Appendix C

Air Quality Impact Assessment

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FINAL

National Ceramic Industries Australia
15 June 2010

AECOM

Air Quality Impact Assessment

NCIA Expansion

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Air Quality Impact Assessment

NCIA Expansion

Prepared for

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15 June 2010

N6050104

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Quality Information

Document	Air Quality Impact Assessment	
Ref	N6050104	
Date	15 June 2010	
Prepared by	Ross Thompson	Author Signature
Reviewed by	David Rollings	Technical Peer Reviewer Signature

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Contents

List of Tables

Body Report

List of Figures

Figures Section

List of Appendices

1.0 Introduction

AECOM Australia Pty Limited (AECOM) was commissioned by National Ceramics Industries Australia (NCIA) to undertake an Air Quality Impact Assessment (AQIA) to assess the potential effects of air emissions from the proposed expansion of their ceramic tile manufacturing facility at Rutherford (the expanded facility is hereafter referred to as the Facility). The proposed expansion involves the construction and operation of a second factory building with four additional production lines on land adjacent to the existing building and other associated infrastructure (refer to **Figure 1**). The purpose of this assessment was to determine the air emissions associated with the construction and operation of the proposed facility (the 'Facility'), and the potential impacts on sensitive receptors and local air quality.

1.1 Scope of Work

The scope of work undertaken by AECOM to assess the proposed expansion included:

- A review of background information relating to site air emissions from the existing site.
- Assessment of the likely air emissions from operation and construction of the Facility.
- Dispersion modelling using identified air emissions during existing and proposed operating conditions of the Facility.
- Assessment of the effects of the proposed development at sensitive receptor locations against relevant statutory guidelines.

Ground level pollutant concentrations resulting from stack emissions of the following air pollutants were assessed:

- Hydrogen fluoride (HF);
- Oxides of nitrogen (NO_X);
- Total suspended particulates (TSP);
- Particulate matter with an aerodynamic diameter less than 10 µm (PM_{10});
- Sulfur dioxide (SO_2);
- Sulfuric acid; and
- Heavy Metals.

Fugitive and odour emissions were not considered by the modelling, as under normal operation of the Facility these types of emissions are not expected to occur.

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2.0 Description of Site and Proposed Expansion

2.1 Site Location

The existing tile plant is located in the Rutherford Industrial Estate, approximately 35 km northwest of Newcastle. The proposed expansion is to be located adjacent to the existing operation, located on Lot 101 DP 1062820 Racecourse Rd, Rutherford, within the local government area of Maitland. The existing tile plant is located within the Rutherford Industrial Estate where land use is predominantly industrial. A former golf course is located on the southern and eastern boundaries of the existing tile plant. Development approval is currently being sought for the construction of residential facilities upon this land. The northern and western boundaries are bordered by industrial developments. The location of the existing tile plant and the location of the proposed expansion are shown in **Figure 1**.

The nearest existing residential premises are located approximately 900 m east of the NCIA property boundary. There are also residential properties 1.5 km to the northeast and 1 km to the north. Representative receptor locations that have been identified and added to the dispersion model are listed in **Section 3.1.7** and shown on **Figure 1**.

2.2 Existing Operations

The existing tile plant produces high quality ceramic wall and floor tiles utilising a number of raw products including clay, feldspar and glazes. The process involves grinding and mixing of predominantly clay and feldspar, followed by a process of drying the mixture, adding dry glaze, roller pressing, additional dry glazing and decorating, additional pressing, cutting to size and firing prior to packaging and dispatch.

The Rutherford tile plant commenced operations in 2004. In accordance with the information described in the Environmental Impact Statement and related conditions of development consent.

The consent stipulated a staged development, which was a result of concerns relating to air emissions from the proposal. As such, a stringent feed-forward/feed-back mechanism was incorporated into the development consent, requiring monitoring and reporting of emissions to confirm environmental performance at each stage, and use of these data to predict air emissions performance for the subsequent stage of the operation prior to its commencement.

The tile manufacturing plants approved development to date has occurred as follows:

- Initial operations consisting of one ceramic tile production line (Stage One) with an average annual production of 3.2 million m^2 of ceramic tile per year, equating to one quarter of the maximum approved annual production of 12.8 million m^2 commenced operation in 2004;
- In 2007 the second phase of the construction of the factory building was finished, which completed the infrastructure required to house the conditionally approved four production lines (Stages One to Four). Construction of the second production line (Stage Two) was completed mid 2008.
- Stage Two operations commenced in August 2009 with a combined production line average annual production of 6.4 million m^2, or half of the maximum approved annual production.

The existing operations have been implemented generally in accordance with the 2002 EIS, the development consent (DA 449-12-2002-i) and environment protection licence (EPL 11956).

2.3 Proposed Expansion

The project includes the construction and operation of a second factory building with four additional production lines on the existing parcel of land adjacent to the existing factory building. This also includes the construction and operation of other associated infrastructure. **Figure 2** shows a site layout of the existing and proposed development at the Facility. The proposed expansion, known as Stages Five to Eight, would involve increasing the approved capacity to 25.6 million m^2 of tiles produced per annum and would include the relinquishment of existing Development Consent (No. 449-12-2002-i) and operation all eight production lines (Stages One – Eight) under a new Project Approval.

The approximate expansion would require the construction of:

- A new factory building to incorporate Stages Five to Eight;

- Additional storage bunkers for raw materials;
- Additional storage silos for dry glazes;
- Installation of four production lines and associated components;
- Addition of multiple emission stacks;
- Construction of internal roadways and additional car parking;
- Construction of new stormwater retention ponds and integration works, and
- Landscaping as required.

The general location for the expansion and the location of existing infrastructure are provided conceptually in **Figure 2**. The building that would be constructed to accommodate Stages Five to Eight would be similar in scale and size of the existing building. Raw materials would be stored at the northern end of the Facility, with the manufacturing process progressing south along the production line prior to dispatch.

2.4 Emission Sources

2.4.1 Operational Air Emissions

The manufacture of ceramic tiles generates air emissions associated with the combustion of natural gas and liberation of compounds from within the clay from which the tiles are manufactured. Approved emission sources associated with the existing tile plant, approved plant and proposed plant are summarised in **Table 1**.

Table 1: Stack Emission Sources

Source/Activity	Existing (Stage 1 and 2)	Approved (Stage 3 and 4)	Proposed (Stage5 to 8)
Clay preparation	CP1	CP2	CP3, CP4
Pressing and drying	PD1	PD2	PD3, PD4
Dryers	D1, D2	D3, D4	D5 – D8
Glaze line	GL1234	-	GL5678
Selection line	SL1234	-	SL5678
Sprayer dryers	SD1	SD2	SD3, SD4
Kilns	KP1, KP2	KP3, KP4	KP5 – KP8
Hot air coolers	HAC1, HAC2	HAC3, HAC4	HAC5 – HAC8

Note that CP1 refers to 'Clay Prep stack, Line 1', CP2 refers to 'Clay Prep stack, Line 2' etc.

Table 3 lists the stack characteristics for the sources listed above. **Section 3.1.6** outlines the expected air emissions rates and concentrations.

2.4.2 Construction Air Emissions

Potential emissions to air from construction activities include products of fuel combustion from vehicles and equipment used in construction and transportation activities. Dust emissions may also occur during construction works.

As the works are to be undertaken with appropriate environmental safeguards and management measures, dust emissions from wind erosion and vehicle emissions are expected to be negligible. As the existing tile plant is currently surrounded by industrial premises and vacant land, any potential dust and exhaust emissions are unlikely to cause off-site nuisance effects. Dispersion modelling was not deemed necessary and was not conducted to quantify the construction impacts of the proposed expansion project.

3.0 Dispersion Modelling Methodology

The AUSPLUME prognostic air dispersion model was used in the AQIA. AUSPLUME is an advanced Gaussian plume dispersion model with algorithms based on the Industrial Source Complex – Short Term (ISCST3) model.

AUSPLUME was developed by the Victorian EPA to enhance the ISCST3 model and make it applicable to Australian conditions. A complete description of the model is provided in the AUSPLUME user manual, which is available upon request.

The model uses the Gaussian dispersion model equations to simulate the dispersion of a plume from point, area or volume sources. Mechanisms for determining the effect of terrain on plume dispersion are also provided. AUSPLUME operates on an hourly time step, and, therefore, requires hourly wind speed, wind direction and other dispersion parameter data. The dispersion of each pollutant plume is determined for each hour using conventional Gaussian model assumptions. It should be noted that Gaussian models are best used to identify pollutant concentrations at receptor locations close to emissions sources, as they can overestimate concentrations at longer distances. Input parameters used in the AUSPLUME dispersion modelling are summarised in **Table 2**.

Table 2: Summary of AUSPLUME Input Parameters

Parameter	Input
AUSPLUME Version	6.0
Modelling Domain	6 km x 6 km
AUSPLUME Modelling Grid Resolution	0.2 km
Number of Sensitive Receptors	19
Terrain Data	Incorporated via terrain file
Building Wake Data	Entered via AUSPLUME's Building Profile Input Program (BPIP)
Dispersion Algorithm	PG (rural ISC curves) & MP Coeff. (Urban)
Hours Modelled	8736 hours (364 days)
Meteorological Data Period	Jan 2004 – Dec 2004

All dispersion modelling was undertaken in accordance with the *Approved Methods for Modelling and Assessment of Air Pollutants* published by the Department of Environment, Climate Change and Water (DECCW) (DEC, 2005). The document prescribes calculation modes to account for terrain effects, building wake effects, horizontal and vertical dispersion curves, buoyancy effects, surface roughness, plume rise, wind speed categories and wind profile exponents.

3.1 Model Inputs

AUSPLUME requires seven main categories of data to determine the dispersion of air emissions:

- Meteorology;
- Terrain effects;
- Building wake effects;
- Modelling scenarios;
- Source characteristics;
- Emissions inventory; and
- Sensitive receptors.

The above inputs are addressed separately in the following sections. AUSPLUME modelling input files are contained in **Appendix A**.

3.1.1 Meteorology

Meteorological data required by AUSPLUME include wind speed, wind direction, temperature and an estimation of the stability class and mixing height for the area surrounding the subject site. It is preferable for meteorological data to be obtained from on-site dedicated meteorological stations that have recorded data over a number of years. NCIA operates a meteorological station on site with the required data for modelling recorded. Analysis of the data recorded however indicated that these data were unlikely to represent regional wind direction as the annual wind rose did not show the typical northwest-southeast dominant wind axis usually observed in the Hunter Valley i.e. significant northwest southeast wind axis. A discussion of the applicability of the on-site data to this study has been provided in **Appendix B**.

As such, meteorological data used in the air dispersion modelling were sourced from the CSIRO TAPM prognostic model for the year 2004 with input data used to 'nudge' the TAPM predictions toward actual observed data (as required from DECCW in the Approved Methods for Modelling). Measured data were sourced from nearby Bureau of Meteorology (BOM) Stations at Cessnock (approximately 18 km southwest of the Facility) and Paterson (located approximately 13 km to the southeast) and data provided by Hydro Aluminium from their weather station at Loxford (approximately 8 km south-southwest). Wind speed and direction data were entered into TAPM to predict meteorological data for the area surrounding the Facility.

In order to determine whether the TAPM meteorological output was representative of long term average meteorological conditions and expected regional behaviour, selected long term meteorological parameters recorded at the Paterson weather station were compared with the same parameters from the meteorological data set generated by TAPM (refer to **Appendix B**). The TAPM-generated data were considered to be acceptable for modelling purposes.

3.1.2 Terrain Effects

The topography of the area surrounding the Facility was digitised from the 1:25,000 topographical map for Maitland (ortho-topographical map 9232-4S). The arbitrary receptor grid used by the dispersion model was approximately 6 km by 6 km with a 200 m grid spacing. The Site is 17 hectares in size, is relatively flat but generally has a slight fall of less than one percent to the south. Surface elevations of the Site range from RL 21 metres Australian Height Datum (AHD) at the north of the Site to RL 16 metres AHD in the south east corner. The site is largely devoid of vegetation.

3.1.3 Building Wake Effects

The dispersion of air emissions around the Facility is likely to be affected by aerodynamic wakes generated by winds having to flow around the existing buildings and plant. Building wakes generally decrease the distance downwind at which the stack plumes come into contact with the ground. This may result in higher ground level concentrations (GLCs) of pollutants closer to the emission source.

PRIME is the US EPA's preferred building wake algorithm (USEPA, 2005). AUSPLUME includes the PRIME building wake algorithm and uses the Building Profile Input Program (BPIP) for entering the location and dimension of buildings. The location and dimensions of buildings located within a distance of 5L (where L is the lesser of the height or width of the building) from each release point for buildings with a height greater than 0.4 times the stack height were entered in the BPIP. The BPIP processing information is included in **Appendix A**.

The Site currently houses NCIA's existing approved operations, which are predominately located with the existing factory building. The tile manufacturing infrastructure is housed within the factory building, which is approximately 488 metres long and 80 metres wide. The height of the building varies with the majority at heights of 6 metres to 8 metres at the eave and 11.5 metres at the ridge. The highest part of the building is 24.5 metres at the eave and 28 metres at the ridge.

3.1.4 Modelling Scenarios

The following two modelling scenarios were examined to determine the likely air quality impacts resulting from the proposed expansion:

- Scenario 1: Approved operations only – assessment of the four stages of the approved development. Scenario 1 was examined to allow the establishment of a baseline approved level of impacts; and
- Scenario 2: Existing and proposed tile plant at agreed emission rates (all existing and future emission sources).

All modelling scenarios outlined above assumed the plant was operating continuously (24 hours per day, 365 days per year). The Facility is unlikely to operate at this level due to operational restrictions (such as breakdowns and routine maintenance), and typically operates for 340 days per year. The scenarios, therefore, represent worst-case conditions for the Facility's operation, and are likely to overestimate the actual long term impacts experienced by receptors surrounding the Facility.

3.1.5 Source Characteristics

Air emissions from the Facility are expected to be emitted from a number of stack sources refer **Figure 2**. A summary of the source characteristics is shown below in **Table 3**.

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Table 3: Approved and Proposed Stack Source Characterisation

Source	Approved	Proposed	Stack Diameter	Stack Height	Exit Temperature	Exit Velocity [1]	Moisture Content	Flow Rate [1]
			(m)	(m)	(^{o}C)	(m/s)*	(%)	(Nm^3/s)**
Clay Preparation	CP1, CP2	CP3, CP4	1.0	32	26	15.8	2.8	10.9
Pressing and Drying	PD1, PD2	PD3, PD4	1.0	32	25	11.9	1.2	8.5
Dryer	D1, D2, D3, D4	D5, D6, D7, D8	0.5	18	111	10.2	8.6	1.2
Glaze Line	GL1234	GL5678	1.0	32	29	12.1	1.8	8.5
Selection Line	SL1234	SL5678	0.5	14	25	2.8	1.2	0.5
Sprayer Dryer	SD1, SD2	SD3, SD4	1.4	32	103	21.3	18.9	19.3
Kiln	KP1, KP2, KP3, KP4	KP5, KP6, KP7, KP8	0.8	24	120	16.6	7.0	6.6
Hot Air Cooling	HAC1, HAC2, HAC3, HAC4	HAC5, HAC6, HAC7, HAC8	1.0	16	115	26.9	1.9	16.5

* Measured at Stack conditions.

** Normalised 0^{o}C 1 atmosphere.

[1] Based on actual stack emission measurements

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3.1.6 Emissions Inventory

Source emissions were based on the results of stack emission testing conducted on Kiln 1 by AECOM between 2007 and 2009 (AECOM, 2007 – 2009). Although results were available at the time of modelling for the newly commissioned second tile production line, results were not yet deemed reliable for long term emissions calculations and were therefore excluded from the emission inventory calculations.

To ensure that the assessment of impacts is representative or worst case actual operations, the following values were used:

- All Total Particulate (TP) and PM_{10} emitted at maximum measured emissions rate;
- With the exception of HF all other pollutants emission data is based on maximum stack emission measurements; and
- HF was modelled at the regulatory emission concentrations limit currently applied to the approved development. The reason for the different approaches was that based on historical data HF was the only pollutant that has the potential to approach it's stack emission licence limits during normal plant operations.

It is acknowledged that the current limits imposed for the stack emissions are higher than the values modelled (with the exception of fluoride). AECOM does not believe it is appropriate to model an operation such as NCIA using emission concentrations that would result in an unrepresentative prediction of potential impacts from the facility. If modelled at emission limits, predicted concentrations would be expected to increase significantly and portray the operation as one which is contributing significantly to regional dust when in reality its contribution is predicted to be low (when actual emissions are used). It is AECOM's belief that limits should ensure a facility operates at a level that protects the environment but still allows for process variation above current low levels.

On this basis, AECOM has not modelled the operation of the NCIA facility at its maximum limits and recommends that the limits currently imposed as part of the EPL be maintained for the new stacks proposed as part of the upgrade.

The emission rates for the PM_{10}, TSP, NO_x, HF and heavy metals for all scenarios are summarised in **Table 4**. The regulatory emission concentration limits listed in **Table 4** reflect emission limits as they occur in the existing Development Consent, and as such are proposed to be adopted for stack emissions for Stage Five – Eight.

All NO_X emissions have been assumed to consist of 100% NO_2 in accordance with Method 1 of Section 8.1.1 of the DECCW Approved Methods.

It should be noted that emissions data for the most recently reported Sulfuric Acid test were not used in the modelling (28 mg/m3 for Sulfuric Acid Mist). This sample was excluded as the sample results on the day of sampling were found to not represent actual operating conditions due to mechanical problems in the exhaust system (which was subsequently rectified with results falling below the 28 mg/m^3). The new results post rectification were not however used in the modelling as they were not available until after the modelling activities had been completed.

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Table 4: Emission Concentrations and Rates – All Scenarios

Source	Pollutant	Emission Rate	Emission Concentration	Regulatory Emission Concentration Limit
		g/s	mg/Nm^3	mg/Nm^3
Clay Preparation	TP	0.03	2.3	20
	PM_{10}	0.02	2.0	-
Pressing and Drying	TP	0.04	4.8	20
	PM_{10}	0.02	2.5	-
Dryer	TP	0.01	12.8	20
	PM_{10}	0.01	8.4	-
	NO_X	0.007	6.0	-
Glaze Line	TP	0.04	4.3	20
	PM_{10}	0.02	1.9	-
Selection Line	TP	0.003	6.3	20
	PM_{10}	0.003	6.3	-
Sprayer Dryer	TP	0.25	13.1	20
	PM_{10}	0.25	13.1	-
	NO_X	0.38	20	-
Kiln	TP	0.03	5.3	20
	PM_{10}	0.03	5.3	-
	HF *	0.03	5.0	5
	Sulfuric Acid	0.06	9.6	100
	Sulfur Dioxide	1.38	210.0	-
	Haz. Substances **	0.0016	0.2	1
	Antimony	0.00009	0.01	-
	Arsenic	0.0001	0.02	-
	Beryllium	0.000002	0.0003	-
	Cadmium	0.00002	0.003	-
	Chromium	0.0001	0.02	-
	Copper	0.0002	0.03	-
	Lead	0.0002	0.03	-
	Magnesium	0.0002	0.03	-
	Manganese	0.0002	0.03	-
	Mercury	0.00007	0.01	-
	Nickel	0.00001	0.002	-
	Zinc	0.004	0.6	-
	NO_X	0.33	50.0	100
Hot Air Cooling	TP	0.04	2.3	5
	PM_{10}	0.01	0.3	-

* Refer to discussion in **Section 4.1.**

****** Emission rate and concentration for Hazardous Substances is provided for comparison against EPL criteria only and has not been modelled as it is a compilation of the heavy metals subsequently listed.

3.1.7 Sensitive Receptors

The AUSPLUME modelling domain incorporates a 6 km by 6 km grid with a resolution of 0.2 km, centred over the Facility. Within this gridded modelling domain, discrete sensitive receptors were modelled in addition to the gridded receptors placed over the entire modelling domain. The DECCW considers sensitive receptors to be areas where people are likely to either live or work, or engage in recreational activities (DEC, 2005). On this basis, representative sensitive receptors were positioned at 22 locations surrounding the Facility. Pollutant Ground Level Concentrations (GLCs) were estimated at each of these locations, shown in **Table 5** and on **Figure 1**, in addition to the gridded receptors that cover the modelling domain.

Table 5: Sensitive Receptor Locations

Sensitive Receptor No.	Sensitive Receptor Description	Type
1	NCIA boundary (Eastern)	Boundary
2	NCIA boundary (South Eastern)	Boundary
3	NCIA boundary (South Western)	Boundary
4	Former Golf Course Clubhouse	Residential
5	Kenvil Close	Residential
6	Gillette Close	Residential
7	Wollombi Road	Residential
8	Mountbatten Close	Residential
9	Justine Parade	Residential
10	Aaron Cove	Residential
11	New England Highway north of site	Residential
12	New England Highway northwest of site	Residential
13	Beacon Hill Road	Residential
14	Finney Close	Residential
15	Bairds Close	Residential
16	Joshua Close	Residential
17	Easton Close	Residential
18	Wollombi Road	Residential
19	Wollombi Road	Residential
20	Heritage Green	Future Residential
21	Heritage Green	Future Residential
22	Heritage Green	Future Residential

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4.0 Assessment Criteria

Table 6 presents the GLC assessment criteria specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW DEC, 2005). These criteria apply to 100th or 99.9th percentile GLC's of air pollutants from a facility when combined with existing background air emission concentrations (defined as cumulative concentrations). In addition, GLC's have been examined in isolation from the background to assess the contribution of the Facility to the surrounding air shed.

Table 6: Relevant Air Quality Impact Assessment Criteria

Air Emission	Averaging Period	Regulatory Limit (µg/m^3)	Percentile
NO_x (as Nitrogen Dioxide (NO_2))	1 hour	246	100
	Annual	62	100
TSP	Annual	90	100
PM_{10}	24 hours	50	100
	Annual	30	100
Sulfur dioxide (SO_2)	10 minutes	712	100
	1 hour	570	100
	24 hour	228	100
	Annual	60	100
Hydrogen fluoride* (HF)	90 days	0.5	100
	7 days	1.7	100
	24 hours	2.9	100
Sulfuric acid (acid mist)	1 hour	18	99.9
Antimony	1 hour	9	99.9
Arsenic	1 hour	0.09	99.9
Beryllium	1 hour	0.004	99.9
Cadmium	1 hour	0.018	99.9
Chromium	1 hour	0.09	99.9
Copper (as dust)	1 hour	18	99.9
Magnesium	1 hour	180	99.9
Manganese	1 hour	18	99.9
Mercury	1 hour	0.18	99.9
Nickel	1 hour	0.18	99.9
Zinc	1 hour	90	99.9
Lead	Annual	0.5	100

*General land use criteria used in this assessment, refer to **Section 4.1** below for detailed discussion of the HF assessment criteria.

4.1 Hydrogen Fluoride Assessment Criteria

In accordance with requirements from the original NCIA development consent, Hydrogen Fluoride (HF) emissions from the existing NCIA tile plant have been historically assessed against the most conservative HF DECCW guideline value. This guideline value was developed for specialised land use areas, which includes areas with vegetation sensitive to fluoride, such as grape vines and stone fruits and was originally applied in the case of NCIA due to the absence of any data discounting the use of the more stringent criteria.

As part of their Environmental Protection Licence, NCIA is required to undertake annual and quarterly visual vegetation surveys for fluoride impacts on the vegetation surrounding the Facility. This monitoring has been undertaken since commissioning and significant backlog of data has now been collected. The most recent survey carried out in 2009 by David Doley (11 and12 February 2009) identified a zone of visual fluoride impacts on vegetation. The zone of affectation (between 2 and 5 per cent of target leaf area impacted) could be detected about 2 km north-west from the kiln stack, on level ground in the vicinity of the Rutherford saleyards (along the axis of the Hunter Valley prevailing winds). Towards the south-east, detectable injury to vegetation occurred at a distance of about 2.5 km, on elevated ground at Gillette Close.

For this assessment, it is proposed to assess against the generalised land use criteria. This change in adopted criteria is based on two observations. The first is that all areas where fluoride impacts may occur around NCIA are devoid of land uses that could be described as HF sensitive (i.e. grape vines in the Hunter). The second observation is based around actual observed fluoride impacts from the Facility being within 3km of the Facility.

On the basis of the above, the assessment criteria chosen for this assessment is the general land use criteria, which is based around impacts on vegetation, not human health impacts as such this criterion can still be considered conservative.

5.0 Existing Air Quality

Air quality in Rutherford is dominated by motor vehicle emissions, and major industry located around the Industrial Estate. Possible sources of air emissions likely to contribute to existing air pollution include the surrounding industrial premises. Additional air emission sources include dust emissions from the coal mining operations and power stations in the Hunter Valley approximately 40 km to 60 km north west of the NCIA site.

The air pollutants of prime concern in NSW are summarised in Table 7.1 of the *Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales* (DEC 2005), with levels of these pollutants on occasion approaching or exceeding the national standards prescribed in the *National Environment Protection Measure for Ambient Air Quality (NEPC, 2003)*. Air emission levels in Hunter, are generally acceptable, with few exceedences noted (*NSW State of the Environment 2006*, *DEC 2006*).

In order to provide a thorough assessment of cumulative impacts, the modelling included regional background air emission data (where available) from NCIA's PM_{10} and HF ambient air monitoring stations (located on site), from Hydro Aluminium (located at Kurri Kurri) and from regulatory monitoring undertaken by DECCW.

It should be noted that the measured concentrations at the ambient air monitoring station on-site would include NCIA's existing air emissions i.e. stages 1 and 2. As such the simple addition of measured onsite background concentrations to predicted pollutant GLC's at sensitive receptors represents a conservative approach to calculating the cumulative impact of the Facility as it may result in double counting of the impact of NCIA's emissions on air quality.

5.1 Particulate Matter

NCIA is required to undertake monitoring of PM_{10} on the northwest (NW) and southeast (SE) areas of the site in accordance with the conditions of EPL 11956. A summary of the NCIA monitoring results is shown in **Table 7**.The sites recorded exceedences of the 24-hour goal during 2007 and 2008.

5.2 Hydrogen Fluoride

NCIA is required to undertake monitoring of HF levels on the northwest (NW) and southeast (SE) areas of the site in accordance with the conditions of EPL 11956. A summary of the NCIA monitoring results is shown in **Table 7**.

In addition to data from the NCIA monitoring network, ambient monitoring data of HF were sourced from Hydro Aluminium. Hydro Aluminium is required to undertake ambient HF monitoring at a nearby vineyard (Wyndham Estate), situated approximately 12 km northwest of NCIA. This site was considered to be representative of background concentrations of HF likely to be experienced in the Rutherford area and, as such, was used for the cumulative assessment undertaken for this report.

5.3 Monitoring Data

A summary of the key statistics for the parameters monitored at both monitoring sites over the past three years is shown in **Table 7**.

Table 7: Ambient Monitoring Data (ug/m^3)

Pollutant	Site	Averaging Period	Year			Maximum Conc. (µg/m^3)
			2007	2008	2009*	
PM_{10} (µg/m^3)	NCIA NW	Maximum 24 hour	142**	68	49	142
	NCIA SE		53	52	41	53
	NCIA NW	Annual	33***	27	26	27
	NCIA SE		20	18	22	22
HF (µg/m^3)	NCIA NW	24 hour	1.6	1.7	0.9	1.7
	NCIA SE		0.6	1.7	0.8	1.7
	Adopted Background[3]		0.3	0.3	0.9	0.9
	NCIA NW	7 day	1.1	0.6	0.3	1.1
	NCIA SE		0.9	0.7	0.1	0.9
	Wyndham Estate[1]		0.2	0.1	0.3	0.3
	NCIA NW	90 Day[2]	0.1	0.3	0.1	0.3
	NCIA SE		0.2	0.2	0.1	0.2
	Wyndham Estate[1]		0.1	0.1	0.1	0.1

* Results until August 1st 2009 which include operation and commissioning of stages 1 and 2.

** Results affected by close, large scale construction beyond the northern NCIA boundary and are not considered representative of background concentrations

*** Analysis of data for 2007 undertaken for this assessment indicates this value may have also been affected by large scale construction occurring close to the NCIA monitoring location and as such is not considered representative of long term air quality conditions.

[1] Raw Wyndham Estate data supplied by Hydro Aluminum; averages calculated by AECOM.
[2] 7 day data used to calculate 90 day average concentrations.
[3] 24 hour values calculated by AECOM see text below

5.3.1 PM_{10} Data

Analysis of the PM_{10} 24 hour data was required to calculate a realistic background concentration for the 24 hour average (taking into account short term elevated PM_{10} concentrations). The maximum result of 142 µg/m^3 occurred during large scale construction beyond the northern NCIA boundary as such it was not considered as representative of the background PM_{10} concentration in the Rutherford area.

The **Figure B1** below presents the measured PM_{10} 24 hour concentration values from both NCIA's onsite monitoring stations. The data show short-term elevated PM_{10} concentrations, particularly in 2007, which were thought to be due to construction activities occurring close to the North West monitoring location. As these results are not considered to be representative of background concentrations, a number of percentile concentrations were examined (ranging from 90th percentile to 99.9th percentile of all monitoring data). Based on visual analysis of the different percentiles calculated, the 95th percentile was chosen as the representation of the realistic maximum concentration representative of the background PM_{10} concentration in the Rutherford area.

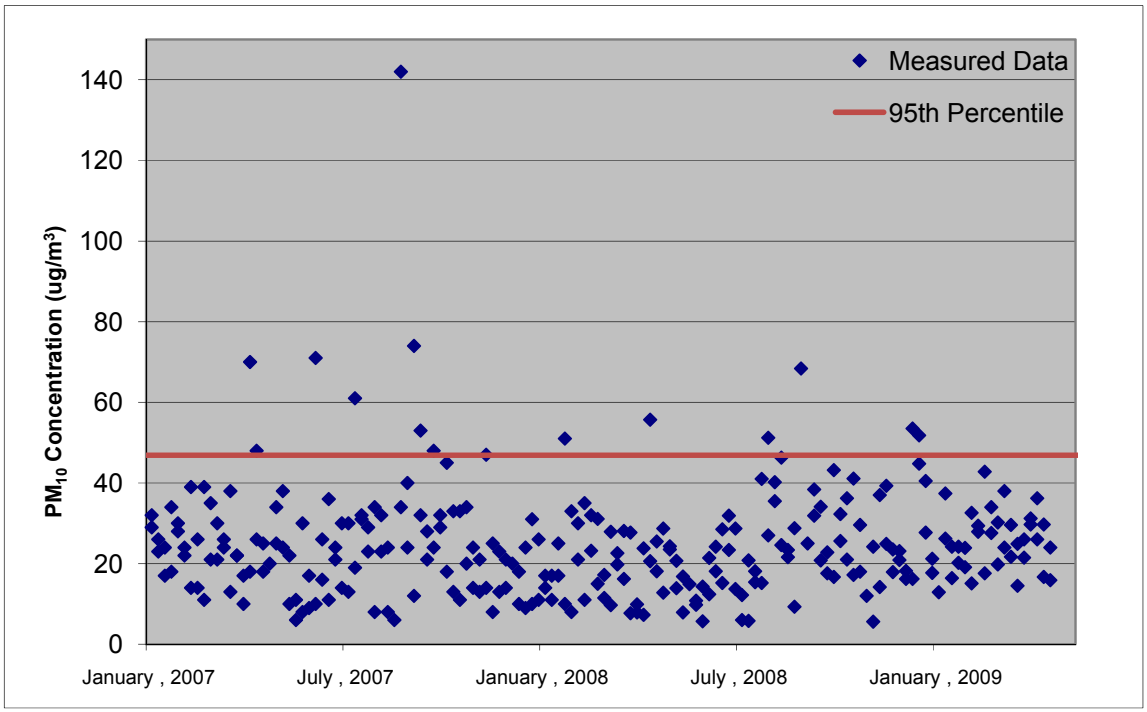

Figure B1 PM_{10} Monitoring Data

5.3.2 24 Hour HF Concentration

Further analysis of the measured HF data was required to allow the calculation of a background concentration of 24 hour average HF (whilst taking into account NCIA's contribution close to the existing tile plant). To allow the calculation of the 24 hour average background concentration at NCIA, the measured concentrations of HF at NCIA were compared with a HF monitoring location which AECOM believes can be considered as representative of regional background HF concentration.

The methodology proposed by this study to calculate the background 24 hour average HF concentration was to firstly determine the contribution of NCIA to the background 7 day average data monitored at NCIA. This was undertaken by subtracting regional HF concentrations from measured 7 day average HF concentrations at NCIA to determine the percentage contribution of NCIA to the background[1]. This calculation is shown in the 7 Day Average concentration portion of **Table 8**. The proportion of HF attributable to NCIA (using the percentages calculated in **Table 8**) was then removed from the 24 hour HF concentrations measured at NCIA to determine the background 24 hour HF concentration (without the contribution from NCIA).

An example calculation for the background calculation is shown for the NCIA NW monitoring location in **Table 8**.

[1] An analysis of the HF monitoring programs currently undertaken by Hydro Aluminium and NCIA highlighted one location as being of sufficient distance from both Hydro Aluminium and NCIA that it could be considered as a regional background. The Wyndham Estate Vineyard monitoring location is approximately 11km NW of NCIA and 16.5km NNW of Hydro Aluminium Smelter.

Table 8: Example calculation for the contribution of NCIA to Background Concentrations of HF (µg/m^3)

Site			Concentration µg/m^3		
			2007	2008	2009
7 Day Average Data	NCIA NW Monitoring Location Concentration		1.1	0.6	0.3
	Wyndham Estate Monitoring Location Concentration		0.2	0.1	0.3
	NCIA Contribution	Concentration (µg/m^3)	0.9	0.5	0
		NCIA Percentage (%)	82 %	84%	0%
24 Hour Average Data	NCIA NW Monitoring Location Concentration		1.6	1.7	0.9
	Adopted background concentration (NCIA measured concentration less NCIA percentage contribution		0.3	0.3	0.9

5.3.3 NO_2 and SO_2 Data

DECCW operates an ambient monitoring station at Beresfield, which is approximately 17 km southeast of the existing tile plant. The Beresfield station monitors levels of various pollutants including nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). A summary of the DECCW monitoring results for these pollutants is shown in **Table 9**.

Table 9: DECCW Ambient Monitoring Data – Beresfield (ug/m^3)

Pollutant	Averaging Period	Year				Maxima
		2003	2004	2005	2006	
NO_2	Annual	31.5	37.2	34.3	40.0	40.0
	1 hour	114.4	125.8	108.7	103.0	125.8
SO_2	1 hour	200.2	114.4	128.7	117.3	200.2
	24 hour	31.5	25.7	20.0	28.6	31.5
	Annual	5.7	11.4	8.6	8.6	11.4

5.3.4 Summary of Background Data

Based on all monitoring data collected by NCIA and others, the following ambient pollutant concentrations were used for the purpose of this assessment:

- Particulate Matter less than 10 microns (PM_{10})
  - 24 hour average – 46.9 µg/m^3;
  - Annual average – 27 µg/m^3;
- Fluoride:
  - 90 day average – 0.1 µg/m^3;
  - 7 day average – 0.3 µg/m^3; and
  - 24 hour average – 0.9 µg/m^3.
- Total Suspended Particulate (TSP)
  - Annual Average –82.5µg/m^3
  - The background TSP level is based on the assumption that approximately 40% of TSP in the Hunter Valley is PM_{10} (NSW Minerals Council, 2000)
- Nitrogen dioxide (NO_2):
  - 1 hour average – 125 µg/m^3; and

  - Annual average – 40 $\mu g/m^3$.
- Sulfur dioxide (SO_2):
  - 1 hour average – 200 $\mu g/m^3$; and
  - 24 hour average – 32 $\mu g/m^3$; and
  - Annual average – 11.4 $\mu g/m^3$.

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6.0 Modelling Results

Dispersion modelling results for Scenario 1 (approved tile plant (Stages 1 to 4) at proposed emission rates) and Scenario 2 (the Approved development and the proposed project (Stages 1 to 8) at proposed emission rates) are summarised in **Tables 10 - 15**. The tables list the 100th percentile predicted GLC for each modelled air emission and the cumulative concentration at each sensitive receptor. Refer to **Figures 3** to **12** for the predicted GLC isopleths of modelled air emission for Scenario 2 from the Facility. Note that only Scenario 2 isopleths were plotted as they are the primary subject of the assessment. Scenario 1 is already approved and was modelled for baseline analysis purposes only. In addition, isopleths have only been plotted for pollutants where exceedences were predicted.

Table 10: Scenario 1 Maximum Predicted Air Emission GLCs of PM_{10}, TSP, and HF (µg/m^3)

Sensitive Receptors		PM_{10}		TSP	Total Fluoride as Hydrogen Fluoride		
		24 Hour	Annual	Annual	24 Hour	7 Day	90 day
Boundary Receptors	1	9.3 (**56.2**)	1.6 (28.6)	1.9 (84.4)	2.0 (2.9)	1.0 (1.3)	**0.56** (**0.66**)
	2	3.8 (**50.7**)	0.4 (27.4)	0.6 (83.1)	1.2 (2.1)	0.3 (0.6)	0.16 (0.26)
	3	4.9 (**51.8**)	0.4 (27.4)	0.6 (83.1)	1.5 (2.4)	0.4 (0.7)	0.16 (0.26)
Residential Receptors	4	3.7 (**50.6**)	0.4 (27.4)	0.5 (83.0)	0.7 (1.6)	0.3 (0.6)	0.19 (0.29)
	5	2.3 (49.2)	0.3 (27.3)	0.5 (83.0)	0.5 (1.4)	0.3 (0.6)	0.16 (0.26)
	6	2.4 (49.3)	0.2 (27.2)	0.3 (82.8)	0.7 (1.6)	0.4 (0.7)	0.14 (0.24)
	7	1.8 (48.7)	0.1 (27.1)	0.1 (82.6)	0.4 (1.3)	0.1 (0.4)	0.03 (0.13)
	8	2.3 (49.2)	0.3 (27.3)	0.4 (82.9)	0.5 (1.4)	0.2 (0.5)	0.12 (0.22)
	9	1.7 (48.6)	0.2 (27.2)	0.2 (82.7)	0.3 (1.2)	0.1 (0.4)	0.06 (0.16)
	10	1.6 (48.5)	0.1 (27.1)	0.2 (82.7)	0.2 (1.1)	0.1 (0.4)	0.03 (0.13)
	11	2.4 (49.3)	0.2 (27.2)	0.3 (82.8)	0.4 (1.3)	0.1 (0.4)	0.05 (0.15)
	12	1.2 (48.1)	0.2 (27.2)	0.3 (82.8)	0.3 (1.2)	0.1 (0.4)	0.08 (0.18)
	13	1.7 (48.6)	0.2 (27.2)	0.2 (82.7)	0.3 (1.2)	0.1 (0.4)	0.06 (0.16)
	14	2.7 (49.6)	0.3 (27.3)	0.3 (82.8)	0.5 (1.4)	0.2 (0.5)	0.12 (0.22)
	15	1.4 (48.3)	0.1 (27.1)	0.2 (82.7)	0.2 (1.1)	0.1 (0.4)	0.05 (0.15)
	16	1.3 (48.2)	0.2 (27.2)	0.2 (82.7)	0.3 (1.2)	0.1 (0.4)	0.05 (0.15)
	17	2.3 (49.2)	0.3 (27.3)	0.3 (82.8)	0.8 (1.7)	0.3 (0.6)	0.14 (0.24)
	18	2 (48.9)	0.1 (27.1)	0.1 (82.6)	0.4 (1.3)	0.1 (0.4)	0.03 (0.13)
	19	1.2 (48.1)	0.1 (27.1)	0.2 (82.7)	0.3 (1.2)	0.1 (0.4)	0.06 (0.16)
	20	6.2 (**53.1**)	1.0 (28.0)	1.3 (83.8)	1.8 (2.7)	0.9 (1.2)	0.43 (**0.53**)
	21	5.5 (**52.4**)	0.8 (27.8)	1.1 (83.6)	1.5 (2.4)	0.7 (1.0)	0.40 (**0.50**)
	22	4.1 (**51.0**)	0.6 (27.6)	0.8 (83.3)	2.1 (**3.0**)	1.2 (1.5)	0.45 (**0.55**)
Criteria		**50**	**30**	**90**	**2.9**	**1.7**	**0.5**

Note: Cumulative data are indicated in parentheses. **Bold** entries indicate exceedences of criterion.

Table 11: Scenario 1 Maximum Predicted Air Emission GLCs of NO_2, and SO_2 ($\mu g/m^3$)

Sensitive Receptors		NO_x as NO_2		SO_2			
		1 Hour	Annual	10 min*	1 Hour	24 Hour	Annual
Boundary Receptors	1	56.0 (181.0)	4.1 (44.1)	298.2	234.1 (434.3)	85.6 (117.1)	12.2 (23.7)
	2	68.1 (193.1)	1.4 (41.4)	247.7	245.0 (445.2)	49.9 (81.4)	4.8 (16.3)
	3	70.6 (195.6)	1.6 (41.6)	295.9	295.2 (495.4)	61.7 (93.2)	5.6 (17.1)
Residential Receptors	4	30.8 (155.8)	1.2 (41.2)	116.6	127.2 (327.4)	28.2 (59.7)	3.6 (15.1)
	5	47.1 (172.1)	1 (41)	112.5	196.7 (396.9)	22.7 (54.2)	3.1 (14.6)
	6	30.3 (155.3)	0.8 (40.8)	182.4	124.5 (324.7)	28.7 (60.2)	2.6 (14.1)
	7	34.8 (159.8)	0.3 (40.3)	212.2	102.6 (302.8)	17.5 (49)	1.1 (12.6)
	8	22.0 (147.0)	0.8 (40.8)	151.5	82.9 (283.1)	20.4 (51.9)	2.5 (14.0)
	9	15.8 (140.8)	0.5 (40.5)	127.8	54.9 (255.1)	10.8 (42.3)	1.4 (12.9)
	10	15.7 (140.7)	0.3 (40.3)	94.9	43.9 (244.1)	10.0 (41.5)	0.9 (12.4)
	11	23.7 (148.7)	0.6 (40.6)	125.7	96.8 (297)	15.7 (47.2)	1.6 (13.1)
	12	20.0 (145.0)	0.7 (40.7)	124.5	81.9 (282.1)	12.7 (44.2)	2.0 (13.5)
	13	29.4 (154.4)	0.5 (40.5)	140.3	90.8 (291)	13.2 (44.7)	1.4 (12.9)
	14	29.9 (154.9)	0.8 (40.8)	265.4	117.7 (317.9)	19.9 (51.4)	2.3 (13.8)
	15	16.0 (141.0)	0.4 (40.4)	219.7	48.6 (248.8)	9.8 (41.3)	1.1 (12.6)
	16	16.9 (141.9)	0.4 (40.4)	262.5	54.6 (254.8)	12.1 (43.6)	1.2 (12.7)
	17	31.2 (156.2)	0.8 (40.8)	227.0	123.0 (323.2)	33.2 (64.7)	2.5 (14.0)
	18	44.3 (169.3)	0.3 (40.3)	302.2	131.9 (332.1)	17.8 (49.3)	0.9 (12.4)
	19	28.9 (153.9)	0.4 (40.4)	188.3	91.3 (291.5)	13.4 (44.9)	1.3 (12.8)
	20	53.5 (178.5)	2.9 (42.9)	228.9	223.3 (423.5)	74.3 (105.8)	9.1 (20.6)
	21	36.9 (161.9)	2.4 (42.4)	136.0	153.9 (354.1)	61.3 (92.8)	8 (19.5)
	22	70.6 (195.6)	2.6 (42.6)	221.1	292.8 (493)	87.8 (119.3)	9.7 (21.2)
Criteria		**246**	**62**	**712**	**570**	**228**	**60**

Note: Cumulative data are indicated in parentheses

* Note that no 10 minute average background SO_2 data was available

Table 12: Scenario 1 Maximum 1 Hour Average Predicted Air Emission GLCs of Hazardous Metals (µg/m^3)

Sensitive Receptors		Sulfuric Acid Mist	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Magnesium	Manganese	Mercury	Nickel	Zinc	Lead (Annual)
Boundary Receptors	1	10.7	0.016	0.02	0.0003	0.003	0.02	0.03	0.04	0.04	0.011	0.002	0.6	0.0019
	2	11.2	0.016	0.02	0.0003	0.003	0.02	0.03	0.04	0.04	0.012	0.002	0.6	0.0008
	3	13.5	0.020	0.02	0.0003	0.004	0.02	0.04	0.05	0.05	0.014	0.003	0.7	0.0009
Residential Receptors	4	5.8	0.008	0.01	0.0001	0.002	0.01	0.02	0.02	0.02	0.006	0.001	0.3	0.0006
	5	9.0	0.013	0.02	0.0002	0.003	0.01	0.02	0.03	0.03	0.009	0.002	0.5	0.0005
	6	5.7	0.008	0.01	0.0001	0.002	0.01	0.02	0.02	0.02	0.006	0.001	0.3	0.0004
	7	4.7	0.007	0.01	0.0001	0.001	0.01	0.01	0.02	0.02	0.005	0.001	0.3	0.0002
	8	3.8	0.005	0.01	0.0001	0.001	0.01	0.01	0.01	0.01	0.004	0.001	0.2	0.0004
	9	2.5	0.004	0.00	0.0001	0.001	0.00	0.01	0.01	0.01	0.003	0.001	0.1	0.0002
	10	2.0	0.003	0.00	0.0001	0.001	0.00	0.01	0.01	0.01	0.002	0.000	0.1	0.0001
	11	4.4	0.006	0.01	0.0001	0.001	0.01	0.01	0.02	0.02	0.005	0.001	0.2	0.0003
	12	3.7	0.005	0.01	0.0001	0.001	0.01	0.01	0.01	0.01	0.004	0.001	0.2	0.0003
	13	4.2	0.006	0.01	0.0001	0.001	0.01	0.01	0.01	0.02	0.004	0.001	0.2	0.0002
	14	5.4	0.008	0.01	0.0001	0.002	0.01	0.01	0.02	0.02	0.006	0.001	0.3	0.0004
	15	2.2	0.003	0.00	0.0001	0.001	0.00	0.01	0.01	0.01	0.002	0.000	0.1	0.0002
	16	2.5	0.004	0.00	0.0001	0.001	0.00	0.01	0.01	0.01	0.003	0.001	0.1	0.0002
	17	5.6	0.008	0.01	0.0001	0.002	0.01	0.02	0.02	0.02	0.006	0.001	0.3	0.0004
	18	6.0	0.009	0.01	0.0002	0.002	0.01	0.02	0.02	0.02	0.006	0.001	0.3	0.0001
	19	4.2	0.006	0.01	0.0001	0.001	0.01	0.01	0.01	0.02	0.004	0.001	0.2	0.0002
	20	10.2	0.015	0.02	0.0003	0.003	0.02	0.03	0.04	0.04	0.011	0.002	0.6	0.0014
	21	7.0	0.010	0.01	0.0002	0.002	0.01	0.02	0.03	0.03	0.007	0.001	0.4	0.0013
	22	13.4	0.019	0.02	0.0003	0.004	0.02	0.04	0.05	0.05	0.014	0.003	0.7	0.0015
Criteria		**18**	**9**	**0.09**	**0.004**	**0.018**	**0.09**	**3.7**	**180**	**18**	**0.18**	**0.18**	**18**	**0.5**

Table 13: Scenario 2 Maximum Predicted Air Emission GLCs of PM_{10}, TSP, and HF ($\mu g/m^3$)

Sensitive Receptors		PM_{10}		TSP	Total Fluoride as Hydrogen Fluoride		
		24 Hour	Annual	Annual	24 Hour	7 Day	90 day
Boundary Receptors	1	14.2 (**61.1**)	3.0 (30.0)	3.8 (86.3)	2.0 (2.9)	1.1 (1.4)	**0.59** (**0.69**)
	2	7.1 (**54**)	0.7 (27.7)	1.1 (83.6)	1.2 (2.1)	0.4 (0.7)	0.18 (0.28)
	3	8.3 (**55.2**)	0.8 (27.8)	1.3 (83.8)	1.5 (2.4)	0.5 (0.8)	0.21 (0.31)
Residential Receptors	4	6.5 (**53.4**)	0.8 (27.8)	1 (83.5)	0.9 (1.8)	0.5 (0.8)	0.28 (0.38)
	5	4.2 (**51.1**)	0.7 (27.7)	0.9 (83.4)	0.7 (1.6)	0.4 (0.7)	0.23 (0.33)
	6	4.4 (**51.3**)	0.5 (27.5)	0.7 (83.2)	1.1 (2.0)	0.6 (0.9)	0.24 (0.34)
	7	3.6 (**50.5**)	0.2 (27.2)	0.3 (82.8)	0.7 (1.6)	0.1 (0.4)	0.06 (0.16)
	8	4.6 (**51.5**)	0.6 (27.6)	0.8 (83.3)	0.7 (1.6)	0.3 (0.6)	0.18 (0.28)
	9	2.8 (49.7)	0.4 (27.4)	0.5 (83.0)	0.5 (1.4)	0.2 (0.5)	0.10 (0.20)
	10	2.9 (49.8)	0.2 (27.2)	0.3 (82.8)	0.4 (1.3)	0.2 (0.5)	0.05 (0.15)
	11	4.7 (**51.6**)	0.5 (27.5)	0.6 (83.1)	0.7 (1.6)	0.2 (0.5)	0.09 (0.19)
	12	2.3 (49.2)	0.4 (27.4)	0.6 (83.1)	0.5 (1.4)	0.2 (0.5)	0.13 (0.23)
	13	3.1 (50)	0.4 (27.4)	0.5 (83.0)	0.6 (1.5)	0.3 (0.6)	0.11 (0.21)
	14	5 (**51.9**)	0.5 (27.5)	0.7 (83.2)	0.9 (1.8)	0.4 (0.7)	0.23 (0.33)
	15	2.5 (49.4)	0.3 (27.3)	0.4 (82.9)	0.4 (1.3)	0.2 (0.5)	0.10 (0.20)
	16	2.9 (49.8)	0.3 (27.3)	0.4 (82.9)	0.6 (1.5)	0.1 (0.4)	0.09 (0.19)
	17	4.7 (**51.6**)	0.5 (27.5)	0.7 (83.2)	1.4 (2.3)	0.5 (0.8)	0.27 (0.37)
	18	4 (**50.9**)	0.2 (27.2)	0.3 (82.8)	0.8 (1.7)	0.2 (0.5)	0.06 (0.16)
	19	2.3 (49.2)	0.2 (27.2)	0.3 (82.8)	0.6 (1.5)	0.2 (0.5)	0.10 (0.20)
	20	10.8 (**57.7**)	1.9 (28.9)	2.5 (85)	1.8 (2.7)	1 (1.3)	0.49 (**0.59**)
	21	8.1 (**55.0**)	1.3 (28.3)	2.1 (84.6)	1.6 (2.5)	0.8 (1.1)	0.47 (**0.57**)
	22	5.8 (**52.7**)	1.0 (28.0)	1.7 (84.2)	2.3 (**3.2**)	1.3 (1.6)	**0.52** (**0.62**)
Criteria		**50**	**30**	**90**	**2.9**	**1.7**	**0.5**

Note: Cumulative data are indicated in parentheses. **Bold** entries indicate exceedences of criterion.

Table 14: Scenario 2 Maximum Predicted Air Emission GLCs of NO_2, and SO_2 ($\mu g/m^3$)

Sensitive Receptors		NO_x as NO_2		SO_2			
		1 Hour	Annual	10 min	1 Hour	24 Hour	Annual
Boundary Receptors	1	57.3 (182.3)	5.7 (45.7)	298.2	234.1 (434.3)	85.7 (117.2)	13.5 (25)
	2	68.4 (193.4)	1.8 (41.8)	247.7	245.0 (445.2)	51.8 (83.3)	5.6 (17.1)
	3	71.3 (196.3)	2.2 (42.2)	295.9	295.2 (495.4)	63.2 (94.7)	6.8 (18.3)
Residential Receptors	4	37.1 (162.1)	2.0 (42.0)	116.6	153.3 (353.5)	37.1 (68.6)	5.7 (17.2)
	5	55.6 (180.6)	1.6 (41.6)	112.5	232.5 (432.7)	31.2 (62.7)	4.7 (16.2)
	6	48.2 (173.2)	1.5 (41.5)	182.4	199.6 (399.8)	47.7 (79.2)	4.6 (16.1)
	7	44.1 (169.1)	0.6 (40.6)	212.2	133.5 (333.7)	29.4 (60.9)	1.9 (13.4)
	8	33.4 (158.4)	1.4 (41.4)	151.5	104.3 (304.5)	28.1 (59.6)	3.9 (15.4)
	9	26.6 (151.6)	0.9 (40.9)	127.8	109.6 (309.8)	19.8 (51.3)	2.4 (13.9)
	10	24.0 (149.0)	0.6 (40.6)	94.9	70.9 (271.1)	16.4 (47.9)	1.5 (13.0)
	11	33.9 (158.9)	1.1 (41.1)	125.7	138.5 (338.7)	27.6 (59.1)	2.7 (14.2)
	12	33.1 (158.1)	1.2 (41.2)	124.5	135.3 (335.5)	22.1 (53.6)	3.3 (14.8)
	13	50.4 (175.4)	1.0 (41.0)	140.3	164.8 (365.0)	24.1 (55.6)	2.7 (14.2)
	14	53.1 (178.1)	1.6 (41.6)	265.4	192.0 (392.2)	39.8 (71.3)	4.5 (16.0)
	15	28.7 (153.7)	0.8 (40.8)	219.7	79.1 (279.3)	17.9 (49.4)	2.1 (13.6)
	16	34.3 (159.3)	0.8 (40.8)	262.5	111.2 (311.4)	23.4 (54.9)	2.4 (13.9)
	17	54.3 (179.3)	1.6 (41.6)	227.0	205.3 (405.5)	59.1 (90.6)	4.7 (16.2)
	18	66.3 (191.3)	0.6 (40.6)	302.2	190.1 (390.3)	33.3 (64.8)	1.8 (13.3)
	19	47.5 (172.5)	0.8 (40.8)	188.3	155.1 (355.3)	23.1 (54.6)	2.4 (13.9)
	20	54.4 (179.4)	4.1 (44.1)	228.9	223.3 (423.5)	77.5 (109)	10.6 (22.1)
	21	36.9 (161.9)	3.1 (43.1)	136.0	153.9 (354.1)	66.2 (97.7)	9.7 (21.2)
	22	70.8 (195.8)	3.4 (43.4)	221.1	292.8 (493)	96.1 (127.6)	12 (23.5)
Criteria		**246**	**62**	**712**	**570**	**228**	**60**

Note: Cumulative data are indicated in parentheses

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Table 15: Scenario 2 Maximum 1 Hour Average Predicted Air Emission GLCs of Hazardous Metals (µg/m^3)

Sensitive Receptors		Sulfuric Acid Mist	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Magnesium	Manganese	Mercury	Nickel	Zinc	Lead
Boundary Receptors	1	10.7	0.016	0.02	0.0003	0.003	0.02	0.03	0.04	0.04	0.011	0.002	0.6	0.0021
	2	11.2	0.016	0.02	0.0003	0.003	0.02	0.03	0.04	0.04	0.012	0.002	0.6	0.0009
	3	13.5	0.020	0.02	0.0003	0.004	0.02	0.04	0.05	0.05	0.014	0.003	0.7	0.0011
Residential Receptors	4	7.0	0.010	0.01	0.0002	0.002	0.01	0.02	0.03	0.03	0.007	0.001	0.4	0.0009
	5	10.6	0.015	0.02	0.0003	0.003	0.02	0.03	0.04	0.04	0.011	0.002	0.6	0.0007
	6	9.1	0.013	0.02	0.0002	0.003	0.01	0.02	0.03	0.03	0.010	0.002	0.5	0.0007
	7	6.1	0.009	0.01	0.0002	0.002	0.01	0.02	0.02	0.02	0.006	0.001	0.3	0.0003
	8	4.8	0.007	0.01	0.0001	0.001	0.01	0.01	0.02	0.02	0.005	0.001	0.3	0.0006
	9	5.0	0.007	0.01	0.0001	0.002	0.01	0.01	0.02	0.02	0.005	0.001	0.3	0.0004
	10	3.2	0.005	0.01	0.0001	0.001	0.01	0.01	0.01	0.01	0.003	0.001	0.2	0.0002
	11	6.3	0.009	0.01	0.0002	0.002	0.01	0.02	0.02	0.02	0.007	0.001	0.4	0.0004
	12	6.2	0.009	0.01	0.0002	0.002	0.01	0.02	0.02	0.02	0.006	0.001	0.3	0.0005
	13	7.5	0.011	0.01	0.0002	0.002	0.01	0.02	0.03	0.03	0.008	0.002	0.4	0.0004
	14	8.8	0.013	0.02	0.0002	0.003	0.01	0.02	0.03	0.03	0.009	0.002	0.5	0.0007
	15	3.6	0.005	0.01	0.0001	0.001	0.01	0.01	0.01	0.01	0.004	0.001	0.2	0.0003
	16	5.1	0.007	0.01	0.0001	0.002	0.01	0.01	0.02	0.02	0.005	0.001	0.3	0.0004
	17	9.4	0.014	0.02	0.0002	0.003	0.01	0.03	0.03	0.04	0.010	0.002	0.5	0.0007
	18	8.7	0.013	0.02	0.0002	0.003	0.01	0.02	0.03	0.03	0.009	0.002	0.5	0.0003
	19	7.1	0.010	0.01	0.0002	0.002	0.01	0.02	0.03	0.03	0.007	0.001	0.4	0.0004
	20	10.2	0.015	0.02	0.0003	0.003	0.02	0.03	0.04	0.04	0.011	0.002	0.6	0.0017
	21	7.0	0.010	0.01	0.0002	0.002	0.01	0.02	0.03	0.03	0.007	0.001	0.4	0.0015
	22	13.4	0.019	0.02	0.0003	0.004	0.02	0.04	0.05	0.05	0.014	0.003	0.7	0.0019
Criteria		**18**	**9**	**0.09**	**0.004**	**0.018**	**0.09**	**3.7**	**180**	**18**	**0.18**	**0.18**	**18**	**0.5**

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7.0 Impact Assessment and Mitigation

7.1 Construction

Potential emissions to air from construction activities include products of fuel combustion from vehicles and equipment used in construction and transportation activities. Dust emissions may also occur during construction works.

A Construction Environmental Management Plan (CEMP) will be prepared prior to commencement of construction of the expansion infrastructure. The CEMP will include as a minimum:

- Control of access via sealed roadways;
- Vehicle speed limits on site;
- Monitoring of wind speed and direction to manage dust-generating activities during undesirable conditions;
- Minimisation of areas of disturbed soils during construction;
- Dust suppression with water sprays or other media during windy periods (as required);
- Stockpiling of soils on site kept to a minimum;
- Construction equipment idling time minimisation and appropriate engine tuning and servicing to minimise exhaust emissions;
- Procedures to address any complaints received; and
- Development of contingency measures for identified potential air quality impact.

7.2 Operation

Operational impacts have been discussed on a pollutant basis in the following sections. The impact assessment and its discussion focus primarily on the predicted modelling results from Scenario 2 (stages 1 to 8) to assess the potential impacts on sensitive receptors and local air quality from the approved development and proposed expansion.

A general trend worth noting from the predicted GLCs in the results table (refer to **Tables 10**-**15**) is the small percentage increase of the GLCs predicted at the three boundary sensitive receptors (ID 1, 2 and 3) when comparing Scenario 1 to Scenario 2. The likely cause is attributed to the closer proximity of these receptors to the proposed stack sources i.e. the receptors are lying within the stack shadow.

This section provides an interpretation of the results obtain from the dispersion modelling.

7.2.1 TSP

The predicted TSP concentrations were below the guideline criteria for both scenarios modelled. As shown in **Table 10 and 13**, the predicted ground level concentrations of TSP resulting from operation of the Facility were small. As such, operation of the Facility is unlikely to result in exceedences of air quality criteria due to TSP. Cumulative concentrations of TSP do not exceed the annual criteria. It should be noted that it is unlikely the manufacturing plant will be operating continuously over a year, with actual ground level pollutant concentrations expected to be lower than the predicted levels.

7.2.2 PM_{10}

Modelled ground level concentrations of PM_{10} particulates are only predicted to increase slightly by the modelling. The annual average PM_{10} GLC is predicted to comply with the relative criteria at all sensitive receptors modelled.

The maximum predicted GLC's at the sensitive receptors for 24 hour average PM_{10} are significantly below the DECCW guideline when modelled in isolation from background PM_{10} concentrations.

The cumulative results are above the guidelines. However, it is not expected that the change in PM_{10} concentration would be discernable at Rutherford resulting in PM_{10} impacts beyond levels already experienced due to elevated background concentrations.

Results for Scenario 2 (operation of the 8 production lines) show the following:

- Maximum increase in the 24 hr average ground level PM_{10} concentration for existing sensitive receptors was 6.5$\mu g/m^3$ at Receptor 4 compared with a criterion of 50 $\mu g/m^3$;

- Maximum cumulative 24 hr average ground level concentration for existing sensitive receptors was 53.4μg/m^3 at Receptor 4 against a criterion of 50 μg/m^3; and
- The cumulative results are above the guidelines. However, it is not expected that the PM_{10} impacts will be beyond levels already experienced.

Despite generally low emission rates of particulates from the stacks, NCIA is continuing to investigate options to reduce its particulate and PM_{10} emissions from its kilns, as part of improvement plans for existing operations (per comms Leonardo Pereira).

7.2.3 Hydrogen Fluoride

GLCs of Total Fluoride as HF both in isolation and cumulatively were generally predicted to comply with the DECCW general vegetation hydrogen fluoride criterion, with the exception of receptors 1, 20, 21, and 22 (eastern boundary receptors). These receptors represent potential future residential receptors near the eastern boundary of the Facility. The predicted exceedences are summarised below:

- 24 Hour Average - no exceedences in isolation; and
- 24 Hour Average -1 cumulative exceedences (receptor 22); and
- 7 day Average - no individual or cumulative exceedences; and
- 90 day Average – 2 exceedences in isolation (receptor 1 and 22); and
- 90 day Average – 2 exceedences in isolation (receptor 1, 20, 21 and 22);

The maximum predicted GLC cumulative contours for HF are shown in **Figures 10 to 12**. The area with HF concentrations above the general vegetation criteria is shown by a red contour (predicted cumulative results).

These contours indicate potential exceedences predominately to the west and east (exceedences extending up to approximately 400m in each direction).

It is acknowledged that the modelled concentrations of HF were less than the maximum measured HF concentrations. NCIA are committed to operating at or below the 5mg/m^3 emission limit specified in their EPL, and on that basis, the 5 mg/m^3 limit has been applied to the modelling. Mitigation measures have recently resulted in reduction of HF values to concentrations below those modelled by this report and by extension the NCIA emission limits. Mitigation Measures undertaken were as follows:

- Modification of the NCIA Kiln baghouse bag mounts to replace hard mounts with soft mounts which result in a better seal, reducing bypassing of bags;
- Change in the type of lime used in the baghouse to increase the percentage of Calcium available for scrubbing of HF;
- Installation of additional monitoring points to monitor baghouse operational parameters e.g. pressure drop to allow more efficient tracking of the performance of the baghouses;
- Baghouse bag brand was changed in an effort to improve the scrubbing efficiency and the lifespan of the bags; and
- All new production lines (from lines 3 to 8) will have all kiln stacks to exhaust external and filtration systems positioned internally to the buildings. The aim of this is to ensure more efficient management of the emissions.

These items have been actioned since the stack emissions testing undertaken in July and August 2009. Recent stack tests have demonstrated compliance with the license conditions with preliminary concentrations measured on 1 June 2010 of 2.2mg/m^3 for Kiln stack 1.

7.2.4 NO_x as NO_2

Ground level concentrations of NO_x as NO_2 are predicted to increase by the modelling. Results for Scenario 2 (operation of the 8 production lines) show the following:

- Maximum cumulative 1 hr average ground level concentration for existing sensitive receptors was 191.3μg/m^3 at Receptor 18 against a criterion of 246 μg/m^3.
- Maximum cumulative Annual average ground level concentration for existing sensitive receptors was 42.0μg/m^3 at Receptor 4 against a criterion of 62 μg/m^3.

The maximum predicted GLC's at all the sensitive receptors for 1 hour average NO_2 are significantly below the DECCW guideline when modelled in isolation from background and cumulatively.

7.2.5 SO_2 and Hazardous Metals

Ground level concentrations of SO_2 and hazardous metals are predicted to increase by the modelling. The maximum predicted GLC's at all the sensitive receptors for all average periods of SO_2 and hazardous metals are significantly below the DECCW guideline when modelled in isolation from background and cumulatively (where background data could be obtained).

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8.0 Conclusion

This air quality impact assessment was undertaken for the proposed expansion of the NCIA Rutherford tile manufacturing plant.

The impact assessment predicted that concentrations of Total Suspended Particulates, NO_2, SO_2, and hazardous metals would be below the assessment criteria defined by DECCW.

PM_{10} predictions suggest the potential for cumulative impacts under worst case conditions to be above the criteria due to elevated background concentrations (which are above the DECCW assessment criteria). However PM_{10} cumulative impacts from the expanded Facility are not expected to be distinguishable from the existing tile plant's impacts and are not considered to be of concern.

The dispersion modelling indicates that existing sensitive receptors are unlikely to experience adverse impacts from HF emissions from the expanded Facility. However predicted HF GLC's suggest near field impacts (approximately less than 400m from the property boundary) have the potential to be above the relevant DECCW criteria.

Based on the results of the impact assessment, no adverse impacts are expected at existing sensitive receptors as a result of the proposed expansion of the NCIA Rutherford tile manufacturing plant.

NCIA is incorporating engineering measures into its new plant design, such as treatment of kiln exhaust with a baghouse, to minimise the impact of the proposed expansion on air quality.

Air quality emissions from the proposed construction activities, due to their temporary nature and variability, were not assessed quantitatively and will be addressed through the development and implementation of a CEMP.

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9.0 References

Department of Environment and Climate Change (DECC), 2009-2010, *Environment Protection Licence No 828*

Department of Environment and Conservation NSW (DEC), 2005, *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*.

Department of Environment and Conservation NSW (DEC), 2006, *NSW State of the Environment Report*.

ENSR, Stack Tests, 2008

ENSR Australia Pty Ltd (ENSR), July 2008, Emission Testing Report NCIA Australia Pty Ltd Annual Testing.

National Environment Protection Council (NEPC), 2003, *National Environment Protection (Ambient Air Quality) Measure*

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National Environment Protection Council (NEPC), 2003, *National Environment Protection (Ambient Air Quality) Measure*

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Figures

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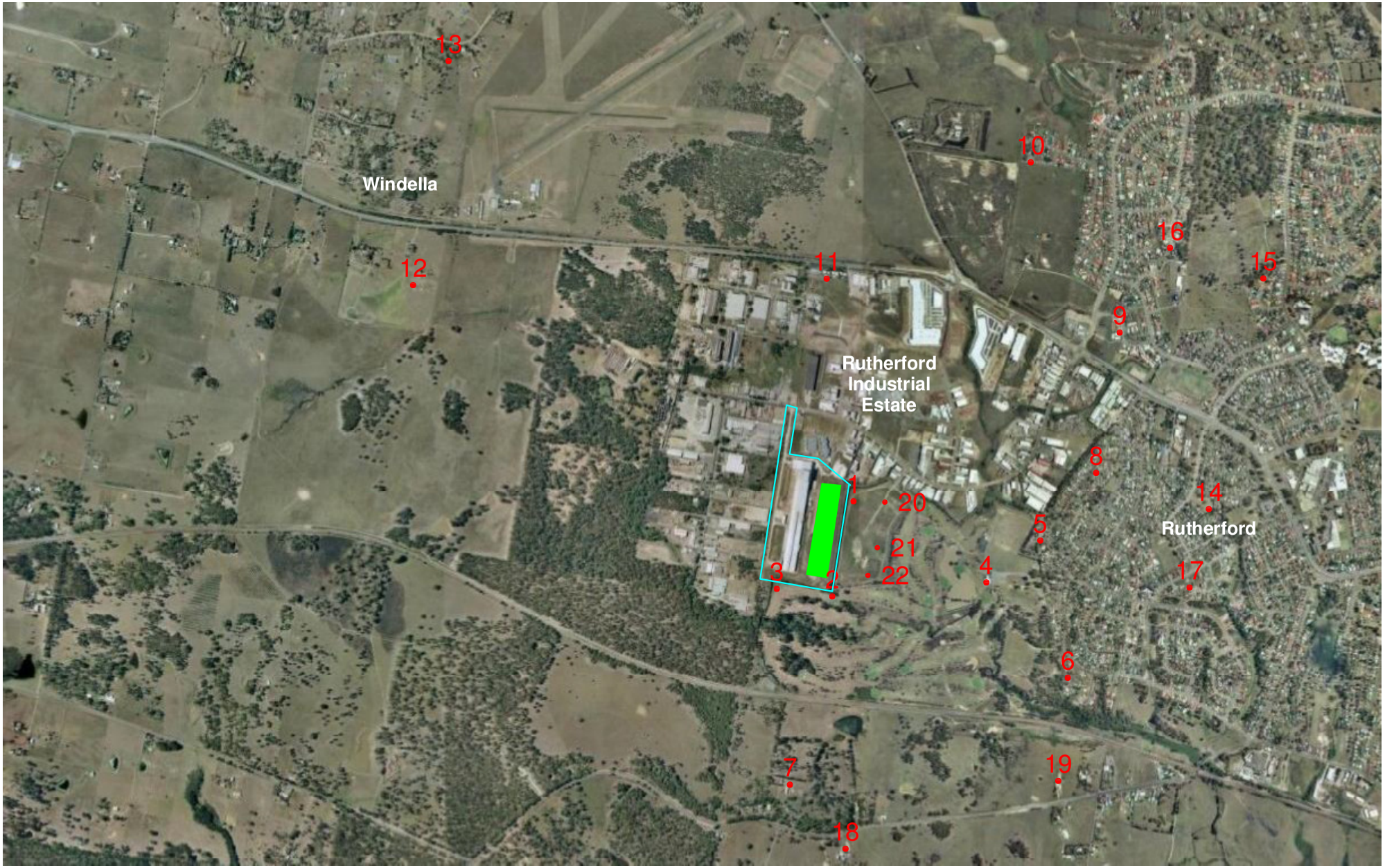

AECOM

0 1000m

- Sensitive Receptor
- Site Boundary
- Proposed Expansion

Figure 1 Site Location and Sensitive Receptors

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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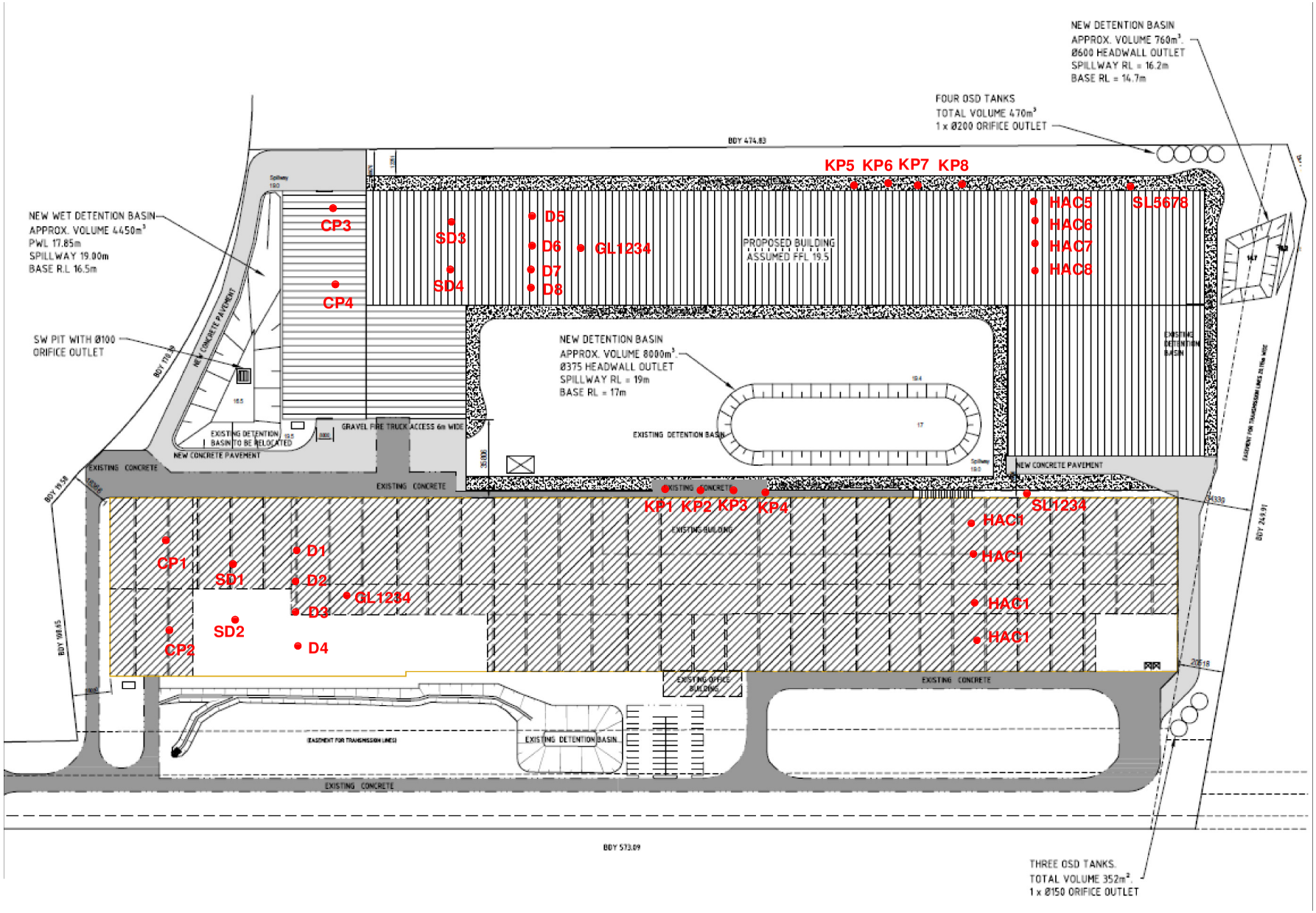

● Approximate Stack Locations

AECOM

0 50m

Figure 2 Site Layout

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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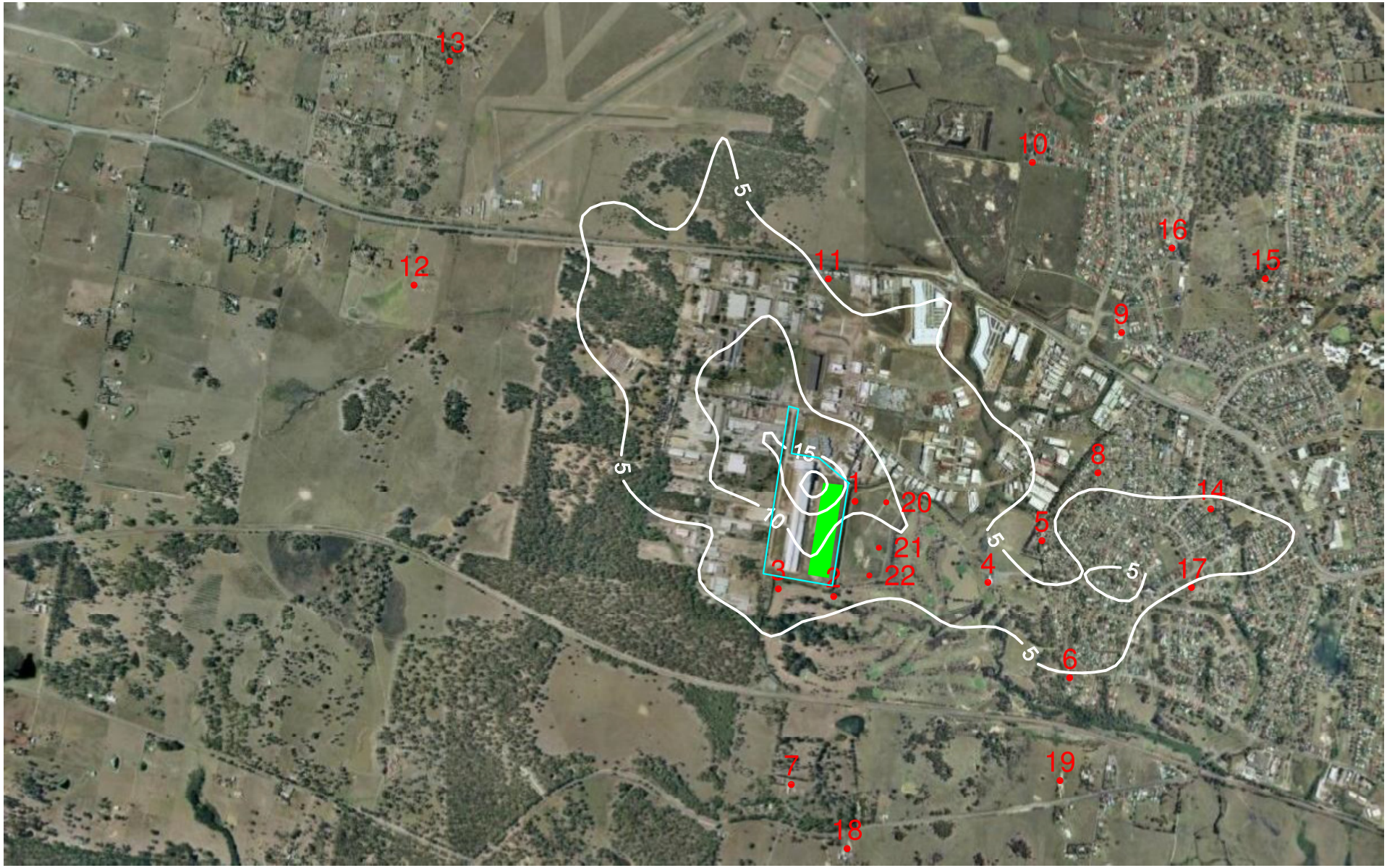

AECOM

0 500m

- Sensitive Receptor
- Site Boundary
- Units: ug/m³
- GLC Criteria: 50 ug/m³

Note: All contours represent NCIA emissions in isolation from background.

Figure 3 Scenario 2 Max PM_{10} 24 hr Average GLC Contours

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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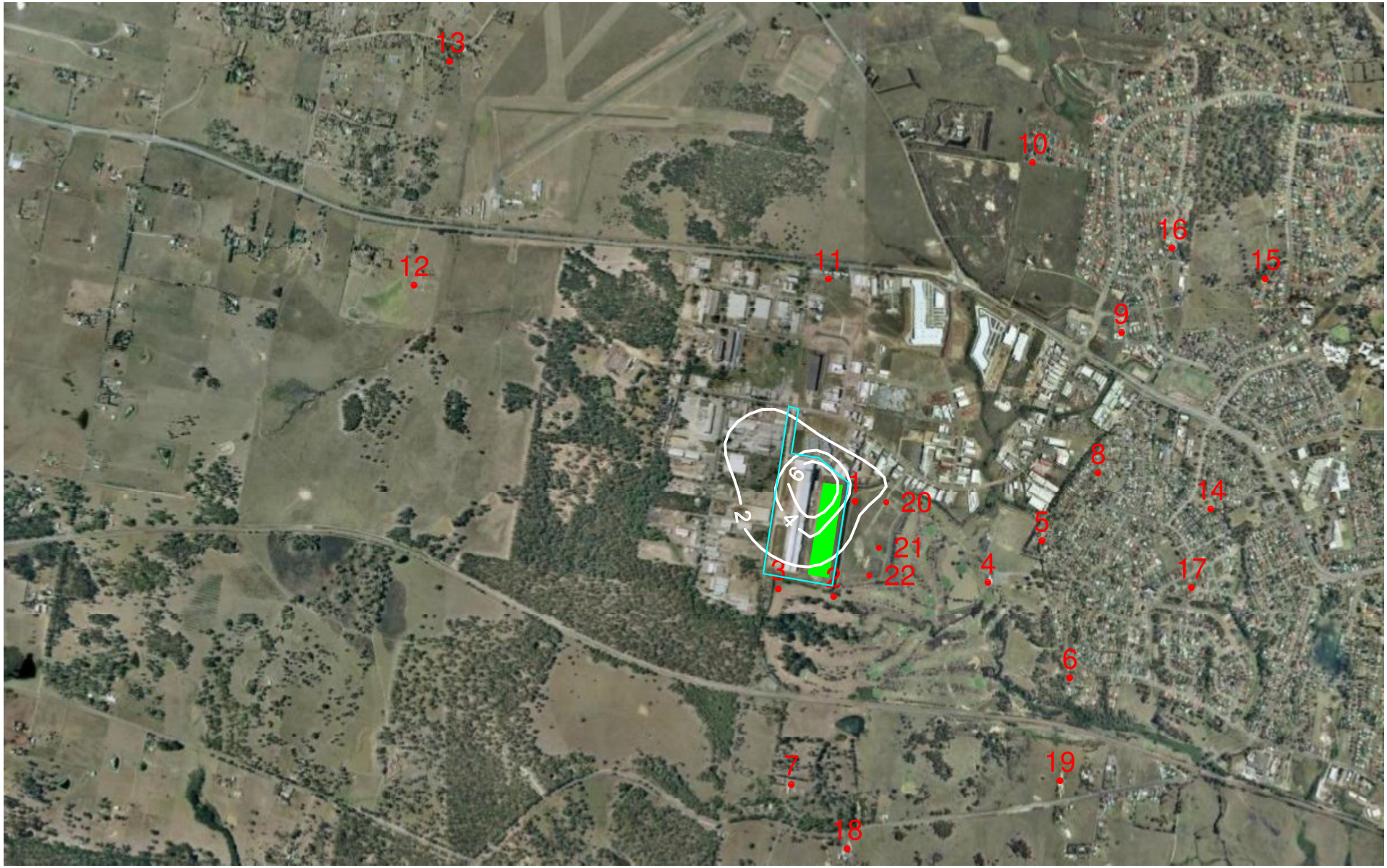

AECOM

0 500m

- Sensitive Receptor
- Site Boundary

Units: ug/m³

GLC Criteria: 30 ug/m³

Note: All contours represent NCIA emissions in isolation from background.

Figure 4 Scenario 2 Max PM_{10} Annual Average GLC Contours

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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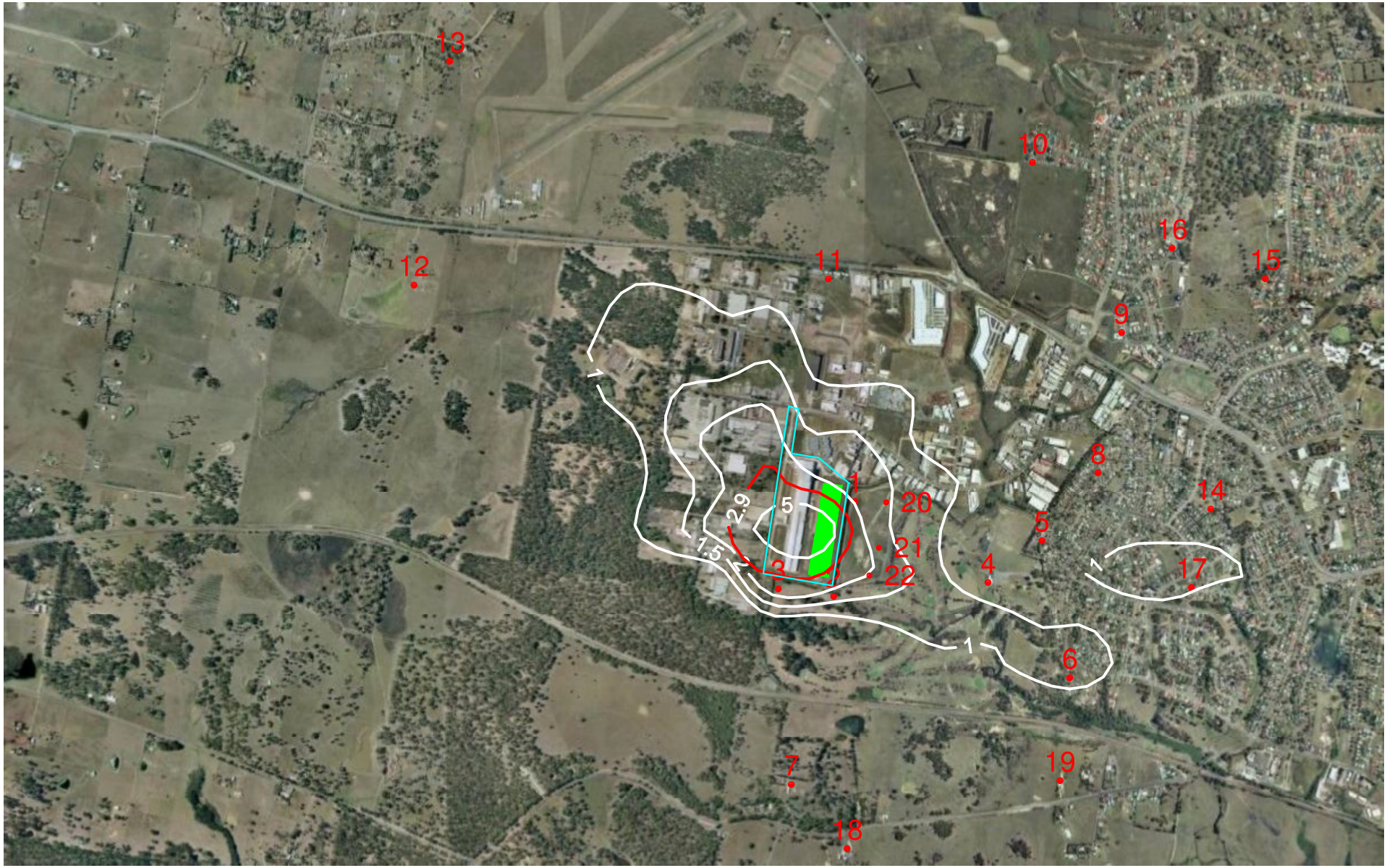

AECOM

0 500m

- Sensitive Receptor
- Site Boundary

Units: ug/m³

GLC Criteria: 2.9 ug/m³

Note: All contours represent NCIA emissions in isolation from background.

Figure 5 Scenario 2 Max HF 24 Hr Average GLC Contours

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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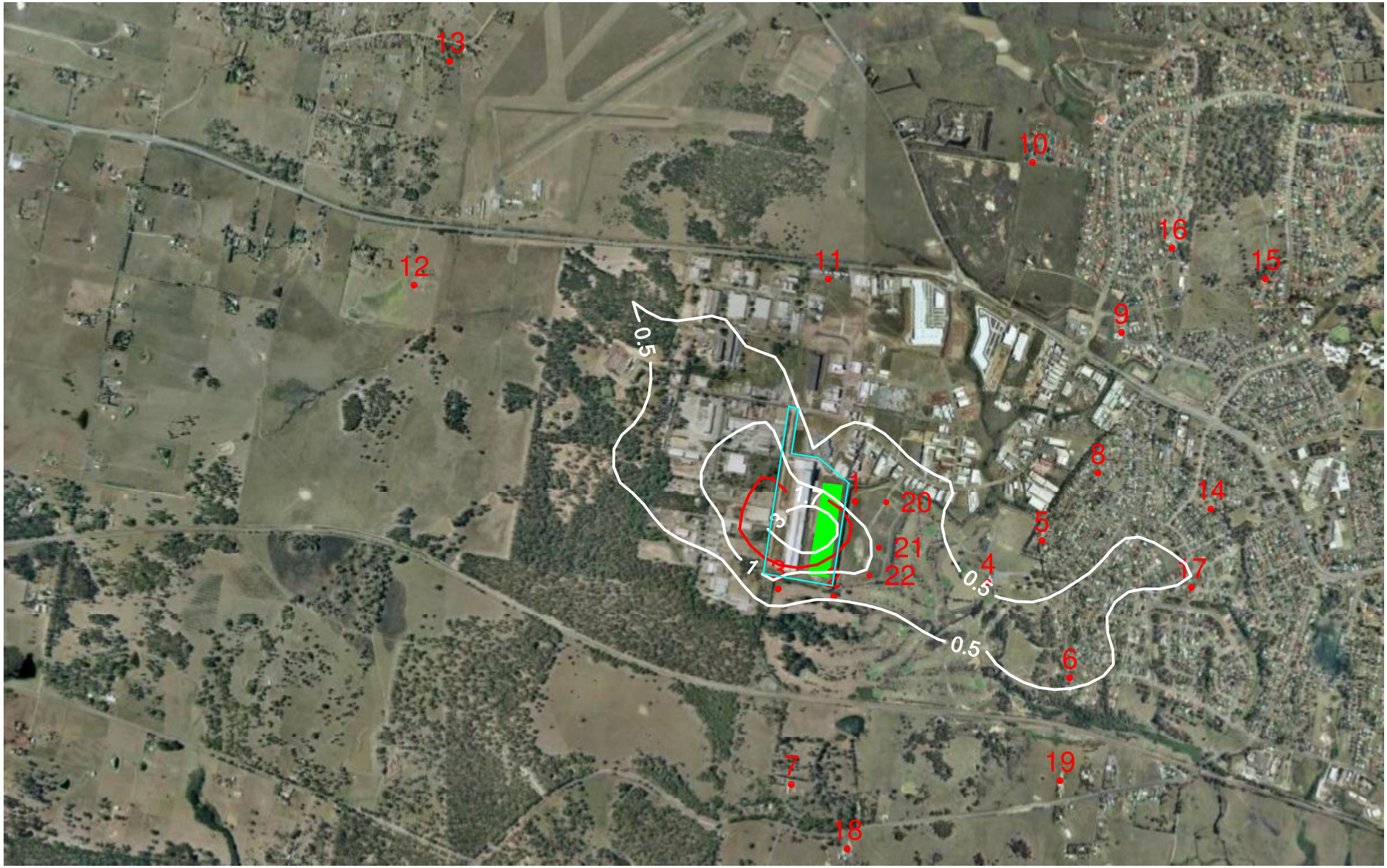

AECOM

0 500m

- Sensitive Receptor
- Site Boundary

Units: ug/m³

GLC Criteria: 1.7 ug/m³

Note: All contours represent NCIA emissions in isolation from background.

Figure 6 Scenario 2 Max HF 7 Day Average GLC Contours

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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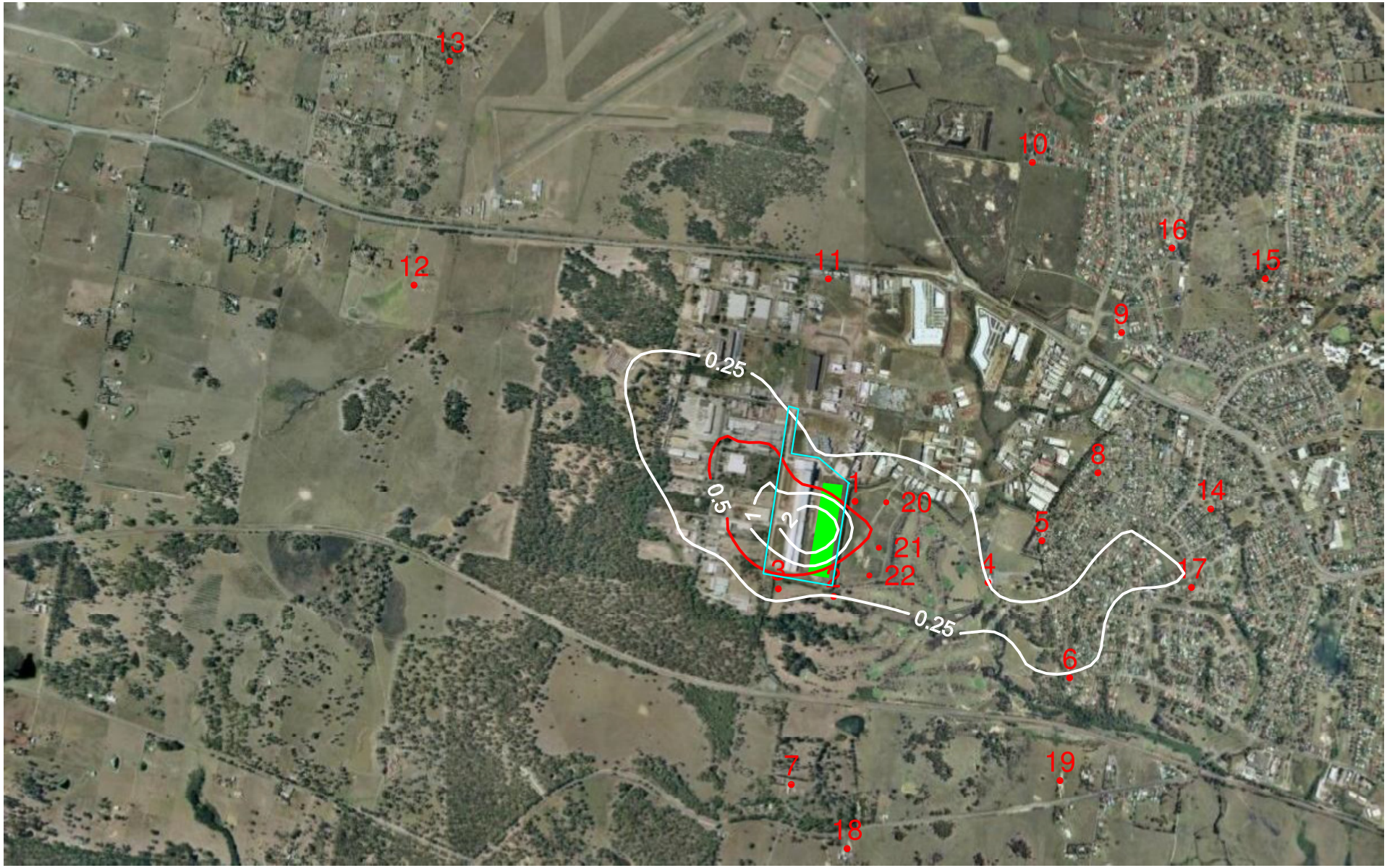

AECOM

0 500m

- Sensitive Receptor
- Site Boundary
- Units: ug/m³

GLC Criteria: 0.5 ug/m³

Note: All contours represent NCIA emissions in isolation from background.

Figure 7 Scenario 2 Max HF 90 Day Average GLC Contours

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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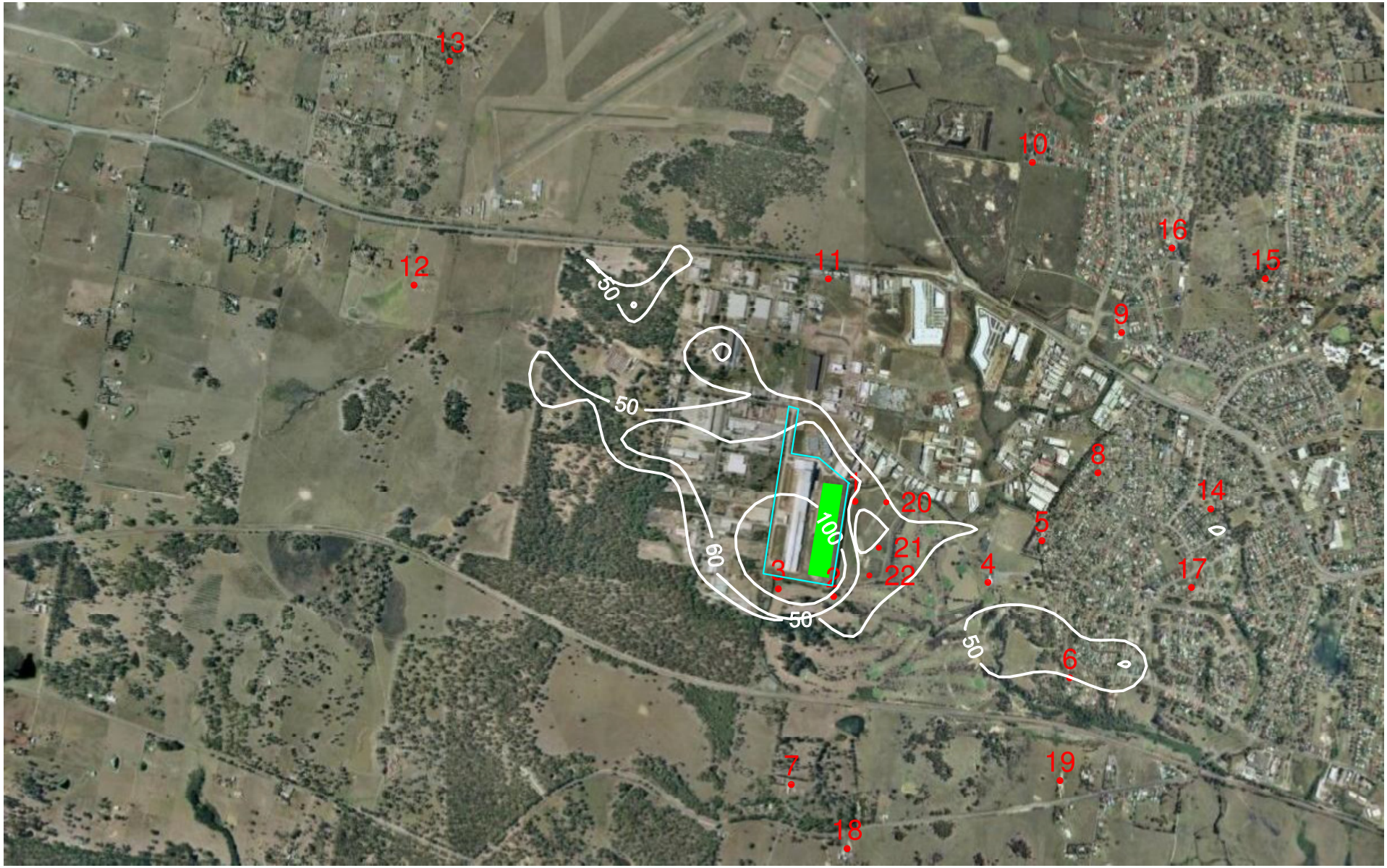

AECOM

0 500m

Sensitive Receptor
Site Boundary
Units: ug/m³
GLC Criteria: 246ug/m³
Note: All contours represent NCIA emissions in isolation from background.

Figure 8 Scenario 2 Max NO_2 1 Hr Average GLC Contours
National Ceramics Industries Australia
Air Quality Impact Assessment
Rutherford NSW

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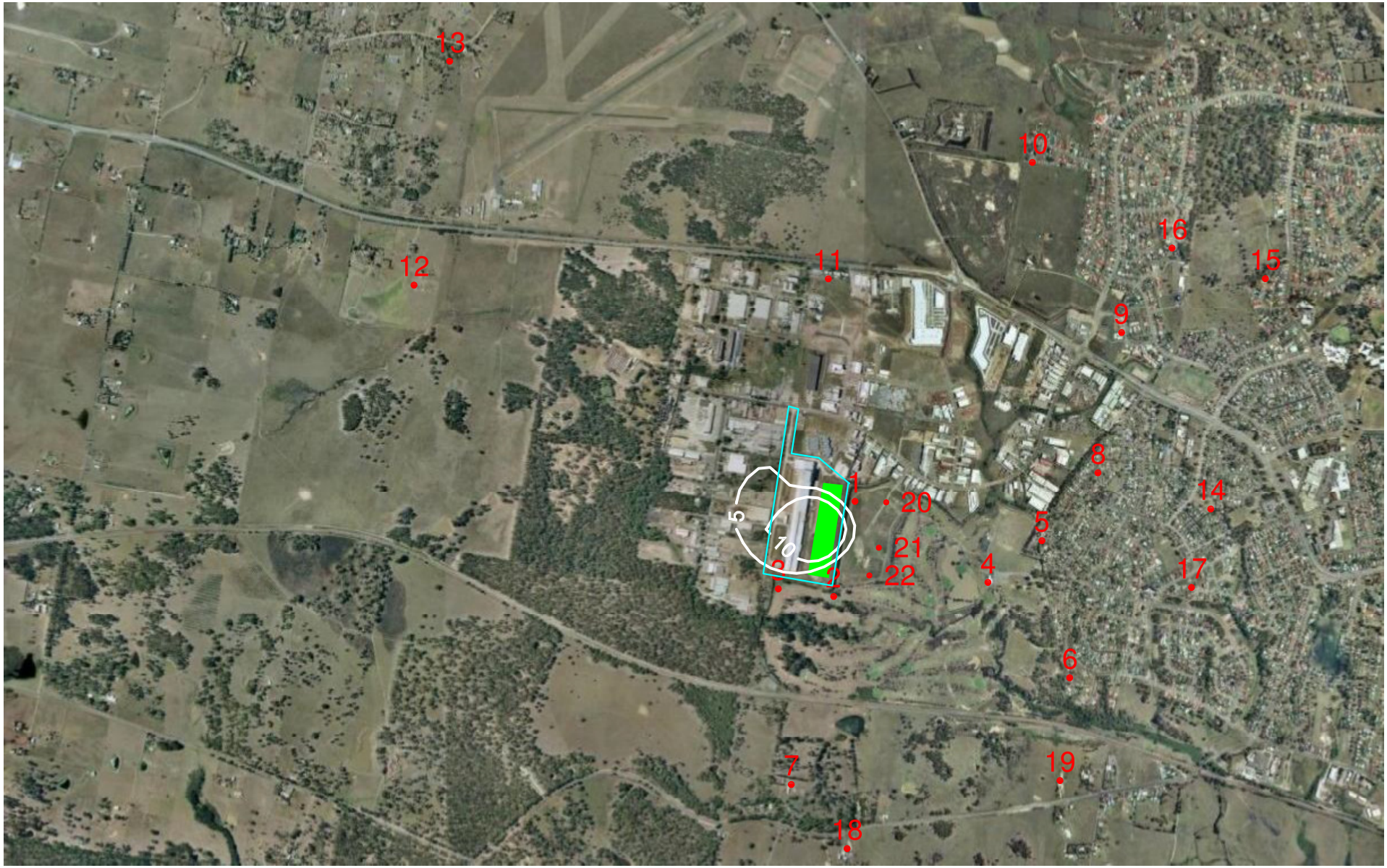

AECOM

0 500m

Sensitive Receptor
Site Boundary
Units: ug/m³
GLC Criteria: 62 ug/m³
Note: All contours represent NCIA emissions in isolation from background.

Figure 9 Scenario 2 Max NO_2 Annual Average GLC Contours

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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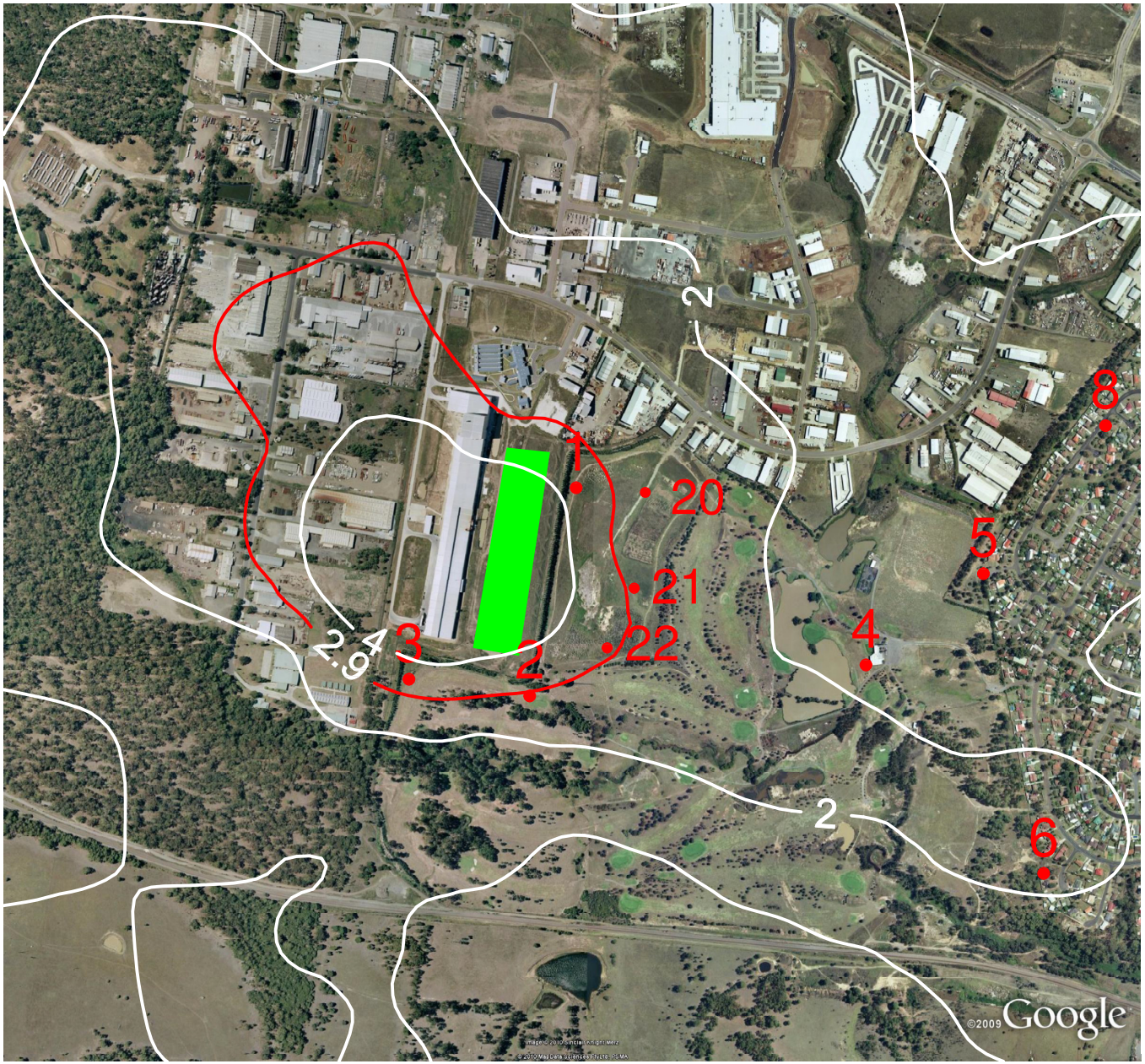

AECOM

0 500m

Sensitive Receptor
Site Boundary
Units: ug/m³

GLC Criteria: 2.9 ug/m³
Background Value: 0.9

Figure 10 Scenario 2 Max HF 24 hr Average GLC Contours (Cumulative)
National Ceramics Industries Australia
Air Quality Impact Assessment
Rutherford NSW

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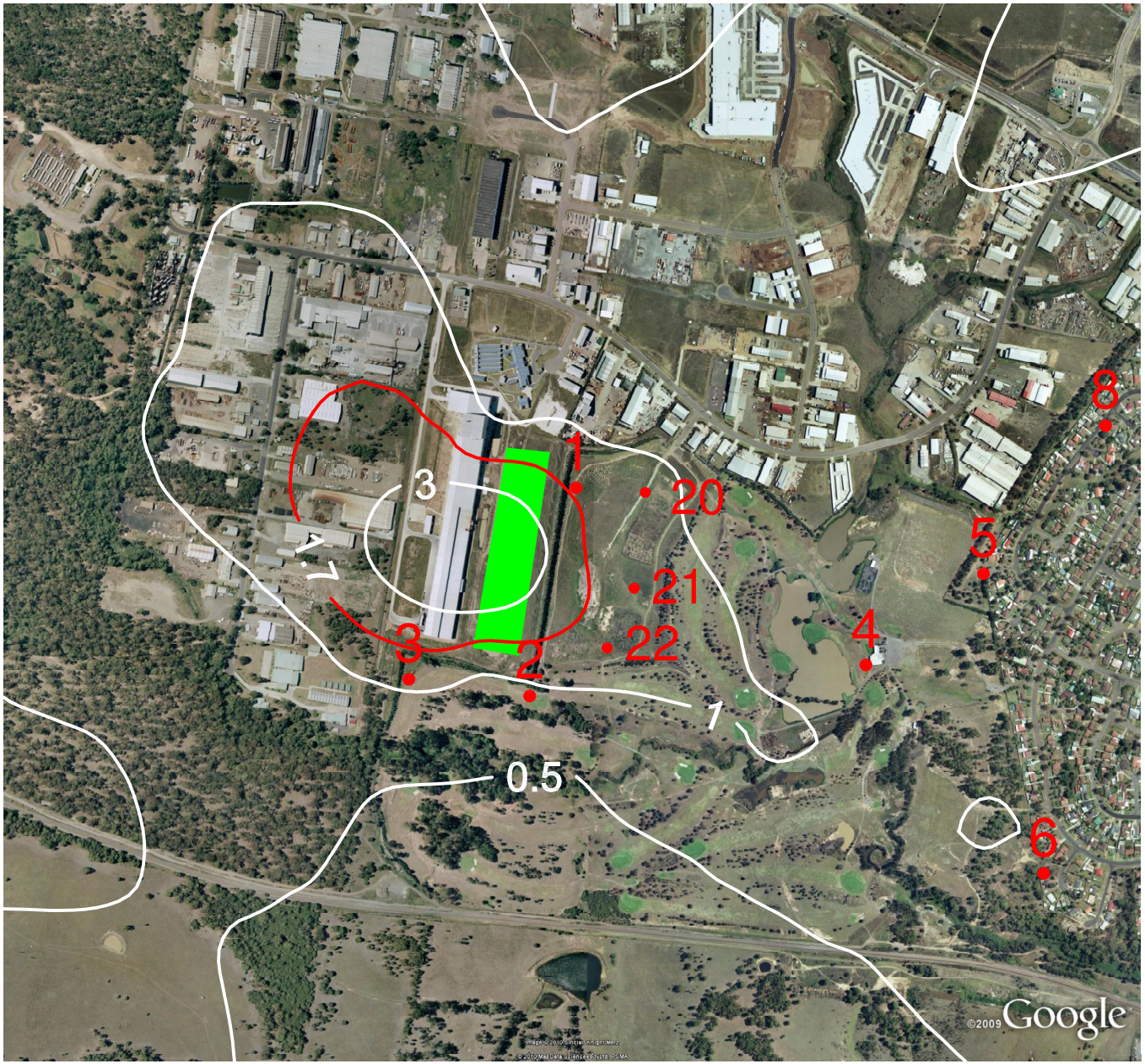

AECOM

N

0 500m

- Sensitive Receptor
- Site Boundary
- Units: ug/m³

GLC Criteria: 1.7 ug/m³
Background Value: 0.3

Figure 11 Scenario 2 Max HF 7 Day Average GLC Contours (Cummulative)

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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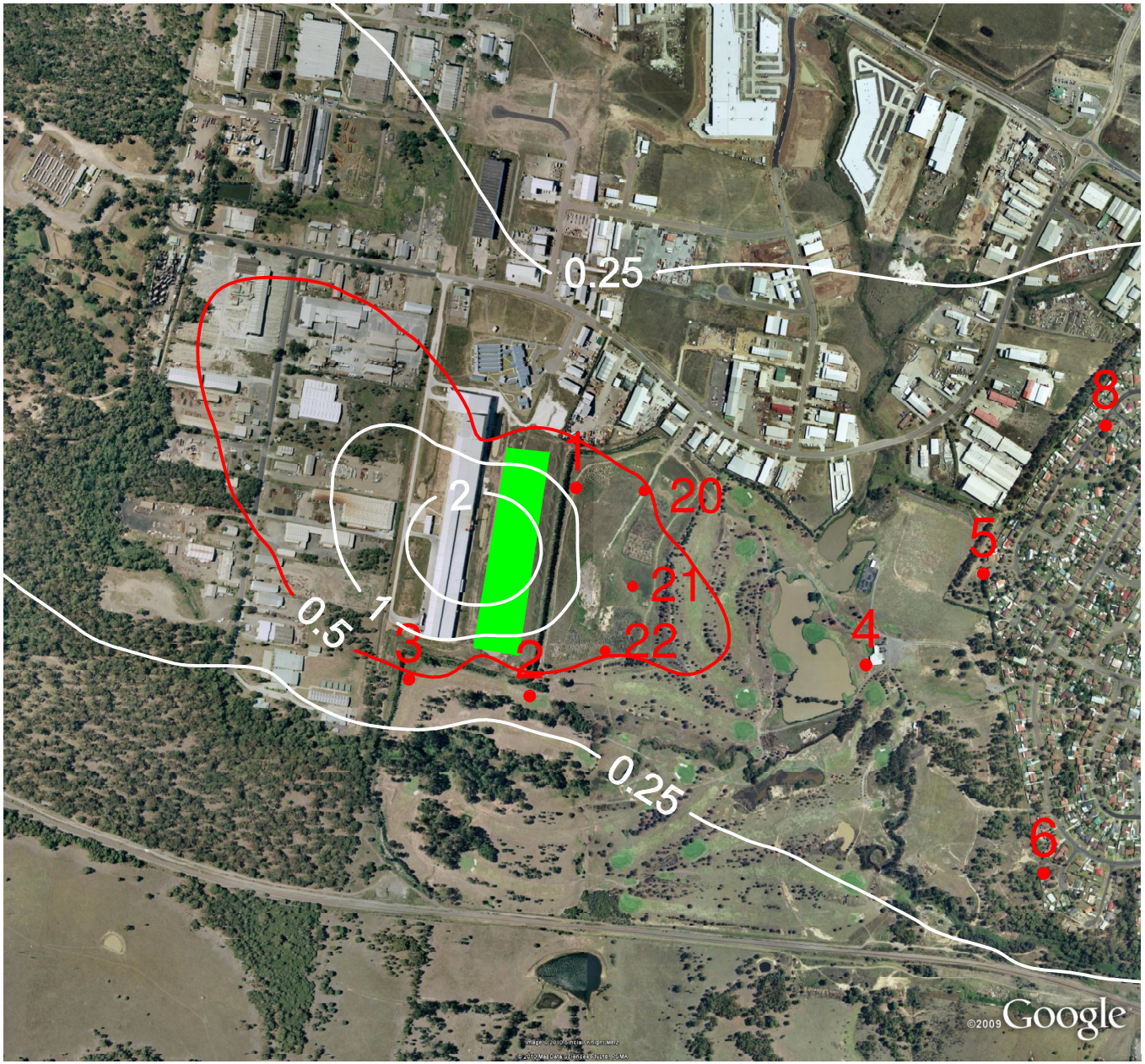

AECOM

N

0 200m

Sensitive Receptor
Site Boundary
Units: ug/m³

GLC Criteria: 0.5 ug/m³
Background Value: 0.1ug/m³

Figure 12 Scenario 2 Max HF 90 Day Average GLC Contours (Cumulative)

National Ceramics Industries Australia

Air Quality Impact Assessment

Rutherford NSW

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Appendix A

Example AUSPLUME File

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1

NCIA PM10 MAX

Concentration or deposition	Concentration
Emission rate units	grams/second
Concentration units	microgram/m3
Units conversion factor	1.00E+06
Constant background concentration	0.00E+00
Terrain effects	Egan method
Smooth stability class changes?	No
Other stability class adjustments ("urban modes")	None
Ignore building wake effects?	No
Decay coefficient (unless overridden by met. file)	0.000
Anemometer height	10 m
Roughness height at the wind vane site	0.300 m
Averaging time for sigma-theta values	60 min.

DISPERSION CURVES

Horizontal dispersion curves for sources <100m high	Sigma-theta
Vertical dispersion curves for sources <100m high	Pasquill-Gifford
Horizontal dispersion curves for sources >100m high	Briggs Rural
Vertical dispersion curves for sources >100m high	Briggs Rural
Enhance horizontal plume spreads for buoyancy?	Yes
Enhance vertical plume spreads for buoyancy?	Yes
Adjust horizontal P-G formulae for roughness height?	Yes
Adjust vertical P-G formulae for roughness height?	Yes
Roughness height	0.400m
Adjustment for wind directional shear	None

PLUME RISE OPTIONS

Gradual plume rise?	Yes
Stack-tip downwash included?	Yes
Building downwash algorithm:	PRIME method.
Entrainment coeff. for neutral & stable lapse rates	0.60,0.60
Partial penetration of elevated inversions?	No
Disregard temp. gradients in the hourly met. file?	No

and in the absence of boundary-layer potential temperature gradients given by the hourly met. file, a value from the following table (in K/m) is used:

Wind Speed Category	Stability Class A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.020	0.035
2	0.000	0.000	0.000	0.000	0.020	0.035
3	0.000	0.000	0.000	0.000	0.020	0.035
4	0.000	0.000	0.000	0.000	0.020	0.035
5	0.000	0.000	0.000	0.000	0.020	0.035
6	0.000	0.000	0.000	0.000	0.020	0.035

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Urban" values (unless overridden by met. file)

AVERAGING TIMES
24 hours
average over all hours

STACK SOURCE: CP1

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359771	6379246	20m	32m	1.00m	26C	15.8m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	82	88	92	93	91	86	79	69	57	45	58	69
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	45	58	68	78	84	88	89	87	83	82	88	92
Along-flow distance from stack	-45	-56	-65	-73	-77	-80	-80	-78	-73	-69	-68	-65
Across-flow distance from stack	28	24	19	13	7	1	-5	-12	-18	-23	-27	-31

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	77	84	88	89	87	83	82	88	92	93	91	86
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	93	91	86	79	69	57	45	58	69	77	84	87
Along-flow distance from stack	-59	-52	-44	-34	-23	-11	1	-2	-3	-5	-7	-8
Across-flow distance from stack	-34	-36	-36	-36	-34	-32	-28	-24	-19	-13	-7	-1

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	79	69	57	45	58	69	77	84	88	89	87	83
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	89	87	83	82	88	92	93	91	86	79	69	57
Along-flow distance from stack	-9	-10	-10	-13	-20	-27	-34	-39	-42	-45	-47	-46
Across-flow distance from stack	6	12	18	23	27	31	34	35	36	36	34	32

(Constant) emission rate = 2.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: PD1

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359755	6379199	20m	32m	1.00m	25C	12.0m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	82	88	92	93	91	86	79	69	57	45	58	69
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	45	58	68	78	84	88	89	87	83	82	88	92
Along-flow distance from stack	4	-6	-16	-26	-35	-43	-49	-54	-57			

-61 -69 -74
Across-flow distance from stack 20 25 28 31 33 33 33 32 30
26 22 18

Flow direction 130° 140° 150° 160° 170° 180° 190° 200° 210°
220° 230° 240°
Effective building width 77 84 88 89 87 83 82 88 92
93 91 86
Effective building height 28 28 28 28 28 28 28 28 28
28 28 28
Along-flow building length 93 91 86 79 69 57 45 58 69
77 84 87
Along-flow distance from stack -77 -78 -77 -72 -66 -58 -49 -52 -52
-51 -49 -45
Across-flow distance from stack 13 7 1 -4 -10 -16 -20 -25 -28
-31 -33 -33

Flow direction 250° 260° 270° 280° 290° 300° 310° 320° 330°
340° 350° 360°
Effective building width 79 69 57 45 58 69 77 84 88
89 87 83
Effective building height 28 28 28 28 28 28 28 28 28
28 28 28
Along-flow building length 89 87 83 82 88 92 93 91 86
79 69 57
Along-flow distance from stack -40 -34 -26 -21 -19 -18 -16 -13 -10
-6 -3 1
Across-flow distance from stack -33 -32 -30 -27 -22 -18 -13 -7 -1
5 10 16

(Constant) emission rate = 2.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: D1

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359737	6379177	20m	18m	0.50m	111C	10.2m/s

Effective building dimensions (in metres)

Flow direction 10° 20° 30° 40° 50° 60° 70° 80° 90°
100° 110° 120°
Effective building width 82 88 92 93 91 86 79 77 65
54 68 69
Effective building height 28 28 28 28 28 28 28 15 15
15 15 28
Along-flow building length 45 58 68 78 84 88 89 95 90
85 90 92
Along-flow distance from stack 29 21 12 3 -7 -16 -24 -53 -51
-47 -49 -70
Across-flow distance from stack 7 15 24 31 38 43 48 4 4
3 1 46

Flow direction 130° 140° 150° 160° 170° 180° 190° 200° 210°
220° 230° 240°
Effective building width 77 84 88 89 87 83 82 88 92
93 91 86
Effective building height 28 28 28 28 28 28 28 28 28
28 28 28
Along-flow building length 93 91 86 79 69 57 45 58 69
77 84 87
Along-flow distance from stack -78 -83 -87 -87 -85 -80 -74 -78 -80
-80 -77 -72
Across-flow distance from stack 41 35 28 20 11 3 -7 -15 -24
-31 -38 -43

Flow direction 250° 260° 270° 280° 290° 300° 310° 320° 330°
340° 350° 360°
Effective building width 79 77 55 39 57 69 77 84 88

89 87 83
Effective building height 28 15 26 26 26 28 28 28 28
28 28 28
Along-flow building length 89 95 112 109 114 92 93 91 86
79 69 57
Along-flow distance from stack -64 -42 -190 -191 -192 -22 -15 -8 1
9 16 23
Across-flow distance from stack -48 -4 28 5 -20 -46 -42 -35 -28
-20 -11 -3

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: D2

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359730	6379178	20m	18m	0.50m	111C	10.2m/s

_____ Effective building dimensions (in metres) _____

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°
100° 110° 120°									
Effective building width	82	88	92	93	91	86	79	69	65
54 68 69									
Effective building height	28	28	28	28	28	28	28	28	15
15 15 28									
Along-flow building length	45	58	68	78	84	88	89	87	90
85 90 92									
Along-flow distance from stack	29	22	15	6	-2	-10	-18	-25	-44
-40 -42 -63									
Across-flow distance from stack	-1	8	17	25	33	39	44	48	3
3 3 48									

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°
220° 230° 240°									
Effective building width	77	84	88	89	87	83	82	88	92
93 91 86									
Effective building height	28	28	28	28	28	28	28	28	28
28 28 28									
Along-flow building length	93	91	86	79	69	57	45	58	69
77 84 87									
Along-flow distance from stack	-72	-78	-82	-84	-83	-79	-74	-80	-83
-84 -82 -77									
Across-flow distance from stack	45	40	34	26	18	10	1	-8	-17
-25 -33 -39									

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340° 350° 360°									
Effective building width	79	69	55	39	57	73	77	84	88
89 87 83									
Effective building height	28	28	26	26	26	26	28	28	28
28 28 28									
Along-flow building length	89	87	112	109	114	115	93	91	86
79 69 57									
Along-flow distance from stack	-71	-62	-197	-198	-199	-193	-21	-13	-4
5 14 22									
Across-flow distance from stack	-44	-48	29	4	-21	-46	-45	-40	-34
-26 -18 -10									

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: D3

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359700	6379175	20m	18m	0.50m	111C	10.2m/s

_____ Effective building dimensions (in metres) _____

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	82	88	92	93	91	86	79	69	65	54	68	79
Effective building height	28	28	28	28	28	28	28	28	15	15	15	15
Along-flow building length	45	58	68	78	84	88	89	87	90	85	90	95
Along-flow distance from stack	38	36	32	28	23	17	11	5	-14	-11	-15	-21
Across-flow distance from stack	-30	-19	-7	4	16	27	37	46	6	11	16	20

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	88	94	98	89	87	83	82	88	92	93	91	86
Effective building height	15	15	15	28	28	28	28	28	28	28	28	28
Along-flow building length	97	96	92	79	69	57	45	58	69	77	84	87
Along-flow distance from stack	-26	-30	-34	-76	-80	-82	-82	-93	-100	-105	-107	-105
Across-flow distance from stack	24	27	30	55	48	40	30	19	7	-4	-16	-27

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	79	69	55	39	57	79	88	94	97	89	87	83
Effective building height	28	28	26	26	26	15	15	15	15	28	28	28
Along-flow building length	89	87	112	109	114	95	97	96	92	79	69	57
Along-flow distance from stack	-100	-92	-227	-227	-226	-74	-71	-66	-59	-3	11	25
Across-flow distance from stack	-37	-46	26	-4	-34	-20	-24	-28	-30	-56	-48	-40

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: D4

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359689	6379176	20m	18m	0.50m	111C	10.2m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	82	88	92	93	91	86	79	69	65	54	68	79
Effective building height	28	28	28	28	28	28	28	28	15	15	15	15
Along-flow building length	45	58	68	78	84	88	89	87	90	85	90	95
Along-flow distance from stack	38	38	37	34	31	26	21	15	-3	0	-4	-11
Across-flow distance from stack	-41	-29	-17	-5	8	20	32	43	5	12	19	25

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	88	94	98	98	95	83	82	88	92	93	91	86
Effective building height	15	15	15	15	15	28	28	28	28	28	28	28
Along-flow building length	97	96	92	86	77	57	45	58	69

77 84 87
Along-flow distance from stack -17 -23 -28 -32 -35 -81 -83 -96 -105 -111 -115 -114
Across-flow distance from stack 31 35 39 41 42 51 41 29 17 5 -8 -20

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	79	69	55	39	57	79	88	94	97	98	95	83
Effective building height	28	28	26	26	26	15	15	15	15	15	15	28
Along-flow building length	89	87	112	109	114	95	97	96	92	86	77	57
Along-flow distance from stack	-110	-103	-238	-238	-237	-84	-80	-74	-65	-54	-42	24
Across-flow distance from stack	-32	-43	27	-5	-37	-25	-31	-35	-39	-41	-42	-51

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GL1234

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359761	6379198	20m	32m	1.00m	28C	12.1m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	82	88	92	93	91	86	79	69	57	45	58	69
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	45	58	68	78	84	88	89	87	83	82	88	92
Along-flow distance from stack	4	-7	-19	-29	-39	-47	-54	-59	-63	-67	-75	-80
Across-flow distance from stack	27	31	34	36	37	37	36	34	31	26	21	16

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	77	84	88	89	87	83	82	88	92	93	91	86
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	93	91	86	79	69	57	45	58	69	77	84	87
Along-flow distance from stack	-83	-82	-81	-75	-68	-59	-49	-50	-50	-48	-45	-40
Across-flow distance from stack	10	3	-4	-10	-16	-22	-26	-31	-34	-36	-37	-37

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	79	69	57	45	58	69	77	84	88	89	87	83
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	89	87	83	82	88	92	93	91	86	79	69	57
Along-flow distance from stack	-35	-28	-20	-14	-13	-12	-10	-8	-6	-3	-1	2
Across-flow distance from stack	-36	-34	-31	-27	-21	-16	-10	-3	3	10	16	22

(Constant) emission rate = 2.00E-02 grams/second

No gravitational settling or scavenging.

STACK SOURCE: SL1234

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359723	6378852	20m	14m	0.50m	25C	2.8m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	57	78	154	206	253	292	322	342	352	354	357	349
Effective building height	12	8	12	12	12	12	12	12	12	12	12	12
Along-flow building length	354	264	349	330	301	262	216	164	106	57	96	153
Along-flow distance from stack	-55	-58	-69	-73	-75	-75	-72	-67	-60	-61	-111	-158
Across-flow distance from stack	32	26	82	98	111	121	127	129	127	123	115	105

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	330	301	262	216	164	106	57	78	154	206	253	292
Effective building height	12	12	12	12	12	12	12	8	12	12	12	12
Along-flow building length	207	253	292	322	342	352	355	265	349	330	301	263
Along-flow distance from stack	-201	-238	-267	-288	-300	-303	-300	-207	-280	-257	-226	-188
Across-flow distance from stack	92	75	57	36	15	-7	-32	-26	-82	-98	-111	-121

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	322	342	352	355	357	348	330	300	262	216	164	106
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	216	164	106	57	96	153	207	253	292	322	342	352
Along-flow distance from stack	-144	-97	-46	4	15	5	-6	-16	-26	-35	-42	-49
Across-flow distance from stack	-127	-129	-127	-122	-116	-105	-91	-76	-57	-36	-15	7

(Constant) emission rate = 3.00E-03 grams/second
No gravitational settling or scavenging.

STACK SOURCE: SD1

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359742	6379234	20m	32m	1.40m	103C	21.3m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	82	88	92	93	91	86	79	69	57	45	58	69
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	45	58	68	78	84	88	89	87	83	82	88	92
Along-flow distance from stack	-28	-35	-40	-45	-47	-49	-49	-47	-44	-42	-45	-45
Across-flow distance from stack	2	1	-1	-2	-3	-3	-4	-5	-6			

-6 -6 -6

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	77	84	88	89	87	83	82	88	92	93	91	86
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	93	91	86	79	69	57	45	58	69	77	84	87
Along-flow distance from stack	-45	-43	-40	-35	-30	-23	-17	-23	-28	-33	-37	-39
Across-flow distance from stack	-6	-6	-5	-4	-3	-3	-2	0	1	2	3	4

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	79	69	57	45	58	69	77	84	88	89	87	83
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	89	87	83	82	88	92	93	91	86	79	69	57
Along-flow distance from stack	-40	-40	-39	-39	-44	-47	-48	-48	-47	-44	-40	-34
Across-flow distance from stack	4	5	6	6	6	6	6	6	5	4	3	3

(Constant) emission rate = 2.50E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: SD2

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359715	6379237	20m	32m	1.40m	103C	21.3m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	82	88	92	93	91	86	79	69	57	45	58	69
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	45	58	68	78	84	88	89	87	83	82	88	92
Along-flow distance from stack	-27	-28	-29	-30	-29	-27	-24	-21	-17	-15	-18	-21
Across-flow distance from stack	-26	-26	-25	-24	-22	-20	-16	-13	-9	-5	0	5

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	77	84	88	89	87	83	82	88	92	93	91	86
Effective building height	28	28	28	28	28	28	28	28	28	28	28	28
Along-flow building length	93	91	86	79	69	57	45	58	69	77	84	87
Along-flow distance from stack	-22	-23	-24	-23	-22	-20	-19	-30	-39	-48	-55	-61
Across-flow distance from stack	9	13	17	20	23	25	26	26	25	24	22	20

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	79	69	57	45	58	69	77	84	88	89	87	83
Effective building height	28	28	28	28	28	28	28	28	28			

28 28 28
Along-flow building length 89 87 83 82 88 92 93 91 86
79 69 57
Along-flow distance from stack -65 -66 -66 -67 -70 -71 -71 -68 -63
-56 -47 -37
Across-flow distance from stack 16 13 9 4 0 -5 -10 -13 -17
-20 -23 -25

(Constant) emission rate = 2.50E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: KP1

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359750	6379033	20m	24m	0.80m	120C	16.6m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	57	96	154	206	253	292	322	342	352	354	357	349
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	354	357	349	330	301	262	216	164	106	57	96	153
Along-flow distance from stack	-238	-242	-240	-229	-212	-188	-159	-125	-87	-56	-75	-91
Across-flow distance from stack	27	27	15	2	-11	-23	-35	-45	-54	-61	-64	-65

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	330	301	262	216	164	106	57	96	115	113	107	98
Effective building height	12	12	12	12	12	12	12	12	26	26	26	26
Along-flow building length	207	253	292	322	342	352	355	357	74	88	99	107
Along-flow distance from stack	-105	-116	-123	-127	-126	-122	-117	-115	-198	-211	-217	-216
Across-flow distance from stack	-64	-62	-57	-51	-43	-34	-27	-27	46	17	-12	-41

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	322	342	352	355	357	348	330	300	262	216	164	106
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	216	164	106	57	96	153	207	253	292	322	342	352
Along-flow distance from stack	-57	-39	-19	-1	-21	-62	-101	-137	-169	-196	-216	-230
Across-flow distance from stack	35	45	54	60	64	65	65	62	57	51	43	34

(Constant) emission rate = 3.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: KP2

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359749	6379014	20m	24m	0.80m	120C	16.6m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°

Effective building width	57	96	154	206	253	292	322	342	352	354	357	349
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	354	357	349	330	301	262	216	164	106	57	96	153
Along-flow distance from stack	-219	-224	-223	-214	-199	-178	-152	-121	-86	-58	-80	-100
Across-flow distance from stack	30	32	23	13	3	-7	-17	-27	-35	-42	-46	-48

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	330	301	262	216	164	106	57	96	154	206	253	292
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	207	253	292	322	342	352	355	357	349	330	301	263
Along-flow distance from stack	-117	-130	-139	-144	-145	-141	-136	-133	-126	-116	-102	-85
Across-flow distance from stack	-49	-49	-47	-44	-39	-33	-30	-32	-23	-14	-3	7

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	322	342	352	355	357	348	330	300	262	216	164	106
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	216	164	106	57	96	153	207	253	292	322	342	352
Along-flow distance from stack	-65	-43	-20	1	-16	-54	-90	-123	-153	-178	-197	-211
Across-flow distance from stack	17	27	35	42	46	48	49	49	47	43	39	33

(Constant) emission rate = 3.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: KP3

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359745	6378993	20m	24m	0.80m	120C	16.6m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	57	96	154	206	253	292	322	342	352	354	357	349
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	354	357	349	330	301	262	216	164	106	57	96	153
Along-flow distance from stack	-198	-203	-203	-196	-183	-164	-141	-113	-82	-58	-84	-107
Across-flow distance from stack	29	36	30	24	17	10	2	-7	-14	-20	-25	-28

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	330	301	262	216	164	106	57	96	154	206	253	292
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	207	253	292	322	342	352	355	357	349	330	301	263
Along-flow distance from stack	-127	-144	-156	-163	-165	-162	-157	-154	-147			

-135 -118 -98
Across-flow distance from stack -31 -32 -33 -33 -31 -29 -29 -36 -30
-24 -17 -10

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340° 350° 360°									
Effective building width	322	342	352	355	357	348	330	300	262
216 164 106									
Effective building height	12	12	12	12	12	12	12	12	12
12 12 12									
Along-flow building length	216	164	106	57	96	153	207	253	292
322 342 352									
Along-flow distance from stack	-76	-51	-24	1	-12	-47	-79	-110	-137
-160 -177 -190									
Across-flow distance from stack	-2	7	14	20	25	28	31	32	33
32 31 29									

(Constant) emission rate = 3.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: KP4

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359742	6378974	20m	24m	0.80m	120C	16.6m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°
100° 110° 120°									
Effective building width	57	96	154	206	253	292	322	342	352
354 357 349									
Effective building height	12	12	12	12	12	12	12	12	12
12 12 12									
Along-flow building length	354	357	349	330	301	262	216	164	106
57 96 153									
Along-flow distance from stack	-178	-184	-185	-179	-168	-152	-131	-107	-79
-58 -87 -114									
Across-flow distance from stack	30	39	37	34	30	25	19	12	5
-1 -6 -10									

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°
220° 230° 240°									
Effective building width	330	301	262	216	164	106	57	96	154
206 253 292									
Effective building height	12	12	12	12	12	12	12	12	12
12 12 12									
Along-flow building length	207	253	292	322	342	352	355	357	349
330 301 263									
Along-flow distance from stack	-137	-156	-171	-179	-183	-181	-176	-173	-165
-151 -133 -111									
Across-flow distance from stack	-14	-18	-21	-23	-25	-26	-30	-39	-37
-34 -30 -25									

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340° 350° 360°									
Effective building width	322	342	352	355	357	348	330	300	262
216 164 106									
Effective building height	12	12	12	12	12	12	12	12	12
12 12 12									
Along-flow building length	216	164	106	57	96	153	207	253	292
322 342 352									
Along-flow distance from stack	-85	-57	-27	1	-9	-40	-70	-97	-122
-143 -159 -171									
Across-flow distance from stack	-19	-12	-5	1	6	10	14	18	21
23 25 26									

(Constant) emission rate = 3.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: HAC1

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359725	6378917	20m	16m	0.80m	115C	26.9m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	57	96	154	206	253	292	322	342	352	354	357	349
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	354	357	349	330	301	262	216	164	106	57	96	153
Along-flow distance from stack	-119	-125	-127	-125	-119	-109	-96	-80	-62	-51	-91	-128
Across-flow distance from stack	23	43	51	57	62	66	66	65	62	58	54	48

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	330	301	262	216	164	106	57	96	154	206	253	292
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	207	253	292	322	342	352	355	357	349	330	301	263
Along-flow distance from stack	-161	-189	-211	-227	-236	-238	-235	-232	-222	-206	-183	-154
Across-flow distance from stack	41	32	22	12	2	-9	-23	-43	-51	-57	-62	-66

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	322	342	352	355	357	348	330	300	262	216	164	106
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	216	164	106	57	96	153	207	253	292	322	342	352
Along-flow distance from stack	-120	-84	-44	-6	-5	-26	-46	-64	-81	-95	-106	-114
Across-flow distance from stack	-66	-65	-62	-58	-54	-48	-40	-32	-22	-12	-2	9

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: HAC2

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359722	6378917	20m	16m	0.80m	115C	26.9m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	57	96	154	206	253	292	322	342	352	354	357	349
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	354	357	349	330	301	262	216	164	106	57	96	153
Along-flow distance from stack	-119	-124	-125	-123	-116	-106	-93	-77	-59	-48	-88	-125
Across-flow distance from stack	20	40	48	55	60	64	65	65	62	59	55	49

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	330	301	262	216	164	106	57	96	154	206	253	292
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	207	253	292	322	342	352	355	357	349	330	301	263
Along-flow distance from stack	-159	-187	-210	-226	-236	-238	-236	-233	-224	-208	-185	-156
Across-flow distance from stack	42	34	25	15	5	-6	-20	-40	-48	-55	-60	-64

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	322	342	352	355	357	348	330	300	262	216	164	106
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	216	164	106	57	96	153	207	253	292	322	342	352
Along-flow distance from stack	-123	-86	-47	-9	-8	-28	-48	-66	-83	-96	-107	-114
Across-flow distance from stack	-65	-65	-62	-59	-55	-50	-42	-35	-25	-15	-5	6

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: HAC3

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359718	6378917	20m	16m	0.80m	115C	26.9m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	57	96	154	206	253	292	322	342	352	354	357	349
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	354	357	349	330	301	262	216	164	106	57	96	153
Along-flow distance from stack	-118	-122	-123	-120	-113	-103	-89	-73	-55	-44	-84	-122
Across-flow distance from stack	16	36	45	52	58	62	64	64	62	60	56	51

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	330	301	262	216	164	106	57	96	154	206	253	292
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	207	253	292	322	342	352	355	357	349	330	301	263
Along-flow distance from stack	-155	-185	-208	-225	-235	-238	-237	-235	-226	-210	-188	-160
Across-flow distance from stack	45	38	28	19	9	-2	-16	-36	-45	-52	-58	-62

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	322	342	352	355	357	348	330	300	262	216	164	106
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	216	164	106	57	96	153	207	253	292			

322 342 352
Along-flow distance from stack -127 -90 -51 -13 -12 -32 -51 -69 -85
-97 -107 -114
Across-flow distance from stack -64 -64 -62 -59 -56 -52 -45 -38 -28
-19 -9 2

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: HAC4

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359715	6378917	20m	16m	0.80m	115C	26.9m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	57	96	154	206	253	292	322	342	352	354	357	349
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	354	357	349	330	301	262	216	164	106	57	96	153
Along-flow distance from stack	-118	-121	-122	-118	-111	-100	-87	-70	-52	-41	-81	-119
Across-flow distance from stack	13	33	42	50	56	61	63	63	62	60	57	53

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	330	301	262	216	164	106	57	96	154	206	253	292
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	207	253	292	322	342	352	355	357	349	330	301	263
Along-flow distance from stack	-153	-183	-206	-224	-235	-238	-237	-236	-227	-212	-190	-162
Across-flow distance from stack	47	40	31	22	11	1	-13	-33	-42	-50	-56	-61

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	322	342	352	355	357	348	330	300	262	216	164	106
Effective building height	12	12	12	12	12	12	12	12	12	12	12	12
Along-flow building length	216	164	106	57	96	153	207	253	292	322	342	352
Along-flow distance from stack	-130	-93	-54	-16	-15	-34	-54	-71	-86	-99	-108	-114
Across-flow distance from stack	-63	-63	-62	-60	-58	-53	-47	-40	-31	-22	-12	-1

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: CP3

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359911	6379191	20m	32m	1.00m	26C	15.8m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	109	114	115	113	107	99	86	72	57	45	58	74

Effective building height	26	26	26	26	26	26	26	26	28	28	28	12
Along-flow building length	40	58	74	88	99	107	112	114	83	82	88	116
Along-flow distance from stack	-68	-82	-93	-102	-107	-109	-108	-104	-213	-216	-218	-86
Across-flow distance from stack	33	24	15	4	-6	-16	-25	-34	38	7	-23	-21

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	88	99	107	112	114	112	109	114	115	113	107	98
Effective building height	12	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	113	107	98	87	72	55	39	57	74	88	99	107
Along-flow distance from stack	-81	-48	-34	-18	-2	14	29	25	20	14	9	2
Across-flow distance from stack	-25	-58	-56	-52	-47	-40	-33	-24	-14	-4	6	16

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	87	72	56	40	58	74	88	99	107	112	114	112
Effective building height	26	26	12	12	12	12	12	26	26	26	26	26
Along-flow building length	112	114	113	109	114	116	114	107	98	86	72	55
Along-flow distance from stack	-4	-10	-22	-21	-26	-30	-33	-60	-65	-68	-70	-69
Across-flow distance from stack	25	34	4	10	15	21	26	58	56	52	47	40

(Constant) emission rate = 2.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: PD3

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359907	6379150	20m	32m	1.00m	25C	12.0m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	109	114	115	113	107	99	86	72	55	40	57	74
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	40	58	74	88	99	107	112	114	112	109	114	115
Along-flow distance from stack	-27	-42	-56	-68	-78	-85	-90	-93	-92	-90	-91	-89
Across-flow distance from stack	36	34	32	28	23	18	12	6	-1	-7	-13	-19

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	88	99	107	112	114	112	109	114	115	113	107	98
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	113	107	98	87	72	55	39	57	74	88	99	107
Along-flow distance from stack	-84	-77	-67	-56	-42	-27	-12	-16	-18	-20	-21	-22
Across-flow distance from stack	-24	-29	-32	-34	-36	-36	-36	-34	-31			

-28 -23 -18

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	87	72	55	39	57	73	87	99	107	112	114	112
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	112	114	112	109	114	115	113	107	98	86	72	55
Along-flow distance from stack	-22	-21	-20	-19	-23	-26	-29	-31	-31	-31	-30	-28
Across-flow distance from stack	-12	-6	1	7	14	19	24	28	32	34	36	36

(Constant) emission rate = 2.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: D5

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359906	6379125	20m	18m	0.50m	111C	10.2m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	109	114	115	113	107	99	86	72	55	40	57	74
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	40	58	74	88	99	107	112	114	112	109	114	115
Along-flow distance from stack	-3	-18	-34	-48	-61	-72	-81	-87	-91	-94	-99	-101
Across-flow distance from stack	39	42	43	43	42	39	35	30	25	18	11	3

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	88	99	107	112	114	112	109	114	115	113	107	98
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	113	107	98	87	72	55	39	57	74	88	99	107
Along-flow distance from stack	-100	-95	-88	-79	-66	-52	-37	-39	-40	-40	-38	-35
Across-flow distance from stack	-4	-12	-18	-25	-30	-35	-39	-42	-43	-43	-42	-39

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	87	72	55	39	57	73	87	99	107	112	114	112
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	112	114	112	109	114	115	113	107	98	86	72	55
Along-flow distance from stack	-31	-27	-21	-15	-15	-15	-13	-12	-10	-8	-6	-3
Across-flow distance from stack	-35	-30	-25	-18	-11	-4	4	12	18	25	30	35

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: D6

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359887	6379128	20m	18m	0.50m	111C	10.2m/s

_____ Effective building dimensions (in metres) _____

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	109	114	115	113	107	99	86	72	55	40	57	69
Effective building height	26	26	26	26	26	26	26	26	26	26	26	28
Along-flow building length	40	58	74	88	99	107	112	114	112	109	114	92
Along-flow distance from stack	-2	-15	-27	-38	-48	-57	-64	-69	-72	-75	-80	-224
Across-flow distance from stack	20	23	25	26	27	27	26	24	22	18	15	13

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	77	84	107	112	114	112	109	114	115	113	107	98
Effective building height	28	28	26	26	26	26	26	26	26	26	26	26
Along-flow building length	93	91	98	87	72	55	39	57	74	88	99	107
Along-flow distance from stack	-224	-217	-76	-69	-60	-49	-38	-43	-47	-50	-51	-50
Across-flow distance from stack	-18	-49	-3	-8	-12	-16	-20	-23	-25	-26	-27	-27

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	87	72	55	39	57	73	87	99	107	112	114	112
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	112	114	112	109	114	115	113	107	98	86	72	55
Along-flow distance from stack	-48	-45	-40	-35	-34	-33	-30	-27	-22	-17	-12	-6
Across-flow distance from stack	-26	-24	-22	-18	-14	-10	-6	-2	3	8	12	16

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: D7

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359861	6379133	20m	18m	0.50m	111C	10.2m/s

_____ Effective building dimensions (in metres) _____

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	109	114	115	113	107	99	86	72	55	40	57	69
Effective building height	26	26	26	26	26	26	26	26	26	26	26	28
Along-flow building length	40	58	74	88	99	107	112	114	112	109	114	92
Along-flow distance from stack	-3	-11	-18	-25	-32	-37	-41	-44	-46	-48	-54	-199
Across-flow distance from stack	-7	-3	0	3	7	9	12	15	17	18	19	22

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°

Effective building width	77	84	88	112	114	112	109	114	115
113	107	98							
Effective building height	28	28	28	26	26	26	26	26	26
26	26	26							
Along-flow building length	93	91	86	87	72	55	39	57	74
88	99	107							
Along-flow distance from stack	-201	-197	-187	-56	-51	-44	-37	-47	-56
-63	-68	-70							
Across-flow distance from stack	-5	-32	-58	15	13	10	6	3	0
-3	-7	-10							

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340°	350°	360°							
Effective building width	87	72	55	39	57	73	87	99	107
112	114	112							
Effective building height	26	26	26	26	26	26	26	26	26
26	26	26							
Along-flow building length	112	114	112	109	114	115	113	107	98
86	72	55							
Along-flow distance from stack	-71	-70	-66	-61	-60	-58	-53	-47	-40
-31	-22	-11							
Across-flow distance from stack	-12	-15	-17	-18	-19	-19	-19	-18	-17
-15	-13	-10							

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: D8

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359839	6379136	20m	18m	0.50m	111C	10.2m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°
100°	110°	120°							
Effective building width	109	114	115	113	107	99	86	72	55
40	57	69							
Effective building height	26	26	26	26	26	26	26	26	26
26	26	28							
Along-flow building length	40	58	74	88	99	107	112	114	112
109	114	92							
Along-flow distance from stack	-2	-6	-10	-14	-17	-19	-22	-23	-24
-26	-32	-178							
Across-flow distance from stack	-29	-25	-21	-16	-10	-4	2	8	14
18	23	30							

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°
220°	230°	240°							
Effective building width	77	84	88	112	114	112	109	114	115
113	107	98							
Effective building height	28	28	28	26	26	26	26	26	26
26	26	26							
Along-flow building length	93	91	86	87	72	55	39	57	74
88	99	107							
Along-flow distance from stack	-182	-180	-173	-45	-44	-41	-38	-52	-64
-75	-82	-88							
Across-flow distance from stack	7	-17	-40	35	34	32	29	25	21
15	10	4							

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340°	350°	360°							
Effective building width	87	72	55	39	57	73	87	99	107
112	114	112							
Effective building height	26	26	26	26	26	26	26	26	26
26	26	26							
Along-flow building length	112	114	112	109	114	115	113	107	98
86	72	55							
Along-flow distance from stack	-91	-91	-88	-83	-82	-78	-72	-64	-53

-41 -28 -14
Across-flow distance from stack -2 -8 -14 -19 -23 -28 -31 -33 -34
-35 -34 -32

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GL5678

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359876	6379100	20m	32m	1.00m	28C	12.1m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	109	114	115	113	107	99	86	64	47	32	50	74
Effective building height	26	26	26	26	26	26	26	15	15	15	15	26
Along-flow building length	40	58	74	88	99	107	112	112	111	109	112	115
Along-flow distance from stack	28	16	3	-10	-22	-33	-44	-63	-66	-67	-71	-87
Across-flow distance from stack	14	22	30	36	42	46	49	17	16	14	11	40

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	88	99	107	112	114	112	109	114	115	113	107	98
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	113	107	98	87	72	55	39	57	74	88	99	107
Along-flow distance from stack	-93	-95	-95	-92	-86	-77	-67	-73	-77	-78	-77	-74
Across-flow distance from stack	34	28	20	12	4	-5	-14	-22	-30	-36	-42	-46

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	87	64	47	32	51	73	87	99	107	112	114	112
Effective building height	26	15	15	15	15	26	26	26	26	26	26	26
Along-flow building length	112	112	111	109	112	115	113	107	98	86	72	55
Along-flow distance from stack	-68	-48	-45	-42	-41	-28	-20	-12	-4	6	14	22
Across-flow distance from stack	-48	-17	-16	-14	-11	-40	-35	-28	-20	-12	-4	5

(Constant) emission rate = 2.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: SL5678

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359874	6378794	20m	14m	0.50m	25C	2.8m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	116	175	229	276	315	344	362	370	366	353	356	355
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8

Along-flow building length	353	356	354	342	319	287	246	197	142
116 175 229									
Along-flow distance from stack	-52	-61	-75	-86	-95	-100	-103	-103	-99
-118 -168 -213									
Across-flow distance from stack	60	80	98	114	125	133	137	137	132
125 117 102									

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°
220° 230° 240°									
Effective building width	342	319	287	245	197	142	116	175	229
276 315 344									
Effective building height	8	8	8	8	8	8	8	8	8
8 8 8									
Along-flow building length	276	315	344	362	370	366	353	356	355
342 319 287									
Along-flow distance from stack	-252	-283	-305	-318	-321	-315	-301	-295	-280
-256 -225 -186									
Across-flow distance from stack	85	65	43	20	-4	-28	-60	-80	-99
-114 -125 -133									

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340° 350° 360°									
Effective building width	363	370	366	353	356	354	342	319	287
245 197 142									
Effective building height	8	8	8	8	8	8	8	8	8
8 8 8									
Along-flow building length	245	197	142	116	175	229	276	315	344
362 370 366									
Along-flow distance from stack	-142	-94	-43	2	-7	-16	-24	-32	-39
-45 -49 -51									
Across-flow distance from stack	-137	-137	-132	-125	-117	-103	-85	-65	-43
-20 4 28									

(Constant) emission rate = 3.00E-03 grams/second
No gravitational settling or scavenging.

STACK SOURCE: SD3

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359905	6379144	20m	32m	1.40m	103C	21.3m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°
100° 110° 120°									
Effective building width	109	114	115	113	107	99	86	72	55
40 57 74									
Effective building height	26	26	26	26	26	26	26	26	26
26 26 26									
Along-flow building length	40	58	74	88	99	107	112	114	112
109 114 115									
Along-flow distance from stack	-21	-36	-50	-62	-72	-80	-87	-90	-90
-89 -91 -90									
Across-flow distance from stack	35	34	33	30	27	22	17	11	6
-1 -7 -13									

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°
220° 230° 240°									
Effective building width	88	99	107	112	114	112	109	114	115
113 107 98									
Effective building height	26	26	26	26	26	26	26	26	26
26 26 26									
Along-flow building length	113	107	98	87	72	55	39	57	74
88 99 107									
Along-flow distance from stack	-87	-80	-71	-60	-48	-33	-19	-22	-24
-26 -27 -27									
Across-flow distance from stack	-18	-23	-27	-30	-33	-34	-35	-34	-33
-30 -27 -22									

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	87	72	55	39	57	73	87	99	107	112	114	112
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	112	114	112	109	114	115	113	107	98	86	72	55
Along-flow distance from stack	-26	-24	-22	-20	-23	-25	-26	-28	-27	-26	-25	-22
Across-flow distance from stack	-17	-11	-6	1	7	13	18	23	27	30	33	34

(Constant) emission rate = 2.50E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: SD4

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359854	6379153	20m	32m	1.40m	103C	21.3m/s

_____ Effective building dimensions (in metres) _____

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	109	114	115	113	107	99	86	72	55	40	58	69
Effective building height	26	26	26	26	26	26	26	26	26	26	28	28
Along-flow building length	40	58	74	88	99	107	112	114	112	109	88	92
Along-flow distance from stack	-21	-27	-32	-36	-39	-41	-42	-41	-39	-38	-178	-183
Across-flow distance from stack	-17	-17	-16	-15	-14	-11	-9	-6	-4	-1	32	8

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	77	84	107	112	114	112	109	114	115	113	107	98
Effective building height	28	28	26	26	26	26	26	26	26	26	26	26
Along-flow building length	93	91	98	87	72	55	39	57	74	88	99	107
Along-flow distance from stack	-183	-177	-38	-35	-30	-24	-19	-31	-42	-52	-60	-66
Across-flow distance from stack	-16	-39	13	15	16	17	17	17	16	15	14	11

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	87	72	55	39	57	73	87	99	107	112	114	112
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	112	114	112	109	114	115	113	107	98	86	72	55
Along-flow distance from stack	-71	-73	-73	-71	-74	-74	-71	-67	-60	-52	-43	-31
Across-flow distance from stack	9	6	4	1	-2	-5	-8	-11	-13	-15	-16	-17

(Constant) emission rate = 2.50E-01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: KP5

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359901	6378952	20m	24m	0.80m	120C	16.6m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	116	175	229	276	315	344	362	370	366	353	356	355
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	353	356	354	342	319	287	246	197	142	116	175	229
Along-flow distance from stack	-213	-219	-225	-225	-217	-203	-183	-157	-126	-117	-139	-157
Across-flow distance from stack	59	52	43	33	22	10	-3	-14	-26	-36	-41	-48

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	342	319	287	245	197	142	116	175	229	276	315	344
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	276	315	344	362	370	366	353	356	355	342	319	287
Along-flow distance from stack	-171	-179	-182	-179	-170	-157	-141	-137	-130	-118	-103	-84
Across-flow distance from stack	-53	-58	-60	-60	-58	-55	-59	-52	-43	-33	-22	-10

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	363	370	366	353	356	354	342	319	287	245	197	142
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	245	197	142	116	175	229	276	315	344	362	370	366
Along-flow distance from stack	-63	-40	-16	1	-36	-72	-105	-136	-162	-184	-199	-209
Across-flow distance from stack	2	14	26	36	41	48	54	58	59	60	58	55

(Constant) emission rate = 3.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: KP6

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359895	6378936	20m	24m	0.80m	120C	16.6m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	116	175	229	276	315	344	362	370	366	353	356	355
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	353	356	354	342	319	287	246	197	142	116	175	229
Along-flow distance from stack	-196	-202	-208	-208	-202	-190	-171	-148	-120	-114	-139	-160
Across-flow distance from stack	56	52	46	38	30	21	11	0	-10	-19	-24	-31

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	342	319	287	245	197	142	116	175	229	276	315	344

Effective building height	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	276	315	344	362	370	366	353	356	355	342	319	287
Along-flow distance from stack	-176	-187	-192	-192	-185	-173	-158	-154	-146	-134	-118	-97
Across-flow distance from stack	-37	-43	-46	-49	-50	-49	-56	-52	-46	-38	-30	-21

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	363	370	366	353	356	354	342	319	287	245	197	142
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	245	197	142	116	175	229	276	315	344	362	370	366
Along-flow distance from stack	-74	-49	-22	-2	-36	-69	-100	-128	-152	-171	-185	-193
Across-flow distance from stack	-11	0	10	19	24	31	37	43	46	49	50	49

(Constant) emission rate = 3.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: KP7

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359895	6378920	20m	24m	0.80m	120C	16.6m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	116	175	229	276	315	344	362	370	366	353	356	355
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	353	356	354	342	319	287	246	197	142	116	175	229
Along-flow distance from stack	-180	-187	-194	-196	-192	-182	-166	-145	-120	-117	-145	-168
Across-flow distance from stack	59	57	54	49	42	34	26	16	6	-4	-9	-17

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	342	319	287	245	197	142	116	175	229	276	315	344
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	276	315	344	362	370	366	353	356	355	342	319	287
Along-flow distance from stack	-187	-200	-206	-207	-201	-189	-173	-169	-160	-146	-128	-105
Across-flow distance from stack	-25	-32	-38	-43	-47	-49	-59	-57	-54	-49	-42	-34

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	363	370	366	353	356	354	342	319	287	245	197	142
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	245	197	142	116	175	229	276	315	344	362	370	366
Along-flow distance from stack	-80	-52	-22	1	-31	-61	-89	-115	-138	-156	-169	-177
Across-flow distance from stack	-26	-16	-6	3	9	17	25	32	38			

43 47 49

(Constant) emission rate = 3.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: KP8

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359892	6378900	20m	24m	0.80m	120C	16.6m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	116	175	229	276	315	344	362	370	366	353	356	355
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	353	356	354	342	319	287	246	197	142	116	175	229
Along-flow distance from stack	-160	-167	-175	-179	-177	-169	-156	-139	-117	-117	-149	-176
Across-flow distance from stack	59	61	61	59	56	50	44	35	26	17	11	2

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	342	319	287	245	197	142	116	175	229	276	315	344
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	276	315	344	362	370	366	353	356	355	342	319	287
Along-flow distance from stack	-197	-213	-222	-225	-220	-209	-194	-189	-179	-163	-143	-118
Across-flow distance from stack	-8	-17	-26	-33	-40	-46	-59	-61	-61	-59	-56	-50

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	363	370	366	353	356	354	342	319	287	245	197	142
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	245	197	142	116	175	229	276	315	344	362	370	366
Along-flow distance from stack	-89	-58	-25	1	-27	-53	-79	-102	-122	-138	-150	-157
Across-flow distance from stack	-43	-35	-26	-17	-11	-2	8	17	26	34	40	46

(Constant) emission rate = 3.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: HAC5

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359868	6378863	20m	16m	1.00m	115C	28.1m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	116	175	229	276	315	344	362	370	366	353	356	355
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	353	356	354	342	319	287	246	197	142	116	175	229

Along-flow distance from stack	-119	-124	-131	-135	-134	-130	-121	-109	-93	-100	-139	-173
Across-flow distance from stack	42	51	59	65	69	70	70	68	63	58	54	46

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	342	319	287	245	197	142	116	175	229	276	315	344
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	276	315	344	362	370	366	353	356	355	342	319	287
Along-flow distance from stack	-203	-226	-242	-251	-252	-246	-234	-232	-223	-207	-185	-157
Across-flow distance from stack	36	25	14	2	-10	-22	-42	-51	-59	-65	-69	-70

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	363	370	366	353	356	354	342	319	287	245	197	142
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	245	197	142	116	175	229	276	315	344	362	370	366
Along-flow distance from stack	-124	-88	-49	-16	-36	-56	-73	-89	-102	-111	-118	-120
Across-flow distance from stack	-70	-68	-63	-58	-54	-46	-36	-25	-14	-2	10	22

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: HAC6

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359855	6378865	20m	16m	1.00m	115C	26.9m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	116	175	229	276	315	344	362	370	366	353	356	355
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	353	356	354	342	319	287	246	197	142	116	175	229
Along-flow distance from stack	-119	-122	-127	-128	-126	-119	-110	-96	-80	-87	-126	-161
Across-flow distance from stack	29	38	47	53	59	62	64	63	61	58	57	50

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	342	319	287	245	197	142	116	175	229	276	315	344
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	276	315	344	362	370	366	353	356	355	342	319	287
Along-flow distance from stack	-191	-216	-234	-245	-248	-244	-235	-235	-228	-214	-194	-167
Across-flow distance from stack	43	34	24	13	2	-9	-29	-38	-47	-53	-59	-62

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°

Effective building width	363	370	366	353	356	354	342	319	287	245	197	142
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	245	197	142	116	175	229	276	315	344	362	370	366
Along-flow distance from stack	-136	-101	-62	-29	-49	-68	-85	-99	-110	-118	-122	-122
Across-flow distance from stack	-64	-63	-61	-58	-57	-51	-43	-34	-24	-13	-2	9

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: HAC7

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359839	6378867	20m	16m	1.00m	115C	26.9m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	116	175	229	276	315	344	362	370	366	353	356	355
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	353	356	354	342	319	287	246	197	142	116	175	229
Along-flow distance from stack	-118	-118	-120	-120	-115	-107	-95	-81	-64	-71	-110	-146
Across-flow distance from stack	13	23	32	40	47	52	56	59	59	59	60	57

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	342	319	287	245	197	142	116	175	229	276	315	344
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	276	315	344	362	370	366	353	356	355	342	319	287
Along-flow distance from stack	-178	-204	-224	-238	-243	-242	-235	-238	-234	-223	-205	-180
Across-flow distance from stack	52	45	37	28	18	7	-13	-23	-32	-40	-47	-52

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	363	370	366	353	356	354	342	319	287	245	197	142
Effective building height	8	8	8	8	8	8	8	8	8	8	8	8
Along-flow building length	245	197	142	116	175	229	276	315	344	362	370	366
Along-flow distance from stack	-150	-116	-78	-45	-65	-83	-98	-111	-120	-125	-127	-124
Across-flow distance from stack	-56	-59	-59	-59	-61	-57	-52	-45	-37	-28	-18	-7

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: HAC8

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359826	6378867	20m	16m	1.00m	115C	26.9m/s

Effective building dimensions (in metres)									
Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°
100° 110° 120°									
Effective building width	116	175	229	276	315	344	362	370	366
353 356 355									
Effective building height	8	8	8	8	8	8	8	8	8
8 8 8									
Along-flow building length	353	356	354	342	319	287	246	197	142
116 175 229									
Along-flow distance from stack	-116	-114	-114	-111	-105	-95	-83	-68	-51
-58 -98 -135									
Across-flow distance from stack	0	10	20	30	39	46	52	56	59
61 65 63									

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°
220° 230° 240°									
Effective building width	342	319	287	245	197	142	116	175	229
276 315 344									
Effective building height	8	8	8	8	8	8	8	8	8
8 8 8									
Along-flow building length	276	315	344	362	370	366	353	356	355
342 319 287									
Along-flow distance from stack	-168	-196	-218	-233	-241	-242	-238	-243	-241
-231 -215 -191									
Across-flow distance from stack	60	55	48	40	30	20	0	-10	-20
-30 -39 -46									

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340° 350° 360°									
Effective building width	363	370	366	353	356	354	342	319	287
245 197 142									
Effective building height	8	8	8	8	8	8	8	8	8
8 8 8									
Along-flow building length	245	197	142	116	175	229	276	315	344
362 370 366									
Along-flow distance from stack	-163	-129	-91	-58	-77	-94	-108	-119	-126
-130 -129 -124									
Across-flow distance from stack	-52	-56	-59	-61	-65	-63	-60	-55	-48
-40 -30 -20									

(Constant) emission rate = 1.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: CP2

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359716	6379254	20m	32m	1.00m	26C	15.8m/s

Effective building dimensions (in metres)									
Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°
100° 110° 120°									
Effective building width	82	88	92	93	91	86	79	69	57
45 58 69									
Effective building height	28	28	28	28	28	28	28	28	28
28 28 28									
Along-flow building length	45	58	68	78	84	88	89	87	83
82 88 92									
Along-flow distance from stack	-44	-45	-45	-43	-40	-36	-31	-25	-18
-13 -13 -13									
Across-flow distance from stack	-28	-31	-33	-34	-35	-34	-32	-29	-26
-21 -16 -10									

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°
220° 230° 240°									
Effective building width	77	84	88	89	87	83	82	88	92
93 91 86									
Effective building height	28	28	28	28	28	28	28	28	28
28 28 28									

Along-flow building length	93	91	86	79	69	57	45	58	69
77	84	87							
Along-flow distance from stack	-12	-11	-10	-7	-5	-3	-2	-13	-24
-34	-44	-51							
Across-flow distance from stack	-5	1	8	13	19	24	28	31	33
35	35	34							

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340°	350°	360°							
Effective building width	79	69	57	45	58	69	77	84	88
89	87	83							
Effective building height	28	28	28	28	28	28	28	28	28
28	28	28							
Along-flow building length	89	87	83	82	88	92	93	91	86
79	69	57							
Along-flow distance from stack	-58	-62	-65	-69	-75	-79	-81	-80	-77
-71	-64	-54							
Across-flow distance from stack	32	29	26	21	16	10	4	-2	-8
-14	-19	-24							

(Constant) emission rate = 2.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: PD2

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359716	6379204	20m	32m	1.00m	25C	12.0m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°
100°	110°	120°							
Effective building width	82	88	92	93	91	86	79	69	57
45	58	69							
Effective building height	28	28	28	28	28	28	28	28	28
28	28	28							
Along-flow building length	45	58	68	78	84	88	89	87	83
82	88	92							
Along-flow distance from stack	6	3	-1	-5	-8	-11	-14	-16	-18
-22	-30	-38							
Across-flow distance from stack	-19	-14	-8	-2	4	10	15	20	25
28	31	33							

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°
220°	230°	240°							
Effective building width	77	84	88	89	87	83	82	88	92
93	91	86							
Effective building height	28	28	28	28	28	28	28	28	28
28	28	28							
Along-flow building length	93	91	86	79	69	57	45	58	69
77	84	87							
Along-flow distance from stack	-44	-49	-53	-54	-55	-53	-51	-60	-67
-73	-76	-76							
Across-flow distance from stack	34	34	33	30	27	24	19	14	8
2	-4	-9							

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340°	350°	360°							
Effective building width	79	69	57	45	58	69	77	84	88
89	87	83							
Effective building height	28	28	28	28	28	28	28	28	28
28	28	28							
Along-flow building length	89	87	83	82	88	92	93	91	86
79	69	57							
Along-flow distance from stack	-75	-71	-65	-60	-58	-54	-49	-42	-34
-24	-15	-4							
Across-flow distance from stack	-15	-20	-25	-29	-31	-33	-34	-34	-33
-31	-27	-24							

(Constant) emission rate = 2.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: CP4

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359911	6379191	20m	32m	1.00m	26C	15.8m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	109	114	115	113	107	99	86	72	57	45	58	74
Effective building height	26	26	26	26	26	26	26	26	28	28	28	12
Along-flow building length	40	58	74	88	99	107	112	114	83	82	88	116
Along-flow distance from stack	-68	-82	-93	-102	-107	-109	-108	-104	-213	-216	-218	-86
Across-flow distance from stack	33	24	15	4	-6	-16	-25	-34	38	7	-23	-21

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°
Effective building width	88	99	107	112	114	112	109	114	115	113	107	98
Effective building height	12	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	113	107	98	87	72	55	39	57	74	88	99	107
Along-flow distance from stack	-81	-48	-34	-18	-2	14	29	25	20	14	9	2
Across-flow distance from stack	-25	-58	-56	-52	-47	-40	-33	-24	-14	-4	6	16

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°	360°
Effective building width	87	72	56	40	58	74	88	99	107	112	114	112
Effective building height	26	26	12	12	12	12	12	26	26	26	26	26
Along-flow building length	112	114	113	109	114	116	114	107	98	86	72	55
Along-flow distance from stack	-4	-10	-22	-21	-26	-30	-33	-60	-65	-68	-70	-69
Across-flow distance from stack	25	34	4	10	15	21	26	58	56	52	47	40

(Constant) emission rate = 2.00E-02 grams/second
No gravitational settling or scavenging.

STACK SOURCE: PD4

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
359907	6379150	20m	32m	1.00m	25C	12.0m/s

Effective building dimensions (in metres)

Flow direction	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
Effective building width	109	114	115	113	107	99	86	72	55	40	57	74
Effective building height	26	26	26	26	26	26	26	26	26	26	26	26
Along-flow building length	40	58	74	88	99	107	112	114	112	109	114	115
Along-flow distance from stack	-27	-42	-56	-68	-78	-85	-90	-93	-92	-90	-91	-89

Across-flow distance from stack	36	34	32	28	23	18	12	6	-1
-7	-13	-19							

Flow direction	130°	140°	150°	160°	170°	180°	190°	200°	210°
220°	230°	240°							
Effective building width	88	99	107	112	114	112	109	114	115
113	107	98							
Effective building height	26	26	26	26	26	26	26	26	26
26	26	26							
Along-flow building length	113	107	98	87	72	55	39	57	74
88	99	107							
Along-flow distance from stack	-84	-77	-67	-56	-42	-27	-12	-16	-18
-20	-21	-22							
Across-flow distance from stack	-24	-29	-32	-34	-36	-36	-36	-34	-31
-28	-23	-18							

Flow direction	250°	260°	270°	280°	290°	300°	310°	320°	330°
340°	350°	360°							
Effective building width	87	72	55	39	57	73	87	99	107
112	114	112							
Effective building height	26	26	26	26	26	26	26	26	26
26	26	26							
Along-flow building length	112	114	112	109	114	115	113	107	98
86	72	55							
Along-flow distance from stack	-22	-21	-20	-19	-23	-26	-29	-31	-31
-31	-30	-28							
Across-flow distance from stack	-12	-6	1	7	14	19	24	28	32
34	36	36							

(Constant) emission rate = 2.00E-02 grams/second
No gravitational settling or scavenging.

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NCIA PM10 MAX

RECEPTOR LOCATIONS

The Cartesian receptor grid has the following x-values (or eastings):
357000.m 357200.m 357400.m 357600.m 357800.m 358000.m 358200.m
358400.m 358600.m 358800.m 359000.m 359200.m 359400.m 359600.m
359800.m 360000.m 360200.m 360400.m 360600.m 360800.m 361000.m
361200.m 361400.m 361600.m 361800.m 362000.m 362200.m 362400.m
362600.m 362800.m 363000.m

and these y-values (or northings):
6376000.m 6376200.m 6376400.m 6376600.m 6376800.m 6377000.m 6377200.m
6377400.m 6377600.m 6377800.m 6378000.m 6378200.m 6378400.m 6378600.m
6378800.m 6379000.m 6379200.m 6379400.m 6379600.m 6379800.m 6380000.m
6380200.m 6380400.m 6380600.m 6380800.m 6381000.m 6381200.m 6381400.m
6381600.m 6381800.m 6382000.m

DISCRETE RECEPTOR LOCATIONS (in metres)

No.	X	Y	ELEVN	HEIGHT	No.	X	Y	ELEVN	HEIGHT
1	359984	6379125	19.0	0.0	11	359865	6380117	21.0	0.0
2	359889	6378701	22.0	0.0	12	358024	6380089	27.0	0.0
3	359643	6378735	22.0	0.0	13	358182	6381087	38.0	0.0
4	360575	6378764	17.0	0.0	14	361565	6379091	59.0	0.0
5	360815	6378950	19.0	0.0	15	361808	6380118	49.0	0.0
6	360938	6378339	35.0	0.0	16	361393	6380254	58.0	0.0
7	359701	6377863	44.0	0.0	17	361480	6378741	53.0	0.0
8	361064	6379252	26.0	0.0	18	359949	6377577	58.0	0.0
9	361169	6379877	25.0	0.0	19	360895	6377880	39.0	0.0

10 360773 6380636   19.0   0.0

METEOROLOGICAL DATA : AUSPLUME METFILE

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Appendix B

Meteorological Data Analysis

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B.1 Introduction

In accordance with its EPL, NCIA operates an on-site meteorological station that collects data that could be used for dispersion modelling. Data collect from the onsite meteorological station was initially prepared for use as an input for this investigation. However upon analysis of the annual wind rose it was noted that the dominant northwest southeast wind axis, (typically present in the Hunter Valley), was not being recorded by the onsite meteorological station as shown in the **Figure B1.** This prompted a further analysis of whether the met data represented a local microclimate of a small area of the Hunter Valley or whether on balance it was more likely that the meteorological station was recording un-representative data. Wind roses have been prepared contrasting the meteorological data prepared using Nudged TAPM data and measured NCIA data (refer **Figure B1**[2]).

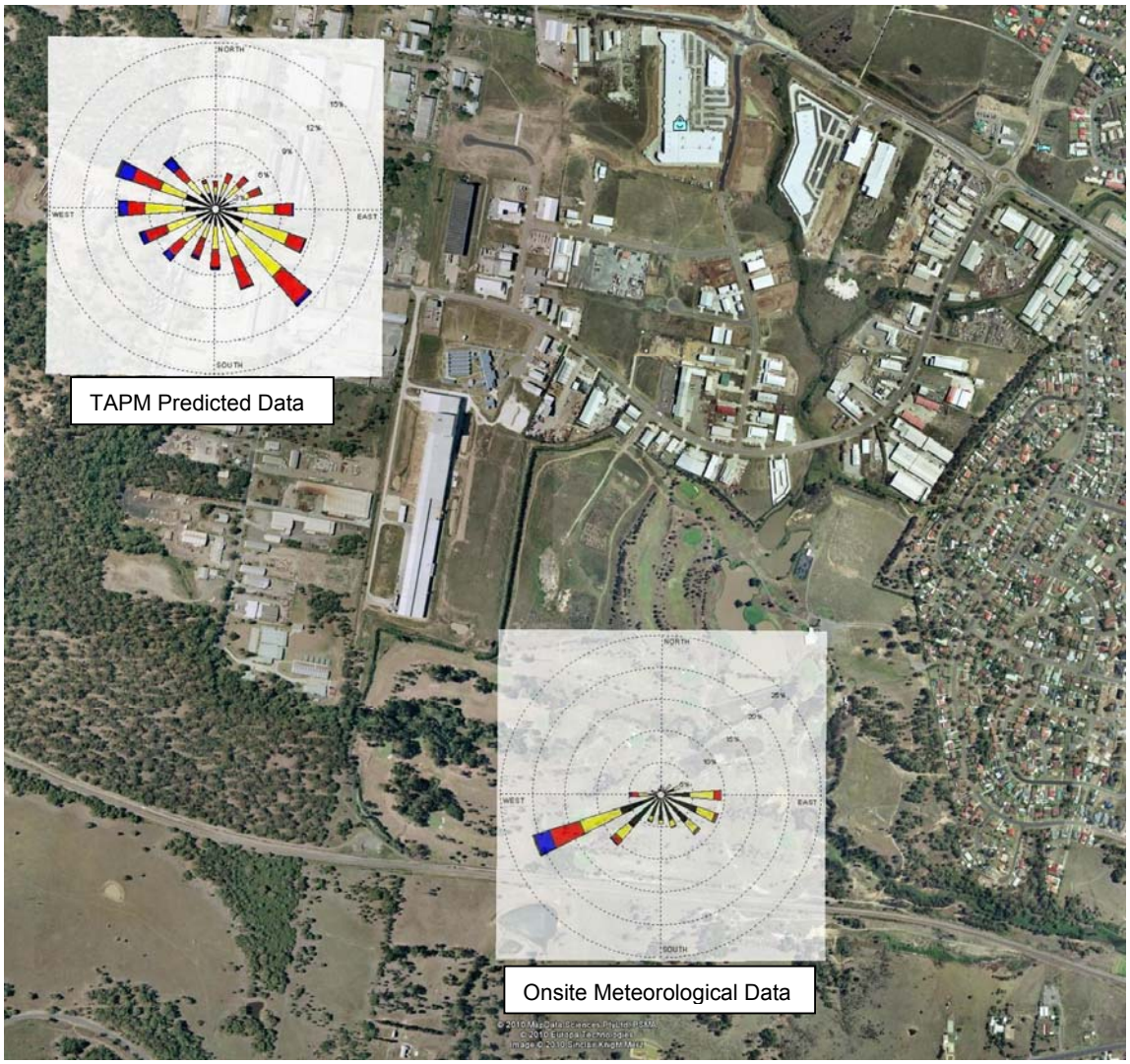

Figure B1: Wind Roses comparison for measured and prognostic meteorological Data for NCIA

As shown in **Figure B1**, there is a significant difference between the measured (bottom right wind rose) and prognostic (top left wind rose) meteorological data for NCIA. The possible reasons for this difference were as follows:

[2] Wind roses show the frequency of occurrence of winds by direction and strength. Each wind rose arm represents a wind blowing from the direction it is projected i.e. arm pointing up represents northerly winds. The length of the bar represents the frequency of occurrence of winds from that direction, and wind speed categories are defined by different colours.

- Meteorological station compliance with standards. The meteorological station is located in an empty paddock to the east of the main NCIA factory. It is positioned in accordance with Australian Standard AS 2922-1987 and complies with measurement requirements for wind speed, wind direction and temperature. On this basis it is considered acceptable.
- Influence of local area characteristics. When the local area around the NCIA facility is considered there appears to be a number of factors which are likely to influence the meteorology measurement. These factors include:
    - The main NCIA facility is upwind from the predominant north-westerly wind flow in the Hunter Valley. Given that the base of the met station is lower than the base elevation of the NCIA facility and that the building is in places greater than the height of the met station, influence from the NCIA building is considered highly likely. In addition, the most frequent wind direction measured at the NCIA facility corresponds to the direction where wind may be funnelled around the southern end of the main building, also supporting the view that this is a significant barrier influencing local meteorology.
    - A tall earthen bund has been built around the eastern and southern boundary of the NCIA facility on top of which tall bamboo grows to a height above the met station recording height (10m). This bund and Bamboo growth would further shield wind flow through the area (particularly from the southeast as shown in **Figure B1**).

On the basis of the above discussion, the annual wind patterns for the measured NCIA data displayed in **Figure B1** was deemed not to be site representative. TAPM predicted meteorological data was generated for the site and was used as an input for the dispersion model. A detailed analysis of the TAPM predicted meteorological data follows.

B.2 Wind

Wind rose diagrams for the 2004 TAPM predicted meteorological data, nudged with data measured at two BOM meteorological station at Paterson and Cessnock and a privately run meteorological station in Kurri Kurri area are shown in **B2** to **B6**. It should be noted that the wind roses displaying the TAPM predicted meteorological data indicate 0% calms; which is due to the TAPM model adjusting any predicted calms to 0.5m/s for input into AUSPLUME.

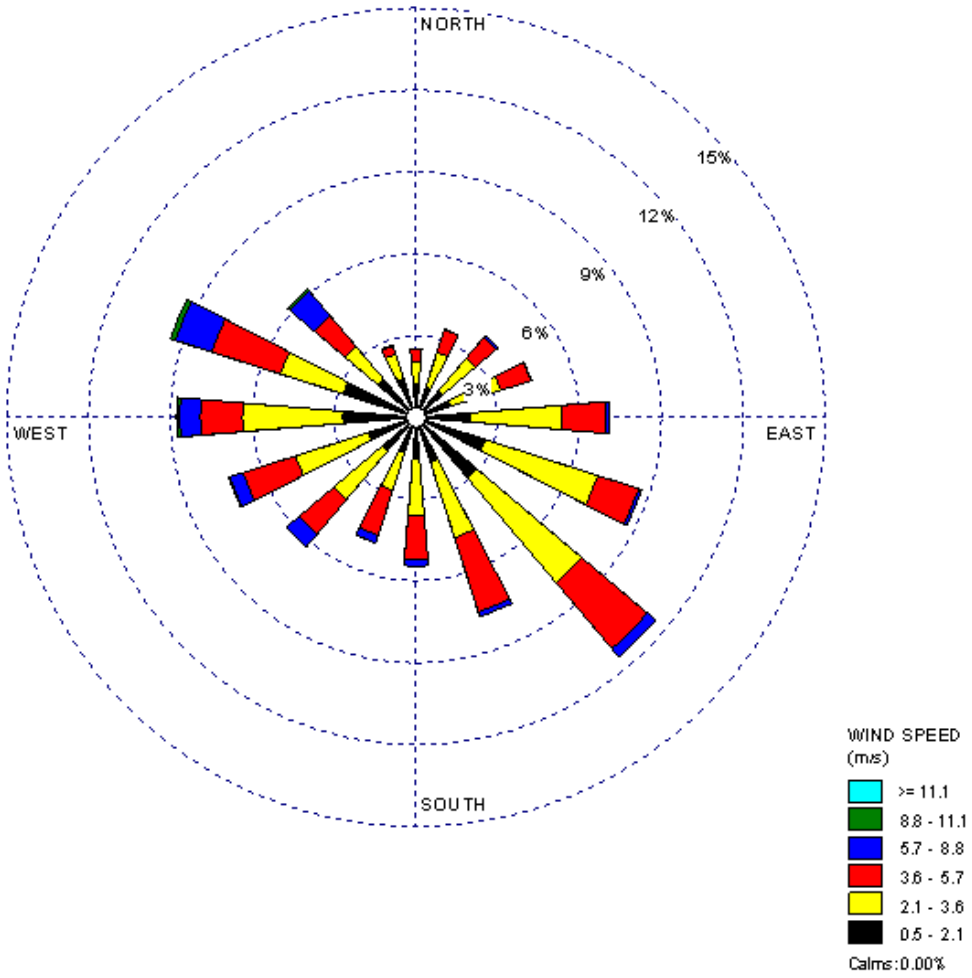

Figure B2: Wind Rose Meteorological Data for TAPM Rutherford, all hours 2004

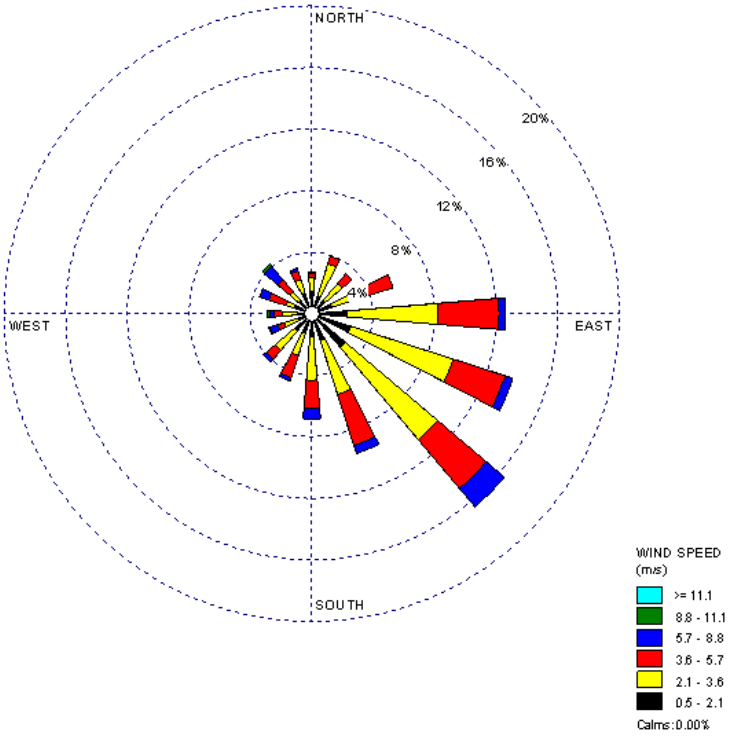

Figure B3: Wind Rose Meteorological Data for TAPM Rutherford Summer, 2004

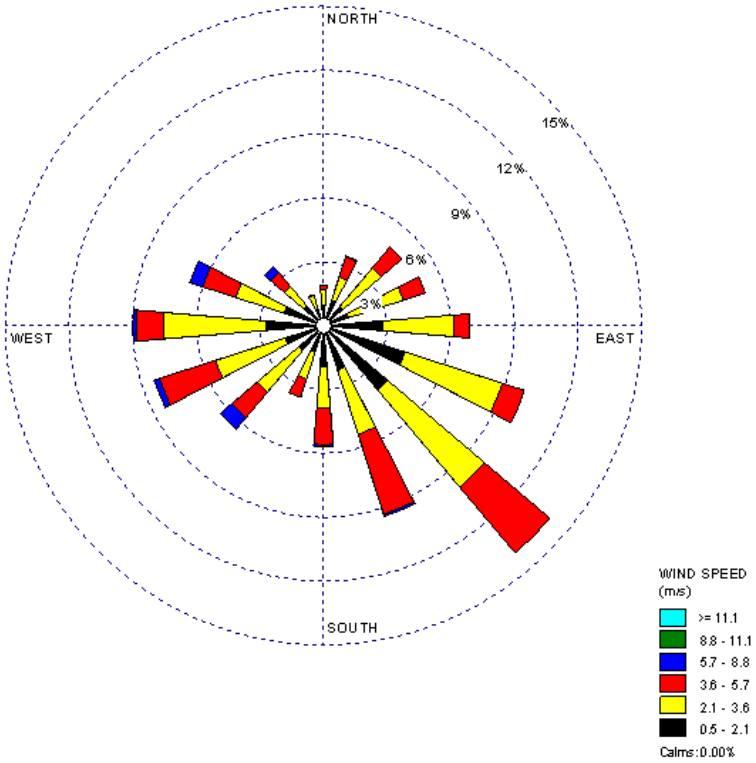

Figure B4: Wind Rose Meteorological Data for TAPM Rutherford Autumn, 2004

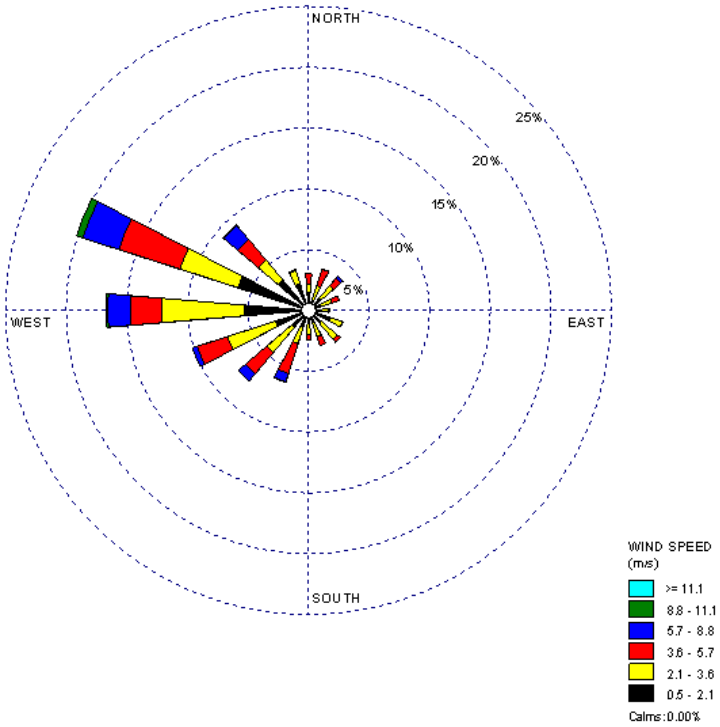

Figure B5: Wind Rose Meteorological Data for TAPM Rutherford Winter, 2004

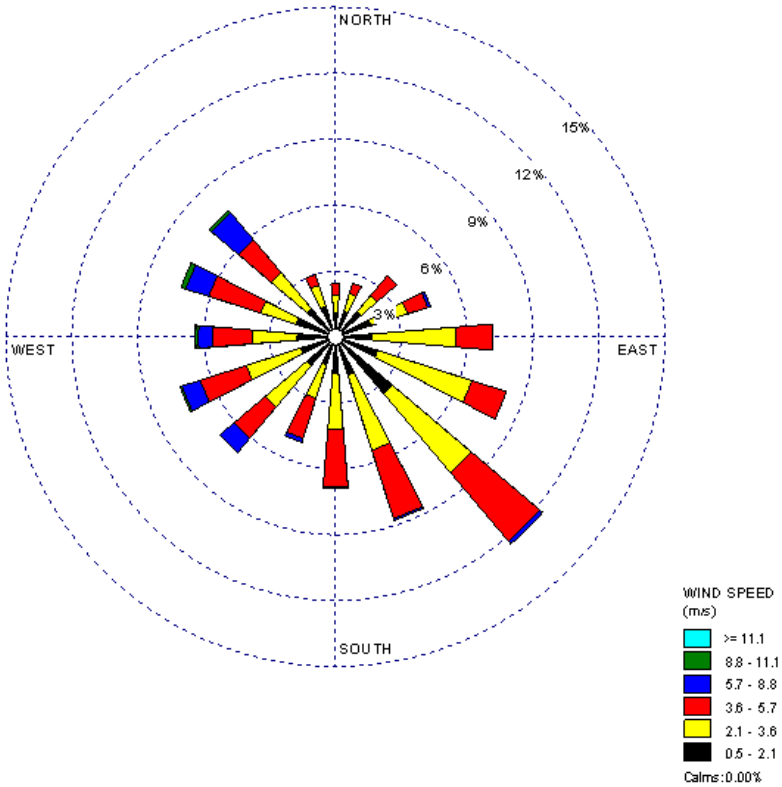

Figure B6: Wind Rose Meteorological Data for TAPM Rutherford Spring, 2004

The wind roses above indicate predicted wind patterns for the Rutherford area are generally dominated by winds in the NW-SE axis. A comparison of the 9am and 3pm windroses for the Bureau of Meteorology (BoM) station at Paterson and the TAPM predicted data follows (refer **Figure B7** and **B8**). **Figure B7** shows similar wind patterns in all quadrants with the exception of winds from the Northeast for the 9am wind rose. The reason for the differences is unclear, however given that the predominant wind patterns observed in the TAPM data are toward residential receptors (very few residential receptors to the southwest), the lack of the northwesterly winds is not considered a limitation to the modelling. 3pm windrose data (refer **Figure B8**) shows similar wind patterns in all quadrants indicating that the predicted data reflects measured data at the Paterson BoM station.

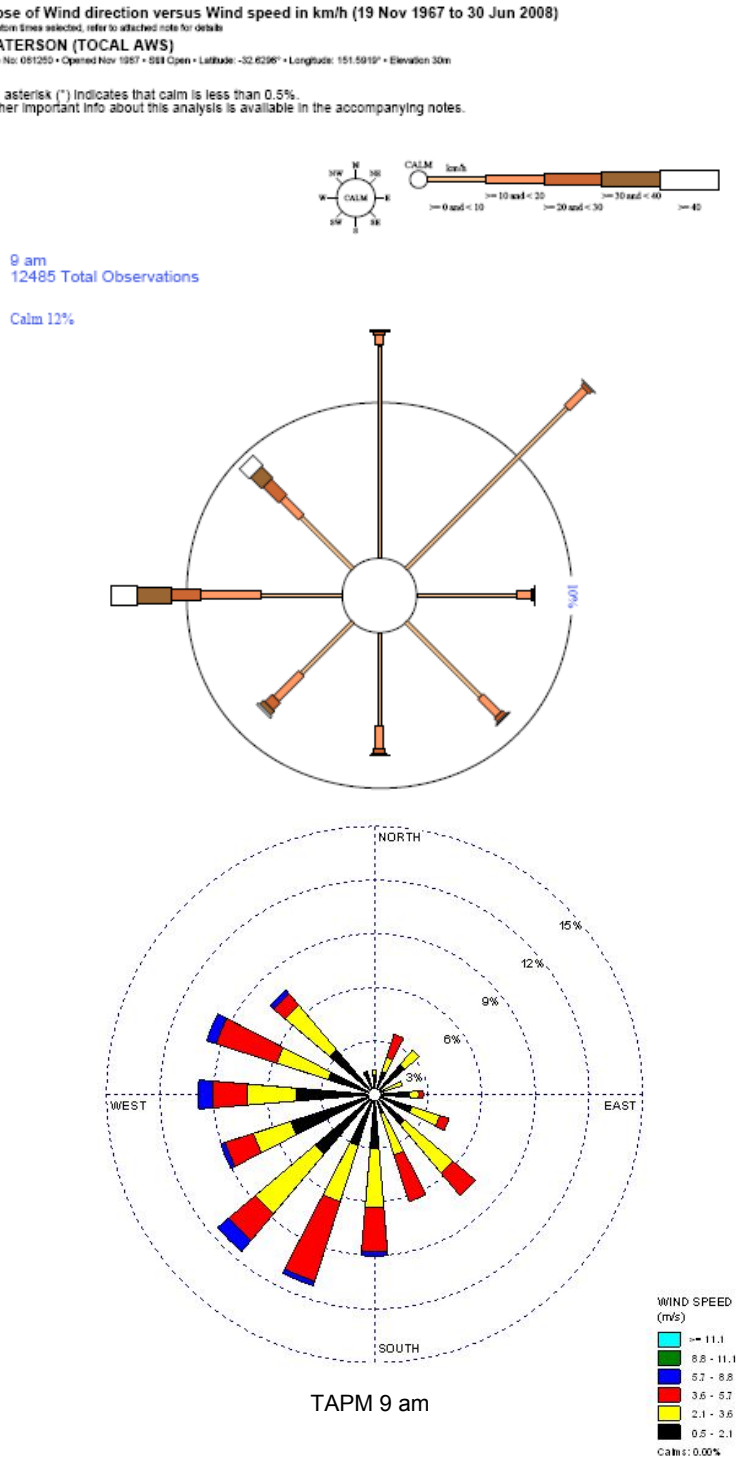

Figure B7: Wind Rose for BoM Data Measured at Paterson at 9 am, 1967 – 2008 and TAPM Rutherford 9 am 2004

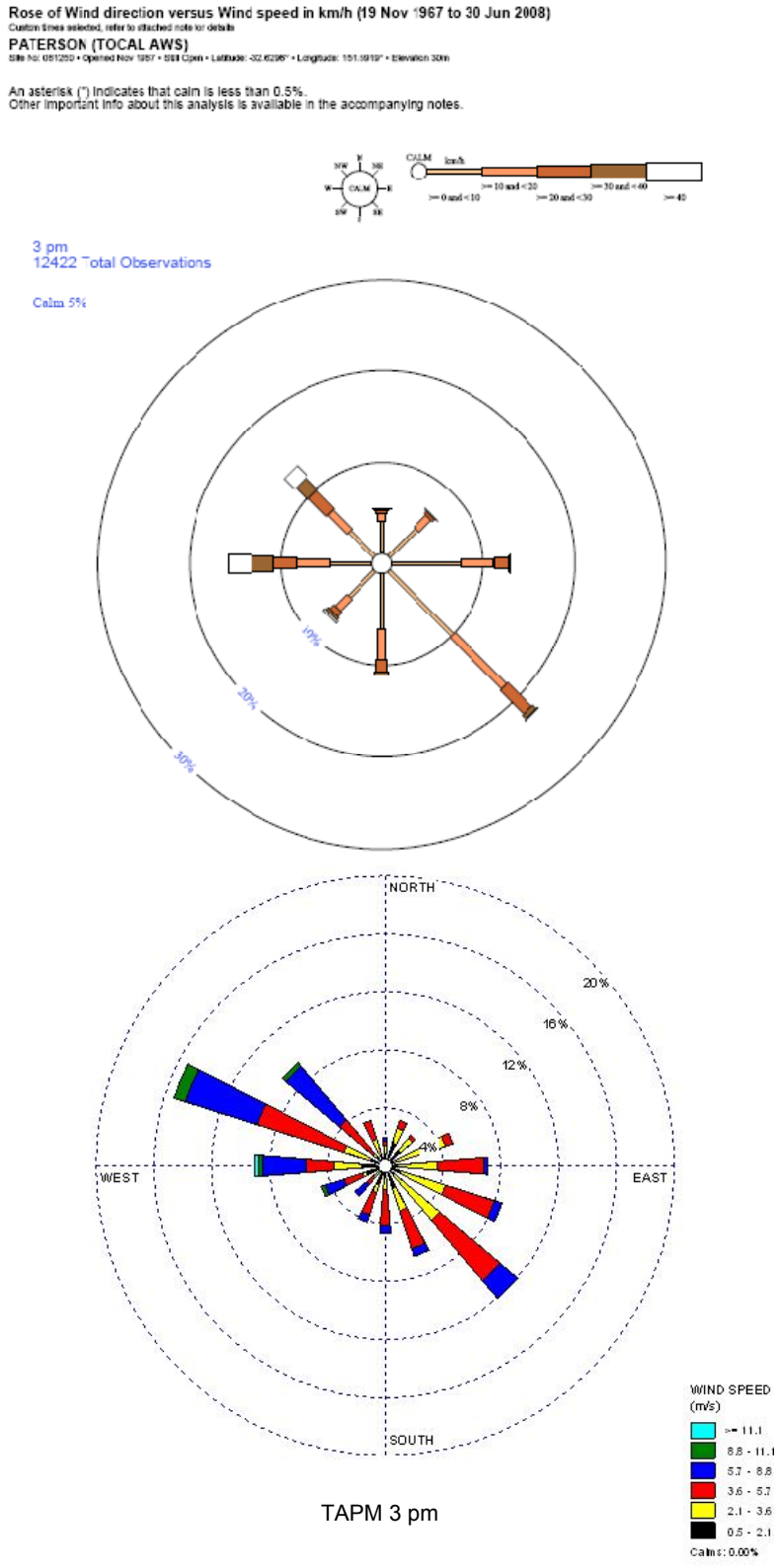

Figure B8: Wind Rose for BoM Data Measured at Paterson at 3 pm, 1967 – 2008 and TAPM Rutherford 3 pm 2004

The estimated mean wind speed for the year at the site is 3.1 m/s, which lies within the range of average wind speeds measured at 9 am and 3 pm for Paterson (2.6 to 4.1 m/s) reported by BoM. The frequency distribution of hourly averaged wind speed values from the TAPM predicted data is shown in **Figure B9**. Wind speeds up to 6 m/s are relatively common with medium to strong winds (> 4 m/s) occurring approximately 45% of the time.

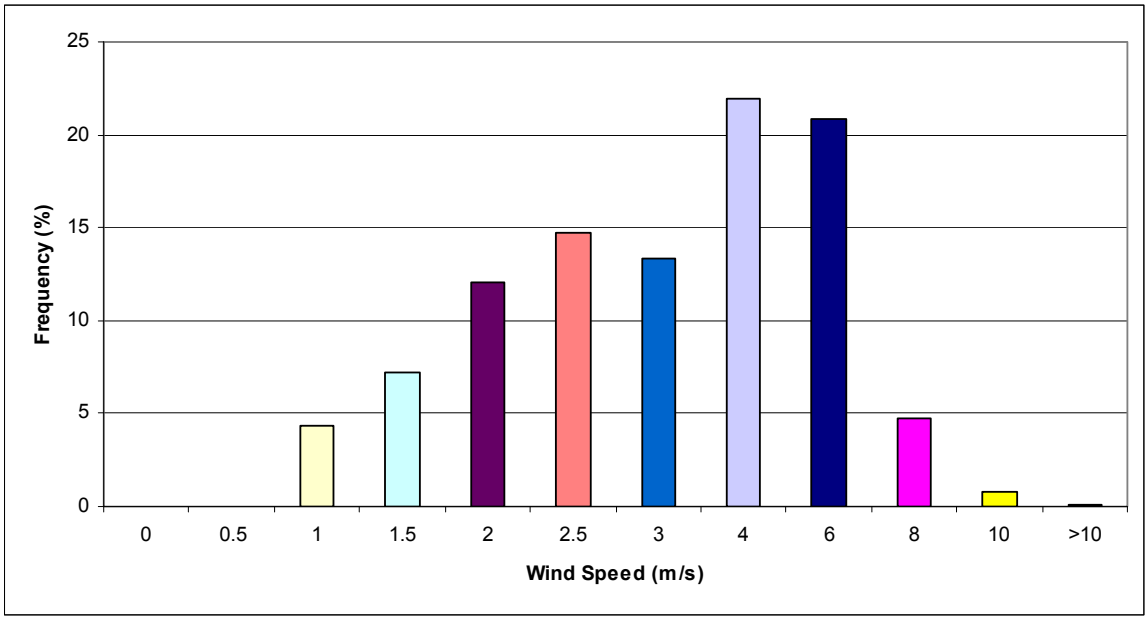

Figure B9: Frequency Distribution of Wind Speed

B.3 Stability Class

An important aspect of plume dispersion is the atmospheric turbulence level in the region of the plume (near the ground in this case). Turbulence acts to increase the cross-sectional area of the plume due to random motions, thus diluting or diffusing a plume. For traditional dispersion modelling using Gaussian plume models, categories of atmospheric stability are used in conjunction with other meteorological data to describe atmospheric conditions and thus dispersion.

The most well-known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds. The frequency distribution of estimated stability classes in the meteorological file is shown in **Figure B10**. The data show a total of approximately 40% of hours with either E or F class. This is consistent with the expected occurrence of slightly stable conditions at such a location, given the inland location.

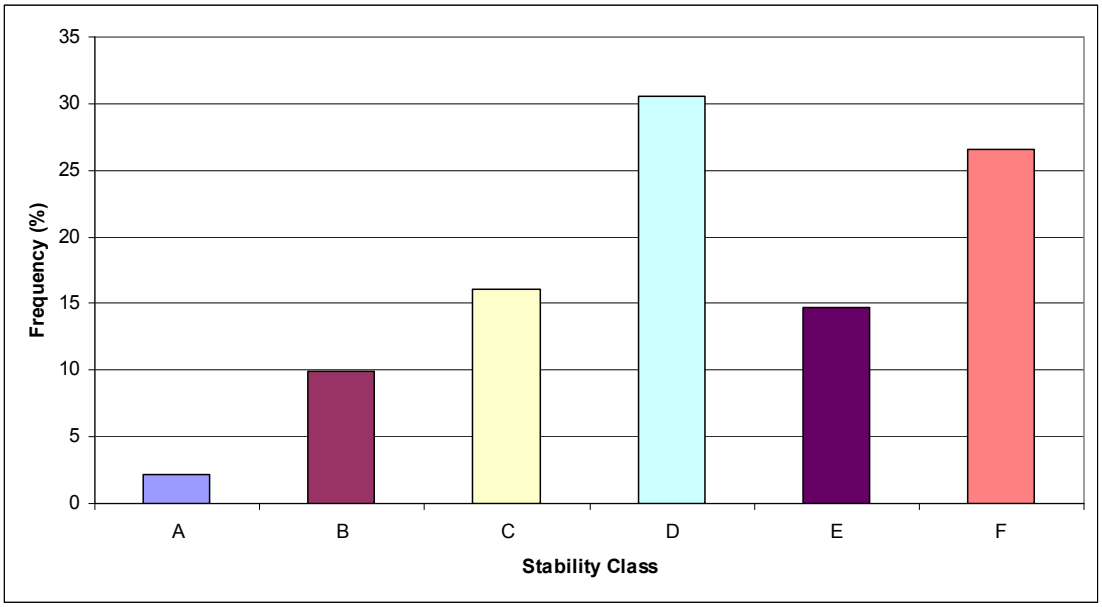

Figure B10: Frequency Distribution of Stability Class

B.4 Mixing Height

Mixing height is the depth of the atmospheric surface layer beneath an elevated temperature inversion. It is an important parameter within air pollution meteorology. Vertical diffusion or mixing of a plume is generally considered to be limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motions.

The diurnal variation of mixing height for the 2004 TAPM predicted data is summarised in **Figure B11**. The average mixing heights are lower during the night and early morning hours (< 400 m), increasing after sunrise to an average of 1200 m by mid-afternoon. This pattern of a diurnal cycle is consistent with the inland site.

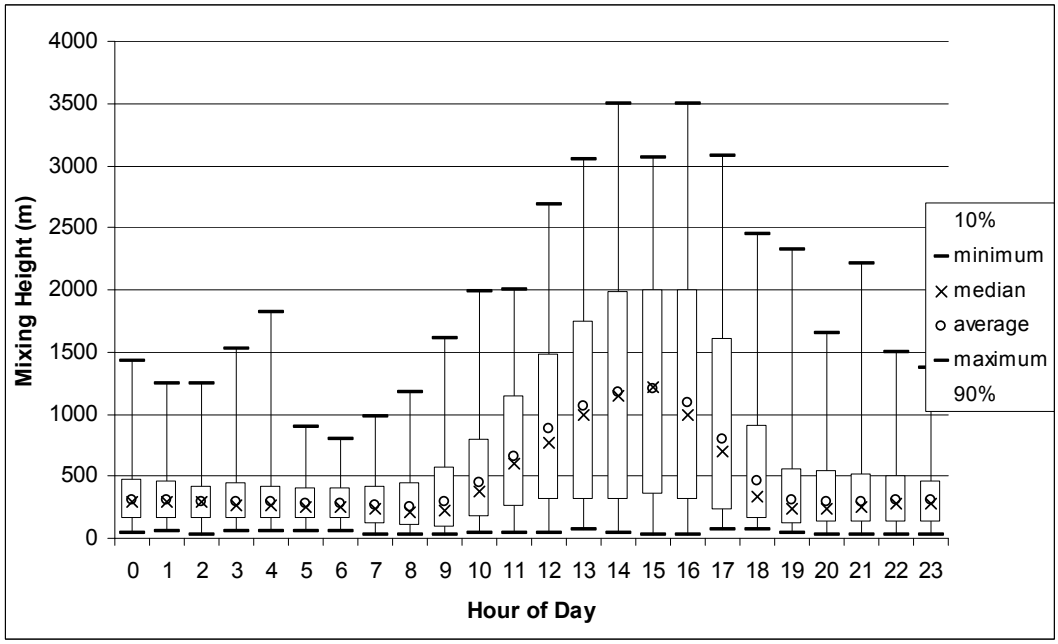

Figure B11: Hourly Mixing Height

B.5 Air Temperature

The following graph illustrates the hourly average air temperature from TAPM compared with measured maximum and minimum monthly temperatures measured at Paterson BoM Station. The graph clearly shows the TAPM hourly average temperature following the local seasonal cycle.

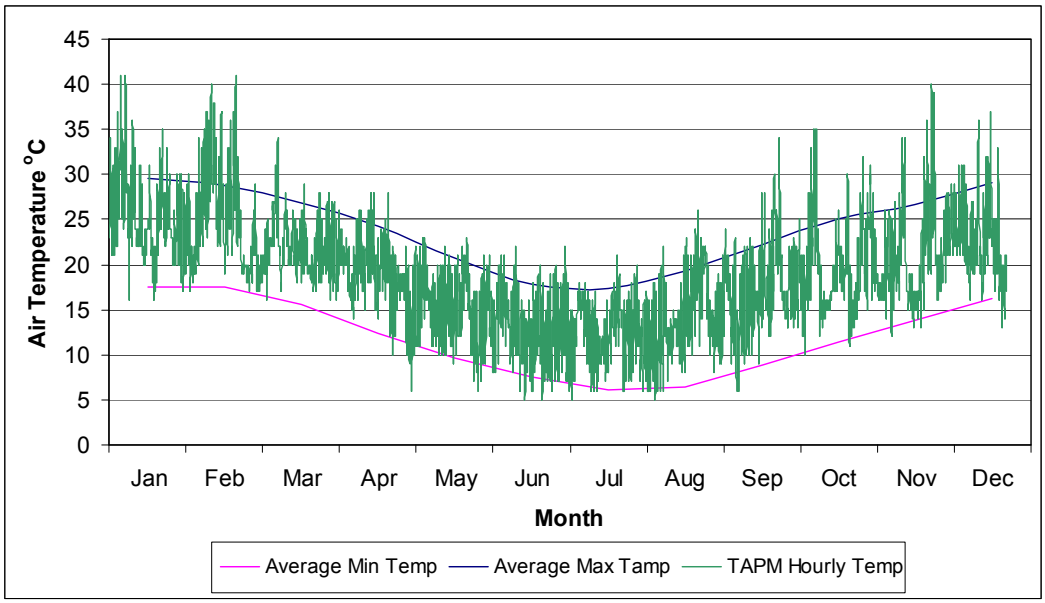

Figure B12: Comparison of TAPM Predicted and Measured Air Temperature

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