1.4X10-02	1.2X10-02	1.2X10-02	1.2X10-02	3.3E+01	6.37X10-12
156	8.36	10.39	14.05	28.06	0.96	1.5X10-02	1.5X10-02	8.1X10-03	2.2X10-02	2.8X10-02	1.7X10-02	1.5X10-02	2.2X10-02	1.7X10-02	1.5X10-02	1.6X10-02	4.1E+01	5.90X10-12
157	9.05	10.59	15.63	37.04	0.94	2.0X10-02	2.0X10-02	1.0X10-02	2.7X10-02	3.7X10-02	2.2X10-02	2.0X10-02	2.7X10-02	2.2X10-02	2.0X10-02	2.1X10-02	5.5E+01	5.58X10-12
158	9.10	10.15	15.92	42.63	0.88	2.3X10-02	2.3X10-02	1.2X10-02	3.0X10-02	4.3X10-02	2.5X10-02	2.3X10-02	3.0X10-02	2.5X10-02	2.3X10-02	2.4X10-02	6.3E+01	5.28X10-12
159	8.39	9.03	14.70	42.97	0.77	2.3X10-02	2.3X10-02	1.1X10-02	2.9X10-02	4.3X10-02	2.5X10-02	2.3X10-02	2.9X10-02	2.5X10-02	2.3X10-02	2.4X10-02	6.4E+01	4.96X10-12
160	6.71	7.60	11.58	29.77	0.67	1.6X10-02	1.6X10-02	8.2X10-03	2.1X10-02	3.0X10-02	1.7X10-02	1.6X10-02	2.1X10-02	1.7X10-02	1.6X10-02	1.7X10-02	4.4E+01	4.57X10-12
161	6.35	7.64	10.64	23.32	0.71	1.3X10-02	1.3X10-02	6.6X10-03	1.8X10-02	2.3X10-02	1.4X10-02	1.3X10-02	1.8X10-02	1.4X10-02	1.3X10-02	1.4X10-02	3.4E+01	4.96X10-12
162	5.69	7.23	9.11	24.83	0.70	1.3X10-02	1.3X10-02	5.8X10-03	1.3X10-02	2.5X10-02	1.3X10-02	1.3X10-02	1.3X10-02	1.3X10-02	1.3X10-02	1.3X10-02	3.7E+01	5.34X10-12
163	4.97	6.59	7.53	26.84	0.68	1.5X10-02	1.5X10-02	6.2X10-03	1.5X10-02	2.7X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	4.0E+01	5.67X10-12
164	3.52	4.93	6.03	27.41	0.60	1.5X10-02	1.5X10-02	6.4X10-03	1.5X10-02	2.8X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	1.5X10-02	4.1E+01	6.29X10-12
165	3.27	4.14	5.88	26.21	0.58	1.4X10-02	1.4X10-02	6.1X10-03	1.4X10-02	2.6X10-02	1.4X10-02	1.4X10-02	1.4X10-02	1.4X10-02	1.4X10-02	1.4X10-02	3.9E+01	6.67X10-12
166	3.65	4.31	6.11	23.06	0.55	1.3X10-02	1.3X10-02	5.4X10-03	1.3X10-02	2.3X10-02	1.3X10-02	1.3X10-02	1.3X10-02	1.3X10-02	1.3X10-02	1.3X10-02	3.5E+01	7.17X10-12
167	3.81	4.74	6.03	18.33	0.53	9.9X10-03	9.9X10-03	4.3X10-03	9.9X10-03	1.8X10-02	9.9X10-03	9.9X10-03	9.9X10-03	9.9X10-03	9.9X10-03	9.9X10-03	2.7E+01	7.72X10-12
168	3.54	4.72	5.02	11.37	0.51	6.2X10-03	6.2X10-03	3.0X10-03	7.8X10-03	1.1X10-02	6.4X10-03	6.2X10-03	7.8X10-03	6.4X10-03	6.2X10-03	6.4X10-03	1.7E+01	8.37X10-12
169	3.28	4.36	4.88	10.21	0.47	5.5X10-03	5.5X10-03	2.8X10-03	7.4X10-03	1.0X10-02	5.9X10-03	5.5X10-03	7.4X10-03	5.9X10-03	5.5X10-03	5.9X10-03	1.5E+01	8.90X10-12
170	3.24	4.60	4.25	10.92	0.49	5.9X10-03	5.9X10-03	2.9X10-03	7.6X10-03	1.1X10-02	6.3X10-03	5.9X10-03	7.6X10-03	6.3X10-03	5.9X10-03	6.2X10-03	1.6E+01	9.12X10-12
171	2.75	4.29	4.52	13.01	0.50	7.0X10-03	7.0X10-03	3.5X10-03	8.9X10-03	1.3X10-02	7.5X10-03	7.0X10-03	8.9X10-03	7.5X10-03	7.0X10-03	7.4X10-03	1.9E+01	9.08X10-12
172	3.13	4.53	5.12	14.86	0.54	8.1X10-03	8.0X10-03	4.0X10-03	1.0X10-02	1.5X10-02	8.5X10-03	8.0X10-03	1.0X10-02	8.5X10-03	8.0X10-03	8.5X10-03	2.2E+01	8.72X10-12
173	3.45	4.05	5.61	16.33	0.69	8.8X10-03	8.8X10-03	4.4X10-03	1.1X10-02	1.6X10-02	9.4X10-03	8.8X10-03	1.1X10-02	9.4X10-03	8.8X10-03	9.3X10-03	2.4E+01	8.16X10-12
174	3.79	4.11	6.15	17.91	0.70	9.7X10-03	9.7X10-03	4.8X10-03	1.2X10-02	1.8X10-02	1.0X10-02	9.7X10-03	1.2X10-02	1.0X10-02	9.7X10-03	1.0X10-02	2.7E+01	7.41X10-12
175	4.03	4.39	6.54	19.05	0.55	1.0X10-02	1.0X10-02	5.1X10-03	1.3X10-02	1.9X10-02	1.1X10-02	1.0X10-02	1.3X10-02	1.1X10-02	1.0X10-02	1.1X10-02	2.8E+01	6.86X10-12
176	4.12	4.50	6.71	19.56	0.57	1.1X10-02	1.1X10-02	5.3X10-03	1.3X10-02	2.0X10-02	1.1X10-02	1.1X10-02	1.3X10-02	1.1X10-02	1.1X10-02	1.1X10-02	2.9E+01	6.57X10-12
177	4.90	8.56	6.78	19.87	0.66	1.1X10-02	1.1X10-02	5.3X10-03	1.4X10-02	2.0X10-02	1.1X10-02	1.1X10-02	1.4X10-02	1.1X10-02	1.1X10-02	1.1X10-02	2.9E+01	6.39X10-12
178	6.66	9.44	6.67	19.66	1.13	1.1X10-02	1.1X10-02	5.3X10-03	1.4X10-02	2.0X10-02	1.1X10-02	1.1X10-02	1.4X10-02	1.1X10-02	1.1X10-02	1.1X10-02	2.9E+01	6.36X10-12
179	5.71	7.12	6.28	18.79	1.16	1.0X10-02	1.0X10-02	5.0X10-03	1.3X10-02	1.9X10-02	1.1X10-02	1.0X10-02	1.3X10-02	1.1X10-02	1.0X10-02	1.1X10-02	2.8E+01	6.33X10-12
180	3.40	3.67	5.98	17.46	0.55	9.4X10-03	9.4X10-03	4.7X10-03	1.2X10-02	1.7X10-02	1.0X10-02	9.4X10-03	1.2X10-02	1.0X10-02	9.4X10-03	9.9X10-03	2.6E+01	6.38X10-12
181	3.34	3.55	5.81	15.43	0.86	8.3X10-03	8.3X10-03	4.1X10-03	1.0X10-02	1.5X10-02	8.8X10-03	8.3X10-03	1.0X10-02	8.8X10-03	8.3X10-03	8.8X10-03	2.3E+01	6.45X10-12
182	3.15	3.40	5.89	13.82	1.04	7.5X10-03	7.4X10-03	3.9X10-03	1.0X10-02	1.4X10-02	8.1X10-03	7.4X10-03	1.0X10-02	8.1X10-03	7.4X10-03	8.0X10-03	2.0E+01	6.64X10-12
183	3.36	3.58	6.16	12.80	0.61	6.9X10-03	6.9X10-03	3.7X10-03	9.9X10-03	1.3X10-02	7.6X10-03	6.8X10-03	9.9X10-03	7.6X10-03	6.9X10-03	7.5X10-03	1.9E+01	7.02X10-12
184	3.41	4.07	5.73	15.19	0.72	8.2X10-03	8.2X10-03	3.9X10-03	9.9X10-03	1.5X10-02	8.6X10-03	8.2X10-03	9.9X10-03	8.6X10-03	8.2X10-03	8.6X10-03	2.3E+01	7.03X10-12

Appendix C

Meteorology

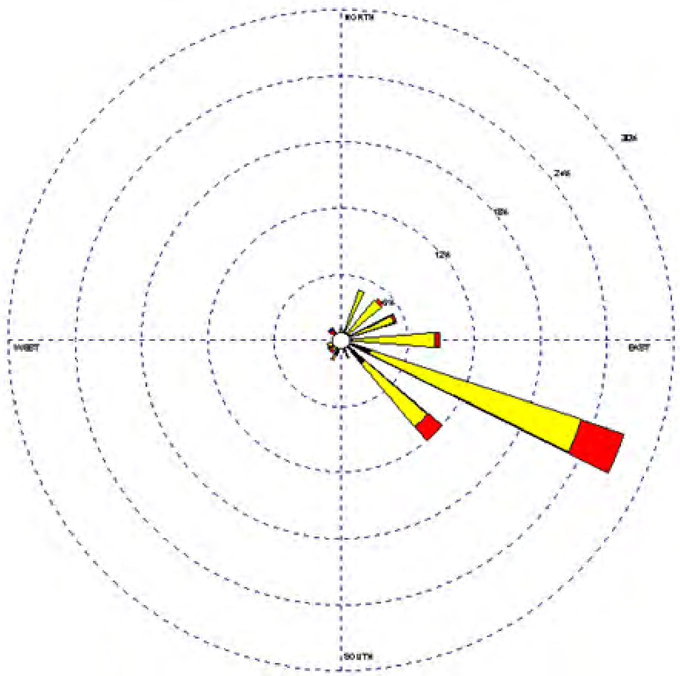
Appendix C Meteorology

Wind roses prepared from the CALMET data used in the modelling were compared to the wind roses from the Hydro Aluminium meteorological station for January – September 2014 (the available data from Hydro Aluminium). As shown in the following plots, there was good agreement between the data sets in terms of wind direction and wind speed. Wind patterns for the full year predominantly occurred within the northeasterly quadrant for both the Hydro Aluminium (measured) and Weston Aluminium (prognostic) data. The Hydro Aluminium data occurred more on the southerly side, while the Weston Aluminium data had a higher proportion of northeasterly winds

There was a large difference between the data sets in terms of the percentage of calm conditions, with the CALMET data predicting substantially lower calm periods. This is expected as the prognostic data were developed using TAPM, which typically predict fewer calm wind conditions than are measured at a given location. The percentage of calm conditions recorded at Hydro Aluminium are, however, much higher than would be expected for a site affected by valley drainage flow. Calm wind conditions typically produce poor dispersion conditions, resulting in greater pollutant concentrations close to the point of emission. As there are few receptors located close to the Weston Aluminium facility, the pollutant plumes are expected to be relatively dispersed and diluted before reaching most receptors.

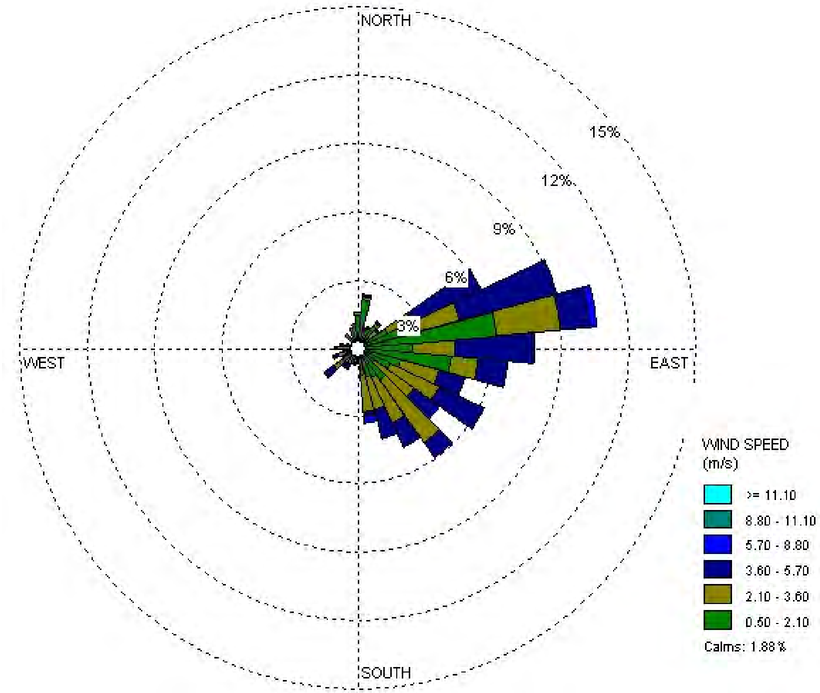
Wind Roses: Hydro Aluminium v CALMET

JANUARY 2014



Hydro Aluminium

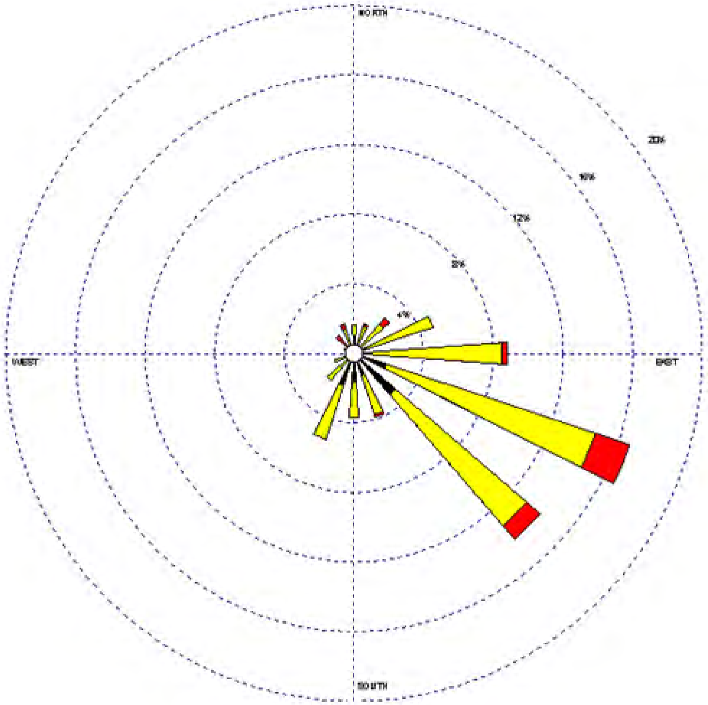
Calms: 26.21%



CALMET

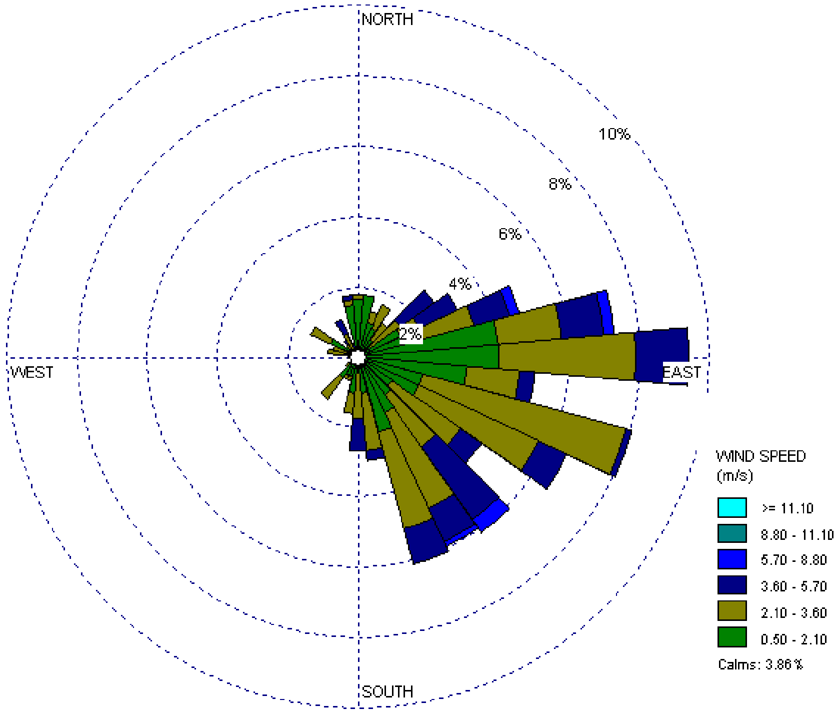
Calms: 1.88 %

FEBRUARY 2014



Hydro Aluminium

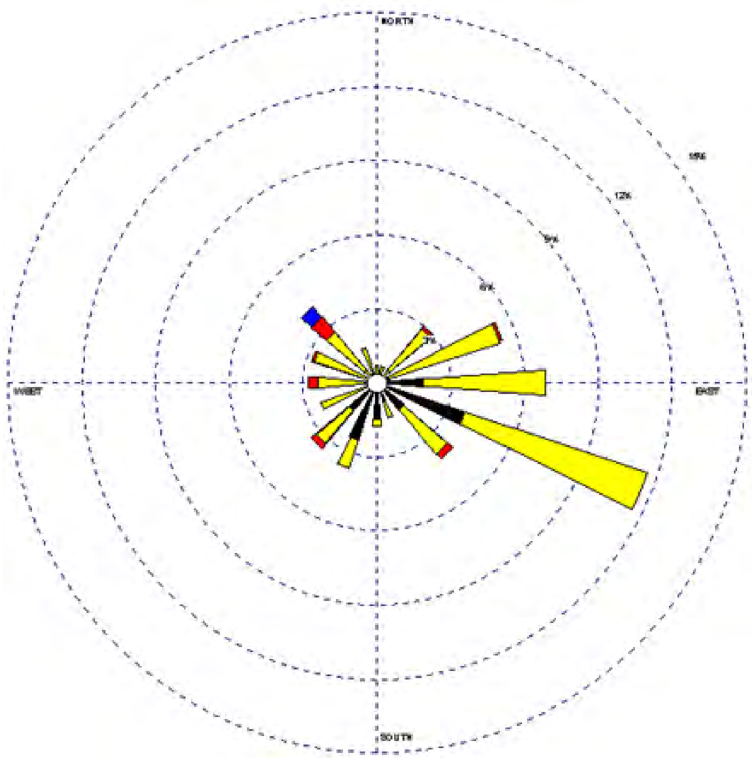
Calms: 29.61 %



CALMET

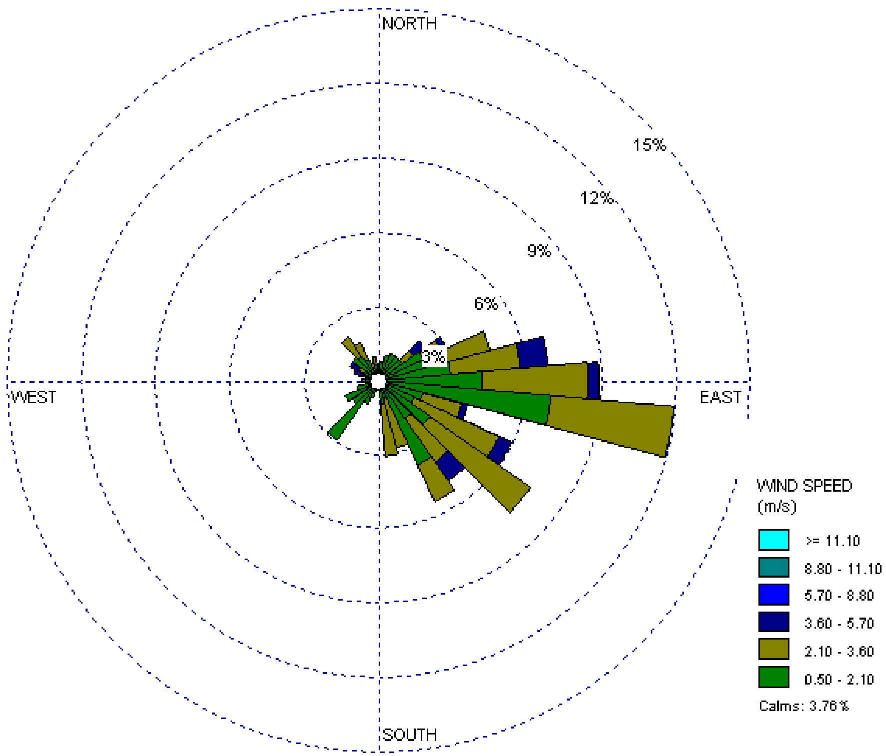
Calms: 3.86 %

MARCH 2014



Hydro Aluminium

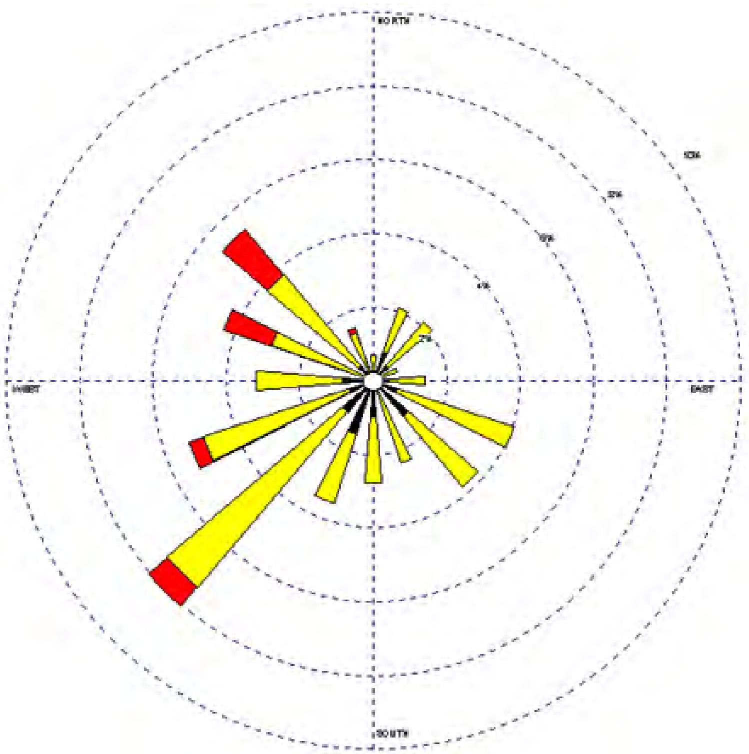
Calms: 43.95 %



CALMET

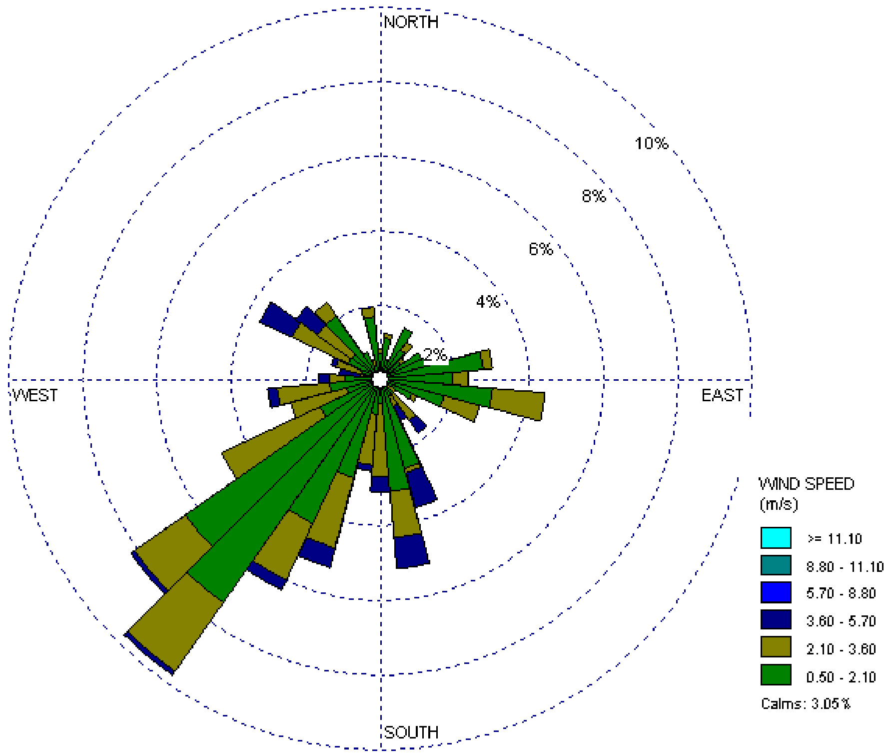
Calms: 3.76 %

APRIL 2014



Hydro Aluminium

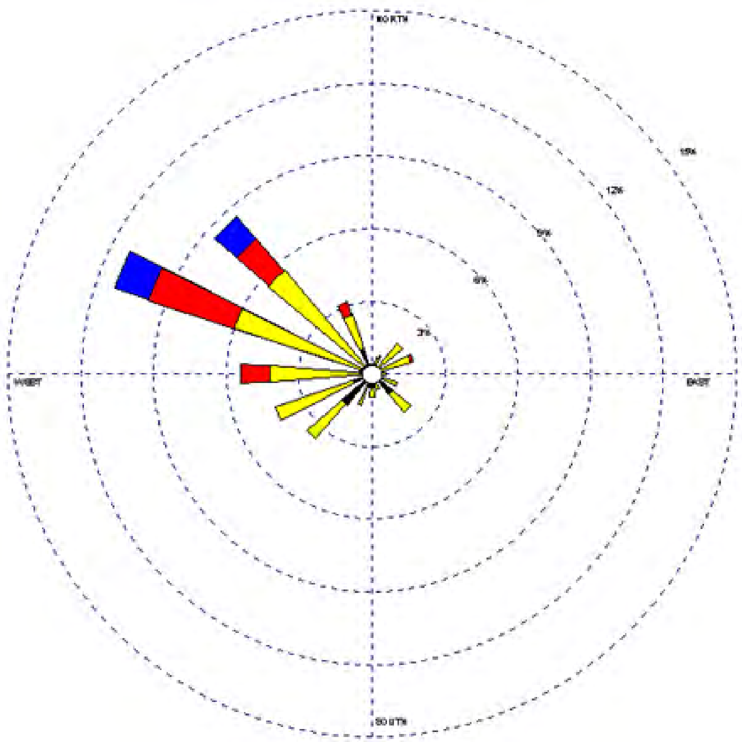
Calms: 48.89 %



CALMET

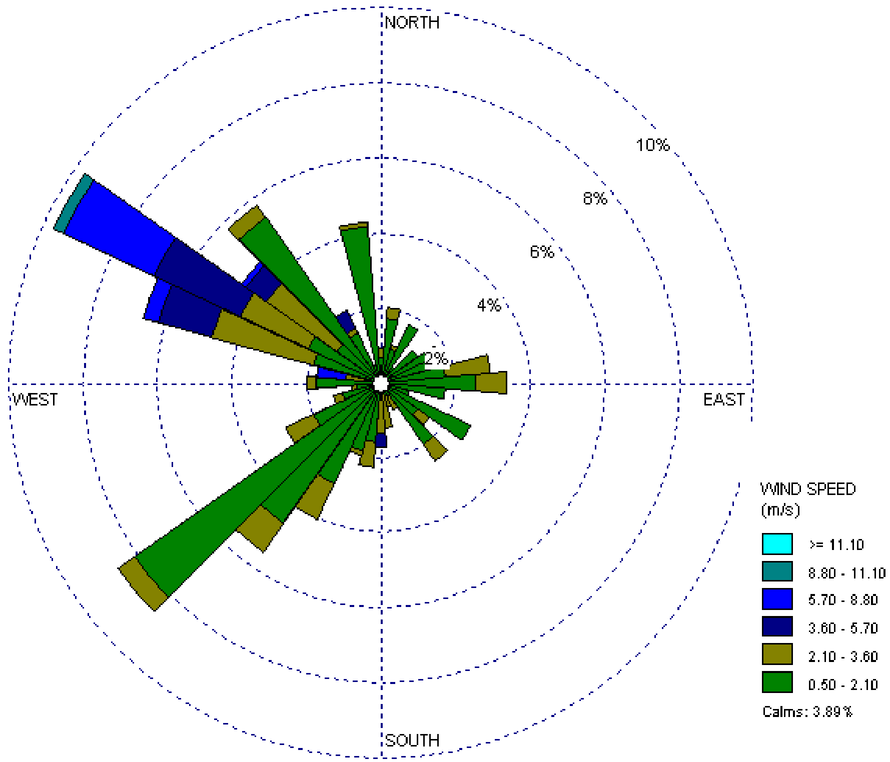
Calms: 3.05 %

MAY 2014



Hydro Aluminium

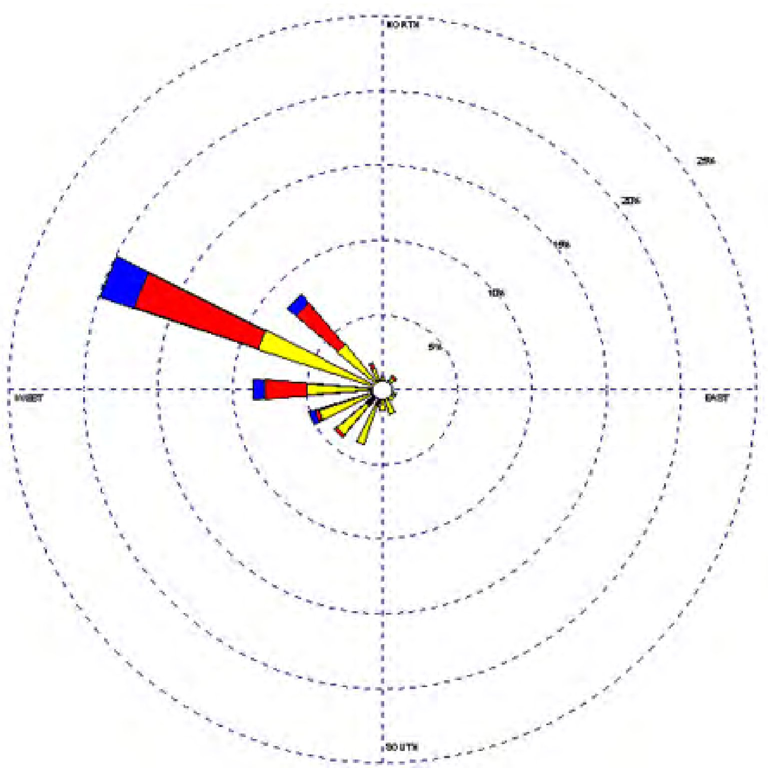
Calms: 52.59 %



CALMET

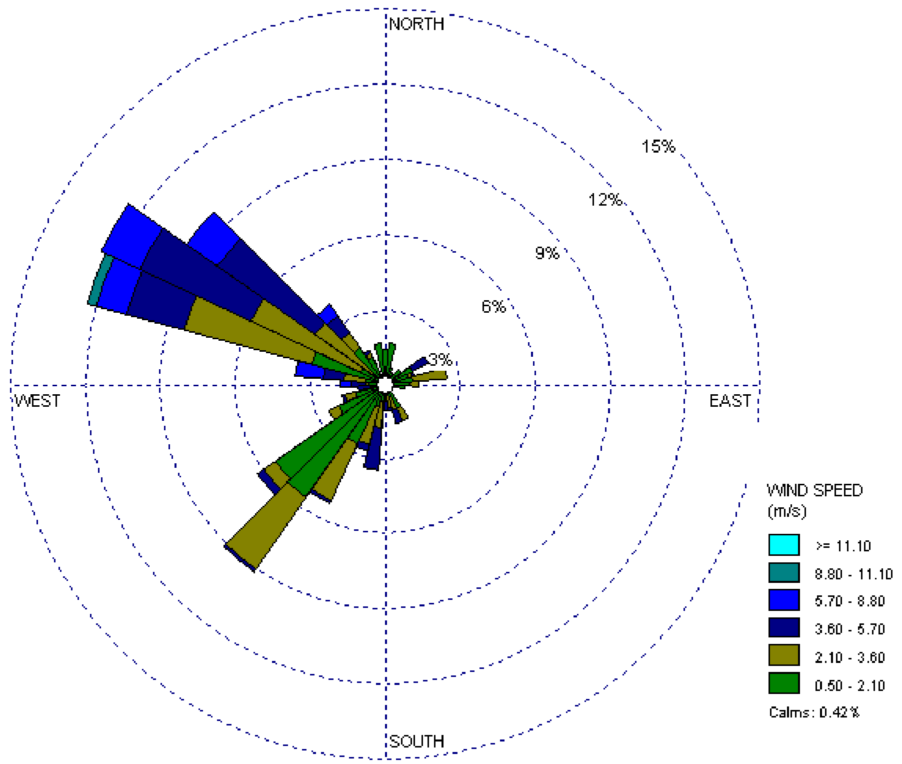
Calms: 3.89 %

JUNE 2014



Hydro Aluminium

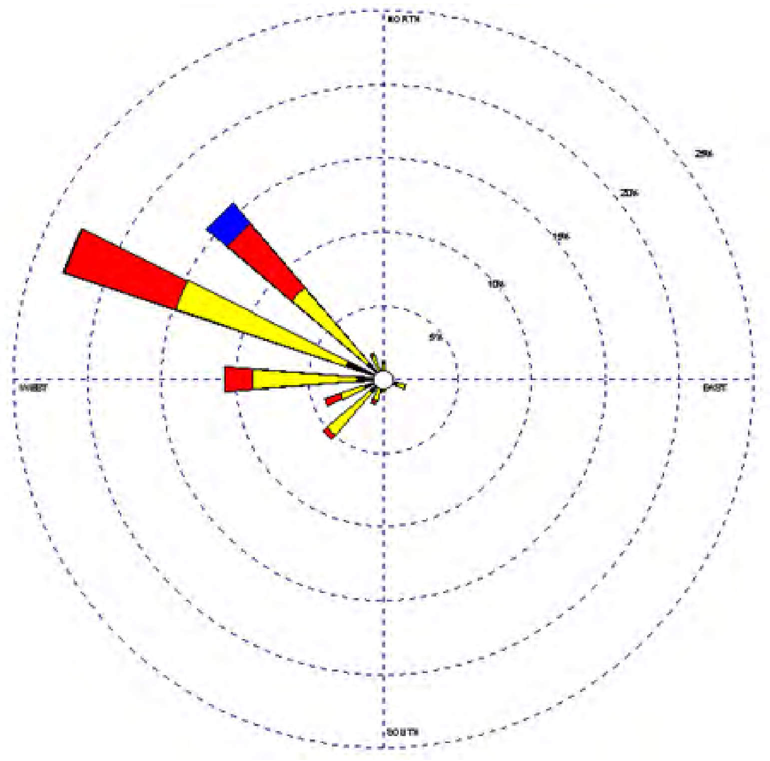
Calms: 39.44 %



CALMET

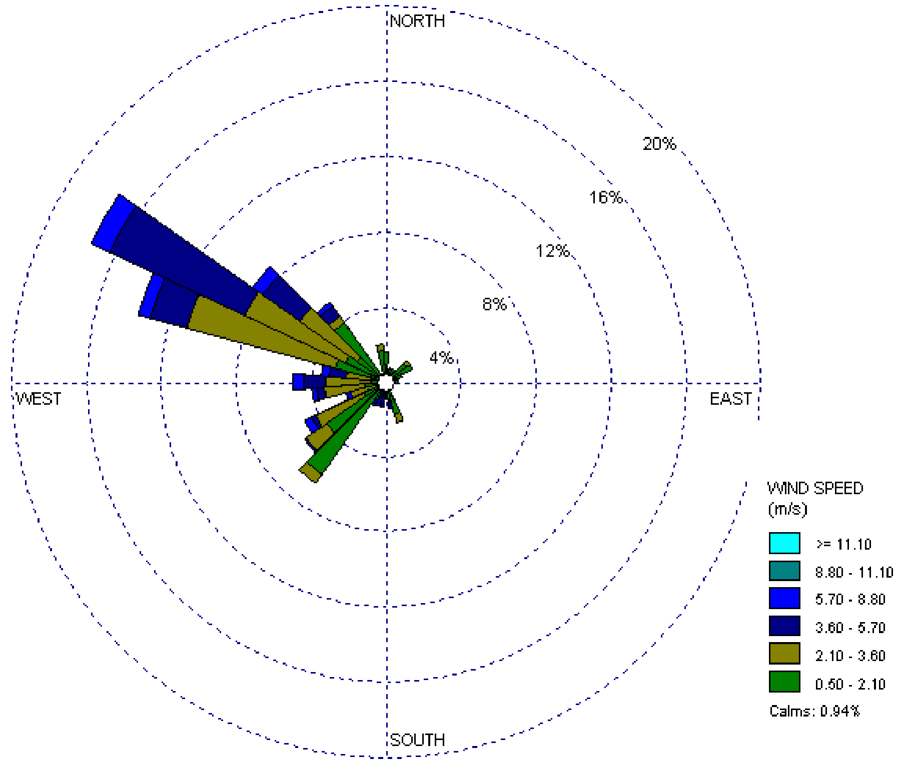
Calms: 0.42 %

JULY 2014



Hydro Aluminium

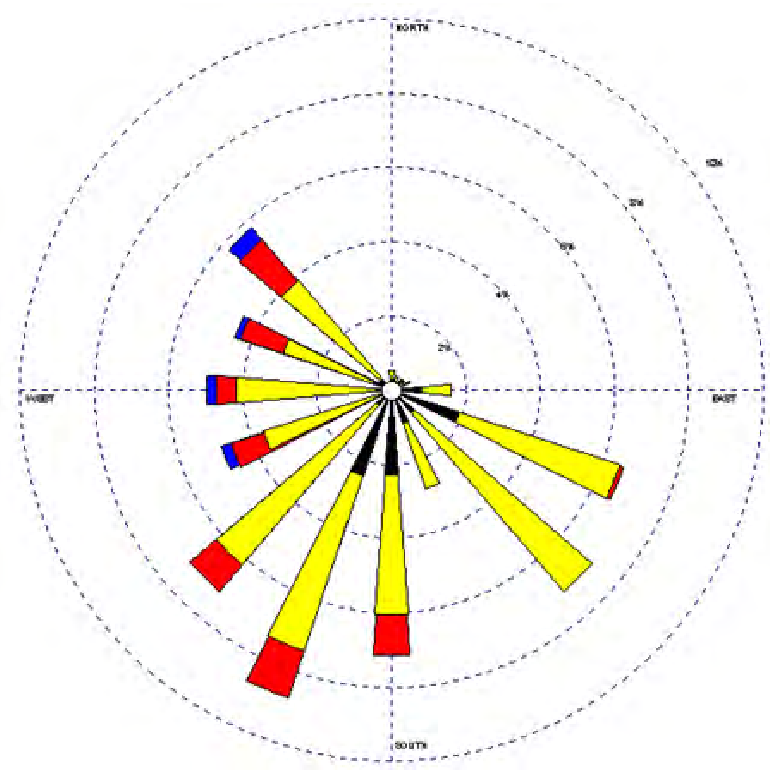
Calms: 32.12 %



CALMET

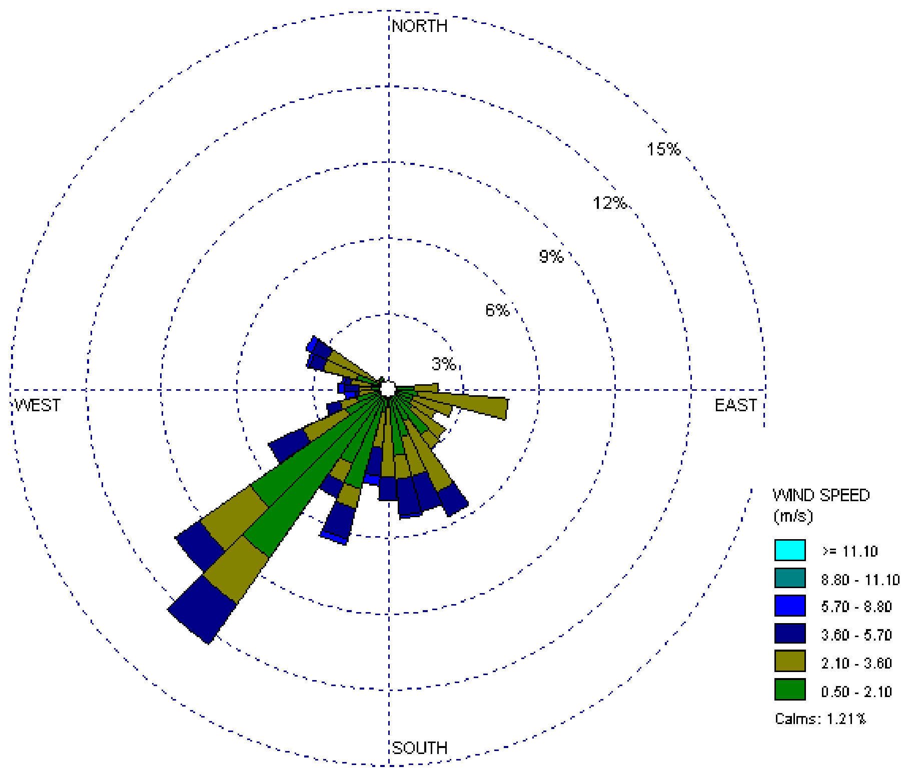
Calms: 0.94 %

AUGUST 2014



Hydro Aluminium

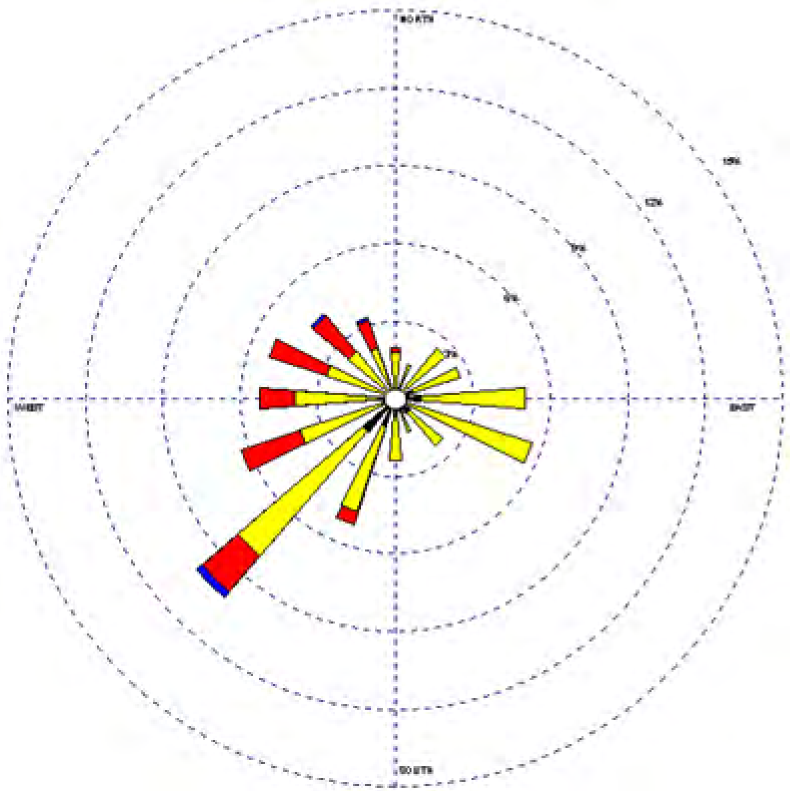
Calms: 36.83 %



CALMET

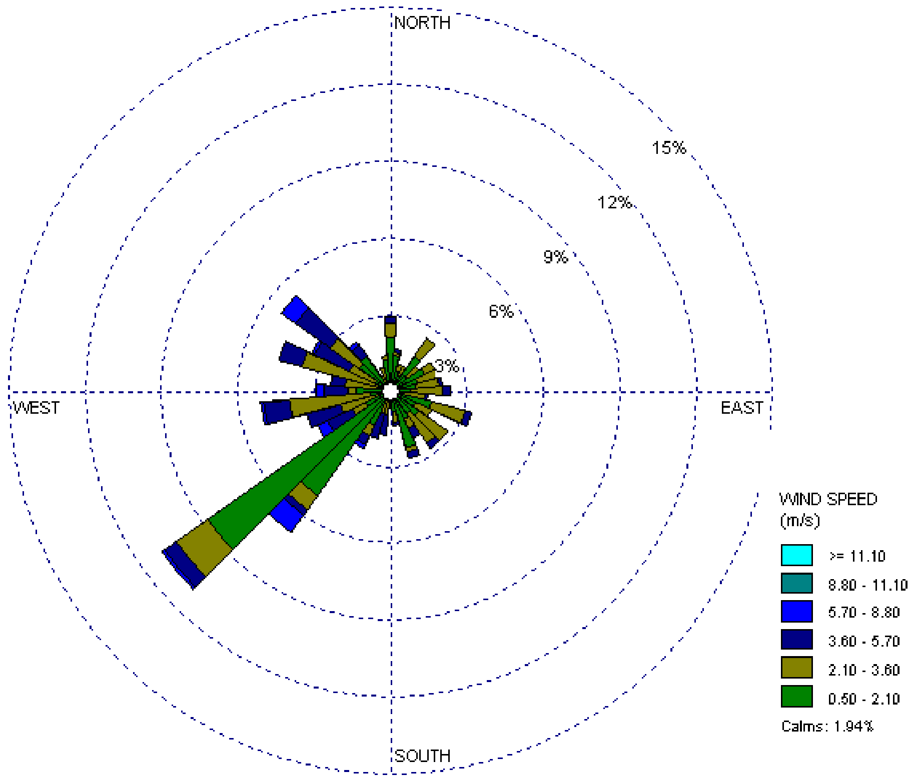
Calms: 1.21 %

SEPTEMBER 2014



Hydro Aluminium

Calms: 35.28 %

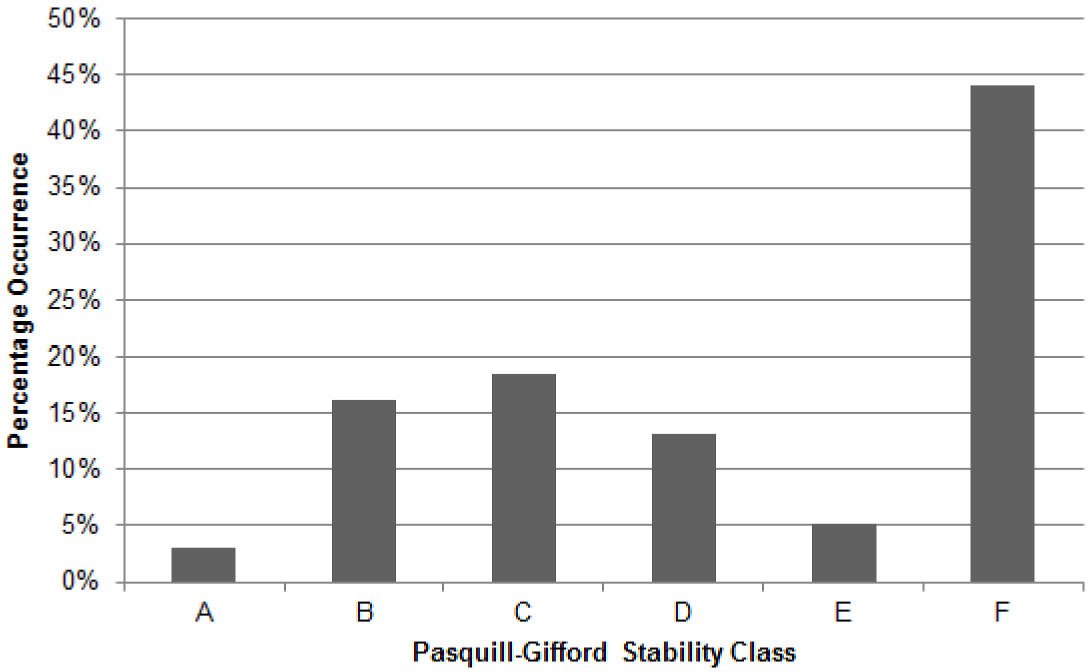


CALMET

Calms: 1.94 %

Atmospheric stability is a measure of atmospheric turbulence and the dispersive properties of the atmosphere. The Pasquill Gifford scheme specifies seven classes of atmospheric stability, which are designated A through G; most dispersion models, however, group Classes F & G together. Class A conditions are very unstable, while Class F conditions are stable, such as occur at night. Class D conditions are neutral.

The distribution of stability classes in the CALMET data is shown in the figure below. As shown, the greatest proportion of conditions were Class F, which represented 44 % of all the hours modelled. Class F stability conditions occur at night; as such, this result is not unexpected. Class C, B and D stability conditions occurred with a similar frequency,



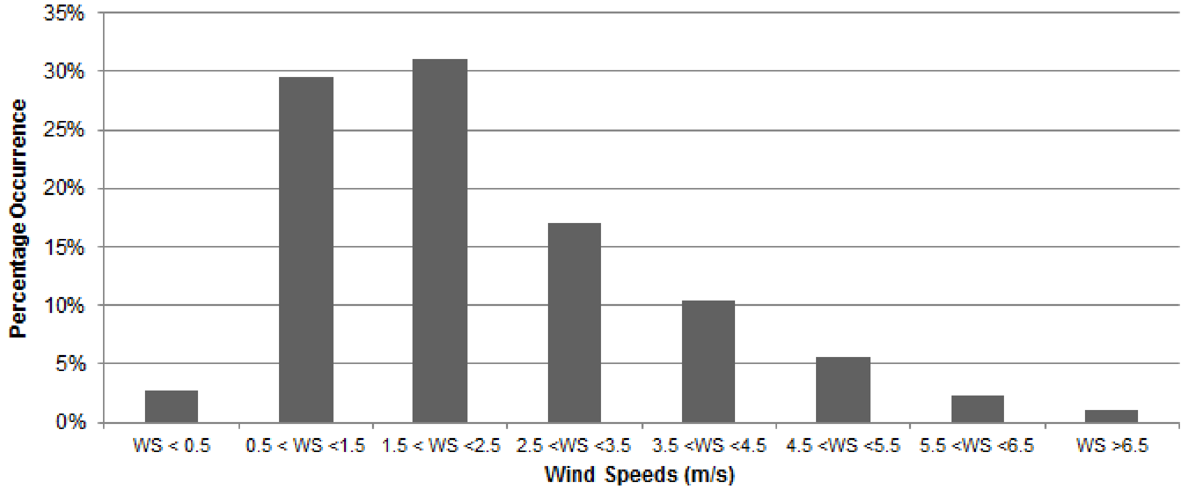
As shown below, the stability classes occurred at the expected times. Class E and F stability occurred only at night and during the early morning, while classes A, B and C occurred during the day; Class D stability (neutral conditions) occurred throughout the 24 hour period, but predominantly during daylight hours, with the highest occurrence in the late afternoon. This pattern is considered to be representative of the meteorological conditions in the area.

Stability Class by Hour of Day

Hour of Day	Stability Class					
	A	B	C	D	E	F
0	0	0	0	8	23	333
1	0	0	0	7	25	332
2	0	0	0	8	29	327
3	0	0	0	6	34	324
4	0	0	0	7	30	327
5	0	0	97	35	27	205
6	0	61	133	61	16	93
7	0	109	168	87	0	0
8	10	192	132	30	0	0
9	16	193	113	42	0	0
10	63	172	95	34	0	0
11	75	166	88	35	0	0
12	62	149	105	48	0	0
13	28	155	113	68	0	0
14	2	125	150	87	0	0
15	2	74	177	111	0	0
16	0	15	178	171	0	0
17	0	5	57	171	15	116
18	0	0	11	97	43	213
19	0	0	0	7	69	288
20	0	0	0	7	44	313
21	0	0	0	7	35	322
22	0	0	0	7	30	327
23	0	0	0	8	25	331

Stable conditions result in poorer dispersion and, subsequently, higher pollutant concentrations; as such, the high proportion of stable conditions (Class E and F combined) mean that the meteorological data used in the assessment are conservative.

The distribution of wind speeds was also reviewed. As shown below, the CALMET data contained mostly low wind speeds, with 64 % of the winds in the meteorological file being less than 2.5 m/s. Low wind speeds can also result in poorer dispersion.



As shown in the following table, the highest wind speeds occurred during Class C and D stability, which is expected as per DEC (2005a). Also as expected, Class A and Class F stability conditions were associated with low wind speeds.

Wind Speed (m/s)	Stability Class					
	A	B	C	D	E	F
0.5	27	33	32	0	0	147
1	48	168	109	0	0	648
1.5	32	239	142	0	0	1150
2	50	210	164	56	48	865
2.5	57	147	165	149	105	626
3	0	206	156	130	51	92
3.5	38	174	161	139	47	260
4	0	33	199	106	55	0
4.5	0	33	199	106	55	0
5	0	11	134	87	36	0
6	0	0	131	206	13	0
7	0	0	10	80	0	0
8	0	0	2	33	0	0
10	0	0	4	26	0	0
12	0	0	7	28	0	0
14	0	0	0	0	0	0

On the basis of the above analysis, the predicted meteorological conditions appear to provide a representative estimation for the local meteorologymeteorological and, as such, were considered appropriate for use in this assessment.

Appendix D

Discrete Receptor Locations

Appendix D Discrete Receptor Location

Table 24 Sensitive Receptors

ID	MGA 56 (m)		Land Use	ID	MGA 56 (m)		Land Use
	X	Y			Y	Y	
1	357580.2	6368434	Recreational	**93**	358169.6	6368525	Residential
2	356435.7	6368332	Recreational	**94**	358081.5	6368483	Residential
3	358173.5	6369639	Commercial/Industrial	**95**	357979.7	6368446	Residential
4	357561.1	6369198	Commercial/Industrial	**96**	357894.1	6368403	Residential
5	356414.7	6368854	Commercial/Industrial	**97**	357833.5	6368376	Residential
6	357334.2	6369029	Commercial/Industrial	**98**	357747.9	6368336	Residential
7	357197.1	6368893	Commercial/Industrial	**99**	357652.8	6368335	Residential
8	357044.7	6368809	Commercial/Industrial	**100**	357575.4	6368281	Residential
9	356931.2	6368706	Commercial/Industrial	**101**	357511.7	6368247	Residential
10	356684.2	6368519	Commercial/Industrial	**102**	357444.1	6368222	Residential
11	357128.4	6369008	Commercial/Industrial	**103**	357391.6	6368197	Residential
12	356830.4	6368829	Commercial/Industrial	**104**	357312.5	6368175	Residential
13	356685.2	6368720	Commercial/Industrial	**105**	357247.7	6368141	Residential
14	356612.7	6368628	Commercial/Industrial	**106**	357195.5	6368110	Residential
15	356515.6	6368586	Commercial/Industrial	**107**	357123.9	6368078	Residential
16	356448.6	6368556	Commercial/Industrial	**108**	357041.7	6368056	Residential
17	356338.8	6368549	Commercial/Industrial	**109**	356934.4	6367994	Residential
18	356361.1	6368657	Commercial/Industrial	**110**	356834.4	6367961	Residential
19	356464.9	6368736	Commercial/Industrial	**111**	356761	6367924	Residential
20	356400.1	6368765	Commercial/Industrial	**112**	356971.5	6368343	Residential
21	356345.1	6368782	Commercial/Industrial	**113**	356884.3	6368289	Residential
22	356714.9	6369079	Commercial/Industrial	**114**	356796.8	6368271	Residential
23	356929	6369037	Commercial/Industrial	**115**	356717.5	6368248	Residential
24	356777.5	6369277	Commercial/Industrial	**116**	356654.5	6368226	Residential
25	356939.9	6368564	Commercial/Industrial	**117**	356620	6368373	Residential
26	357099.4	6368456	Commercial/Industrial	**118**	356684.5	6368371	Residential
27	357185.2	6368422	Commercial/Industrial	**119**	356732.7	6368410	Residential
28	357248.6	6368455	Commercial/Industrial	**120**	356810.9	6368454	Residential

ID	MGA 56 (m)		Land Use	ID	MGA 56 (m)		Land Use
	X	Y			Y	Y	
29	357147.4	6368711	Commercial/Industrial	**121**	356872.9	6368503	Residential
30	357230.2	6368777	Commercial/Industrial	**122**	357467	6368788	Residential
31	357272.7	6368674	Commercial/Industrial	**123**	357091	6370000	Residential
32	357289.3	6368585	Commercial/Industrial	**124**	357741.6	6369959	Residential
33	357309.6	6368558	Commercial/Industrial	**125**	358088.4	6370204	Residential
34	357312.6	6368537	Commercial/Industrial	**126**	358154.8	6370188	Residential
35	357249.7	6368475	Commercial/Industrial	**127**	358206.1	6370072	Residential
36	357292.9	6368816	Commercial/Industrial	**128**	358313.6	6370019	Residential
37	357354.8	6368741	Commercial/Industrial	**129**	358403.1	6369962	Residential
38	357330.7	6368688	Commercial/Industrial	**130**	356493.8	6369540	Residential
39	357374	6368597	Commercial/Industrial	**131**	356574.2	6369475	Residential
40	357387.2	6368535	Commercial/Industrial	**132**	356380.2	6369869	Residential
41	357398.5	6368518	Commercial/Industrial	**133**	356336.1	6369757	Residential
42	357480.4	6368755	Commercial/Industrial	**134**	356372.7	6369622	Residential
43	357475.6	6368674	Commercial/Industrial	**135**	356391.4	6369531	Residential
44	357576.9	6368661	Commercial/Industrial	**136**	356402.7	6369463	Residential
45	357626	6368787	Commercial/Industrial	**137**	356371.7	6369290	Residential
46	357691.9	6368686	Commercial/Industrial	**138**	356369.3	6369239	Residential
47	358307.6	6368785	School TAFE	**139**	356357.4	6369175	Residential
48	358516.9	6368924	Residential	**140**	356351.3	6369136	Residential
49	358401.8	6368881	Residential	**141**	356347	6369082	Residential
50	358090.6	6368748	Residential	**142**	356342	6369032	Residential
51	358020.6	6368715	Residential	**143**	356331.2	6368986	Residential
52	357944.8	6368690	Residential	**144**	356319	6368942	Residential
53	357860.1	6368641	Residential	**145**	356305.4	6368888	Residential
54	357776.9	6368612	Residential	**146**	356295.8	6368839	Residential
55	357674.9	6368559	Residential	**147**	356291.6	6368788	Residential
56	357587.4	6368523	Residential	**148**	356282.4	6368738	Residential
57	357503	6368490	Residential	**149**	356271.6	6368708	Residential
58	357428.2	6368460	Residential	**150**	356267.8	6368641	Residential

ID	MGA 56 (m)		Land Use	ID	MGA 56 (m)		Land Use
	X	Y			Y	Y	
59	357365.4	6368424	Residential	**151**	356261	6368591	Residential
60	357311.5	6368395	Residential	**152**	356248.3	6368564	Residential
61	357230.1	6368368	Residential	**153**	356249.2	6368483	Residential
62	357149	6368326	Residential	**154**	356238.1	6368431	Residential
63	357094.3	6368304	Residential	**155**	356225.6	6368382	Residential
64	357040.8	6368276	Residential	**156**	356218.1	6368326	Residential
65	356976.4	6368254	Residential	**157**	356213.3	6368278	Residential
66	356910.5	6368233	Residential	**158**	356206.3	6368229	Residential
67	356773.7	6368158	Residential	**159**	356194.2	6368176	Residential
68	356689.2	6368137	Residential	**160**	355951.2	6368107	Residential
69	356744.2	6367995	Residential	**161**	355961.9	6368172	Residential
70	356850.6	6368026	Residential	**162**	355977.3	6368227	Residential
71	356949.1	6368066	Residential	**163**	355989.9	6368271	Residential
72	357038.3	6368110	Residential	**164**	356000.1	6368343	Residential
73	357112.4	6368139	Residential	**165**	356007.8	6368378	Residential
74	357186.4	6368176	Residential	**166**	356012.9	6368420	Residential
75	357279.5	6368260	Residential	**167**	356018.1	6368464	Residential
76	357368.9	6368253	Residential	**168**	356021.9	6368519	Residential
77	357430.3	6368279	Residential	**169**	356036	6368580	Residential
78	357590.5	6368343	Residential	**170**	356050.3	6368626	Residential
79	357672.9	6368385	Residential	**171**	356054.8	6368677	Residential
80	357747.9	6368412	Residential	**172**	356060.1	6368725	Residential
81	357804.3	6368446	Residential	**173**	356073.6	6368773	Residential
82	357885.3	6368482	Residential	**174**	356084.2	6368828	Residential
83	357973.3	6368502	Residential	**175**	356089.2	6368879	Residential
84	358079.2	6368556	Residential	**176**	356101.8	6368923	Residential
85	358156.7	6368589	Residential	**177**	356107.9	6368984	Residential
86	358448.7	6368729	Residential	**178**	356116.1	6369022	Residential
87	358547.3	6368770	Residential	**179**	356128.3	6369078	Residential
88	358615.3	6368712	Residential	**180**	356134.3	6369126	Residential

ID	MGA 56 (m)		Land Use	ID	MGA 56 (m)		Land Use
	X	Y			Y	Y	
89	358537.9	6368684	Residential	**181**	356139.1	6369175	Residential
90	358477.5	6368652	Residential	**182**	356146.7	6369219	Residential
91	358377.5	6368620	Residential	**183**	356161.9	6369288	Residential
92	358277.6	6368577	Residential	**184**	356265.7	6369535	Residential