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**AIR QUALITY IMPACT ASSESSMENT
OF THE ABC BIRKENHEAD CEMENT
FACILITY – 2H 2016**

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1.0 INTRODUCTION

AirLabs Environmental Pty Ltd (AirLabs) was commissioned by Adelaide Brighton Cement Limited (ABC) to conduct an air quality assessment of the ABC Birkenhead Cement Plant (the facility) located in Birkenhead, South Australia.

This assessment is based on data obtained during source sampling undertaken by Airlabs during October 2016 (Airlabs Report OCT16190.2, issued on 23rd February, 2017). The objective of this assessment is to numerically determine the air quality impacts beyond the facility's boundary. This is achieved by undertaking dispersion modelling.

In response to comments issued by the SA Environment Protection Authority (SA EPA) (correspondence date 7th November 2016, email to Tim Radimissis, from Gerard Hocking - Senior Marine Adviser), the following changes have been incorporated in this report:

- **Section 3 - Regulatory Guidelines** have been updated to reflect the changes in AAQ NEPM and South Australia's new Environment Protection (Air Quality) Policy 2016.
- **Meteorological Modelling** - Meteorology dataset from 2009 have been developed and used in dispersion modelling as year 2009 is considered a typical year and consistent with advice provided by SA EPA for impact assessment for other operations/facilities.
- **CALPUFF Dispersion Model** – Air quality impact assessment for this report have been carried out using CALPUFF dispersion model (instead of AUSPLUME) considering the coastal location of the facility.
- **The use of 1st rank values instead of 99.9th percentile** – Predicted ground level concentration have been assessed using 100th percentile values instead of 99.9th percentile.
- **Inclusion of Background Concentrations** – The Design Ground Level Pollutant Concentrations (DGLC) criteria have now been superseded with South Australia's new Environment Protection (Air Quality) Policy 2016. To compare the predicted concentrations from the facility with the new Air EPP criteria, inclusion of representative background is necessary. Background levels have been included for the criteria pollutants (NO₂, SO₂, CO and particulates) using observed values at NEPM monitoring stations in the vicinity of the facility.

This report presents a brief overview of the assessment methodology, an outline of the regulatory framework and a summary of the findings of the assessment.

2.0 SOURCE LOCATION AND DESCRIPTION

The Birkenhead facility manufactures cement used in the construction and mining industry. Based on previous modelling studies undertaken and Airlabs' knowledge of the facility, the main sources include the licenced Dry Process Kiln Stack (Stack 4A) and the Pre-Calciner Plant Stack (Stack 4B). Source parameters are discussed in the subsequent sections of this report.

Figure 1: Stack 4A and Stack 4B – ABC Birkenhead Facility

Dry Process Kiln Stack (Stack 4A)



Pre-Claciner Plant Stack (Stack 4B)

3.0 REGULATORY GUIDELINES

3.1 National Legislation

In June 1988, the National Environment Protection Council (NEPC) developed the Ambient Air Quality National Environmental Protection Measure (NEPM) which set uniform standards for air quality at the national level and included ambient air quality standards for carbon monoxide, nitrogen dioxide, photochemical oxidants (as ozone), sulphur dioxide, lead and particulate matter (PM₁₀ and PM_{2.5}). The National Environmental Protection (Air Toxics) Measure (NEPM, 2004) includes standards for toxics such as Polycyclic Aromatic Hydrocarbons (PAHs).

In December 2015, the NEPC approved a variation (NEPM, 2015) to the *Ambient Air Quality Measure* to incorporate annual and daily reporting standards for PM_{2.5} of 8 µg/m³ and 25 µg/m³ respectively.

3.2 South Australia Legislation

The Environment Protection Air Quality Policy 2016 (SA Air EPP, 2016) came into effect on 23rd July 2016 and provides a legislative basis for air quality regulation and management in the state of South Australia. The policy simplifies the regulation of air quality by consolidating several previous guidelines and environment protection policies.

The EPA also recognises the air quality standards set by National Environmental Protection Council under the National Environmental Protection (Ambient Air Quality) Measure (NEPM, 2015) and National Environmental Protection (Air Toxics) Measure (NEPM, 2004).

3.3 Summary of Air Criteria for the Project Goals

The air quality criteria adopted for the Project considering the local and national regulatory guidelines are summarised in **Table 1**.

Table 1: Air Quality Criteria for the Project

Pollutant	Averaging Period	Criteria ($\mu\text{g}/\text{m}^3$)	Classification
Criteria Pollutants			
Nitrogen dioxide (NO ₂)	1 hour	250	Toxicity
Nitrogen dioxide (NO ₂)	Annual	60	Toxicity
Sulfur dioxide (SO ₂)	1 hour	570	Toxicity
Sulfur dioxide (SO ₂)	24 hours	230	Toxicity
Sulfur dioxide (SO ₂)	Annual	60	Toxicity
Carbon monoxide (CO)	1 hour	31,240	Toxicity
Carbon monoxide (CO)	8 hour	11,250	Toxicity
Particulate matter (PM ₁₀)	24 hours	50	Health
Particulate matter (PM _{2.5})	24 hours	25	Health
Particulate matter (PM _{2.5})	Annual	8	Health
Metals, Metalloids and Metal Fumes			
Antimony and compounds	3 minutes	19	Toxicity
Arsenic and compounds	3 minutes	0.19	Toxicity
Barium (soluble compound)	3 minutes	19	Toxicity
Benzene	3 minutes	58	IARC Group 1 Carcinogen
Benzene	Annual	10	IARC Group 1 Carcinogen
Beryllium and compounds	3 minutes	0.008	IARC Group 1 Carcinogen
Cadmium and compounds	3 minutes	0.036	Toxicity , IARC Group 1 Carcinogen
Chromium (III) compounds	3 minutes	19	Toxicity
Chromium (VI) compounds	3 minutes	0.19	IARC Group 1 Carcinogen
Copper fumes	3 minutes	7.3	Toxicity
Iron oxide fumes	3 minutes	190	Toxicity
Lead (as particles)	Annual	0.5	Toxicity
Magnesium oxide fumes	3 minutes	360	Toxicity
Manganese and compounds	3 minutes	36	Toxicity
Mercury - inorganic	3 minutes	4	Bioaccumulation
Mercury - organic	3 minutes	0.36	Bioaccumulation
Nickel and compounds	3 minutes	0.36	IARC Group 1 Carcinogen
Zinc oxide	3 minutes	190	Toxicity

Pollutant	Averaging Period	Criteria ($\mu\text{g}/\text{m}^3$)	Classification
Polycyclic Aromatic Hydrocarbons (PAH)			
PAH (Bap-TEQ _{PAH})	3 minutes	0.8	IARC Group 1 Carcinogen
PAH (Bap-TEQ _{PAH})	Annual	0.0003	IARC Group 1 Carcinogen
Acid Gases			
Hydrogen chloride	3 minutes	270	Toxicity
Halogens			
Chlorine	3 minutes	110	Toxicity
Fluoride	24 hours	3	Bioaccumulation
	7 days	2	Bioaccumulation
	90 days	1	Bioaccumulation

4.0 ASSESSMENT METHODOLOGY

In order to predict the impacts from 4A and 4B stacks, dispersion modelling has been used, details of which are presented in this section of the report.

4.1 Meteorological Modelling

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. The local meteorology at the site plays a significant role in understanding the pollutant transport and dispersion mechanisms, and in order to adequately characterise the local meteorological conditions, information is needed on key parameters such as prevailing wind regime, mixing depth, atmospheric stability, ambient temperatures, rainfall and relative humidity.

For this assessment, the meteorological model ‘The Air Pollution Model (TAPM) (Version 4.0.5)’ was used to generate the prognostic output. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which is used to predict three-dimensional meteorological data and air pollution concentrations. TAPM allows users to generate synthetic observations by referencing in-built databases (e.g. terrain information, synoptic scale meteorological observations, vegetation and soil type etc.) which are subsequently used in generating site-specific hourly meteorological data (Hurley P.J., 2008). Hourly varying wind speed and wind direction data from the North Western Adelaide Le Fevre 1 Monitoring station (located 1 km south west of the facility) was assimilated into TAPM to nudge the predicted solution towards the observation.

Details of the TAPM configuration for this project are outlined in **Table 2**.

Table 2: TAPM Model Configuration for the Project

Parameter	Value
Year of analysis	2009 (01/01/2009 to 31/12/2009)
Centre of analysis (Easting, Northing) (m)	271636, 6142852 (UTM Zone 54 S)
Number of grids (spacing)	4 (30km, 10km, 3km, 1km)
Grid dimensions (nx, ny, nz)	25, 25, 25
Data assimilation	North Western Adelaide Le Fevre 1 Met station

CALMET (version 6.4.0) was used to derive meteorological fields at 100 m resolution over a 10 km x 10 km modelling domain centred over the Project site.

The Geophysical dataset for CALMET contains terrain and land use information for the modelling domain. For this assessment, terrain for the CALMET grid was extracted from 1- arc second (30 m) spaced elevation data obtained via NASA’s Shuttle Radar Topography Mission (SRTM, 2000). A three-dimensional view of the terrain data at 100 m resolution overlaid over the aerial base map is shown in **Figure 2**. The figure highlights the relatively flat terrain along the coastline and area in the vicinity of the facility.

The land use or land cover data for the modelling domain as shown in **Figure 3** was manually generated based on aerial images from Google earth. The geotechnical parameters for the land use classification were adopted from the default CALMET corresponding land use categories.

Using geophysical datasets, prognostic and surface observational data, CALMET then develops the higher resolution flow fields to include (in general) the kinematic effects of terrain, slope flows,

blocking effects and 3-dimensional divergence minimisation as well as differential heating and surface roughness associated with variations in land use categories across the modelling domain.

CALMET was ran in No-Obs mode in accordance with the 'Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia' (OEH, 2011).

The domain size, grid resolution and other configuration of the CALMET model is specified in **Table 3**.

Table 3: CALMET Model Configuration for the Project

Parameter	Value
Year of Analysis	2009
No. X Grid Cells (NX), No. Y Grid Cells (NY)	101, 101
Grid spacing (DGRIDKM) (km)	0.1
XORIGIN (km), YORIGIN (km)	266.56132, 6137.79521
No. of Vertical Levels	10
Radius of influence RMAX1,RMAX2,RMAX3 (km)	10,10,10
Radius of influence of terrain TERRAD (km)	10
No Observation Mode (NOOBS)	2 (i.e. use MM4/MM5/3D for surface, overwater, and upper air data)
Terrain data	1-arc second, 30 m resolution (SRTM, 2000)
Land cover data	Manually generated from aerial imagery

Figure 2: CALMET – Simulated Terrain at 100 m Resolution (10 km x 10 km Domain)

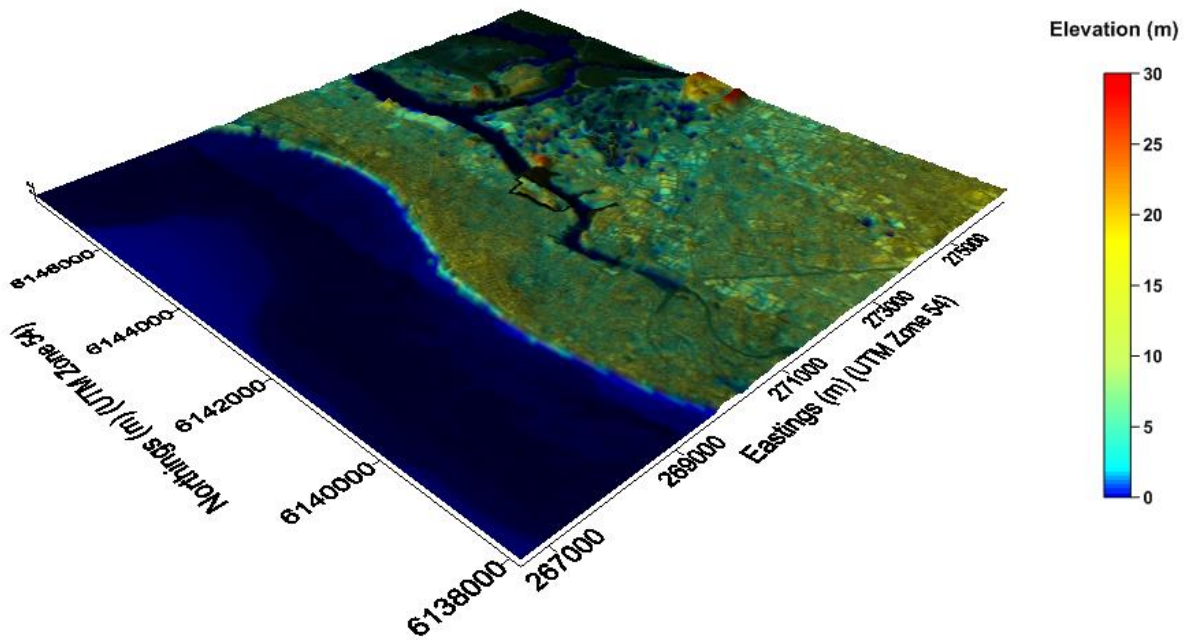
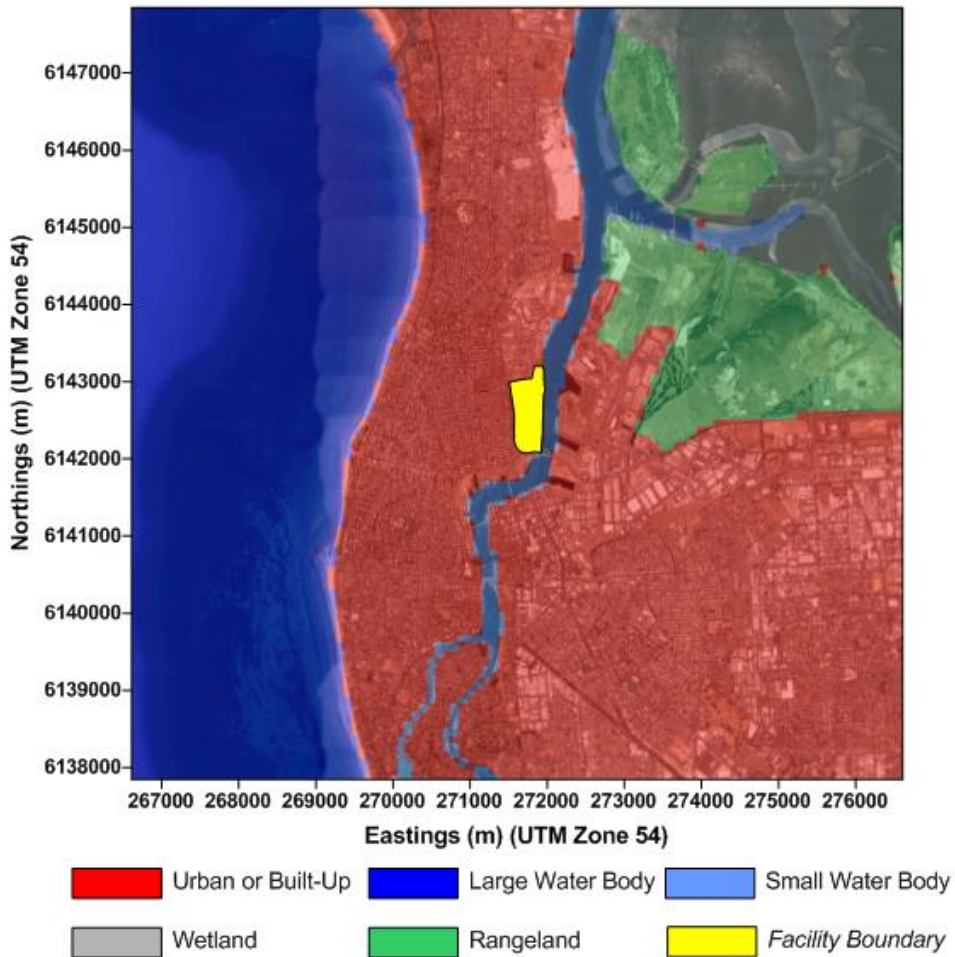
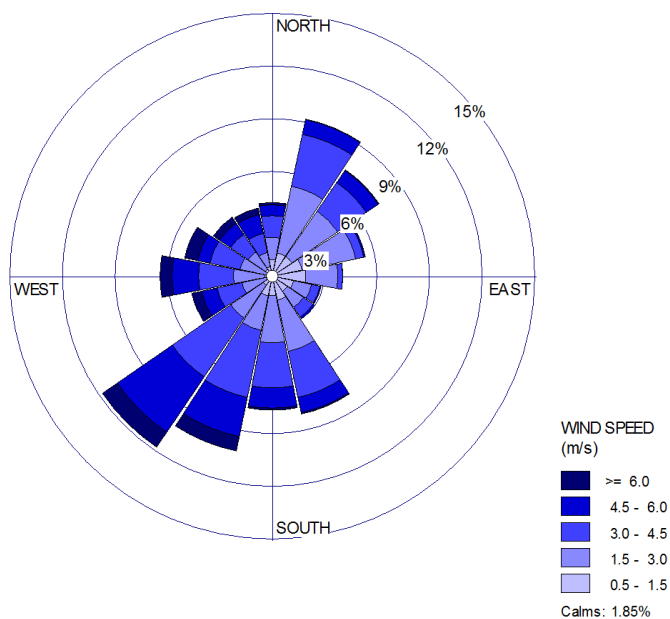


Figure 3: CALMET – Simulated Land Cover at 100 m Resolution (10 km x 10 km Domain)



Hourly wind speeds and directions for calendar year 2009 were extracted from the CALMET output at the centre of the facility and is visually presented in the form of wind roses in **Figure 4**. Winds are dominant from southwest direction followed by northeast. Infrequent winds are observed from other directions.

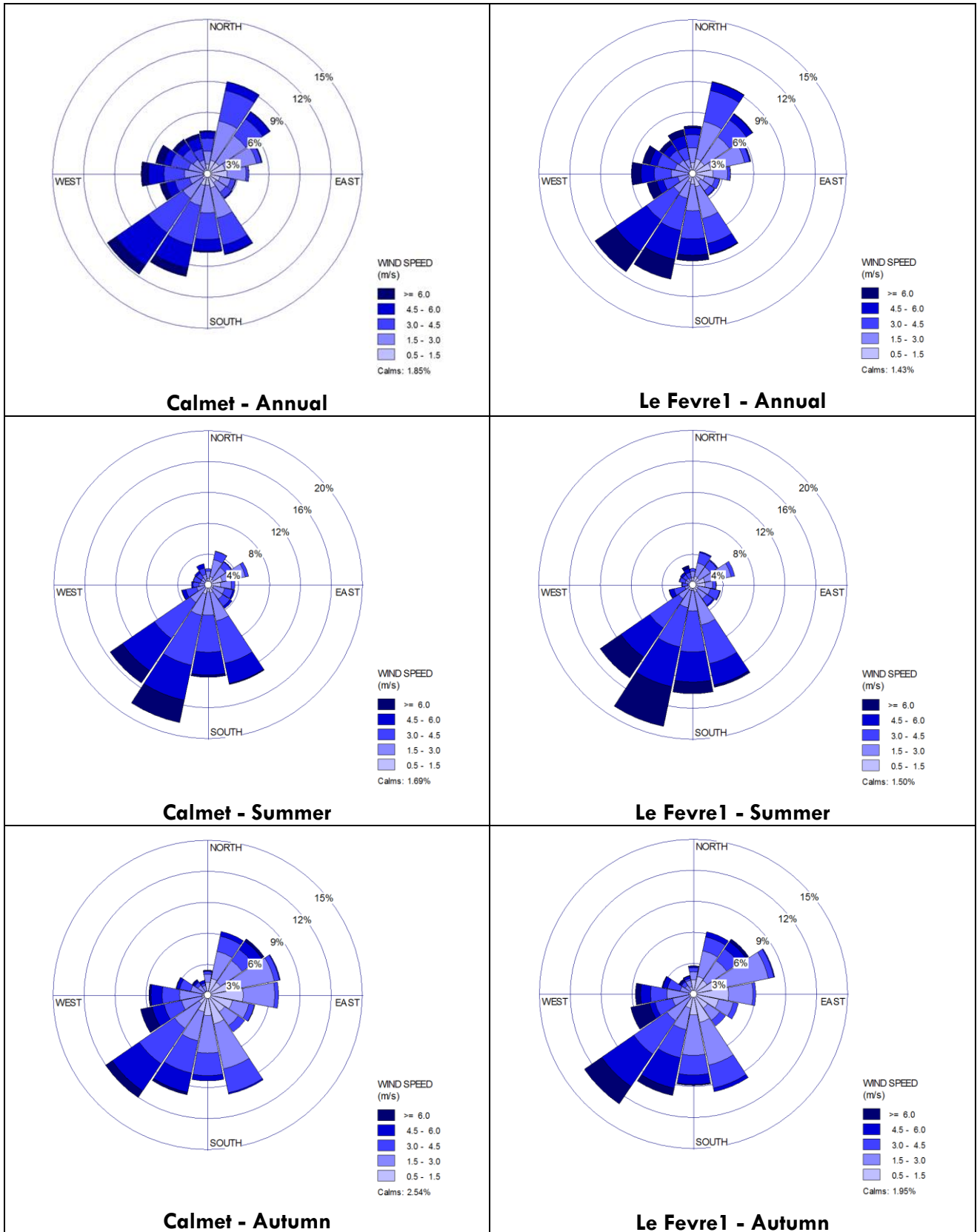
Figure 4: CALMET Annual Wind Roses for Meteorological Year – 2009



4.2 Comparison of Observed Le Fevre 1 Meteorological Data with Model Data

Comparison of annual and season winds observed at the Le Fevre1 monitoring station (located 1.0 km southwest of the facility) with Calmet predicted winds at the facility location is presented in **Figure 4**. Observed wind pattern at the Le Fevre 1 station throughout the year are similar to that of simulated winds predicted by Calmet. Comparison of the wind class frequency distribution (**Figure 6**) shows that Calmet predicted slightly higher percentage of calms and lower percentage of higher wind speeds compared to Le Fevre1 observations. Occurrence of higher percentage of calms may lead to poor dispersion and higher predicted pollutant concentration in the vicinity of source. However the difference in Calmet predicted and observed (Le Fevre1) calms percentage is not significant to cause erroneous predictions from the model.

Figure 5: Comparison of Annual and Seasonal Wind Roses for Meteorological Year – 2009



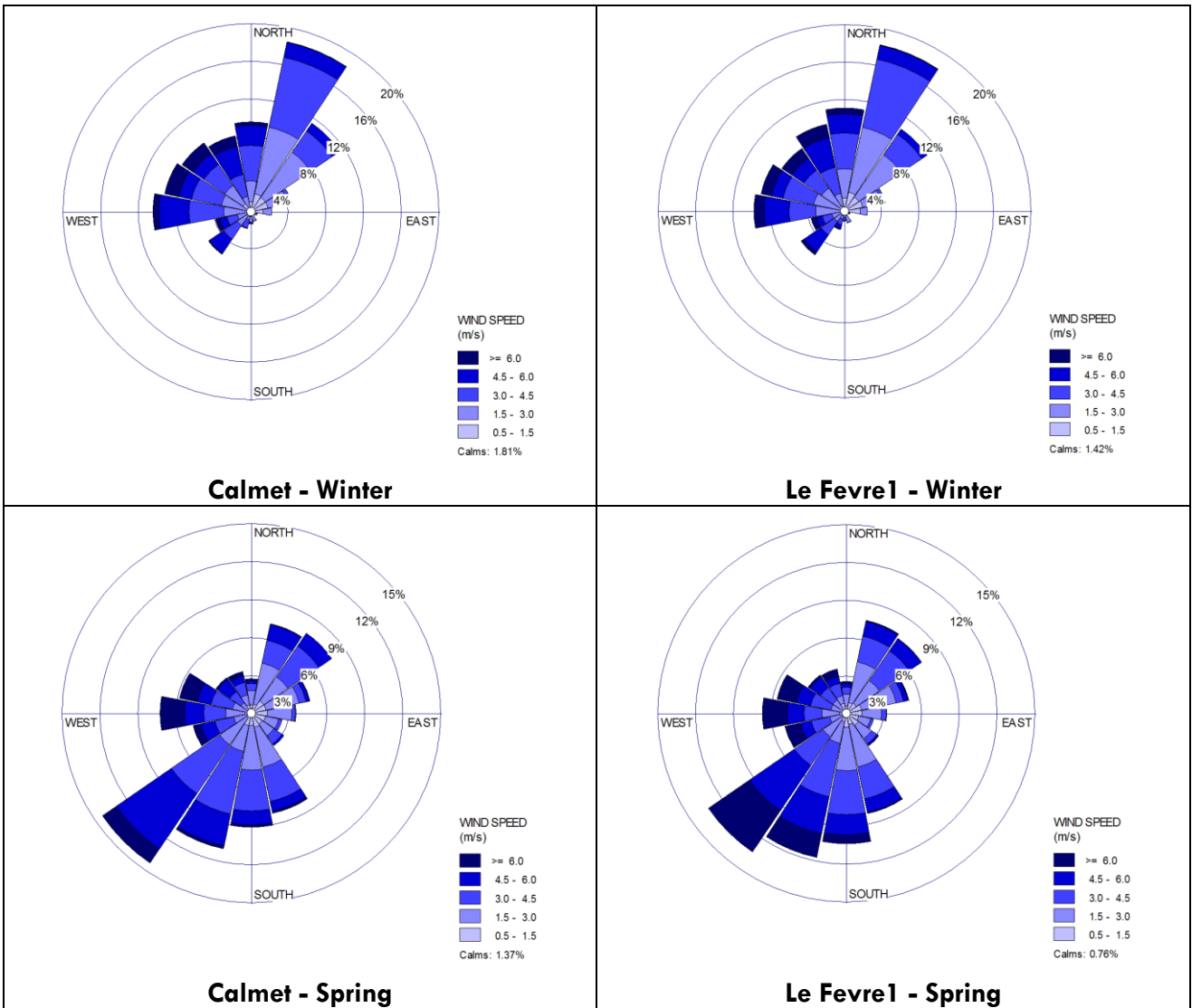
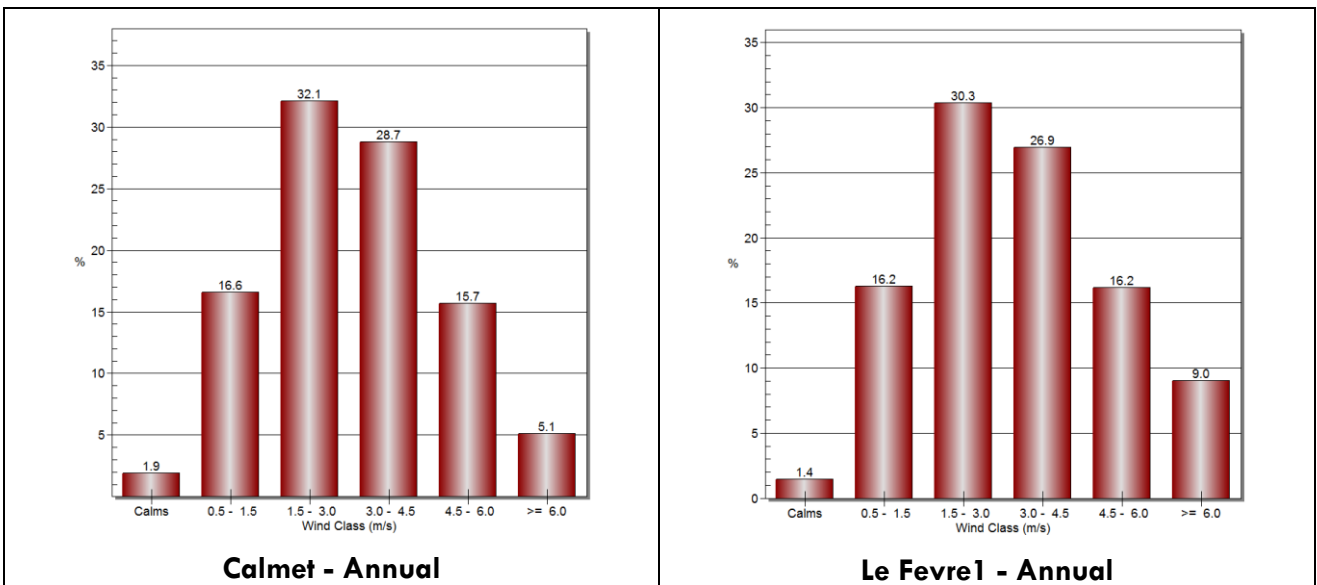
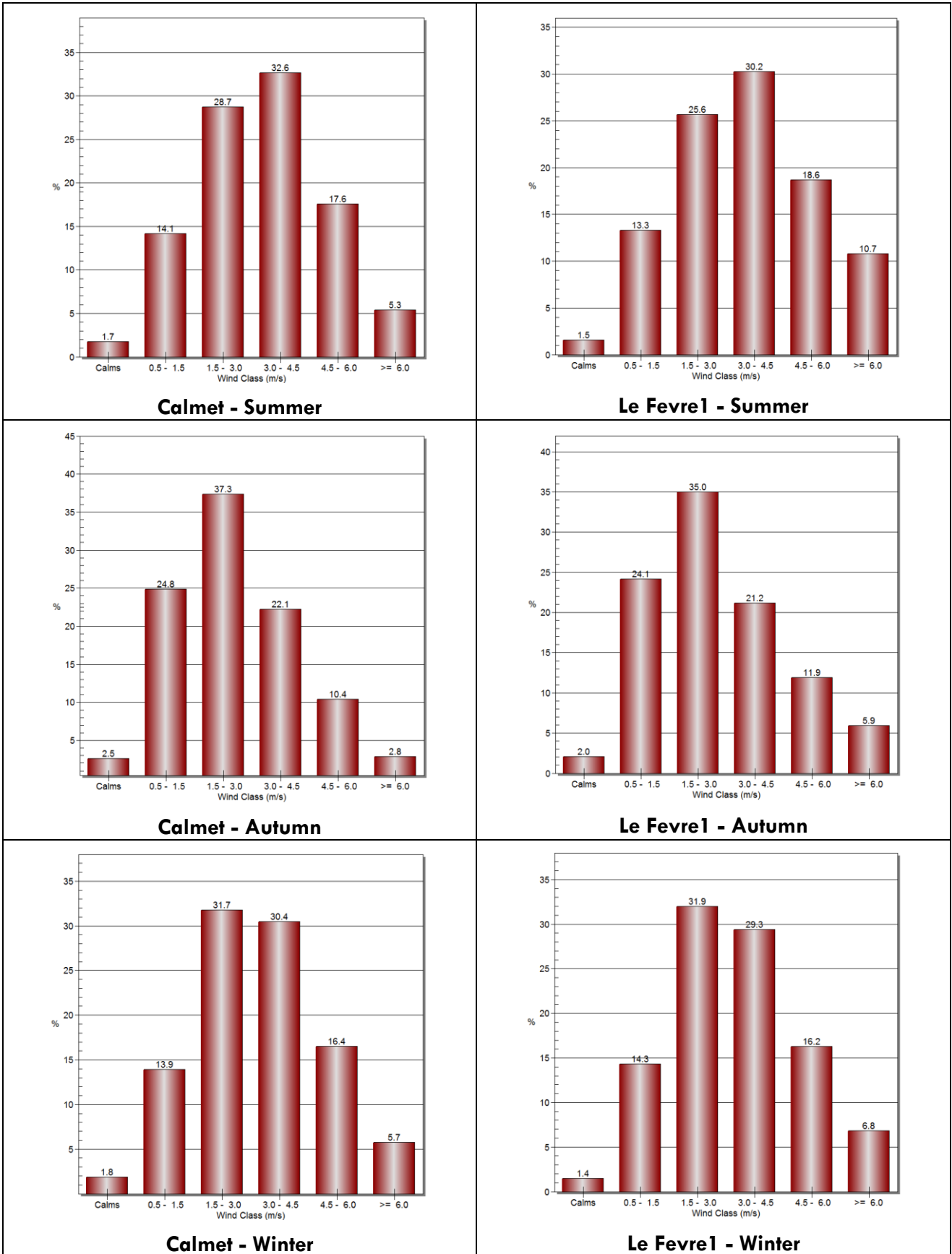
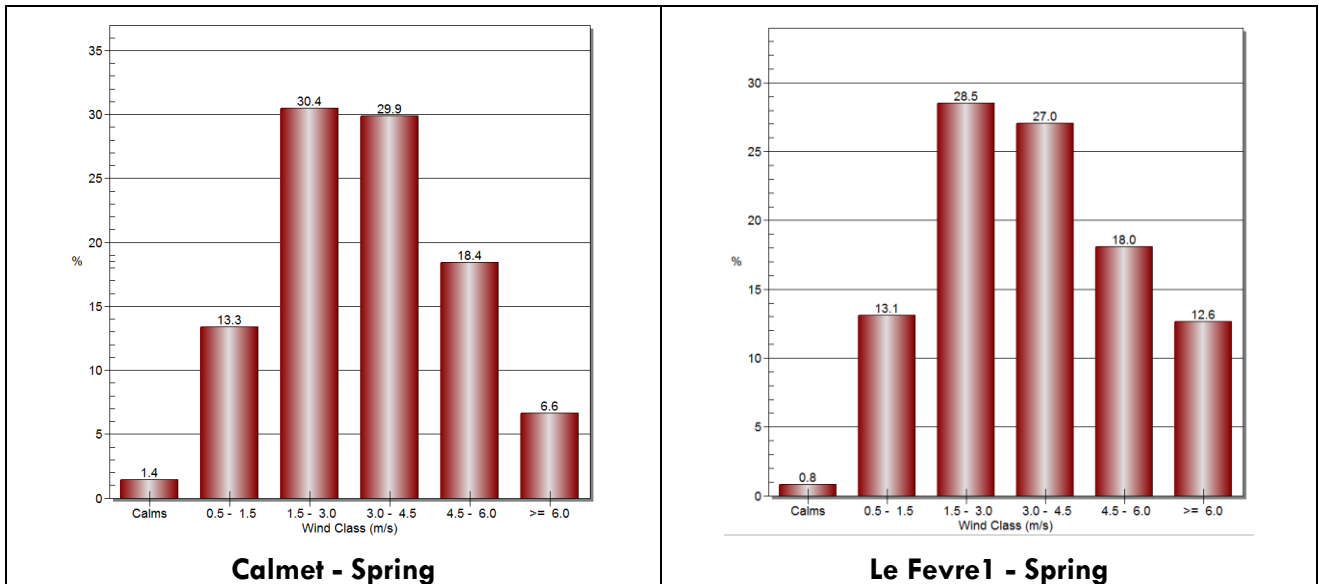


Figure 6: Comparison of Wind Class Frequency Distribution for Meteorological Year – 2009







4.3 Emission Rates and Source characteristics

Stack testing was conducted in October 2016 (Airlabs Report OCT16190.2 – Air Emissions Monitoring of Release Points 4A & 4B at Adelaide Brighton Cement Ltd in Birkenhead, issued on 23rd February, 2017) to sample the emission rates and source characteristics from Stacks 4A and 4B. Dispersion modelling parameters obtained from the stack testing undertaken in October 2016 are presented in **Table 4**. Emission rates used in the dispersion modelling assessment are presented in **Table 5**.

Table 4: Stack Parameters (Stack 4A and Stack 4B)

Parameter	Stack 4A	Stack 4B
Sampling Date	24 th – 25 th October 2016	24 th – 25 th October 2016
Stack height (m)	75.5	96
Stack diameter (m)	3.23	3.0
Stack temperature (°C)	107	105
Exit velocity (m/s)	19.3	18.6

Table 5: Modelled Emission Rates (Stack 4A and Stack 4B)

Pollutant	Emission Rates (g/s)	
	Stack 4A 24 th – 25 th October 2016	Stack 4B 24 th – 25 th October 2016
Criteria Pollutants		
Oxides of nitrogen (as NO ₂) - Minimum	51.0	42.7
Oxides of nitrogen (as NO ₂) - Average	62.5	50.3
Oxides of nitrogen (as NO ₂) - Maximum	81.0	57.8
Sulfur dioxide (SO ₂)	4.2	0.2
Carbon monoxide (CO)	28.5	22.7

Pollutant	Emission Rates (g/s)	
	Stack 4A 24 th – 25 th October 2016	Stack 4B 24 th – 25 th October 2016
Particulate matter (PM ₁₀)	2.37	0.83
Particulate matter (PM _{2.5})	0.62	0.42
Metals, Metalloids and Metal Fumes⁽¹⁾		
Arsenic and compounds	0.000037	0.000013
Antimony and compounds	0.000010	0.000008
Barium	0.00038	0.00018
Benzene	0.008	0.014
Beryllium and compounds	0.000010	0.000008
Cadmium and compounds	0.0000025	0.0000007
Chromium (III) compounds	0.00043	0.00005
Chromium (VI) compounds	0.000053	0.000012
Copper oxide	0.00183	0.00023
Iron oxide	0.053	0.018
Lead	0.00010	0.00003
Magnesium oxide fumes	0.23	0.11
Manganese and compounds	0.0014	0.0004
Mercury - inorganic	0.0000016	0.0000008
Mercury - organic	0.0000007	0.0000003
Nickel and nickel compounds	0.000103	0.000032
Zinc oxide	0.00092	0.00035
Polycyclic Aromatic Hydrocarbons (PAH)		
PAH (as Benzo (a)pyrene) (Bap-TEQ _{PAH})	0.00000082	0.00000112
Acid Gases		
Hydrogen chloride	0.45	0.53
Halogens		
Chlorine	0.40	0.16
Fluoride	0.010	0.008

Notes:

(1): Where the measured results were less than the detection limit, the detection limit was used for modelling purposes.

4.5 Estimates of Background Levels for Criteria Pollutants

For the purpose of this assessing background levels for the Project, ambient monitoring data for the latest year (2016) was collated for the NEPM monitoring stations located in the vicinity of the facility (SA EPA, 2017).

The nearest ambient monitoring station (Le Fevre1) to the facility records observations of particulates (PM₁₀ and PM_{2.5}) only. The nearest monitoring station recording NO₂ and SO₂ observations is Le Fevre2. CO monitoring is not currently undertaken at Le Fevre1 or Le Fevre2 monitoring stations hence the recorded observations from Adelaide CBD monitoring station were used. The relative location of the three monitoring stations with respect to the facility is shown in **Figure 7**.

The suitable percentile employed in estimating background concentration of a particular pollutant may depend on a number of factors such as representativeness of the monitoring data set in terms

of influence from local sources, representativeness of meteorological conditions at monitoring site and dominance of emission source. Environmental Protection Authority Victoria (VIC EPA, 2001) recommends the use of the 70th percentile (Victoria, 2001). The approach in NSW (NSW, 2016) is to utilise data time series contemporaneously to assess the predicted impacts for Level 2 assessment. For this assessment 100th percentile background concentration have been used as background for NO₂, SO₂ and CO.

For 24-hour average particulates (PM₁₀ and PM_{2.5}) concentration, a background level of 90th percentile have been used in the assessment. Exceedence of the PM₁₀ 24-hour average criteria was observed during the year 2016 at Le Fevre1 station (due to regional storm events), hence 90th percentile value were estimated and used for the background.

The background pollutant levels adopted for the purposes of this assessment are presented in **Table 6**.

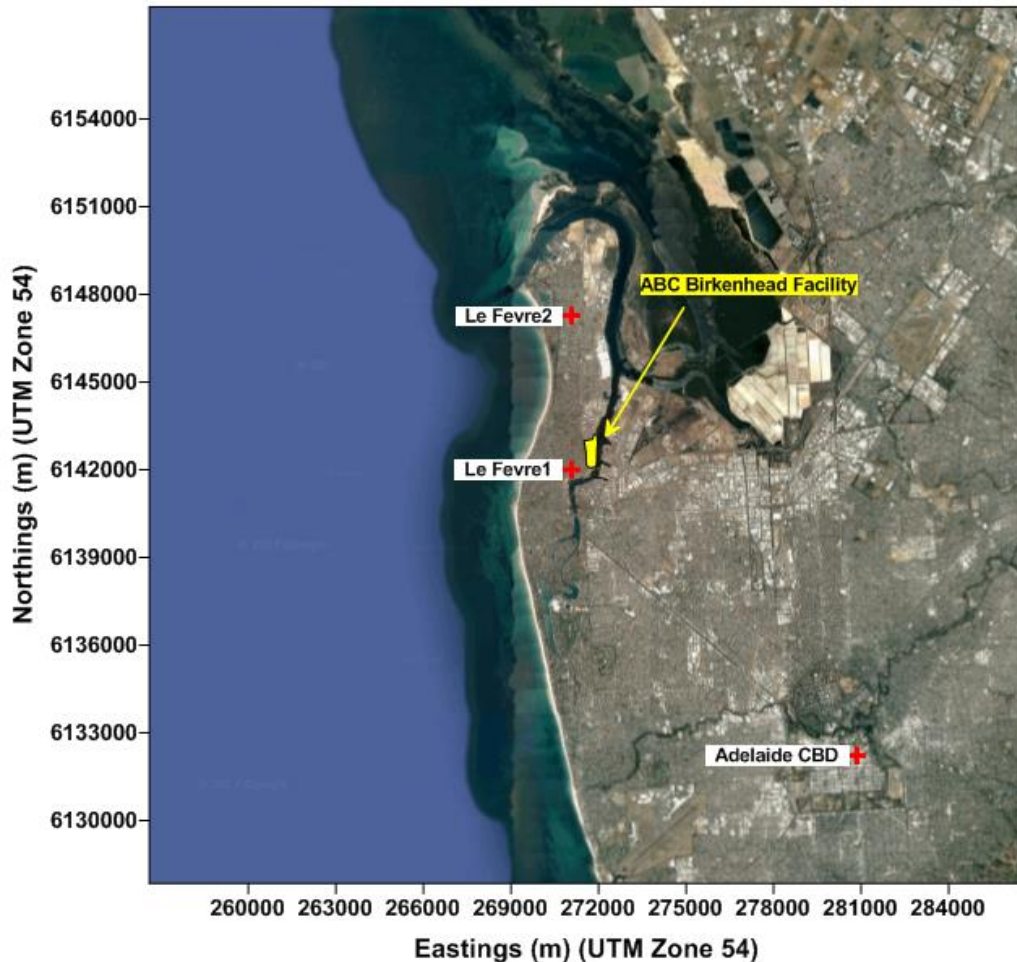
Table 6: Estimates of Background Levels

Pollutant	Averaging Period	Background Level (µg/m ³)	Reference
NO ₂	1 hour	63.9	Maximum observed hourly record at Le Fevre2 (2016) monitoring station
NO ₂	Annual	8.0	Annual average of observed hourly records at Le Fevre2 (2016) monitoring station
SO ₂	1 hour	57.6	Maximum observed hourly record at Le Fevre2 (2016) monitoring station
SO ₂	24-hour	6.5	Maximum observed daily record (calculated from hourly data) at Le Fevre2 (2016) monitoring station
SO ₂	Annual	0.5	Annual average of observed hourly records at Le Fevre2 (2016) monitoring station
CO	1 hour	2,800	Maximum observed hourly record at Adelaide CBD (2016) monitoring station
CO	8 hours	2,600	Maximum 8 hourly record (calculated from hourly data) at Adelaide CBD (2016) monitoring station
PM ₁₀	24 hours	29.9	90 th percentile of daily observed records (calculated from hourly data) at Le Fevre1 (2016) monitoring station ¹
PM _{2.5}	24 hours	10.8	90 th percentile of daily observed records (calculated from hourly data) at Le Fevre1 (2016) monitoring station ¹
PM _{2.5}	Annual	7.6	Annual average of observed hourly records at Le Fevre1 (2016) monitoring station

Notes:

(1): Particulate data were missing for the first two months in 2016 at Le Fevre1 monitoring station hence the missing records during the months of January and February were replaced with 2015 data from the same monitoring station where available.

Figure 7: Location of Background Monitoring Stations



4.5 Dispersion Modelling

Dispersion modelling was undertaken using the CALPUFF model v.6.42 utilising meteorological wind fields generated through CALMET for the year 2009. A 5 km by 5 km subset of CALMET modelling domain centred over the facility was sufficient to capture the impacts of stack emissions on the local surroundings. Gridded receptors were sampled at 100 m resolution. General run control parameters and technical options that were selected are presented in **Table 7**. The location of the two stack sources with reference to the facility boundary is shown in **Figure 1**.

Table 7: CALPUFF Model Configuration

Parameter	Value
CALPUFF version	6.42
Year modelled	2009
Stack modelled	4A & 4B (as point source)
Computational grid size	5 km x 5 km Subset of CALMET
Computational grid resolution	100 m
Gridded receptors used (LSAMP)	True
Gridded receptor grid resolution	100 m

Discrete receptors modelled	False
Building wake algorithm	BPIP Prime
Method used to compute dispersion coefficient (MDISP)	3
Dry Deposition modelled	False
Wet deposition	False

Buildings in the vicinity of the sources play a major role in pollutant dispersion as they may create zones of strong turbulence and enhance downward mixing resulting in higher ground-level concentrations. The impact of building wake effects on plume dispersion has been included in the modelling for buildings and structures located around the stack. The heights and locations of these structures were entered into the Building Profile Input Program (BPIP) utility using PRIME algorithm. The wind direction-specific building dimensions calculated by BPIP for each stack were entered into the CALPUFF model.

Peak to mean ratio to estimate the 3 minute average concentrations from hourly averages generated by dispersion modelling was based on CSIRO peak-to-mean scaling (CSIRO, 2008).

Measurements of oxides of nitrogen (NO_x) emissions around Power Station plume in central Queensland (Bofinger, 1986) indicate that up to 30% of NO_x may be transformed into nitrogen dioxide (NO_2). The ratio accounts for the expectation that approximately 5%-10% of the NO_x is emitted from the source as NO_2 . The remaining portion of the NO_2 is transformed from the photochemical oxidation of nitric oxide, which tends to peak at approximately 30%, ten to fifteen kilometres downwind.

To account for the chemical transformation of NO_x to NO_2 with distance downwind of the facility, emission rates of total oxides of nitrogen were modelled and the results within the domain were scaled with the scale factor varying linearly with distance from the kiln sources. The scale factor ranged from 10% (kiln sources) to 30% (at a distance of 10 km from the site boundary).

5.0 RESULTS AND DISCUSSION

CALPUFF dispersion model was set to predict concentrations of modelled pollutants at gridded receptor at 100 m resolution over the 5 km x 5 km modelling domain. Contour plots showing the predicted impacts on local surrounding were generated based on results at these gridded receptors using kriging algorithm.

The predicted ground level concentrations of all air pollutants modelled are summarised in **Table 8** below. Maximum concentrations presented are 100th percentile for all pollutants and averaging period. Representative background levels are included for the criteria pollutants to assess the cumulative impacts.

From the results outlined in **Table 8**, it is observed that predicted cumulative ground level concentrations of all pollutants are below their respective criteria. Of all the modelled pollutants, highest concentrations were observed for particulate matter $\text{PM}_{2.5}$ followed by NO_2 .

The maximum predicted cumulative $\text{PM}_{2.5}$ annual average concentrations outside the facility boundary is $7.7 \mu\text{g}/\text{m}^3$ (inclusive of $7.6 \mu\text{g}/\text{m}^3$ background) compared to criterion of $8 \mu\text{g}/\text{m}^3$. The maximum predicted cumulative $\text{PM}_{2.5}$ 24-hour average concentrations outside the facility boundary is $11.7 \mu\text{g}/\text{m}^3$ (inclusive of $10.8 \mu\text{g}/\text{m}^3$ background) compared to criterion of $25 \mu\text{g}/\text{m}^3$.

The maximum predicted cumulative PM_{10} 24-hour average concentrations outside the facility boundary is $32.5 \mu\text{g}/\text{m}^3$ (inclusive of $29.9 \mu\text{g}/\text{m}^3$ background) compared to criterion of $50 \mu\text{g}/\text{m}^3$.

The maximum predicted cumulative NO₂ 1-hour average concentrations outside the facility boundary ranges from 88% to 71% of the air quality criteria for upper bound and lower bound of emission rates, respectively.

The maximum predicted cumulative CO 8-hour average concentrations outside the facility boundary is 2719 µg/m³ (inclusive of 2600 µg/m³ background) compared to criterion of 11,250 µg/m³.

The maximum predicted cumulative SO₂ 1-hour average concentrations outside the facility boundary is 117.6 µg/m³ (inclusive of 57.6 µg/m³ background) compared to criterion of 570 µg/m³.

For all other modelled pollutants, the maximum predicted ground level concentrations were below 20% of the air quality criteria adopted for this project.

For visual illustration, the highest 1-hour average NO₂ concentration isopleths for lower, average and upper bound emission rates are presented in **Figure 8** , **Figure 9** and **Figure 10**, respectively.

Table 8: Dispersion Modelling Results – Predicted Maximum Concentration ($\mu\text{g}/\text{m}^3$) outside Facility Boundary

Pollutant	Averaging Period	Criteria ($\mu\text{g}/\text{m}^3$)	Predicted Incremental From Facility ($\mu\text{g}/\text{m}^3$)	Incremental (% of Criteria)	Estimated Background Concentration ($\mu\text{g}/\text{m}^3$)	Background (% of Criteria)	Cumulative (Incremental + Background) ($\mu\text{g}/\text{m}^3$)	Cumulative (% of Criteria)
Nitrogen Dioxide (NO_2) – Minimum Emissions	1 hour	250	112.5	45.0%	63.9	25.6%	176.4	70.6%
	Annual	60	0.7	1.1%	8	13.3%	8.7	14.5%
Nitrogen Dioxide (NO_2) – Average Emissions	1 hour	250	133.5	53.4%	63.9	25.6%	197.4	79.0%
	Annual	60	0.8	1.4%	8	13.3%	8.8	14.7%
Nitrogen Dioxide (NO_2) – Maximum Emissions	1 hour	250	156.4	62.6%	63.9	25.6%	220.3	88.1%
	Annual	60	1.0	1.7%	8	13.3%	9.0	15.0%
Sulfur dioxide (SO_2)	1 hour	570	59.9	10.5%	57.64	10.1%	117.6	20.6%
	24 hours	230	4.0	1.7%	6.5	2.8%	10.5	4.5%
	Annual	60	0.3	0.5%	0.5	0.8%	0.8	1.4%
Carbon monoxide (CO)	1 hour	31240	675	2.2%	2800	9.0%	3475	11.1%
	8 hours	11250	119	1.1%	2600	23.1%	2719	24.2%
Particulate matter (PM_{10})	24 hours	50	2.6	5.2%	29.9	59.8%	32.5	65.0%
Particulate matter ($\text{PM}_{2.5}$)	24 hours	25	0.9	3.4%	10.8	43.2%	11.7	46.6%
	Annual	8	0.1	0.9%	7.6	95.0%	7.7	95.9%
Antimony and compounds	3 minutes	19	0.0007	0.004%	0	0%	0.0007	0.004%
Arsenic and compounds	3 minutes	0.19	0.0018	0.93%	0	0%	0.0018	0.93%
Barium (soluble compound)	3 minutes	19	0.019	0.10%	0	0%	0.019	0.10%
Benzene	3 minutes	58	0.989	1.7%	0	0%	0.989	1.7%
	Annual	10	0.0015	0.01%	0	0%	0.0015	0.01%
Beryllium and compounds	3 minutes	0.008	0.0007	8.8%	0	0%	0.0007	8.8%
Cadmium and compounds	3 minutes	0.036	0.0001	0.32%	0	0%	0.0001	0.32%
Chromium (III) compounds	3 minutes	19	0.019	0.10%	0	0%	0.019	0.10%

Pollutant	Averaging Period	Criteria (µg/m ³)	Predicted Incremental From Facility (µg/m ³)	Incremental (% of Criteria)	Estimated Background Concentration (µg/m ³)	Background (% of Criteria)	Cumulative (Incremental + Background) (µg/m ³)	Cumulative (% of Criteria)
Chromium (VI) compounds	3 minutes	0.19	0.0024	1.27%	0	0%	0.0024	1.27%
Copper oxide fumes	3 minutes	7.3	0.079	1.09%	0	0%	0.079	1.09%
Iron oxide fumes	3 minutes	190	2.56	1.35%	0	0%	2.56	1.35%
Lead (as particles)	Annual	0.5	0.000009	0.002%	0	0%	0.000009	0.002%
Magnesium oxide fumes	3 minutes	360	11.83	3.3%	0	0%	11.83	3.3%
Manganese & compounds	3 minutes	36	0.064	0.18%	0	0%	0.064	0.18%
Mercury - inorganic	3 minutes	4	0.0001	0.002%	0	0%	0.0001	0.002%
Mercury - organic	3 minutes	0.36	0.00003	0.01%	0	0%	0.00003	0.01%
Nickel & compounds	3 minutes	0.36	0.0049	1.35%	0	0%	0.0049	1.35%
Zinc oxide	3 minutes	190	0.045	0.02%	0	0%	0.045	0.02%
PAH (as Benzo(a)pyrene) (Bap-TEQ _{PAH})	3 minutes	0.8	0.00008	0.01%	0	0%	0.00008	0.01%
	Annual	0.0003	0.0000001	0.04%	0	0%	0.0000001	0.04%
Hydrogen chloride	3 minutes	270	40.7	15.1%	0	0%	40.7	15.1%
Chlorine	3 minutes	110	19.7	17.9%	0	0%	19.7	17.9%
Fluoride (as HF)	24 hours	3	0.015	0.51%	0	0%	0.015	0.51%
	7 days	2	0.0045	0.22%	0	0%	0.0045	0.22%
	90 days	1	0.0023	0.23%	0	0%	0.0023	0.23%

Figure 8: Predicted Maximum Cumulative Ground Level Concentrations of NO₂ (µg/m³) (1 hour averaging period) Based on Lower Bound of Emission Rates

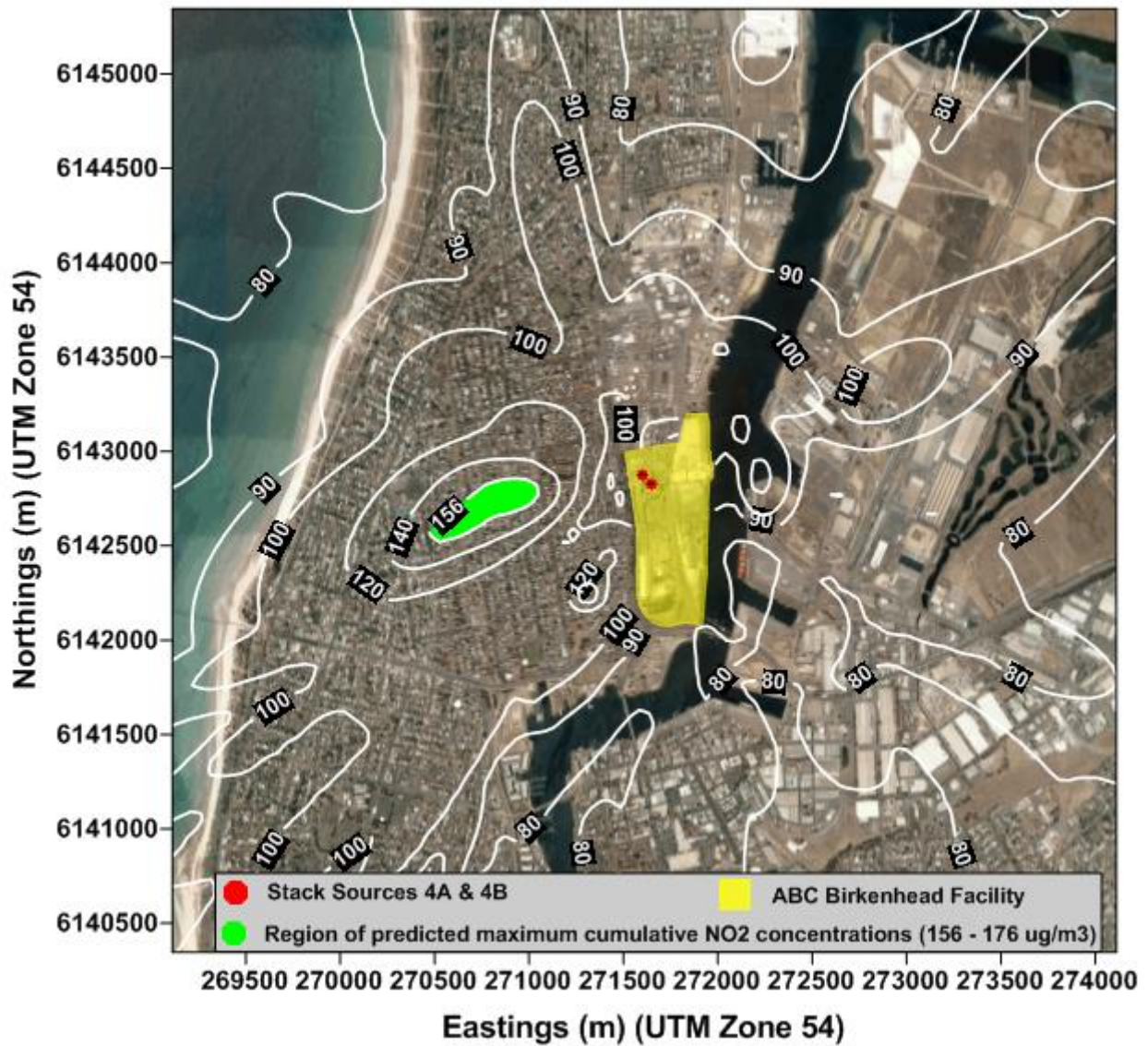


Figure 9: Predicted Maximum Cumulative Ground Level Concentrations of NO₂ (µg/m³) (1 hour averaging period) Based on Average Bound of Emission Rates

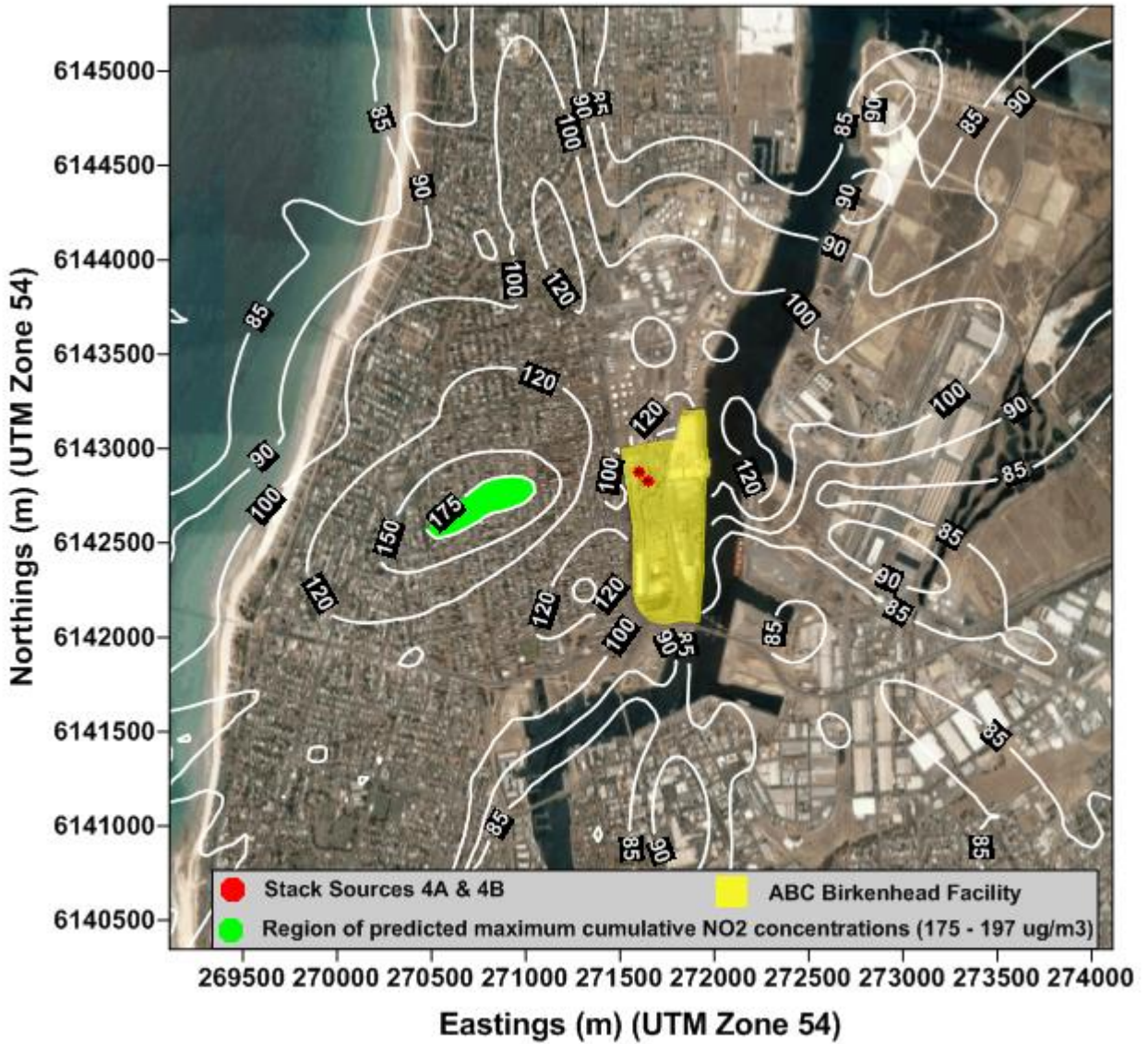
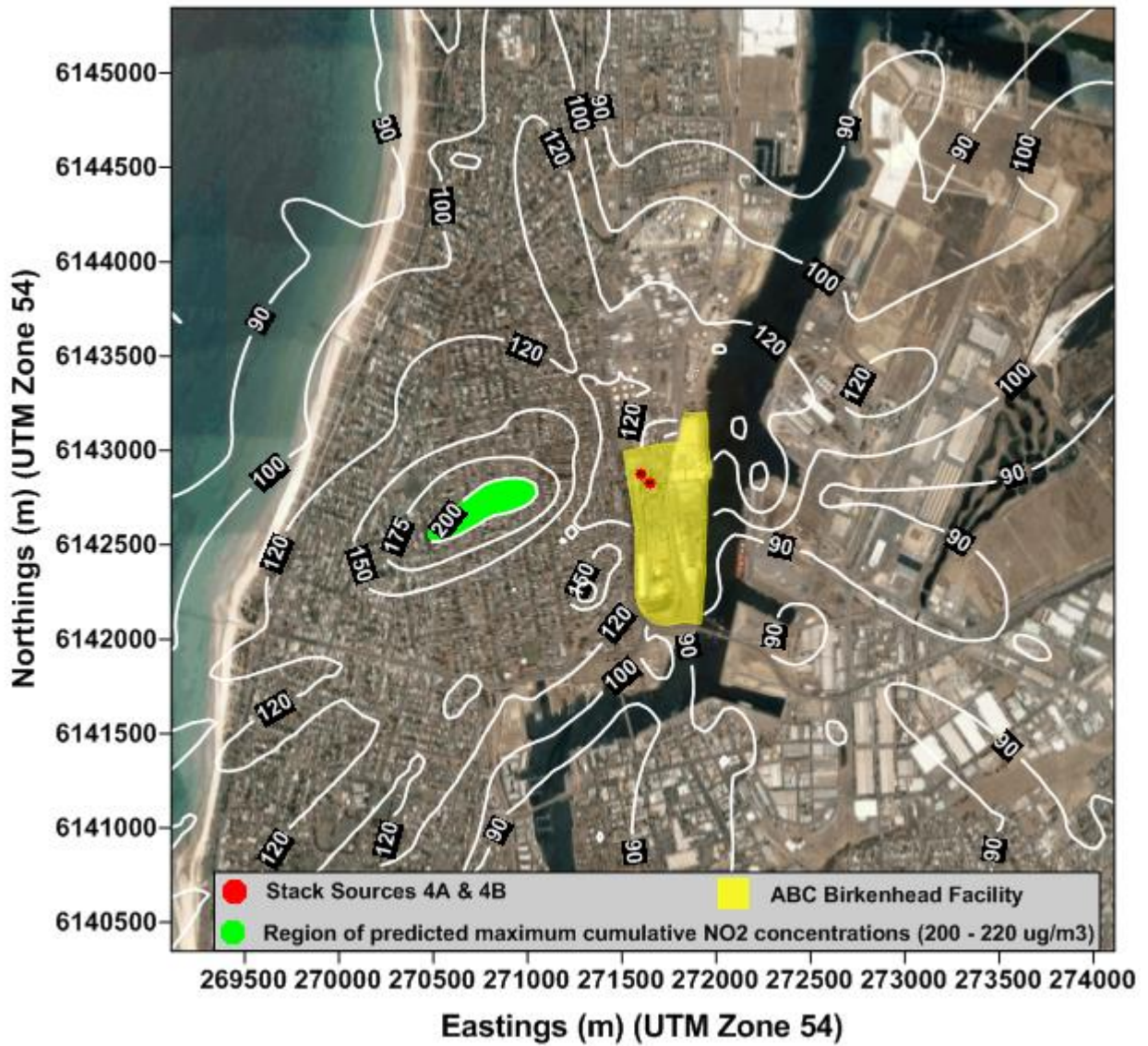


Figure 10: Predicted Cumulative Maximum Ground Level Concentrations of NO₂ (µg/m³) (1 hour averaging period) Based on Upper Bound of Emission Rates



6.0 CONCLUSIONS

The CALPUFF dispersion model, in conjunction with TAPM/CALMET generated meteorological data for the year 2009, was used to predict the maximum ground level concentrations of various air pollutants outside the boundaries of the Adelaide Brighton Cement facility in Birkenhead. Emission rates for stack 4A and 4B considered in this assessment were based on results from stack testing conducted by Airlabs Environmental during October 2016 (Airlabs Report OCT16190.2).

In response to comments issued by SA EPA (correspondence dated 7th November 2016) appropriate changes have been incorporated in this report.

Results from the dispersion modelling (**Table 8**) suggest that all the modelled pollutants are below their respective regulatory criteria.

7.0 REFERENCES

AirLabs Environmental (2017): Test report OCT16190.2 *Air Emissions Monitoring of Release Points 4A & 4B At Adelaide Brighton Cement Ltd in Birkenhead, 24th – 25st October, 2016*. Prepared for Adelaide Brighton Cement. Report dated 23rd February, 2017.

Bofinger (1986): Bofinger, N.D., Best, P.R., Cliff, D.I., Stumer, L.J., (1986): *The oxidation of nitric oxide to nitrogen dioxide in power station plumes*, Proceedings of the Seventh World Clean Air Congress, Sydney, 384-392.

CSIRO (2008): The peak-to-mean-scaling, CSIRO Marine and Atmospheric Research website <http://www.cmar.csiro.au/airquality/peaktomean.html>

Hurley P.J. (2008): TAPM V4. Part 1: Technical Description, CSIRO Marine and Atmospheric Research Paper No. 25.

NEPM (1998): National Environment Protection (Ambient Air Quality) Measure. National Environment Protection Council.

NEPM (2004): National Environment Protection (Air Toxic) Measure. National Environment Protection Council.

NEPM (2015): National Environmental Protection (Ambient Air Quality) Measure. National Environmental Protection Council. Revised in December 2015.

NSW (2016): Approved Methods for the Modelling and Assessment of Air Pollutions in New South Wales.

OEH (2011): *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'*, March 2011.

SA Air EPP (2016): The Environment Protection (Air Quality) Policy 2016 (Air Quality EPP). South Australia Environment protection Agency (SA EPA).

SA EPA (2017): Ambient hourly air monitoring data for Le Fevre1, Le Fevre2 and Adelaide CBD, downloaded from SA EPA website <https://data.sa.gov.au/data/organization/environment-protection-authority-epa>

SRTM (2000): Shuttle Radar Topography Mission SRTM 1 Arc-Second Global data, downloaded from USGS website.

Vic EPA (2001): Victoria Environmental Protection Agency (VIC-EPA) Air Quality Guidelines – VIC EPA Gazette S 240 Schedule A