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Delta electricity

Mt Piper Power Station Extension Environmental Assessment

AIR QUALITY ASSESSMENT

- 18 September 2009

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1. Introduction

This report has been prepared by Sinclair Knight Merz (SKM) for Delta Electricity ("Delta"). The purpose of the report is to quantitatively assess the potential air quality impacts of the proposed extension to the Mt Piper Power Station, near Lithgow (the "Project"). This report forms part of an Environmental Assessment (EA) for the Project.

The Director-General's requirements for air quality assessment within the EA were:

The Environmental Assessment must include a comprehensive air quality impact assessment prepared in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (DEC, 2005) (Approved Methods) considering worst case operating scenarios and meteorological conditions, representative monitoring and receiver locations and cumulative impacts, as applicable, from the nearby Mount Piper and Wallerawang Power Stations. The Environmental Assessment must address air quality impacts at a local, regional and interregional level and the potential impacts of emissions on photochemical smog formation in the Sydney basin. The assessment must demonstrate that the project would meet the impact assessment criteria in Section 7 of the Approved Methods and the requirements of the Protection of the Environment Operations (Clean Air) Regulation 2002. The Environmental Assessment must clearly demonstrate that the project has been designed to include the application of Best Available Control technology (BACT) in relation to air emissions. The assessment must include a framework for the mitigation, management and monitoring of air quality impacts, particularly with respect to sensitive receptors likely to be significantly impacted by cumulative air quality impacts in the local area.

The Environmental Assessment must also include a preliminary screening of potential risks to aviation safety associated with exhaust plumes from the operation of the project with consideration to the Commonwealth Civil Aviation Safety Authority's Advisory Circular Guidelines for Conducting Plume Rise Assessments (June 2004).

The air quality assessment follows the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*, published by the Department of Environment and Climate Change (DECC) (**DEC, 2005**). A computer-based dispersion model has been used to predict ground-level pollutant concentrations due to the identified emission sources, and model predictions have been compared with relevant air quality criteria to assess the effect that the Project would have on the existing air quality environment.

In summary, the report includes information on the following:

- Existing and proposed power station operations (**Section 2**);
- Pollutants and air quality criteria that are relevant to this Project (**Section 3** and **4**);
- Meteorological conditions in the study area (**Section 5.1**);
- Existing air quality, as characterised by local monitoring data (**Section 5.4**);
- Estimated pollutant emissions (**Section 6**);
- Methods used to predict off-site air quality impacts (**Section 8**);
- Predicted dispersion patterns and concentrations and assessment of these predictions against air quality criteria (**Section 9.1, 9.2** and **9.3**);
- Potential cumulative impacts with other emission sources (**Section 9.3**);
- Construction impacts and identification of suitable mitigation measures (Section **9.5**);
- Potential regional air quality impacts (**Section 9.6**);
- Potential hazards to aviation (**Section 9.7**).

2. Project Description

The Mt Piper Power Station is located 20 kilometres (km) northwest of Lithgow, in the central tablelands of New South Wales (NSW).

Figure 1 shows the location of Mt Piper Power Station. The area supports a variety of uses, including coal mining operations, pastoral grazing and agriculture. Wallerawang Power Station is to the southeast of Mt Piper. Also shown in **Figure 1** are the air quality and meteorological monitoring sites and data collected from these sites are discussed in **Section 5.4**.

The area is well vegetated with undulating terrain. **Figure 2** shows a pseudo three-dimensional representation of the local terrain.

The Mt Piper Power Station comprises two 700 megawatt (MW) steam turbine generators, driven by steam from coal fired boilers. Delta Electricity is proposing to extend the existing power station to accommodate the predicted increase in electricity demand in NSW.

The extension would comprise the construction and operation of either:

- A new 2,000 MW ultra-supercritical (USC) coal-fired plant; or
- A new 2,000 MW combined cycle gas turbine (CCGT) plant.

For the purposes of this assessment it was assumed that the USC option would comprise two 1,000 MW steam turbine generators, while the CCGT option would comprise six gas turbines to make up the 2,000 MW output. Notional site layouts for the USC and CCGT options are shown in **Figure** 3. This figure also shows the proposed exhaust stacks for each option, the emissions of which are the focus of this assessment.

Further details on the proposed plant and infrastructure are provided in the main body of the EA.

3. Relevant Air Pollutants

This section discusses the key air pollutants associated with the Project, namely:

- Oxides of nitrogen (NO_x);
- Oxides of sulphur as sulphur dioxide (SO_2); and
- Airborne particulate matter as total suspended particulates (TSP) or particulate matter with equivalent aerodynamic diameter less than or equal to 10 microns (PM_{10}).

There are also other pollutants emitted, but to a lesser extent in terms of impact, including carbon monoxide, fluoride, antimony, arsenic, beryllium, cadmium, chromium III, chromium VI, lead, mercury (inorganic), nickel, dioxins and furans, and polycyclic aromatic hydrocarbons (PAH) as benzo[a]pyrene. The health and environmental effects of NO_x, SO_2 and particulate matter are discussed below. The impacts described are not those typically experienced at concentrations found in ambient air and, in general, represent the extreme upper end of dose-response relationships.

3.1. Oxides of Nitrogen

Oxides of nitrogen (NO_x) is the collective term for nitric oxide (NO), nitrogen dioxide (NO_2) and nitrous oxide (N_2O). Nitrogen oxide is colourless, odourless and can oxidise in the atmosphere to form NO_2 and NO_3. Lightning and the oxidation of ammonia can form oxides of nitrogen naturally. However, combustion of fossil fuels by automobiles and industry are the main sources of NO_x in the atmosphere. The main emissions of NO_x from the Project will be through the combustion of coal or gas.

NO_2 is a pungent, brown, acidic, highly corrosive gas and has impacts on human health including detrimental effects on the human respiratory tract and increased susceptibility to asthma and respiratory infections. High concentrations of NO_x can affect vegetation by retarding growth rates and crop yields. Oxides of nitrogen are a main cause of ozone production at ground-level and can also lead to acid rain by forming nitrous and/or nitric acid in airborne water droplets.

3.2. Sulphur Dioxide

Sulphur dioxide is an acid gas formed when sulphur combines with oxygen, usually as a result of the combustion of fossil fuels, which contain a small percentage of sulphur. Other oxides of sulphur are also often formed in the combustion process, or subsequently in the atmosphere. Sulphur dioxide also has natural sources such as volcanic eruptions and the oxidation of hydrogen sulfide, which is produced from decomposing vegetation under anaerobic (oxygen deficient) conditions. At concentrations of 10,000 µg/m^3 the gas has a pungent irritating odour. The odour threshold is several thousand µg/m^3 (**WHO, 2000**).

Sulphur dioxide can contribute to or exacerbate respiratory illnesses (such as asthma or bronchitis), especially in elderly or young people. When sulphur dioxide attaches to small ambient particulates it can be inhaled deeply into the lungs and intensify its health effects. Sulphur dioxide dissolves readily in water and can form acid rain. Acid rain has detrimental effects on the environment by damaging crops, ecosystems, monuments and historic buildings, although acid rain is not generally an issue for Australia.

3.3. Particulate Matter

Airborne or suspended particulate matter can be defined by size, chemical composition, source and whether it is primary or secondary. Primary particles include suspended fine fractions of soil by wind erosion, sea salt from evaporating sea spray, pollens and soot particles from incomplete combustion. Secondary particles include those that are formed from gas to particle conversion and include, for example, sulphate to sulphur dioxide.

Particulate matter is also defined by its size. Particle size is an important factor that influences dispersion and transport of dust emitted into the atmosphere and the consequent human health and environmental effects. Total suspended particulates (TSP) generally refer to particles of approximately 50 microns or less in equivalent aerodynamic diameter. Smaller particulates (for example, PM_{10} and $PM_{2.5}$) tend to have the most effect on children, the elderly, those with existing respiratory problems and/or people with cardiovascular problems.

Health effects of PM_{10} and $PM_{2.5}$ may include exacerbation of respiratory problems, decreased lung function, irregular heartbeat and premature death in people with heart or lung disease. Particles greater than 10 µm in diameter generally adhere to the mucous in the nose, mouth, pharynx and larger bronchi. These particles can be removed by swallowing, clearing the mouth or coughing and pose a lesser health threat than $PM_{2.5}$.

Particulate matter can enhance some chemical reactions in the atmosphere and reduce visibility. Deposition of larger particles can lead to staining and soiling of surfaces, aesthetic changes to the environment, and chemical contamination of water bodies or vegetation. Deposition can lead to forest damage, crop damage, and reduction in diversity of ecosystems and impact on personal comfort, amenity and health.

4. Emission Standards and Air Quality Criteria

Air quality impacts from industry are regulated by means of air emission standards which specify stack discharge limits and ambient air quality criteria. Typically, air quality criteria are used to assess the potential for ambient air quality to give rise to adverse health or nuisance effects.

4.1. Air Emissions Standards

The *Protection of the Environment Operations (Clean Air) Regulation 2002* (the Regulation) sets, among other parameters, the maximum limits on emissions from activities and plant for a number of substances. Activities are grouped according to the activity carried out, start date of operation and continued operation. The Mt Piper Power Station Extension belongs to Group 6. Schedule 3 of the Regulation provides standards of concentration that can be emitted from the plant (Group 6). These standards are provided in **Table 1**.

- **Table 1 Emission limits for electricity generation (Clean Air Regulation)**

Air Impurity	Activity or plant	Standard of concentration
Solid particles (Total)	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel.	50 mg/m^3
Nitrogen dioxide (NO_2) or nitric oxide (NO) or both, as NO_2 equivalent	Any boiler operating on a fuel other than gas, including a boiler used in connection with an electricity generator that forms part of an electricity generating system with a capacity of 30 MW or more.	500 mg/m^3
	Any turbine operating on gas, being a turbine used in connection with an electricity generating system with a capacity of 30 MW or more.	70 mg/m^3
Fluorine (F_2) and any compound containing fluorine, as total fluoride (HF) equivalent	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel.	50 mg/m^3
Type 1 substances and Type 2 substances (in aggregate)	Any activity or plant using a non-standard fuel.	1 mg/m^3
Cadmium (Cd) or mercury (Hg) individually	Any activity or plant using a non-standard fuel.	0.2 mg/m^3
Dioxins or furans	Any activity or plant using a non-standard fuel that contains precursors of dioxin or furan formation.	0.1 ng/m^3
Volatile organic compounds (VOCs), as n-propane equivalent	Any activity or plant using a non-standard fuel.	40 mg/m^3 VOCs or 125 mg/m^3 CO
Smoke	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel – in approved circumstances.	Ringelmann 3 or 60% opacity
	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel – in other circumstances.	Ringelmann 1 or 20% opacity

The proposed generators associated with the USC or CCGT plant options will comply with these limits. **Section 6** provides the details on stack emission rates and concentrations.

In addition to the standards defined above, the DECC has placed licence conditions on emission points at the existing power station. The Mt Piper Power Station licence states that concentrations at each discharge point must not exceed those provided in **Table 2**.

- **Table 2 Stack emission licence limits at Mt Piper Power Station**

Pollutant	Maximum concentration	Units of measure
Cadmium	0.2	mg/m^3
Chlorine	200	mg/m^3
Mercury	0.2	mg/m^3
Nitrogen oxides	1.5	g/m^3
Volatile organic compounds	40	mg/m^3
Dioxins and furans	0.1	ng/m^3
Hydrogen chloride	100	mg/m^3
Solid particles	50	mg/m^3
Sulphuric acid mist and sulphur trioxide (as SO_3)	100	mg/m^3
Total fluoride	50	mg/m^3
Type 1 and Type 2 substances in aggregate	1.0	mg/m^3

4.2. Ambient Air Quality Criteria

The DECC regulates air quality criteria in NSW. **Table 3** lists the air quality assessment criteria from the DECC that are relevant to pollutants assessed in this study (**DEC, 2005**). These levels are generally set for the protection of human health.

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Table 3 Relevant air quality assessment criteria

Pollutant	Averaging Period	Concentration (μg/m^3)
Sulphur dioxide (SO_2)	10 minutes	712
	1 hour	570
	24 hours	228
	Annual	60
Nitrogen dioxide (NO_2)	1 hour	246
	Annual	62
Carbon monoxide (CO)	1 hour	30,000
	8 hours	10,000
Photochemical oxidants (as ozone)	1 hour	214 (100 ppb)
	4 hours	171 (80 ppb)
PM_{10}	24 hours	50
	Annual	30
TSP	Annual	90
Fluoride (as hydrogen fluoride)	90 days	0.5
	30 days	0.84
	7 days	1.7
	24 hours	2.9
Antimony	1 hour	9
Arsenic	1 hour	0.09
Beryllium	1 hour	0.004
Cadmium	1 hour	0.018
Chromium III	1 hour	9
Chromium VI	1 hour	0.09
Lead	Annual	0.5
Mercury (inorganic)	1 hour	1.8
Nickel	1 hour	1.8
Dioxins and furans	1 hour	0.000002
PAH	1 hour	0.4

5. Existing Environment

For air quality assessment purposes, the existing environment of the Project area (refer **Figure 1**) can be characterised by the prevailing meteorology and the existing air quality. This section provides a review of meteorological and ambient air quality monitoring data that have been collected in the Project area. This information has been used to characterise air quality in the local airshed and to establish potential sources of air pollution. Climatic data have also been reviewed to provide a more complete picture of the local environment.

5.1. Dispersion Meteorology

Meteorology will vary across the region, particularly wind patterns. The meteorology has been incorporated into the assessment by considering data from relevant monitoring stations and extrapolating these data to other areas using a wind-field model.

Meteorological conditions are important for determining the direction and rate at which pollutant emissions will disperse. The meteorology in the Project area would be influenced by several factors including the local terrain and landuse. On a relatively small scale, winds would be largely affected by the local topography (see **Figure 2** for a representation of the local terrain). At larger scales, winds are affected by synoptic scale winds, which are modified by convective processes in the daytime and also by a complex pattern of regional drainage flows that develop overnight.

Given that the Project area contains relatively diverse terrain and land use, there would be variations in wind patterns at different locations. In the air quality assessment undertaken for this report it is not necessary to document the complex mechanisms that affect air movements in the area, it is simply necessary to ensure that these air movements are incorporated into the dispersion modelling studies that are conducted.

A limitation of common Gaussian plume dispersion models (such as AUSPLUME) is that they assume that the meteorological conditions are the same, spatially, over the entire modelling domain for any given hour. This may be adequate for sources in relatively uncomplicated terrain, although when the terrain or landuse is more complex the meteorological conditions can be more precisely represented using wind field and puff models.

This assessment has made use of the CALPUFF dispersion model. The CALPUFF model, through the CALMET meteorological processor, simulates complex meteorological patterns that exist in a particular region. The effects of local topography and changes in land surface characteristics can be incorporated into the model.

One of the objectives for reviewing local meteorological data was to assess the suitability of the data for the CALPUFF modelling. Typically, one year of hourly records will be sufficient to cover most variations in meteorology, such as seasonal variations, that will be experienced at a site. It is important, however, that the year of data available is generally representative of the prevailing meteorology.

Data from a meteorological station at the Mt Piper Power Station were assessed for suitability to the meteorological and air dispersion modelling. This station is located approximately 1 km to the north of the power station (see **Figure 1**). Measurements included hourly records of wind speed, wind direction, temperature, pressure, relative humidity and solar radiation and Delta have provided data for 2001 to 2005.

Table 4 shows a range of statistics from each year of available data. These data show that 2001 was the most complete dataset.

- **Table 4 Comparison of meteorological data statistics for 2001 to 2005**

Year	Data recovery	Mean wind speed	Percentage of calms
2001	100% (8760 hourly records)	2.5 m/s	4.9%
2002	96% (8394 hourly records)	2.4 m/s	11.8%
2003	96% (8397 hourly records)	2.4 m/s	7.0%
2004	99% (8704 hourly records)	2.2 m/s	7.4%
2005	41% (3611 hourly records)	2.1 m/s	21.2%

Wind-roses have been prepared from the meteorological data to show the pattern of winds that are experienced in the area. **Figure 4** shows the annual wind-roses from wind speed and wind direction data collected at the power station site. These wind-roses were prepared to assess the variation in wind patterns from year-to-year and it can be seen from this figure that all years between 2001 to 2005 experienced a similar pattern of winds. In all years, the most common winds were from the west-southwest.

Seasonal wind-roses have also been prepared and are shown in **Figure 5**, where wind data for 2001 were processed. The wind-roses show that winds from the west-southwest prevail in all seasons of the year although, in summer, winds from the east-southeast are also quite common. Annually, the area experiences a low proportion of calms (that is, winds less than or equal to 0.5 m/s) at around 5%.

From the above comparison of the wind patterns for the past five years, 2001 can be considered a representative year. Data for 2001 were therefore selected for development of the meteorological wind field.

Upper air data (temperature, wind speed, wind direction, pressure and height) are also required by the CALMET model. Unfortunately, there are no Bureau of Meteorology stations close to the area of interest that collect the necessary data. The closest station with these data is Sydney Airport, over 120 km to the east-southeast. In the absence of suitable upper air data sources, these data were generated by the CSIRO's prognostic model known as TAPM (The Air Pollution Model). TAPM is a prognostic model which has the ability to generate meteorological data for any location in Australia (from 1997 onwards) based on synoptic information determined from the six hourly Limited Area Prediction System (LAPS). TAPM is further discussed in the model's user manual (**Hurley, 2008**) and numerous model verification studies (see for example **Hurley 2009**).

While there is some influence of real observations to TAPM inputs (that is, through the LAPS data), it is recognised that this approach is a simulation of actual conditions. In recognition of using a prognostic model to generate upper air data, the wind extrapolation function in CALMET has been biased towards using the surface data observations for the lower, six, model levels.

A summary of the data and parameters used as part of the meteorological component of this study is shown below in **Table 5**.

- **Table 5 Summary of meteorological parameters used for this study**

TAPM (v 4.0.2)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	25 x 25 x 25
Year of analysis	Jan 2001 to Dec 2001, with one "spin-up" day
Centre of analysis	Mt Piper Power Station (33°21.5' S, 150°2' E)
Meteorological data assimilation	Wind speed and wind direction data from Mt Piper Power Station, assimilated with a horizontal radius of influence of 5 km and through the lowest 8 model levels.
CALMET (v 6.326)	
Meteorological grid domain	25 km x 25 km (50 x 50 x 10 grid dimensions)
Meteorological grid resolution	0.5 km
Surface meteorological stations	One site, using: - Wind speed and wind direction from Mt Piper Power Station - Ceiling height, temperature, relative humidity and pressure data generated for the power station site by the TAPM simulation. - Cloud cover data (total amount) from Bureau of Meteorology records for Katoomba. Seven observations per day interpolated to hourly.
Upper air meteorological station	Generated for Mt Piper Power Station by the TAPM simulation
Simulation length	8760 hours (Jan 2001 to Dec 2001)

Figure 6 shows the model extents, terrain and landuse information used as input to the CALMET model. The location of the surface meteorological station is also shown. Terrain information was extracted from the NASA Shuttle Research Topography Mission (SRTM) database which has global coverage at approximately 90 metre resolution. Landuse data were extracted from aerial imagery.

Figure 7 shows a snapshot of winds as simulated by the CALMET model for stable night-time conditions. The diagram shows the effect of the terrain on the flow of winds for a particular set of atmospheric conditions where the difference in wind speed and direction at various locations of the study area is evident.

5.2. Atmospheric Stability

Dispersion models typically require information on atmospheric stability. The atmospheric stability class is a measure of the turbulence of the atmosphere and, in the Pasquill-Gifford stability class assignment scheme, ranges from Class A to Class F. Class A is associated with highly unstable or turbulent conditions, while class F relates to stable conditions and typically at night when a temperature inversion is present.

Plume dispersion models, such as AUSPLUME, usually assume that the atmospheric stability is uniform over the entire study domain and these estimates are commonly calculated from measurements of sigma-theta, cloud cover information or solar radiation and temperature.

The CALPUFF dispersion model, however, obtains estimates of atmospheric stability from the CALMET meteorological model. CALMET determines these parameters using the cloud cover data and temperature profiles it is provided in order to run. The output of the CALMET model can subsequently be processed to extract meteorological information for any site of interest in the modelling domain, including atmospheric stability. **Table 6** provides the frequency of occurrence of the six stability classes as determined by CALMET for the power station site.

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- **Table 6 Frequency of occurrence of atmospheric stability classes**

Stability class	Frequency of occurrence, as predicted by CALMET for the Mt Piper Power Station site (%)
A	0.9
B	6.3
C	14.8
D	42.2
E	5.6
F	30.1
Total	**100**

It can be seen from **Table 6** that the most common stability class is determined to be D-class, at around 42%. Pollutant dispersion is rapid under D-class stabilities since these conditions are generally associated with overcast conditions and with moderate to strong winds.

Statistics on the frequency of wind speed, wind direction, stability class and mixing height data for the power station site, as determined by CALMET, are provided in **Appendix A**.

5.3. Climatic Information

The Bureau of Meteorology collects climatic information from Lithgow, to the east of the study area, and a range of meteorological data collected from this station is presented in **Table 7** (**Bureau of Meteorology, 2009**).

Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

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Table 7 Climatic information for Lithgow

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean maximum temperature (C)	26	25	22	18	14	11	10	12	15	19	22	25	18
Mean minimum temperature (C)	12	12	10	7	4	2	1	1	3	6	8	10	6
Mean rainfall (mm)	94	84	84	63	63	67	68	63	59	68	70	76	858
Highest rainfall (mm)	242	330	339	295	336	242	350	374	196	233	187	236	1346
Lowest rainfall (mm)	5	0	7	2	3	9	3	2	7	3	2	0	451
Mean number of days of rain	11	10	11	9	10	12	12	11	10	10	10	10	126
Mean number of clear days	7	5	7	8	7	6	8	10	9	7	7	8	90
Mean number of cloudy days	12	12	12	10	13	14	12	11	10	11	11	10	140
Mean 9am temperature (C)	19	18	16	12	9	6	5	6	10	14	16	18	12
Mean 9am relative humidity (%)	64	70	73	76	81	82	79	73	64	60	60	61	70
Mean 9am wind speed (km/h)	7	6	7	8	7	8	8	10	11	10	9	8	8
Mean 3pm temperature (C)	24	23	21	17	13	10	9	11	14	17	20	23	17
Mean 3pm relative humidity (%)	54	58	60	59	66	67	66	56	54	51	53	50	58
Mean 3pm wind speed (km/h)	10	9	9	9	10	11	11	13	13	12	11	11	11

Monthly climate statistics for Lithgow (Birdwood Street), station number 063224. Commenced: 1889; Last record: 2006; Latitude (deg S): -33.49; Longitude (deg E): 150.15; Elevation: 950 m; State: NSW. Source: ***Bureau of Meteorology, 2009.***

The data from **Table 7** show that the area is characterised by mild to warm summers and cold winters. January is typically the warmest month with a mean daily maximum temperature of 26°C. July is the coolest month with a mean daily minimum temperature of 10°C. In summer, the average maximum temperature ranges from 25 to 26°C and the minimum temperature ranges from 10 to 12°C. In winter, the average maximum temperature ranges from 10 to 12°C and the minimum temperature ranges from 1 to 2°C.

Rainfall data collected at Lithgow show that January is usually the wettest month with mean rainfall of 94 mm, falling over an average of 11 days in the month. The lowest monthly rainfall on average is September, with a mean monthly rainfall of 59 mm over 10 raindays. The mean annual rainfall is 858 mm with an average of 126 raindays each year.

5.4. Existing Air Quality

This section presents a review of air quality monitoring data that have been collected in the Project area. One objective of this review was to quantify the existing levels of air pollutants in the local and regional airshed, as relevant to the Project. The data are used as indicators of the existing air quality and can be compared with relevant air quality criteria.

At any location within the airshed the "background" pollutant concentrations are determined by the contributions from all sources that have at some stage or another been upwind of the source. In the case of PM_{10} for example, the background concentration may contain emissions from the combustion of wood from domestic heating, from bushfires, from industry, roads, wind-blown dust from nearby and remote areas, fragments of pollens, moulds, and so on. For SO_2, there may only be a few key sources that contribute to measured levels, such as power station emissions.

Air quality monitoring stations are located at Blackmans Flat and Wallerawang (refer to **Figure 1** for their locations). Historically, there has been up to six ambient air quality monitoring locations (since 1992), including sites at Bowenfels, Springvale, Cullen Bullen and Portland. In 1996, Pacific Power reviewed all monitoring data between 1992 and 1995 and found that there was no evidence to suggest that the commissioning of the Mt Piper Power Station had increased short-term or long-term NO_x and SO_2 concentrations (**Pacific Power, 1996**). The NO_x and SO_2 monitoring sites at Bowenfels, Springvale, Cullen Bullen and Portland were subsequently decommissioned. Monitoring at Blackmans Flat and Wallerawang continued as these two sites had measured the highest short-term concentrations of all sites.

The Blackmans Flat and Wallerawang sites record hourly averages of total NO_x, NO_2, NO and SO_2. Data for 2001 are discussed in this section to provide consistency with modelled year of meteorology. **Table 8** provides a summary of the air quality monitoring data for 2001.

- **Table 8 Summary of ambient air quality monitoring for 2001**

Pollutant and averaging time	Blackmans Flat	Wallerawang	DECC assessment criteria ($\mu g/m^3$)
Maximum 1-hour average NO_x ($\mu g/m^3$)	302	269	-
Annual average NO_x ($\mu g/m^3$)	16	16	-
Maximum 1-hour average NO_2 ($\mu g/m^3$)	79	59	246
Annual average NO_2 ($\mu g/m^3$)	10	10	62
Maximum 1-hour average SO_2 ($\mu g/m^3$)	353	424	570
Maximum 24-hour average SO_2 ($\mu g/m^3$)	70	47	228
Annual average SO_2 ($\mu g/m^3$)	13	7	60

The monitored levels shown in **Table 8** would have contained contributions from all sources relevant to the monitoring location, including but not limited to power station emissions, motor vehicles, and agricultural and construction activities. The sources that may have contributed to the monitored levels need to be considered when determining background levels to ensure that there is minimal “double-counting” if model predictions are to be added.

These concentrations are relevant to each monitoring location, and it should be noted that although these sites have historically measured the highest levels of all past monitoring locations, it is possible that they may not necessarily be the location of maximum impacts due to power station emissions. The Blackmans Flat and Wallerawang sites are, however, positioned to monitor ambient levels in the closest populated areas to the power stations.

5.4.1. Nitrogen Dioxide

The monitoring data from Blackmans Flat and Wallerawang (**Table 8**) show that NO_2 concentrations are well below DECC criteria. Maximum 1-hour average concentrations have reached 79 µg/m^3 at Blackmans Flat and 59 µg/m^3 at Wallerawang, both of which are below the 246 µg/m^3 criterion. Similarly, annual average NO_2 concentrations have not exceeded the DECC's 62 µg/m^3 criterion.

Figure 9 shows a time series of hourly average NO_2 (and NO_x) concentrations from both monitoring sites. This figure clearly shows the variation in levels over time. It is also important to note the fraction of NO_2 in the NO_x, when the NO_x concentration is at a maximum. Typically the NO_2 fraction is around 20%. This fraction is discussed in more detail in **Section 9.2**.

Also shown in **Figure 9** are pollution roses which illustrate hourly NO_x concentrations with wind direction. Pollution roses are often useful for identifying the direction of pollution sources relative to monitoring locations. It can be seen from the roses that, at Blackmans Flat, the maximum NO_x level occurred with winds from the north, potentially influenced by Mt Piper emissions, but the link between winds from power stations and high concentrations is not strong. At Wallerawang, the highest NO_x concentrations occurred when the winds were from the west-northwest and while this is not the direction to either the Mt Piper or Wallerawang power stations, it is possible that some recirculation of stack pollutants has influenced the monitored levels.

A summary of the NO_x monitoring data from 2002 to 2008 has also been obtained and these records are shown in **Table 9**. It can be seen from these data that annual average NO_x (NO_2 data were not available) concentrations have remained relatively constant at Blackmans Flat while average levels at Wallerawang have fallen in recent years. Maximum 1-hour concentrations show some large fluctuations from year to year. No further analysis has been undertaken on these data.

- **Table 9 Summary of NO_x monitoring data from 2002 to 2008**

Year	Blackmans Flat		Wallerawang	
	Annual average NO_x (µg/m^3)	Maximum 1-hour average NO_x (µg/m^3)	Annual average NO_x (µg/m^3)	Maximum 1-hour average NO_x (µg/m^3)
2002	14	474	18	285
2003	8	303	2	211
2004	14	215	14	189
2005	16	387	14	248
2006	14	730	4	482
2007	14	529	4	316
2008	14	703	4	451

5.4.2. Sulphur Dioxide

The monitoring data from Blackmans Flat and Wallerawang (**Table 8**) show that SO_2 concentrations are below DECC criteria. Maximum 1-hour average concentrations have reached 353 µg/m^3 at Blackmans Flat and 424 µg/m^3 at Wallerawang, both of which are below the 570 µg/m^3 criterion. Similarly, 24-hour average and annual average SO_2 concentrations have not exceeded their respective DECC criteria.

Figure 9 shows a time series of hourly average SO_2 concentrations from both monitoring sites. This figure clearly shows that, in 2001, monitored concentrations were below the DECC criterion of 570 µg/m^3. The pollution roses show that, at Blackmans Flat, maximum hourly levels occurred with winds from the northwest and north, which (the northwest winds) suggests that SO_2 emissions from Mt Piper are detectable at Blackmans Flat but again, the link between winds from power stations and high concentrations is not strong.

At the Wallerawang monitoring site, the highest SO_2 concentration occurred when the wind direction (at Mt Piper) was from the west-northwest. This direction is not consistent with the directions to either the Mt Piper or Wallerawang power stations, although there were also some elevated concentrations under north-northwest and east-northeast winds that could be more definitively linked to Mt Piper or Wallerawang power station emissions.

A summary of the SO_2 monitoring data from 2002 to 2008 has also been obtained and these records are shown in **Table 10**. As for recent NO_x monitoring results, the annual averages have remained relatively constant at Blackmans Flat, while average levels at Wallerawang have shown some larger fluctuations. An exceedance of the 570 µg/m^3 criteria was recorded at Blackmans Flat in 2002 although hourly records were not available to carry out a more detailed assessment of this event; that is, to potentially identify the contributing source. Similarly, two exceedances of the 1-hour average SO_2 criteria were recorded at Wallerawang in 2003 and 2006 and there have been some large fluctuations in the maximum 1-hour concentrations. No further analysis has been undertaken on these data.

Table 10 Summary of SO_2 monitoring data from 2002 to 2008

Year	Blackmans Flat		Wallerawang	
	Annual average SO_2 ($\mu g/m^3$)	Maximum 1-hour average SO_2 ($\mu g/m^3$)	Annual average SO_2 ($\mu g/m^3$)	Maximum 1-hour average SO_2 ($\mu g/m^3$)
2002	6	**712**	6	423
2003	5	309	19	**595**
2004	6	363	3	246
2005	6	249	6	257
2006	6	452	23	**684**
2007	6	363	17	458
2008	6	489	17	526

6. Emission Estimates

Pollution emissions due to the Mt Piper Extension will arise from the combustion of coal in the USC case or from the combustion of gas in the CCGT case. It is anticipated that NO_x and SO_2 concentrations will be the most critical pollutants for the Project. Other pollutants (CO, TSP, HF and individual air toxics) are also discussed, but the assessment places less emphasis on these pollutants, due to significantly lower impacts, as will be demonstrated by the model results.

The CALPUFF dispersion model requires information on the source location, the source height, internal source tip diameter, temperature of emissions, exit velocity of emissions and the mass emission rate of the pollutants to be assessed. Temperature, exit velocity and mass emissions rates can be provided to the model as hourly records for an entire year (variable emissions) or as constant emissions. In this study, constant emissions have been used for providing consistency when comparing the model scenarios.

Table 11 shows the assumed stack source and emission characteristics, as used in the dispersion modelling. The emissions assume that the power stations are operating continuously under full load. This is a conservative approach, in particular for predicting long-term concentrations, as there may be times when the power stations operate at less than full load. An added element of conservatism is that the effect of enhanced buoyancy due to the merging of exhaust stack plumes has not been modelled.

Emissions for the USC option were calculated by assuming the flue gas concentrations remain the same as for the existing Mt Piper A stack, except in the case of NO_x where a 500 mg/Nm^3 limit was set. The USC plant was assumed to be 7% more efficient[1] (per MW) than the existing plant and the flow rates were scaled up accordingly (that is, by 1000/660/1.07).

Table 11 shows that the in-stack emissions concentrations comply with both the *Protection of the Environment Operations (Clean Air) Regulation* as well as with the current Mt Piper licence requirements.

[1] Based on an average condenser pressure of 10 kPa or higher, with a design efficiency of approximately 40.5%, and using the highest steam conditions currently in service, gives a reduction of 7% on Mt Piper design value.

Table 11 Assumed emission characteristics for the dispersion modelling

	Mt Piper Power Station								Wallerawang Power Station	
	Existing	USC option	Combined cycle gas turbine option							
	Mt Piper A 2x660MW	Mt Piper B 2x1000MW	GT1	GT2	GT3	GT4	GT5	GT6	Stack 1	Stack 2
MGA Easting (m)	223805	223476	223416	223446	223476	223506	223535	223567	228726	228795
MGA Northing (m)	6305070	6305183	6304704	6304792	6304879	6304964	6305053	6305143	6300324	6300279
Height (m)	250	250	40	40	40	40	40	40	177	177
Base elevation (m)	946	941	942	942	942	941	942	942	883	884
Diameter (m)	11.12	13	6.44	6.44	6.44	6.44	6.44	6.44	6.96	6.96
Cross sectional area (m^2)	97.1	132.7	32.6	32.6	32.6	32.6	32.6	32.6	38.0	38.0
Temperature (C)	124.0	124.0	88	88	88	88	88	88	121	121
Flow rate (Nm^3/s)	1469	2080	519	519	519	519	519	519	696	612
Velocity (m/s)	22.00	22.79	21.1	21.1	21.1	21.1	21.1	21.1	26.4	23.2
Temperature (K)	397	397	361	361	361	361	361	361	394	394
Mass emission rates (g/s)										
NO_x	1422	1040.2	28.9	28.9	28.9	28.9	28.9	28.9	366.4	368.6
SO_2	1550	2194.8							716.0	720.0
CO			5.3	5.3	5.3	5.3	5.3	5.3		
TSP	23	32.6							34.0	34.1
PM_{10}	1.25	1.8							2.7	2.7
Fluoride	10	14.2							2.3	2.3
Antimony	1.8E-04	2.5E-04							1.6E-04	1.6E-04
Arsenic	7.3E-04	1.0E-03							6.7E-04	6.7E-04
Beryllium	2.4E-04	3.4E-04							4.1E-04	4.1E-04
Cadmium	4.7E-04	6.7E-04							2.9E-04	2.9E-04
Chromium III	1.8E-03	2.5E-03							3.1E-03	3.1E-03
Chromium IV	9.0E-05	1.3E-04							1.6E-04	1.6E-04
Lead	2.3E-03	3.2E-03							4.6E-03	4.6E-03
Mercury (inorganic)	8.7E-03	1.2E-02							3.8E-04	3.8E-04

	Mt Piper Power Station								Wallerawang Power Station	
	Existing	USC option	Combined cycle gas turbine option							
	Mt Piper A 2x660MW	Mt Piper B 2x1000MW	GT1	GT2	GT3	GT4	GT5	GT6	Stack 1	Stack 2
Nickel	6.9E-03	9.8E-03							3.1E-03	3.1E-03
Dioxins (x 10-6)	1.3E+00	1.8E+00								
PAHs	1.3E-03	1.9E-03								
In-stack concentrations (mg/Nm^3)										
NO_x	968	500	56*	56*	56*	56*	56*	56*	526	603
SO_2	1055	1055							1029	1177
CO			10	10	10	10	10	10		
TSP	1.6E+01	1.6E+01							4.9E+01	5.6E+01
PM_{10}	8.5E-01	8.5E-01							3.9E+00	4.4E+00
Fluoride	6.8E+00	6.8E+00							3.3E+00	3.8E+00
Antimony	1.2E-04	1.2E-04							2.3E-04	2.6E-04
Arsenic	5.0E-04	5.0E-04							9.6E-04	1.1E-03
Beryllium	1.6E-04	1.6E-04							5.9E-04	6.7E-04
Cadmium	3.2E-04	3.2E-04							4.2E-04	4.7E-04
Chromium III	1.2E-03	1.2E-03							4.5E-03	5.1E-03
Chromium IV	6.1E-05	6.1E-05							2.3E-04	2.6E-04
Lead	1.5E-03	1.5E-03							6.6E-03	7.5E-03
Mercury (inorganic)	5.9E-03	5.9E-03							5.5E-04	6.2E-04
Nickel	4.7E-03	4.7E-03							4.4E-03	5.0E-03
Dioxins (x 10-6)	8.8E-01	8.8E-01								
PAHs	9.0E-04	9.0E-04								

** 51 mg/Nm^3 at 15% O_2*

The emissions for all sources shown in **Table 11** have been assumed to be constant for every hour of the modelled year.

Table 12 shows the key model scenarios that were developed for the cumulative assessment. Predicted contributions from the individual sources have also been presented in tabular form.

Table 12 Cumulative model scenarios

Scenario and description	Source			
	Mt Piper A	Mt Piper B (USC)	CCGT x 6	Wallerawang
Scenario 1 (Mt Piper and Wallerawang)*	X			X
Scenario 2 (Mt Piper and USC)*	X	X		
Scenario 3 (Mt Piper and CCGT)*	X		X	
Scenario 4 (Mt Piper, USC and Wallerawang)	X	X		X
Scenario 5 (Mt Piper, GGCT and Wallerawang)	X	X		X

** Denotes the scenarios that were developed into contour plots*

It should be noted that the emissions for the existing Mt Piper turbines relate to two 660 MW units. These two units have subsequently been upgraded and now operate at 700 MW each at full capacity. SKM analysed existing measurements of in-stack NO_x concentrations for Units 1 and 2 and used these data to extrapolate potential concentrations at 700 MW (**SKM, 2008**). The analysis suggested that in-stack NO_x concentrations will have increased by between 4 and 7% over the modelled existing Mt Piper source. These changes are indicative of expected changes to model predictions for the existing Mt Piper source.

7. Emission Control Technologies

For conservatism, no additional emission control measures (over the proposed technology) have been assumed for modelling the USC and CCGT plants. It is useful, however, to identify the technologies which can be used to minimise emissions. Four emission control technologies are discussed below.

7.1. Low NO_x Combustors

Low NO_x combustors are an effective NO_x emissions control technique. In most jurisdictions, the use of low NO_x combustors for gas firing would be considered best available control technology (BACT) for NO_x emissions from gas turbines (**SKM, 2007**). The emission estimates for the CCGT modelling in this assessment assume dry low NO_x (DLN) combustors are being used.

In DLN burners, the formation of thermal NO_x is reduced by creating lean-premix conditions in the combustion system to reduce the flame temperature. The combustion process is controlled such that temperatures above 1500°C are avoided and relatively little NO_x is generated.

In NSW the *Clear Air Plant Equipment Regulation 2002* requires that all new gas turbine plants (Group 6) achieve less than 25 ppm (51 mg/Nm^3) NO_x on gas. This is consistent with what is achievable for DLN systems. The option for a CCGT plant will incorporate DLN burners. For coal-fired boilers, the *Clear Air Plant Equipment Regulation 2002* specifies a limit of 500 mg/Nm^3 NO_x, based on low NO_x combustors.

7.2. Selective Catalytic Reduction

While DLN is probably the most widely used NO_x control in gas turbine power plants, selective catalytic reduction (SCR) is also an effective mechanism for reducing NO_x emissions. SCR is a post-combustion process that is used to convert NO_x, with the presence of a catalyst, into diatomic nitrogen (N_2) and water (H_2O). A gaseous reductant is also added to the flue gas stream which is absorbed onto the catalyst. Commercial SCR systems may typically reduce NO_x emissions by 70 to 95% for coal-fired power stations.

Capital cost estimates are of the order of US$50-110 per kW (assume US$80), with operating and maintenance costs ranging between US$1.6-3.2M per boiler per year (assume $2.4M). Applying these data to the proposed 2,000 MW of capacity from the two coal-fired boilers will result in an additional capital cost of approximately US$160M. Operating and maintenance costs will be in the order of US$4.8M per year.

SKM has estimated the capital cost of SCR for a 400 MW class CCGT at approximately AU$22.4M (**SKM, 2007**), which equates to approximately AU$134.4M for six turbines.

SKM

7.3. Flue Gas Desulphurisation

Flue gas desulphurisation (FGD) is a technology for removing SO_2 emissions, mainly from exhaust flue gases associated with coal or oil fired power plants. There are a variety of methods with the most common being:

- Wet scrubbing using a slurry of alkaline sorbent;
- Spray-dry scrubbing using similar sorbents;
- Wet sulphuric acid process; and
- Dry sorbent injection systems.

For a typical coal-fired power station, FGD will remove 95% or more of the SO_2 in the flue gases. No specific capital or operating and maintenance costs have been determined for FGD on the USC plant for this assessment, although it is estimated that these costs may be in the range of US$200-4000 per tonne of SO_2 removed, depending on the SO_2 removal method.

7.4. Fabric Filters

Fabric filters, or baghouses, use filtration to remove particulates from exhaust gases. They are one of the most efficient types of dust collectors available with collection efficiencies of 99% or more for fine particulates. The option for a coal-fired (USC) plant will incorporate fabric filters and particulate emissions will be maintained below the *Clear Air Plant Equipment Regulation 2002* limit of 50 mg/Nm^3.

7.5. Application of Emission Control Technologies

The discussion above shows that there are some commercially available technologies that can further reduce NO_x and SO_2 emissions from the proposed USC or CCGT plants. The review also highlights a potentially high cost with implementation and operation of some of these technologies, relative to the initial capital costs.

It will be seen later (**Section 9**) that based on the historical monitoring data, the conservatism in the modelling and from the current and historical performance of the model, the Project is unlikely to adversely affect air quality for either the USC or CCGT options. These conclusions were reached with the currently proposed technology, and assumed emissions data from **Table 11**, that is, DLN for the CCGT plant and low NO_x combustors and fabric filters for the USC plant.

8. Assessment Methodology

This assessment has followed the DECC's *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (**DEC, 2005**), which provides guidance on how air quality impact assessments should be undertaken. The approach taken in this assessment follows the approach suggested by the guidelines and the following sections describe the way in which a computer-based dispersion model has been used to predict ground-level pollutant concentrations, due to modelled emission sources.

Ground-level pollutant concentrations have been predicted using CALPUFF (Version 6.263). CALPUFF is a Lagrangian dispersion model that simulates the dispersion of emissions by representing emissions as a series of puffs emitted sequentially. Provided the rate at which the puffs are emitted is sufficiently rapid, the puffs will overlap and the serial release will represent a continuous release.

The CALPUFF model differs from traditional Gaussian plume models (such as AUSPLUME and ISCST3) in that it can model spatially varying wind and turbulence fields that are important in complex terrain, long-range transport and near calm conditions. It is the preferred model of the US Environmental Protection Agency for the long-range transport of pollutants and for complex terrain (**TRC, 2007**). CALPUFF has the ability to model the effect of emissions entrained into the thermal internal boundary layer that forms over land, both through fumigation and plume trapping.

The modelling has been performed using the meteorological information provided by the CALMET model (**Section 5.1**) and the emission information from **Section 6**. The way in which the model has been used in this study has been to predict the pollutant concentrations at a set of receptors covering a region of 25 km by 25 km. Gridded receptors with spacing of 500 m were used for the entire model domain while a finer spaced set of discrete receptors was added for areas close to the Mt Piper and Wallerawang power stations. Spacing between the discrete receptors was set finer (approximately 100 m spacing) in areas closer to the emission sources and coarser in areas further from sources. The receptor spacing and locations have been chosen to provide high resolution model output where needed. Predictions were made at ground-level and relevant local building effects were included.

Dispersion coefficients have used turbulence computed from micrometeorology and, for tall (say, greater than 100 m) sources with buoyant plumes, the probability density function (PDF) was enabled. Partial plume path was used for terrain adjustment.

Contour plots have been prepared showing the distribution of predicted concentrations and the results have been compared with the relevant air quality criteria (refer **Section 4**).

9. Assessment of Impacts

This section provides an assessment of the air quality impacts associated with the Mt Piper Extension Project.

9.1. Model Results

The dispersion modelling has been undertaken using the emissions data from **Section 6** and the meteorological information described in **Section 5.1**. Model results have been presented in both tabular form and as contour plots. To assess the potential impacts of the Project, the modelling results have been compared to the relevant air quality criteria.

The results are shown as contour plots in **Figure 10** to **Figure 17** and are summarised in **Table 13**.

Table 13 clearly shows that NO_2 and SO_2 have the highest potential to cause exceedances of the DECC criteria. These pollutants are the focus of the assessment. All other pollutants are predicted to comply with DECC by one or more orders of magnitude at the most affected ground-level location for all assessment scenarios.

Table 13 Summary of dispersion model results

Pollutant and averaging time	Individual contributions				Cumulative scenarios (showing the sources included)				
	MP-A	MP-B (USC)	MP-CCGT	Wallerawang	MP-A, Wallerawang	MP-A, MP-B (USC)	MP-A, MP-CCGT	MP-A, MP-B (USC), Wallerawang	MP-A, MP-CCGT, Wallerawang
1-hour average NO_X (μg/m^3)									
Highest GLC in model domain	829	660	334	904	919	1128	830	1218	919
Highest GLC at Blackmans Flat	135	51	162	151	167	178	162	189	173
Highest GLC at Wallerawang	98	62	117	881	881	132	117	881	881
Air quality criteria	-	-	-	-	-	-	-	-	-
1-hour average NO_2 (μg/m^3) (assumes that 30% of the NO_x is NO_2)									
Highest GLC in model domain (maximum no. hours above criterion)	**249 (1)**	198 (0)	100 (0)	**271 (1)**	**276 (1)**	**338 (2)**	**249 (1)**	**365 (2)**	**276 (1)**
Highest GLC at Blackmans Flat	40	15	49	45	50	53	49	57	52
Highest GLC at Wallerawang	29	19	35	**264**	**264**	40	35	**264**	**264**
Air quality criteria	246	246	246	246	246	246	246	246	246
Annual average NO_X (μg/m^3)									
Highest GLC in model domain	2.1	1.0	8.7	4.8	5.7	3.1	9.2	6.1	10.2
GLC at Blackmans Flat	0.8	0.3	1.1	0.7	1.5	1.1	1.9	1.9	2.6
GLC at Wallerawang	0.8	0.3	1.0	0.9	1.6	1.1	1.8	2.0	2.6
Air quality criteria	62	62	62	62	62	62	62	62	62
10-minute average SO_2 (μg/m^3)*									
Highest GLC in model domain (maximum no. hours above criterion)	**1293 (2)**	**1993 (3)**	-	**2527 (5)**	**2527 (5)**	**2439 (5)**	**1293 (2)**	**2665 (6)**	**2527 (5)**
Highest GLC at Blackmans Flat	210	155	-	421	424	340	210	481	424
Highest GLC at Wallerawang	153	187	-	**2462**	**2462**	**296**	**153**	**2462**	**2462**
Air quality criteria	712	712	712	712	712	712	712	712	712

Pollutant and averaging time	Individual contributions				Cumulative scenarios (showing the sources included)				
	MP-A	MP-B (USC)	MP-CCGT	Wallerawang	MP-A, Wallerawang	MP-A, MP-B (USC)	MP-A, MP-CCGT	MP-A, MP-B (USC), Wallerawang	MP-A, MP-CCGT, Wallerawang
1-hour average SO_2 (μg/m^3)									
Highest GLC in model domain (maximum no. hours above criterion)	**904 (2)**	**1393 (2)**	- (0)	**1767 (5)**	**1767 (5)**	**1706 (4)**	**904 (2)**	**1864 (5)**	**1767 (5)**
Highest GLC at Blackmans Flat	147	108	-	295	296	238	147	336	296
Highest GLC at Wallerawang	107	131	-	**1722**	**1722**	207	107	**1722**	**1722**
Air quality criteria	570	570	570	570	570	570	570	570	570
24-hour average SO_2 (μg/m^3)									
Highest GLC in model domain	57	82	-	135	136	139	57	148	136
Highest GLC at Blackmans Flat	16	15	-	37	41	26	16	45	41
Highest GLC at Wallerawang	18	19	-	78	84	36	18	90	84
Air quality criteria	228	228	228	228	228	228	228	228	228
Annual average SO_2 (μg/m^3)									
Highest GLC in model domain	2.2	2.2	-	9.4	10.4	4.4	2.2	11.2	10.4
GLC at Blackmans Flat	0.9	0.7	-	1.5	2.3	1.6	0.9	3.0	2.3
GLC at Wallerawang	0.9	0.7	-	1.7	2.5	1.6	0.9	3.2	2.5
Air quality criteria	60	60	60	60	60	60	60	60	60
1-hour average CO (μg/m^3)									
Highest GLC in model domain	-	-	61	-	-	-	61	-	61
Highest GLC at Blackmans Flat	-	-	30	-	-	-	30	-	30
Highest GLC at Wallerawang	-	-	21	-	-	-	21	-	21
Air quality criteria	30000	30000	30000	30000	30000	30000	30000	30000	30000
8-hour average CO (μg/m^3)									
Highest GLC in model domain	-	-	23	-	-	-	23	-	23
Highest GLC at Blackmans Flat	-	-	4	-	-	-	4	-	4
Highest GLC at Wallerawang	-	-	4	-	-	-	4	-	4
Air quality criteria	10000	10000	10000	10000	10000	10000	10000	10000	10000

Pollutant and averaging time	Individual contributions				Cumulative scenarios (showing the sources included)				
	MP-A	MP-B (USC)	MP-CCGT	Wallerawang	MP-A, Wallerawang	MP-A, MP-B (USC)	MP-A, MP-CCGT	MP-A, MP-B (USC), Wallerawang	MP-A, MP-CCGT, Wallerawang
Annual average TSP (µg/m^3)									
Highest GLC in model domain	3.3E-02	3.2E-02	-	4.4E-01	4.6E-01	6.5E-02	3.3E-02	4.7E-01	4.6E-01
GLC at Blackmans Flat	1.3E-02	1.0E-02	-	6.9E-02	8.2E-02	2.3E-02	1.3E-02	9.2E-02	8.2E-02
GLC at Wallerawang	1.3E-02	1.0E-02	-	7.9E-02	9.2E-02	2.3E-02	1.3E-02	1.0E-01	9.2E-02
Air quality criteria	90	90	90	90	90	90	90	90	90
24-hour average PM_{10} (µg/m^3)									
Highest GLC in model domain	4.6E-02	6.7E-02	-	5.1E-01	5.1E-01	1.1E-01	4.6E-02	5.1E-01	5.1E-01
Highest GLC at Blackmans Flat	1.3E-02	1.2E-02	-	1.4E-01	1.4E-01	2.1E-02	1.3E-02	1.4E-01	1.4E-01
Highest GLC at Wallerawang	1.5E-02	1.6E-02	-	2.9E-01	3.0E-01	2.9E-02	1.5E-02	3.0E-01	3.0E-01
Air quality criteria	50	50	50	50	50	50	50	50	50
Annual average PM_{10} (µg/m^3)									
Highest GLC in model domain	1.8E-03	1.8E-03	-	3.5E-02	3.6E-02	3.6E-03	1.8E-03	3.7E-02	3.6E-02
GLC at Blackmans Flat	6.9E-04	5.7E-04	-	5.5E-03	6.2E-03	1.3E-03	6.9E-04	6.8E-03	6.2E-03
GLC at Wallerawang	6.9E-04	5.7E-04	-	6.3E-03	7.0E-03	1.3E-03	6.9E-04	7.6E-03	7.0E-03
Air quality criteria	30	30	30	30	30	30	30	30	30
24-hour average Fluoride (as HF) (µg/m^3)									
Highest GLC in model domain	3.7E-01	5.3E-01	-	4.3E-01	4.4E-01	9.0E-01	3.7E-01	9.3E-01	4.4E-01
Highest GLC at Blackmans Flat	1.0E-01	9.5E-02	-	1.2E-01	1.5E-01	1.7E-01	1.0E-01	2.0E-01	1.5E-01
Highest GLC at Wallerawang	1.2E-01	1.2E-01	-	2.5E-01	2.9E-01	2.3E-01	1.2E-01	3.3E-01	2.9E-01
Air quality criteria	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
7 day average Fluoride (as HF) (µg/m^3)									
Highest GLC in model domain	7.9E-02	8.4E-02	-	1.3E-01	1.5E-01	1.6E-01	7.9E-02	1.6E-01	1.5E-01
Highest GLC at Blackmans Flat	2.3E-02	1.9E-02	-	3.2E-02	3.8E-02	4.2E-02	2.3E-02	4.5E-02	3.8E-02
Highest GLC at Wallerawang	3.0E-02	3.3E-02	-	5.0E-02	7.1E-02	6.3E-02	3.0E-02	1.0E-01	7.1E-02
Air quality criteria	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Pollutant and averaging time	Individual contributions				Cumulative scenarios (showing the sources included)				
	MP-A	MP-B (USC)	MP-CCGT	Wallerawang	MP-A, Wallerawang	MP-A, MP-B (USC)	MP-A, MP-CCGT	MP-A, MP-B (USC), Wallerawang	MP-A, MP-CCGT, Wallerawang
30 day average Fluoride (as HF) (μg/m^3)									
Highest GLC in model domain	4.2E-02	4.5E-02	-	7.7E-02	8.9E-02	8.7E-02	4.2E-02	1.0E-01	8.9E-02
Highest GLC at Blackmans Flat	1.2E-02	1.1E-02	-	1.1E-02	1.6E-02	2.3E-02	1.2E-02	2.8E-02	1.6E-02
Highest GLC at Wallerawang	1.5E-02	1.5E-02	-	1.4E-02	2.8E-02	3.0E-02	1.5E-02	4.3E-02	2.8E-02
Air quality criteria	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
1-hour average Antimony (μg/m^3) (99.9th percentile)									
Highest GLC in model domain	2.4E-05	2.2E-05	-	9.7E-05	9.7E-05	4.2E-05	2.4E-05	9.7E-05	9.7E-05
Highest GLC at Blackmans Flat	9.3E-06	7.7E-06	-	4.6E-05	4.6E-05	1.7E-05	9.3E-06	4.6E-05	4.6E-05
Highest GLC at Wallerawang	9.2E-06	9.2E-06	-	6.2E-05	6.2E-05	1.9E-05	9.2E-06	6.2E-05	6.2E-05
Air quality criteria	9	9	9	9	9	9	9	9	9
1-hour average Arsenic (μg/m^3) (99.9th percentile)									
Highest GLC in model domain	9.6E-05	8.8E-05	-	4.0E-04	4.0E-04	1.7E-04	9.6E-05	4.0E-04	4.0E-04
Highest GLC at Blackmans Flat	3.8E-05	3.1E-05	-	1.9E-04	1.9E-04	6.9E-05	3.8E-05	1.9E-04	1.9E-04
Highest GLC at Wallerawang	3.7E-05	3.7E-05	-	2.6E-04	2.6E-04	7.6E-05	3.7E-05	2.6E-04	2.6E-04
Air quality criteria	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
1-hour average Berylium (μg/m^3) (99.9th percentile)									
Highest GLC in model domain	3.2E-05	3.0E-05	-	2.5E-04	2.5E-04	5.7E-05	3.2E-05	2.5E-04	2.5E-04
Highest GLC at Blackmans Flat	1.2E-05	1.0E-05	-	1.2E-04	1.2E-04	2.3E-05	1.2E-05	1.2E-04	1.2E-04
Highest GLC at Wallerawang	1.2E-05	1.3E-05	-	1.6E-04	1.6E-04	2.5E-05	1.2E-05	1.6E-04	1.6E-04
Air quality criteria	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1-hour average Cadmium (μg/m^3) (99.9th percentile)									
Highest GLC in model domain	6.2E-05	5.9E-05	-	1.8E-04	1.8E-04	1.1E-04	6.2E-05	1.8E-04	1.8E-04
Highest GLC at Blackmans Flat	2.4E-05	2.1E-05	-	8.4E-05	8.4E-05	4.5E-05	2.4E-05	8.4E-05	8.4E-05
Highest GLC at Wallerawang	2.4E-05	2.5E-05	-	1.1E-04	1.1E-04	5.0E-05	2.4E-05	1.2E-04	1.1E-04
Air quality criteria	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018

Pollutant and averaging time	Individual contributions				Cumulative scenarios (showing the sources included)				
	MP-A	MP-B (USC)	MP-CCGT	Wallerawang	MP-A, Wallerawang	MP-A, MP-B (USC)	MP-A, MP-CCGT	MP-A, MP-B (USC), Wallerawang	MP-A, MP-CCGT, Wallerawang
1-hour average Chromium III (μg/m^3) (99.9th percentile)									
Highest GLC in model domain	2.4E-04	2.2E-04	-	1.9E-03	1.9E-03	4.2E-04	2.4E-04	1.9E-03	1.9E-03
Highest GLC at Blackmans Flat	9.3E-05	7.7E-05	-	9.0E-04	9.0E-04	1.7E-04	9.3E-05	9.0E-04	9.0E-04
Highest GLC at Wallerawang	9.2E-05	9.2E-05	-	1.2E-03	1.2E-03	1.9E-04	9.2E-05	1.2E-03	1.2E-03
Air quality criteria	9	9	9	9	9	9	9	9	9
1-hour average Chromium VI (μg/m^3) (99.9th percentile)									
Highest GLC in model domain	1.2E-05	1.1E-05	-	9.7E-05	9.7E-05	2.2E-05	1.2E-05	9.7E-05	9.7E-05
Highest GLC at Blackmans Flat	4.6E-06	4.0E-06	-	4.6E-05	4.6E-05	8.7E-06	4.6E-06	4.6E-05	4.6E-05
Highest GLC at Wallerawang	4.6E-06	4.8E-06	-	6.2E-05	6.2E-05	9.7E-06	4.6E-06	6.2E-05	6.2E-05
Air quality criteria	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Annual average Lead (μg/m^3)									
Highest GLC in model domain	3.3E-06	3.2E-06	-	6.0E-05	6.1E-05	6.5E-06	3.3E-06	6.3E-05	6.1E-05
GLC at Blackmans Flat	1.3E-06	1.0E-06	-	9.4E-06	1.1E-05	2.3E-06	1.3E-06	1.2E-05	1.1E-05
GLC at Wallerawang	1.3E-06	1.0E-06	-	1.1E-05	1.2E-05	2.3E-06	1.3E-06	1.3E-05	1.2E-05
Air quality criteria	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1-hour average Mercury (μg/m^3) (99.9th percentile)									
Highest GLC in model domain	1.1E-03	1.1E-03	-	2.3E-04	1.2E-03	2.0E-03	1.1E-03	2.1E-03	1.2E-03
Highest GLC at Blackmans Flat	4.5E-04	3.7E-04	-	1.1E-04	4.6E-04	8.2E-04	4.5E-04	8.2E-04	4.6E-04
Highest GLC at Wallerawang	4.4E-04	4.4E-04	-	1.5E-04	4.7E-04	9.1E-04	4.4E-04	9.1E-04	4.7E-04
Air quality criteria	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
1-hour average Nickel (μg/m^3) (99.9th percentile)									
Highest GLC in model domain	9.1E-04	8.7E-04	-	1.9E-03	1.9E-03	1.6E-03	9.1E-04	1.9E-03	1.9E-03
Highest GLC at Blackmans Flat	3.6E-04	3.0E-04	-	9.0E-04	9.0E-04	6.6E-04	3.6E-04	9.5E-04	9.0E-04
Highest GLC at Wallerawang	3.5E-04	3.6E-04	-	1.2E-03	1.2E-03	7.3E-04	3.5E-04	1.3E-03	1.2E-03
Air quality criteria	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8

Pollutant and averaging time	Individual contributions				Cumulative scenarios (showing the sources included)				
	MP-A	MP-B (USC)	MP-CCGT	Wallerawang	MP-A, Wallerawang	MP-A, MP-B (USC)	MP-A, MP-CCGT	MP-A, MP-B (USC), Wallerawang	MP-A, MP-CCGT, Wallerawang
1-hour average Dioxins (µg/m^3) (99.9th percentile)									
Highest GLC in model domain	1.7E-07	1.6E-07	-	-	1.7E-07	3.1E-07	1.7E-07	3.1E-07	1.7E-07
Highest GLC at Blackmans Flat	6.7E-08	5.5E-08	-	-	6.7E-08	1.2E-07	6.7E-08	1.2E-07	6.7E-08
Highest GLC at Wallerawang	6.6E-08	6.6E-08	-	-	6.6E-08	1.4E-07	6.6E-08	1.4E-07	6.6E-08
Air quality criteria	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06
1-hour average PAHs (µg/m^3) (99.9th percentile)									
Highest GLC in model domain	1.7E-04	1.7E-04	-	-	1.7E-04	3.1E-04	1.7E-04	3.1E-04	1.7E-04
Highest GLC at Blackmans Flat	6.7E-05	5.8E-05	-	-	6.7E-05	1.3E-04	6.7E-05	1.3E-04	6.7E-05
Highest GLC at Wallerawang	6.6E-05	7.0E-05	-	-	6.6E-05	1.4E-04	6.6E-05	1.4E-04	6.6E-05
Air quality criteria	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

GLC = Ground-level concentration

** 10-minute averages were determined from the 1-hour averages according to the empirical relationship below (VEPA, 1986):*

$$C_t = C_{60}\left[\frac{60}{t}\right]^{0.2}$$

where:
C_t = Concentration for time, t
C_{60} = Concentration for averaging time, 60 minutes
t = time, in minutes

SKM

9.2. Model Performance Assessment

The performance of the model has been investigated by comparing the results with monitored data, for the Blackmans Flat and Wallerawang monitoring sites. The purpose of the performance assessment was to gauge how close the model predictions might be to actual levels (as measured), both with and without the Project.

The comparison is shown below in **Table 14**, where cumulative model results for the existing Mt Piper and Wallerawang sources were used, based on hourly varying[2] emissions and flow rates from each source. In this instance, only SO_2 predictions have been evaluated, as there will only be a minor contribution from other, non-modelled, sources for this pollutant. That is, ambient SO_2 concentrations in the region will be influenced largely by emissions from the modelled power station stacks.

- **Table 14 Comparison of model predictions with measured concentrations**

Pollutant and averaging time	Blackmans Flat		Wallerawang	
	Measured	Predicted	Measured	Predicted
Maximum 1-hour average SO_2 (µg/m^3)	353	269 8 Feb 2001 hour 12 Ws = 1.7 m/s Wd = 183 deg Stability = A	424	795 4 Jun 2001 hour 9 Ws = 0.5 m/s Wd = 24 deg Stability = B
Maximum 24-hour average SO_2 (µg/m^3)	70	34	47	41
Annual average SO_2 (µg/m^3)	13	1.8	7	2.0

Table 14 shows that, for the Blackmans Flat site, maximum 1-hour average SO_2 concentrations were under-predicted by about 30%. This would generally be regarded as a good performance for a dispersion model. At the Wallerawang monitoring site however, the model prediction was nearly twice as high as the maximum measured level. These results provide some insight into the expected performance of the model when assessing future scenarios. It is also useful to note that modelling of the existing Mt Piper and Wallerawang sources using constant, full load emissions gives more conservative results than those presented in **Table 14** (that is, 296 µg/m^3 for Blackmans Flat and 1,722 µg/m^3 for Wallerawang, from **Table 13**).

The meteorology giving rise to the predictions in **Table 14** are characteristic of unstable conditions, where convective-driven turbulence dominates the dispersion. As discussed in **Section 5.1**, TAPM was used to provide upper air meteorological information to the CALMET model. Examination of the TAPM upper air data for the hours leading up to the 795 µg/m^3 prediction showed that there

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[2] Hourly varying emissions, temperature and exit velocities, as presented in Holmes Air Sciences (2005).

was initially a stable lower atmosphere and temperature inversion present up to approximately 50 m. From 9 am onwards, the atmosphere rapidly changed to an unstable atmosphere. Under these conditions, CALPUFF would have simulated a concentrated, elevated plume that is brought to ground, leading to the predicted high levels close to the emission source.

The comparison of measured and predicted SO_2 concentrations is also shown in **Figure 10**, where the ranked model predictions have been plotted against the ranked measurements. The slight under-prediction at Blackmans Flat is evident, while for the Wallerawang site, there is a clear outlier in the model predictions and the second or third highest model prediction shows better agreement with maximum measured levels.

The predictions for maximum 24-hour average SO_2 concentrations show that there was under-prediction for Blackmans Flat, but very good agreement for Wallerawang. Predicted annual average SO_2 concentrations were lower than measured levels, presumably because the model cannot fully capture all residual background SO_2 concentrations in the area.

The model performance assessment has therefore shown that:

- The second or third highest prediction might be a better indicator of expected maximum 1-hour average levels, rather than the highest prediction, for some locations;
- Modelled 24-hour averages provide a reasonable indication of expected impacts. That is, within a factor of 2; and
- Modelled annual averages will require more emphasis on background levels.

While the assessment that follows is based on the very highest model predictions, it is also important to consider the outcomes of the model performance assessment described above. Further, a number of similar studies (see **HAS, 2005** for example) have evaluated the performance of CALPUFF, particularly for predicting short-term (1-hour average) ground-level concentrations. These studies have indicated that the model has a tendency to over-estimate short-term concentrations under convective meteorological conditions, where the extreme model predictions are much higher than observed levels.

9.3. Operational Impacts

9.3.1. Nitrogen Dioxide

Model predictions of total NO_x and NO_2 are presented in **Table 13**. It is important to distinguish between total NO_x and NO_2 and it is useful to assess the likely fraction of NO_x that is converted to NO_2, at the point of maximum impact from a source such as a stack.

Nitrogen oxides are produced in most combustion processes. During high-temperature processes there will be a variety of nitrogen oxides formed including nitric oxide (NO) and NO_2. Generally, at the point of emission NO will comprise the greatest proportion of the emission with 95% by volume of the NO_x. The remaining 5% will be mostly NO_2. It is the NO_2 which is linked to health effects.

Ultimately, however, all nitric oxides emitted into the atmosphere are oxidised to NO_2 and then further to other higher oxides of nitrogen. The rate at which this oxidisation takes place depends on prevailing atmospheric conditions and the presence of other substances in the atmosphere such as ozone. The oxidation process can vary from a few minutes to many hours. The rate of conversion is quite important because from the point of emission to the point of maximum ground-level concentration there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the plume to the point where the concentration is very low it is not important that the oxidation has taken place. However, if the oxidation is rapid and the dispersion slow then high concentrations of NO_2 can occur.

At the point of maximum ground-level NO_x impacts from a power station stack, the time interval may be such that only small fractions of the NO_x will be oxidised to NO_2. Holmes Air Sciences analysed ambient NO_x concentration data around Mt Piper (**HAS, 2005**) and highlighted the relationship between NO_2 and NO_x in the ambient air. The percentage of NO_2 in the NO_x was shown to be inversely proportional to the total NO_x concentration, and when NO_x concentrations were high, the percentage of NO_2 in the NO_x was between 21 and 26%. For conservatism, this assessment has assumed that 30% of the NO_x is NO_2 by the time the plume has reached the point where the maximum 1-hour average ground-level NO_x concentrations are predicted. For annual averages, 100% of the NO_x was assumed to be NO_2.

Figure 11 shows the maximum 1-hour average ground-level NO_x predictions for six scenarios, including individual contributions and cumulative impacts.

There are several comparisons that can be made from the results. Given that one of the main objectives of this study is to assess the potential change in impacts, the comparisons between the existing Mt Piper PS impacts and existing Mt Piper PS with USC or CCGT are perhaps the most relevant.

Table 13 shows that the highest 1-hour average NO_2 concentration due to the existing Mt Piper power station is predicted to be 249 µg/m^3. This result is above the 246 µg/m^3 criterion and assumes that 30% of the NO_x is NO_2 at the point of maximum ground-level NO_x concentration. From **Figure 11**, the most-affected location is predicted to be close to the plant and a maximum of 1 hour in the year (**Table 13**) was above 246 µg/m^3.

In addition to the Mt Piper A contribution, **Table 13** show the NO_2 contributions from the USC, CCGT and Wallerawang sources. The existing and proposed Mt Piper sources have been considered first.

If the USC option is adopted, the modelling suggests that:

- Maximum 1-hour average NO_2 concentrations will increase from 249 to 338 µg/m^3, and the maximum number of hours above 246 µg/m^3 will increase from 1 to 2 hours per year, due to Mt Piper sources, and
- The highest levels will be close to the plant (that is, within 2 km).

If the CCGT option is adopted, the modelling suggests that:

- There will be no change to maximum 1-hour average NO_2 concentrations. That is, the highest 1-hour average NO_2 concentrations will be 249 µg/m^3, with a maximum of 1 hour above the criterion.
- The highest levels will be close the plant, with no exceedances of 246 µg/m^3 at any sensitive receptor location.

The results above show that the number of additional exceedances of short-term NO_2 criteria due to Mt Piper will be small, for either the USC or CCGT options. It should be noted also, that adopting a less conservative fraction of NO_2 in the NO_x (say, between 21 and 26% instead of 30%) will result in lower predictions of 1-hour average NO_2 concentrations than those presented in **Table 13**.

The predicted impacts of Wallerawang power station are also included in **Table 13**. These results show that maximum 1-hour average NO_2 concentrations may exceed the 246 µg/m^3 criterion, due to Wallerawang emissions. The impacts are likely to be close to the source, as noted by relatively high predictions at the Wallerawang monitor which is only about 2 km from the power station. However, it is outside the scope of this study to assess any predicted exceedances of criteria due to this source. **Table 13** shows that, with all sources include in the model, the USC option potentially increases the maximum number of existing (Mt Piper A plus Wallerawang) NO_2 exceedances from 1 to 2 hours per year. For the CCGT option, no increases in the maximum number of hours above the criterion are predicted.

Annual average NO_x predictions are provided in **Table 13** and in **Figure 12**. The highest NO_x concentration in the modelled domain, of all scenarios, is 10.2 µg/m^3. This demonstrates compliance with the DECC criterion 62 µg/m^3, even when assuming all the NO_x is NO_2. Adding background NO_2 concentrations to predictions would not result in cumulative levels exceeding the 62 µg/m^3 criterion.

As mentioned in **Section 6**, it has been assumed that all power stations are operating under full load and continuously for the modelled year. Statistically, this means that there is less probability that maximum emissions will coincide with meteorological conditions conducive to high ground-level impacts from tall sources.

9.3.2. Sulphur Dioxide

In the case of SO_2, ambient concentrations in the region will be influenced largely by emissions from the power station stacks, discussed in this assessment. There will only be a minor contribution from other, non-modelled, sources.

Maximum 1-hour average SO_2 concentrations are presented in **Figure 13** and **Table 13**. It should be noted some of the very highest levels predicted (**Table 13**) may not appear in the contour plots. This is because the highest levels generally occupy very small regions which are not resolved on the size of the contour plots. The highest levels in the modelled domain are predicted to exceed the 570 µg/m^3 criterion for all cumulative scenarios, and also due to individual modelled sources. (It should be noted that, in **Figure 13**, the contour inside the 570 µg/m^3 contour is 1,000 µg/m^3). In fact, predicted maximum 1-hour average SO_2 concentrations are much higher than those which are currently, and have historically, been monitored in the region (refer **Section 5.4**). This suggests that the model has over-estimated maximum short-term SO_2 concentrations.

Of all the sources, Wallerawang is predicted to have the highest individual contribution to maximum ground-level SO_2 concentrations at 1,767 µg/m^3, giving rise to a predicted maximum of 5 hours above the 570 µg/m^3 criterion per year. As for NO_x, these predictions assume that emissions are at a constant maximum rate for all hours in the year.

The following observations were made from the model results of maximum 1-hour average SO_2 concentrations:

- Impacts due to existing sources (that is, Mt Piper and Wallerawang) are dominated by the contribution of Wallerawang emissions;
- There is a maximum of 5 hours per year when the SO_2 concentration is predicted to exceed 570 µg/m^3, due to existing (that is, Mt Piper and Wallerawang) sources;

- The maximum number of hours above 570 µg/m^3 is predicted to remain unchanged at 5 hours if either the USC or CCGT plants is added to all existing sources;
- The maximum number of hours above 570 µg/m^3 due to Mt Piper sources only, is predicted to increase from 2 to 4 hours if the USC plant is added; and
- The maximum number of hours above 570 µg/m^3 due to Mt Piper sources only, is predicted to remain unchanged at 2 hours if the CCGT plant is added, since the SO_2 emissions from the CCGT plant will be zero.

Figure 13 shows the location of maximum 1-hour average SO_2 concentrations at ground-level. It can be seen from this figure that the highest levels are generally close to the emission sources. **Figure 14** provides further investigation into these levels by showing the predicted number of hours above 570 µg/m^3. This figure shows the spatial variation in hours above 570 µg/m^3, where the Wallerawang source is predicted to produce the maximum number of hours above 570 µg/m^3, at 5 hours per year. None of the cumulative options (that is, Mt Piper with USC or CCGT) increase the maximum number of exceedances above this 5 hours per year, although for the USC case, some areas are predicted to experience one or two more exceedance hours, compared with the modelled existing situation.

The second highest 1-hour average SO_2 concentration was subsequently developed and is shown in **Figure 15**. This figure assumes that the second highest model prediction might provide a better indication of the maximum 1-hour average SO_2 concentrations that would be measured (as discussed in **Section 9.2**). It can be seen from this figure that the extent of the 570 µg/m^3 contours is reduced (over maximum levels) for all scenarios.

In addition to 1-hour average concentrations, **Figure 16** and **Figure 17** show the maximum 24-hour and annual average SO_2 predictions respectively. These results (with interpretation from **Table 13**) show compliance with the DECC criteria for all scenarios.

9.3.3. Other Pollutants

In addition to NO_2 and SO_2 discussed above, modelling has also been undertaken for other pollutants including carbon monoxide, fluoride (as HF), particulates, antimony, arsenic, beryllium, cadmium, chromium III and VI, lead, mercury (inorganic), nickel, dioxins and polycyclic aromatic hydrocarbons. The results for these pollutants, as predictions for Wallerawang, Blackmans Flat and for the whole modelling domain, are provided in **Table 13**.

It can be seen from **Table 13** that the predicted ground-level concentrations of these pollutants and for all scenarios are well below the relevant criteria. Most of the predictions are more than an order of magnitude lower than the relevant criteria. These results suggest that the impact of the Project, with respect to air quality, will be acceptable.

9.4. Potential Impacts on Vegetation

In addition to harmful effects on the respiratory system, SO_2 can also have harmful effects on vegetation. Over a 1-hour period, traces of injury to vegetation were reported by **WHO (1987)** when SO_2 levels reach approximately 3000 µg/m^3 or more.

In 2000, the WHO revised their guidelines and provided an air quality guideline of 20 µg/m^3 as a mean winter and an annual average for forests and natural vegetation (**WHO, 2000**). This was based on evidence of periods of high sensitivity of specific vegetation types, which renders them more sensitive to pollution stress.

The model results from **Table 13** show that all ground-level locations will experience annual average SO_2 concentrations less than the WHO guideline of 20 µg/m^3, for all assessment scenarios. This suggests that there will be no adverse impacts on vegetation.

9.5. Construction Impacts

Construction activities may generate dust emissions and these emissions have the potential to cause nuisance impacts if not properly managed. In practice, it is not possible to realistically quantify impacts using dispersion modelling. To do so would require knowledge of weather conditions for the few weeks that work will be taking place at each location on the site. Air quality impacts during construction have therefore been assessed by identifying the main dust generating activities and noting the most effective measures to control emissions.

Dust emissions will arise primarily from the following activities:

- Clearing of vegetation and topsoil;
- Loading of material to trucks;
- Trucks travelling over unsealed roads; and
- Wind erosion from unsealed surfaces and stockpiles.

The construction activities listed above would be expected to be completed over a twelve month period.

Emissions from the construction activities can be readily controlled through the following measures:

- Ensuring that all unsealed trafficable areas are kept sufficiently damp (with water) during working hours to minimise wind blown or traffic generated dust emissions;
- Ensuring that all equipment used and all facilities erected are designed and operated to control the emission of smoke, dust, fumes and other pollution into the atmosphere;

- Minimisation of areas of surface disturbance to ensure dust generation is kept to a minimum;
- Stabilisation of working areas as soon as practicable to prevent or minimise wind blown dust;
- Covered or watering of stockpile, wherever practicable;
- Restricting traffic to defined roads;
- Imposing a low speed limit on unsealed roads; for example, 20 km/h or less; and
- Covering of truck loads to prevent wind blown emissions and spillage.

These measures will ensure that dust emissions are subject to a high level of control. Given that the nearest residences are approximately two kilometres from the site (Blackmans Flat), it is unlikely that a suitably managed construction site will result in any off-site air quality impacts.

9.6. Inter-Regional Transport

The foregoing assessment has focussed primarily on air quality impacts at the local scale (that is, within a domain of approximately 30 km around the Project site). At the regional and interregional scale, the complex chemical transformations that take place over long distances become more important and it is necessary to employ a modelling system that is designed to simulate these mechanisms. The three-dimensional modelling system known as TAPM-CTM is suitable in this instance.

TAPM-CTM couples the chemical-transport modelling system (CTM) with the numerical weather prediction system, TAPM. Both of these systems were developed by CSIRO. TAPM-CTM has been used to assess the impact of NO_x emissions from the Project on photochemical smog formation in the Sydney metropolitan region and surrounding areas, referred to as the Metropolitan Air Quality Study Region (MAQSR). The MAQSR covers Sydney, Illawarra, Newcastle and west to the central tablelands (an area of approximately 350 km by 350 km, see **Figure 18**).

The main objective of the TAPM-CTM modelling was to predict regional levels of NO_2 and ozone (O_3), both with and without the Project. Ozone is of particular concern, due to observed exceedances of the DECC's 1-hour and 4-hour average criteria (100 ppb and 80 ppb respectively) in recent years. The DECC's 1-hour average criterion for NO_2 (246 µg/m^3 or 120 ppb) is rarely exceeded.

9.6.1. Methodology

In 2007, CSIRO undertook an assessment of the regional air quality impacts of a proposed extension to the Mt Piper Power Station (**CSIRO, 2007**). This study was based on an earlier proposal for Mt Piper and assessed the potential impact of the Project on photochemical smog levels in the Sydney basin.

The methodology for the CSIRO study included:

- Identification of four 3-day photochemical smog events (case-study periods);
- Modelling using TAPM-CTM to predict regional NO_2 and O_3 levels for each case-study period;
- Two emission scenarios (namely, existing sources and existing sources plus proposed source); and
- Assessment of model results for changes to NO_2 and O_3 levels.

CSIRO concluded that the (then) proposed extension to Mt Piper Power Station would not result in any additional exceedances of air quality criteria for NO_2 and O_3. The current assessment adopts a similar approach to the CSIRO study, but updates the model simulations with information as relevant to the USC and CCGT proposals.

The Inter-regional Transport of Air Pollutants Study (IRTAPS) identified days with high ozone levels and where the meteorological conditions were suitable for inter-regional transport between the northwest power stations and the Sydney basin (**Nelson *et al*., 2002**). These days were 8 February 1997, 27 October 1997 and 13 March 1998. CSIRO confirmed (**CSIRO, 2007**) that these days were representative of conditions conducive to transporting emissions from Mt Piper to Sydney. An additional event was also identified by CSIRO as being 8 February 2004.

Emissions for the current modelling were derived from the MAQS emission inventory (**Carnovale *et al.*, 1996**) and recent updates. The inventories included:

- Commercial-domestic emissions;
- Motor vehicle emissions updated for 2002 (**Xu, 2002**); and
- Industrial emissions updated by CSIRO to include major industrial NO_x emitters in the Hunter, Central Coast and Western Coalfields (**Nelson *et al*., 2002**).

Biogenic emission were determined by CTM internal algorithms.

The industrial emissions inventory has been modified to include proposed emissions from either the USC plant or the CCGT plant, using emissions data as per **Table 11**. Three emission scenarios were modelled, as follows:

- Existing sources only ("base" case);
- Existing sources plus proposed USC ("test" case 1); and
- Existing sources plus proposed CCGT ("test" case 2).

The predicted changes to NO_2 and O_3 between the base case and test case scenarios have been assessed for each case-study period.

TAPM-CTM was run in nested mode, with two 120 x 120 grid point modelling domains and with grid spacings of 9 km for meteorology and 3 km for both meteorology and air quality. Local wind observations for up to 36 meteorological stations in the MAQSR were assimilated into the model for each case-study period.

Background concentrations for selected pollutants were as follows:

- 65 ppb for CO for all model levels;
- 1 ppb for SO_2 for all model levels;
- 1 ppb for NO_2 for all model levels;
- 0.1 ppb for NO for all model levels; and
- 15 ppb for O_3, increasing to 20 ppb at higher vertical levels.

These concentrations are consistent with the earlier CSIRO modelling.

Model results have been prepared into suitable contour plots and graphs to show the predicted change in NO_2 and O_3 concentrations due to the Project. The main objective of this assessment was to determine whether the Project would cause any additional exceedances of NO_2 or O_3 air quality criteria.

9.6.2. Results

The first step in the assessment of regional air quality has been to analyse the performance of the model. **Figure 19** shows the predicted and measured NO_2 and O_3 concentrations for each case-study period, for one monitoring location. In this instance, the DECC's Blacktown site has been selected as this site is central to the Sydney basin.

Figure 19 shows that O_3 concentrations have been very well predicted by TAPM-CTM, in terms of both the peak concentrations as well as the diurnal variations. Predicted NO_2 concentrations are predicted reasonably well but the diurnal variations are not as consistent with the observations than for O_3. Peak NO_2 concentrations however show good agreement with the measurement data in most instances. In general, the predicted peak NO_2 concentrations are higher than the observations.

Regional predictions of NO_2 and O_3 with the Project are presented in **Figure 20** to **Figure 27**. Contour plots show the base case predictions as well as the predicted change due to the two Project options. Graphs have also been prepared to show the predicted changes for every grid point on the MAQSR model domain (that is, the inner 3 km TAPM-CTM grid). Results for each case-study period are discussed below.

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6 to 8 February 1997

Figure 20 shows contour plots of maximum 1-hourly average ground-level NO_2 and O_3 concentrations for 6 to 8 February 1997. Base case predictions are presented as well as the predicted change in concentrations with the USC or CCGT Project options.

The maximum hourly average NO_2 concentration was 67 ppb for the base case, located in western Sydney. The O_3 concentration was predicted to be up to 118 ppb approximately 50 km southwest of the Sydney CBD. The model has predicted that the highest changes to NO_2 and O_3 concentrations will be to the west of Penrith, and not near the locations of maximum concentrations. Some noise in the model predictions was observed for very low concentration changes (in particular, off the coast for the change with CCGT case).

Predicted changes to NO_2 and O_3 concentrations for every grid point in the model domain have been plotted in **Figure 21**. This plot includes 1-hour average NO_2 and 1-hour and 4-hourly average O_3 concentrations. It can be seen from this figure that the highest increases in maximum 1-hourly average NO_2 concentrations are 1 ppb due to the USC proposal and 2.5 ppb due to the CCGT proposal. These increments will not cause exceedances of the 120 ppb criterion.

The highest increases in maximum 1-hourly average O_3 concentrations are predicted to be 1.3 ppb and 0.4 ppb due to the USC and CCGT proposals respectively. These increments are unlikely to cause additional exceedances of the 100 ppb criterion. The highest increments in the model domain are around 14 ppb due to the USC plant and 9 ppb due to the CCGT plant, both of which are predicted when base case concentrations are around 50 ppb.

In the general areas of maximum base case NO_2 and O_3 concentrations, the contribution from the proposed emission sources is small.

25 to 27 October 1997

Figure 22 shows contour plots of maximum 1-hourly average ground-level NO_2 and O_3 concentrations for 25 to 27 October 1997. Base case predictions are presented as well as the predicted change in concentrations with the USC or CCGT Project options.

The maximum hourly average NO_2 concentration was 99 ppb for the base case, located in approximately 10 km to the south of the Sydney CBD. The O_3 concentration was predicted to be up to 89 ppb, in the Wollongong region. The model has predicted that the highest changes to NO_2 and O_3 concentrations will be mainly in the Lithgow area, and not near the locations of maximum concentrations. Again, some noise in the model predictions was observed for very low concentration changes (in particular, for the change with CCGT case).

Predicted changes to NO_2 and O_3 concentrations for every grid point in the model domain have been plotted in **Figure 23**. This plot includes 1-hour average NO_2 and 1-hour and 4-hourly average O_3 concentrations. It can be seen from this figure that the highest increases in maximum 1-hourly average NO_2 concentrations are 2.9 ppb due to the USC proposal and 1.4 ppb due to the CCGT proposal. These increments will not cause exceedances of the 120 ppb criterion.

The highest increases in maximum 1-hourly average O_3 concentrations are predicted to be 1.5 ppb and 0.8 ppb due to the USC and CCGT proposals respectively. These increments will not cause additional exceedances of the 100 ppb criterion. The highest increments in the model domain are around 14 ppb due to the USC plant and 9 ppb due to the CCGT plant, both of which are predicted when base case concentrations are around 40 to 50 ppb.

In the general areas of maximum base case NO_2 and O_3 concentrations, the contribution from the proposed emission sources is small.

11 to 13 March 1998

Figure 24 shows contour plots of maximum 1-hourly average ground-level NO_2 and O_3 concentrations for 11 to 13 March 1998. Base case predictions are presented as well as the predicted change in concentrations with the USC or CCGT Project options.

The maximum hourly average NO_2 concentration was 91 ppb for the base case, located in approximately 20 km to the south of the Sydney CBD. The O_3 concentration was predicted to be up to 101 ppb, between Sydney and Wollongong. The model has predicted that the highest changes to NO_2 and O_3 concentrations will be mainly in the Lithgow area, and not near the locations of maximum concentrations. There was however some change to O_3 concentrations predicted to the north of Penrith for the USC case.

Predicted changes to NO_2 and O_3 concentrations for every grid point in the model domain have been plotted in **Figure 25**. This plot includes 1-hour average NO_2 and 1-hour and 4-hourly average O_3 concentrations. It can be seen from this figure that the highest increases in maximum 1-hourly average NO_2 concentrations are 2.4 ppb due to the USC proposal and 2 ppb due to the CCGT proposal. These increments will not cause exceedances of the 120 ppb criterion.

The highest increases in maximum 1-hourly average O_3 concentrations are predicted to be 2.7 ppb and 0.5 ppb due to the USC and CCGT proposals respectively. These increments are unlikely to cause additional exceedances of the 100 ppb criterion. The highest increments in the model domain are around 14 ppb due to the USC plant and 10 ppb due to the CCGT plant, both of which are predicted when base case concentrations are around 50 to 60 ppb.

In the general areas of maximum base case NO_2 and O_3 concentrations, the contribution from the proposed emission sources is small.

6 to 8 February 2004

Figure 26 shows contour plots of maximum 1-hourly average ground-level NO_2 and O_3 concentrations for 6 to 8 February 2004. Base case predictions are presented as well as the predicted change in concentrations with the USC or CCGT Project options.

The maximum hourly average NO_2 concentration was 109 ppb for the base case, located in approximately 20 km to the south of the Sydney CBD. The O_3 concentration was predicted to be up to 126 ppb, in southwest Sydney but there were also some elevated concentrations predicted (over 100 ppb) west of the Blue Mountains and south of Lithgow. The model has predicted that the highest changes to NO_2 and O_3 concentrations will be mainly in the Lithgow area, and not near the locations of maximum concentrations. There was however some change to O_3 concentrations predicted to the northwest of Penrith for the USC case.

Predicted changes to NO_2 and O_3 concentrations for every grid point in the model domain have been plotted in **Figure 27**. This plot includes 1-hour average NO_2 and 1-hour and 4-hourly average O_3 concentrations. It can be seen from this figure that the highest increases in maximum 1-hourly average NO_2 concentrations are 3.3 ppb due to the USC proposal and 2.2 ppb due to the CCGT proposal. These increments will not cause exceedances of the 120 ppb criterion.

The highest increases in maximum 1-hourly average O_3 concentrations are predicted to be 2.1 ppb and 1.6 ppb due to the USC and CCGT proposals respectively. These increments are unlikely to cause additional exceedances of the 100 ppb criterion. The highest increments in the model domain are around 13 ppb due to the USC or CCGT plants, which is predicted when base case concentrations are around 60 ppb.

In the general areas of maximum base case NO_2 and O_3 concentrations, the contribution from the proposed emission sources is small.

9.6.3. Summary

TAPM-CTM modelling has been undertaken to predict the impact of the Project on regional-scale NO_2 and O_3 concentrations. Model results for base case scenarios showed good agreement with measured concentrations and the two Project options were added to the simulations to assess any potential change to NO_2 and O_3 concentrations.

Table 15 provides a summary of the regional maximum NO_2 and O_3 concentrations, as predicted by TAPM-CTM.

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Table 15 Summary of regional maximum NO_2 and O_3 concentrations

Case-study period	Base case	Base case plus USC	Base case plus CCGT
Maximum 1-hour average NO_2 concentrations (ppb)			
6-8 February 1997	66.5	67.5	69.1
25-27 October 1997	98.5	101.4	100.4
11-13 March 1998	90.8	93.2	92.8
6-8 February 2004	109.0	112.3	111.1
Maximum 1-hour average O_3 concentrations (ppb)			
6-8 February 1997	117.8	119.1	118.2
25-27 October 1997	88.5	90.0	89.3
11-13 March 1998	100.7	103.4	101.4
6-8 February 2004	126.1	130.9	128.3
Maximum 4-hour average O_3 concentrations (ppb)			
6-8 February 1997	98.2	99.3	98.5
25-27 October 1997	74.7	75.2	75.0
11-13 March 1998	92.5	95.4	93.3
6-8 February 2004	112.9	114.6	114.2

The results from **Table 15** show that:

- Regional maximum 1-hourly average NO_2 concentrations may increase by up to 3.3 ppb for the USC plant and up to 2.6 ppb for the CCGT plant;
- Regional maximum 1-hourly average O_3 concentrations may increase by up to 4.8 ppb for the USC plant and up to 2.2 ppb for the CCGT plant; and
- Regional maximum 4-hourly average O_3 concentrations may increase by up to 2.9 ppb for the USC plant and up to 1.3 ppb for the CCGT plant.

While the emissions from the Project options are unlikely to cause additional exceedances of NO_2 or O_3 criteria, some areas outside the Sydney basin are predicted to experience increases in hourly O_3 of up to 15 ppb. These increments are predicted for existing concentrations between 40 and 70 ppb.

9.7. Hazards to Aviation

The existing and proposed stacks at Mt Piper Power Station may pose a hazard to aircraft flying in the vicinity of the exhaust plumes. The risk to an aircraft during low level flight can be managed or reduced if information is available to pilots so that they can avoid the likely area of air disturbance.

Aviation authorities have determined that damage to the frame of an aircraft may occur when the vertical velocity of a wind gust exceeds 4.3 metres per second (m/s). The Civil Aviation Safety Authority (CASA) has subsequently required that proponents of a facility where the vertical velocity of exhaust plumes exceed 4.3 m/s at an aerodrome Obstacle Limitation Surface (OLS), or at 110 metres above ground level anywhere else, must undertake plume rise modelling to assess the potential hazard to aircraft operations. Requirements of the plume rise modelling are outlined in CASA's Advisory Circular titled *Guidelines for Conducting Plume Rise Assessment* (**CASA, 2004**).

To address the potential hazard to aviation, a screening level assessment has been undertaken to quantify the existing and potential aviation hazard. The assessment includes:

- Identification of the nearest airport;
- Plume rise modelling for a one year simulation period;
- Analysis of model results for the regions of space where plume vertical velocities are predicted to exceed 4.3 m/s.

The nearest airport to Mt Piper is Bathurst, approximately 40 km to the west. This large distance was the main factor to suggest that a screening level assessment would be adequate in this instance.

Table 16 provides a summary of plume rise modelling parameters for the screening level assessment.

Table 16 Summary of plume rise modelling parameters

Model	TAPM version 4.0.2
Number of grids (spacing)	3 (30 km, 10 km, 3 km)
Number of grid points	25 x 25 x 25
Simulation period	Jan 2001 to Dec 2001 inclusive, with one "spin-up" day
Terrain information	AUSLIG 9 second DEM data
Centre of analysis	Mt Piper Power Station (33°21.5' S, 150°2' E)
Local data assimilation	Wind speed and wind direction data from Mt Piper Power Station, assimilated with a horizontal radius of influence of 5 km and through the lowest 8 model levels.
Mode	Meteorology and pollution mode
Sources	Mt Piper A, Mt Piper B (USC) and one CCGT stack Emission characteristics as per Table 11 No buoyancy enhancement due to merged plumes

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The TAPM output from the one year simulation period included a file with information on plume location and movement for every hour and for each stack. The plume rise data included vertical velocity, plume height and plume dimensions from the time of release to the time of final plume height. An analysis of the data was undertaken to determine the maximum, minimum and average heights at which the plume vertical velocity exceeded the critical velocity of 4.3 m/s. Results of this analysis are shown in **Table 17**.

- **Table 17 Summary of height at which plume vertical velocity falls below 4.3 m/s**

Stack ID	Stack name	Height at which plume vertical velocity falls below 4.3 m/s (m)		
		Minimum	Maximum	Average
1	Existing Mt Piper A stack	265	885	308
2	Proposed Mt Piper B (USC) stack	271	1076	324
3	One proposed CCGT stack	53	222	73

Over the one year modelling period the maximum height at which the plume vertical velocity falls below 4.3 m/s for the existing Mt Piper stack is predicted to be 885 m. For the proposed USC plant, the maximum height of the critical vertical velocity is slightly higher at 1,076 m. For the CCGT plant the maximum height of the critical vertical velocity is only 222 m, which is lower than the height of the existing stack.

The region of space where the vertical velocity of the plume centreline exceeds 4.3 m/s, for all hours in the model simulation, is shown in **Figure 28**. This shows that the maximum height of the plume vertical velocity exceeding 4.3 m/s is located approximately above each stack location. This figure has been created to help CASA identify a restricted flight area.

From **Figure 28** it can be seen that with the USC plant, the potential aviation hazard area changes slightly from the existing hazard area; that is, approximately 400 m further to the west and approximately 200 m higher above local ground-level. It is likely that CASA has already identified a region of space around Mt Piper Power Station that poses a potential hazard to aircraft. The proposed extension options are unlikely to change the existing restricted area.

10. Management of Impacts

Section 9 has provided forecasts of the potential air quality impacts of the Project. The methodology for forecasting impacts has evolved over many years and has generally been accepted by the scientific community as providing a useful indication of actual impacts. However, uncertainties will always exist in predictive modelling mainly because the atmospheric behaviour and source emission conditions can never be reproduced perfectly.

In contrast to predictive modelling, monitoring data are usually taken to be the true measure of air quality, whether the monitoring is for ambient air quality or for detecting impacts or contributions from known emission sources. In this assessment, emissions from proposed new sources have been evaluated for the potential to adversely affect ambient air quality at nearest sensitive receptors. It is therefore beneficial to include a program of air quality monitoring which is designed to detect maximum potential impacts from the Project, at the nearest sensitive receptors.

As for model predictions, limitations also exist in monitoring programs. The main limitation is that it is often difficult to ensure that a monitoring location will be the exact point at where maximum impacts from the Project will occur, if this is one objective for the monitoring. The most practical monitoring locations, however, tend to be where there is a reasonably high potential for impacts from the sources of interest and where there are sensitive receptors. Other factors, such as site access, security and power, may also play a part.

The predictive modelling has clearly shown that while there is conservatism in the assessment, NO_2 and SO_2 have the highest potential to affect local air quality. Although the Environment Protection Licence for Mt Piper Power Station (13007) does not specify a requirement to monitor ambient air pollution levels, continuation of the existing monitoring program will be useful to quantify any change in air quality at the closest populated areas.

The current Blackmans Flat and Wallerawang monitoring sites remain suitable sites for quantifying any changes to air quality at the closest populated areas for the following reasons:

- They both include monitoring of SO_2 and NO_x;
- The Blackmans Flat site is one of the closest residential areas to the Mt Piper Power Station, and is also be downwind of the station under the frequently occurring westerly winds; and
- The Wallerawang site is predicted to experience close to the maximum ground-level short-term concentrations due to both the Mt Piper and Wallerawang power stations, whilst also being situated in a populated area.

These two monitoring locations will continue to be useful for both Mt Piper and Wallerawang power stations to identify contributions from emission sources to sensitive receptor locations. Periodic review and analysis of the monitoring data will provide the necessary information on whether the Project is affecting local air quality and whether any operational adjustments are necessary.

11. Conclusions

This report has provided an assessment of the potential air quality impacts of the proposed Mt Piper Power Station Extension. Computer-based dispersion modelling has been used to predict ground-level pollutant concentration due to emissions from stack sources. The modelling took account of topographical, land-use, building and meteorological information and the model predictions were compared to relevant air quality criteria to assess the potential impacts. Impacts of NO_x and SO_2 were the focus of the assessment, although a range of other pollutants were also investigated.

Two project options were considered (USC and CCGT) and the conclusions of the study can be summarised as follows:

- Of all the pollutant emissions from the power station stacks, NO_2 and SO_2 have the highest potential to cause short-term air quality impacts, based on model predictions which consume the greatest fraction of the air quality criteria.
- For cumulative scenarios, emissions from Wallerawang are predicted to have the greatest impact on ground-level NO_x and SO_2 concentrations.
- Emissions from existing sources are predicted to be causing exceedances of NO_2 and SO_2 criteria in some parts of the study area, although for SO_2, the highest predictions are much higher than any relevant measurement data that have been collected.
- There is some evidence to suggest that maximum 1-hour average SO_2 concentrations might be better predicted by adopting the second or third highest model prediction, rather than the highest model prediction.
- No impacts on forests or natural vegetation are predicted for all assessment scenarios.
- Project emissions are unlikely to cause exceedances of air quality criteria for CO, TSP, PM_{10}, Fluoride (as HF), Antimony, Arsenic, Beryllium, Chromium (III and VI), Lead, Mercury (inorganic), Nickel, Dioxins and PAHs at all ground-level locations.

Specifically, for the USC option:

- Maximum 1-hour average NO_2 concentrations are predicted to increase slightly, and the maximum number of hours above the DECC's 246 $\mu g/m^3$ criterion is predicted to increase from 1 to 2 hours per year. This level of change is small and is unlikely to be detectable. The predicted change can be effectively taken to be zero if the second or third highest model predictions are adopted, or if the conservative nature of the assessment is considered.
- Maximum 1-hour average SO_2 concentrations are predicted to increase, although the maximum number of hours above the DECC's 570 $\mu g/m^3$ criterion will remain unchanged from existing impacts, at 5 hours per year.

Specifically, for the CCGT option

- No change to maximum 1-hour average NO_2 concentrations is predicted, although the modelling suggests that the existing emission sources contribute a maximum 1-hour average NO_2 concentration of approximately 249 µg/m^3, which is above the DECC's 246 µg/m^3 criterion. Further, the modelling predicts no change to the maximum number of hours above 246 µg/m^3.
- No change to maximum 1-hour average SO_2 concentrations is predicted, since SO_2 emissions from the CCGT plant will be zero.

Based on the modelling and assessment, the USC option has a higher potential to cause adverse air quality impacts than the CCGT option. However, both the USC and CCGT plant proposals are unlikely to result in any air quality impacts, given that modelled maximum concentrations are much higher than have historically been measured in the region and from the history of similar studies that have shown a tendency for the dispersion model to over-estimate short-term concentrations. These conclusions have been reached for the modelled emissions conditions which assume no additional emission control measures over the Project's proposed technology.

Finally, it is worth noting some conservative aspects of the modelling. In particular, the power stations have been assumed to be operating at full load and continuously for every hour of the modelled year and no buoyancy enhancement of multiple, overlapping plumes has been modelled.

Potential air quality impacts on the regional scale were also assessed through dispersion modelling using TAPM-CTM. The modelling showed that the emissions from either Project option are unlikely to cause additional exceedances of NO_2 or O_3 criteria in the Sydney basin. Some areas outside the Sydney basin are, however, predicted to experience increases in hourly O_3 of up to 15 ppb.

Plume rise modelling was undertaken to quantify the region of space above the power station which might pose a rise to aircraft. The small changes to the region of space above the power station are unlikely to affect the extent of the hazardous flight zone which will already be defined.

While the Environment Protection Licence for Mt Piper Power Station (13007) does not specify a requirement to monitor ambient air pollution levels, continuation of the monitoring at the existing Blackmans Flat and Wallerawang sites will be useful to quantify any change in air quality at the closest populated areas.

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Appendix A Meteorological data statistics

STATISTICS FOR FILE: D:\Projects\EN01942_MtPiper\calmet\prtmet\prttime.aus
MONTHS: All
HOURS : All
OPTION: Frequency

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.012935	0.025984	0.008356	0.000458	0.000000	0.000000	0.000000	0.000000	0.047734
NE	0.004006	0.013851	0.009959	0.000343	0.000000	0.000000	0.000000	0.000000	0.028159
ENE	0.003777	0.007898	0.001946	0.000000	0.000114	0.000000	0.000000	0.000000	0.013736
E	0.004006	0.008471	0.004350	0.001603	0.000229	0.000000	0.000000	0.000000	0.018658
ESE	0.006181	0.013164	0.020375	0.004235	0.000916	0.000000	0.000000	0.000000	0.044872
SE	0.004235	0.024954	0.018429	0.006754	0.000229	0.000000	0.000000	0.000000	0.054602
SSE	0.003434	0.020375	0.008127	0.002976	0.000114	0.000000	0.000000	0.000000	0.035027
S	0.007212	0.017399	0.010073	0.003892	0.000114	0.000000	0.000000	0.000000	0.038690
SSW	0.011676	0.017743	0.006181	0.002289	0.000916	0.000000	0.000000	0.000000	0.038805
SW	0.044986	0.035485	0.019345	0.005838	0.001374	0.000114	0.000000	0.000000	0.107143
WSW	0.101877	0.030220	0.022436	0.018086	0.006639	0.002404	0.000916	0.000229	0.182807
W	0.021177	0.024038	0.027930	0.014194	0.009272	0.001717	0.000343	0.000000	0.098672
WNW	0.014538	0.016369	0.016941	0.007326	0.002633	0.000343	0.000114	0.000000	0.058265
NW	0.015339	0.019460	0.008814	0.003205	0.000343	0.000000	0.000000	0.000000	0.047161
NNW	0.018887	0.027930	0.007097	0.001488	0.000229	0.000000	0.000000	0.000000	0.055632
N	0.018315	0.037431	0.012821	0.001259	0.000229	0.000000	0.000000	0.000000	0.070055
CALM									0.059982
TOTAL	0.292582	0.340774	0.203182	0.073947	0.023352	0.004579	0.001374	0.000229	1.000000

MEAN WIND SPEED (m/s) = 2.45
NUMBER OF OBSERVATIONS = 8736

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000000	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000458
NE	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
ENE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
ESE	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000229
SE	0.000000	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000458
SSE	0.000000	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000458
S	0.000000	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000572
SSW	0.000114	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000572
SW	0.000000	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000572
WSW	0.000000	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000572
W	0.000114	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000572
WNW	0.000114	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
NW	0.000114	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
NNW	0.000114	0.001259	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001374
N	0.000000	0.001717	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001717
CALM									0.000229
TOTAL	0.001030	0.007669	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.008929

MEAN WIND SPEED (m/s) = 2.07
NUMBER OF OBSERVATIONS = 78

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.003663	0.001030	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.005151
NE	0.001030	0.001145	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
ENE	0.000572	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001145
E	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
ESE	0.000687	0.001030	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001717
SE	0.001030	0.001374	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
SSE	0.000572	0.001145	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.002060
S	0.001145	0.001145	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
SSW	0.001488	0.001946	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.003663
SW	0.000801	0.002518	0.002404	0.000000	0.000000	0.000000	0.000000	0.000000	0.005723
WSW	0.000916	0.000687	0.001488	0.000114	0.000000	0.000000	0.000000	0.000000	0.003205
W	0.000572	0.001946	0.002862	0.000458	0.000000	0.000000	0.000000	0.000000	0.005838
WNW	0.001603	0.001488	0.002175	0.000687	0.000000	0.000000	0.000000	0.000000	0.005952
NW	0.001259	0.001603	0.000687	0.000343	0.000000	0.000000	0.000000	0.000000	0.003892
NNW	0.001145	0.003549	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.005495
N	0.002060	0.004235	0.002060	0.000000	0.000000	0.000000	0.000000	0.000000	0.008356
CALM									0.002633
TOTAL	0.018887	0.025412	0.014194	0.001603	0.000000	0.000000	0.000000	0.000000	0.062729

MEAN WIND SPEED (m/s) = 2.18
NUMBER OF OBSERVATIONS = 548

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PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.003091	0.003205	0.001488	0.000000	0.000000	0.000000	0.000000	0.000000	0.007784
NE	0.000687	0.001259	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.002747
ENE	0.000687	0.000572	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.001603
E	0.000801	0.001259	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002175
ESE	0.001488	0.001030	0.001832	0.000458	0.000000	0.000000	0.000000	0.000000	0.004808
SE	0.000458	0.001374	0.000916	0.000114	0.000000	0.000000	0.000000	0.000000	0.002862
SSE	0.000458	0.001717	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.002404
S	0.001030	0.002060	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.003777
SSW	0.001717	0.002862	0.001030	0.000000	0.000000	0.000000	0.000000	0.000000	0.005609
SW	0.004235	0.005151	0.005266	0.001374	0.000229	0.000000	0.000000	0.000000	0.016255
WSW	0.004808	0.003777	0.005266	0.003892	0.000572	0.000000	0.000000	0.000000	0.018315
W	0.002747	0.002633	0.006868	0.004121	0.001145	0.000229	0.000000	0.000000	0.017743
WNW	0.002175	0.001717	0.005952	0.002060	0.000458	0.000114	0.000114	0.000000	0.012592
NW	0.002747	0.002976	0.002404	0.001030	0.000000	0.000000	0.000000	0.000000	0.009158
NNW	0.004121	0.006067	0.001259	0.000343	0.000000	0.000000	0.000000	0.000000	0.011790
N	0.004006	0.008127	0.002633	0.000572	0.000000	0.000000	0.000000	0.000000	0.015339
CALM									0.013507
TOTAL	0.035256	0.045788	0.037088	0.013965	0.002404	0.000343	0.000114	0.000000	0.148466

MEAN WIND SPEED (m/s) = 2.56
NUMBER OF OBSERVATIONS = 1297

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.003320	0.017170	0.006296	0.000458	0.000000	0.000000	0.000000	0.000000	0.027244
NE	0.001374	0.009501	0.008585	0.000343	0.000000	0.000000	0.000000	0.000000	0.019803
ENE	0.001259	0.005952	0.001488	0.000000	0.000114	0.000000	0.000000	0.000000	0.008814
E	0.001374	0.005838	0.004121	0.001603	0.000229	0.000000	0.000000	0.000000	0.013164
ESE	0.002175	0.008356	0.017628	0.003777	0.000916	0.000000	0.000000	0.000000	0.032853
SE	0.001603	0.016941	0.017285	0.006639	0.000229	0.000000	0.000000	0.000000	0.042697
SSE	0.001374	0.014423	0.007555	0.002976	0.000114	0.000000	0.000000	0.000000	0.026442
S	0.002175	0.010417	0.008471	0.003892	0.000114	0.000000	0.000000	0.000000	0.025069
SSW	0.002633	0.006410	0.004006	0.002060	0.000916	0.000000	0.000000	0.000000	0.016026
SW	0.004693	0.009386	0.006181	0.003777	0.001145	0.000114	0.000000	0.000000	0.025298
WSW	0.005495	0.007212	0.010989	0.012134	0.006067	0.002404	0.000916	0.000229	0.045444
W	0.001946	0.006296	0.014995	0.008929	0.008127	0.001488	0.000343	0.000000	0.042125
WNW	0.000916	0.006067	0.007097	0.004464	0.002175	0.000229	0.000000	0.000000	0.020948
NW	0.002060	0.006983	0.005037	0.001603	0.000343	0.000000	0.000000	0.000000	0.016026
NNW	0.003320	0.011790	0.004808	0.000801	0.000229	0.000000	0.000000	0.000000	0.020948
N	0.004121	0.018658	0.008127	0.000687	0.000229	0.000000	0.000000	0.000000	0.031822
CALM									0.007440
TOTAL	0.039835	0.161401	0.132669	0.054144	0.020948	0.004235	0.001259	0.000229	0.422161

MEAN WIND SPEED (m/s) = 3.30
NUMBER OF OBSERVATIONS = 3688

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000000	0.002633	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002747
NE	0.000000	0.001259	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.001488
ENE	0.000000	0.000458	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000572
E	0.000000	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000801
ESE	0.000000	0.002175	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.002862
SE	0.000000	0.003205	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.003320
SSE	0.000000	0.002404	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002404
S	0.000000	0.001946	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.002289
SSW	0.000000	0.001946	0.000687	0.000229	0.000000	0.000000	0.000000	0.000000	0.002862
SW	0.000000	0.002976	0.004464	0.000687	0.000000	0.000000	0.000000	0.000000	0.008127
WSW	0.000000	0.003205	0.004006	0.001946	0.000000	0.000000	0.000000	0.000000	0.009158
W	0.000000	0.004693	0.002289	0.000687	0.000000	0.000000	0.000000	0.000000	0.007669
WNW	0.000000	0.002747	0.001145	0.000114	0.000000	0.000000	0.000000	0.000000	0.004006
NW	0.000000	0.001946	0.000572	0.000229	0.000000	0.000000	0.000000	0.000000	0.002747
NNW	0.000000	0.001946	0.000229	0.000343	0.000000	0.000000	0.000000	0.000000	0.002518
N	0.000000	0.002862	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002862
CALM									0.000000
TOTAL	0.000000	0.037202	0.014995	0.004235	0.000000	0.000000	0.000000	0.000000	0.056433

MEAN WIND SPEED (m/s) = 2.87

NUMBER OF OBSERVATIONS = 493

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.002862	0.001488	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004350
NE	0.000572	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
ENE	0.001259	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001603
E	0.001488	0.000458	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002060
ESE	0.001717	0.000458	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.002404
SE	0.001145	0.001603	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002747
SSE	0.001030	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
S	0.002862	0.001259	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.004464
SSW	0.005723	0.004121	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.010073
SW	0.035256	0.014881	0.001030	0.000000	0.000000	0.000000	0.000000	0.000000	0.051168
WSW	0.090659	0.014766	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.106113
W	0.015797	0.008013	0.000916	0.000000	0.000000	0.000000	0.000000	0.000000	0.024725
WNW	0.009730	0.004121	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.014423
NW	0.009158	0.005723	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.014995
NNW	0.010188	0.003320	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.013507
N	0.008127	0.001832	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009959
CALM									0.036172
TOTAL	0.197573	0.063301	0.004235	0.000000	0.000000	0.000000	0.000000	0.000000	0.301282

MEAN WIND SPEED (m/s) = 1.21

NUMBER OF OBSERVATIONS = 2632

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FREQUENCY OF OCCURENCE OF STABILITY CLASSES
-------------------------------------------
  A : 0.9%
  B : 6.3%
  C : 14.8%
  D : 42.2%
  E : 5.6%
  F : 30.1%


------------------------------
STABILITY CLASS BY HOUR OF DAY
------------------------------
Hour   A    B    C    D    E    F
  01 0000 0000 0000 0097 0045 0222
  02 0000 0000 0000 0110 0037 0217
  03 0000 0000 0000 0120 0027 0217
  04 0000 0000 0000 0112 0025 0227
  05 0000 0000 0000 0101 0026 0237
  06 0000 0000 0064 0125 0022 0153
  07 0000 0018 0110 0140 0015 0081
  08 0000 0034 0161 0169 0000 0000
  09 0000 0084 0094 0186 0000 0000
  10 0002 0077 0086 0199 0000 0000
  11 0017 0078 0096 0173 0000 0000
  12 0022 0070 0105 0167 0000 0000
  13 0022 0062 0112 0168 0000 0000
  14 0015 0058 0101 0190 0000 0000
  15 0000 0046 0088 0230 0000 0000
  16 0000 0020 0096 0248 0000 0000
  17 0000 0001 0104 0259 0000 0000
  18 0000 0000 0053 0219 0016 0076
  19 0000 0000 0027 0153 0035 0149
  20 0000 0000 0000 0101 0071 0192
  21 0000 0000 0000 0124 0042 0198
  22 0000 0000 0000 0102 0044 0218
  23 0000 0000 0000 0098 0045 0221
  24 0000 0000 0000 0097 0043 0224

--------------------------------
STABILITY CLASS BY MIXING HEIGHT
--------------------------------
Mixing height     A    B    C    D    E    F
    <=500 m     0000 0083 0476 1605 0447 2632
   <=1000 m     0017 0249 0435 1369 0046 0000
   <=1500 m     0042 0157 0224 0478 0000 0000
   <=2000 m     0015 0050 0128 0181 0000 0000
   <=3000 m     0004 0009 0034 0055 0000 0000
    >3000 m     0000 0000 0000 0000 0000 0000
```

MIXING HEIGHT BY HOUR OF DAY

Hour	0000 to 0100	0100 to 0200	0200 to 0400	0400 to 0800	0800 to 1600	1600 to 3200	Greater than 3200
01	0218	0054	0059	0027	0006	0000	0000
02	0231	0048	0051	0025	0008	0001	0000
03	0232	0048	0050	0027	0007	0000	0000
04	0238	0046	0042	0032	0006	0000	0000
05	0252	0044	0035	0025	0007	0001	0000
06	0243	0044	0043	0026	0008	0000	0000
07	0146	0060	0087	0057	0014	0000	0000
08	0063	0048	0075	0133	0044	0001	0000
09	0001	0028	0050	0197	0085	0003	0000
10	0000	0000	0018	0201	0135	0010	0000
11	0000	0000	0001	0159	0182	0022	0000
12	0000	0000	0000	0110	0218	0036	0000
13	0000	0000	0000	0081	0222	0061	0000
14	0000	0000	0001	0068	0221	0074	0000
15	0000	0001	0003	0067	0219	0074	0000
16	0000	0000	0014	0105	0172	0073	0000
17	0038	0016	0059	0109	0121	0021	0000
18	0097	0051	0054	0111	0050	0001	0000
19	0162	0062	0084	0043	0013	0000	0000
20	0192	0069	0062	0032	0009	0000	0000
21	0204	0059	0053	0042	0006	0000	0000
22	0225	0049	0054	0024	0012	0000	0000
23	0222	0056	0045	0035	0006	0000	0000
24	0225	0054	0044	0035	0006	0000	0000

Figures

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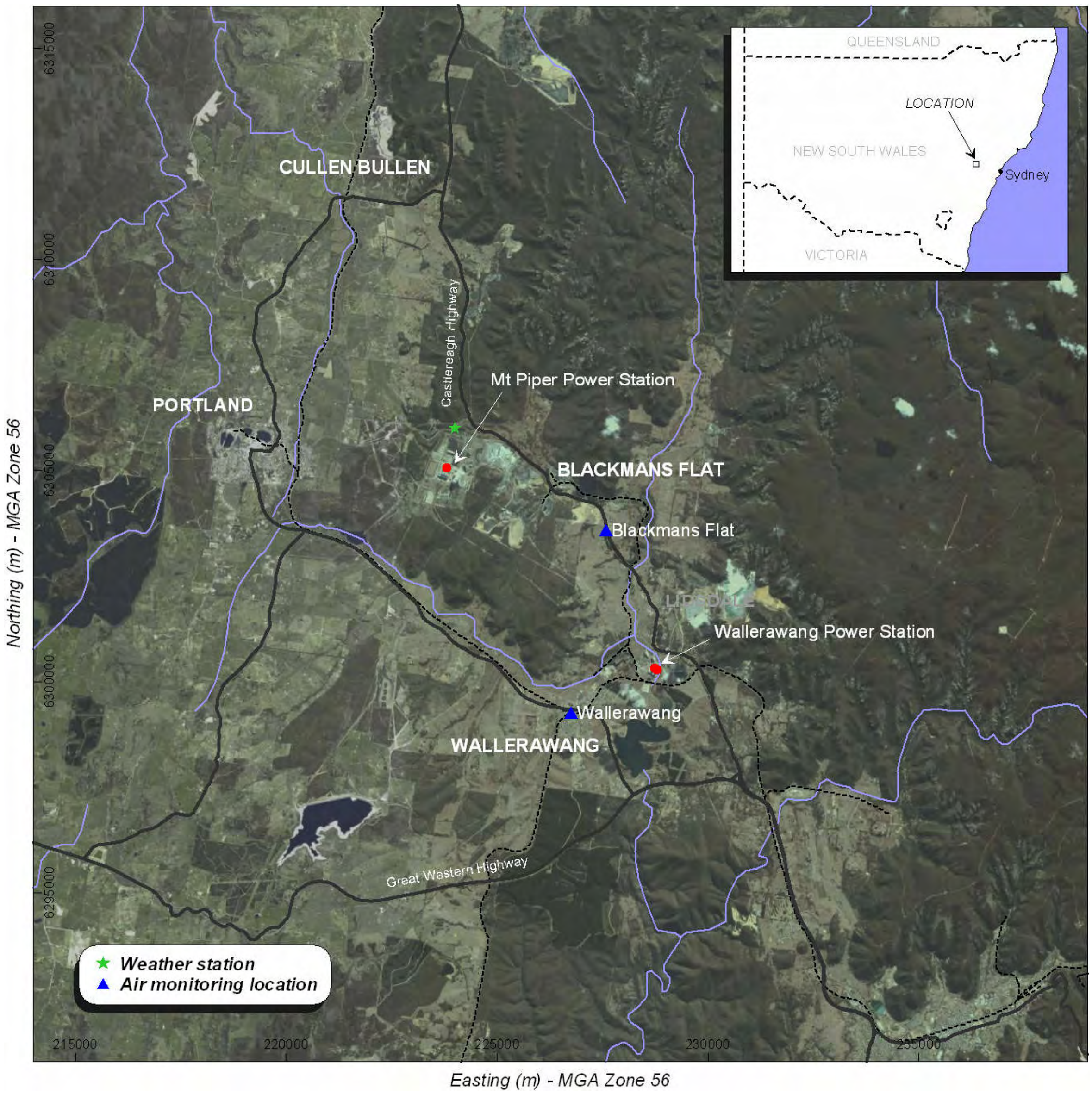
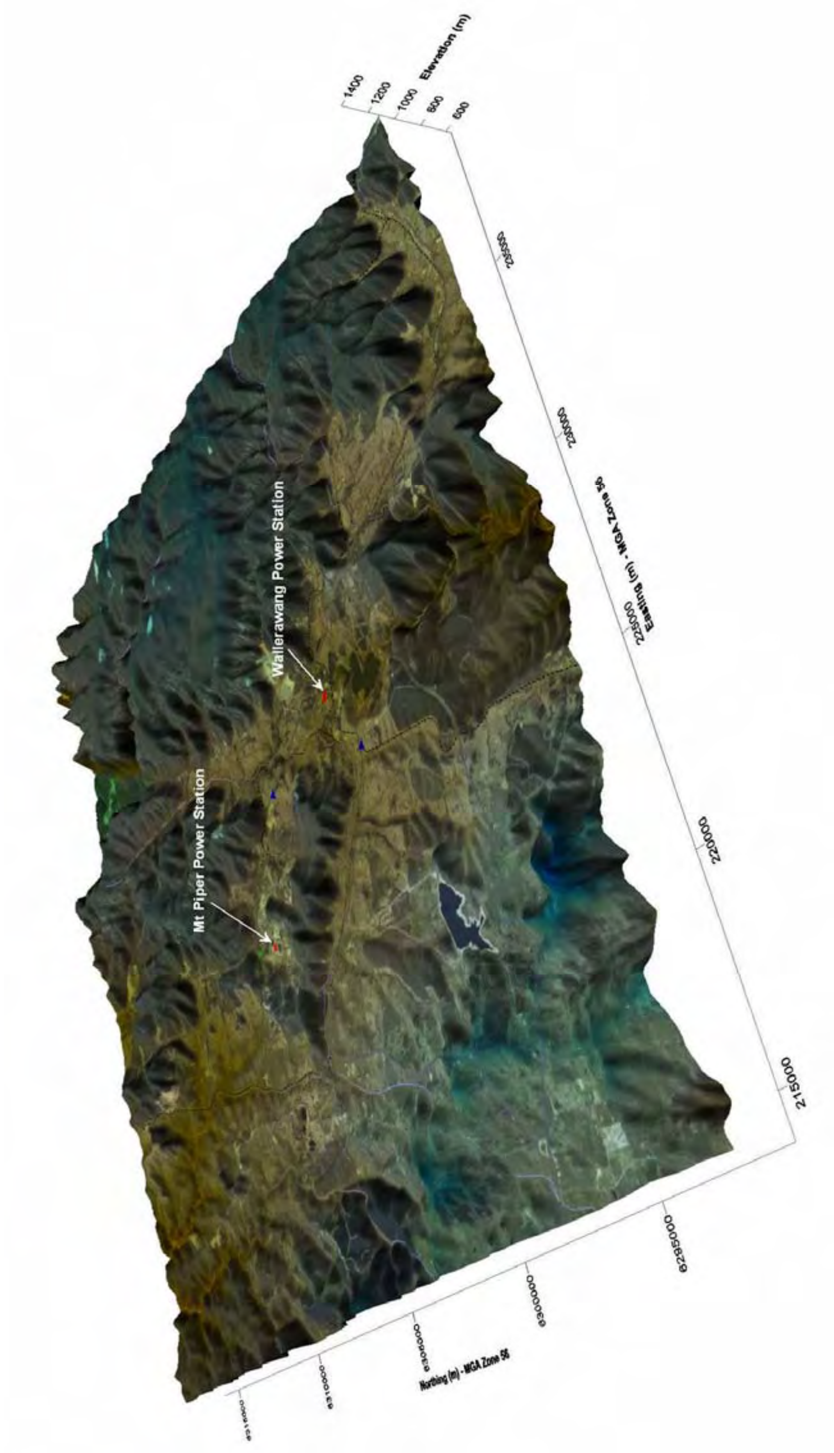
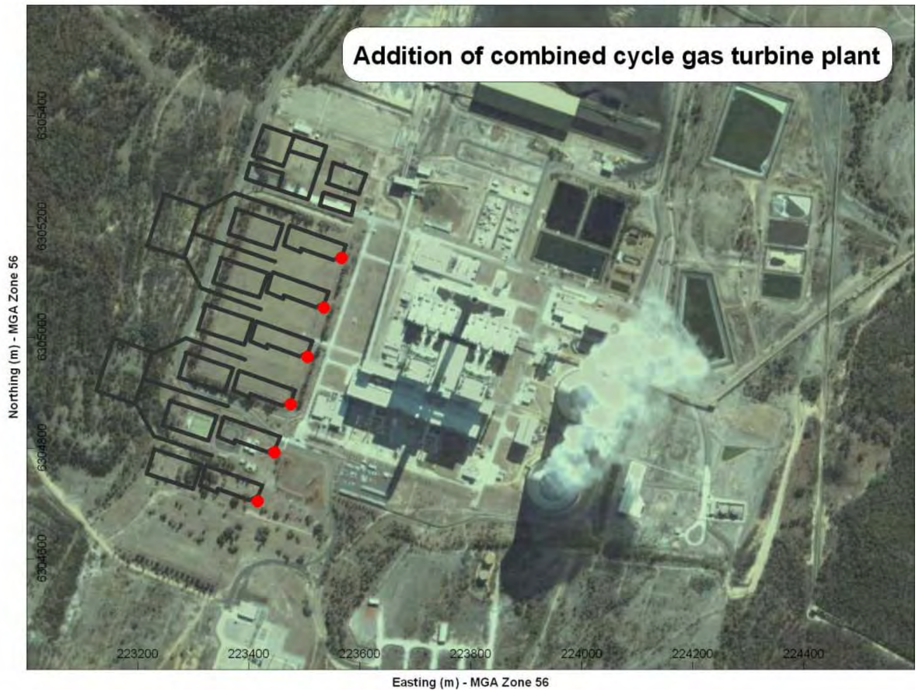
▪ Figure 1 Location of Mt Piper Power Station



- **Figure 2 Pseudo three dimensional representation of the local terrain**



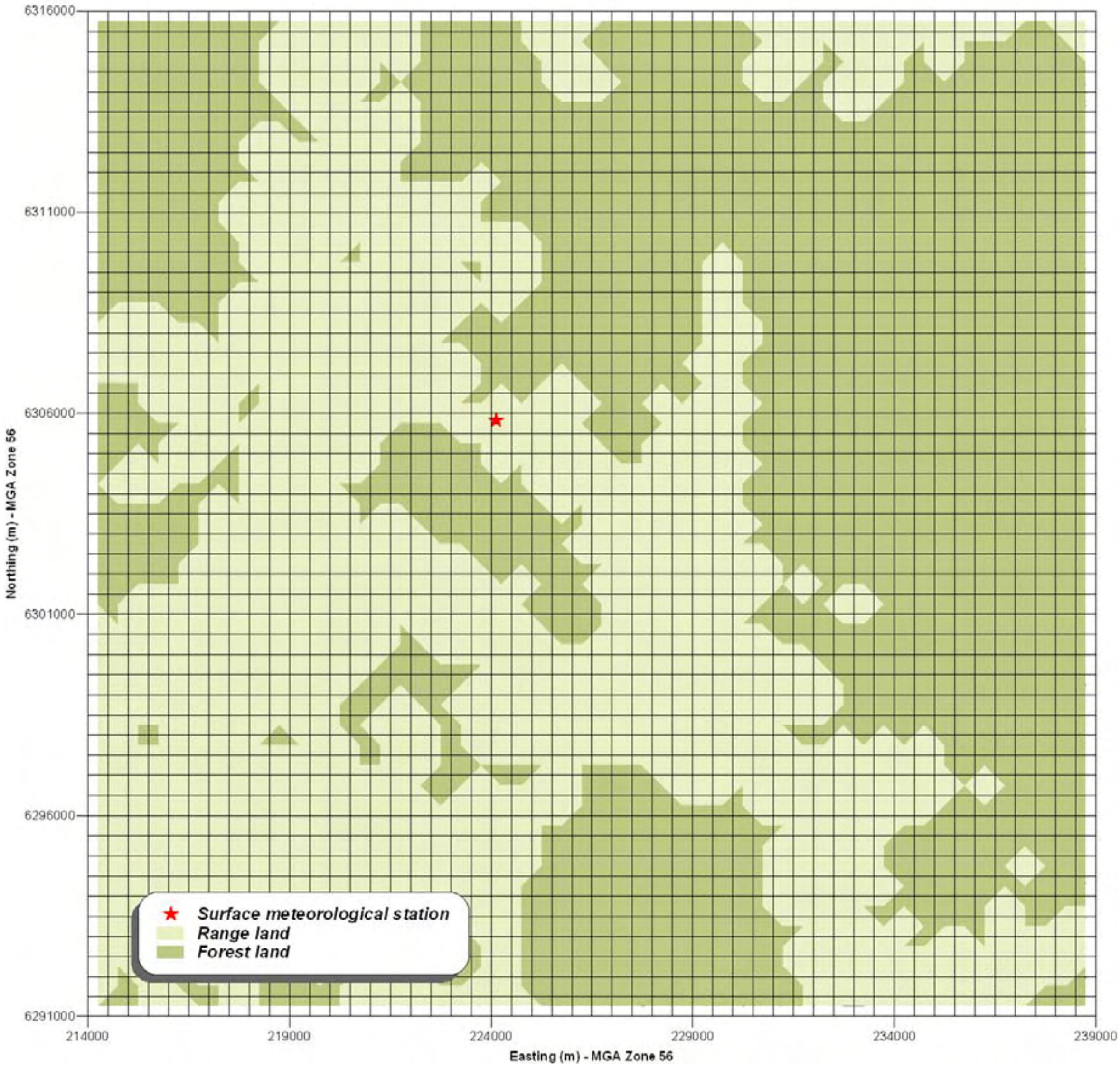
▪ Figure 3 Plant layout options



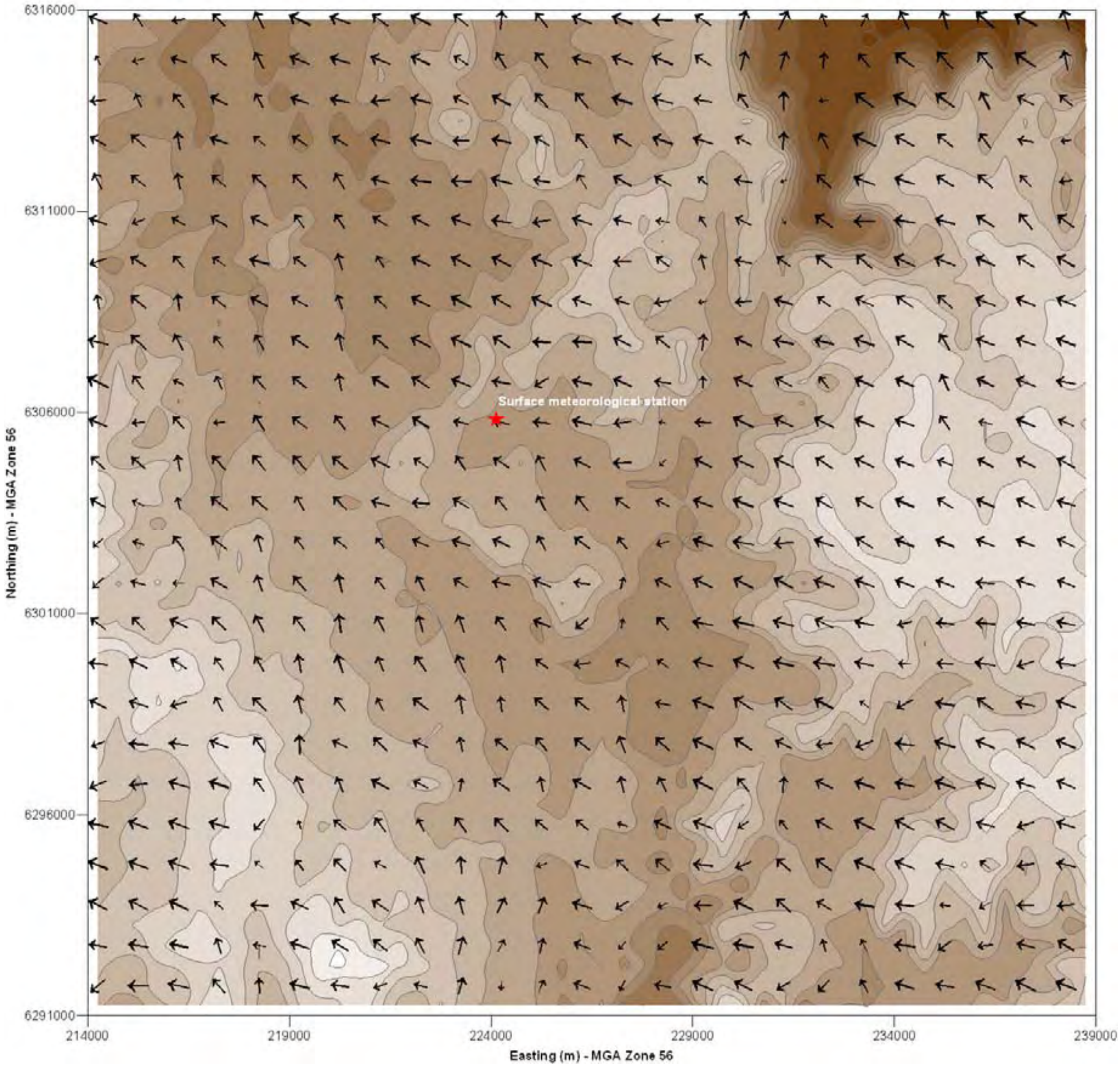
- **Figure 4 Annual wind-roses for Mt Piper Power Station**

- **Figure 5 Annual and seasonal wind-roses for Mt Piper Power Station (2001)**

- **Figure 6 CALMET model extents, grid spacing and landuse setup**

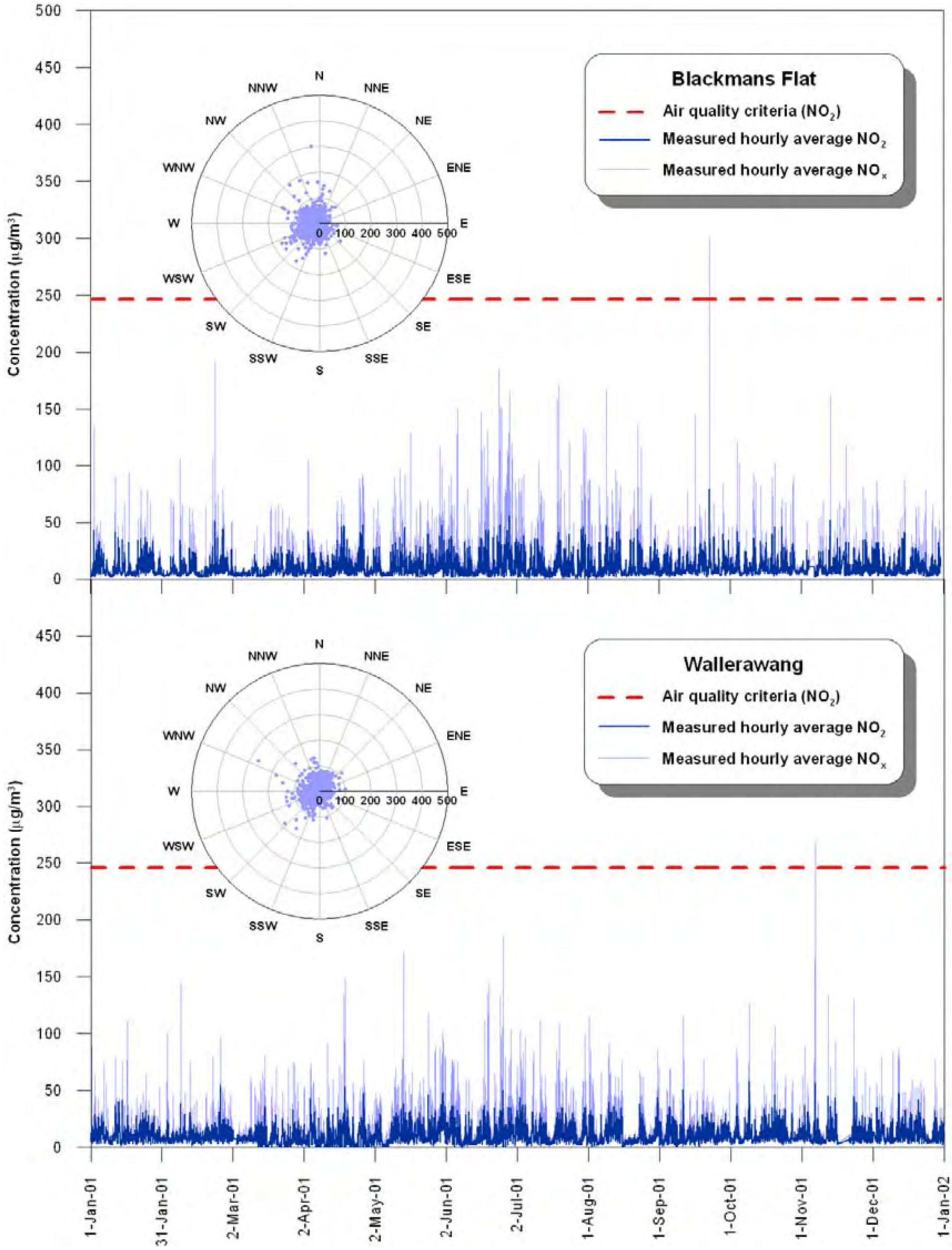


■ **Figure 7 Example of ground-level wind patterns as simulated by CALMET**



The above wind patterns are for 1 Jan 2001 hour 3.

■ **Figure 8 Measured NO_x concentrations in the study area**



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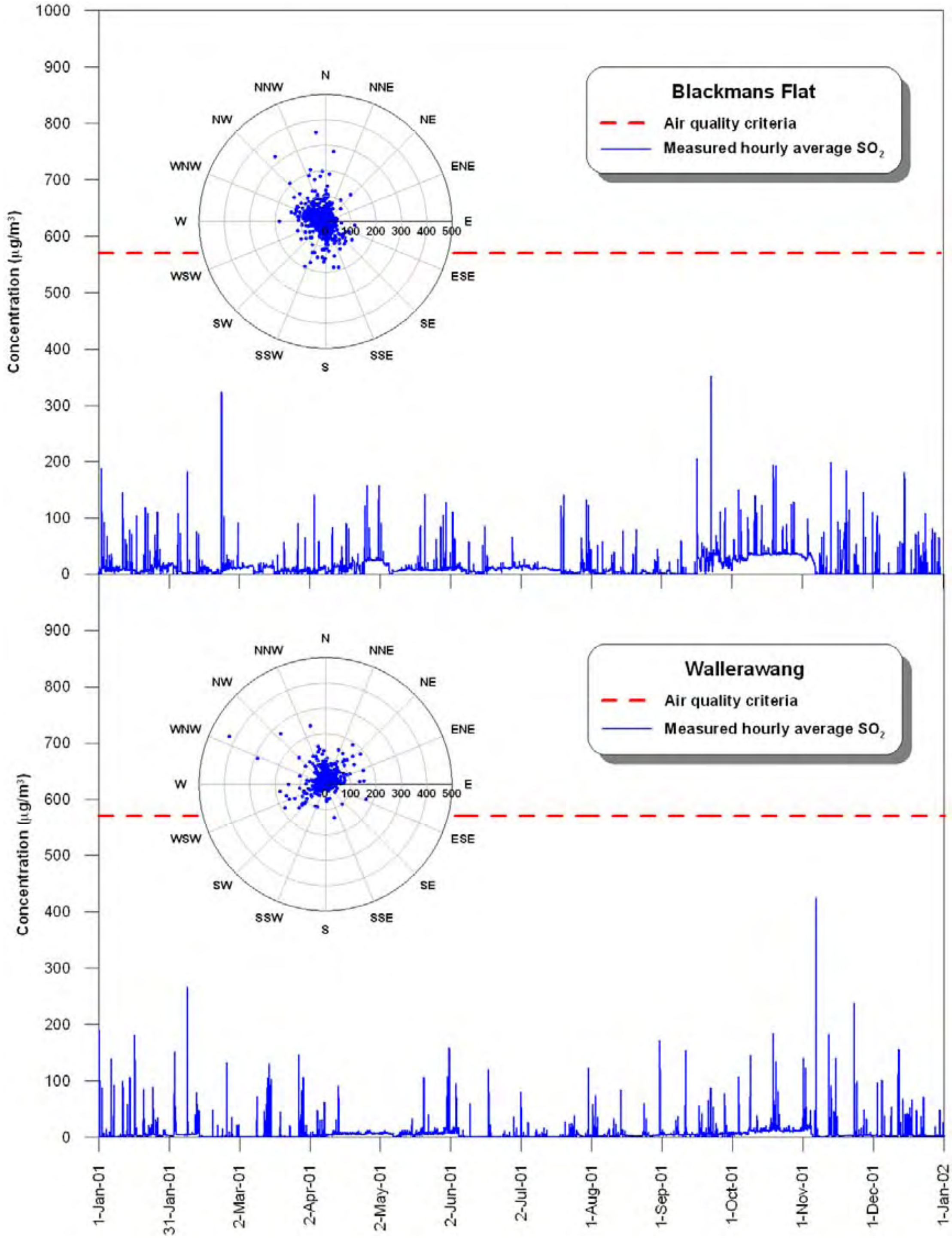
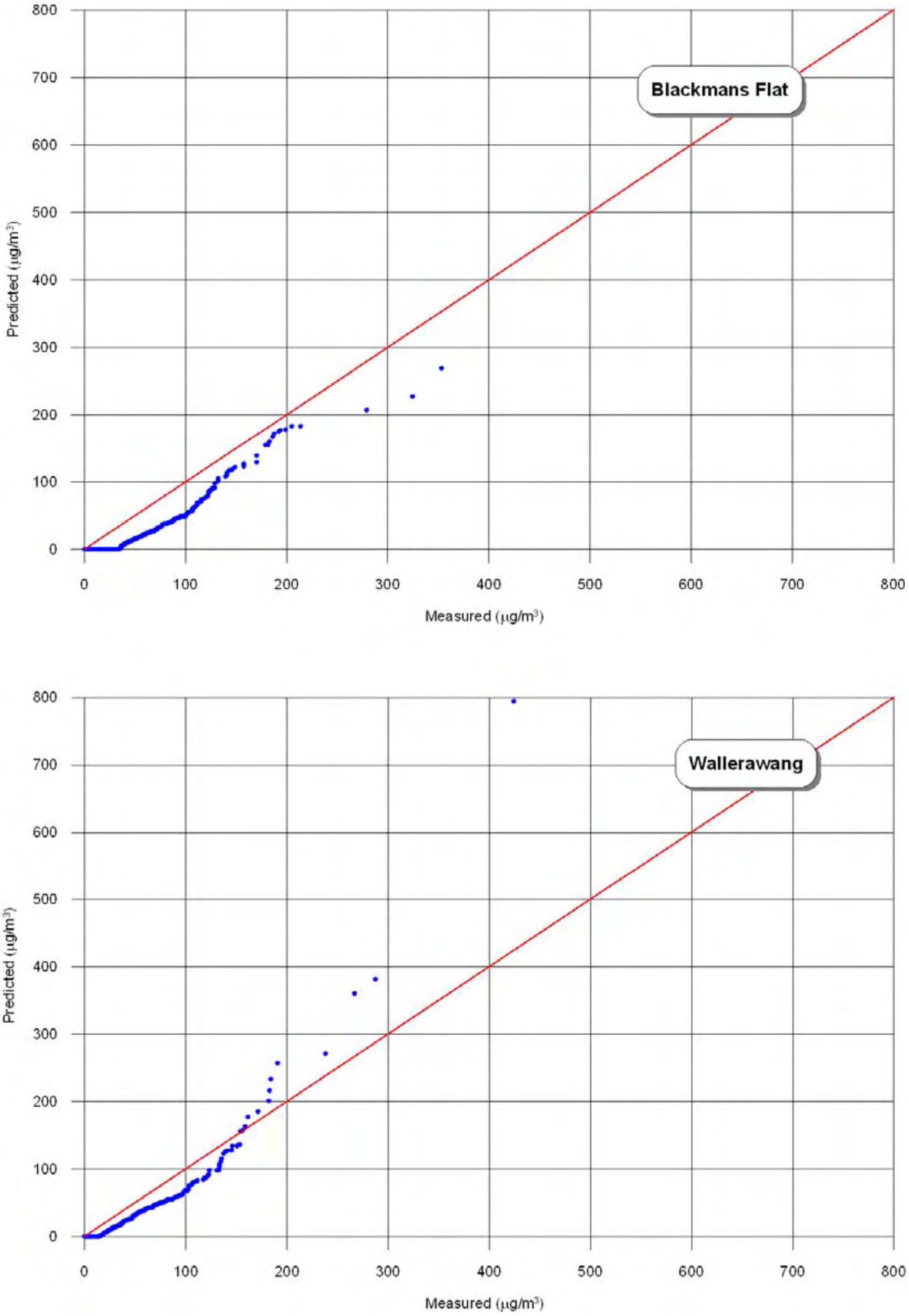
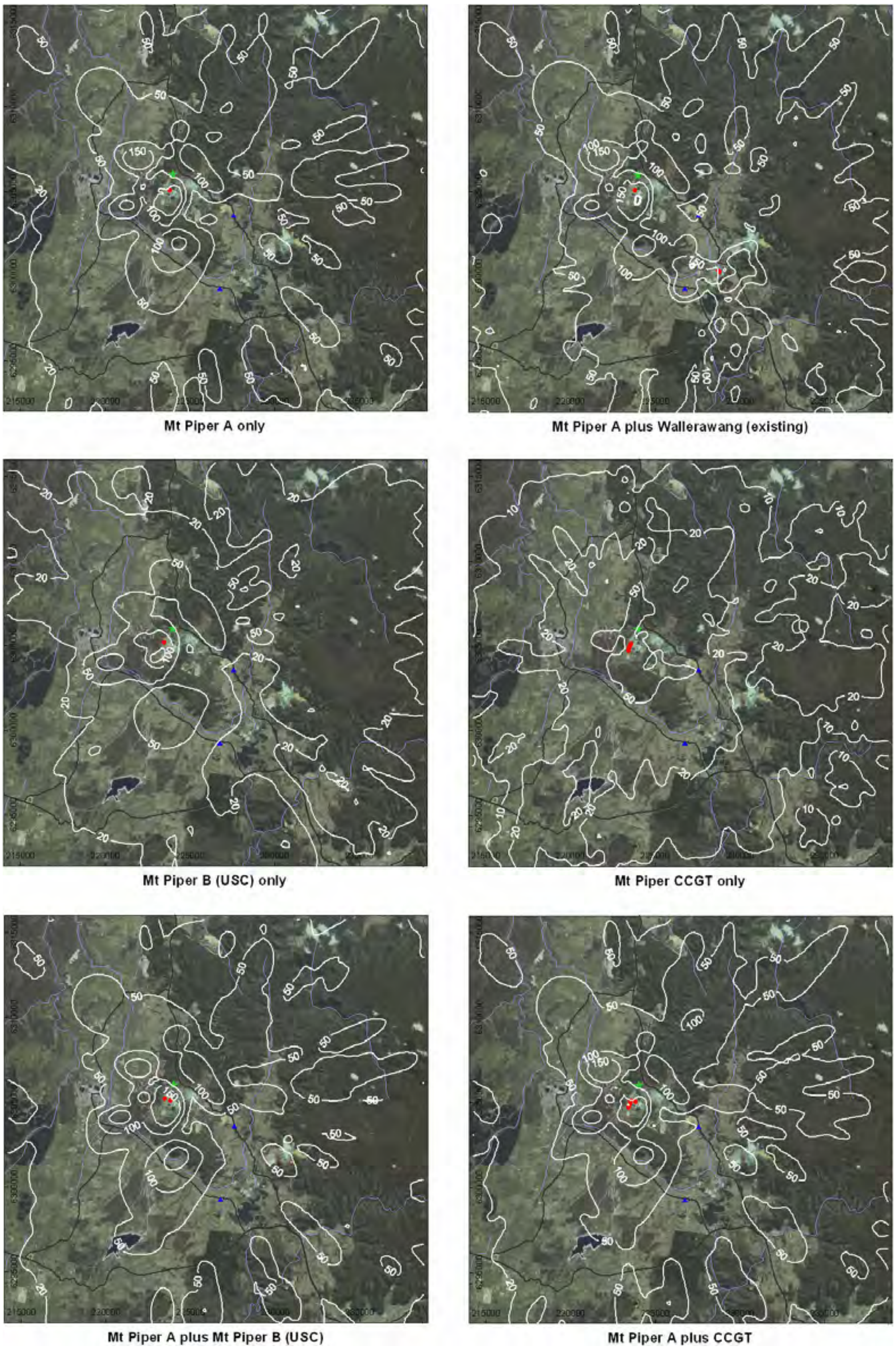
- **Figure 9 Measured SO_2 concentrations in the study area**



▪ **Figure 10 Ranked comparison of measured and predicted SO_2 concentrations**



■ **Figure 11 Predicted maximum 1-hour average NO_2 concentrations (µg/m^3)**



SKM

- **Figure 12 Predicted annual average NO_x concentrations (µg/m^3)**

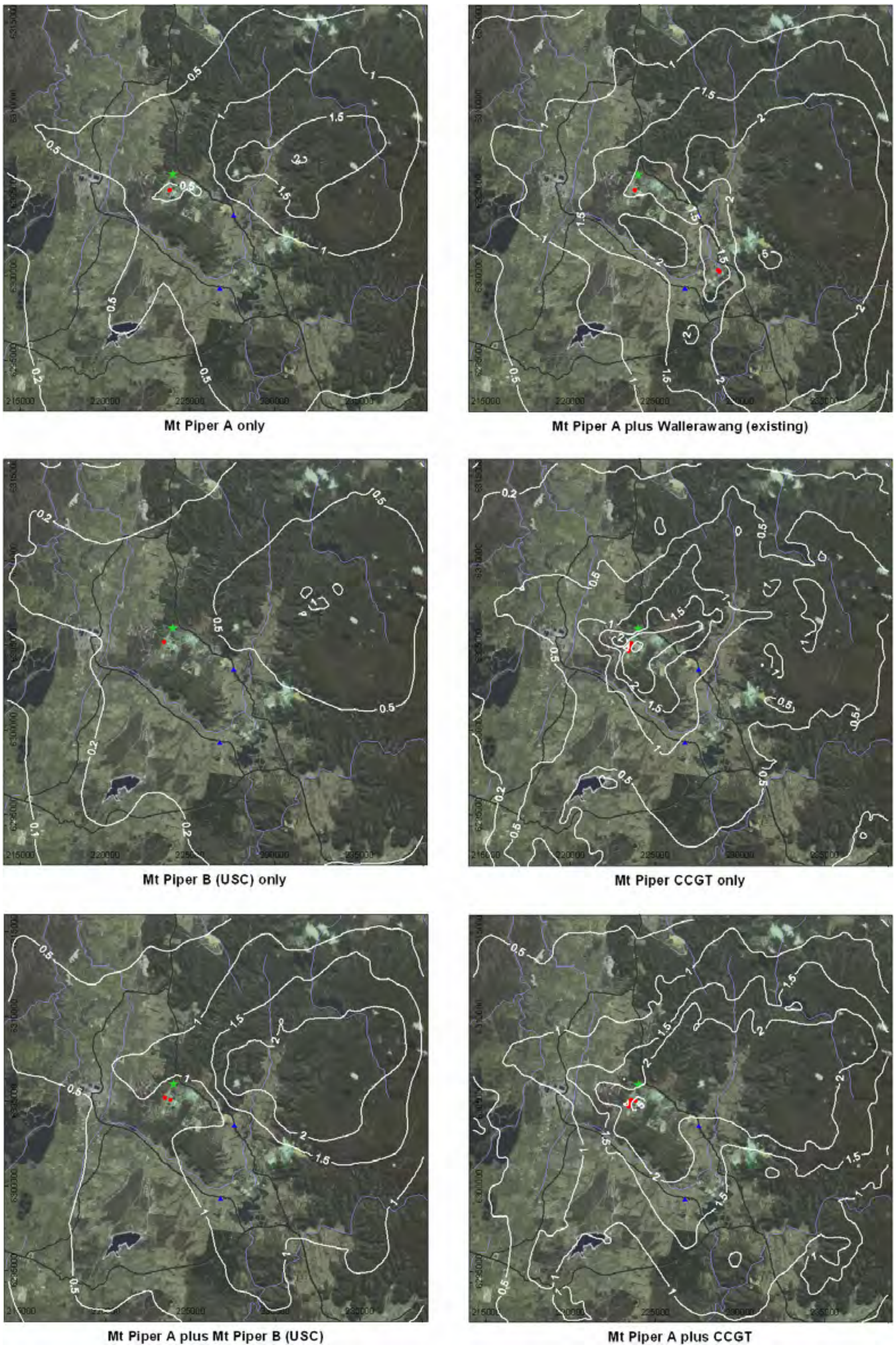


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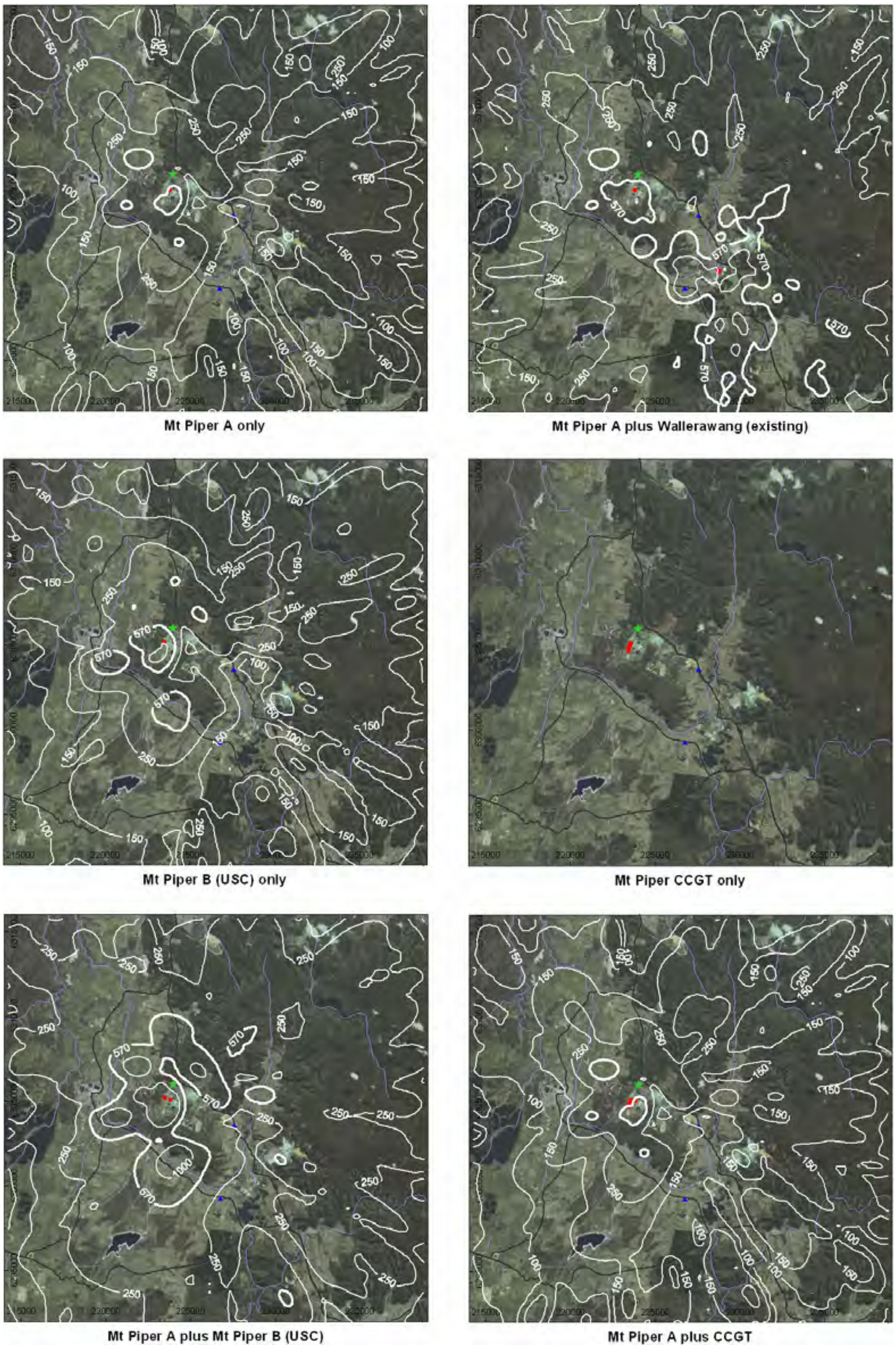
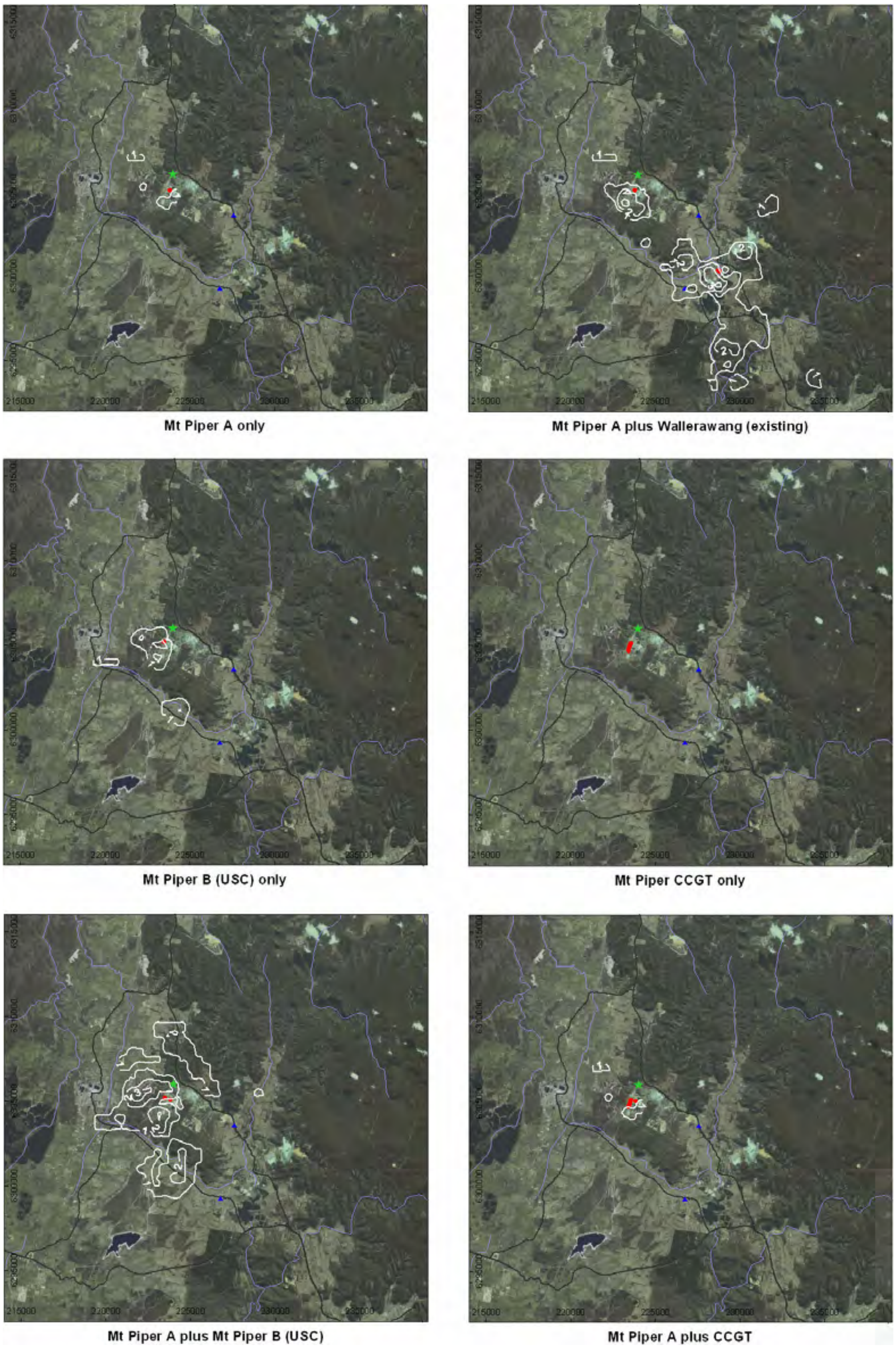
Figure 13 Predicted maximum 1-hour average SO_2 concentrations (µg/m^3)

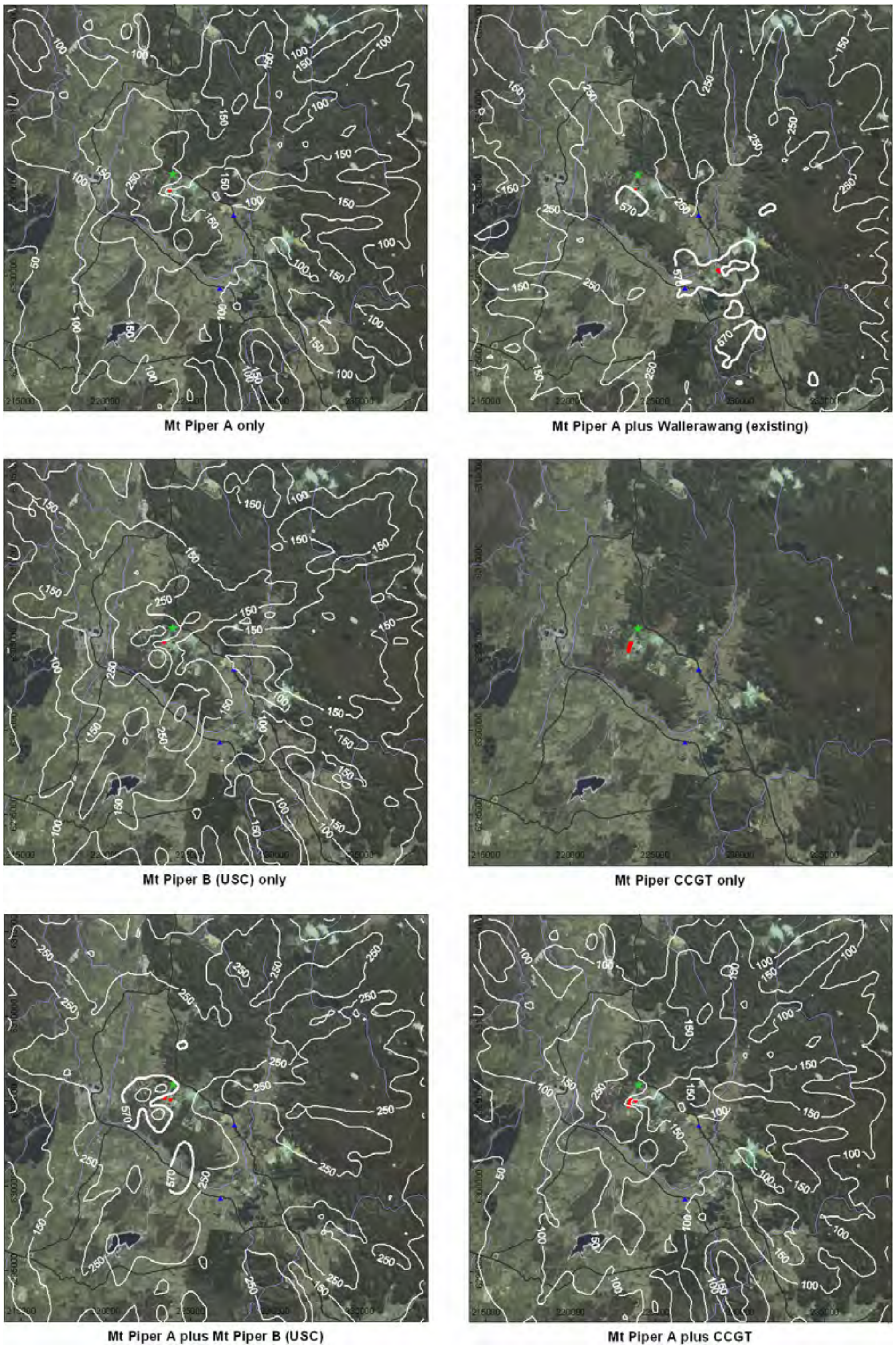


SKM

- **Figure 14 Predicted number of hours per year when SO_2 exceeds 570 µg/m^3**

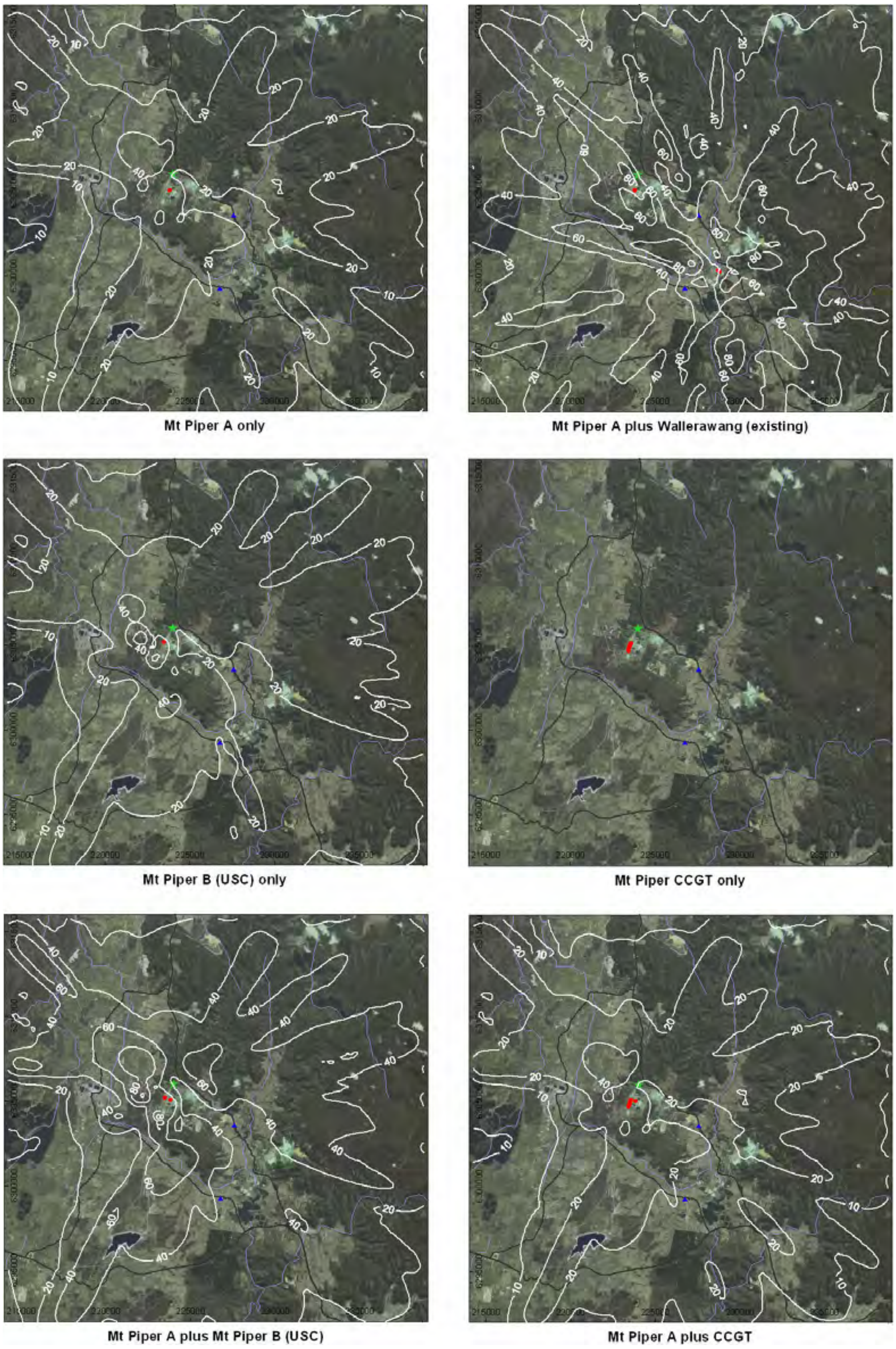


- **Figure 15 Predicted second highest 1-hour average SO_2 concentrations (µg/m^3)**



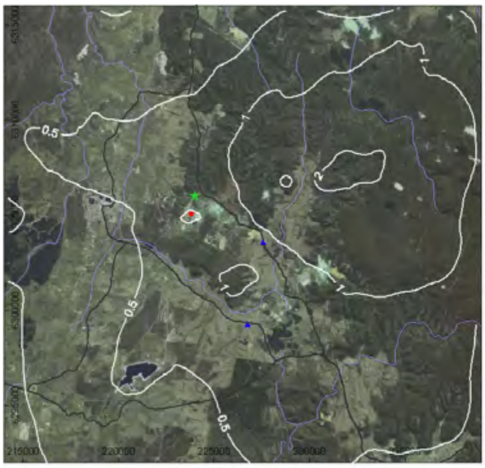
SKM

- **Figure 16 Predicted maximum 24-hour average SO_2 concentrations (µg/m³)**



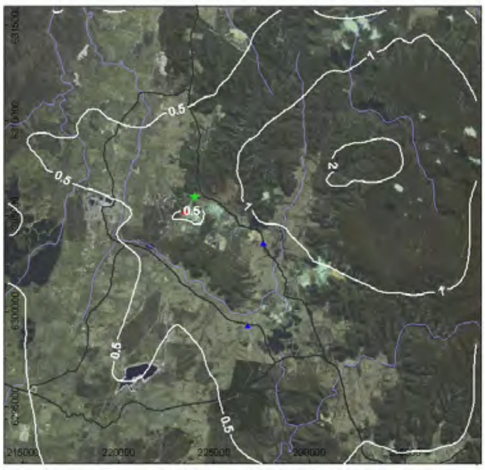
SKM

- **Figure 17 Predicted annual average SO_2 concentrations (µg/m³)**

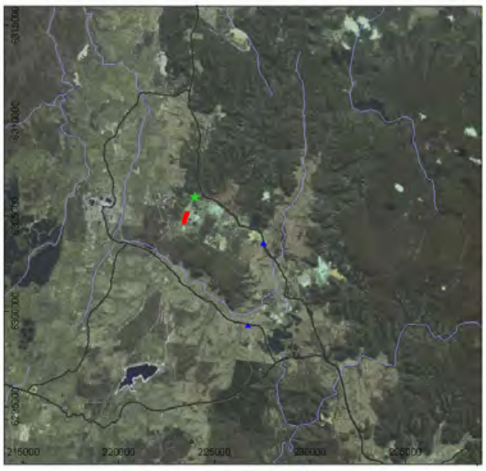


Mt Piper A only

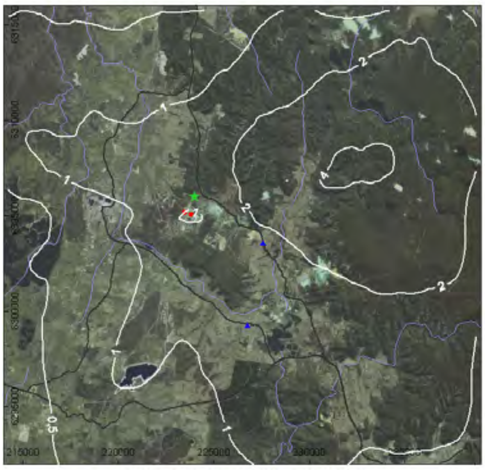
Mt Piper A plus Wallerawang (existing)



Mt Piper B (USC) only



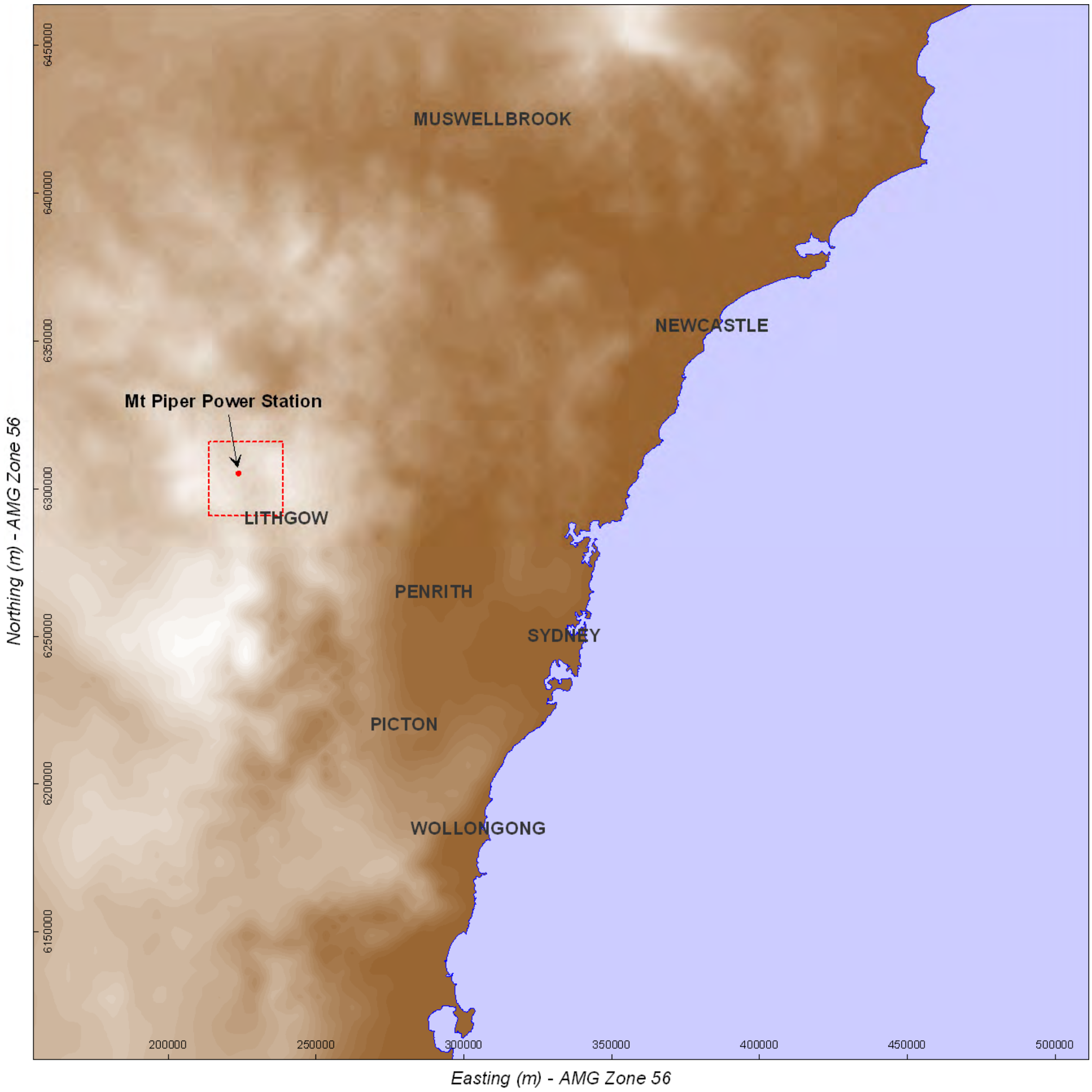
Mt Piper CCGT only



Mt Piper A plus Mt Piper B (USC)

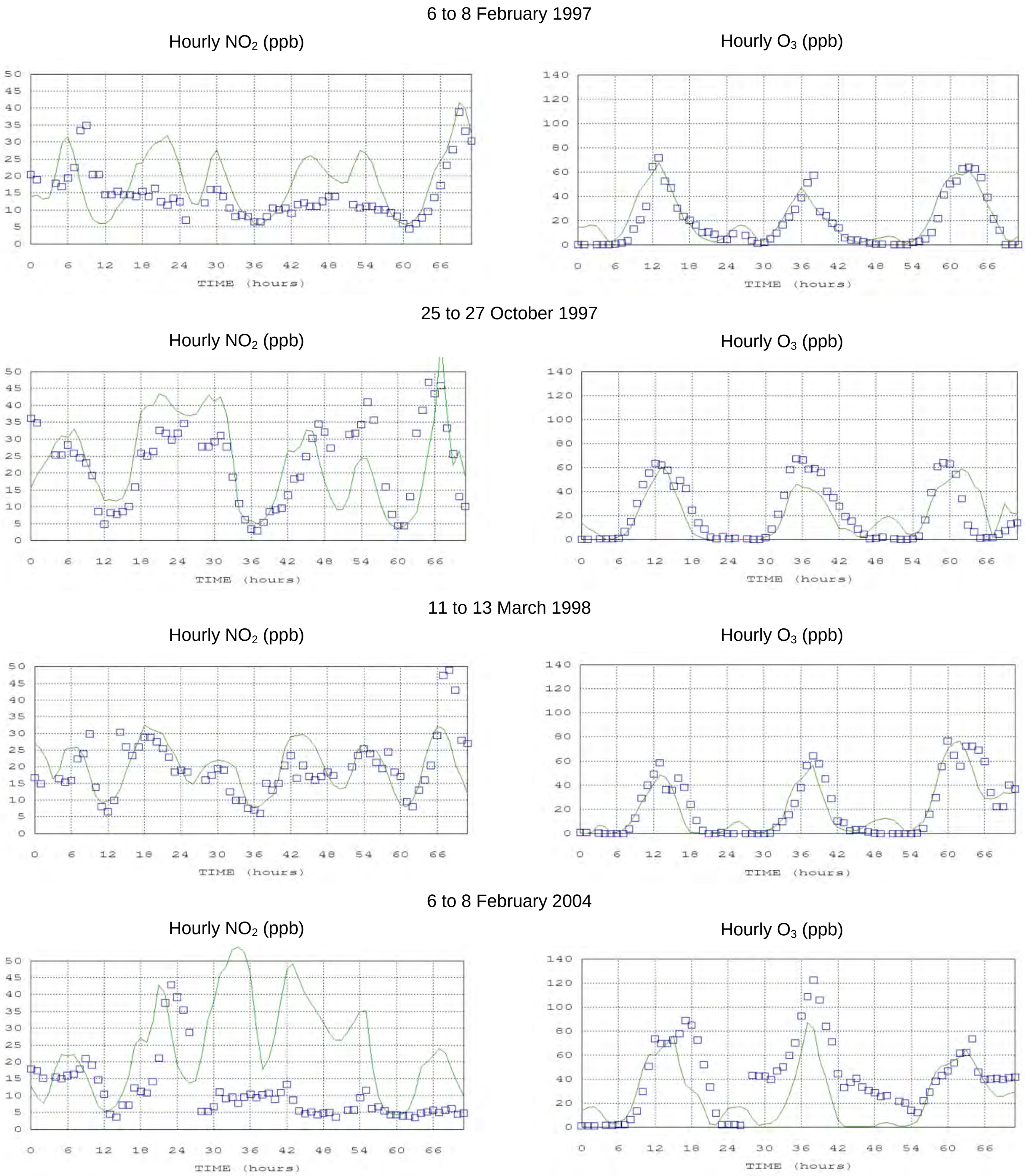
Mt Piper A plus CCGT

- **Figure 18 The Metropolitan Air Quality Study Region**



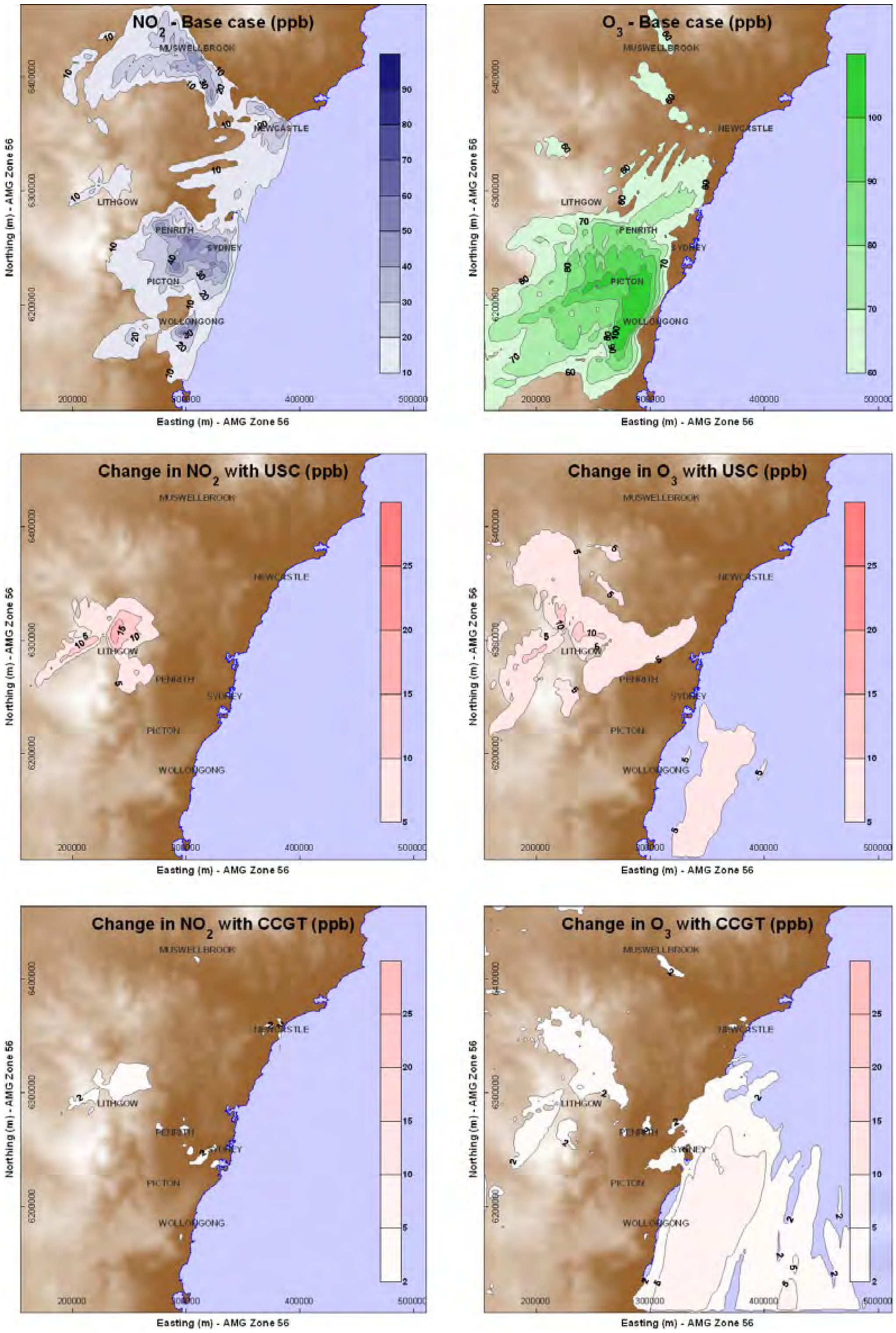
SKM

Figure 19 Comparison of regional model predictions with observations

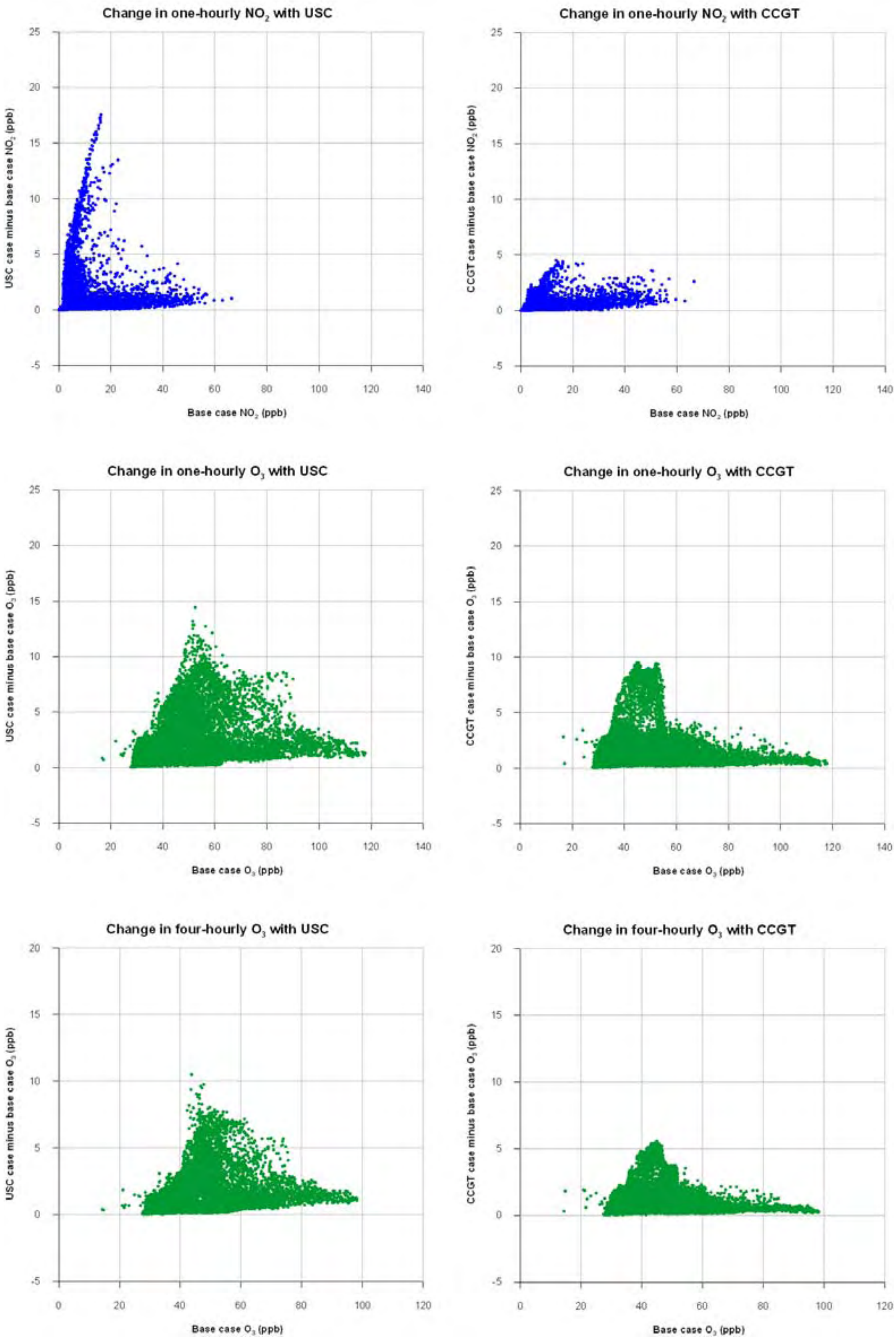


Observations from Blacktown. — Observation, □ Base case prediction

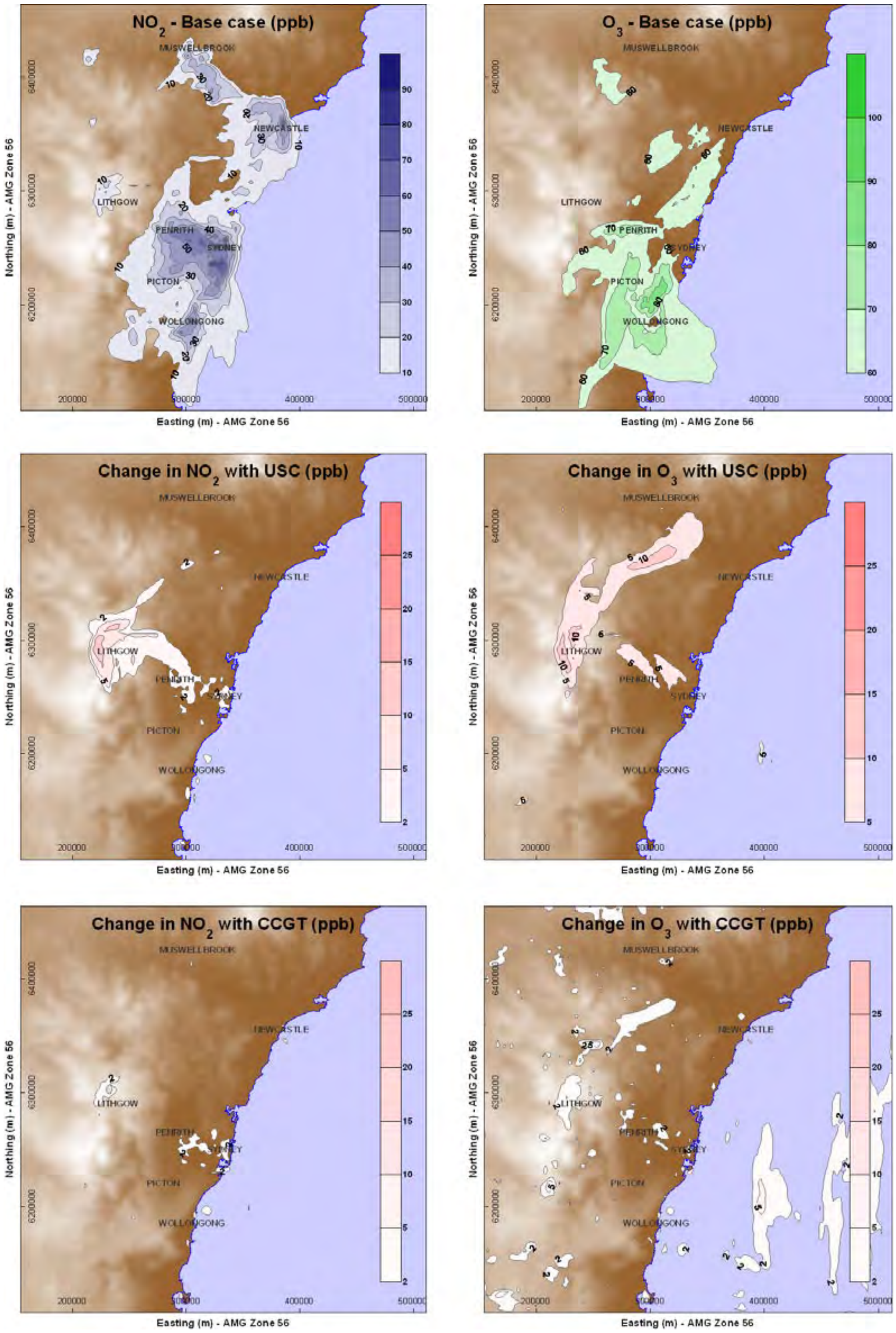
- **Figure 20 Predicted regional NO_2 and O_3 concentrations for 6-8 February 1997**



■ **Figure 21 Predicted changes to NO_2 and O_3 concentrations for 6-8 February 1997**

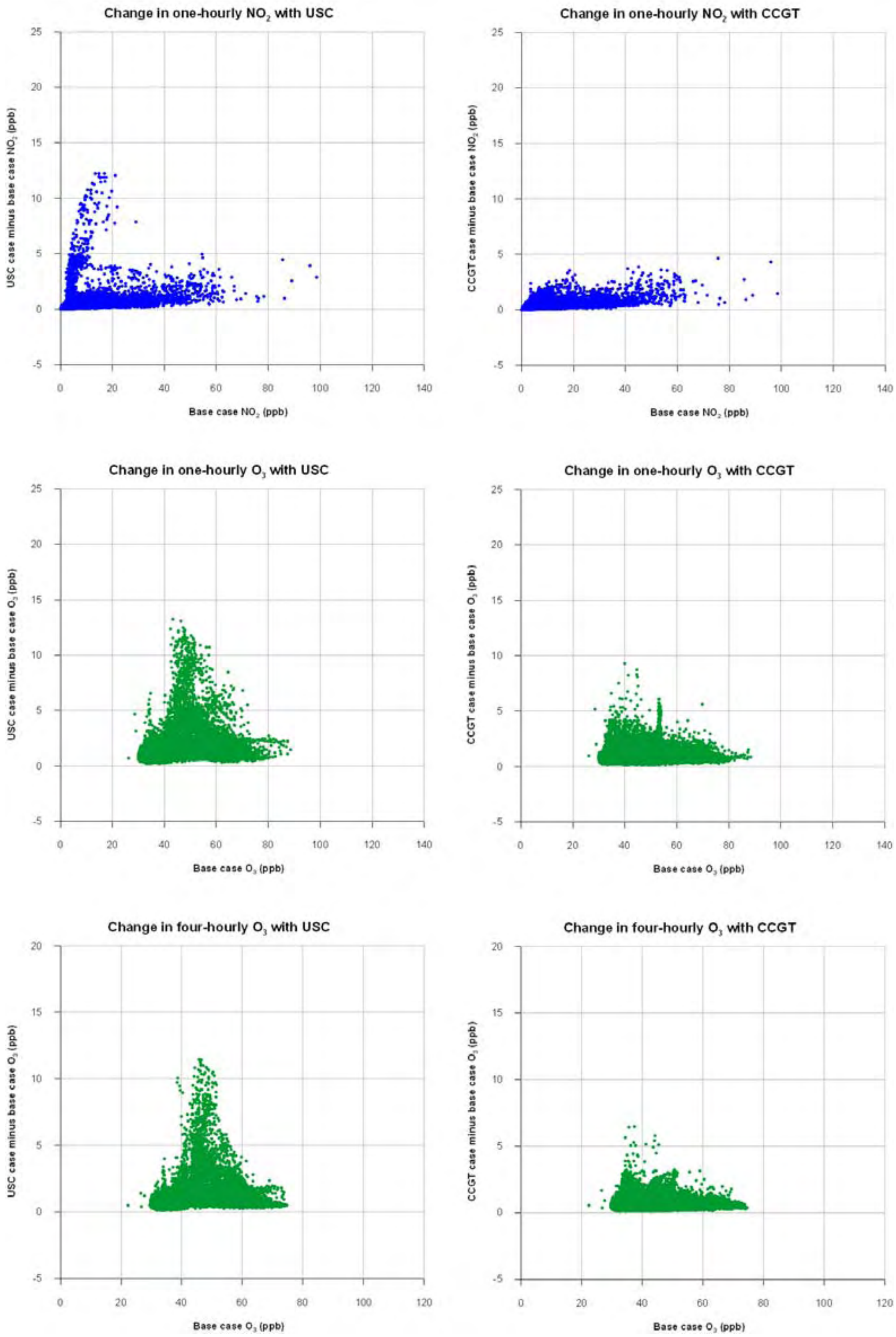


▪ **Figure 22 Predicted regional NO_2 and O_3 concentrations for 25-27 October 1997**



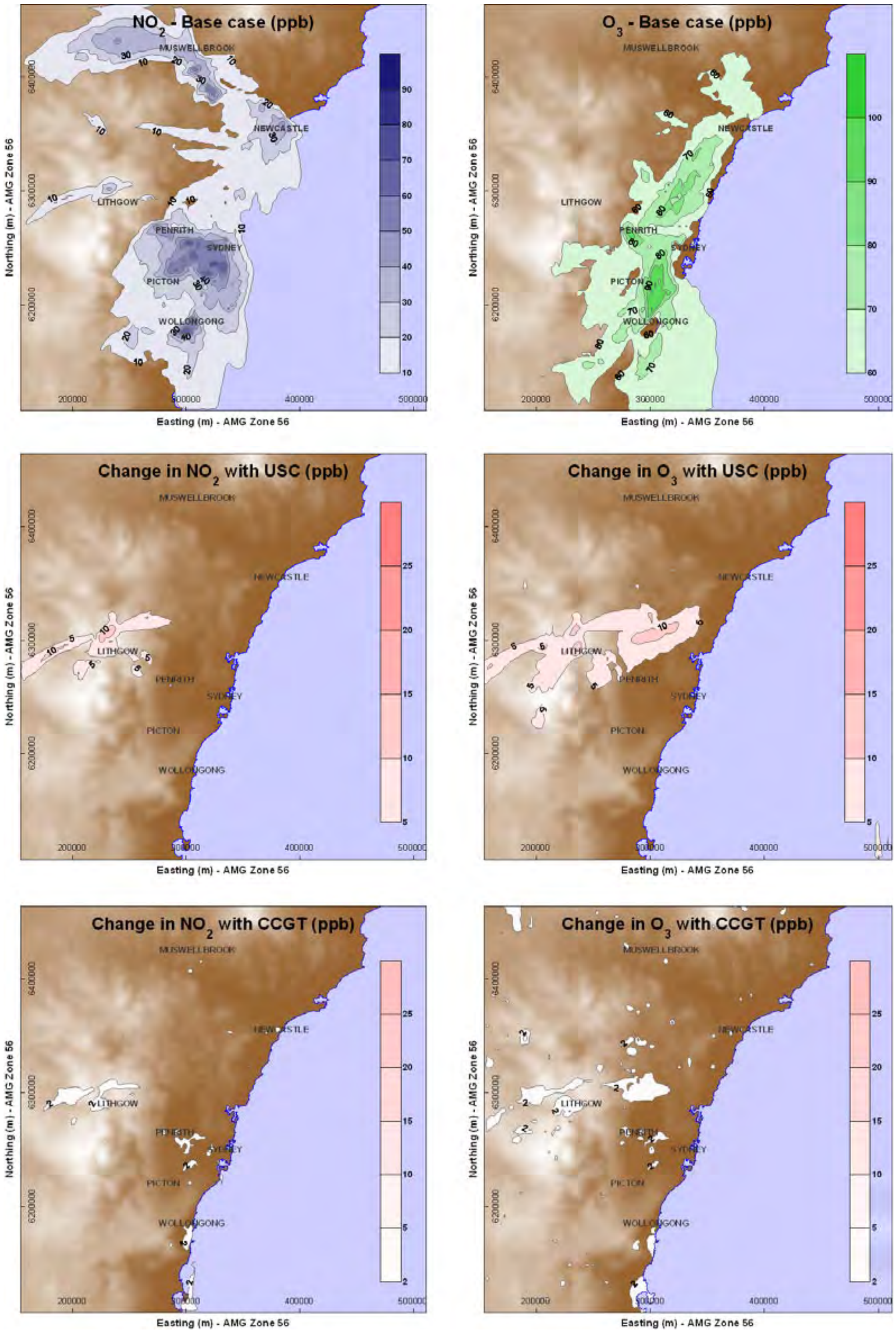
SKM

- **Figure 23 Predicted changes to NO_2 and O_3 concentrations for 25-27 October 1997**



SKM

- **Figure 24 Predicted regional NO_2 and O_3 concentrations for 11-13 March 1998**



- **Figure 25 Predicted changes to NO_2 and O_3 concentrations for 11-13 March 1998**

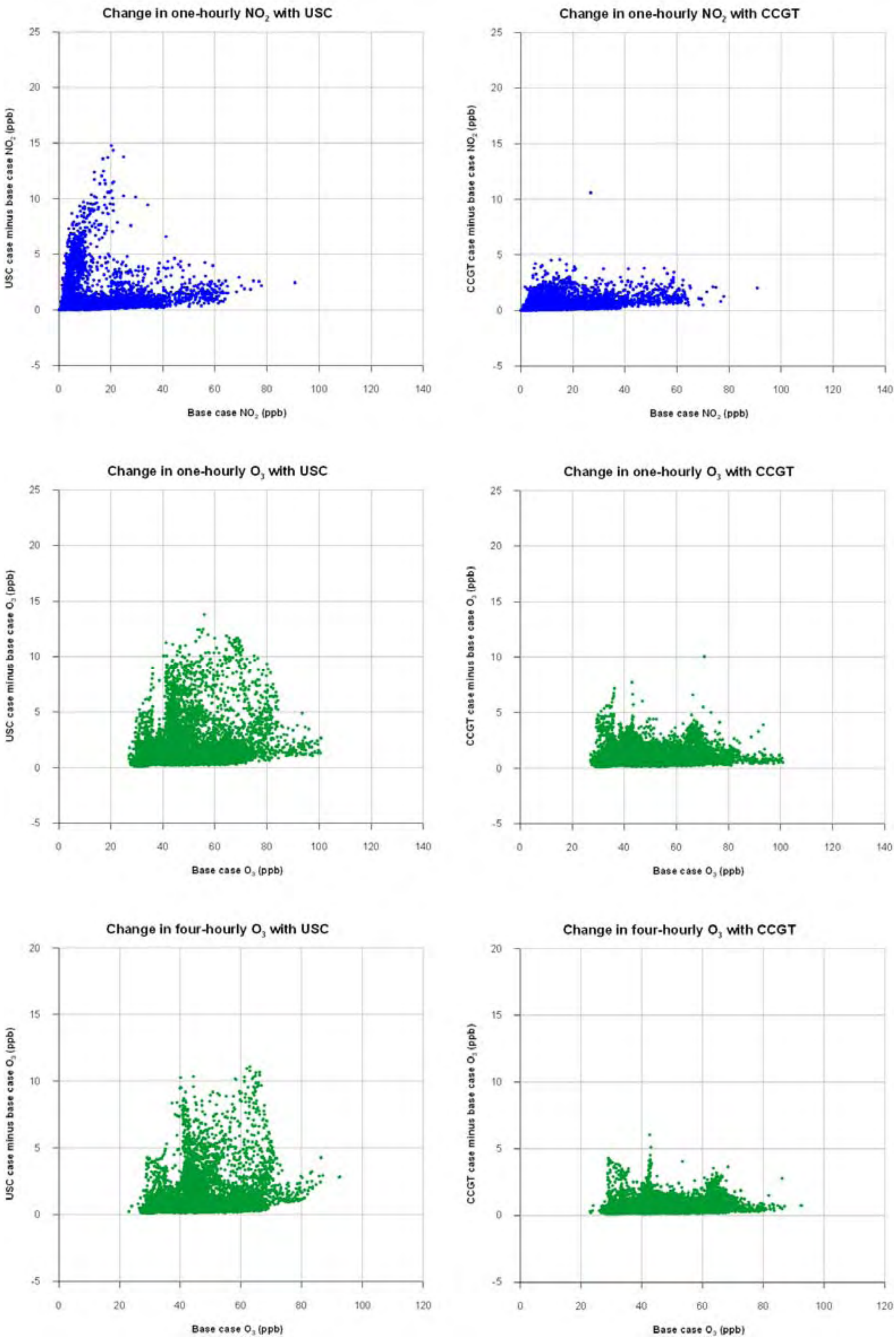
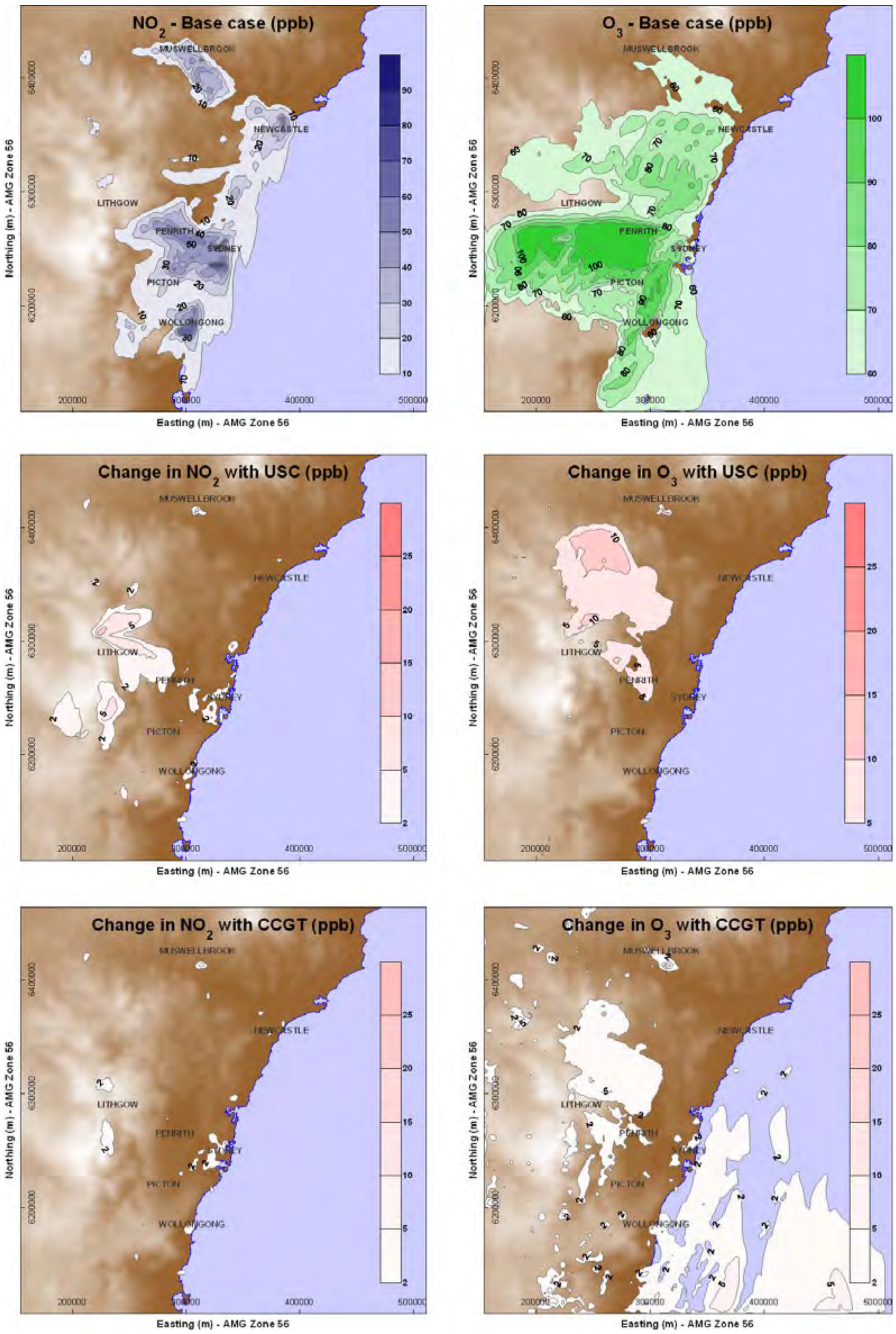
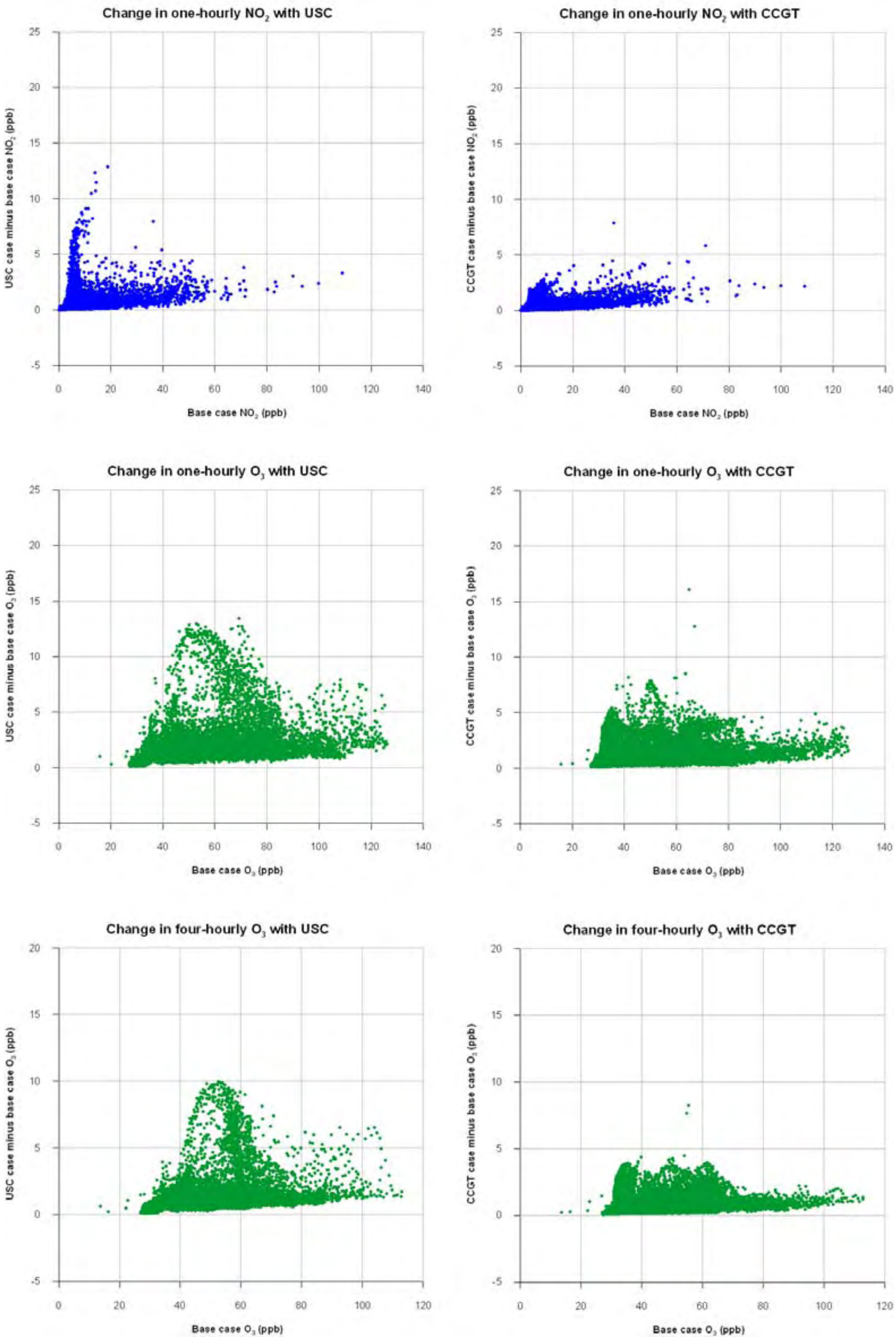


Figure 26 Predicted regional NO_2 and O_3 concentrations for 6-8 February 2004



SKM

- **Figure 27 Predicted changes to NO_2 and O_3 concentrations for 6-8 February 2004**



SKM

- **Figure 28 Region of space in which plume vertical velocity falls below 4.3 m/s**