Appendix I Air

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QUEENSLAND COKE & ENERGY

STANWELL CORPORATION LIMITED

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Appendix I Air

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Appendix I.1

Air Quality Impact Assessment of Stanwell Coke Plant

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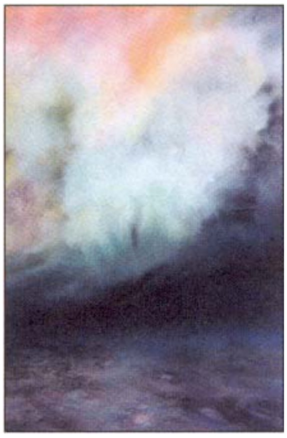

Katestone Environmental
ABN. 92 097 270 276

REPORT FROM
KATESTONE ENVIRONMENTAL
TO URS AUSTRALIA

AIR QUALITY IMPACT ASSESSMENT OF STANWELL COKE PLANT

January 2006

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1. Introduction

The proposed Queensland Coke Plant (operated by Queensland Coke and Energy, QCE) and Power Station (operated by Stanwell Corporation Limited) is to be located at Stanwell, in central Queensland. Katestone Environmental has been commissioned to prepare the air quality assessment for input into the Environmental Impact Statement (EIS). This is a report of the findings of the air quality impact study.

This assessment presents details of the emissions to the atmosphere for all pollutants emitted from the proposed coke plant for both normal operations and one alternative operating scenario. Ground-level concentrations of criteria pollutants (SO_2, NO_2, PM_{10}) have been estimated using a dispersion model and compared with the Queensland EPA, Environmental Protection Policy (Air) goals and the National Environmental Protection Measure for Ambient Air Quality standards.

This report examines cumulative airshed impacts of the coke plant in combination with the existing Stanwell Power Station operating a peak load and licence limit emission rates as a worst-case scenario. Particular attention has been given to the closest residential areas and isolated residences to the south of Stanwell Township. Various metals, hazardous air pollutants and volatile organic compounds are emitted to the atmosphere during the coking process. These pollutants have been assessed in relation to their potential for causing odour impacts and health impacts at key sensitive locations.

2. Description of proposal

The Coke Plant will be located in the Stanwell Energy Park, adjacent to the Stanwell Power Station (SPS). The plant will have a total capacity of 3.2 Mt per year of coke, requiring up to 5.0 Mt of wet coking coal per year as the raw material for the process. The plant will have 640 coke ovens and cover an area of approximately 100 hectares. The coke plant consists of coke ovens arranged in banks (known as batteries), four quench towers, heat recovery systems, materials handling equipment, coal and coke stockpiles and other ancillary equipment and activities.

The coke is loaded into the ovens via a coal charging machine. After charging the oven is sealed to begin coking. The refractory bricks inside the oven heat the coal, releasing flammable gases from the coal. These gases are combusted to provide further heat during the process to carbonise the top and bottom of the bed. Hot combustion gases from a bank of ovens are collected and sent to the heat recovery boilers for energy recovery. The coke is removed from the oven using a pusher car and is cooled by water in the quenching tower. The coke product is moved to the sizing plant and then either to stockpiles or directly to trains.

There are five main areas of the process that will produce emissions to the atmosphere, these areas are:

- Material handling (coke and coal);
- Emissions from the ovens during the coal charging process;
- Process emissions vented through the main stacks;
- Emissions during the pushing of coke from the ovens; and
- Quench tower emissions.

Emissions arising from transport of the coke to the port for exporting are not included in this assessment as they are the responsibility of the rail transport operator.

Air emissions from the non-recovery process are claimed to be relatively small compared to a byproduct coke plant, as the ovens are operated under negative pressure and thus have a low likelihood of fugitive emissions. The generation of dust is minimised by using coke pushers.

The coke plant will operate 24 hours per day and 365 days per year. Continuous operations have been assumed for all scenarios assessed in the dispersion modelling. Two operational scenarios have been investigated in this assessment. For the majority of the time the plant will operate in waste heat recovery mode, this is referred to in the report as normal operations. Occasionally the plant may operate in non-heat recovery mode. During this time the air pollutant emissions from the plant will be unchanged but the temperature of the plumes emitted from the main stacks will be significantly higher.

The pollutants that are potentially emitted from the coke plant are: particulate matter (PM_{10}), carbon monoxide (CO), sulphur dioxide (SO_2), oxides of nitrogen (NO_x), volatile organic compounds (VOC), polycyclic aromatic hydrocarbons (PAH) and metals. A full list of all the emissions is presented in the following sections.

3. Atmospheric emissions

The process has been broken into four steps to categorise the emissions. A brief description of each step and the associated emissions are presented in the following sections.

3.1 Coal charging

This process involves loading the coke ovens with raw coal. The loading process is undertaken through the oven door by a coal conveyor whilst the oven is under negative pressure. This process results in significantly less fugitive emissions of coke ovens gas escaping from the oven during the charging process and leakages from the ovens during processing than the byproduct coke process. A total of eight coal charges will service the entire coke plant.

The major air pollutants emitted from the coal charging process are particulates followed by PAHs.

3.2 Process emissions - main stacks

The process gas combustion emissions are vented to the atmosphere through four 90 m stacks at a temperature of about 100°C during normal operations with heat recovery. On occasions when the heat recovery generators are either out of service for maintenance or repair the emissions from the main stacks will increase in temperature to over 800°C. This operating scenario has been assessed in the report and is called non-heat recovery mode. Due to the significant increase in the exhaust temperature the plumes will be more buoyant and result in lower ground level concentrations than normal operations.

The major air pollutants emitted from the main stacks are sulphur dioxide followed by nitrogen oxides and particulates. Minor amounts of other pollutants are also emitted including various VOCs, PAHs and trace metals.

3.3 Pushing and quenching

At the end of a coke cycle, doors at both ends of the oven are opened and the hot processed coke is pushed out onto a quench car. The coke is then transferred to the quench tower where it is drenched with water to stop the coke from burning due to exposure to oxygen in air. During the quenching process a plume of steam will be vented through the top of the 18 m high quench tower. Four quench towers will service the entire coke plant. The process is intermittent occurring only when coke from an oven is quenched. However, due to the significant number of coke ovens (640 in total) each quench tower will emit a plume every 5 minutes or less. For the purpose of dispersion modelling quenching emissions have been assumed to be essentially constant.

The major pollutants emitted during the pushing process are sulphur dioxide and particulates, some VOCs and benzene soluble organics (BSO). Quenching results in emissions of particulates, trace metals and some PAHs.

3.4 Summary of Total Plant Emissions

Table 1 presents a summary of the estimated total annual atmospheric emissions from the coke plant. The emissions were supplied by URS Australia (coke inventory rev17.xls).

Table 1: Summary of all atmospheric emissions (tonnes per year) for proposed Coke plant from each part of the process.

Air pollutant	Coal Charging	Main Stack	Pushing	Quenching	Total
TSP	6.90E+00	2.18E+03	7.30E+01	3.06E+02	2.58E+03
PM_{10}	-	2.18E+03	7.30E+01	1.12E+02	2.37E+03
SO_2	2.12E-01	1.48E+04	1.37E+02	-	1.49E+04
NOx	-	2.65E+03	4.84E+01	-	2.70E+03
CO	7.20E+00	1.25E+02	1.61E+02	-	2.93E+02
VOC	5.20E+00	5.73E+01	3.07E+01	-	9.32E+01
H_2SO_4	-	7.78E+01	-	-	7.78E+01
Benzene	9.20E-02	1.23E+00	-	-	1.32E+00
Bromoform	-	3.07E-03	-	-	3.07E-03
Bromomethane	-	1.43E+00	-	-	1.43E+00
2-Butanone	-	1.61E-01	-	-	1.61E-01
Carbon Disulphide	5.36E-03	4.09E-02	-	-	4.62E-02
Chlorobenzene	-	3.07E-03	-	-	3.07E-03
Chloromethane	5.12E-03	1.94E+00	-	-	1.95E+00
Chloroform	-	2.81E-02	-	-	2.81E-02
Cumene	-	3.58E-03	-	-	3.58E-03
Ethyl Benzene	1.86E-03	8.18E-03	-	-	1.00E-02
Iodomethane	-	1.61E-02	-	-	1.61E-02
Isooctane	-	4.09E-02	-	-	4.09E-02
Methylene Chloride	-	1.69E+00	-	-	1.69E+00
n-Hexane	-	3.83E-02	-	-	3.83E-02
4-Methyl-2-Pentanone	-	2.27E-02	-	-	2.27E-02
2- Methylphenol	-	-	-	3.96E-02	3.96E-02
4- Methylphenol/3-Methylphenol	-	-	-	1.28E-01	1.28E-01
Phenol	-	1.81E-01	-	9.33E-02	2.75E-01
Styrene	-	1.76E-02	-	-	1.76E-02
Tert-butyl Methyl Ether	-	1.20E-04	-	-	1.20E-04
Tetrachloroethene	-	1.05E-03	-	-	1.05E-03

Air pollutant	Coal Charging	Main Stack	Pushing	Quenching	Total
1,1,2,2-Tetrachloroethane	-	5.11E-03	-	-	5.11E-03
Toluene	4.34E-02	1.30E+00	-	-	1.35E+00
1,1,1-Trichloroethane	-	6.39E-03	-	-	6.39E-03
1,1,2-Trichloroethane	-	1.48E-03	-	-	1.48E-03
Trichloroethene	-	2.22E-02	-	-	2.22E-02
Vinyl Acetate	-	1.76E-02	-	-	1.76E-02
Xylenes	1.71E-02	4.14E-02	-	-	5.85E-02
BSO	-	-	5.36E-01	-	5.36E-01
Total PAHs	1.12E-01	7.18E-01	-	2.82E-02	8.59E-01
Naphthalene	3.57E-02	2.28E-01	-	8.97E-03	2.73E-01
Acenaphthylene	5.76E-03	3.68E-02	-	1.45E-03	4.40E-02
Acenaphthene	8.07E-03	5.15E-02	-	2.02E-03	6.16E-02
Fluorene	2.54E-02	1.62E-01	-	6.36E-03	1.94E-01
Phenanthrene	1.50E-02	9.57E-02	-	3.76E-03	1.14E-01
Fluoranthene	3.46E-03	2.21E-02	-	8.68E-04	2.64E-02
Pyrene	1.15E-02	7.36E-02	-	2.89E-03	8.81E-02
Benzo[a]pyrene	5.76E-04	3.68E-03	-	1.45E-04	4.40E-03
Indeno[123-c,d]pyrene	1.15E-03	7.36E-03	-	2.89E-04	8.81E-03
Benzo[g,h,I]perylene	5.76E-03	3.68E-02	-	1.45E-03	4.40E-02
Antimony	-	1.24E-02	-	1.31E-02	2.55E-02
Arsenic	2.01E-05	9.61E-03	5.01E-04	2.02E-02	3.03E-02
Beryllium	1.36E-05	2.77E-03	-	1.26E-03	4.05E-03
Cadmium	-	9.03E-04	-	-	9.03E-04
Chromium	1.69E-04	9.40E-02	-	7.12E-03	1.01E-01
Cobalt	4.76E-04	-	-	5.10E-03	5.57E-03
Lead	2.91E-04	7.96E-01	2.22E-02	1.67E-02	8.35E-01
Manganese	2.36E-03	1.36E-01	1.08E-02	2.49E-01	3.98E-01
Mercury	2.22E-04	1.94E-01	-	-	1.94E-01
Nickel	1.27E-04	4.32E-02	-	5.15E-03	4.85E-02
Phosphorous	-	3.16E+00	-	2.96E-01	3.46E+00
Selenium	-	3.17E-02	-	2.22E-02	5.38E-02

Note: Data supplied by URS Australia, Coke Inventory Rev17.xls

3.5 Emissions used in modelling

Source characteristics and emission rates used in the modelling are presented in Table 2 and Table 3 as supplied by URS Australia.

Due to the high temperatures of the coke ovens, the charging and pushing processes have been modelled as buoyant area sources (see Table 3). This will take into account the potential buoyancy of the emissions from these sources due to the temperature with no additional plume rise due to momentum (i.e. zero exit velocity).

Table 2: Summary of stack and emission characteristics for stack sources used in the modelling of the proposed Stanwell Coke Plant

Parameter	Units	Main Stacks	Quenching towers
Number of stacks	-	4	4
Location	AMG (m)	226,555 7,398,760 226,858 7,398,977 227,117 7,398,608 226,827 7,398,372	226,704 7,398,613 226,766 7,398,657 226,899 7,398,752 226,961 7,398,794
Base elevation	m	51	51
Stack height	m	90	18.3
Stack diameter	m	5.64	9.42
Exhaust temperature	°C	94 (normal) 827 (non-heat recovery)	94
Exit velocity	m/s	20.7 (normal) 62 (non-heat recovery)	5.1
Assumed hours of operation	Hrs/yr	8760	8760
Building wake effects included		no	All 15 m high Batteries included
Emission rates (per stack)			
TSP	g/s	1.73E+01	2.43E+00
PM_{10}	g/s	1.73E+01	8.91E-01
SO_2	g/s	1.17E+02	-
NOx	g/s	2.10E+01	-
CO	g/s	9.91E-01	-
VOC	g/s	4.54E-01	-
H_2SO_4	g/s	6.17E-01	-
Benzene	g/s	9.72E-03	-
Bromoform	g/s	2.43E-05	-
Bromomethane	g/s	1.13E-02	-
2-Butanone	g/s	1.28E-03	-
Carbon Disulphide	g/s	3.24E-04	-
Chlorobenzene	g/s	2.43E-05	-
Chloromethane	g/s	1.54E-02	-
Chloroform	g/s	2.23E-04	-
Cumene	g/s	2.84E-05	-
Ethyl Benzene	g/s	6.48E-05	-
Iodomethane	g/s	1.28E-04	-
Isooctane	g/s	3.24E-04	-
Methylene Chloride	g/s	1.34E-02	-
n-Hexane	g/s	3.04E-04	-
4-Methyl-2-Pentanone	g/s	1.80E-04	-
2- Methylphenol	g/s	-	3.14E-04
4- Methylphenol/3-Methylphenol	g/s	-	1.01E-03
Phenol	g/s	1.44E-03	7.39E-04
Styrene	g/s	1.40E-04	-
Tert-butyl Methyl Ether	g/s	9.52E-07	-
Tetrachloroethene	g/s	8.30E-06	-
1,1,2,2-Tetrachloroethane	g/s	4.05E-05	-
Toluene	g/s	1.03E-02	-
1,1,1-Trichloroethane	g/s	5.06E-05	-
1,1,2-Trichloroethane	g/s	1.17E-05	-
Trichloroethene	g/s	1.76E-04	-
Vinyl Acetate	g/s	1.40E-04	-
Xylenes	g/s	3.28E-04	-
Total PAHs	g/s	5.69E-03	-
Naphthalene	g/s	1.81E-03	7.11E-05

Parameter	**Units**	**Main Stacks**	**Quenching towers**
Acenaphthylene	g/s	2.92E-04	5.04E-05
Acenaphthene	g/s	4.09E-04	-
Fluorene	g/s	1.28E-03	-
Phenanthrene	g/s	7.59E-04	-
Fluoranthene	g/s	1.75E-04	6.88E-06
Pyrene	g/s	5.84E-04	2.29E-05
Benzo[a]pyrene	g/s	2.92E-05	1.15E-06
Indeno[123-c,d]pyrene	g/s	5.84E-05	2.29E-06
Benzo[g,h,I]perylene	g/s	2.92E-04	1.15E-05
Antimony	g/s	9.80E-05	1.04E-04
Arsenic	g/s	7.61E-05	1.60E-04
Beryllium	g/s	2.20E-05	1.00E-05
Cadmium	g/s	7.16E-06	-
Chromium	g/s	7.46E-04	5.64E-05
Cobalt	g/s	-	4.04E-05
Lead	g/s	6.31E-03	1.32E-04
Manganese	g/s	1.08E-03	1.97E-03
Mercury	g/s	1.54E-03	-
Nickel	g/s	3.42E-04	4.08E-05
Phosphorous	g/s	2.51E-02	2.35E-03
Selenium	g/s	2.51E-04	1.76E-04

Note: Data supplied by URS Australia, Coke Inventory Rev17.xls

Table 3: Summary of emission characteristics for buoyant area sources used in the modelling of the Stanwell Coke Plant

Parameter	**Units**	**Charging**		**Pushing**	
Number of sources modelled	-	1		1	
Base elevation	m	51		51	
Corners of area source	AMG (m)	226,565	7,398,972	226,565	7,398,972
		226,657	7,399,037	226,657	7,399,037
		227,105	7,398,393	227,105	7,398,393
		227,027	7,398,349	227,027	7,398,349
Height	m	7.5		7.5	
Initial plume diameter	m	50		50	
Exhaust temperature	°C	207		207	
Exit velocity	m/s	0		0	
Assumed hours of operation	Hrs/yr	8760		8760	
Building wake effects included		no		no	
Emission rates (per source)					
TSP	g/s	2.2E-01		2.31E+00	
PM_{10}	g/s	-		2.31E+00	
SO_2	g/s	6.7E-03		4.36E+00	
NOx	g/s	-		1.53E+00	
CO	g/s	2.3E-01		5.11E+00	
VOC	g/s	1.6E-01		9.73E-01	
Benzene	g/s	2.9E-03		-	
Carbon Disulphide	g/s	1.7E-04		-	
Chloromethane	g/s	1.6E-04		-	
Ethyl Benzene	g/s	5.9E-05		-	
Toluene	g/s	1.4E-03		-	
Xylenes	g/s	5.4E-04		-	
BSO	g/s	-		1.70E-02	
Total PAHs	g/s	3.6E-03		-	
Naphthalene	g/s	1.1E-03		-	
Acenaphthylene	g/s	1.8E-04		-	

Parameter	Units	Charging	Pushing
Acenaphthene	g/s	2.6E-04	-
Fluorene	g/s	8.0E-04	-
Phenanthrene	g/s	4.8E-04	-
Fluoranthene	g/s	1.1E-04	-
Pyrene	g/s	3.7E-04	-
Benzo[a]pyrene	g/s	1.8E-05	-
Indeno[123-c,d]pyrene	g/s	3.7E-05	-
Benzo[g,h,I]perylene	g/s	1.8E-04	-
Arsenic	g/s	6.4E-07	1.59E-05
Beryllium	g/s	4.3E-07	-
Chromium	g/s	5.4E-06	-
Cobalt	g/s	1.5E-05	-
Lead	g/s	9.2E-06	7.05E-04
Manganese	g/s	7.5E-05	3.41E-04
Mercury	g/s	7.1E-06	-
Nickel	g/s	4.0E-06	-

Note: Data supplied by URS Australia, Coke Inventory Rev17.xls

Source characteristics for all material handling and storage activities are presented in Table 4 along with the emission rate of PM_{10} per activity. The emission rates of particulates were supplied by URS Australia. Details of the level of control that has been assumed in the calculation of the emission rates have not been supplied. The expected emissions are very low.

Table 4: Summary of fugitive dust source characteristics and particulate emission rates used in the modelling of the Stanwell Coke Plant.

Source	Source type	Source location or corners of area source		Emission rate of PM_{10} per source (g/s)	Height (m)	Area (m^2)
Coal unloading from QR	Volume	225,806.2	7,398,355	0.037	10	-
Coal loading Point to stockpile	Volume	225,807	7,398,214	0.007	10	-
		225,807	7,398,283			
		225,796	7,398,347			
		225,803	7,398,429			
		225,794	7,398,489			
Coal Storage Pile	Area	225,759	7,398,528	0.070	10	45500
		225,823	7,398,531			
		225,848	7,398,185			
		225,772	7,398,185			
Coal Loadout Point to stockpile	Volume	225,807	7,398,214	0.007	10	-
		225,807	7,398,283			
		225,796	7,398,347			
		225,803	7,398,429			
		225,794	7,398,489			
Total Loading Emissions to Charging Machine	Volume	225,794	7,398,489	0.012	10	-
Total Loadout Emissions from Quenching Machine	Volume	225,794	7,398,489	0.025	10	-
Coke loading Point to stockpile	Volume	226,033.9	7,398,999	0.002	10	-
		226,117.3	7,399,093	0.002		
Coke Storage Pile 1	Area	225,994.7	7,398,985	0.019	10	22,750
		226,029.7	7,398,952			
		226,174.1	7,399,112			
		226,136.9	7,399,144			
Coke Storage Pile 2	Area	226,191.6	7,399,089	0.019	10	22,750
		226,230.8	7,399,055			
		226,094.2	7,398,899			
		226,047.2	7,398,931			
Coke Loadout Point to stockpile	Volume	226,090	7,398,944	0.004	10	-
		226,195.8	7,399,053			
Coke Loadout Point to train	Volume	225,806.2	7,398,355	0.025	10	-
Coke Loading Point to emergency stockpile	Volume	226,345.7	7,399,333	0.002	10	-
Coke Storage Pile to emergency stockpile	Area	226,307.2	7,399,274	0.004	10	2,500
		226,347.8	7,399,249			
		226,382.9	7,399,306			
		226,345.7	7,399,333			
Coke Loadout Point to emergency stockpile	Volume	226,345.7	7,399,333	0.002	10	

4. Air Quality Guidelines

4.1 Standard criteria pollutants

The Environmental Protection Policy (Air) (EPP (Air), 1997) and its amendments contain air quality indicators and goals that are relevant to air quality assessment studies that are undertaken in Queensland. The indicators and goals are contained in Schedule 1 and are separated into three parts. The indicators and goals in Part 1 relate to maintaining the aesthetic enjoyment of places and visual and local amenity. Part 2 contains indicators and goals for biological integrity. Part 3 contains indicators and goals for protecting other unspecified atmospheric qualities; these generally relate to health and nuisance. Table 5 and Table 6 summarise Parts 1 and 3 of the EPP (Air) for indicators that are relevant to this assessment and that are expected to be emitted by the coke plant.

The EPP Part 2 indicators for biological integrity have been considered in the vegetation assessment in the main EIS document. Consequently, these indicators are not discussed further here.

There are no recommendations as to where these goals should be achieved or how often exceedances can be tolerated. The evaluation of the air quality impact of an industrial complex by the Queensland EPA allows for consideration of land-use, biological sensitivity and public cost-benefits in judging the seriousness of any exceedances of the goals.

The National Environmental Protection Council (NEPC) produced national standards in 1998 for regional air quality to be achieved within 10 years of commencement. The standards and associated monitoring and reporting requirements are published in the National Environmental Protection (Ambient Air Quality) Measure (NEPM, NEPC 2003). Two advisory reporting standards have been added to the NEPM for $PM_{2.5}$. These are 25 $\mu g/m^3$ for a 24-hour average and 8 $\mu g/m^3$ for an annual average. These advisory reporting standards have been defined for the purpose of collecting and evaluating monitoring data to aid in the development of $PM_{2.5}$ standard as part of the NEPM review process. These standards are presented in Table 7.

The NEPM contains a list of air quality standards and allowable exceedance rates at neighbourhood locations (i.e. at major urban sites and moderate townships). They do not give recommendations for "peak" sites such as near roadways and industrial plants. The NEPM standards will be applied to the township of Stanwell in this assessment.

Air quality within a site boundary is more often judged against occupational guidelines for workers' health. Such an assessment has not been included here.

For evaluation of health impacts, it is usual to apply the air quality goals as detailed in the EPP (Air) at the nearest residence (or prospective residence). Due to the rural nature of the proposed development location and its proximity to the Stanwell Power Station this report has assessed compliance with the air quality goals at the closest existing residential dwellings.

The allowable frequency of exceedance of the NEPM standards is generally one event per year, except for PM_{10}, which has five allowable exceedances per year. The EPA has, in the past, used the National Health and Medical Research Council (NHMRC, 1985) guideline for assessment of dispersion modelling results in small communities such as Stanwell - this gives hourly levels to be exceeded no more than once per month, leading to consideration of the predicted 99.9th percentile concentrations against such goals. For this assessment the 99.9th percentile has been used to assess compliance with the short-term air quality goals (3-minute, 10-minute, 30-minute and 1-hour averages), predicted maximum concentrations have been used for all other averaging periods. More recently the 99.9th percentile has come to be interpreted as the ninth highest hour for a one-year simulation, consistent with the requirements of other state jurisdictions such as NSW and Victoria. Therefore it has been assumed for this assessment that eight events above the goal per year is acceptable.

Table 5: Indicators and goals relevant to the aesthetic enjoyment of places and visual and local amenity (Part 1, Environmental Protection (Air) Policy 1997, Schedule 1 Air quality indicators and goals).

Air quality indicator	Air quality goal		
	Averaging time	$\mu g/m^3$	ppm
Carbon disulphide	30-minute	20	0.006
Styrene	30-minute	70	0.01
Toluene	30-minute	1,000	0.2

Table 6: Other Indicators and Goals (Part 3, Environmental Protection (Air) Policy 1997, Schedule 1 Air quality indicators and goals).

Air quality indicator	Air quality goal		
	Averaging time	$\mu g/m^3$ (except where noted)	ppm
Cadmium	1 -year	20 ng/m^3 (maximum with no increase above existing levels)	n/a
Carbon disulphide	24-hour	100	0.03
Carbon monoxide	8-hour	10 mg/m^3	8
Dichloromethane	24-hour	3 mg/m^3	0.8
Formaldehyde	30-minute	100	0.07
Lead	90-day	1.5	n/a
Manganese	1-year	1	n/a
Nitrogen dioxide	1-hour	320	0.16
Ozone and photo-chemical oxidants	1-hour 4-hour	210 170	0.098 0.079
Particles (as PM_{10})	24-hour 1-year	150 50	n/a n/a
Particles (as total suspended particulate)	1-year	90	n/a
Styrene	24-hour	800	0.2
Sulphur dioxide	10-minute 1-hour 1-year	700 570 60	0.25 0.2 0.02
Trichloroethylene	24-hour	1 mg/m^3	0.2
Toluene	24 hrs	8 mg/m^3	2

Table 7: National Environment Protection Council (Ambient Air Quality) Measure – Schedule 2, Standards and goals

Pollutant	Averaging period	Maximum concentration (µg/m^3)	Goal within 10 years. Maximum Allowable Exceedances
Nitrogen dioxide	1-hour	246	1 day a year
	1 year	62	none
Sulphur dioxide	1-hour	570	1 day a year
	1-day	228	1 day a year
	1-year	60	none
Particles (as PM_{10})	1-day	50	5 days a year
Particles (as $PM_{2.5}$)[1]	1-day	25	Collect data to assist in making a standard
	1-year	8	
Photochemical oxidants (as ozone)	1-hour	214	1 day a year
	4-hour	171	1 day a year

Note: [1] The NEPM for $PM_{2.5}$ is an advisory reporting standard. The goal of the NEPM for $PM_{2.5}$ is to collect sufficient data across Australia to support the development of a standard in 2005.

Odour guidelines for new industries are specified by the Queensland EPA (EPA, 2004) based on whether the source is a tall stack source or a ground-level source. The proposed coke plant has a mixture of both stack sources and ground-based sources, therefore this assessment has been broken into these categories and the appropriate guideline applied to each. Modelled odour concentrations at the most exposed existing or likely future off-site sensitive receptors should be compared to the guideline of 0.5 odour units (ou), 1-hour average, 99.5th percentile for stack sources and 2.5 ou 1-hour average, 99.5th percentile for ground-based sources.

4.2 Design Criteria for Toxic Air Pollutants

The EPP (Air) does not contain goals for all toxic air pollutants. For example there are no EPP (Air) goals for PAHs, VOC and most metals. In order to assess the risk of adverse impact of these pollutants, the Victorian Environment Protection Agency *State Environment Protection Policy Schedule A Class 1,2, 3 and Unclassified Indicators and Design Criteria* (Victorian Government, 2001) have been used. Table 8 presents the list of Design Criteria relevant to the pollutants emitted from the coke plant. The reason for the classification is also indicated. Where two guidelines are indicated, such as those based on odour, the lowest criteria has been used in this assessment.

Table 8: Design Criteria for Toxic Air Pollutants relevant to the Stanwell Coke Plant emissions (3-minute average ground-level concentrations)

Pollutants	VICEPA guidelines Reason For Classification	Design Criteria Toxicity (mg/m³)	Design Criteria Odour (mg/m³)
Sulphuric Acid	Toxicity	0.033	
Benzene	IARC Group 1carcinogen	0.053	
Bromoform	Toxicity	0.17	
Bromomethane	Toxicity	0.63	
2-Butanone	Odour	16	5.9
Carbon Disulphide	Odour	1.01	0.13

Pollutants	VICEPA guidelines Reason For Classification	Design Criteria Toxicity (mg/m³)	Design Criteria Odour (mg/m³)
Chlorobenzene	Odour	1.5	0.2
Chloromethane	Toxicity	3.4	
Chloroform	Toxicity	0.33	
Cumene	Odour	8.1	0.39
EthylBenzene	Toxicity	14.5	
Methylene Chloride	Toxicity	5.8	
n-Hexane	Toxicity	5.9	
4-Methyl-2-Pentanone	Odour	6.7	0.41
Phenol	Odour	0.13	0.036
Styrene	Odour	6.97	0.21
Toluene	Odour	12.3	0.65
1,1,1-Trichloroethane	Toxicity	22.7	
1,1,2-Trichloroethane	Toxicity	1.8	
Xylenes	Odour	11.4	0.35
Total PAHx	IARC Group 2A carcinogen	0.00073	
Antimony	Toxicity	0.017	
Arsenic	IARC Group 1carcinogen	0.00017	
Beryllium	IARC Group 1carcinogen	0.000007	
Cadmium	IARC Group 1carcinogen	0.000033	
Chromium VI compounds	IARC Group 1carcinogen	0.00017	
Chromium III compounds	Toxicity	0.017	
Maganese	Toxicity	0.033	
Mercury Organic	Bioaccumulation	0.00033	
Nickel	IARC Group 1carcinogen	0.00033	

Note: IARC – International Agency for Research on Cancer

The National Environment Protection Council has recently published the National Environment Protection (Air toxics) Measure (NEPC 2004). The aim of this measure is to gather sufficient information on a number of air toxics over the next eight years to facilitate the development of national standards. The monitoring investigation levels are presented in Table 9 and have been used in this assessment as a guide only.

Table 9: National Environment Protection (Air Toxics) Measure – Monitoring investigation levels

Pollutant	Averaging period	Monitoring investigation level	Goal
Benzene	Annual average*	0.003 ppm	8-year goal is to gather sufficient data nationally to facilitate development of a standard.
Benzo(a)pyrene as a marker for Polycyclic Aromatic Hydrocarbons	Annual average*	0.3 ng/m^3	
Formaldehyde	24 hours#	0.04 ppm	
Toluene	24 hours# Annual average*	1 ppm 0.1 ppm	
Xylenes (as total of ortho, meta and paraisomers)	24 hours# Annual average *	0.25 ppm 0.2 ppm	

*For the purposes of this Measure the annual average concentrations in Column 3 are the arithmetic mean concentrations of 24-hour monitoring results.

For the purposes of this Measure monitoring over a 24 hour period is to be conducted from midnight to midnight.

Reference: NEPC (2004).

5. Existing Environment

5.1 Topography and land use

The proposed coke plant is located near the Stanwell Township. The nearest major city to Stanwell is Rockhampton, located approximately 25 km from Stanwell towards the northeast.

The major source of air pollutants in the region is the Stanwell Power Station, which is adjacent to the proposed development site. Other local sources of air pollution in Stanwell are vehicles in town (contributing a small amount to levels of oxides of nitrogen, particles and VOCs) and regional air pollution events such as bushfires and dust storms (contributing mainly to levels of particulate matter).

There are no major industrial sources in Rockhampton that would significantly affect the Stanwell airshed. The nearest major industrial facilities with significant air emissions are in Gladstone. Gladstone is located to the southeast of Stanwell at a distance of over 100 km. Air quality monitoring around Gladstone has shown significant air quality impacts from local industrial sources occur close to the source. It is highly unlikely that significant air quality events would occur in Stanwell due to the Gladstone industrial sources, as the intervening distance and mountainous terrain are significant. From inspection of the monitoring data collected around Stanwell no clear signal of increased sulphur dioxide can be attributed to winds from the south-easterly sector (i.e. potential transport from Gladstone). Minor increases in ozone could possibly be attributed to Gladstone emissions on the rare occasion (possibly less than a couple of events per year). Without undertaking a detailed regional wind field and trajectory analysis the exact frequency and type of meteorological conditions resulting in these events cannot be determined.

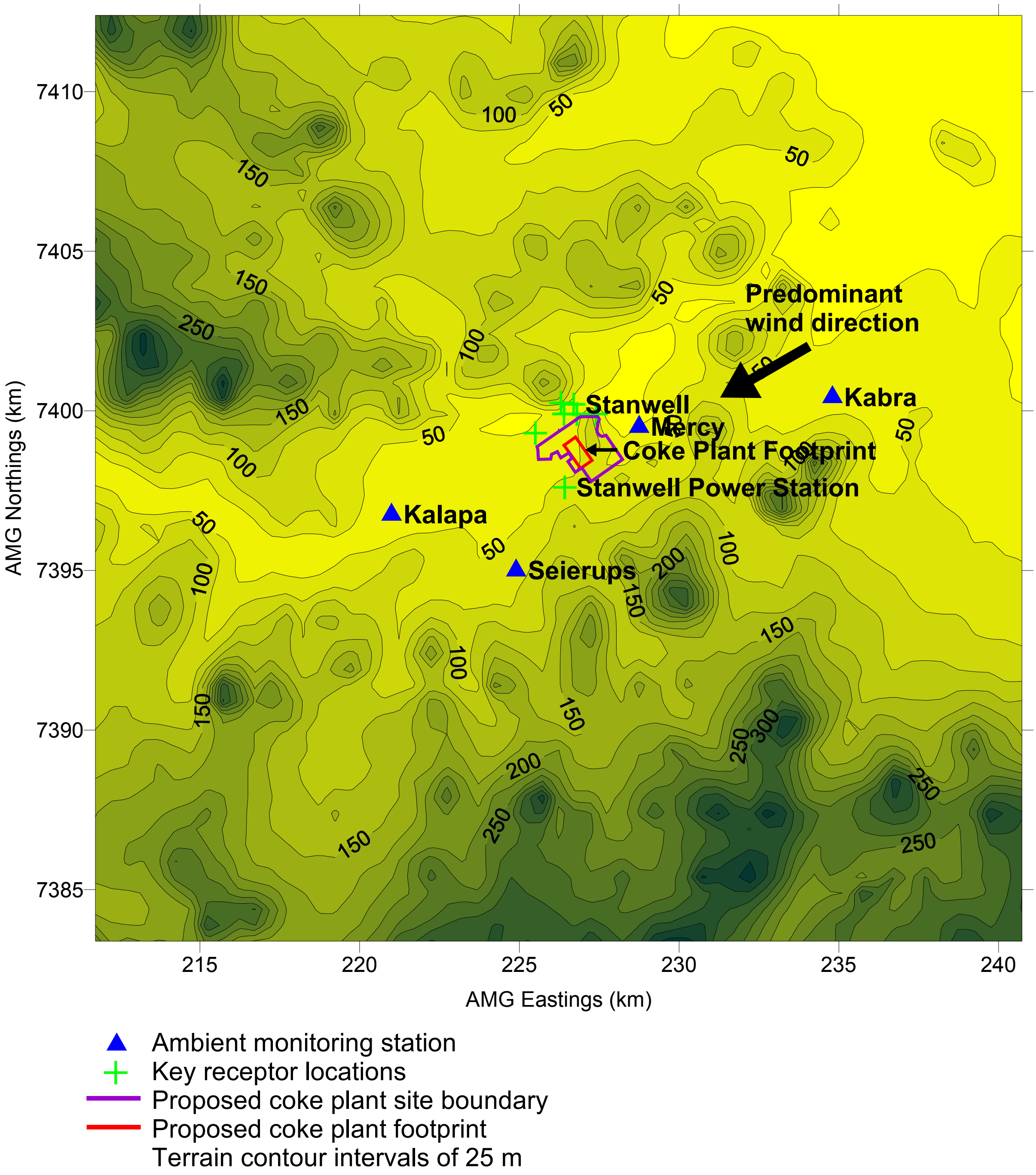
A ridge of 140 m high hills is located both upstream and downstream for the predominant wind directions. The valley basin narrows to the east and expands to the west, with the orientation being east-northeast to west-southwest. The proposed site is 40 km from the coast and to the west of the main Fitzroy basin. To the south lies a range of hills that extends to the south of Mt. Morgan to a height of 350 m.

There is little indication of significant topographical effects on plume behaviour from the Stanwell Power Station during the daytime (in accord with past field experiments). A small set of air quality measurements on elevated terrain at the Mercy and Native Cat Range sites has shown that some nighttime conditions have produced moderate ground-level concentrations, but at levels much lower than those that occur during daytime at flat terrain sites much closer to the power station.

Blocking effects due to nearby ranges for southerly and northerly winds can reduce the occurrence of high wind speeds, resulting in higher pollutant concentrations. Conversely, accelerated flow along the valley can reduce such levels where the thermal turbulence is no longer dominant.

The terrain information used in the dispersion modelling and generation of regional wind-fields are presented in Figure 1. This figure also indicates the location of ambient monitoring stations, key receptors for air quality and the proposed site boundary.

Figure 1: **Terrain contours, location of monitoring stations, key receptors and site boundary for modelling domain.**



5.2 Climate and Meteorology

The coke plant is proposed to be located near the Stanwell Power Station, which has conducted extensive monitoring of meteorological and air quality parameters over several years. The data are summarised in this section, with acknowledgement to Stanwell Power Station for allowing the use of the data.

Stanwell Power Station has been monitoring air quality at a total of seven monitoring sites in the Stanwell region since December 1997 until the decommissioning of the last monitoring site in November 2003. The Seierup, Kalapa and Mercy sites provide a long-term data set, with other stations operated for shorter time intervals. Meteorological parameters (wind speed, wind direction, sigma theta, vertical wind speed) were measured at six locations. The Seierup site (2.5 km to the southwest of SPS) also measured temperature, net radiation, solar radiation, rain, relative humidity at 10 m height, and horizontal and vertical winds, temperature and relative humidity at 30 m height. This comprehensive dataset is of good quality and has been used in characterising the local climate.

5.2.1 Temperature

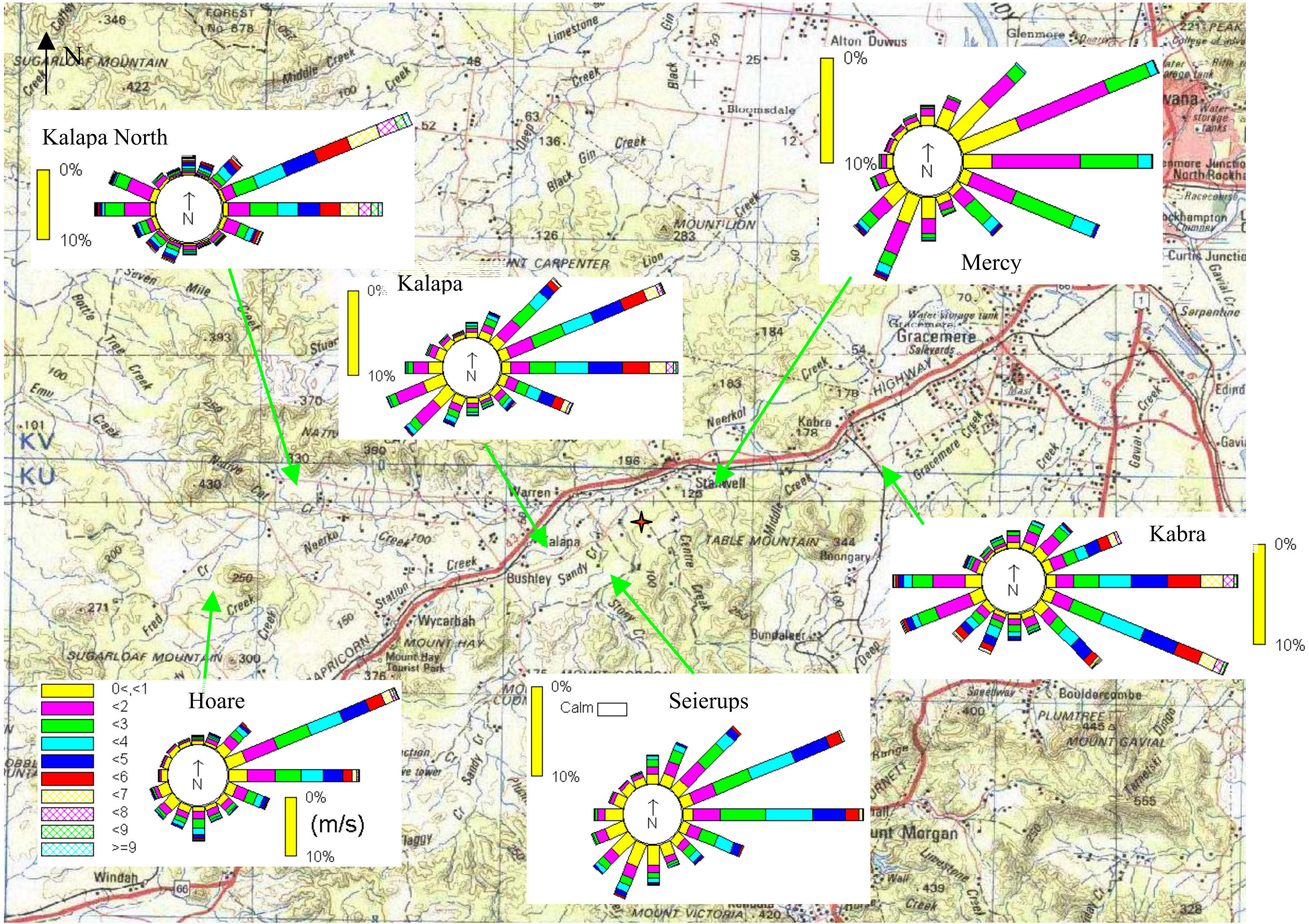
Long term temperature measurements were recorded at Seierups at 1.2 m and at 30 m for the period from December 1997 to November 2003. The monthly averages range between 27°C during summer to 16°C in the winter. A maximum temperature of 43.7 °C was recorded on the 25 December 2001 at 3:40 pm and a minimum of –0.8 °C on 19 August 1999 at 7 am.

5.2.2 Winds

The terrain to the northwest and south of the proposed site significantly influences the wind flows around the Stanwell area. The winds are channelled in a dominant east-west direction. A summary of the winds (recorded at the 10 m height) for the entire monitoring period for each site is shown in Figure 2.

The Mercy site shows lighter winds compared to the other monitoring sites, as the location was quite sheltered due to local terrain and vegetation, and as such is not representative of regional flows. The Kabra site is the furthest east of the monitoring sites and is less affected by the terrain to the northwest. As a consequence, this site has recorded a higher proportion of east-southeasterly winds.

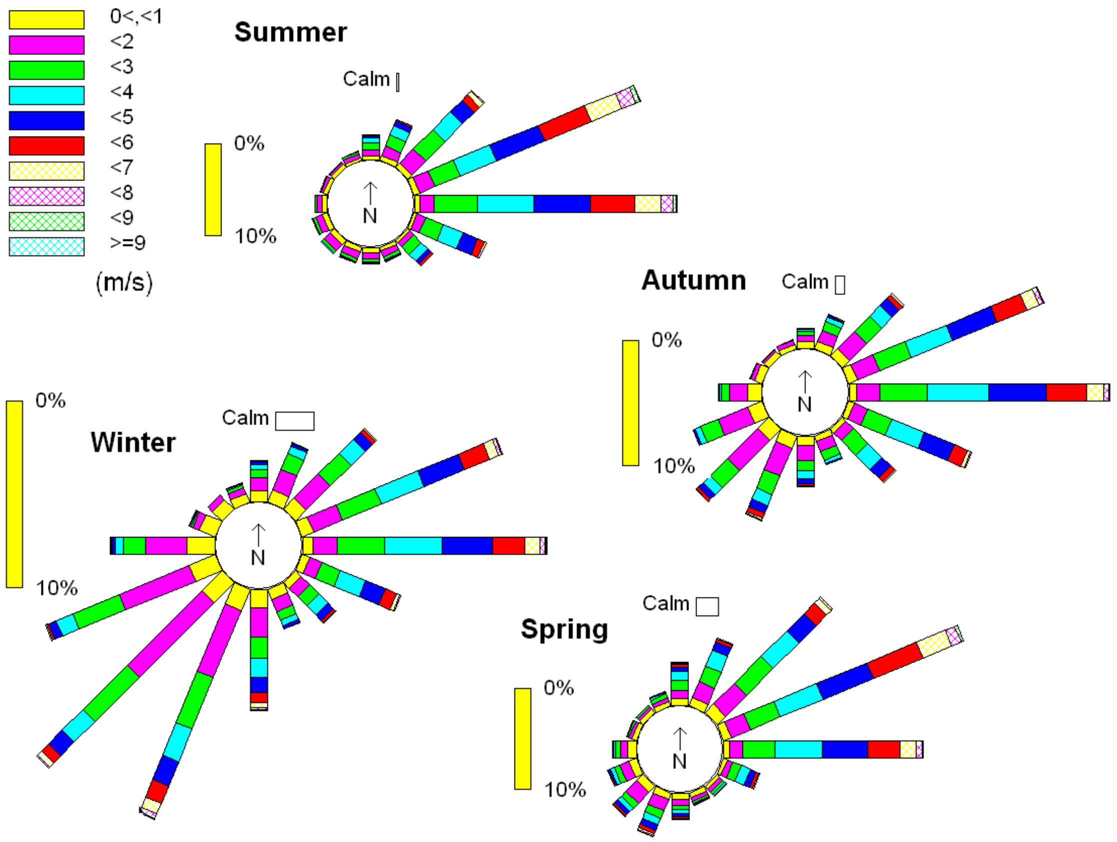
Figure 2: Wind roses for each of the monitoring sites recorded (note: different periods for each site).



✦ Location of power station

Seasonal wind roses for the Seierups site (longest monitoring period) at a height of 30 m are presented in Figure 3. There is very little seasonal variation in wind pattern recorded at Stanwell. Winter winds are more frequently from the southwest compared to the rest of the year and generally lighter. A higher frequency of calms are also recorded during winter.

Figure 3: Seasonal wind roses for Stanwell (Seierups 30 m winds 1997 - 2003)



The winds recorded at 30 m at Seierup show a similar dominance of northeasterly winds but with much higher wind speeds than at the 10 m level, as expected. During the daytime the windspeed is almost three times higher at 30 m than at the 10 m level. During the nighttime the average wind speed at 30 m is generally double that at 10 m. The diurnal variations of wind speeds indicate that the winds are strongest at about 5 pm (due to the presence of the late sea breeze) and lightest in the early morning. The morning drainage flows are generally from the southwest and northeast, with a high tendency of calm winds during the period from midnight to 6 am.

The median value of the standard deviation of wind direction (5-minute averages) varied from about 20° overnight to 30° at about noon, with the 10th and 90th percentiles of the noon observations being 20° and 80° respectively.

Southerly winds are required to transport emissions from the proposed coke plant to closest residential areas of the Stanwell Township. Winds from this sector occur relatively infrequently (less than 5% of the time).

5.2.3 Radiation

Solar radiation is a measure of the amount of incoming solar radiation and is therefore zero at nighttime. The main features that influence the solar radiation measured at a site are the time of day, the distance from the equator, the time of year and amount of cloud cover in the sky. Net radiation is the difference between the amount of incoming solar radiation and the amount of radiation going out due to reflection from clouds and radiation from the earth. At night net radiation is generally negative during cloudless nights and positive during overcast nights. Solar radiation is one of the variables used to calculate mixing heights. Net radiation is one of the variables used to calculate atmospheric stability.

The peak radiation levels are generally recorded at 11 am to 12 pm. The proportion of net radiation to solar radiation at this peak time is 0.6. During summer sunrise to sunset is typically 5-6 am to 6-7 pm while for winter sunrise is 6-7 am and sunset is 5-6 pm.

5.2.4 Rainfall

Rainfall has been recorded at Seierups and indicates maximum monthly average rainfall during February (120 mm) and a minimum during July (10 mm). The peak monthly rainfall has exceeded 300 mm and the minimum monthly rainfall is 0 mm. Annual rainfall ranges between 340 mm and 790 mm with an average of 690 mm.

5.2.5 Derived parameters

5.2.5.1 Mixing heights and temperature inversions

The extent of the mixing height and the strength of the temperature inversion are very important features that can limit the degree of dispersion of pollutants. The height of the mixed layer changes with time of day and season. Shallow mixing heights occur at night under stable atmospheric conditions. Generally lower mixing heights occur during winter when stronger temperature inversions and reduced solar radiation restrict the growth of the mixing depth until later in the morning. The degree of dispersion or mixing within the mixed layer is determined by the atmospheric stability.

Under stable atmospheric conditions (most of the evening and nighttime) a buoyant plume will rise until it reaches the inversion height and will remain elevated and will be unlikely to give rise to any impact at ground level except if the plume strikes elevated terrain. Similarly, a plume that is released above the inversion height (such as from a tall stack) will remain elevated and unlikely to impact at ground level.

After daybreak the mixing height increases due to two processes. The first is solar radiation heating the ground and consequent heating of the air close to the ground causing the air to rise and secondly winds creating turbulence at the surface. Fumigation occurs for elevated plumes when the depth of the mixed layer grows to the height of the plume, causing the plume to be brought to ground. These events can typically be expected for a short period over the first few kilometres from the stack.

When the mixing height exceeds the height of the plume, the plume appears to have a sinuous vertical structure caused by strong convective heating of the air at ground level. The thermal elements take the plume alternatively upwards and to ground (with a typical period of 5-20 minutes). In this situation, maximum concentrations are experienced close to the stack and are usually the highest experienced throughout the day and night for stack sources. In the late afternoon the intensity of convection decreases, the plume regains a more coherent shape and any ground-level impact from stack sources is unlikely as the nighttime radiation inversion reforms.

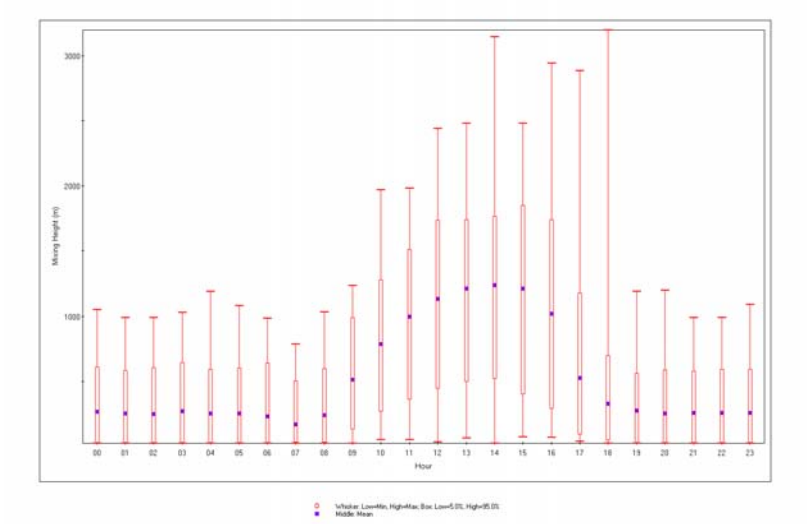
Figure 4 shows the calculated mixing heights versus hour of day generated by the TAPM model for the proposed site for all hours of a year and for each season. The mixing heights show a typical diurnal profile increasing from 8 am and reducing from 3 pm. The highest average mixing heights are predicted from 12 pm to 3 pm, which is typical of strongly convective conditions.

Mixing heights vary seasonally with summer mixing heights typically above 500 m by 8 am reaching peaks over 2,000 m during the afternoon. During winter mixing heights are much lower and growth in the mixed layer starts later in the day (e.g. 500 m mixing height is typically reached by 10 am). The slower increase in mixing heights during winter is due to the presence of stronger temperature inversions and less solar heating than during the warmer months.

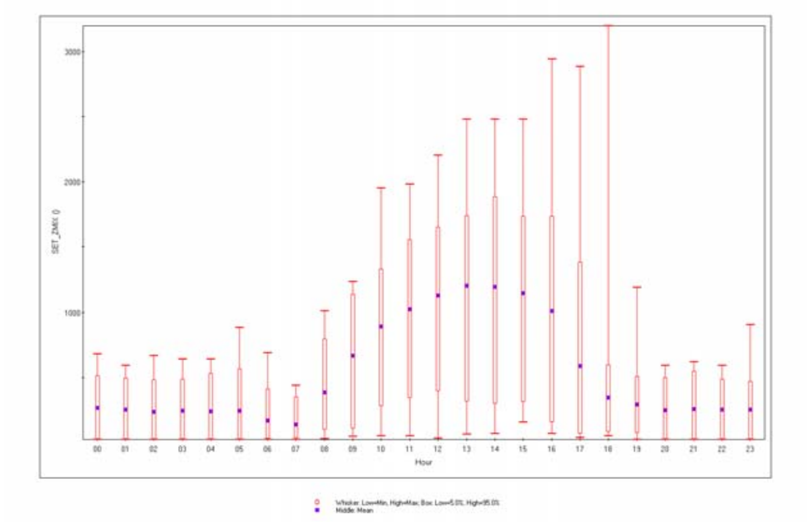
Figure 5 presents the seasonal changes in temperature inversions represented by the relative difference in temperature measurements from 30 m to 2 m above ground level (as recorded at the Seierups station). A positive number indicates an inversion and the larger the number the stronger the inversion. During winter temperature inversions typically occur from 3 pm to 9 am with a mean strength of 4°C and maximum strength of over 11°C. The strength and duration of inversions decrease in the warmer months with typical inversions of 1-2°C occurring between 5 pm and 7 am during summer with a maximum strength of 5°C.

Figure 4: **Mixing heights (m) calculated for the proposed site generated from TAPM for 1999 (a) All year (b) Summer (c) Autumn (d) Winter (e) Spring.**

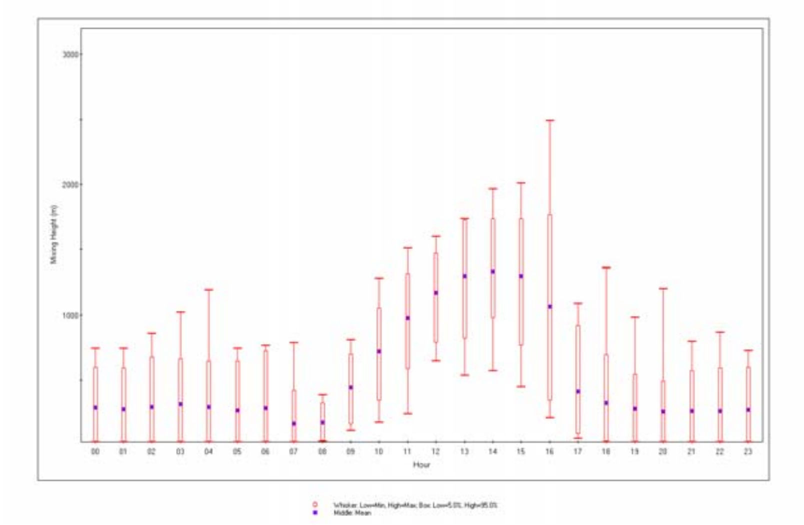
(a) Annual



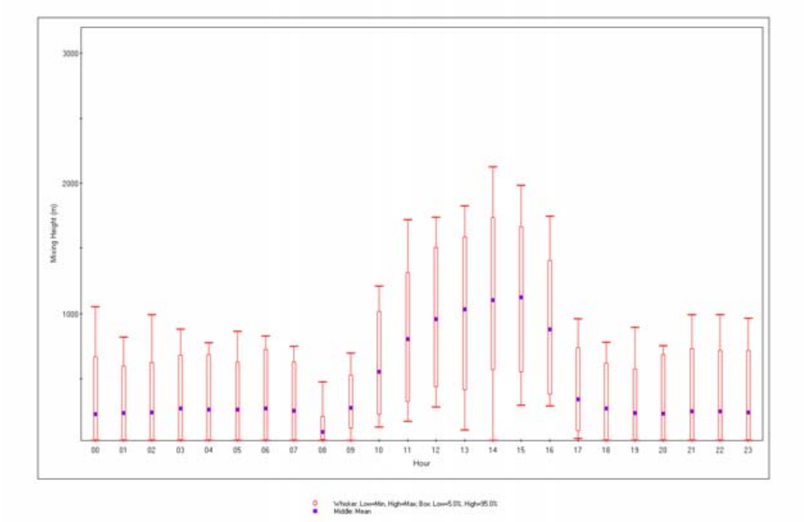
(b) Summer



(c) Autumn



(d) Winter



(e) Spring

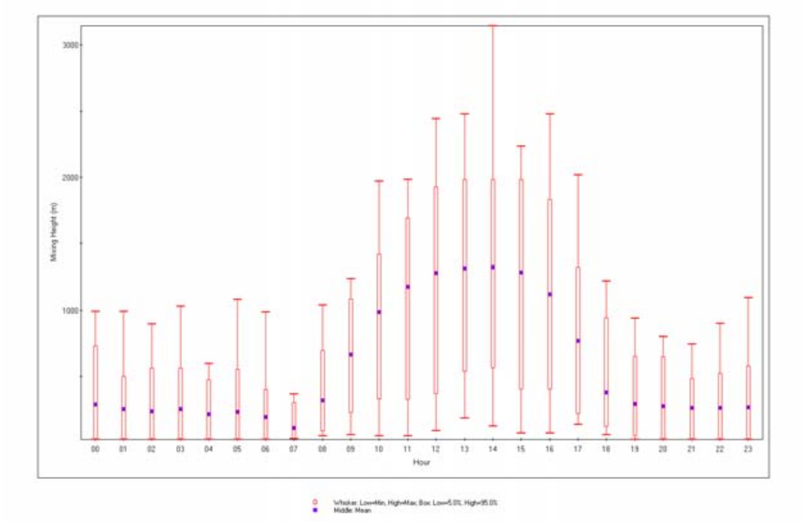
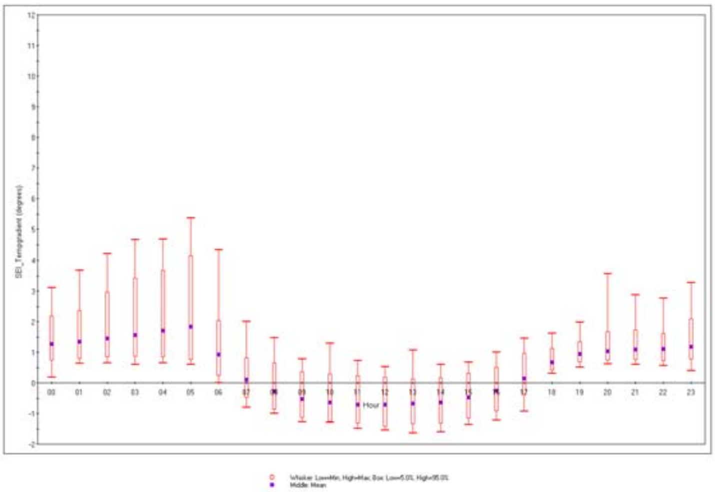
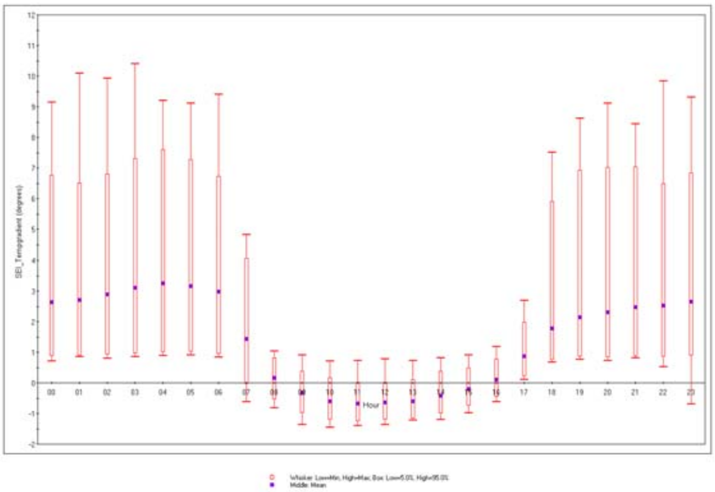


Figure 5: **Seasonal temperature gradients calculated from Seierups 30 m minus 2 m temperature. (a) Summer (b) Autumn (c) Winter (d) Spring.**

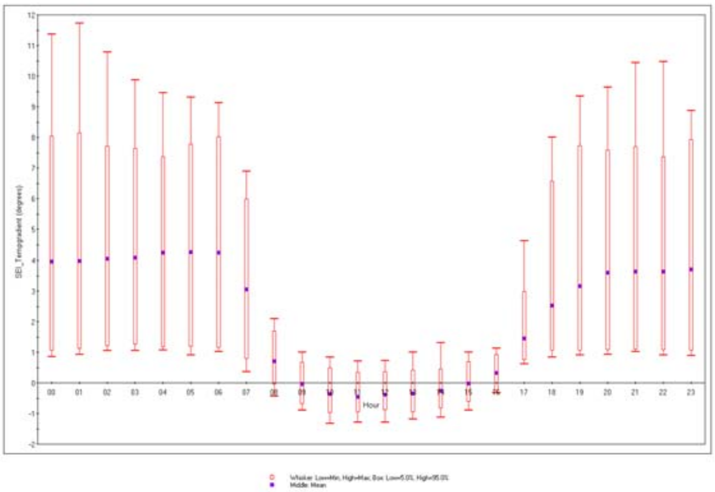
(a) Summer



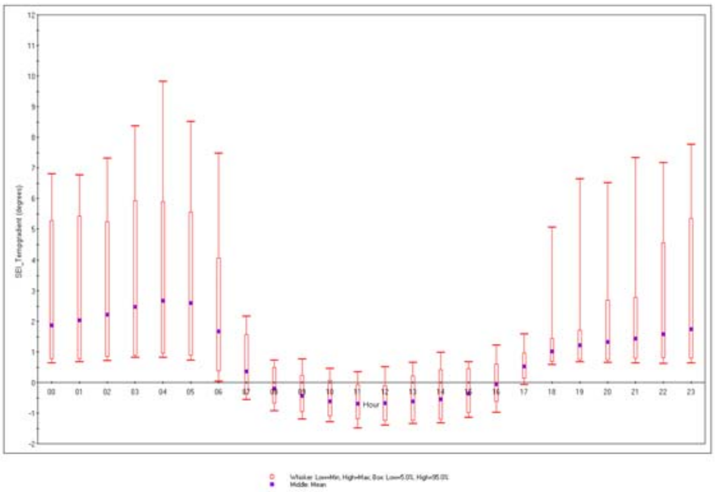
(b) Autumn



(c) Winter



(d) Spring



5.2.5.2 Stability

Stability classification is a measure of the atmospheric turbulence Class A represents very unstable atmospheric conditions that may typically occur on a sunny day. Class F represents very stable atmospheric conditions that typically occur during light wind conditions at night. During unstable conditions (stability class A-C), atmospheric turbulence caused by solar heating of the ground is greater and is responsible for the degree of dispersion. Dispersion processes for the most frequently occurring Class D conditions are dominated by mechanical turbulence generated as the wind passes over irregularities in the local surface. The higher wind speeds associated with Class D conditions generally result in lower ground-level concentrations than classes A-C.

During the nighttime the atmospheric conditions are predominantly stable (Class E and F). During stable conditions the plume released from the stack will be subject to minimal atmospheric turbulence. A plume that is hotter than its surroundings and emitted above the nighttime inversion will remain relatively undiluted but will be trapped above the inversion layer and will not reach the ground unless it encounters elevated terrain. For a ground-based low buoyancy emission source the air pollutants will be trapped under the inversion layer and during very stable conditions will not mix as well and result in elevated ground-level concentrations.

Table 10 shows the percentage of stability classes determined from the TAPM model. The high proportion of F Class stability is due to the high frequency of light winds that occur at the site at nighttime.

Table 10: Frequency of occurrence (%) of surface atmospheric stability conditions for Stanwell area based on TAPM modelling.

Pasquill-Gifford Stability Class	Frequency (%)	Classification
A	9.5	Extremely unstable
B	12.5	Unstable
C	16.1	Slightly unstable
D	19.5	Neutral
E	17.1	Slightly stable
F	25.3	Stable

6. Existing Air Quality

6.1 Ambient monitoring

Air quality measurements have been recorded at seven monitoring stations in the Stanwell region by the Stanwell Power Station over a six year period from 1997. The data has been recorded as 10-minute averages for various air quality parameters comprising sulphur dioxide (SO_2), oxides of nitrogen (NO_x), nitrogen dioxide (NO_2), particulates (TSP, PM_{10}, $PM_{2.5}$) and ozone (O_3). Instantaneous 5-8 second maximum measurements have also been recorded for a short period at some sites.

The station at Seierups represents the longest data set with six years of meteorological and ambient monitoring data recorded. Other long-term data sets include Kalapa and Mercy; these sites operated for about 3 years (1997 to 2000). A mobile site was also in operation for the three years from 1997 to 2000 covering a number of sites including Brooks Farm, Kalapa North, Kabra and Hoare. A very good data set of ambient monitoring and meteorological information are available for 1999; therefore this year was chosen for detailed analysis and verification of the dispersion model.

Generally the air quality within the Stanwell airshed is considered good with low levels of sulphur dioxide and oxides of nitrogen recorded most of the time. The Stanwell Power Station is the main source of sulphur dioxide and oxides of nitrogen within the airshed.

Table 11 presents a summary of the maximum levels recorded at each monitoring station for a range of pollutants for averaging periods relevant to an ambient air quality goal. Note that the table also includes the NEPM standards for nitrogen dioxide, sulphur dioxide, ozone, PM_{10} and the NEPM advisory reporting standard for $PM_{2.5}$ for comparison. However, none of these monitoring stations meet the requirements of a NEPM monitoring station, as they are not representative of an urban population; therefore an assessment of compliance with the NEPM standards is not valid. Over the full monitoring period some events above the ambient air quality goals have been recorded, a full list of these events is presented below:

- Four events above the sulphur dioxide 10-minute goal of 700 $\mu g/m^3$ recorded at Seierups;
- One event above the 4-hour average goal for ozone recorded at Seierups;
- Two events above the 24-hour average PM_{10} EPP goal of 150 $\mu g/m^3$ recorded at Seierups; and

- One event above the 4-hour average nitrogen dioxide goal of 95 μg/m^3 recorded at Mercy.

Table 11: Comparison of maximum air quality measurements for each site for various averaging periods with the Queensland EPA goals and NEPM standards (numbers in brackets represent the number of events above the standards)

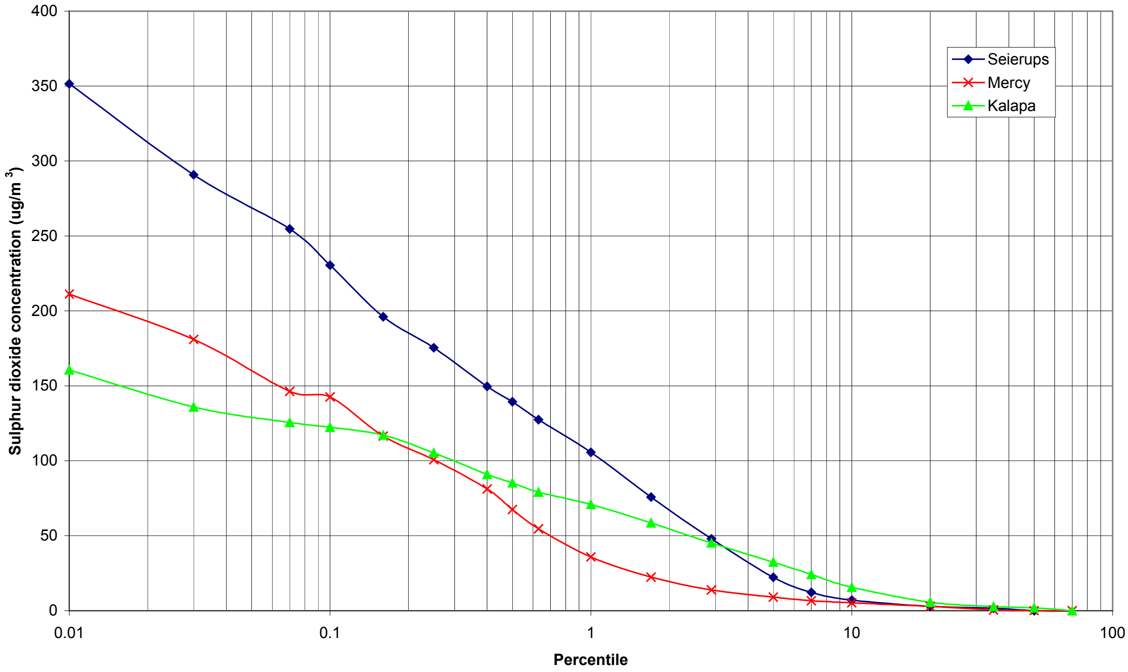
Pollutant	Averaging period	Goal/Standard	Maximum recorded at each site (μg/m^3)						
			Brooks	Hoare	Kabra	Kalapa	Kalapa North	Mercy	Seierups
Sulphur dioxide	10-minute	700	509	203	169	354	240	414	811 (4)
	1-hour	570	181	106	109	191	146	231	471
	24-hour	100	41	25	19	33	28	35	77
	Annual	60	6	n/a	n/a	8	n/a	3	7
Nitrogen dioxide	1-hour	320[1] 246[2]	71	47	56	69	68	217	101
	4-hour	95	60	32	54	53	50	111	82
	Annual	30	7	n/a	n/a	9	n/a	5	6
Ozone	1-hour	210	-	-	-	-	-	-	186
	4-hour	170	-	-	-	-	-	-	174 (1)
TSP	Annual	90	-	-	-	18	-	-	-
PM$_{10}$	24-hour	150[1] 50[2]	-	-	15	31	-	-	257 (2)[1]
PM$_{2.5}$	24-hour	25[2]	-	-		17	-	-	90

n/a could not be calculated as only a few months of monitoring data in period.
1 Environmental Protection (Air) Amendment Policy (No. 1) 1997, Schedule 1.
2 National Environment Protection Council (NEPC), (1998). "National Environment Protection Measure for ambient air quality".

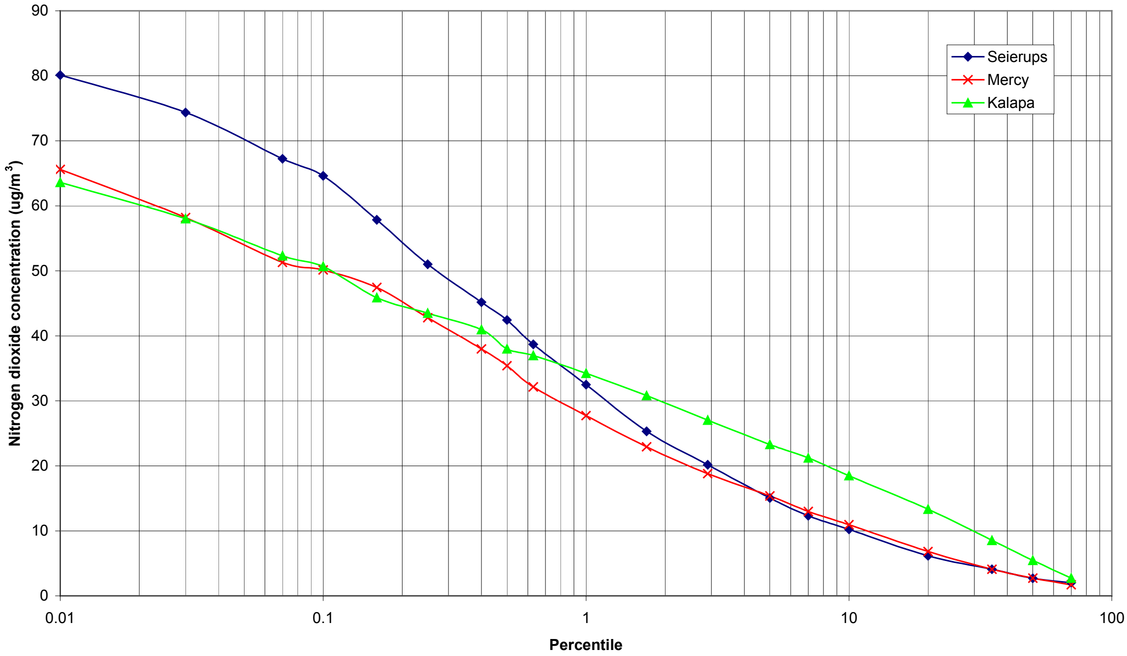
For the majority of the time concentrations recorded by the monitoring stations are well below the levels presented in Table 11. The frequency of hourly average concentrations of sulphur dioxide and nitrogen dioxide recorded over the entire monitoring period at Seierups, Mercy and Kalapa sites are presented in Figure 6. It can be seen that for the majority of the time the levels recorded at these sites is low and well below the ambient air quality goals. Seierups is the most affected site with levels above 350 μg/m^3 for 0.01% of the time (this is equivalent to less than one hour per year or six hours over the six years of monitoring). At Mercy and Kalapa the 99.9th percentile for sulphur dioxide is less than 150 μg/m^3 or 25% of the ambient goal. Nitrogen dioxide levels recorded at all sites are very low and are rarely recorded above 25% of the ambient goal of 320 μg/m^3.

Figure 6: Cumulative frequency distributions of hourly average concentrations recorded at Seierups, Mercy and Kalapa for (a) sulphur dioxide and (b) nitrogen dioxide (µg/m^3)

(a)



(b)



The 95th percentile is typically used to represent the background level of air pollutants in an area. For this assessment sulphur dioxide and nitrogen dioxide have been modelled from the Stanwell Power Station and included in the cumulative modelling results. There are no other important sources of these pollutants. Background levels of particulates due to Stanwell Power Station have also been modelled. Other sources in the region have been included by use of the measured 95th percentile values, as the power station does not represent the only source of particulates in the area. Table 12 presents the background particulate levels determined from measurements.

Table 12: Background levels of particulates from measurements in the Stanwell area.

Site	95th percentile 24-hour average particulate measurements		Average of all data recorded at site		
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	TSP
Seierups	24.8	10.9	15.7	6.2	N/a
Kabra	12.6	N/a	6.5	N/a	N/a
Kalapa	22.1	9.7	14.3	6.4	15.8

Note: sampling periods differ for each pollutant and site.

6.2 Predicted Existing Air Quality

6.2.1 Criteria Pollutants

A simple model verification study has been undertaken to compare the performance of the model against the comprehensive ambient monitoring data for the region and to provide confidence in the model's ability to realistically characterise impacts from the proposal. This verification study is presented in detail in Appendix A and shows that the model provides a good representation of regional and local impacts due to the power station.

The major pollutant emitted from the Stanwell Power Station that will contribute significantly to the background air quality in the Stanwell area is sulphur dioxide. Measurements indicate that on occasions events above the sulphur dioxide and PM_{10} short-term air quality goals have been recorded. Measured concentrations of all other pollutants are well below ambient air quality goals.

Contours of background concentrations of sulphur dioxide and nitrogen dioxide due to Stanwell Power Station, as predicted by the model are presented in below. This assessment assumes that the power station is operating at licence limits and full load for the entire year (i.e. theoretical capacity factor of 100%). This is a conservative assumption and will result in the highest possible impacts due to the power station operations.

Figure 7 presents contours of the predicted ground-level concentrations of sulphur dioxide due to the operation of the Stanwell Power Station for a 1-hour average (99.9th percentile), maximum 24-hour average and annual average. The predicted number of events above the 1-hour average goal of 570 µg/m³ is also presented.

Short-term maximum concentrations are predicted to occur relatively close to the power station to the south and southwest during the day. This is consistent with the location of the maximum recorded peaks at the Seierups site. At peak operating conditions a few events above the ambient goal are predicted within 2-3 km of the station, the maximum number of hours (5) above the goal are predicted to the northeast of the station and the highest number (19) of 10-minute average events above the goal predicted to the south of the station. For typical emissions from the power station only one exceedances of the 1 hour goal is predicted and a maximum of seven events above the 10-minute goal. No events above the 1-hour average goal have ever been recorded at the Stanwell monitoring stations, and only four events above the 10-minute average goal have been recorded at the Seierups site, therefore the modelling results are conservative. The model verification study presented in Appendix A also indicates the modelling assessment of the existing power station impacts may be conservative.

Typically the power station will vary its load throughout the day (lower at night) and season and the actual plant availability is typically only 90-92% per year. The emission rates of sulphur dioxide are directly proportional to the amount of sulphur present in the coal delivered to the site. This will also vary and is generally at least 45% lower than the licence limit value of 0.8%. The emission rate of nitrogen oxides is directly related to the load and to some extent the coal quality. Nitrogen oxides have been modelled at the licence limit for this assessment, which is about 50% higher than typical operating levels. Table 13 presents a summary of average emission rates and coal sulphur content for each year from 1999 to 2005. This table shows that the actual power station emission rates are typically significantly lower than the licence limit emission rates used in the modelling. Contours representing the typical sulphur dioxide emission levels from the power station are also presented below (Figure 8).

Table 13: Summary of operating emissions for the Stanwell Power Station (based on NPI calculations)

	Average (1999-2005)	1999	2000	2001	2002	2003	2004	2005
Average SO_2 emission rate (g/s)	1036	966	880	1123	1157	1130	955	1040
Average Coal S %	0.51	0.49	0.44	0.55	0.55	0.55	0.51	0.51
Average NO_x emission rate (g/s)	952	994	1000	942	970	948	861	N/a

Date supplied by Stanwell Corporation Limited

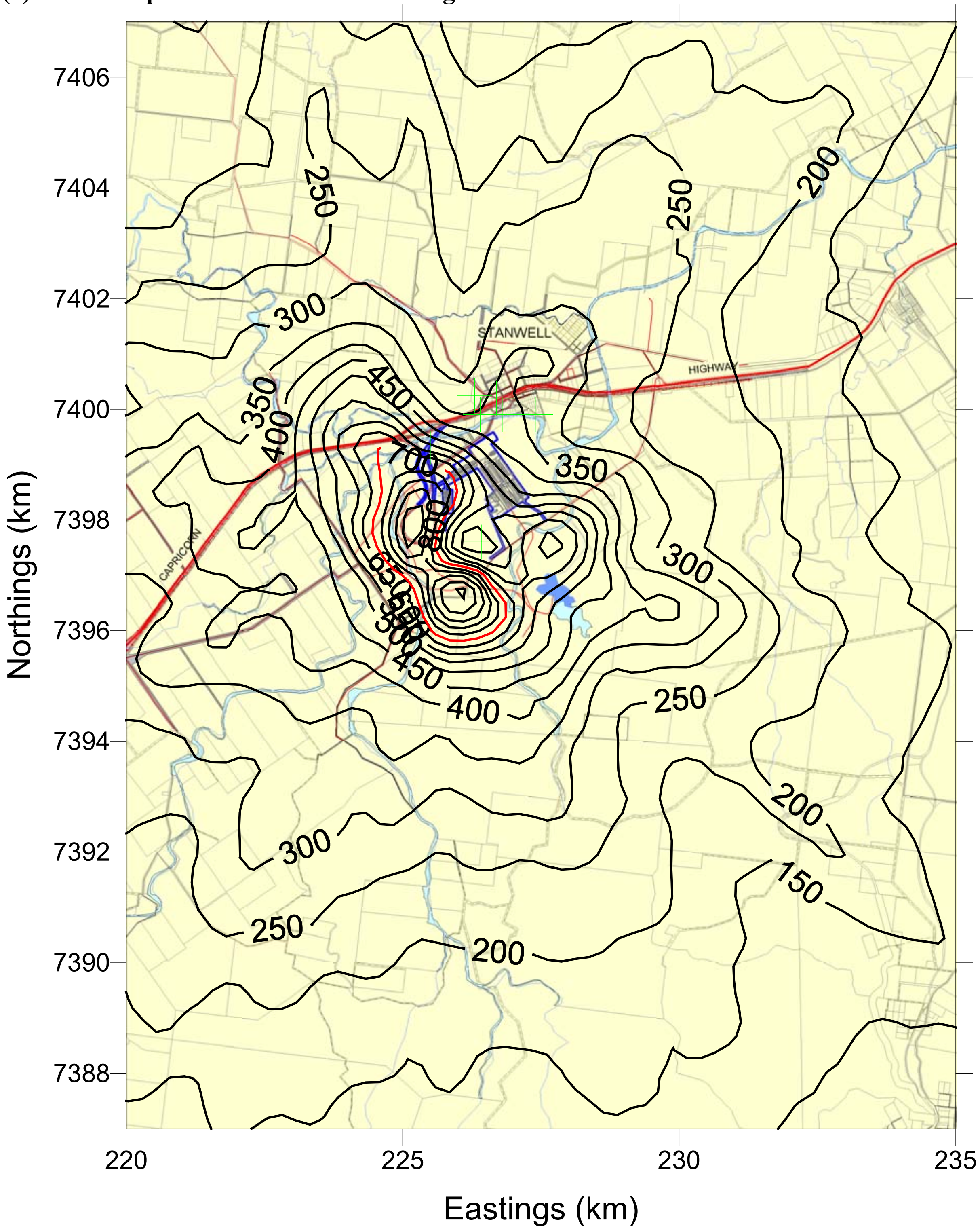
Maximum long-term average concentrations are predicted to the southwest of the station at approximately 5-7 km from the power station near the location of the Kalapa monitoring station. This is consistent with the monitoring information, which recorded the maximum annual average concentration of sulphur dioxide at the Kalapa site of similar magnitude.

Figure 9 presents the predicted nitrogen dioxide concentration contours for the power station operating at full load and licence limit emission levels of NO_x. A ratio of 30% has been assumed for all contour plots, which is likely to be conservative very close to the power station.

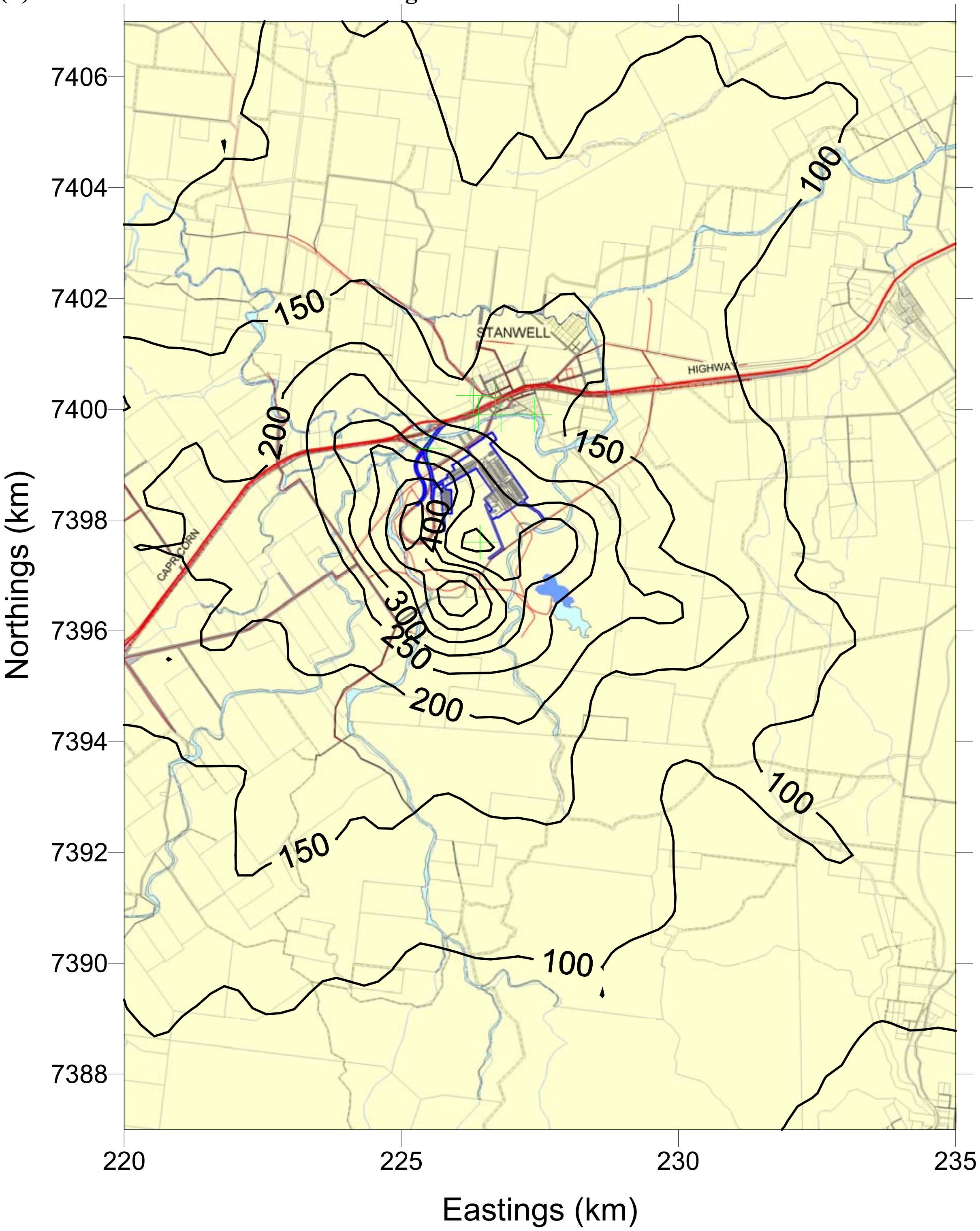
The predicted maximum particulate concentrations due to the operation of the power station are very low and well below the levels recorded at the ambient monitoring stations. Other sources of particulates, such as farming activities, exposed land and bushfires will dominate the overall particulate levels in the region.

Figure 7: Predicted sulphur dioxide concentration (µg/m^3) due to operation of the Stanwell Power Station at full load and licence limit coal sulphur content for (a) 99.9th percentile 10-minute average (b) 99.9th percentile 1-hour average (c) 24-hour average (d) annual average (e) number of events above the 10-minute average goal (f) number of events above the 1-hour average goal.

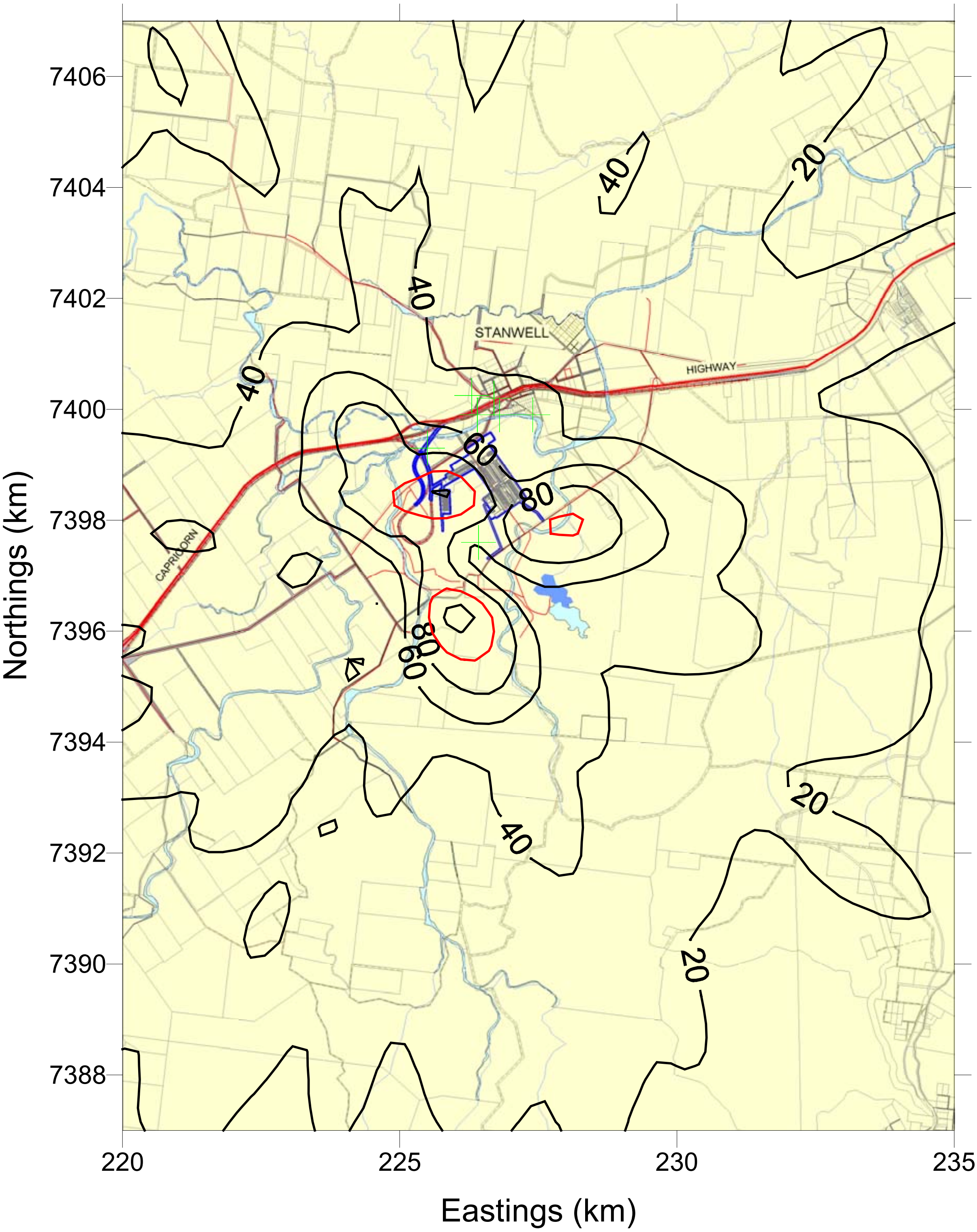
(a) 99.9th percentile 10-minute average



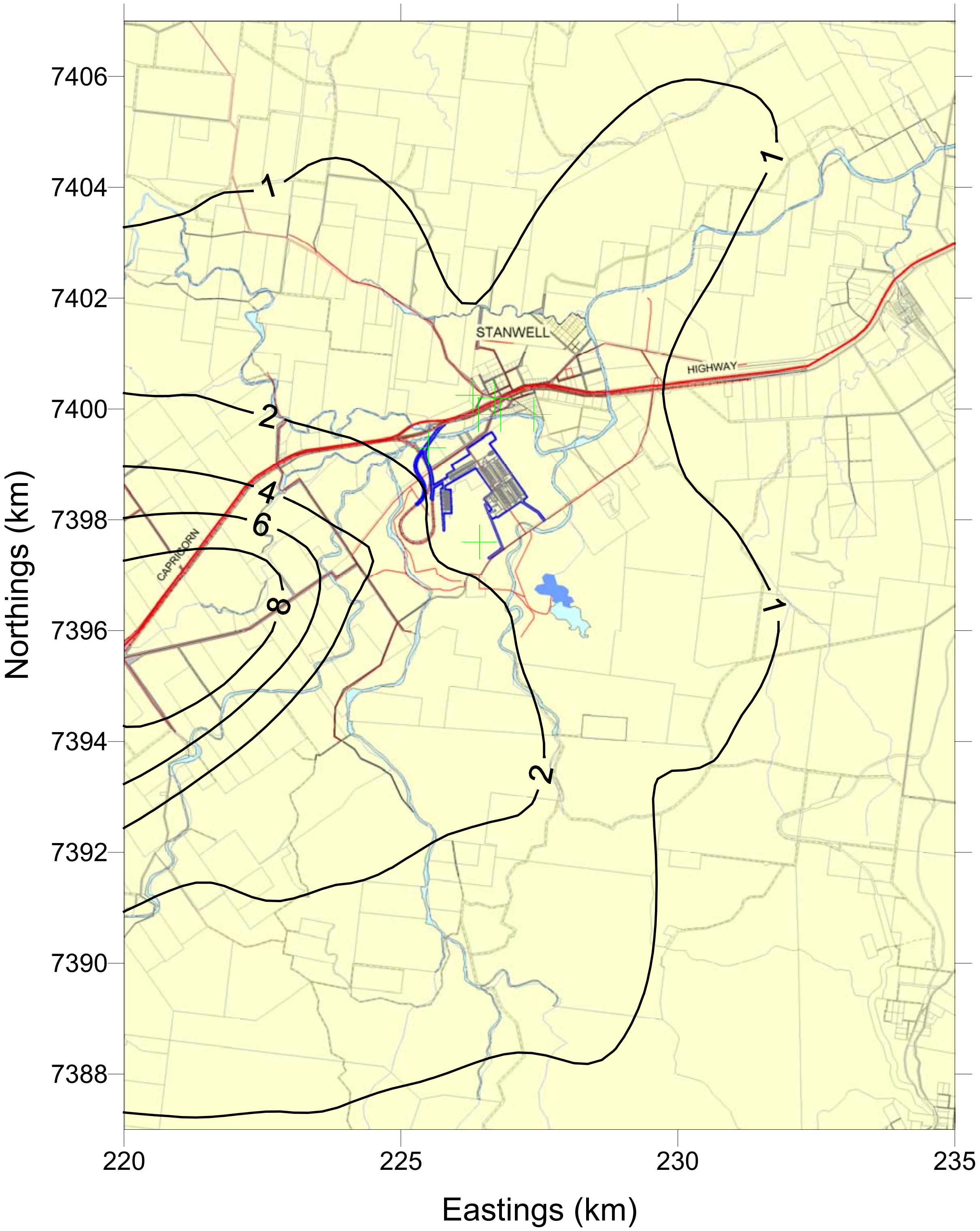
(b) 99.9th Percentile 1-hour average



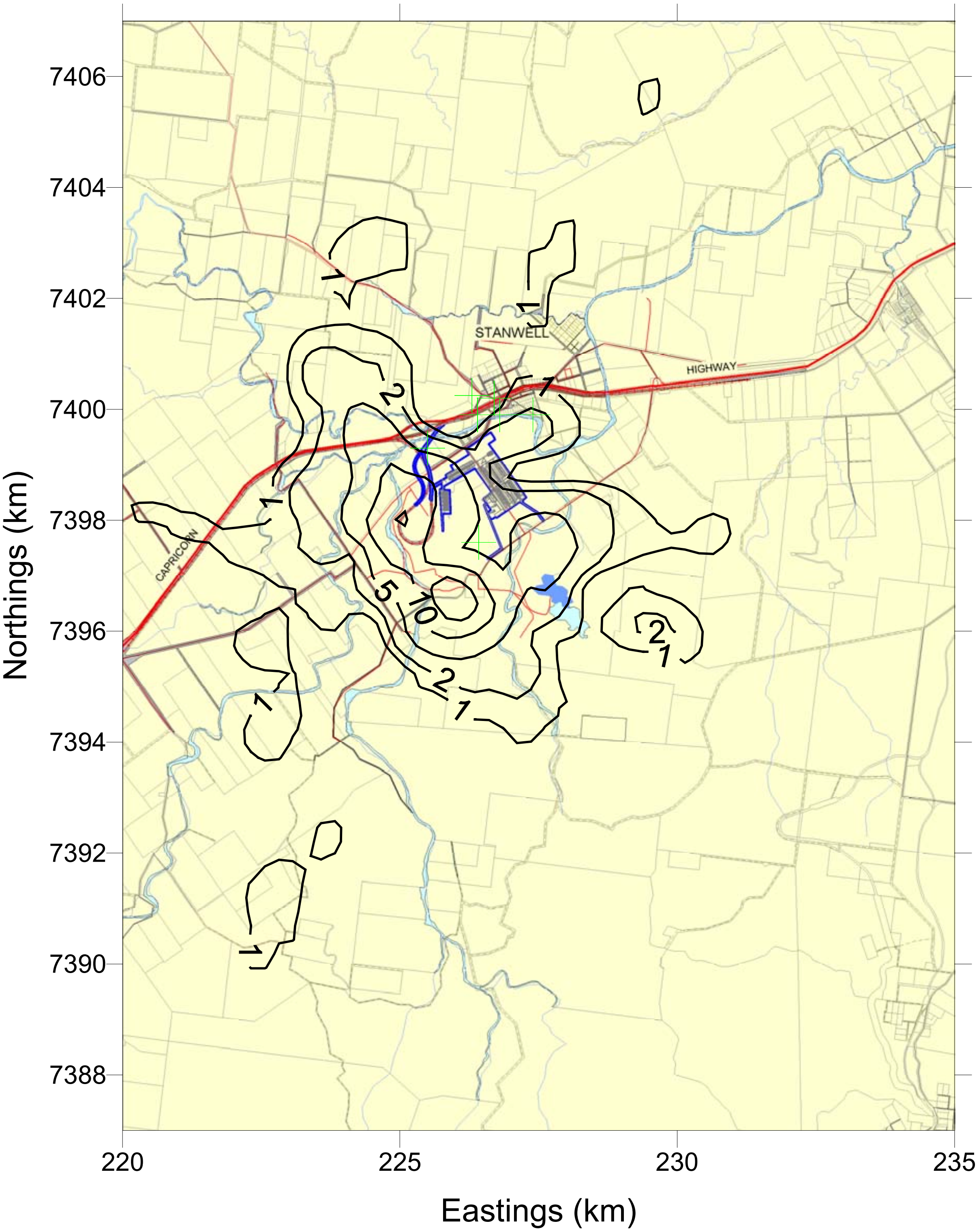
(c) Maximum 24-hour average



(d) Annual average



(e) Number of events above the 10-minute goal



(f) Number of events above the 1-hour goal

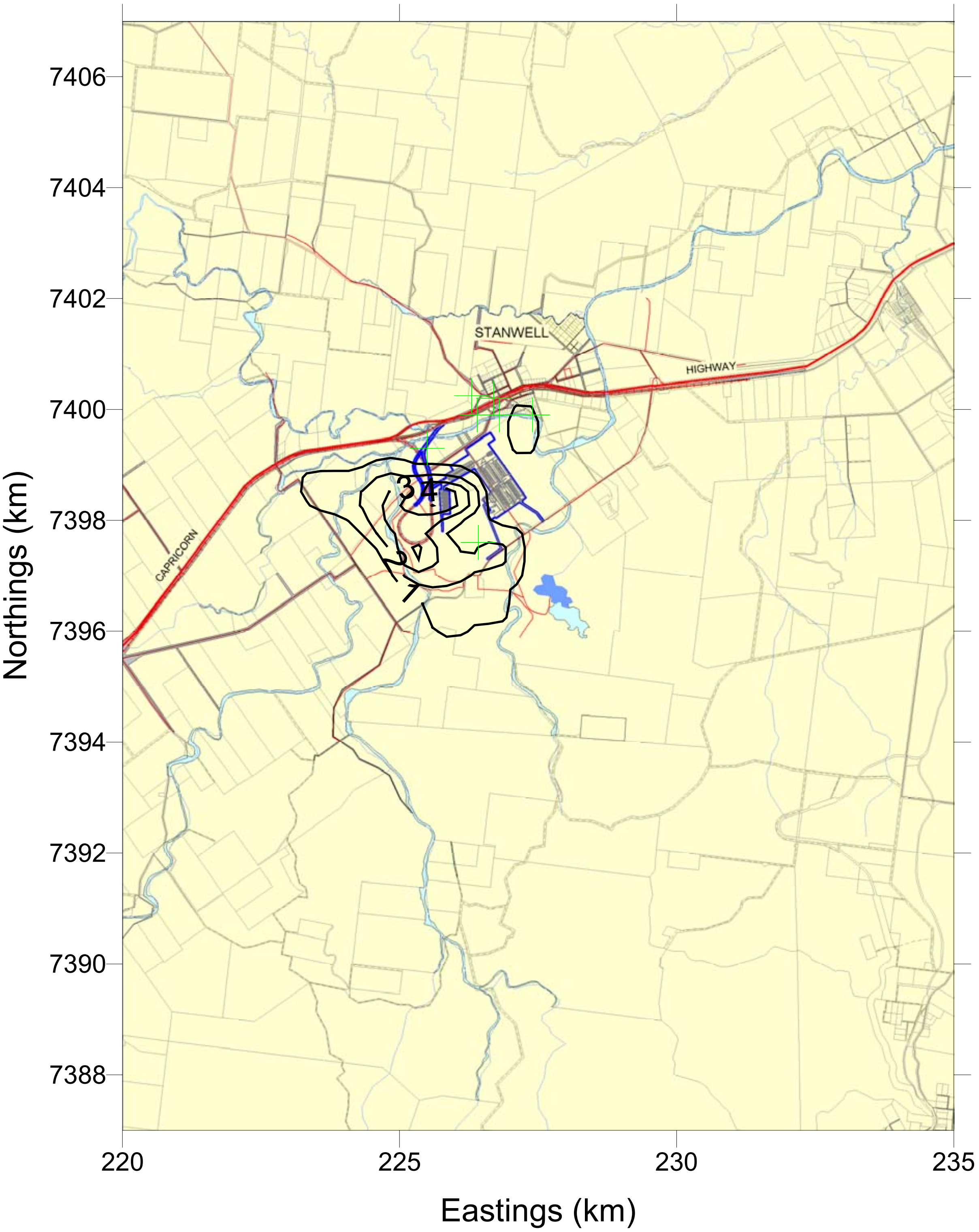
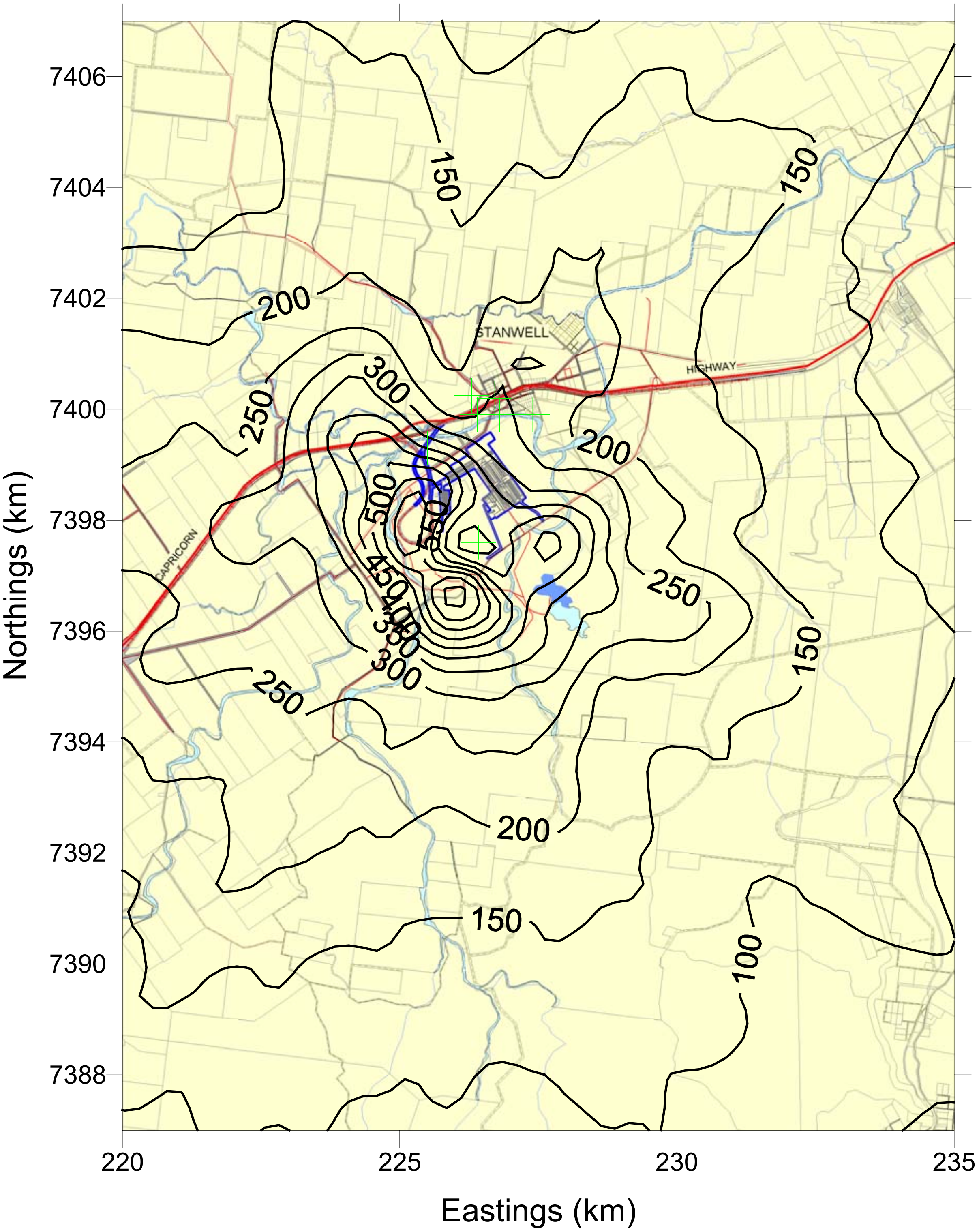


Figure 8: Predicted sulphur dioxide concentration (µg/m^3) due to operation of the Stanwell Power Station (typical emissions) (a) 99.9th percentile 10-minute average (b) 99.9th percentile 1-hour

(a) **99.9th percentile 10-minute average**



(b) 99.9th percentile 1-hour average

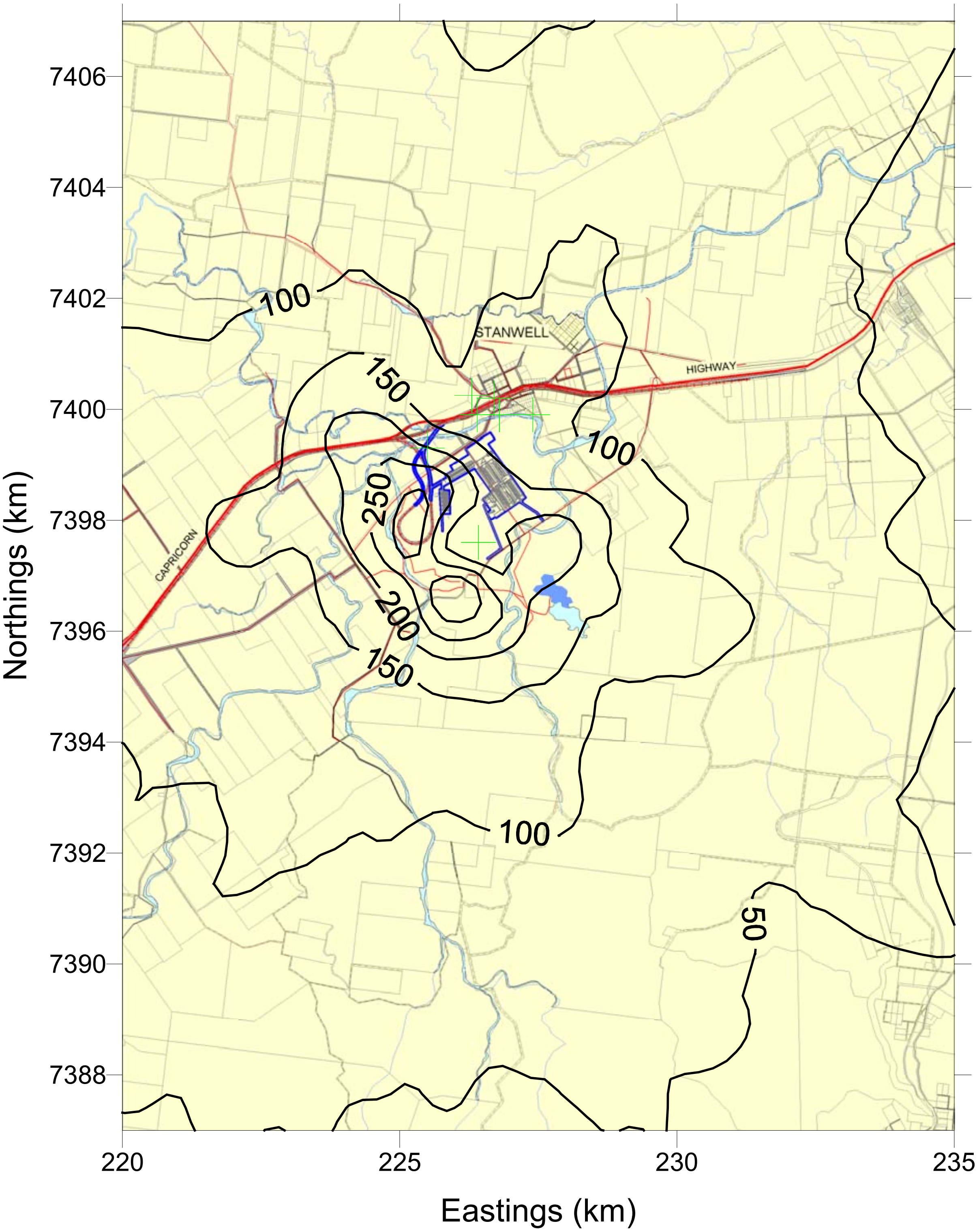
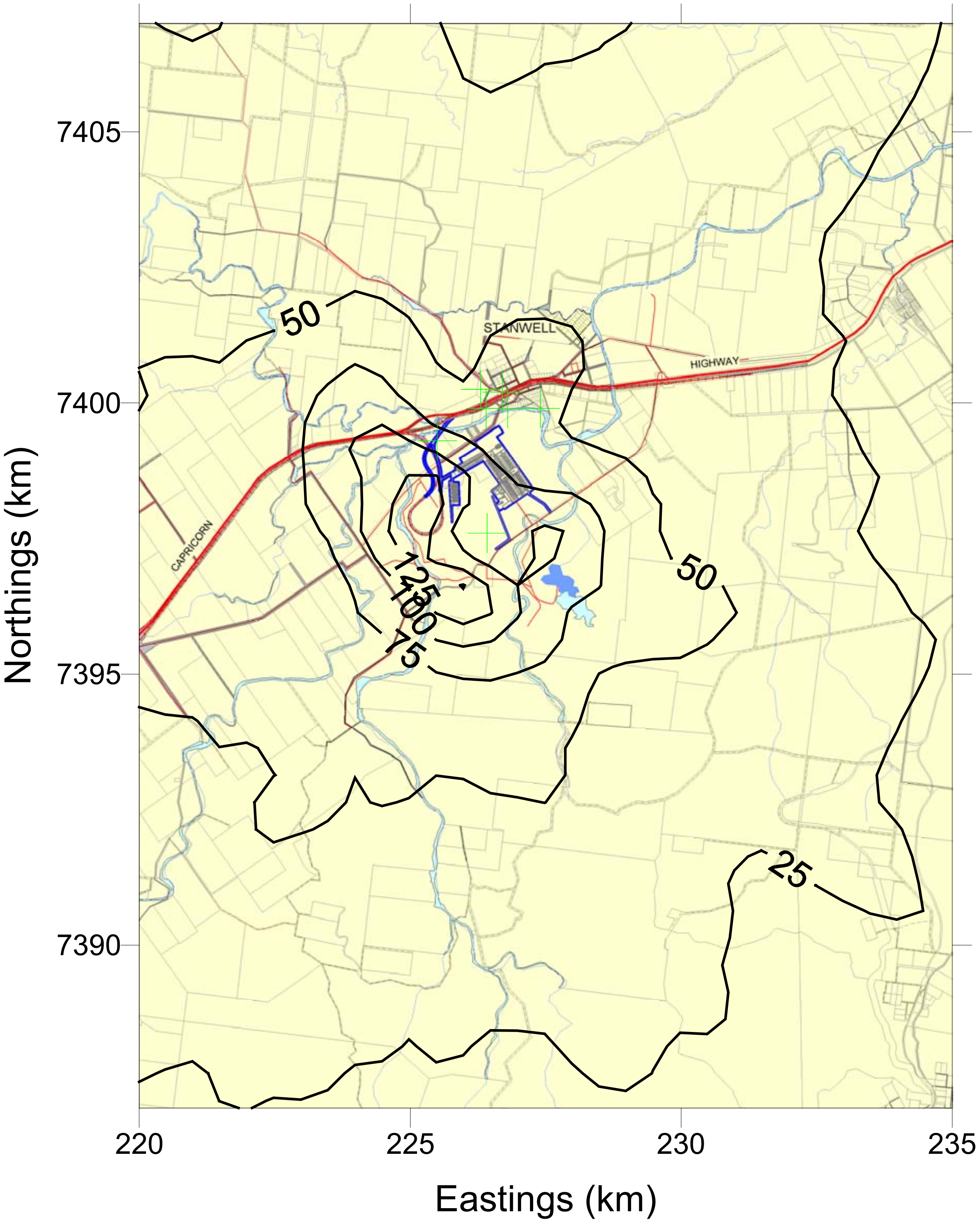


Figure 9: **Predicted nitrogen dioxide concentration (µg/m^3) due to operation of the Stanwell Power Station at full load and licence limit emission levels for 99.9th percentile 1-hour average (note: 30% NO_2/NO_x ratio assumed)**



6.2.2 Toxic air pollutants and trace elements

Other pollutants emitted from the power station that are also emitted from the coke plant include PAHs and some metals. Based on measurements from the power station stacks (as presented in Table 14) the levels of most pollutants are very low (below detection limit of the instruments for some) and mostly below ambient guidelines within the stack. The additional dilution the plume will achieve by the time it reaches the ground will be sufficient to warrant exclusion of these pollutants as background levels in the cumulative assessment of coke plant impacts.

Table 14: Concentration of trace elements and toxic air pollutants emitted from Stanwell Power Station

Element/compound	Units	Typical concentration for each unit at Stanwell Power Station[1]
Aggregate of: Sb, As, Be, Cd, Cr, Co, Pb, Mn, Hg, Ni, Se, Sn, V	mg/Nm³	<0.14[2]
Aggregate of: Sb, As, Cr, Co, Pb, Cu, Mn, Ni, V	mg/Nm³	<0.13[3]
Cd+Tl	mg/Nm³	<0007[3]
Benzene	µg/m³	< 50
Toluene	µg/m³	60
Ethylbenzene	µg/m³	< 50
Xylene (total of m, o, p isomers)	µg/m³	< 50
Total PAH (as BaP)[4]	µg/m³	0.006

Note [1] All pollutant concentrations are expressed as dry, 101.3 kPa, 273 K.

[2] Concentrations corrected to 7 % O_2.

[3] Concentrations corrected to 6 % O_2.

[4] Total PAH (as BaP) calculated from California EPA Potency Equivalency Factors (CARB 1994).

7. Modelling methodology

7.1 Model setup

The potential air quality impact due to the proposed development has been assessed using a combination of the TAPM and Calmet models to provide windfield data for the region, and the Calpuff model to predict ground-level concentrations of pollutants. This model setup and combination of models is the same scheme as used in the EPA Gladstone Airshed Modelling System. Similar modelling schemes have been used for many other large-scale industrial projects in Australia in recent years. The model simulation was performed for 1999, as good data coverage was available for this year from the ambient monitoring network. Meteorological monitoring data from Stanwell monitoring network were included in the modelling assessment.

The CSIRO's TAPM modelling scheme (Hurley, 2005) is based on synoptic analysis data provided by the Bureau of Meteorology's LAPS model. The nesting scheme in TAPM allows the proper simulation of regional flows, which cannot be simulated in Calmet. Detailed 9-second arc terrain data (approximately 250m) and local land use data were used in the model. TAPM Version 2.8 was used in this assessment.

The CSIRO and Katestone Environmental have validated TAPM for various sources and regions (see www.dar.csiro.au/TAPM/ for more details on the model and validation results from the CSIRO). For the Stanwell region a simple verification study was undertaken to ensure the model performed adequately. Details of the verification study can be found in Appendix A.

For this project, TAPM has been used with a data assimilation component to provide hourly predictions of boundary layer parameters, which were used directly as an input into Calmet. Upper air data was generated from TAPM at the coke plant site, as the closest measured upper air station is at Rockhampton.

The Calmet and Calpuff models were developed by Earth Tech (Earth Tech, 2000a and 2000b), and have been accepted by the EPA for numerous recent air quality assessments. The Calmet model was run over a model domain of 30 km by 30 km, at a resolution of 500 m for a one year time period (1999). The prognostic data derived from TAPM (used as "first guess" data), as well as the available network of surface meteorological monitoring data, were used as inputs to Calmet.

The Calmet wind-fields are used to drive the Calpuff dispersion model. Calpuff was set up over the same model domain as Calmet. With results presented for a smaller area of 15 km by 15 km in order to show the detail of impacts close to the coke plant. All maximum are located within the domain presented in the report. Sources were modelled as either point sources, volume sources, area sources or buoyant area sources. Dispersion coefficients were computed from turbulence estimation derived from the micrometeorology, and the partial plume path terrain option was used to treat terrain effects. The quench tower plumes are the only wake affected stack source included in the modelling and these were taken into account using the ISC method. More details of the model setup can be found in the model verification report included in Appendix A.

A full list of emission rates and source characteristics used as input in the dispersion model are presented in Section 3.5.

7.1.1 Peak-to-mean ratios

The averaging periods of less than 1 hour, such as 10-minute concentrations of sulphur dioxide and 3-minute average were estimated from the 1-hour average predictions using the power law correction for averaging times, with an exponent of 0.38 (Hibberd, 1998) for tall stack source and 0.2 for all other sources.

7.1.2 NO_2 to NO_x ratio

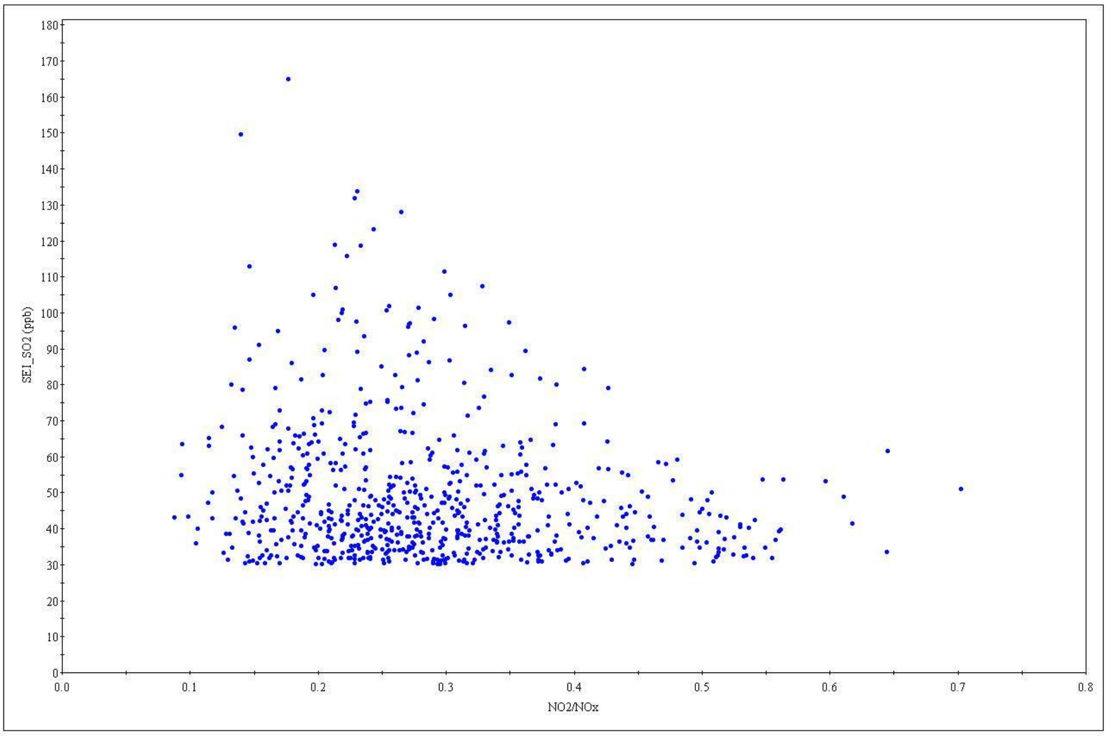
The nitrogen dioxide predictions presented in this report have been calculated assuming that 30% of the oxides of nitrogen emitted are converted to nitrogen dioxide. The percentage of nitrogen dioxide within the plume exiting the stacks is expected to be approximately 5-10%. After its release from the stack, the nitric oxide is gradually oxidised to nitrogen dioxide. The rate at which this occurs depends on the presence of other atmospheric pollutants such as ozone, and the presence of sunlight. Measurements around power stations in Central Queensland show, under worst possible cases, that 25-40% of the nitrogen oxide to nitrogen dioxide within the first 10 km of plume travel. During days with elevated background levels of hydrocarbons (generally originating from bush-fires, hazard reduction burning or other similar activities), the resulting conversion is usually below 50% in the first 30 km of plume travel (Bofinger et al 1986).

From monitoring information collected at the Seierups site, located approximately 2 km from the power station the NO_2/NO_x ratio for high sulphur dioxide events (assume events greater than 350 $\mu g/m^3$ (120 ppb)) is always less than 30%. Figure 10 presents a scatter plot and a histogram of recorded NO_2/NO_x ratios for measurements at Seierups. The scatter plot indicates the very low ratios for high SO_2 events and the histogram shows that for all events greater than 85$\mu g/m^3$ (as an indicator of the power station plume) the ratio is less than 30% for 60% of the time.

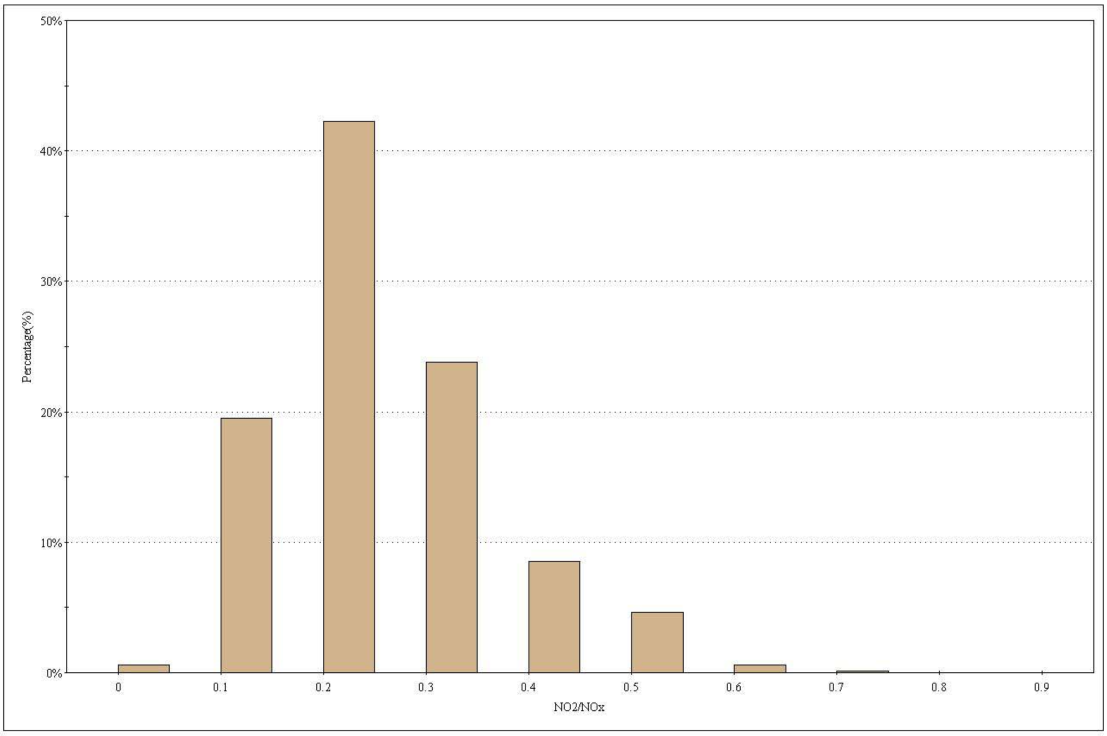
Considering the relatively short distance between the coke plant and residential areas (less than 2 km) the conversion of nitric oxide to nitrogen dioxide is unlikely to be substantial, and the estimate of 30% used in this report is conservative.

Figure 10: NO_2/NO_x ratio measured at Seierups site for SO_2 events above 30 ppb (85µg/m^3) (a) scatter plot (b) histogram.

(a)



(b)



7.1.3 Odour

An assessment of odour impacts was undertaken by estimating the odour concentration of each chemical component by using the odour threshold of each constituent and then summing them together. A list of the odour thresholds used in this assessment is included in Appendix B. This method has been used in the past by Katestone Environmental and tested against odour measurements for some applications. The tests indicate that using odour thresholds to estimate total odour levels produces comparable results. Due to the distinct odour from the coke plant we have assessed the odours from the proposed plant in isolation.

8. Assessment of criteria pollutants

Dispersion modelling results are presented for two operating scenarios, normal operations and non-heat recovery mode. Results for each of these scenarios are presented separately. For normal operation of the coke plant results have been presented for the coke plant with and without background sources. Contours of the predicted ground-level concentrations of sulphur dioxide are presented in Figure 11 for the coke plant plus Stanwell Power Station.

8.1 Normal operations

8.1.1 Coke plant impacts only

Table 15 presents the predicted ground-level concentrations of air pollutants relevant to human heath (EPP (Air) Schedule 1 Part 3) due to normal operation of the coke plant without the addition of background sources. The results are presented for the closest sensitive receptors, or residential dwellings. The location of each receptor is indicated in Figure 1 and as green crosses on the pollutant contour plots. All pollutants are well below the available EPP (Air) goals except for sulphur dioxide.

Short-term peak concentrations of sulphur dioxide are predicted above the air quality goals outside the site boundary and at residential receptor locations for a small number of events per year. Only one event is predicted above the 1-hour goal for sulphur dioxide and four events above the 10-minute goal for operation of the coke plant in isolation. Careful consideration of sulphur dioxide impacts with the inclusion of background sources will be required to determine the potential exposure at these locations.

Table 15: Predicted concentrations at the closest sensitive receptors of pollutants relevant to human health due to normal operation of the Stanwell Coke Plant in isolation (μg/m^3) and comparison with EPP(Air) goals

Pollutant	Averaging periods & percentile	EPP (Air) Goal	Predicted concentration at each residential receptor location due to normal operations of coke plant						
			Rec 1	Rec 2	Rec 3	Rec 4	Stanwell Post office	School	Stanwell Power Station
Sulphur dioxide	10-min - max	700	577	814	800	1138	664	664	638
	10-min - 99.9th		583	441	362	269	391	397	421
	No. of events above goal	8	0	1	2	1	0	0	0

Pollutant	Averaging periods & percentile	EPP (Air) Goal	Predicted concentration at each residential receptor location due to normal operations of coke plant						
			Rec 1	Rec 2	Rec 3	Rec 4	Stanwell Post office	School	Stanwell Power Station
	1-hour - max	570	292	412	405	576	336	336	323
	1-hour - 99.9th		205	223	183	136	198	201	213
	No. of events above goal	8	0	0	0	1	0	0	0
	Annual	60	9.6	7.7	5.2	8.7	5.7	4.8	6.3
Nitrogen dioxide	1-hour -max	320	16.1	22.2	21.8	30.9	18.3	18.2	17.9
	1-hour - 99.9th		11.2	12.0	11.6	8.6	10.8	10.8	11.8
CO	8-hour max	10,000	82.138	96.57	72.86	55.4	66.8	57.3	86.1578
PM_{10}	24-hour max	150	25.5	20.2	12.1	13.4	15.5	11.7	20.8
	Annual	50	4.4	3.3	2.1	3.7	2.2	1.7	2.4
Carbon disulphide	24 hour max	100	1.3E-03	1.2E-03	8.1E-04	8.0E-04	8.0E-04	6.0E-04	1.2E-03
Dichloromethane	24 hour max	3,000	5.6E-03	7.4E-03	6.8E-03	4.0E-03	6.0E-03	6.0E-03	6.2E-03
Styrene	24 hour max	800	6.0E-05	8.0E-05	7.0E-05	4.0E-05	7.0E-05	7.0E-05	6.0E-05
Trichloroethylene	24 hour max	5,000	7.0E-05	9.8E-05	9.0E-05	5.0E-05	8.0E-05	8.0E-05	8.0E-05
Toluene	24 hour max	8,000	1.4E-02	1.1E-02	6.5E-03	7.0E-03	7.0E-03	6.0E-03	1.1E-02
Lead	90 day max	1.5	1.5E-03	9.7E-04	5.4E-04	9.0E-04	7.1E-04	5.0E-04	9.7E-04
Manganese	Annual	1	2.2E-04	1.7E-04	1.2E-04	2.3E-04	1.3E-04	1.0E-04	1.5E-04
Cadmium	Annual	0.02	2.0E-07	2.0E-07	1.0E-07	2.0E-07	2.0E-07	1.0E-07	2.0E-07

Table 16 presents the predicted ground-level concentrations of air pollutants relevant to the aesthetic enjoyment of places and visual and local amenity (EPP (Air) Schedule 1 Part 3) due to normal operation of the coke plant without the addition of background sources. This basically refers to odour impacts and therefore we have also included the predicted odour levels due to the coke plant in this table. It can be seen that the predicted impacts of individual odourous pollutants such as carbon disulphide are very low and well below the relevant goal. The combined odour impact was estimated by predicting the impacts of all odourous compounds emitted from the coke plant, dividing the predicted impact by the odour threshold for each compound and then adding up the potential odour due to each compound to determine a combined odour impact. Appendix B presents a list of the odour threshold values used in this assessment.

Ground-level concentrations of odour due to stack sources and area (or ground-based) sources are assessed separately as they have different guideline values. Stack sources were taken as the combined impacts due to the main stacks and the quench tower emissions. Ground-based sources include the charging and pushing sources and provide a minor contribution to odour impacts. The stack sources result in predicted 99.5th percentile 1-hour average ground-level concentrations of odour that are below the 0.5 ou guideline at all sensitive receptor locations. On a few hours per year (less than the allowable 44 hours) odour may be noticeable from the coke plant operations.

Table 16: Predicted concentrations of pollutants relevant to the aesthetic enjoyment of places and visual and local amenity due to normal operation of the coke plant in isolation (μg/m^3, unless otherwise stated) and comparison with EPP(Air) goals and the EPA's odour guideline

Pollutant	**Averaging periods & percentile**	**Goal**	**Predicted concentration at each residential receptor location due to normal operations of coke plant**						
			Rec 1	**Rec 2**	**Rec 3**	**Rec 4**	**Stanwell Post office**	**School**	**Stanwell Power Station**
Odour - stack	99.5th percentile 1-hour average	0.5 ou	0.23	0.24	0.17	0.18	0.23	0.21	0.22
Odour - fugitive	99.5th percentile 1-hour average	2.5 ou	0.12	0.12	0.11	0.09	0.09	0.09	0.11
Carbon Disulphide	30-min -max	20	less than 0.01						
Styrene	30-min -max	70	less than 0.001						
Toluene	30-min -max	1,000	less than 0.1						

8.1.2 Coke plant plus background sources

Table 17 presents the predicted ground-level concentrations of sulphur dioxide, nitrogen dioxide and PM_{10} due to the normal operation of the coke plant plus operation of Stanwell Power Station at full load and licence limit emissions. The assessment of particulate levels also includes a background level due to other sources in the area taken from measurements. Contour plots of the predicted maximum ground-level concentrations of sulphur dioxide and nitrogen dioxide are presented for various averaging periods in Figure 11 and Figure 12. Contours of the frequency of events above the goals are also presented.

Section 6.2 and Figure 7 present the predicted background levels of sulphur dioxide due to the operation of the power station at full-load and licence limit emissions (a hypothetical worst-case). The background levels of sulphur dioxide are quite high in some areas for short-term averaging periods, including some events above the short-term goals. Inspection of Figure 7 (f) shows that, for the most exposed residential receptors (namely Receptors 1 to 4 presented in this report), there is one event above the 1-hour goal at Receptor 1 due to the power station. At the most exposed residential receptors the number of additional events above the 1-hour sulphur dioxide goal due to normal operation of the coke plant is one to two events per year. The EPP goal is exceeded if more than eight events per year are predicted to occur in excess of the threshold, therefore the impact due to the coke plant plus background sources complies with the EPP goal.

For the shorter-term 10-minute goal, up to nine events per year are predicted above the goal at one sensitive receptor location (Receptor 2) for normal operation of the coke plant plus the power station. Assuming that eight events per year are allowed above the goal, this location has one minor excursion above the 10-minute sulphur dioxide goal with the addition of the coke plant. The modelling undertaken in this assessment includes a number of conservative assumptions that would lead to the conclusion that the one minor excursion of the 10-minute goal at one location is not a significant issue.

The following assumptions in the modelling methodology result in the 10-minute sulphur dioxide impacts being over-estimated:

- Peak sulphur dioxide emissions assumed from the power station occur at all times (at least 45% higher then typical operations). Assuming a 45% reduction in Stanwell Power Station emissions the number of 10-minute exceedances at the most exposed receptor is reduced to five.
- Conservative peak-to-mean ratio used to convert the hourly average modelling predictions into 10-minute peak events. Measurements from the Seierups site indicate that for the top 10 sulphur dioxide events recorded over the six-year period of monitoring the range of peak-to-mean ratios is 1.3 to 1.9 (average of 1.6). This assessment used a ratio of 1.98. Assuming the range of ratios recorded at Seierups, the number of events above the 10-minute goal would range between one and nine with an average of four.
- The dispersion model may be over estimating the impacts due to the power station, particularly for sites close to Stanwell Township. See Figure 16(c) in Appendix A for model predictions at the Mercy site.

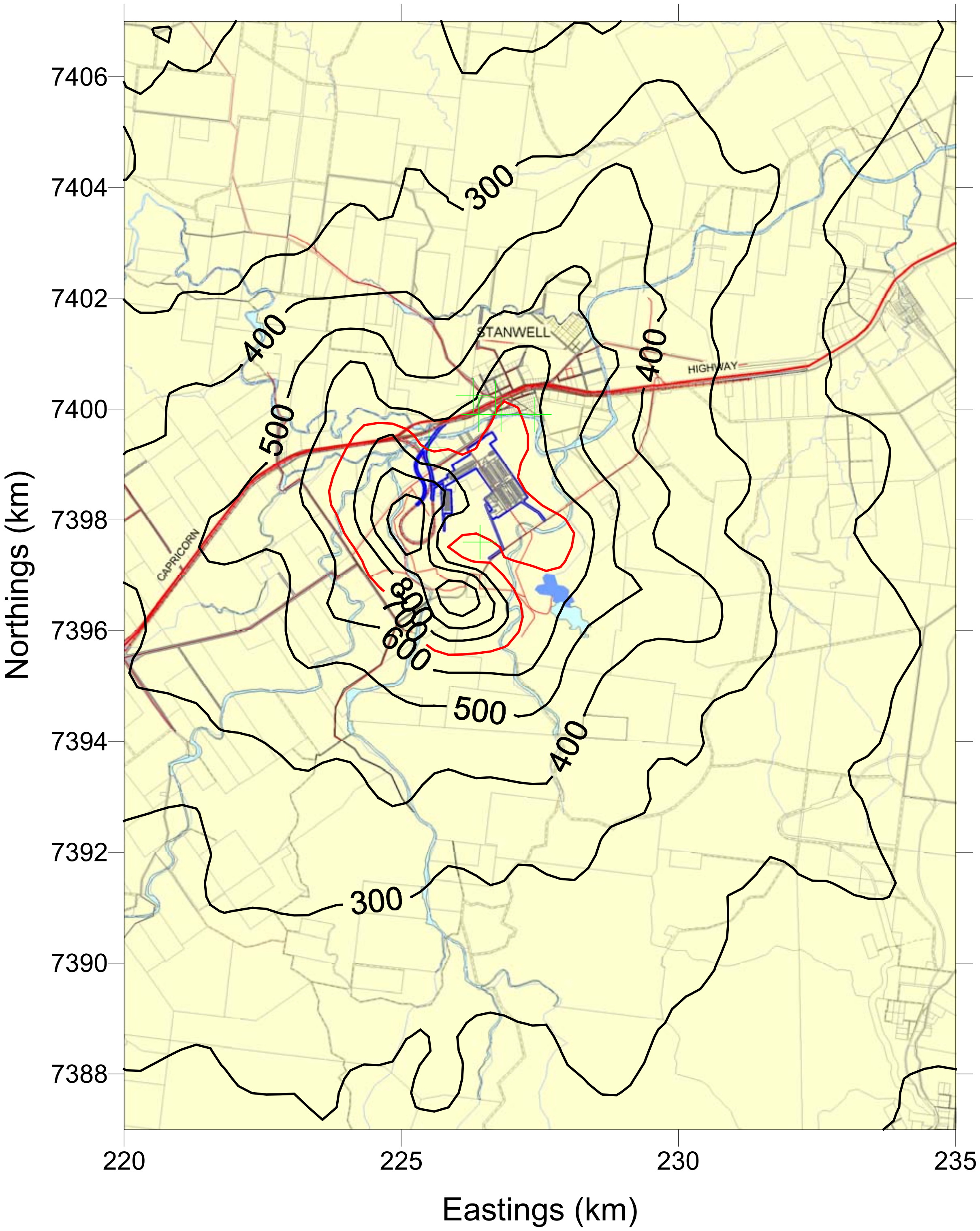
Table 17: Predicted concentrations of pollutants relevant to human health due to normal operation of the Stanwell Coke Plant plus background sources (µg/m^3) and comparison with EPP(Air) goals

Pollutant	Averaging periods & percentile	Goal	Predicted concentration at each residential receptor location due to normal operations of coke plant plus background sources						
			Rec 1	**Rec 2**	**Rec 3**	**Rec 4**	**Stanwell Post office**	**School**	**Stanwell Power Station**
Sulphur dioxide	10-min – max	700	1523	1168	974	1444	927	796	1681
	10-min - 99.9th		634	759	589	658	668	589	614
	No. of events above goal	9	6	9	6	7	6	4	7
	1-hour – max	570	771	591	493	731	469	403	851
	1-hour - 99.9th		321	384	298	333	338	298	311
	No. of events above goal	9	2	1	0	2	0	0	3
	Annual	60	11.1	9.3	6.3	10.3	6.9	5.9	7.4
Nitrogen dioxide	1-hour –max	320	206	162	105	229	118	95	322
	1-hour - 99.9th		58	73	62	97	69	55	93
PM_{10} [1]	24-hour max [1]	150	47.7	42.3	36.2	35.5	37.6	34.6	42.9
	Annual [2]	50	18.8	17.7	16.5	18.1	16.6	16.1	16.7

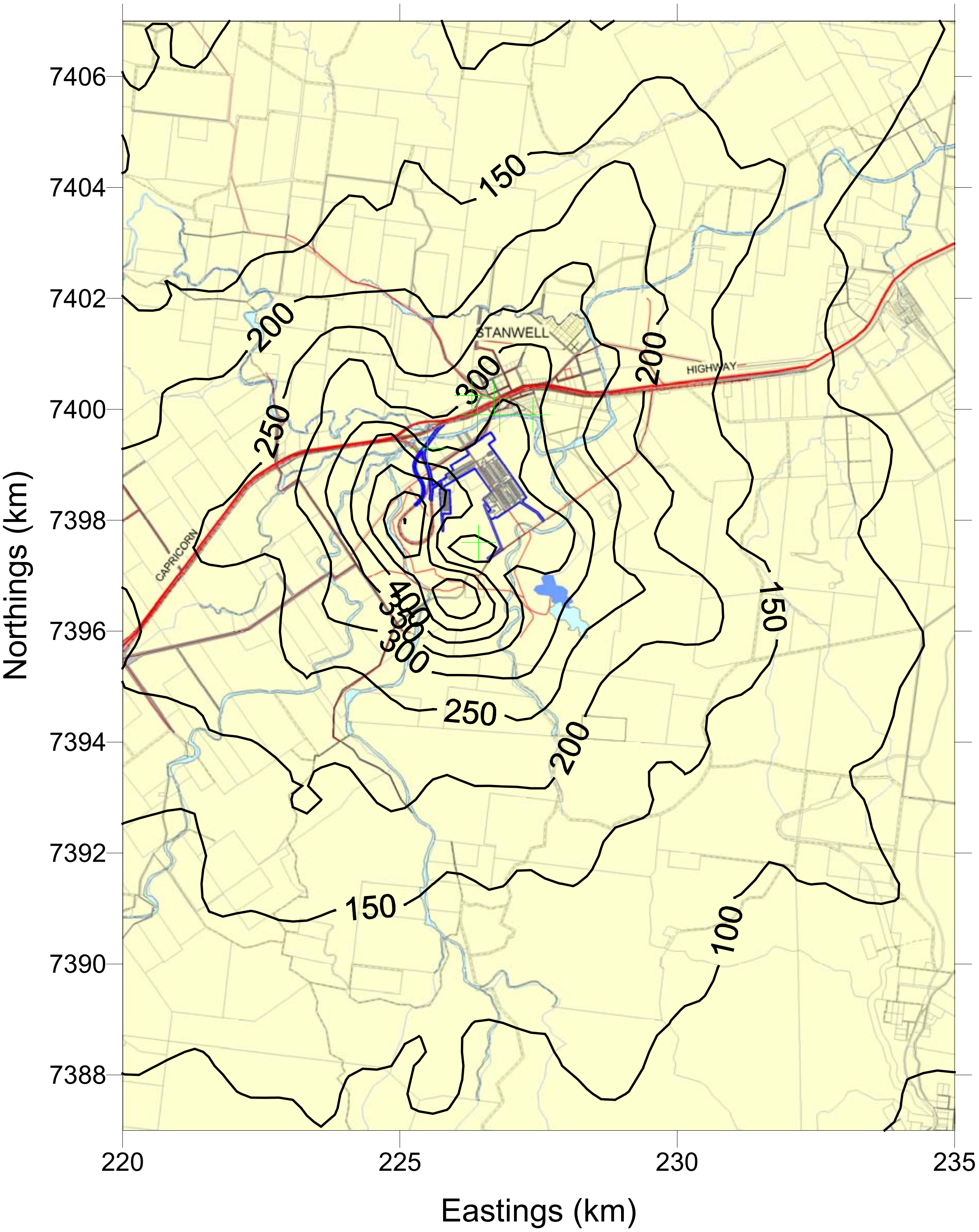
Note: [1] Background measurements (95th percentile 24-hour and annual average from Kalapa) also included in combined impact.

Figure 11: **Predicted ground-level concentrations (µg/m^3) of sulphur dioxide due to normal operation of the Stanwell Coke Plant plus Stanwell Power Station for (a) 99.9th percentile 10-minute average (b) 99.9th percentile 1-hour average (c) maximum 24-hour average (d) Annual average (e) Number of events above 10-minute goal (f) Number of events above the 1-hour goal.**

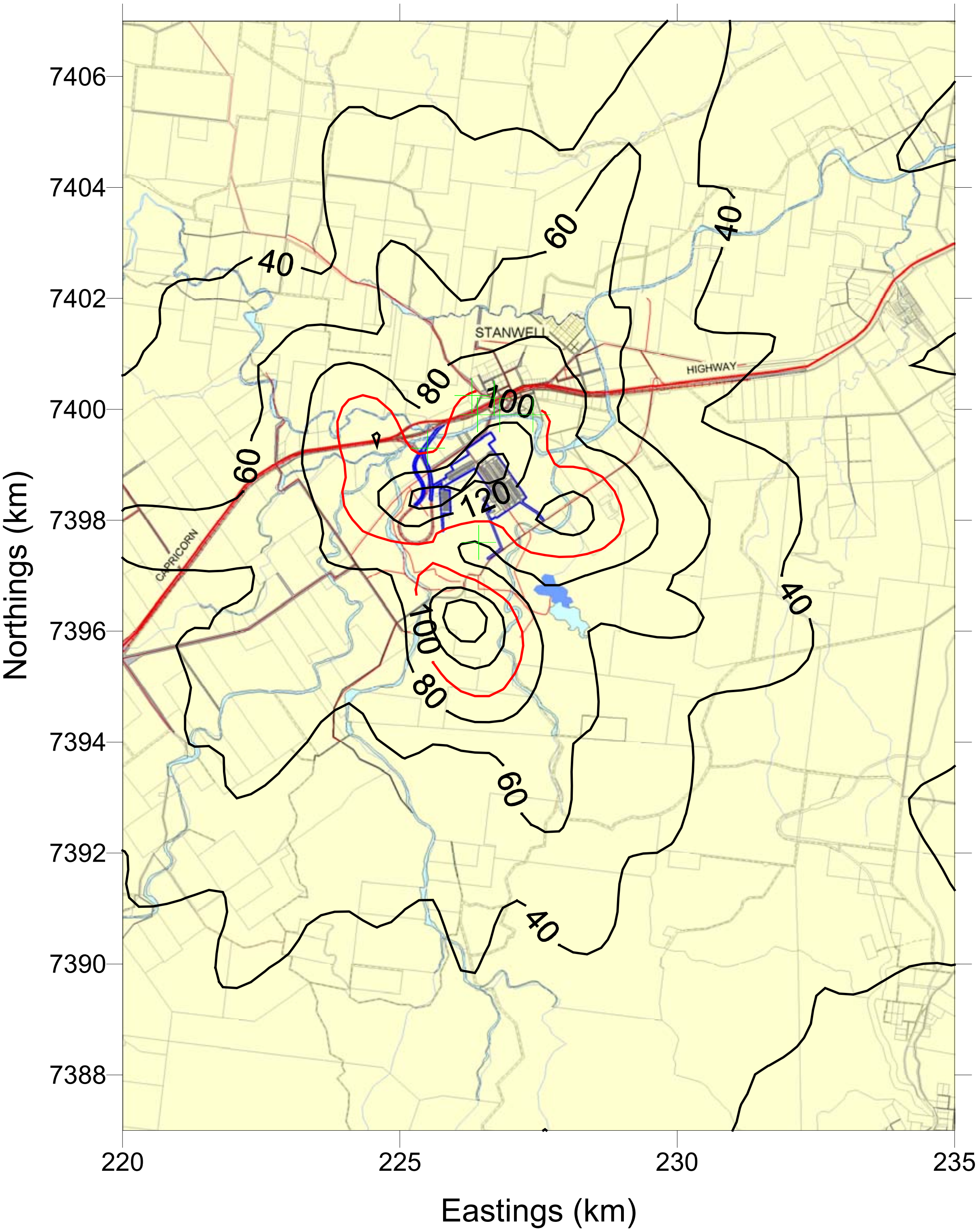
(a) 99.9th percentile 10-minute average



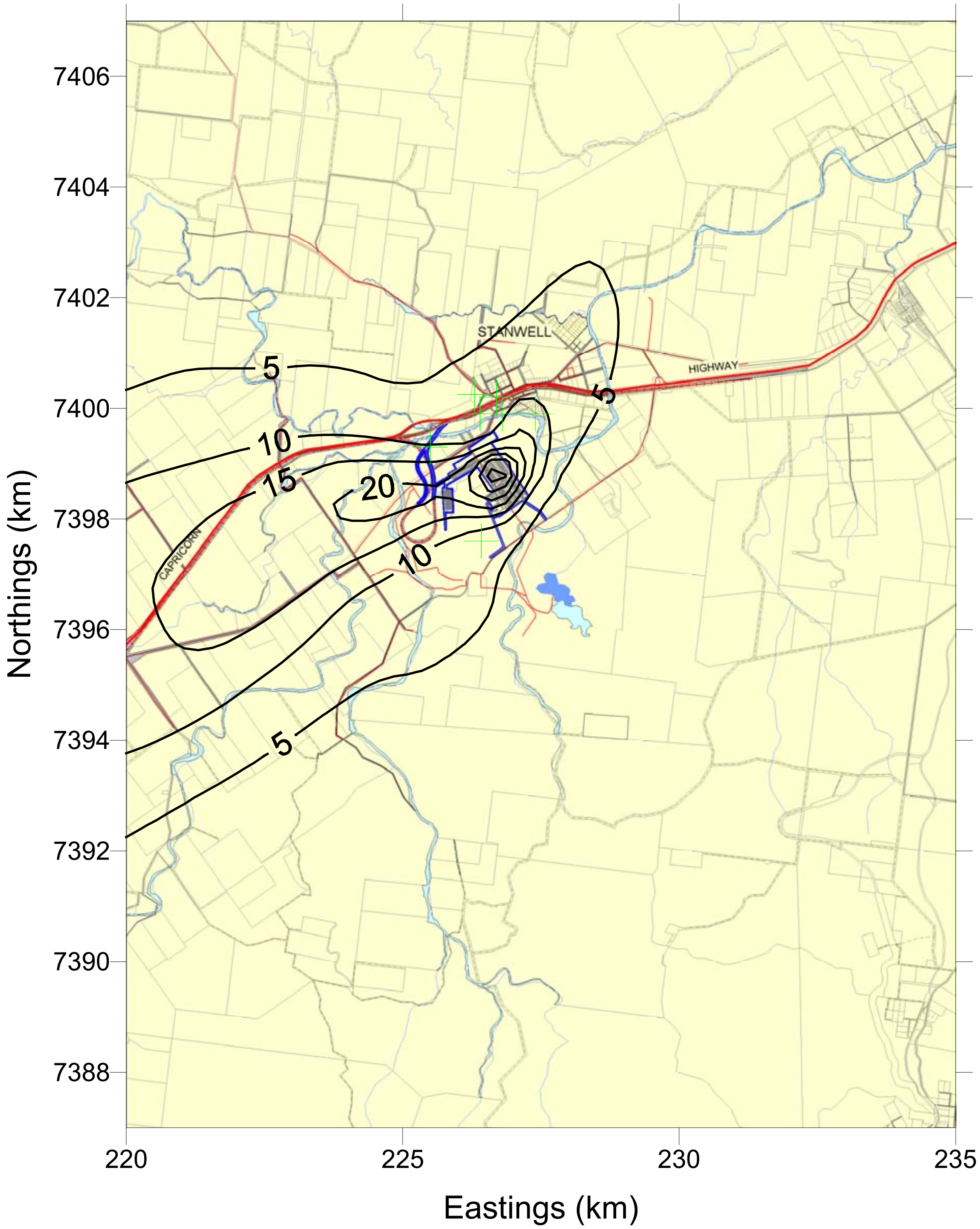
(b) 99.9th percentile 1-hour average



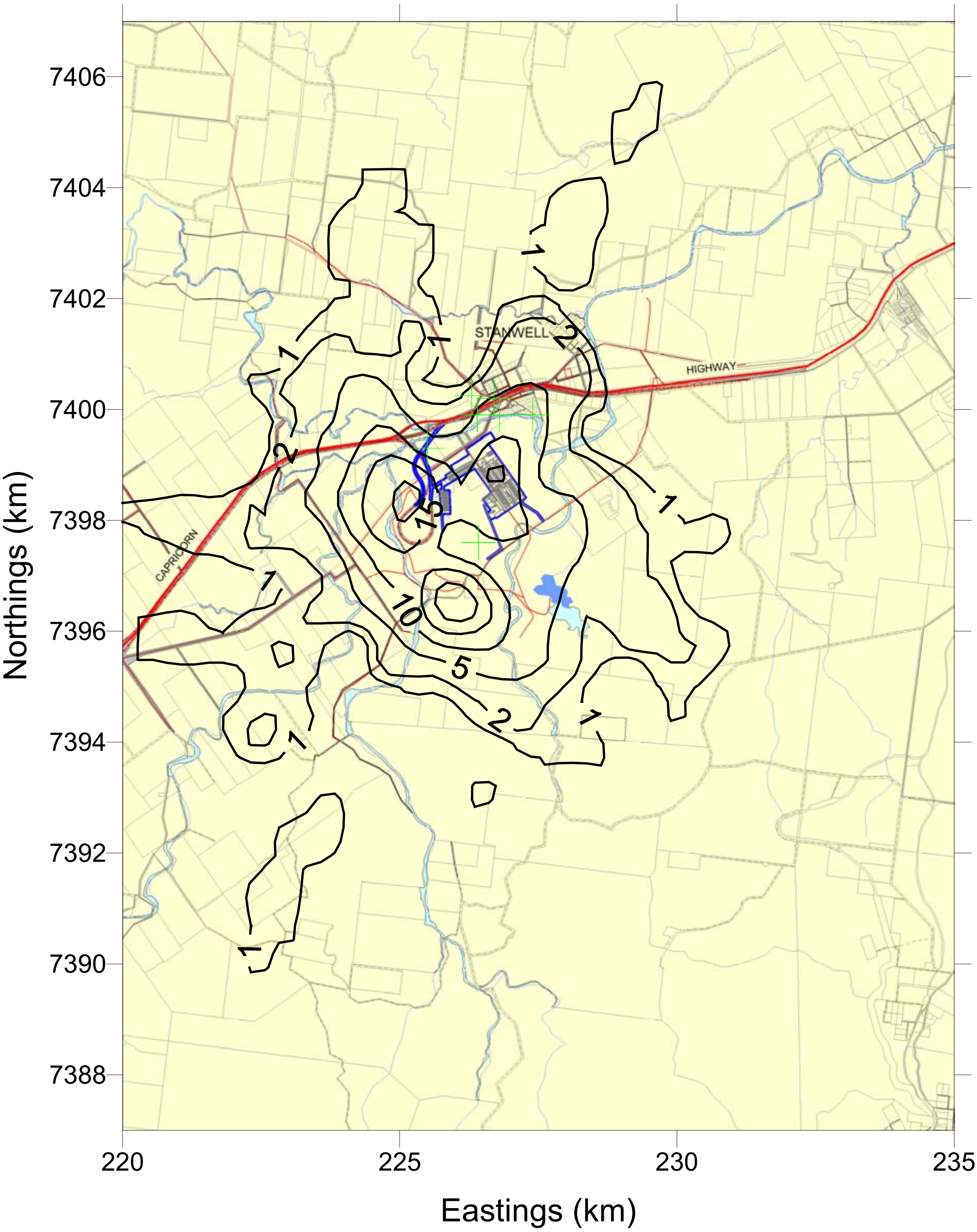
(c) Maximum 24-hour average



(d) Annual average



(e) Number of events above the 10-minute goal



(f) Number of events above the 1-hour goal

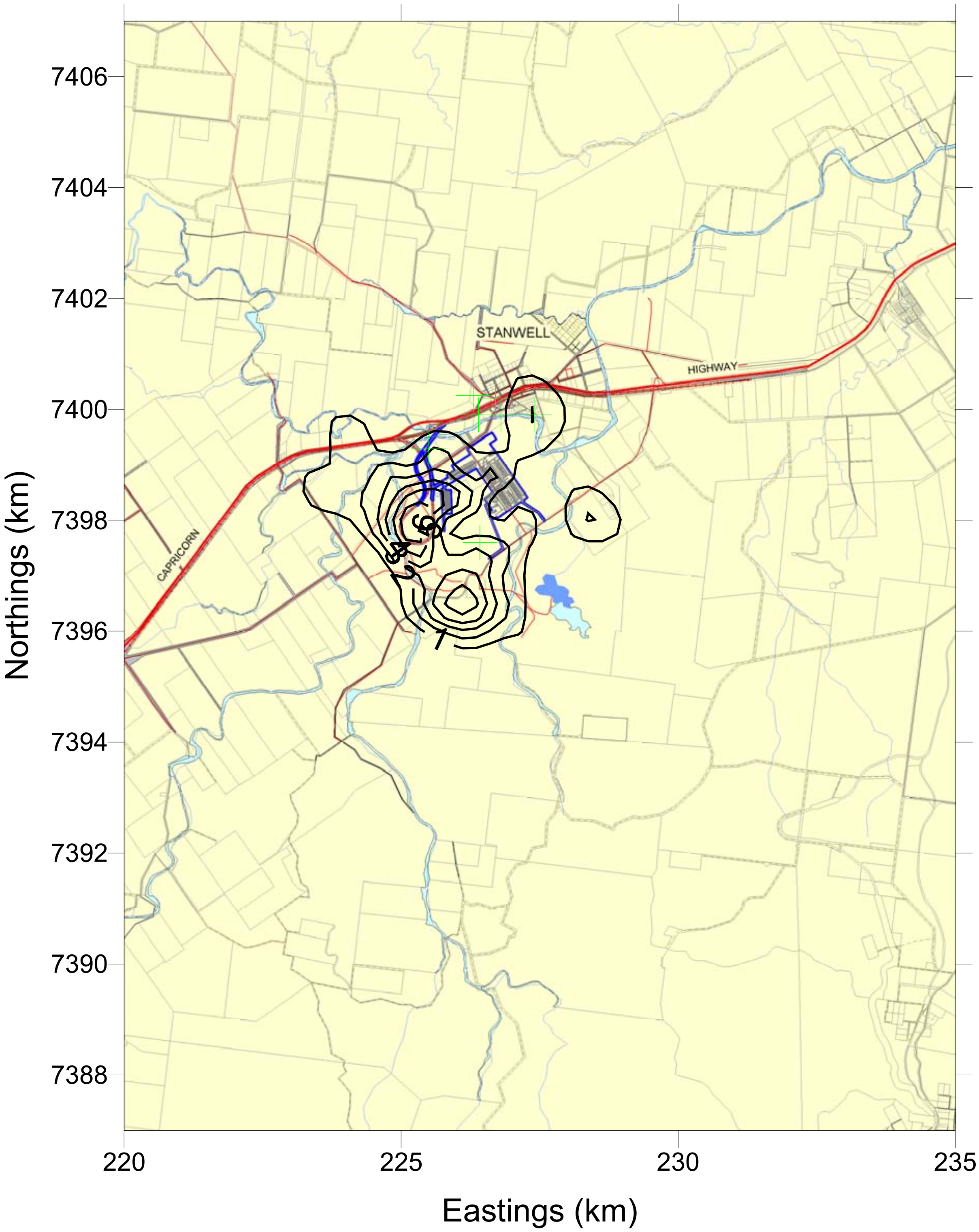
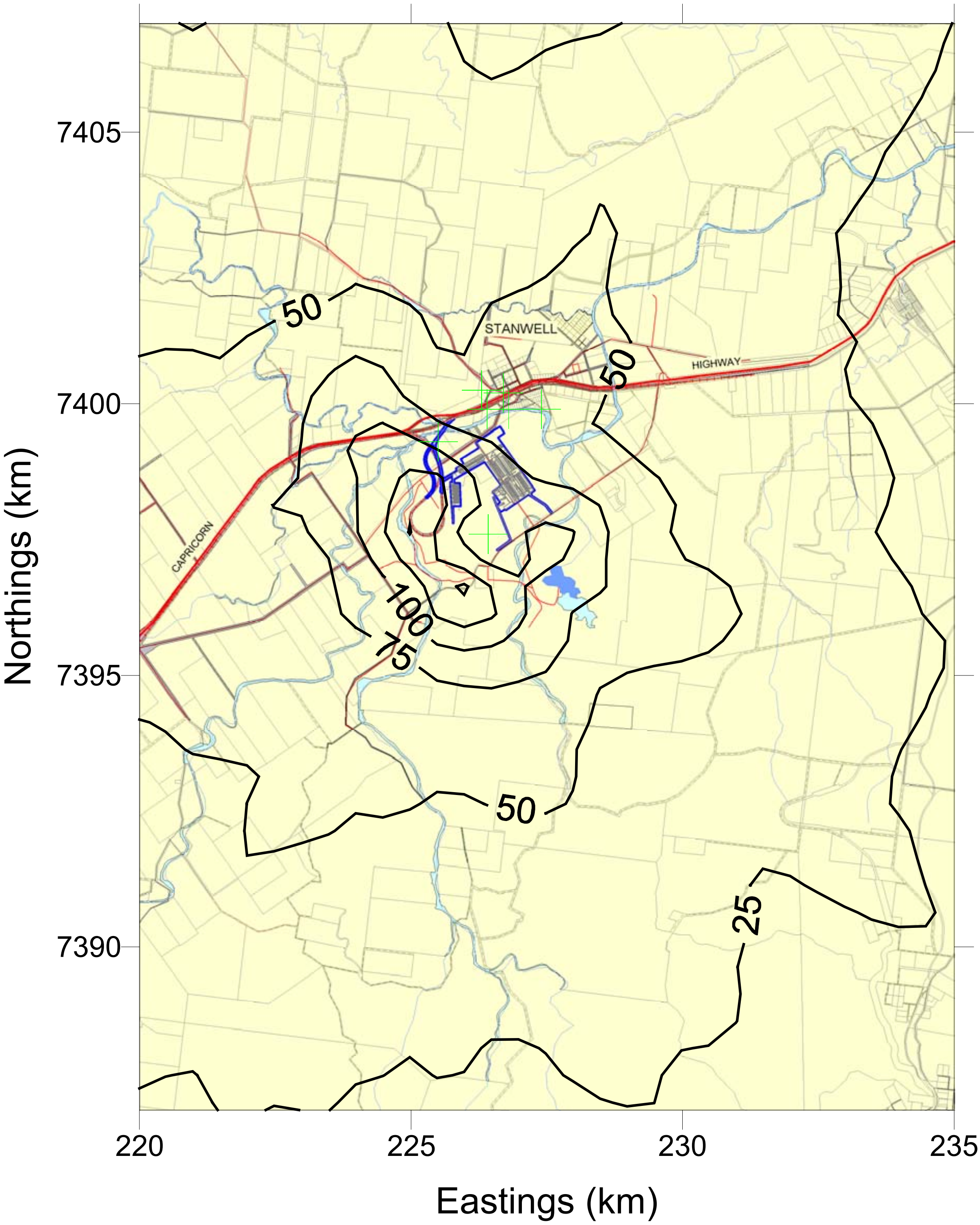


Figure 12: **Predicted ground-level concentrations (µg/m^3) of nitrogen dioxide due to normal operation of the Stanwell Coke Plant plus Stanwell Power Station for 99.9th percentile 1-hour (note: 30% NO_2/NO_x ratio assumed)**



8.2 Coke plant non-heat recovery mode

Intermittently the coke plant may not operate with heat recovery. In this mode all combustion gases will be released through the main stacks at very high temperature. The total mass of emissions from the plant will remain unchanged, however, due to the higher temperature of the plume the predicted impacts at ground level are different to normal operations. The only pollutant identified which is of potential concern for short-term affects during normal operation of the coke plant is sulphur dioxide. Therefore this section presents results for predicted impacts due to the coke plant operating without heat recovery for sulphur dioxide only.

Table 18 presents the modelling results for sulphur dioxide for operation of the coke plant in non-heat recovery mode with the inclusion of Stanwell Power Station operating at full-load and licence limit emissions. A comparison with Table 15 for normal operations indicates that the operations during non-heat recovery mode decrease the peak impacts at most locations by 10-40%. At receptors 3 and 4 the absolute maximum predicted over a full year of operation in non-heat recovery mode is slightly higher than normal operations, however the 99.9th percentiles are all lower than normal operations. The operation of the coke plant in non-heat recovery mode does not results in a significant change in predicted ground level concentrations of key pollutants and does not require further investigation.

Table 18: Summary of predicted maximum ground level concentrations of sulphur dioxide due to operation of the Stanwell Coke Plant in non-heat recovery mode plus background sources

Averaging period	Guideline	Predicted concentrations of sulphur dioxide (µg/m³)						
		Rec 1	Rec 2	Rec 3	Rec 4	Stanwell Post office	School	Stanwell Power Station
10-min - max	-	1215	1002	1177	1598	931	1019	1503
10-min - 99.9th	700	387	423	391	601	425	364	593
No. of events above goal [1]	8	3	4	2	3	2	1	4
1-hour -max	-	615	507	596	809	471	516	761
1-hour - 99.9th	570	196	214	198	304	215	184	300
No. of events above goal [1]	8	1	0	1	1	0	0	2

Note: [1] The number of events above the goals is based on operation of the plant in non-heat recovery mode for a full year.

9. Assessment of toxic air pollutants

An assessment of the impacts of various toxic air pollutants emitted from the coke plant has been undertaken using the VIC EPA Design Criteria. All pollutants modelled are well below the criteria at all locations.

Table 19: Predicted 3-minute average ground level concentrations of various toxic air pollutants for operation of the coke plant only compared to the VIC EPA Design Criteria.

Pollutant	**VIC EPA Design Criteria ($\mu g/m^3$)**	**Predicted 99.9th percentile 3-minute average ground level concentrations due to normal operation of the coke plant ($\mu g/m^3$)**						
		Rec 1	**Rec 2**	**Rec 3**	**Rec 4**	**Stanwell Post office**	**Stanwell School**	**Stanwell Power Station**
H_2SO_4	33	3.3E+00	3.5E+00	2.9E+00	2.2E+00	3.2E+00	3.2E+00	3.3E+00
Benzene	53	1.0E-01	1.2E-01	1.1E-01	8.6E-02	1.1E-01	9.1E-02	1.1E-01
Bromoform	170	1.3E-04	1.4E-04	1.2E-04	8.6E-05	1.3E-04	1.3E-04	1.3E-04
Bromomethane	630	6.1E-02	6.5E-02	5.4E-02	4.0E-02	5.8E-02	5.8E-02	6.0E-02
2-Butanone	5,900	6.8E-03	7.3E-03	6.1E-03	4.5E-03	6.6E-03	6.6E-03	6.8E-03
Carbon Disulphide	130	5.8E-03	6.9E-03	6.4E-03	5.0E-03	6.4E-03	5.3E-03	6.5E-03
Chlorobenzene	200	1.3E-04	1.4E-04	1.2E-04	8.6E-05	1.3E-04	1.3E-04	1.3E-04
Chloromethane	3,400	8.2E-02	8.8E-02	7.3E-02	5.5E-02	7.9E-02	7.9E-02	8.2E-02
Chloroform	330	1.2E-03	1.3E-03	1.1E-03	7.9E-04	1.1E-03	1.1E-03	1.2E-03
Cumene	390	1.5E-04	1.6E-04	1.4E-04	1.0E-04	1.5E-04	1.5E-04	1.5E-04
Ethyl Benzene	14,500	2.0E-03	2.4E-03	2.2E-03	1.7E-03	2.2E-03	1.8E-03	2.3E-03
Methylene Chloride	5,800	7.2E-02	7.6E-02	6.4E-02	4.8E-02	6.9E-02	6.9E-02	7.1E-02
n-Hexane	5,900	1.6E-03	1.7E-03	1.4E-03	1.1E-03	1.6E-03	1.6E-03	1.6E-03
4-Methyl-2-Pentanone	410	9.6E-04	1.0E-03	8.6E-04	6.4E-04	9.3E-04	9.3E-04	9.6E-04
Phenol	36	9.3E-03	9.9E-03	9.3E-03	6.4E-03	9.2E-03	8.9E-03	9.5E-03
Styrene	210	7.5E-04	8.0E-04	6.6E-04	5.0E-04	7.2E-04	7.2E-04	7.4E-04
Toluene	650	5.8E-02	6.3E-02	5.9E-02	4.4E-02	5.8E-02	5.5E-02	6.0E-02
1,1,1-Trichloroethane	22,700	2.7E-04	2.9E-04	2.4E-04	1.8E-04	2.6E-04	2.6E-04	2.7E-04
1,1,2-Trichloroethane	1,800	6.3E-05	6.7E-05	5.6E-05	4.2E-05	6.0E-05	6.0E-05	6.3E-05
Xylenes	350	1.9E-02	2.2E-02	2.0E-02	1.6E-02	2.0E-02	1.7E-02	2.1E-02
Total PAHs	0.73	1.2E-01	1.4E-01	1.3E-01	1.0E-01	1.3E-01	1.1E-01	1.4E-01
Antimony	17	8.3E-04	8.3E-04	7.3E-04	5.5E-04	8.3E-04	7.2E-04	8.0E-04
Arsenic	0.17	9.3E-04	9.6E-04	8.0E-04	6.8E-04	8.9E-04	7.6E-04	9.6E-04
Beryllium	0.007	1.4E-04	1.5E-04	1.4E-04	9.7E-05	1.4E-04	1.4E-04	1.4E-04
Cadmium	0.033	3.8E-05	4.1E-05	3.4E-05	2.5E-05	3.7E-05	3.7E-05	3.8E-05
Chromium	0.17	4.1E-03	4.4E-03	3.7E-03	2.7E-03	4.0E-03	4.0E-03	4.1E-03
Lead	3	3.5E-02	3.7E-02	3.3E-02	2.5E-02	3.4E-02	3.3E-02	3.5E-02
Manganese	33	1.5E-02	1.8E-02	1.6E-02	1.3E-02	1.4E-02	1.4E-02	1.6E-02
Mercury	0.33	8.2E-03	8.8E-03	7.3E-03	5.5E-03	7.9E-03	7.9E-03	8.2E-03
Nickel	0.33	1.9E-03	2.1E-03	1.7E-03	1.3E-03	1.9E-03	1.9E-03	1.9E-03

The VIC EPA Design Criteria assess short-term impacts rather than long-term averages. In order to assess the potential long-term impacts of various toxic air pollutants emitted from the coke plant operations a comparison with the NEPM (Air Toxics) recommended monitoring investigation levels has been undertaken. The results of predicted maximum ground level concentrations for each pollutant listed in the NEPM (Air Toxics) are presented in Table 20. It should be noted that these are not standards but investigation levels. The aim is to obtain sufficient information from monitoring over the next eight years to facilitate development of a standard.

The long-term average concentrations of all NEPM (Air Toxics) pollutants are well below the monitoring investigation levels for normal operation of the coke plant.

Table 20: Predicted long-term average concentrations of Air Toxic NEPM pollutants for normal operations of Stanwell Coke Plant only.

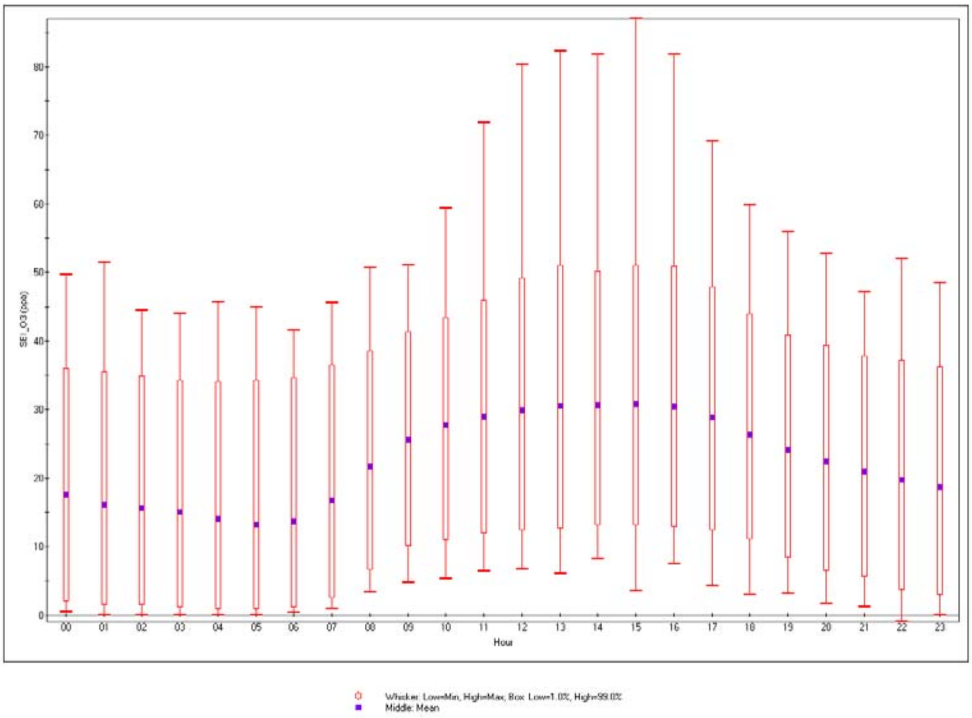
Pollutant	**NEPM monitoring investigation levels (µg/m^3)**	**Predicted ground level concentrations due to normal operation of the coke plant (µg/m^3)**						
		Rec 1	**Rec 2**	**Rec 3**	**Rec 4**	**Stanwell Post office**	**Stanwell School**	**Stanwell Power Station**
Benzene	9.4 Annual	5.0E-03	3.5E-03	2.2E-03	3.9E-03	2.2E-03	1.7E-03	2.5E-03
Toluene	52.8 24 hr	1.4E-02	1.1E-02	6.5E-03	7.0E-03	7.0E-03	6.0E-03	1.1E-02
	5.3 Annual	2.0E-03	1.8E-03	1.1E-03	2.0E-03	1.2E-03	9.4E-04	1.3E-03
Xylenes	7.8 24 hr	1.3E-01	1.2E-01	8.4E-02	8.4E-02	8.5E-02	6.6E-02	1.1E-01
	6.1 Annual	2.7E-02	2.0E-02	1.2E-02	2.2E-02	1.2E-02	9.3E-03	1.4E-02
Benzo(a)Pyrene	3.0E-04 Annual	3.0E-05	1.1E-06	1.0E-05	2.0E-05	1.0E-05	1.0E-05	2.0E-05

10. Photochemical activity

Major urban areas can experience elevated levels of photochemical smog, typically on spring or summer days with light winds when pollutants are retained within the airshed and undergo a prolonged exposure to sunlight. Ozone is not emitted directly by any combustion source (e.g. traffic or major industry) but forms through a complex series of chemical reactions in the atmosphere. Photochemical smog is usually measured by the presence of ozone and occurs due to enhancement of the naturally-occurring reactions. The reactions require the presence of hydrocarbons and significant ultra-violet radiation. Primary industrial and urban air pollutants such as nitric oxide are transformed through a series of reactions into ozone and other photochemical products.

Ozone levels at ground-level have a pronounced diurnal variation, with levels of 10-20 ppb (20-40 µg/m³) overnight rising relatively quickly in the early to mid-morning and reaching a maximum of 25-35 ppb in the early afternoon. The origins of ozone in a non-urban area are the downward diffusion of stratospheric ozone and the interaction between naturally occurring hydrocarbons and oxides of nitrogen. For urban areas, the maximum values can often be enhanced above 50 ppb by the presence of anthropogenic emissions of volatile organic compounds, oxides of nitrogen and water vapour. An analysis of data collected at Stanwell indicates that ozone levels rarely exceed normal rural background levels. Ozone levels were typically higher from August to November. Over the six years of monitoring, only 13 days recorded maximum hourly ozone above 60 ppb and only 4 or these days reached above 80 ppb.

Figure 13: Diurnal profile of ozone recorded at Seierups monitoring stations (December 1997- November 2003)



The transformation of oxides of nitrogen and possible formation of ozone involves a number of chemical reactions. Most combustion sources have 90-95% of the oxides of nitrogen in the form of nitric oxide. Ozone can only be formed once this nitric oxide has been transformed into nitrogen dioxide and nitrates. This is a multi-stage reaction process.

Generally, during the first phase of chemical transformations, the mixing of the NO_x-rich plume with ambient air results in a local reduction of ambient ozone, through titration of the emitted nitric oxide as it reacts with ozone to form nitrogen dioxide. The second phase (ozone generation) will commence only if the ambient air is sufficiently photochemically aged (i.e. reactions have reached an equilibrium where no more nitrogen dioxide is produced). This phase continues with ozone being both generated and diluted in the plume. The generation continues until the final phase, the NO_x-limited state, is reached in the plume. The duration of each phase will depend on the nature of the ambient air, the emission rates and characteristics of the industrial source and the dispersion rates.

Within Queensland, there are relatively few studies of ozone generation within industrial plumes. Monitoring networks around Tarong, Callide and Gladstone power stations have tended to focus on those areas within 10-15 km of the power stations; areas that are unlikely to experience extra ozone generation. There have not been any readily identifiable episodes of ozone generation during those times when the power station plumes have been present at the monitoring locations. In nearly all situations, the power station events have been those for which ozone titration is still occurring.

The first investigation of the chemical transformations in power station plumes was undertaken in 1986 around Gladstone Power Station, a major emitter of nitrogen oxides (over 2000 g/s at full load, or almost 20 times the total emission rate for the proposed coke plant). An aerial survey measured oxides of nitrogen and ozone concentrations at distances out to 200 km for a set of late winter conditions. These studies have been very useful to determine the relatively slow rate of transformation of emitted nitric oxide into nitrogen dioxide. However, there were no events when an ozone generation stage was encountered.

A set of numerical simulations were undertaken for Gladstone Power Station, both with and without enhanced background VOC levels. For a summer day with bushfire activity, it was predicted by the LADM model (the CSIRO model that preceded TAPM) that ozone generation could occur as close as 15 km to the power station. Ozone generation could then be fairly substantial (up to 40 ppb) within the plume.

As shown above, the impact of oxides of nitrogen emissions in a rural environment on ozone levels are minimal, even for a major power station with significantly higher emissions than for the proposed coke plant. The current atmospheric environment in Stanwell receives generally low ozone levels with only a few days per year when levels are above background concentrations. These occasional ozone events recorded in Stanwell are not due to emissions from within the Stanwell area but due to emissions from Rockhampton or possibly Gladstone. The Stanwell power station plume impacts at the monitoring stations actually cause a decrease in local ozone levels.

The peak contribution of the proposed coke plant to levels of oxides of nitrogen at 10 km from the site are predicted to be between 5 and 30 µg/m³ (2.5 – 15 ppb). As an extremely conservative assumption, the total amount of oxides of nitrogen emitted could react to produce ozone, resulting in an additional 2.5 to 15 ppb of ozone. Adding the maximum coke plant contribution to the 99th percentile ozone levels typically recorded in the afternoon (i.e. when ozone generation is more likely) of 50 ppb results in maximum ozone levels well below the ambient air quality guideline of 100 ppb for a 1-hour average. Therefore, the contribution of the proposed coke plant to regional photochemical activity is at worst minor and unlikely to be of any cause for concern or require further assessment.

11. Conclusions

A comparison of the modelling results with ambient air quality goals presented in the EPP (Air), indicates that during normal and non-heat recovery operating conditions all pollutants generally are well below acceptable levels except for short-term excursions above the goals for sulphur dioxide.

During normal operation of the coke plant a small number of events are predicted above the EPP (Air) goal for sulphur dioxide at residential locations. The Stanwell Power Station operating at peak load and licence limit emissions (a hypothetical worst-case) contributes to a high background of sulphur dioxide including some events above the short-term goals. With the addition of the coke plant to the existing predicted level of sulphur dioxide, one to two additional events above the 1-hour sulphur dioxide goal are predicted. The total number of events greater than the goal for a full year of operation is predicted to be less than eight per year at all locations. These events above the goals for sulphur dioxide are predicted to be relatively infrequent and less than the allowable eight events per year.

A small number of additional events above the 10-minute goal are also predicted due to the additional contribution of the coke plant emissions. For the shorter-term 10-minute goal, up to nine events per year are predicted above the goal at one sensitive receptor location (Receptor 2) for normal operation of the coke plant plus the power station. Assuming that eight events per year are allowed above the goal, this location has one minor excursion above the 10-minute sulphur dioxide goal with the addition of the coke plant. The modelling undertaken in this assessment includes a number of conservative assumptions that would lead to the conclusion that the one minor excursion of the 10-minute goal at one location is not a significant issue. The background levels of sulphur dioxide due to the operation of the power station have been over-estimated and in reality are well above those likely to occur resulting in a conservative assessment of the cumulative impacts due to the coke plant.

An assessment of potential toxic air pollutants emitted from the coke plant has been undertaken based on a comparison with the VIC EPA Design Criteria for short-term averages and against the NEPM (Air Toxics) monitoring investigation levels for long-term averages. All pollutants are predicted to be well below the criteria for normal operation of the coke plant without background sources.

An estimate of potential odour emissions from the coke plant has been undertaken using odour threshold values for each pollutant emitted from the operations. The predicted 99.5th percentile odour levels are well below the QLD EPA criteria for stack and area based sources. Therefore, for normal operations of the coke plant, odour should not be a concern to local residents.

12. References

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13. Glossary

SPS	Stanwell Power Station
EPA	Environmental Protection Authority
$\mu g/m^3$	micrograms per cubic metre
mg/m^3	milligrams per cubic metre
ppm	Parts per million

ppb	Parts per billion
NO_x	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NO	Nitrogen Oxide
PM_{10}	Particulate Matter less than 10 µm in aerodynamic diameter
$PM_{2.5}$	Particulate Matter less than 2.5 µm in aerodynamic diameter
SO_2	Sulphur Dioxide
VOC	Volatile Organic Compounds
CO	Carbon Monoxide
PAH	Polycyclic Aromatic Hydrocarbons
BSO	Benzene Soluble Organics
IARC	International Agency for Research on Cancer

Appendix A – Model Verification Study

14. Model setup

14.1 TAPM

The Air Dispersion Model (TAPM) was used to predict the regional and upper level meteorological conditions in the Stanwell area. The basic setup of TAPM is detailed below.

Key features of the TAPM setup are as follows:

- TAPM Version 3.0
- 4 grids (30 km, 10 km, 3 km and 1 km)
- 30 x 30 grid points and 25 levels
- 1 year time scale (1999) at 1 hour intervals;
- All default options selected
- Wind data assimilation for Seierups 30 m winds only (reliability factor of 1). Assimilated over levels 1-4 with 8 km radius of influence.

The meteorological component of TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical coordinate for three-dimensional simulations. The model solves the momentum equations for horizontal wind components, the incompressible continuity equations for vertical velocity and scalar equations for potential virtual temperature and specific humidity of water vapour, cloud water and rain water. The Exner pressure function is split into hydrostatic and non-hydrostatic components, and a Poisson equation is solved for the non-hydrostatic component. Explicit cloud micro-physical processes are included. The turbulence terms in these equations have been determined by solving equations for turbulence kinetic energy and eddy dissipation rate, and then using these values to represent the vertical fluxes by a gradient diffusion approach, including a counter-gradient term for heat flux. A vegetation canopy and soil scheme was used at the surface, while radiative fluxes, at surface and at upper levels are also included.

14.2 Calmet

Key features of Calmet used to generate the wind-fields are as follows:

- Calmet Version 5.53a;
- Domain area of 30 km by 30 km with 500 m grid spacing;
- Origin 211.479 km, 7383.136 km;
- 1 year time scale (1999) at 1 hour intervals;
- 12 vertical levels; cell face heights of 0, 20, 40, 60, 100, 150, 200, 250, 350, 600, 1200, 2000 and 3000 m;
- Prognostic wind-fields input as CSUMM for initial guess field only (as generated from TAPM);
- Mixing height parameters all set as default;
- Temperature parameters used $1/R^2$ as interpolation method, with radius of influence of 500 km;
- Surface stations located at Mercy, Kalapa and Seierups (10 and 30 m) included in wind-fields;

- Surface winds always extrapolated using similarity theory;
- Vertical profile generated from TAPM for location (226.479, 7397.136);
- Vertical bias (i.e. weighting the use of the vertical profile generated by TAPM) set at –1 for level 1, -0.75 for level 2, -0.5 for level 3, -0.25 for level 4 and 0 for all other layers (note: –1 is a bias towards the surface data, 0 is equal weighting to surface and upper air data);
- Step 1 wind-field options include kinematic effects, divergence minimisation, Froude adjustment to a critical Froude number of 1 and slope flows;
- Terrain radius of influence set at 4 km;
- Radius of influence of observation data set at 4 km; and
- Relative weighting of step 1 wind-fields versus observations set at 4 km for surface and 10 km aloft.

TAPM is a nested model that has been used to generate wind-fields over the Calmet model domain. These wind-fields are then used by Calmet as a prognostic input for the initial guess field. This method has been accepted by the Queensland Environmental Protection Agency and used successfully by Katestone Environmental in a large number of locations with similar topographic complexity to the subject site.

Using the TAPM-generated initial “guess” field results in a better regional wind-field in Calmet for the project area, in particular for the vertical structure of winds. A comparison of the TAPM-generated wind-fields with the surface measurements at various monitoring stations are presented in the following section.

14.3 Calpuff

Key features of Calpuff used to generate the ground-level concentrations are as follows:

- Calpuff Version 5.711a;
- Calmet wind-fields as detailed above;
- Domain area of 25 km by 25 km with 500 m grid spacing;
- 17 discrete receptors identified;
- 12 vertical levels (same as Calmet);
- Origin 211.479, 7383.136;
- 1 year time scale (1999) at 1 hour intervals;
- Terrain method - partial plume path adjustment;
- Transitional plume rise computed;
- Stack tip downwash;
- ISC method for simulation of building downwash;
- Vertical wind shear not modelled;
- Puff splitting not allowed;
- No chemical mechanisms modelled;
- No wet or dry deposition modelled;
- Dispersion coefficients internally calculated using micrometeorological variables;
- Partial plume penetration of elevated inversions allowed; and
- PDF used for dispersion under convective conditions.

15. Verification

15.1 TAPM

A validation of wind-fields was undertaken by visual inspection of hourly wind-fields over all layers and inspection of vertical structure over a large number of days, inspection of observed and predicted annual wind roses at non-assimilated sites and statistical performance measures.

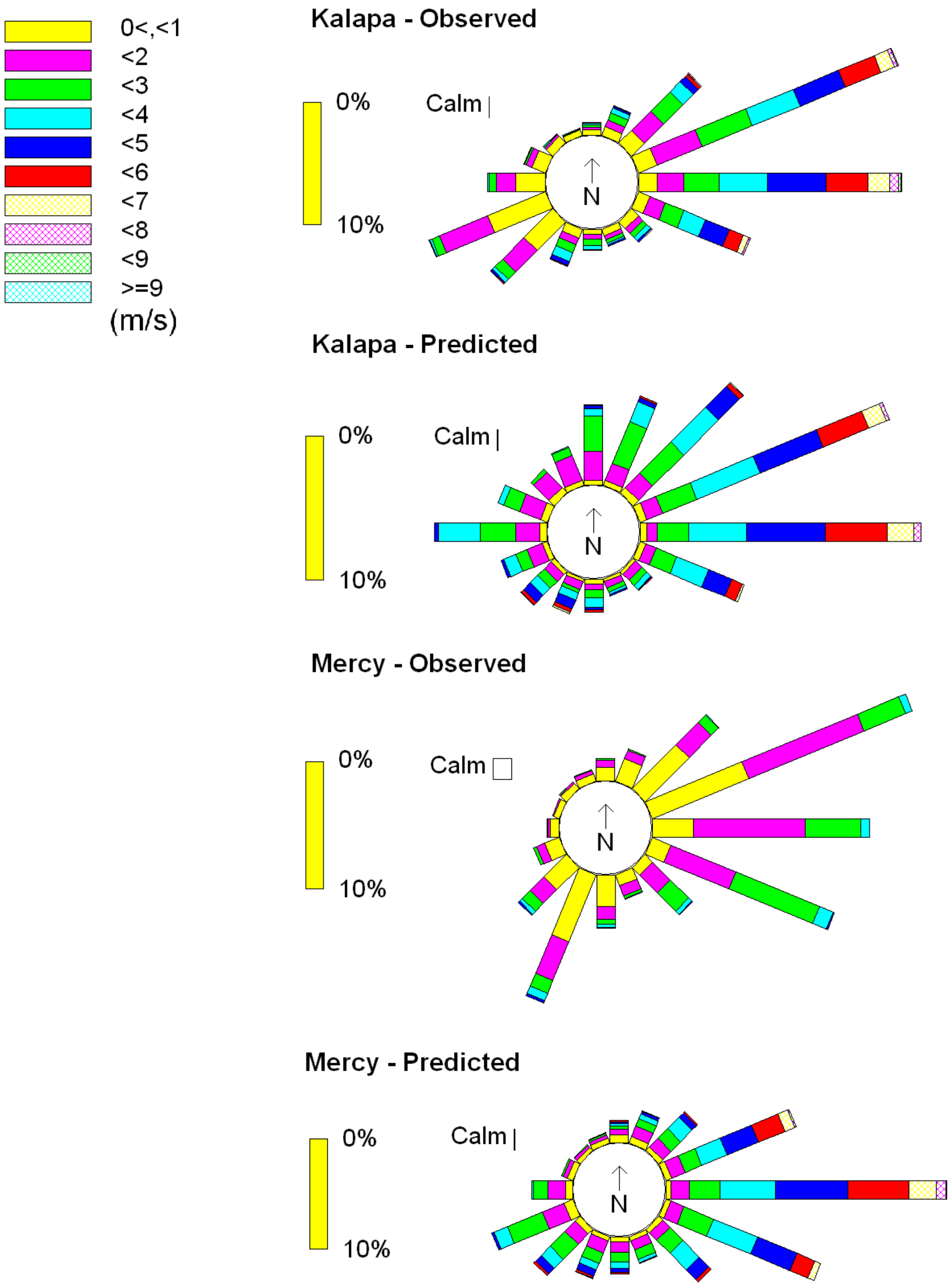
The sites available for statistical comparison are Mercy and Kalapa for winds and Seierups for temperature, relative humidity and radiation (net and solar). The Mercy site was located on the side of a hill and the monitor was sheltered due to local terrain and vegetation. This resulted in very low wind speeds recorded at this site. The data has been included in Table 21 and Figure 14 for completeness, however it should not be taken as an indicator of the models overall performance.

Generally the performance of TAPM for the Stanwell region is very good with index of agreement above 0.8 for all parameters (except for winds at Mercy site) and high Pearsons coefficient. The closer the prediction to an index of agreement and Pearsons coefficient of one, the better the models performance. The root mean square error is also less than the standard deviation for all but Mercy winds. Inspection of the annual wind roses in Figure 14 shows good agreement of wind direction for both sites, but due to the sheltered nature of the Mercy monitoring station a slight over prediction of wind speed at this site.

Table 21: Performance statistics for TAPM predictions

Site	Parameter	Units	Predicted Mean	Observer Mean	Predicted Standard Deviation	Observed Standard Deviation	Pearson Correlation Coefficient	Root Mean Square Error	Index of Agreement
Mercy	V-wind component	-	-0.331	-0.224	1.553	0.922	0.83	0.963	0.839
	U – wind component	-	1.947	0.838	2.694	1.169	0.862	2.144	0.703
	WS	m/s	3.217	1.403	1.575	0.894	0.734	2.16	0.532
Kalapa	V-wind component	-	0.506	0.096	1.59	1.312	0.798	1.043	0.864
	U – wind component	-	1.626	1.781	2.647	2.389	0.907	1.126	0.948
	WS	m/s	3.176	2.679	1.527	1.852	0.845	1.109	0.89
Seierups	Temperature		21.285	22.724	6.19	6.403	0.907	3.097	0.939
	Relative Humidity	%	60.478	70.319	17.694	19.979	0.769	16.326	0.821
	Net Radiation	W/m^2	147.059	101.469	258.479	175.509	0.926	125.917	0.914
	Solar Radiation	W/m^2	276.194	211.229	356.534	288.356	0.923	157.826	0.939

Figure 14: Annual wind roses for Mercy and Kalapa as observed and predicted by TAPM



Kalapa - Observed

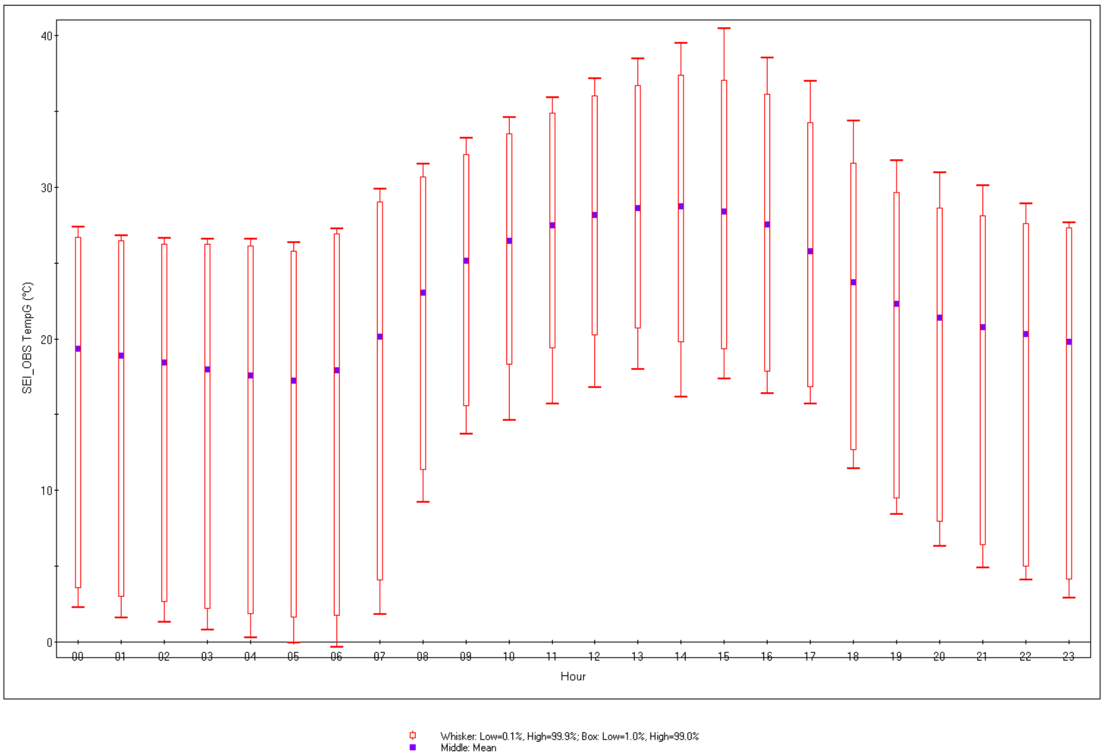
Kalapa - Predicted

Mercy - Observed

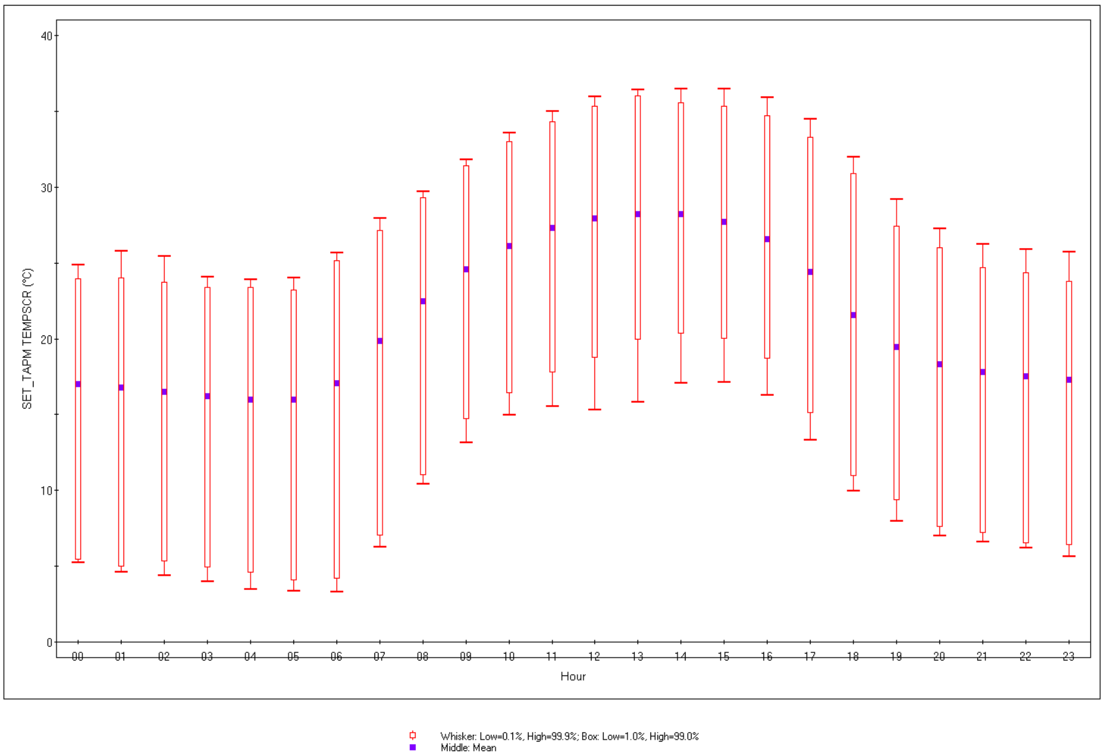
Mercy - Predicted

Figure 15: Diurnal variation of observations and predictions at Seierups for (a) temperature and (b) solar radiation.

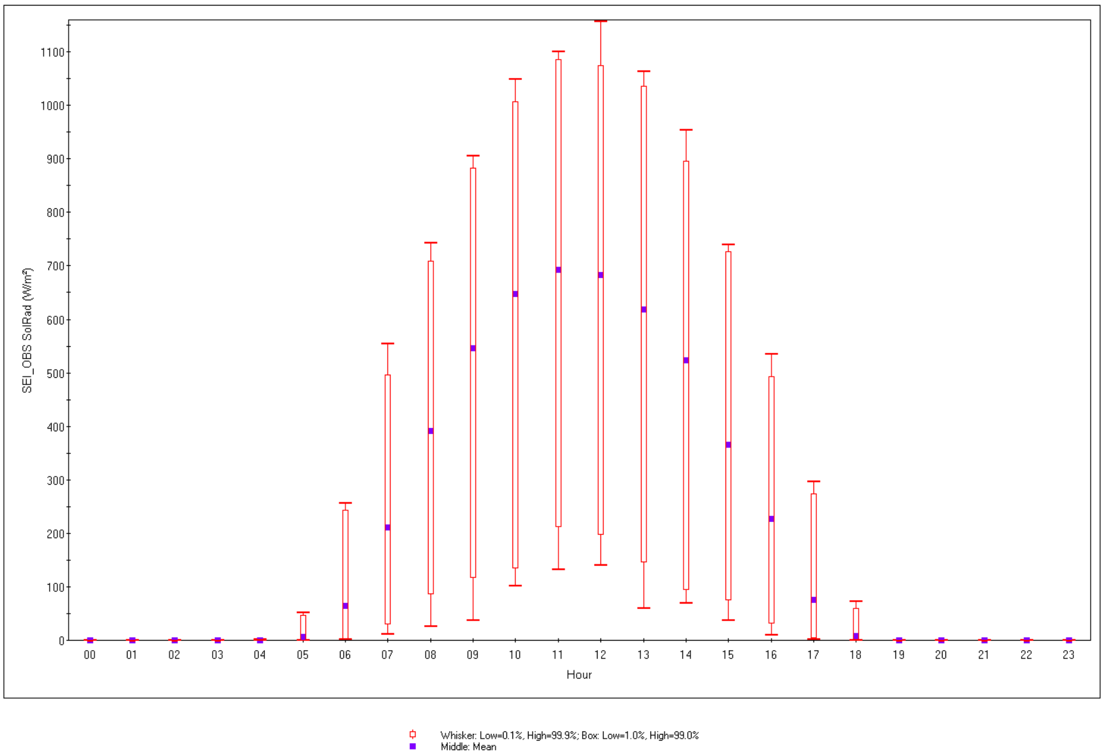
(a) Observed temperature



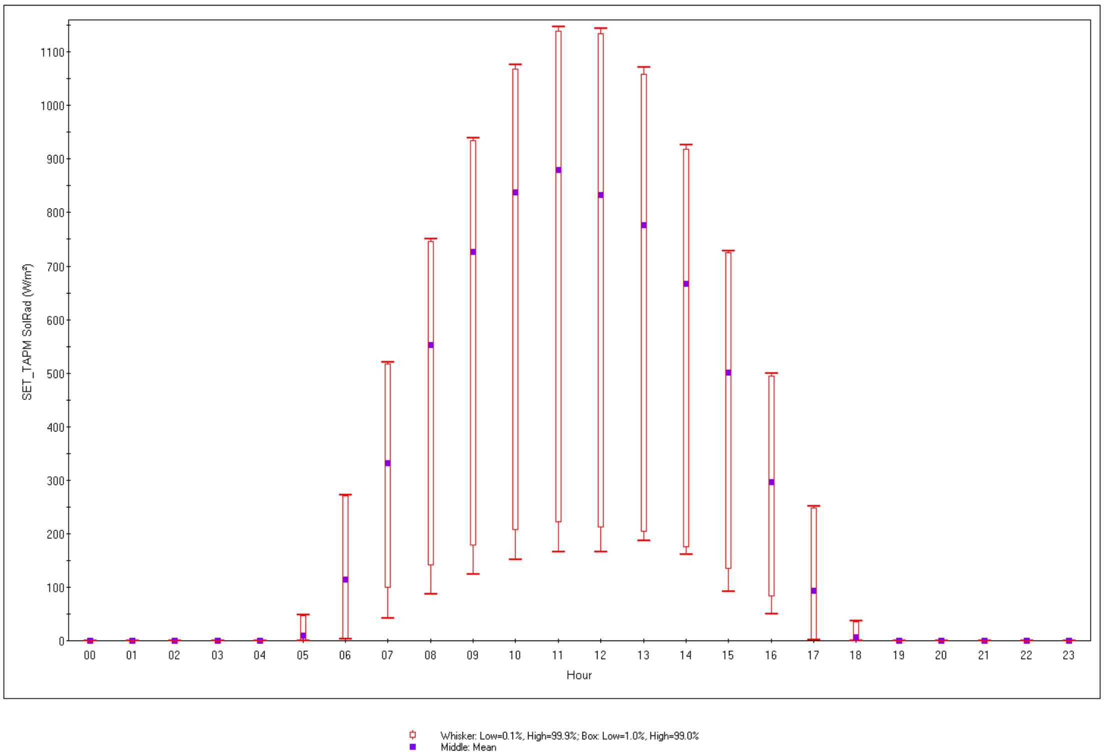
Predicted temperature



(b) Observed solar radiation



Predicted radiation



15.2 Calmet

As all available monitoring data were used in the generation of the Calmet wind-fields no statistical verification can be undertaken. A validation of wind-fields was undertaken by visual inspection of hourly wind-fields over all layers and inspection of vertical structure over a large number of days, using the Caldesk software. This indicated that the wind-fields were consistent and suitable for use in the Calpuff dispersion model.

15.3 Calpuff

In order to determine the performance of the model in the Stanwell region a comparison of predicted impacts due to the power station with measurements was undertaken. Unfortunately detailed information on the actual emissions from the power station during the period of intensive ambient monitoring was not available, therefore some assumptions have been made as to the emission rates and operating capacity of the units. Two emission scenarios were assessed one based on an average emission rate and the other on peak emissions (i.e. As used in the coke plant impact assessment).

Figure 16 presents quantile-quantile plots (Q-Q plots) of predictions verses observations for hourly sulphur dioxide concentrations at three monitoring locations. These plots pair the predictions with observations based on the maximum, second highest etc for each data set. They do not match predictions with observations in time. In order to determine the peak predictions are occurring during the right meteorological conditions frequency distributions with time of day are presented in Figure 17 for each site.

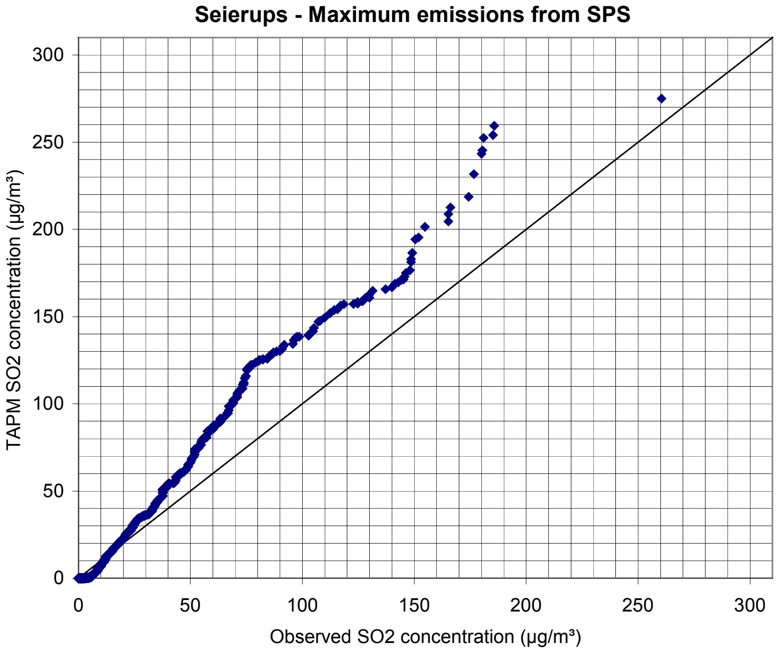
The Q-Q plots indicate that the model does very well at the Seierups site for average emissions and slightly over predicts the impacts if maximum emissions are assumed. The Seierups site records the highest impacts of all monitoring stations and it is therefore critical to this assessment that these maximums are reproduced. The predictions at both Kalapa and Mercy sites are over predicted by the model for both emission scenarios, which may indicate that the model is over predicting the impacts due to the power station at more distant locations including over the Stanwell Township. Interpretation of the modelling results presented in the impact assessment should be viewed in light of this over prediction of the background levels of sulphur dioxide due to the power station.

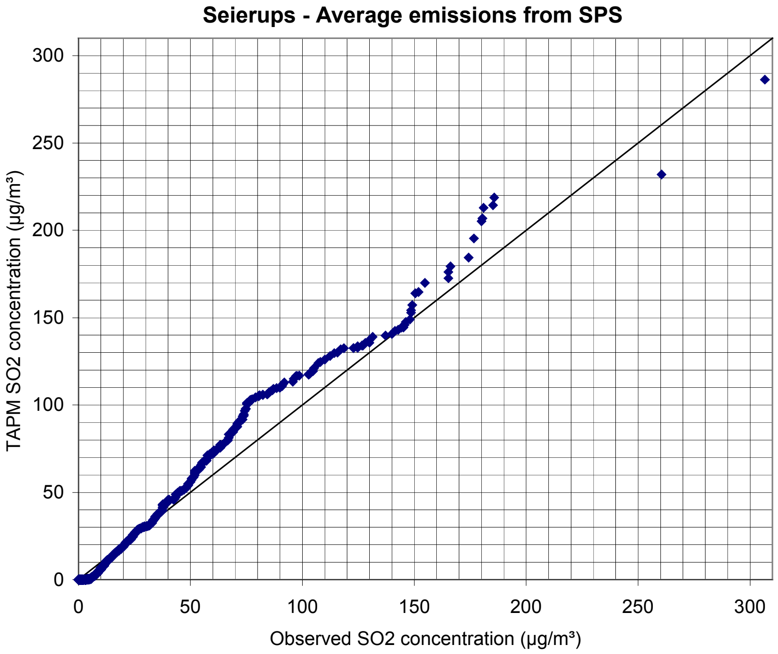
Diurnal variation in predicted impacts at all sites presented in Figure 17 shows that the peak impacts are predicted during the daytime, which is consistent with the time of the observed maximums. Therefore the model is predicting that the peak impacts occur for the same meteorological conditions as the measured peaks.

Overall the performance of Calpuff in predicting the peak impacts due to the power station can be considered very good, and likely to slightly overestimate.

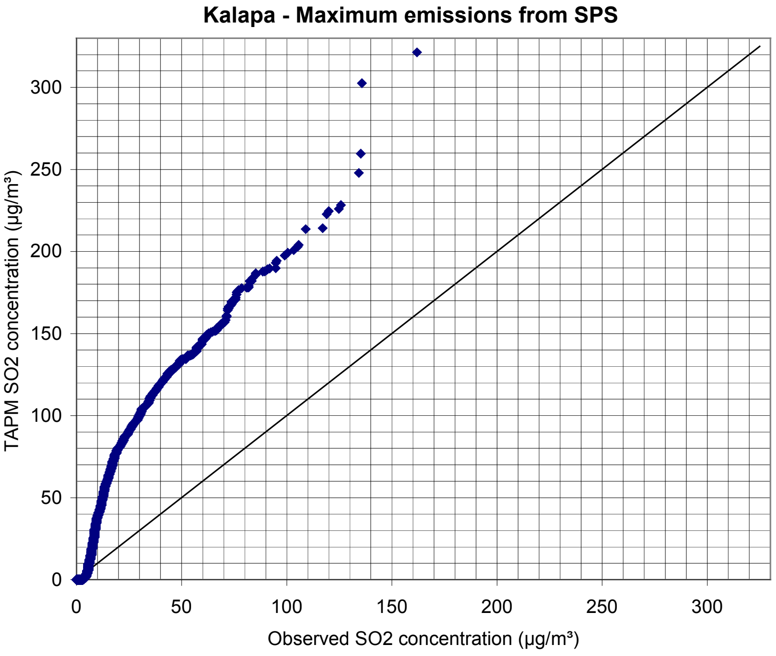
Figure 16: Quantile-Quantile plots of predicted and observed sulphur dioxide concentrations for maximum and average emission levels at (a) Sierups (b) Kalapa and (c) Mercy.

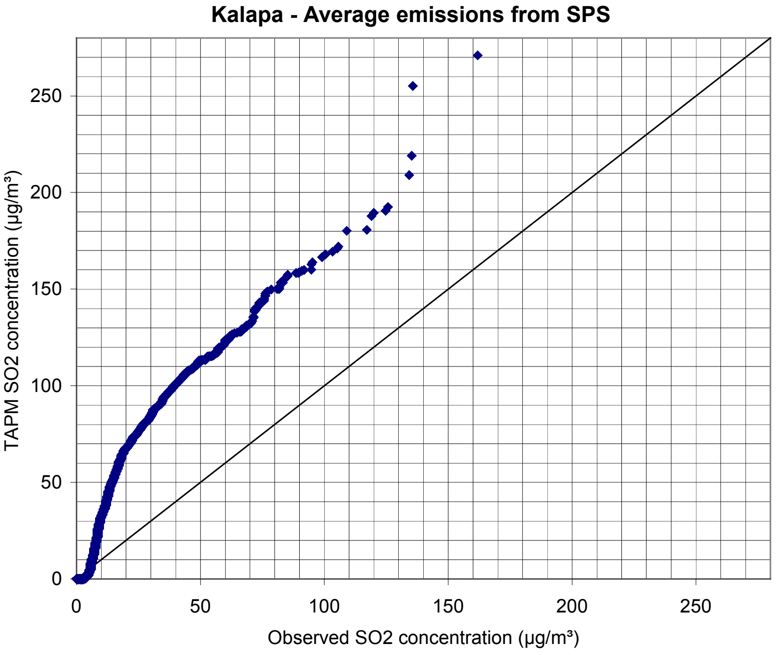
(a)



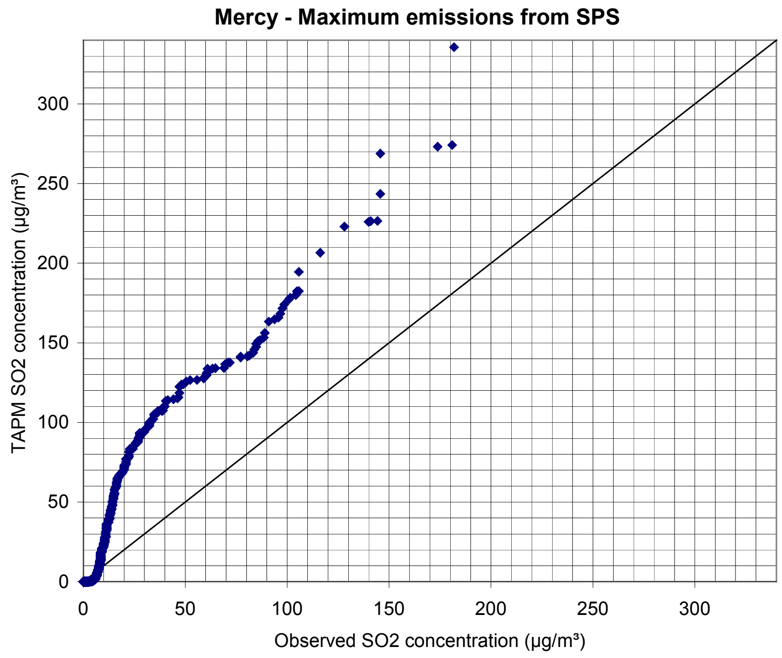


(b)


Kalapa - Maximum emissions from SPS
TAPM SO2 concentration (µg/m³)
Observed SO2 concentration (µg/m³)
0
50
100
150
200
250
300


Kalapa - Average emissions from SPS
TAPM SO2 concentration (µg/m³)
Observed SO2 concentration (µg/m³)
0
50
100
150
200
250

(c)


Mercy - Maximum emissions from SPS
TAPM SO2 concentration (µg/m³)
0
50
100
150
200
250
300
Observed SO2 concentration (µg/m³)
0
50
100
150
200
250
300

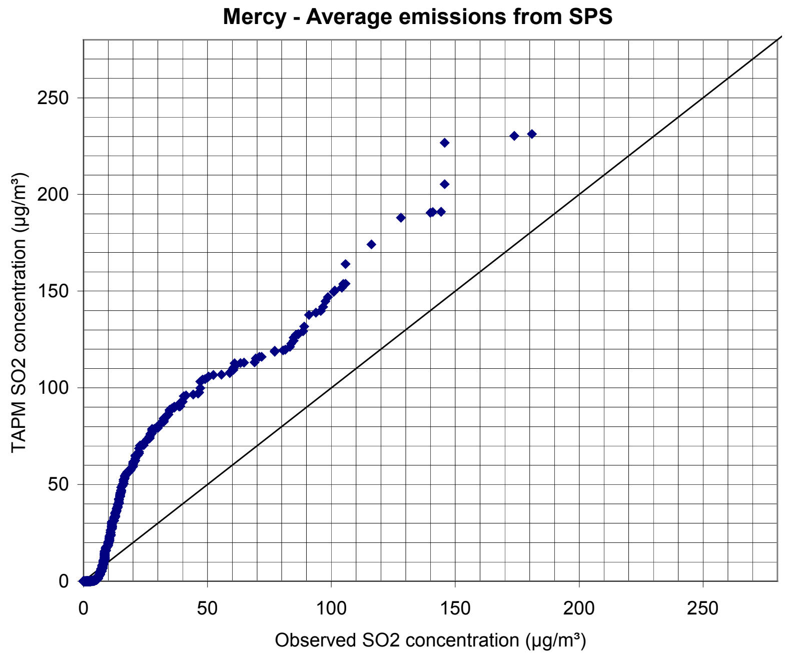
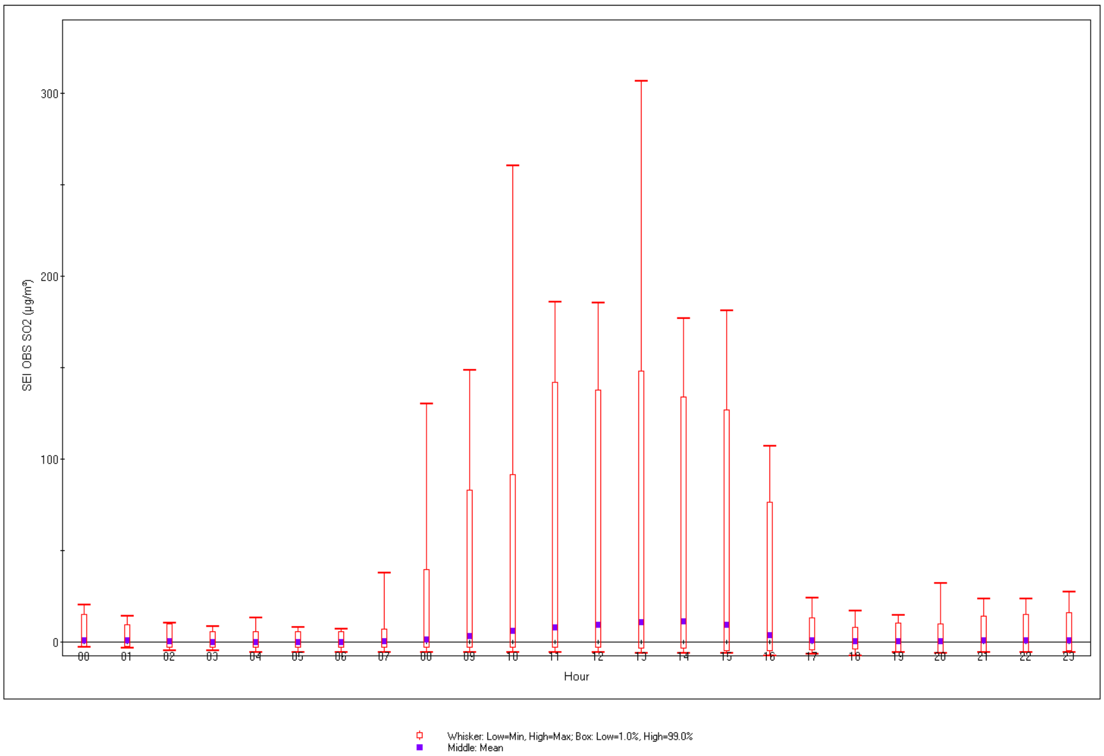
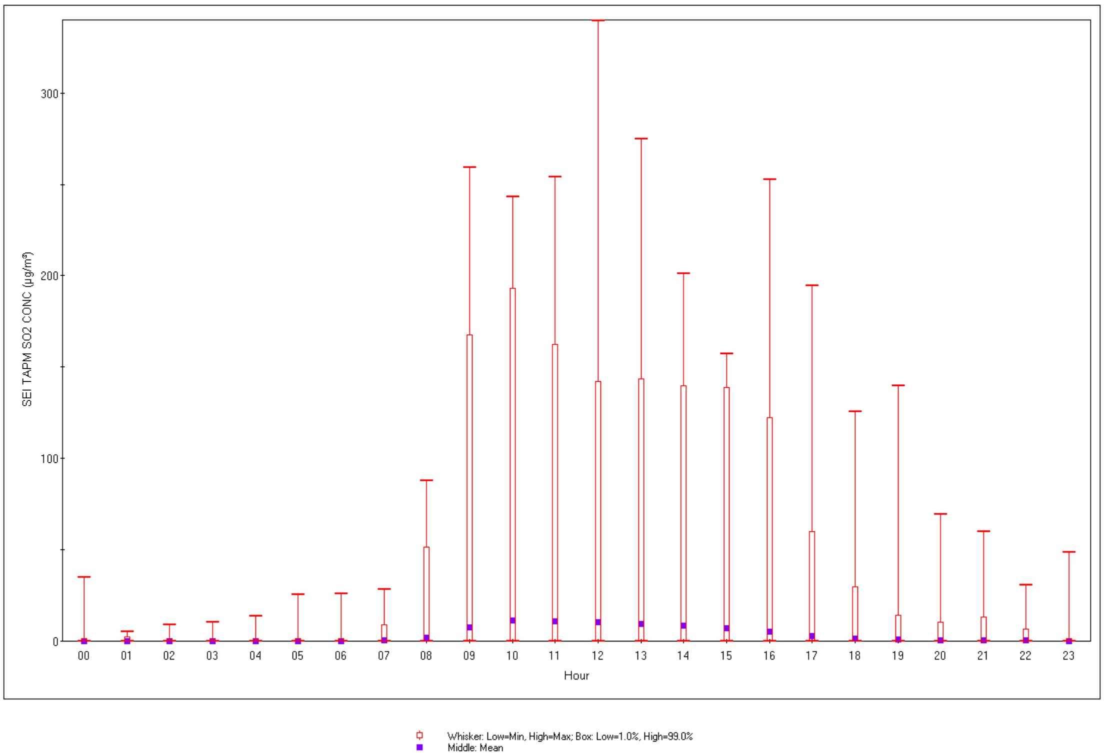

Mercy - Average emissions from SPS
TAPM SO2 concentration (µg/m³)
0
50
100
150
200
250
Observed SO2 concentration (µg/m³)
0
50
100
150
200
250

Figure 17: Diurnal variation of hourly sulphur dioxide concentrations observed and predicted by TAPM for maximum emissions at (a) Seierups (b) Kalapa and (c) Mercy.

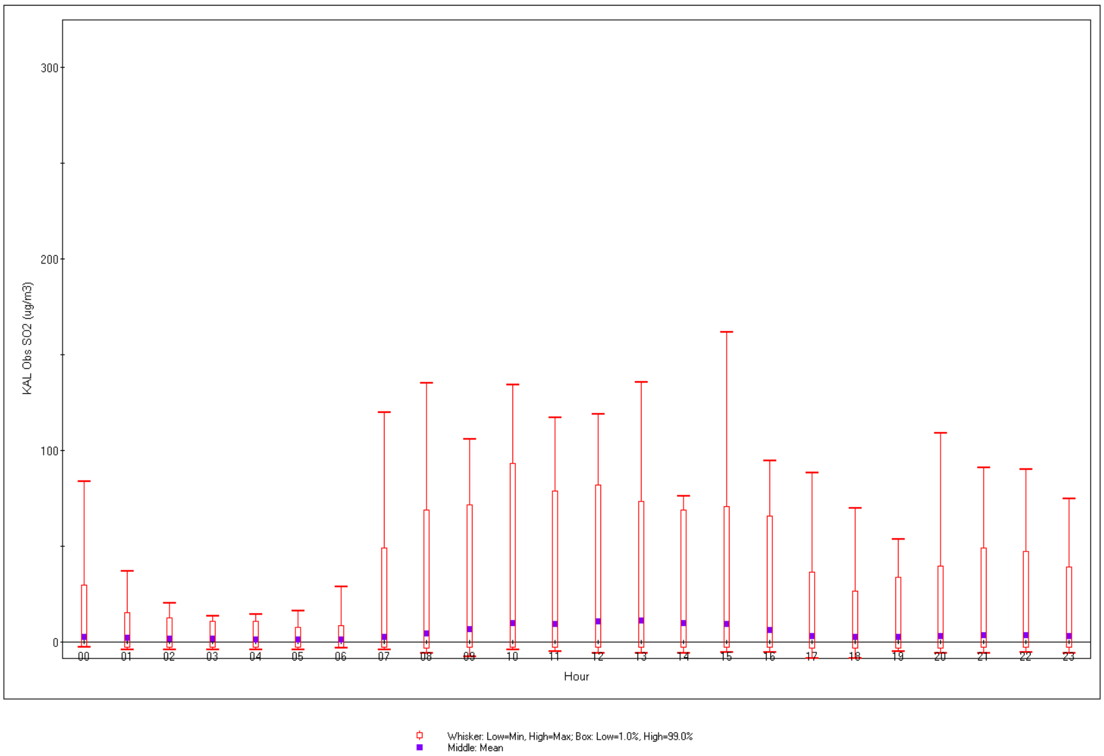
(a) Observations



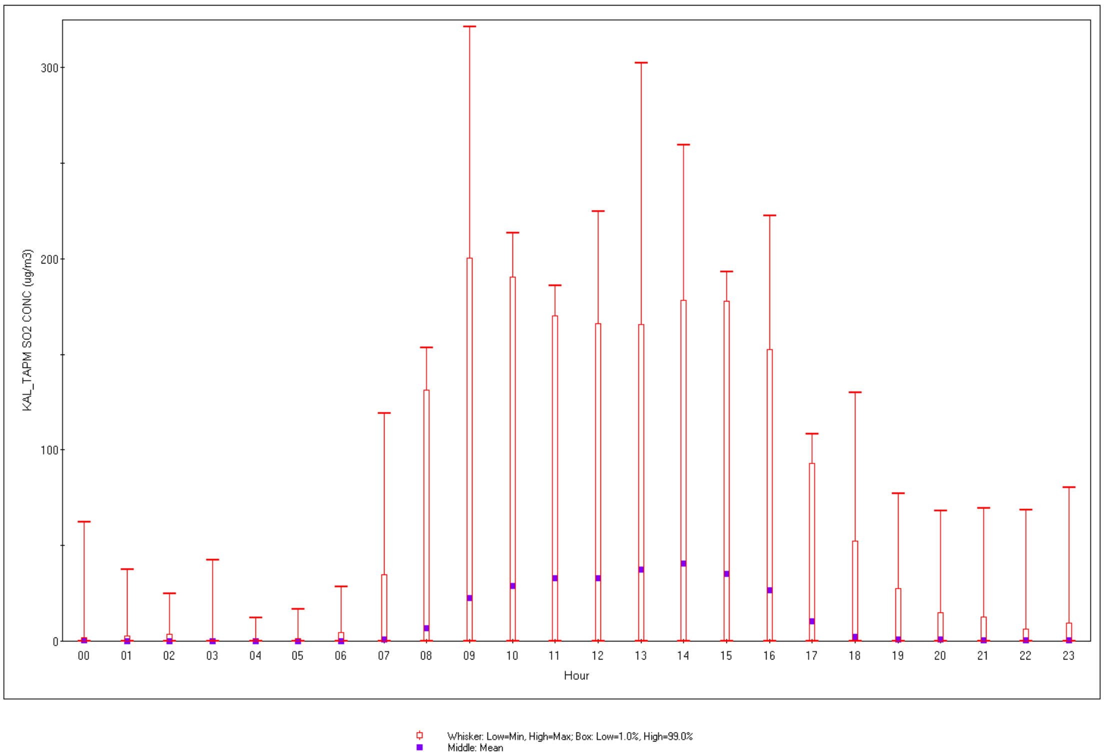
Predictions



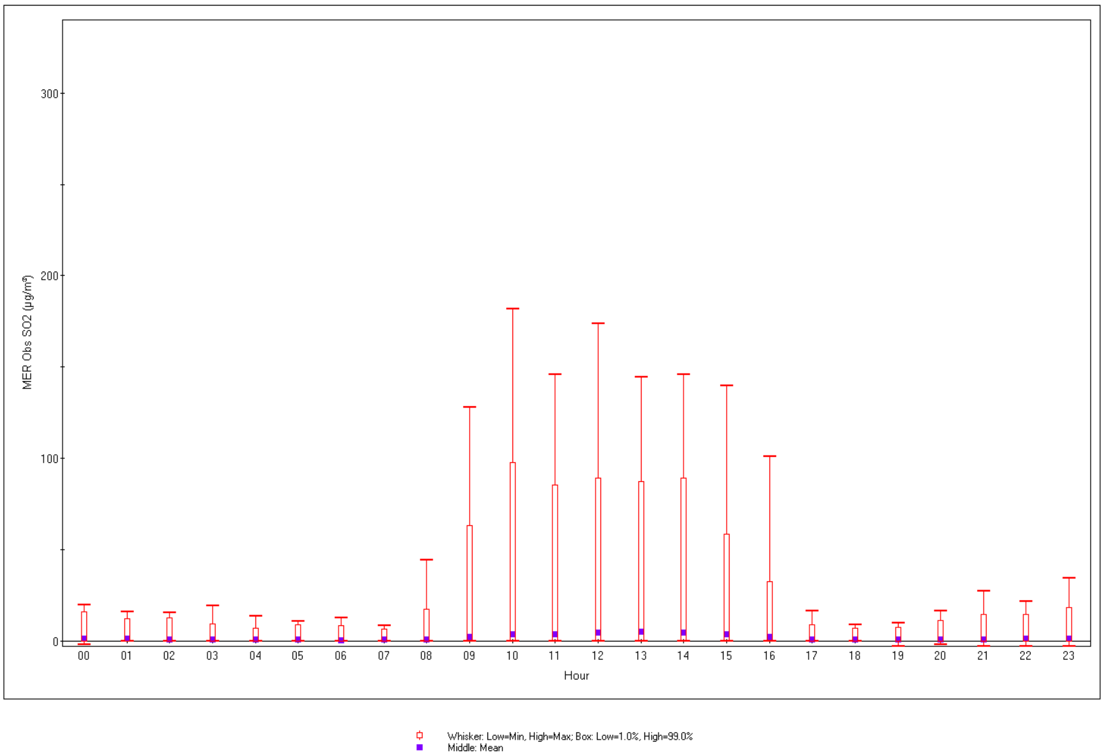
(b) Observations



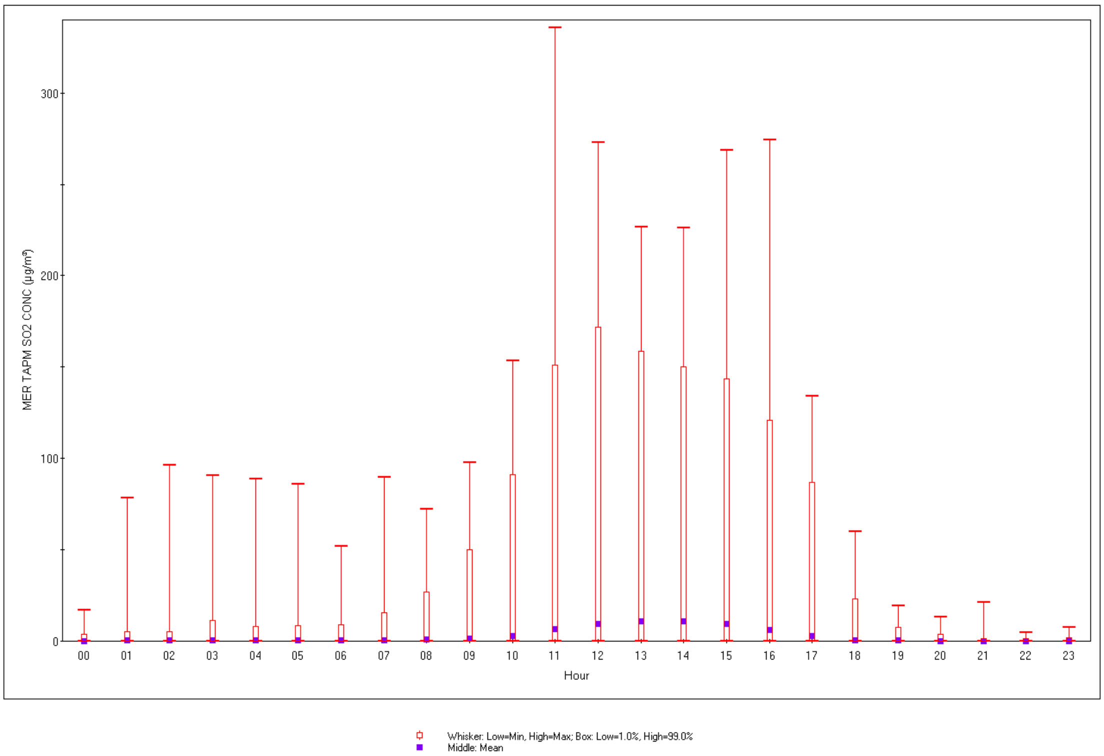
Predictions



(c) Observations



Predictions



Appendix B – List of odour thresholds used to estimate odour concentration

Species	Odour threshold (mg/m^3)	Comment or other common names for species
Sulphur dioxide	1.175	
Nitrogen dioxide	0.215985	
Nitrogen oxide	0.85918	
Oxides of nitrogen	0.63406175 [1]	
Carbon monoxide	-	
VOC	3	
H_2SO_4	1	
Benzene	4.5	
Bromoform	5300	
Bromomethane	80	
2-Butanone	15.822	
Carbon Disulphide	0.0243	
Chlorobenzene	0.098	
Chloromethane	21	
Chloroform	250	
Cumene	0.0392	
Ethyl Benzene	8.7	
Iodomethane	21500	
Isooctane	-	no odour threshold available
Methylene Chloride	540	
n-Hexane	457.6	
4-Methyl-2-Pentanone	0.41	methyl isobutyl ketone
2- Methylphenol	0.0012376	o-cresol
4- Methylphenol/3-Methylphenol	1.22172E-05	m-cresol/p-cresol
Phenol	0.1786	
Styrene (unInhibited)	0.2021	
Tert-butyl Methyl Ether	0.15523	MTBE - methyl tert-butyl ether
Tetrachloroethene	21	
1,1,2,2-Tetrachloroethane	21	
Toluene	17.5	
1,1,1-Trichloroethane	648	Methyl chloroform
1,1,2-Trichloroethane	-	no odour threshold available
Trichloroethene	1.134	trichloroethylene
Vinyl Acetate	0.36	
Xylenes	0.348	
BSO	-	Benzene soluble organics
Total PAHs	0.824	
Anthracene	-	
Benzo (b&k) Fluoranthene	-	
Benzo (a) pyrene	-	
Chrysene	-	
Flouranthene	-	
Fluorene	-	
2- Methylnaphthalene	0.0581	
Naphthalene	0.44	
Phenanthrene	-	
Pyrene	-	

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Appendix I.2
Calculation of Air Emissions

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Appendix I.2
Calculation of Air Emissions

1.1 Calculation Methodology

The proposed Queensland Coke and Power Plant Project (the Project) will release emissions to the air from material handling of coal and coke, coal charging, process emissions, coke pushing and quenching. The pollutants potentially emitted are particulate matter, sulphur dioxide (SO_2), nitrogen oxides (NO_x) carbon monoxide (CO), volatile organic compounds (VOC), polyaromatic hydrocarbons (PAH) and trace metals. The types of pollutants released from each operation are:

- Material handling of coal, comprising unloading of trains, stacking and reclaiming to coal stockpile and loading to charging machine – particulate matter;
- Coal charging to ovens – particulate matter, SO_2, CO, VOC, PAH, trace metals;
- Process emissions through the main stacks – particulate matter, SO_2, NO_x, CO, VOC, PAH, trace metals;
- Pushing coke from ovens – particulate matter, SO_2, NO_x, CO, VOC, trace metals;
- Quench tower – particulate matter, VOC, PAH, trace metals; and
- Material handling of coke, comprising loadout from quench car, stacking and reclaiming to coke stockpile, stacking and reclaiming to emergency coke stockpile and loading to trains – particulate matter.

The Project is designed to produce 3.2 Mtpa of coke, using 5 Mtpa of coal as the feedstock. Detailed emission data is not available from the Project design. To obtain representative emissions data from the heat-recovery type of coke production, reference has been made to data obtained for a recently proposed coke plant overseas. This report in turn was based on emission factors from the USEPA's AP-42 document for coke production (USEPA, 2000).

The overseas project proposed a coke plant design that is very similar in operation to that proposed by Queensland Coke and Energy. Specific differences in the design between the two coke plants were taken into account in estimating the emissions from the Project. For example, the overseas plant proposed using a flue-gas desulphurisation unit (FGD), whereas the Project does not include FGD. This and other differences between the two coke plant designs were accounted for in the preparation of the emission inventory for the Project.

The overseas plant was proposed to produce a total of 1.7 Mtpa of furnace coke, approximately half the capacity of the Project. Emissions from the charging, pushing, main stack and quench stack operations were derived directly from the overseas plant permit application documentation. Adjustments were made for the capacity of the plant and the differences in the composition of trace elements between the proposed coal for the overseas plant and the Australian coal that is planned for the Project, as presented in Table 1 (ACARP, 1996).

Appendix I.2
Calculation of Air Emissions

Table 1 Comparison of trace element analysis for coal

Trace element	Symbol	Average for overseas plant proposed coal (ppm)	Average for Australian coal (ppm)
Antimony	Sb	0.92	0.39
Arsenic	As	19.9	0.7
Beryllium	Be	1.8	1.12
Cadmium	Cd	0.06	0.0125
Chromium	Cr	12.4	8.2
Cobalt	Co	6.2	4.8
Lead	Pb	5.8	6.6
Manganese	Mn	21.1	42.4
Mercury	Hg	0.12	0.042
Nickel	Ni	11.4	3.8
Phosphorus	P	126.8	
Selenium	Se	2.7	1.2

The average sulphur content of Australian coal used for calculation of emissions was 0.47% (ACARP, 1996). The pre-feasibility study for the project (Barlow Jonker, 2004) estimated that 65% of the sulphur will remain in the coke after the coking process, hence 35% will be released during the coking process. All sulphur released from the coke was assumed to be oxidised to sulphur dioxide (SO_2). Emission calculations for the overseas project assumed that 99.1% of SO_2 emissions were released through the main stack, 0.9% was released through pushing emissions and 0.001% was released through charging emissions. This break-up of SO_2 emissions was used in the estimation of emissions for the Project.

There is very little information available on PAH emissions from coke plants that do not recover byproducts, such as the proposed QCE Project. Available emission information for total polyaromatic hydrocarbons (PAH) was derived from the AP-42 emission factors for the coking process. The PAH split that was used in the overseas plant assessment was adopted for the project, namely 13.1% of total PAH emissions were from charging, 83.6% were released during the coking process through the main stack and 3.3% of total PAH emissions were released during quenching. The total PAH emissions need to be separated into the contributing compounds for comparison to guidelines. Data were obtained from Stanwell Power Station for the PAH composition from Australian coal and applied to the total PAH emissions from each source. While the power station is a different process, it remains the best source of information available on the relative occurrence of the various PAH species.

Data supplied by Stanwell Power Station for Australian coal shows that BaP is around 0.5% of the total PAH emissions. The distribution of PAH between various PAH species is presented in Table 2, and was used in the estimation of emissions for all PAH species from all sources.

Appendix I.2
Calculation of Air Emissions

Table 2 Speciation of polyaromatic hydrocarbons (PAH) from the Project, based on data supplied by Stanwell Power Station for Australian coal

PAH Species	Proportion of total PAH (%)
Naphthalene	31.0%
Acenaphthylene	5.0%
Acenaphthene	7.0%
Fluorene	22.0%
Phenanthrene	13.0%
Fluoranthene	3.0%
Pyrene	10.0%
Benzo[a]pyrene	0.5%
Indeno[123-c,d]pyrene	1.0%
Benzo[g,h,I]perylene	5.0%
Total	97.5%

1.2 Emissions to air

1.2.1 Control measures

Controls that have been used in the estimation of emissions for the Project are presented in Table 3. The charging and pushing emissions will be controlled by the use of a travelling hood to trap particulate matter. Emissions from the quenching process, containing a high proportion of water, will be trapped by the use of baffles to remove excess water and particulate matter.

The coke ovens are operated under negative pressure. This design feature does not allow fugitive emissions to escape from the coke ovens. Emission control devices are thus not required for the coke ovens.

Emissions that may arise during the charging, coking and pushing operations of the oven are minimised by the design of the process, including

- Stamp charging of coke ovens, minimising the time required to load the ovens;
- Design incorporating small gaps between coal charge and oven doors;
- Use of travelling hoods to capture emissions during charging and pushing;
- Operation of coke ovens under negative pressure (vacuum) to trap air emissions;
- Combustion of gases generated during coking process to minimise release of volatile organic matter and PAH;
- Pushing coke product onto flat-bed receiving car, and minimising the drop height such that the coke charge remains in a stamped block;
- Baffles on the quench tower to capture particulate matter and water droplets;

- Installation of a de-dusting device in the coke screening room.

The control factors that apply for each of these operations within the coking process are summarised in Table 3. A control factor of 70% implies that 70% of the emissions that would be generated for an uncontrolled process are in fact captured or reduced by the method described. These control factors have been applied for the calculation of emission rates for each pollutant and for each of the processes for the Project.

Table 3 Control factors applied to various processes for the Queensland Coke and Power Plant Project

Process	Control factor	Description
Coal unloading from trains	70%	Watering and partially enclosed transfer points
Coal stockpile	50%	Watering of open storage pile
Coal reclaiming	70%	Watering and partially enclosed transfer points
Coal loading to charging machines	90%	Travelling hood/bag filter
Coke pushing	90%	Travelling hood/bag filter
Quenching process	70%	Baffles to capture suspended particles and steam
Coke unloading from quenching	70%	Bag filter
Coke stockpiling	70%	Watering and partially enclosed transfer points
Coke stockpile	50%	Watering of open storage pile
Coke loading to trains	70%	Watering and partially enclosed transfer points
Emergency coke stockpile	50%	Watering of open storage pile

1.2.2 Coal and coke handling emissions

The emissions from materials handling of coal and coke are primarily particulate matter. Particulate matter is considered in two particle size ranges; Total Suspended Particulates (TSP) generally describe particles with an aerodynamic diameter less than approximately 30 µm, while PM_{10} describes particles with an aerodynamic diameter less than 10 µm. Particles in the PM_{10} size range are considered detrimental to health if they exceed the ambient air quality limits.

The emission rate of pollutants from coal and coke handling operations, including unloading coal from the train, coal stockpile emissions, loading to the charging machine, loadout from quenching, coke stockpile, loading coke to the train and the emergency coke stockpile emissions are presented in Table 4. The estimated hourly average emission rate of pollutants are presented in Section 7 of the EIS.

Table 4 Emission rate of pollutants per year from coal and coke handling operations

Pollutant	Emission rate of pollutants (tpa)						
	Coal unloading from train	Coal stockpile	Loading to Charging Machine	Loadout from Quenching	Coke stockpile	Loading to train	Emergency coke stockpile
TSP	1.16	4.52	0.39	0.79	1.55	0.79	0.29
PM_{10}	0.54	2.80	0.18	0.37	0.77	0.37	0.14

1.2.3 Coking process emissions

The annual emission rate of pollutants from the Project for charging, coking process, pushing and quenching, based on the estimated emission of pollutants from the overseas project data, local coal composition and control technologies adopted by the Project, are presented in Table 5. The average hourly emission rates of pollutants in grams per second were estimated from the annual emission rate and the hours of operation of the site, and are presented in Section 7 of the EIS. All operations were assumed to occur for 24 hours a day, 365 days per year.

Table 5 Emission rate of pollutants per year from charging, main stack, pushing and quenching operations

Pollutant	Emission rate of pollutants (tpa)				
	Coal Charging	Main Stack	Pushing	Quenching	Total for pollutant
TSP	6.9	2184.0	73.0	306.0	2579.4 [a]
PM10		2184.0	73.0	112.4	2374.6 [a]
SO2	0.2	14785.9	137.4		14923.4
NOx		2653.0	48.4		2701.4
CO	7.2	125.0	161.0		293.2
VOC	5.2	57.3	30.7		93.2
H2SO4		77.8			77.8
Benzene	0.09	1.2			1.3
Bromoform		0.003			0.003
Bromomethane		1.4			1.4
2-Butanone		0.16			0.16
Carbon Disulphide	0.01	0.041			0.046
Chlorobenzene		0.003			0.003
Chloromethane	0.01	1.9			1.9
Chloroform		0.028			0.028
Cumene		0.004			0.004
Ethyl Benzene	0.002	0.008			0.010
Iodomethane		0.016			0.016
Isooctane		0.041			0.041
Methylene Chloride		1.7			1.7
n-Hexane		0.038			0.038
4-Methyl-2-Pentanone		0.023			0.023
2- Methylphenol				0.040	0.040
4- Methylphenol/3-Methylphenol				0.13	0.13
Phenol		0.18		0.09	0.27
Styrene		0.018			0.018
Tert-butyl Methyl Ether		0.0001			0.0001
Tetrachloroethene		0.001			0.001
1,1,2,2-Tetrachloroethane		0.005			0.005
Toluene	0.04	1.3			1.3
1,1,1-Trichloroethane		0.006			0.006
1,1,2-Trichloroethane		0.001			0.001
Trichloroethene		0.022			0.022

Pollutant	Emission rate of pollutants (tpa)				
	Coal Charging	**Main Stack**	**Pushing**	**Quenching**	**Total for pollutant**
Vinyl Acetate		0.018			0.018
Xylenes	0.02	0.041			0.059
BSO			0.54		0.54
Total PAHs	0.11	0.72		0.03	0.86
Naphthalene	0.04	0.23		0.01	0.27
Acenaphthylene	0.01	0.037		0.001	0.044
Acenaphthene	0.01	0.052		0.002	0.062
Fluorene	0.03	0.16		0.01	0.19
Phenanthrene	0.01	0.10		0.00	0.11
Fluoranthene	0.00	0.022		0.001	0.026
Pyrene	0.01	0.074		0.003	0.088
Benzo[a]pyrene	0.00	0.004		0.000	0.004
Indeno[123-c,d]pyrene	0.00	0.007		0.000	0.009
Benzo[g,h,I]perylene	0.01	0.037		0.001	0.044
Antimony		0.012		0.013	0.025
Arsenic	0.00	0.010	0.001	0.020	0.030
Beryllium	0.00	0.003		0.001	0.004
Cadmium		0.001			0.001
Chromium	0.00	0.09		0.01	0.10
Cobalt	0.00			0.005	0.006
Lead	0.00	0.80	0.02	0.02	0.84
Manganese	0.00	0.14	0.01	0.25	0.40
Mercury	0.00	0.19			0.19
Nickel	0.00	0.043		0.005	0.048
Phosphorous		3.2		0.3	3.5
Selenium		0.032		0.022	0.054

[a] includes emissions from coal and coke handling

1.3 References

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