Appendix B

Air Quality Assessment

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Executive Summary

The impact of the proposed Tallawarra Stage B power station on local air quality and regional photochemical smog levels has been investigated. Local impacts of nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter (PM_{10}) were assessed using the prognostic meteorological and air pollution model, TAPM version 3.0.7 (CSIRO, Hurley, 2005a, 2005b) for 2002 meteorological conditions. A review of the Department of Environment and Climate Change (DECC) air quality monitoring records for the Illawarra region for the years 2000 to 2006 identified that the year 2002 experienced the highest levels of NO_2 concentrations. Regional photochemical impacts were assessed on days identified as being conducive to high photochemical activity, using the chemistry mode of TAPM-GRS v3.0.7 (Hurley, 2005a, 2005b).

In summary, the modelling results show that, across the study area, the impacts of the proposed Tallawarra Stage B power station, as either an OCGT or a CCGT, are predicted to be within the DECC criteria for nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and particulate matter (as PM_{10}) and ozone (O_3) as a measure of photochemical smog.

For the Tallawarra Stage B plant, either OCGT or CCGT, the maximum NO_2 cumulative ground level concentrations are predicted to occur during hours of relatively low incremental impacts from the power station, combined with high background concentrations. The highest incremental impacts of the power station are predicted to occur during hours of relatively low background concentrations.

This assessment analyses nitrogen oxide (NO_X) impacts using the Ozone Limiting Method (OLM) which is among the approved methods recommended by NSW DECC (2005). The method assumes that the amount of nitrogen oxide (NO) that is converted to NO_2 is limited by the ambient ozone concentration. Modelled (NO_X) increments on ground level concentrations were analysed using the OLM to determine NO_2 ground level concentrations. The incremental NO_2 impacts of the power station were added to the background NO_2 concentrations (recorded for the corresponding hour at the Kembla Grange DECC air quality monitoring station) to give the cumulative NO_2 concentrations. Results are discussed in further detail below.

The assessment included modelling of the NO_2 impacts of the Tallawarra Stage A CCGT plant, which has recently entered commercial operation. Considering Tallawarra Stage A under full load operations, the maximum cumulative NO_2 1-hour average concentration, at any point across the modelling domain, is predicted to be 151 $\mu g/m^3$, which represents approximately 61 percent of the DECC criterion of 246 $\mu g/m^3$. The maximum cumulative 1-hour NO_2 concentrations, across the sensitive receptor sites, are predicted to be less than 70 $\mu g/m^3$. Compliance with DECC criteria is achieved for Tallawarra Stage A under hot, warm and cold start-up operations.

A review was undertaken of the air dispersion modelling results prepared as part of the Environmental Impact Statement (EIS) for the approved Tallawarra A CCGT Plant (EIA, Azzi, *et al*. 1998). The review acknowledged that differences in the modelling methods limit a comparison between the results of the EIS and the results in this report. Nevertheless, the air dispersion modelling results for the approved Tallawarra A CCGT presented in the EIS (Azzi, *et al*. 1998) compare well with the current results of modelling Tallawarra A at full load and assuming that NO_2 comprises 100 percent of NO_X in ground level plume impacts. Based on this assumption, the current study predicts a maximum hourly concentration of 81 μg/m^3 (3.9 parts per hundred million, pphm) for the Tallawarra A CCGT plant, which compares well with maximum hourly concentrations of 84 μg/m^3 (4.1 pphm) predicted by the EIS (Azzi *et al*. 1998).

Considering the impact of Tallawarra A and Tallawarra B OCGT, under full load operations, the maximum cumulative NO_2 1-hour average concentration at any point across the modelling domain was predicted to be 151 μg/m^3, which represents approximately 61 percent of the DECC criterion of 246 μg/m3. The average annual impact was predicted to be 17 μg/m^3 representing 27 percent of the DECC criterion of 62 μg/m^3. Considering start and part load operations, the maximum cumulative 1 hour NO_2 concentration at any point within the modelling domain (the local study area) is predicted to be 155 μg/m^3, during start-load operation of both Tallawarra A CCGT and Tallawarra B OCGT.

Tallawarra A and B, both as identical CCGT plants, under full load operations, are predicted to result in a maximum cumulative NO_2 1-hour average concentration of 161 μg/m^3, which represents 65 percent of the DECC criterion of 246 μg/m^3. The average annual impact was predicted to be 18 μg/m^3 representing 29 percent of the DECC criterion of 62 μg/m^3. Modelling of a set of start-load scenarios identified a worst-case cumulative impact during the operation of Tallawarra A during the first hour of warm start conditions combined with the first hour of Tallawarra B at cold start conditions. The worse-case impact was predicted to be 205 μg/m^3, which represents 83 percent of the DECC 1 hour NO_2 criterion of 246 μg/m^3.

The regional photochemical modelling methodology, as required by DECC in this assessment, used TAPM-GRS to evaluate a base case impact in the Illawarra, from existing emissions of NO_X and volatile organic compounds (VOCs) from the whole of the Sydney Greater Metropolitan Region (GMR) (excluding Tallawarra power station). It compared modelled results with ozone concentrations at the four DECC air quality monitoring sites in the Illawarra region.

Site-study days were selected according to the following criteria:

- Days displaying hours during which the observed hourly average concentrations recorded at the monitoring sites were > 60 ppb and within 20 ppb of the TAPM Base Case concentration predicted for the same hour at the relevant site.

This screening of modelled and observed ozone concentrations identified 19 days over four summer periods (2000-2001, 2003-2004, 2004-2005 and 2005-2006) that reproduced high ozone events well, according to the above criteria.

Secondly, the DECC methodology required test case modelling of the impact on ozone concentrations resulting from the additional NO_X emissions from Tallawarra A CCGT and Tallawarra B OGCT. The analysis compared modelled base case and test case ozone impacts for the site-study hours as well as the duration of modelled ozone concentrations over 60 ppb.

Analysis of individual ozone events, during five-month periods over four summers predicted that the additional emissions from Tallawarra A and B OCGT would result in predominantly no change in high ozone plume duration events. There were a small number of hours with predicted increased or decreased duration of high ozone plume concentration events.

In conclusion, the modelling results from this assessment show that the impacts of the extension to Tallawarra power station, as either OCGT or CCGT, meet the DECC criteria for NO_2, SO_2, and PM_{10} as well as O_3 as a measure of photochemical smog.

1. Introduction

1.1. General Introduction

TRUenergy has recently commissioned a 400 MW combined cycle gas turbine (CCGT) power plant on the site of the former Tallawarra coal-fired power station at Yallah on Lake Illawarra, known as Tallawarra Stage A. The power station site is approximately 13 km south of Wollongong and 60 km south of Sydney. TRUenergy now proposes to construct an extension to the power station, known as Tallawarra Stage B.

Sinclair Knight Merz (SKM) has been engaged by TRUenergy to complete an Environmental Assessment (EA) for the extension to the power station under Part 3A of the *Environmental Planning and Assessment (EP&A) Act, 1979*. This air quality report forms part of the EA and assesses the local and regional impacts of a range of scenarios for the extension of the Tallawarra power station.

Figure 1-1 provides a site locality plan showing the location of Tallawarra power station and nearby urban settlements.

- **Figure 1-1 Site Locality Plan**

1.2. Project Identification

In December 2008, TRUenergy finished the commissioning of the Tallawarra Stage A CCGT power station at Yallah, NSW. The proposed development involves the additional construction of the Tallawarra Stage B plant, either a second CCGT plant or an OCGT peaking station. For the OCGT plant option, it is proposed to comprise two units that operate with duel fuel burners to allow the use of liquid fuel (diesel) as a backup for gas. Site plans showing the plant layout for the OCGT and CCGT are included as **Figure 1-2** and **Figure 1-3.**

This study assesses the cumulative air quality impact of the full generation capacity of the Stage A and Stage B power stations, in particular an assessment of the following air pollutants:

- Nitrogen dioxide (NO_2);
- Ozone (O_3) as a measure of photochemical smog;
- Particulate matter (as PM_{10}, particles with diameters less than 10 micrometers, $\mu g/m^3$); and
- Sulphur dioxide (SO_2).

The assessment utilises The Air Pollution Model (TAPM), developed by CSIRO Atmospheric Research (Hurley 2005a, 2005b, Hurley *et al.*, 2005), to assess the air quality impacts of the power station operations. To assess local scale impacts, TAPM simulated the power station emissions as a trace of pollution released from the stacks. The incremental impact of the power station is then added to the background concentration of the relevant pollutant in the ambient air refer to **Section 5.5** and **Sections 6** to **6.4**.

To assess the regional scale photochemical impacts of the power station, TAPM-GRS was used which took into account the estimated air emissions from all the pollution sources in the Sydney GMR including the Illawarra and Hunter regions. This method, prescribed by the DECC, uses the standard version TAPM-GRS to investigate the change in O_3 impacts over four summer periods (refer to **Section 5.6** and **Section 7**). In addition, TAPM-CTM, an advanced version of the model developed to assess photochemical transport, was also used to assess the impact of Tallawarra power station on an elevated ozone event (refer to **Appendix D**).

The main operating scenarios in this assessment are presented below. Tallawarra A refers to the CCGT plant recently commissioned and Tallawarra B refers to the proposed extension. The assessment considers the options of Tallawarra B, first as an OGCT plant comprised of two additional stacks (B1 and B2) and second as a CCGT plant with one additional stack identical to the Tallawarra A stack.

Model scenarios are as follows:

- Tallawarra A CCGT (gas fired): NO_2 local scale impacts, maximum hourly average and annual average concentrations, normal (full load) and start-load operations;
- Tallawarra A CCGT (gas fired) and B CCGT (gas fired): maximum hourly average and annual average concentrations, normal and start-load operations;
- Tallawarra A CCGT (gas fired) and B OCGT (diesel fired): NO_2 PM_{10}, SO_2, local scale impacts, maximum hourly average and annual average concentrations, normal, start-load and part load operations; and
- Tallawarra A CCGT (gas fired) and B OCGT (diesel fired): O_3 regional scale photochemical impacts using TAPM_GRS (DECC method investigating summer months for four years) and TAPM-CTM (CSIRO method for investigating an elevated ozone event):
  - Base Case: existing air emissions in Sydney GMR excluding Tallawarra power station
  - Test Case: existing air emissions in combination with Tallawarra Stacks A, B1 and B2, full load.

Figure 1-2 Tallawarra Power Station Site Plan - Tallawarra B OCGT Plant

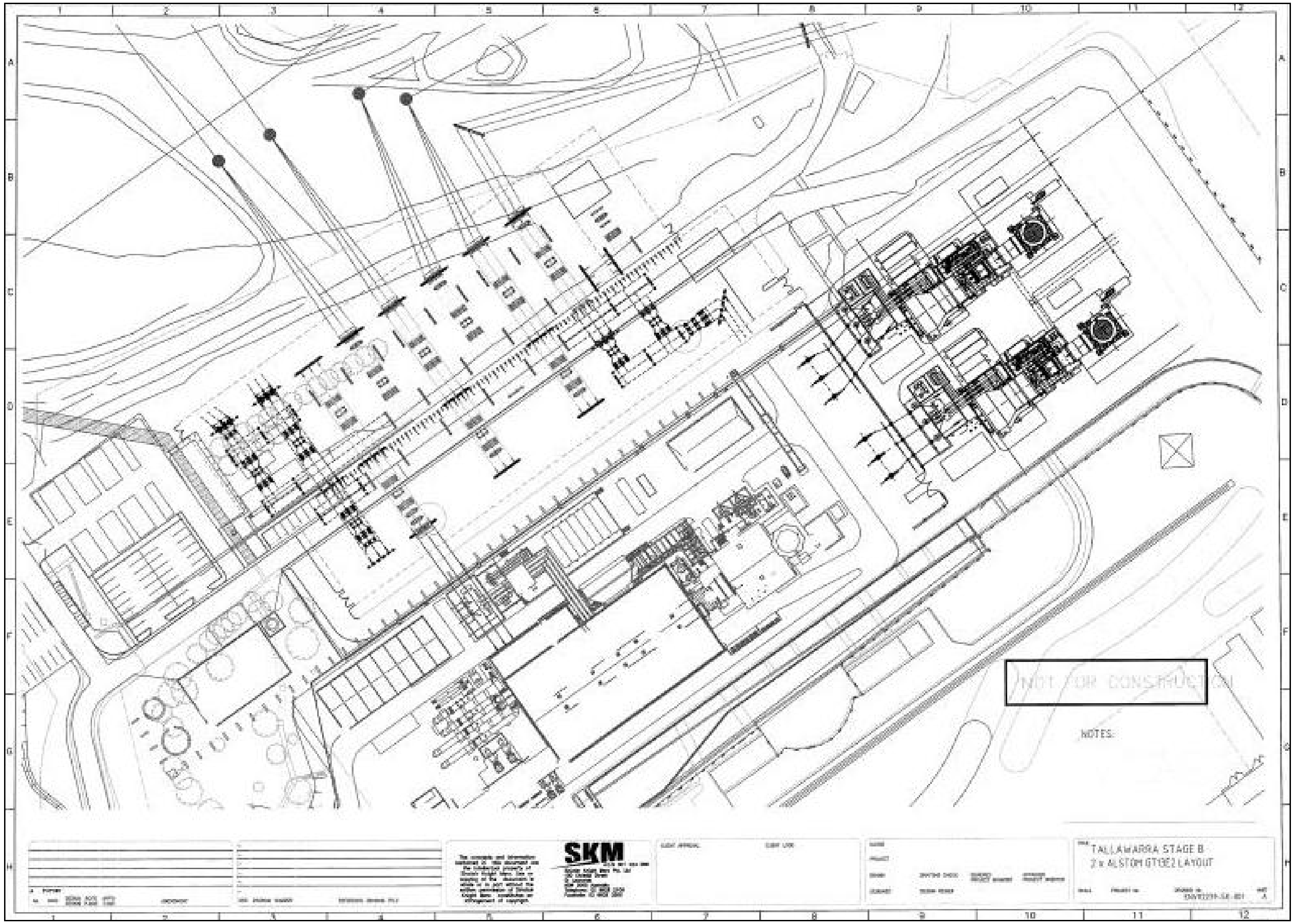
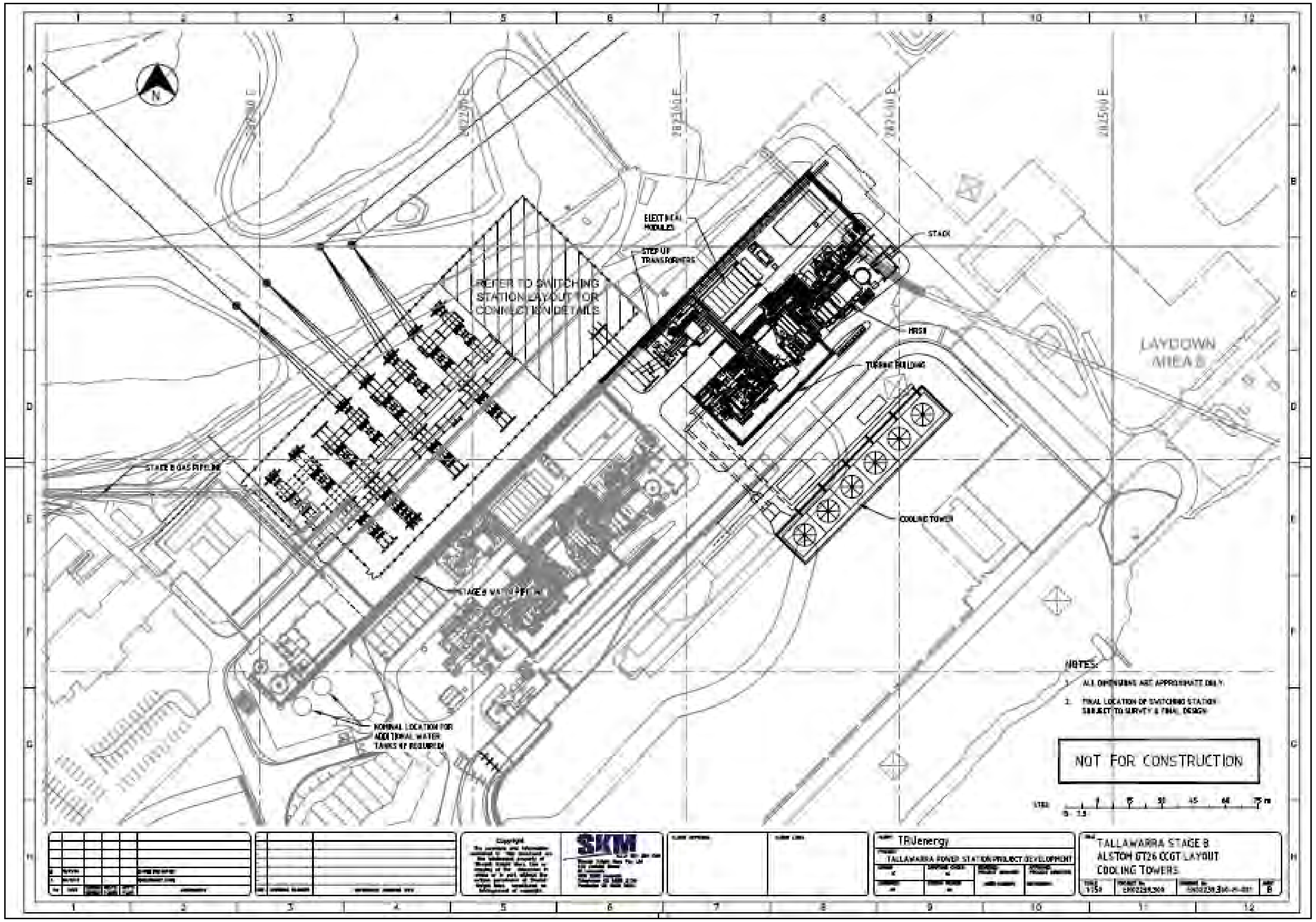


Figure 1-3 Tallawarra Power Station Site Plan – Tallawarra B CCGT Plant



2. Air Quality Issues and Emissions

2.1. Overview

This section of the report sets out air quality issues and emissions associated with the project and details considered as part of the assessment including both industrial and general airshed emissions.

2.2. Proposed Tallawarra B Gas Turbine Plant

TRUenergy expects the Tallawarra B project will consist of either two or three OCGT units delivering an output of up to 400 MW when operating on gas, or one CCGT plant.

The candidate gas turbines most likely to give the best overall project outcome for TRUenergy are:

- 2 x Alstom 13E2;
- 2 x Siemens SGT52000E;
- 2 x Siemens SGT53000E;
- 2 x GE Frame 9E;
- 3 x GE LMS100;
- 2 x Mitsubishi 701DA; and
- 1 x Alstom GT26 (CCGT option only).

With the exception of the LMS100 which is an aeroderivative gas turbine the other models are commonly referred to as industrial, heavy duty or frame gas turbines, to distinguish them from aeroderivative designs. These gas turbines typically have exhaust gas temperatures in the order of 550°C, when operating in open cycle. Fuels supplied to the plant will be pipeline quality natural gas and low sulphur diesel (no more than 50 parts per million, ppm) as a back-up fuel for the OCGT plant option.

Typically, the gas turbines (GTs) will be supplied with Dry Low NO_X (DLN) combustors and achieve NOx emissions levels lower than 25 ppm on gas (dry) and 42 ppm for the OCGT plant on liquid fuel (with water injection). **Table 2-1** summarises what SKM expects the suppliers of the respective GTs would guarantee not to exceed for NO_X emissions.

Table 2-1 Expected NO_x Emissions that Suppliers would Guarantee

Plant Type	NOx Guarantee (ppm)
Alstom 13E2	25
Alstom GT26	25
Siemens SGT52000E	25
Siemens SGT53000E	15
GE Frame 9E and	15 to 25
GE LMS100	25
Mitsubishi 701DA.	25

For the purpose of the air quality assessment, the modelling uses emission estimates for the Alstom 13E2 machines for the OCGT option and the Alston GT26 machine for the CCGT option, as provided by the software package GTPro. The 13E2 was chosen for the OCGT option because it was determined to have higher NO_X emissions than each of the main candidate gas turbines. In most cases, NO_X emissions were very similar and the 13E2 generally had marginally higher NO_X emissions, thus providing a worst case scenario. The exception was the LMS100 which would be a three unit configuration compared with two units for each of the others. The NOx emission rate for 2 x 13E2s was considerably higher than 3 x LMS100s. In the case of a CCGT, the GT26 was chosen as this is the same machine that has been used at Tallawarra A, and for commercial reasons if TRUenergy decide on a CCGT plant for Tallawarra B, a second GT26 would be the logical choice of gas turbine.

2.3. Oxides of Nitrogen and Photochemical Smog

2.3.1. Photochemical Pollutants and Air Chemistry

Photochemical smog consists of a mixture of pollutants, predominantly ozone (O_3) and oxides of nitrogen (NO_x) that are formed when NO_x and volatile organic compounds (VOCs) react in the presence of sunlight. A number of reaction rates are temperature dependent and thus photochemical smog tends to occur more often in the summer months.

The production of NO_x occurs in most combustion processes due to the oxidation of nitrogen in the fuel and air. A number of nitrogen oxides are formed including nitric oxide (NO) and nitrogen dioxide (NO_2). Generally, at the point of emission, NO to NO_2 ratio is 90:10 by volume of the NO_x. Ultimately, the entire NO emitted into the atmosphere is oxidised to NO_2 and to other oxides of nitrogen. The rate at which this conversion occurs depends on a number of factors including temperature, topography, local meteorological circulation patterns, the presence of an inversion and the presence of ozone (O_3). This conversion rate is important due to the associated affect on ground level concentrations of NO_2.

2.3.2. Harmful Effects of Photochemical Pollutants

A primary concern is that photochemical pollutants can have harmful effects on the health of humans. The health effects of some of the major primary and secondary pollutants in photochemical smog are provided in **Table 2-2** below.

- **Table 2-2 Health Effects of Photochemical Pollutants**

Pollutant	Effects
Nitrogen Oxides	Can contribute to problems with heart and lungs; links to decreased resistance to infection.
VOCs	Eye irritation; respiratory problems; some compounds are carcinogens.
Ozone	Coughing and wheezing; eye irritation; respiratory problems (particularly for those with conditions such as asthma).

In addition, NO_x and O_3 may have harmful effects on plants. These substances may decrease or even stop the rate of growth of plants by affecting photosynthesis. Ozone damages materials, for example, by causing the cracking of rubber and paint, the reduction in tensile strength of textiles and the fading of dyed fibres. Of cultural importance is the potential of O_3 to damage artworks and books.

2.3.3. Ozone as an Air Quality Issue in the Illawarra

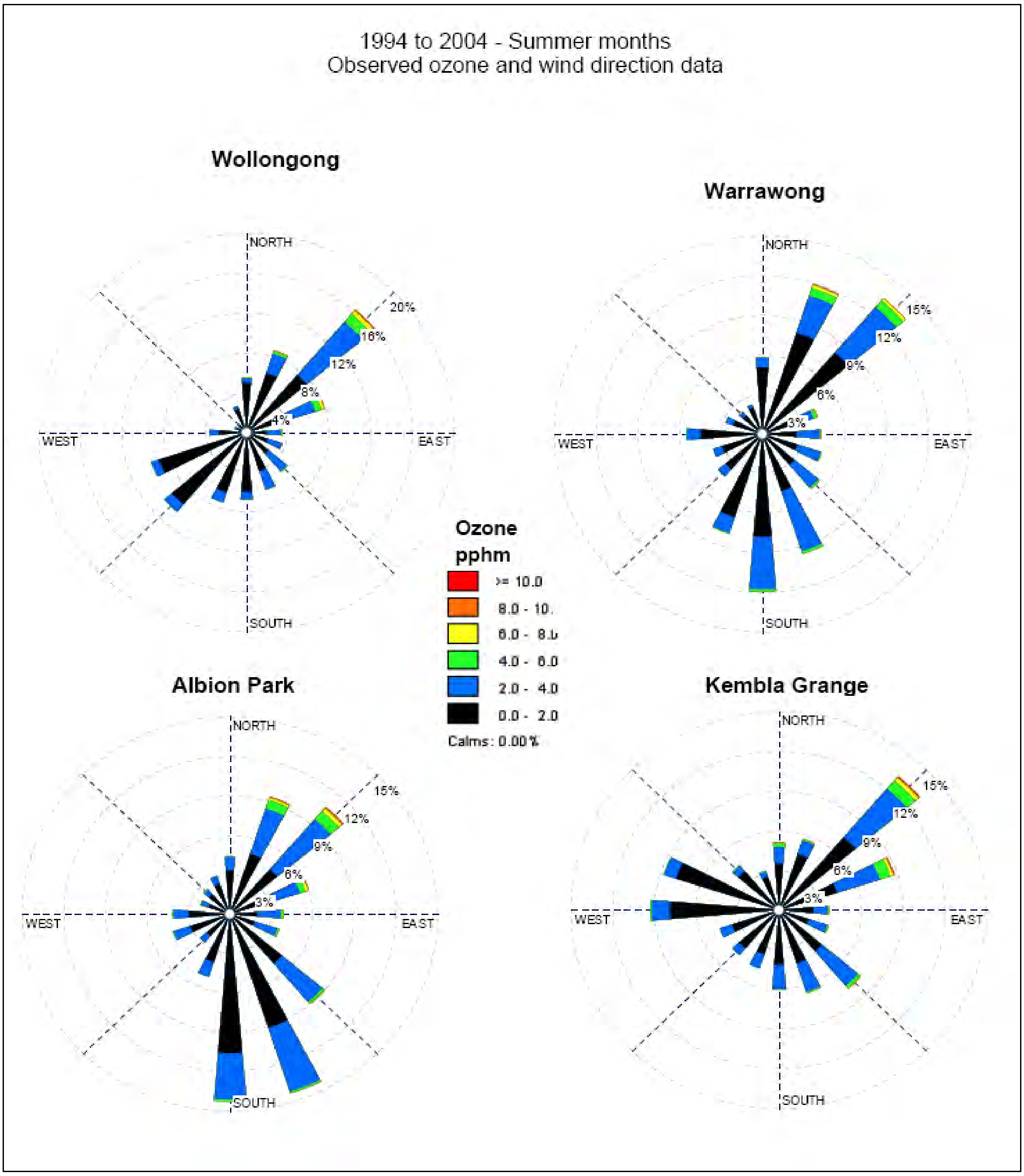
The research project *The State of Knowledge: Air Quality in the Illawarra Region* (SOKAQIR, DECC, 2007) comprehensively assessed the major urban air pollutants in against national air quality standards. The relevant findings of the study in terms of ozone pollution are presented below.

> *Ozone in the Illawarra region can occur as a result of photochemical smog produced from local emissions or from smog or precursors transported down the coast from the Sydney region (DECC 2007). It appears that most ozone events in the Illawarra occur as a result of the combined effect of these two factors. The sea breeze, generally north-easterly in direction, is the dominant meteorological influence on elevated concentrations of ozone in the region* (DECC, 2007:20)

Figure 2-1 presents a pollution rose to illustrate hourly average ozone concentrations from 1994 to 2004 with corresponding hourly wind direction at each site in the Illawarra region. The branches of the pollution rose indicate the directions from which the wind blows. . Ozone concentrations associated with prevailing winds are indicated by the thickness and colour of branch segments. The segment length is proportional to the frequency of winds blowing within the corresponding range of ozone concentration, represented as parts per hundred million (pphm). In summary, the data demonstrates that the majority of ozone exceedances (> 10 pphm) are associated with a north-easterly winds at each site, while ozone concentrations associated with south to westerly flows do not exceed the standard (DECC, 2007). This suggests that the transport of pollutants from the Sydney region is the major contributor to elevated ozone concentrations in the Illawarra region.

■ Figure 2-1 Observed Ozone and Associated Wind Direction in the Illawarra Region

Source: DECC, 2007:22

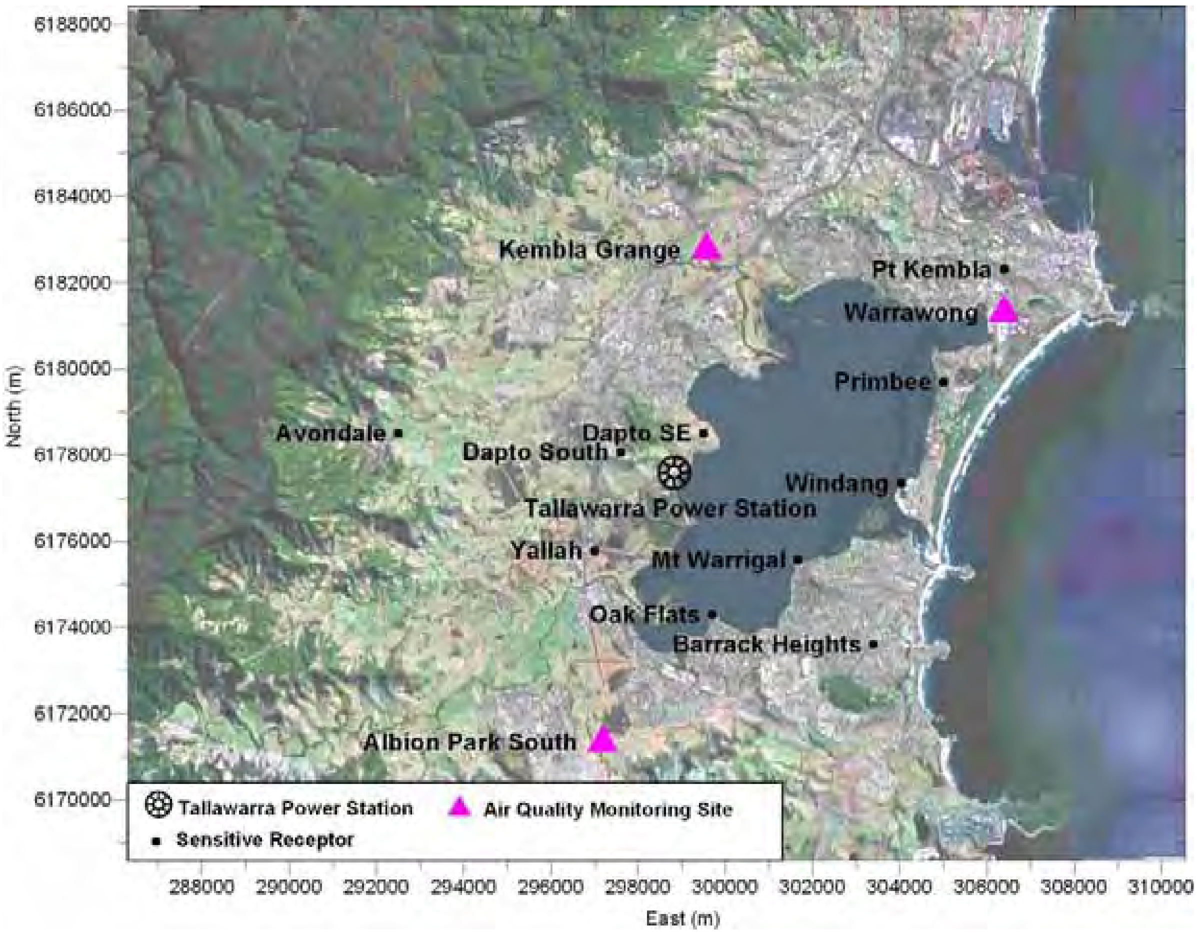


3. Meteorology and Existing Air Quality

3.1. Overview

This section of the report describes the dispersion meteorology and existing air quality in the Illawarra airshed. Meteorological data has been obtained from the NSW DECC meteorology monitoring sites at Kembla Grange, Warrawong, Wollongong, and Albion Park, as well as from the Bureau of Meteorology (BoM) automatic weather stations at Port Kembla, Wollongong and Kiama. The nearest BoM site is located at Port Kembla, approximately 6 km north-east of the Tallawarra power station site (refer to **Figure 3-1**).

- **Figure 3-1 Location of Air Quality Monitoring Sites and Sensitive Receptors**



3.2. General Climate Conditions

The climate of the Illawarra region may be described as temperate, with warm summers and cool winters. The region is located on a narrow coastal strip with a steep escarpment to the west. The width of the coastal strip increases from north to south until it terminates in a ridge of hills running from the escarpment to the sea. The region's climate is strongly influenced by its latitude, coastal location including Lake Illawarra and the escarpment to the west (DECC, 2007).

As the significant topographic feature, the escarpment is a major influence on local meteorology and hence on air quality in the region. The escarpment can direct winds longitudinally along the coast, as well as create a decoupling effect on the winds above and below the escarpment. As a result, an inversion can form at the top of the escarpment, limiting the dispersion of pollutants in the Illawarra region (Hyde *et al*., 1997).

The region is also strongly influenced by sea breezes. In the north of the region, these tend to be steered by the topography to become north-north-easterly to north-easterly. In the south of the region, sea breezes tend to be more north-easterly to easterly. Return-flow has been observed above the sea breeze in the Illawarra region (Hyde and Prescott, 1984). Westerly drainage flows have been observed to develop in the region overnight (Hyde and Prescott, 1984) and to influence air quality (refer to **Section 2.3.3** and **Figure 2-1**).

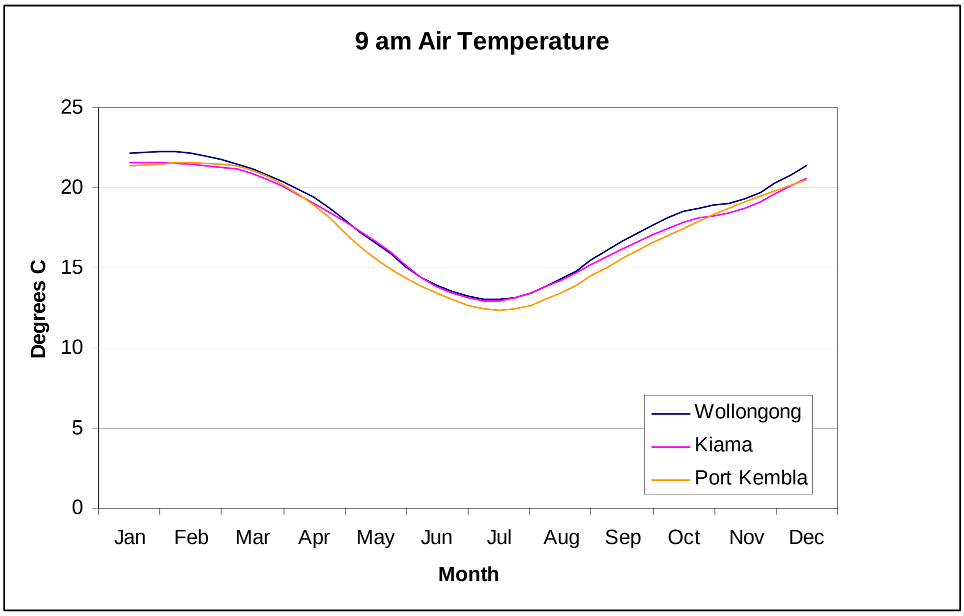
The Illawarra region is 80 km to the south of the Sydney region. On occasions, pollutants will be transported between these two regions, particularly from Sydney to the Illawarra. Ozone in the Illawarra region can occur as a result of photochemical smog produced from local emissions or from smog or precursors transported down the coast from the Sydney region. It appears that most ozone events in the Illawarra occur as a result of the combined effect of these two factors (DECC, 2007).

Long-term climate statistics, as measured in the Illawarra by the BoM at Port Kembla, Wollongong and Kiama, are presented and compared for regional climate variability below.

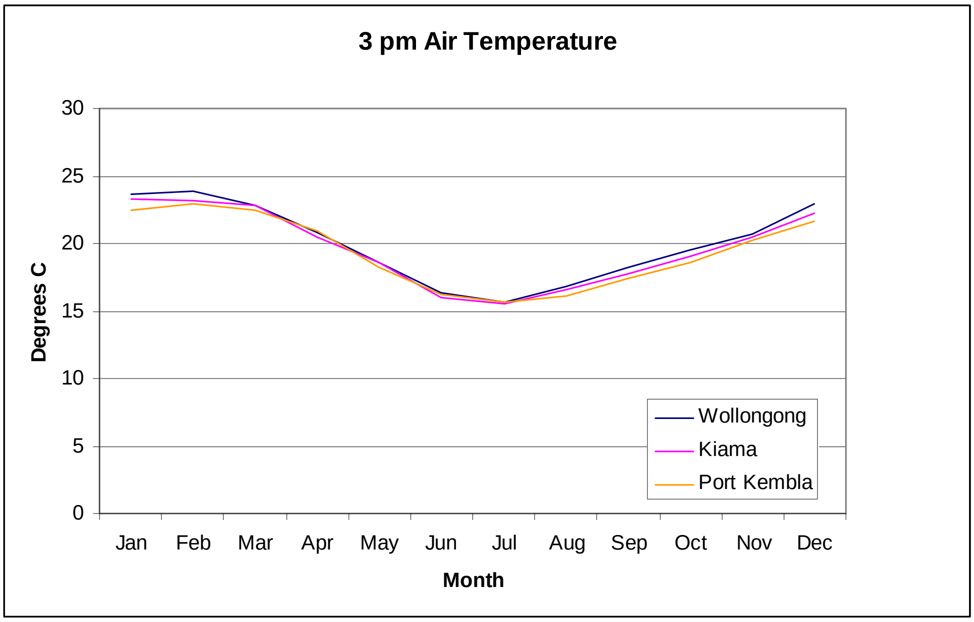
3.2.1. Temperature

The Illawarra experiences warm summers and cool winters. Mean 9 am temperatures at Port Kembla weather station range between 12.4°C in July to 21.6°C in February. The 3 pm mean temperature range is between 15.6°C in July to 22.9°C in February. Kiama and Wollongong experience very similar temperatures as Port Kembla (refer to **Figure 3-2** and **Figure 3-3)**.

▪ Figure 3-2 Mean 9 am Temperature Ranges in the Illawarra Region



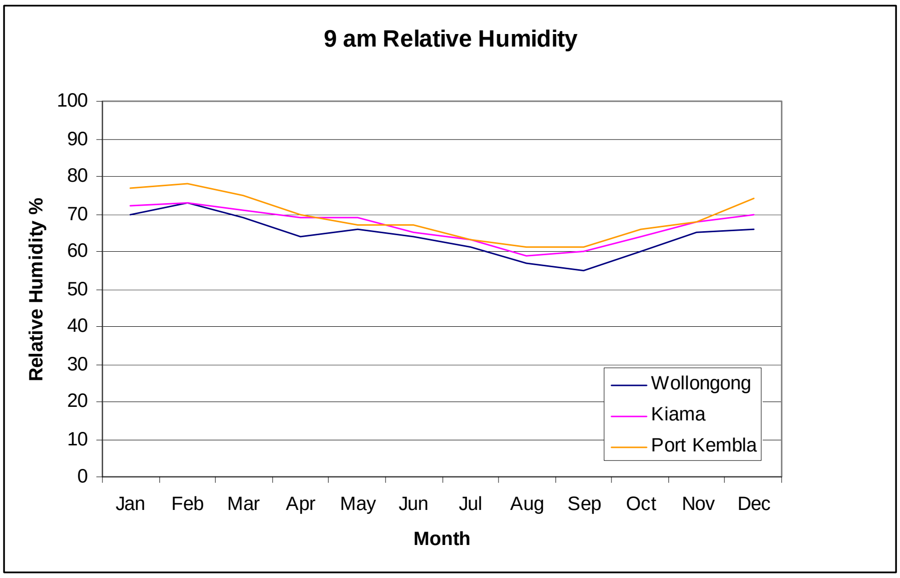
▪ Figure 3-3 Mean 3 pm Temperature Ranges in the Illawarra Region



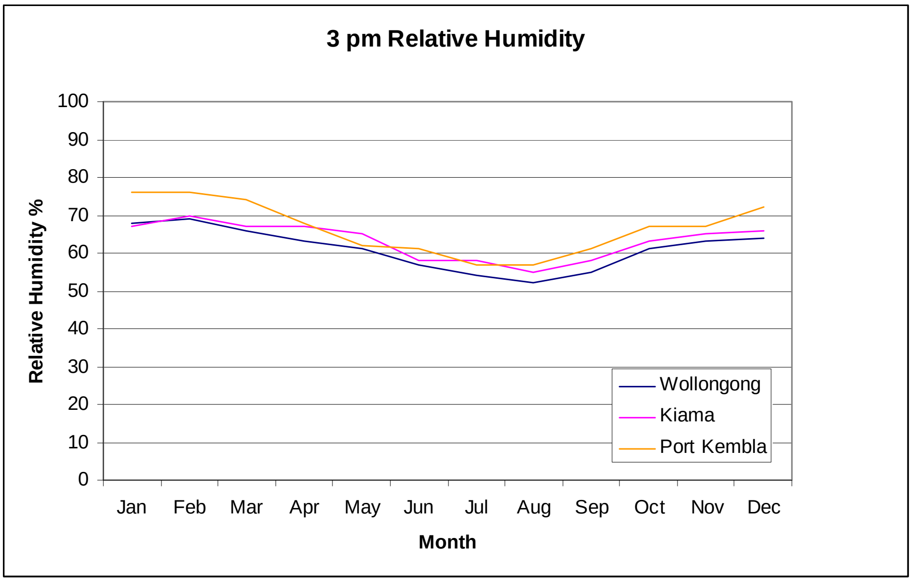
3.2.2. Relative Humidity

Figure 3-4 and **Figure 3-5** show monthly average relative humidity for 9 am and 3 pm. The 9 am and 3 pm relative humidity recorded in the Illawarra region remains moderate throughout the year. Humidity is higher in the summer season. The 3 pm relative humidity readings are generally slightly lower than the 9 am readings throughout the year.

- **Figure 3-4 Mean 9 am Relative Humidity in the Illawarra**



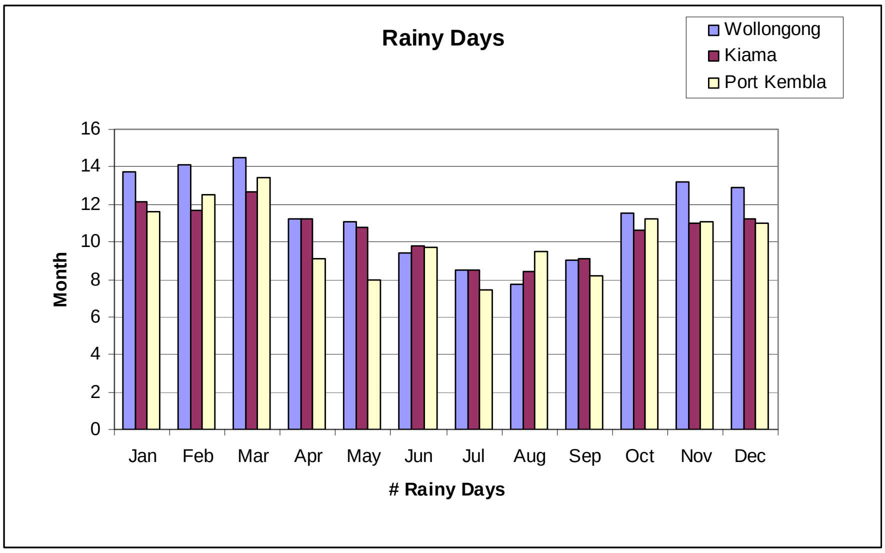
- **Figure 3-5 Mean 3 pm Relative Humidity in the Illawarra**



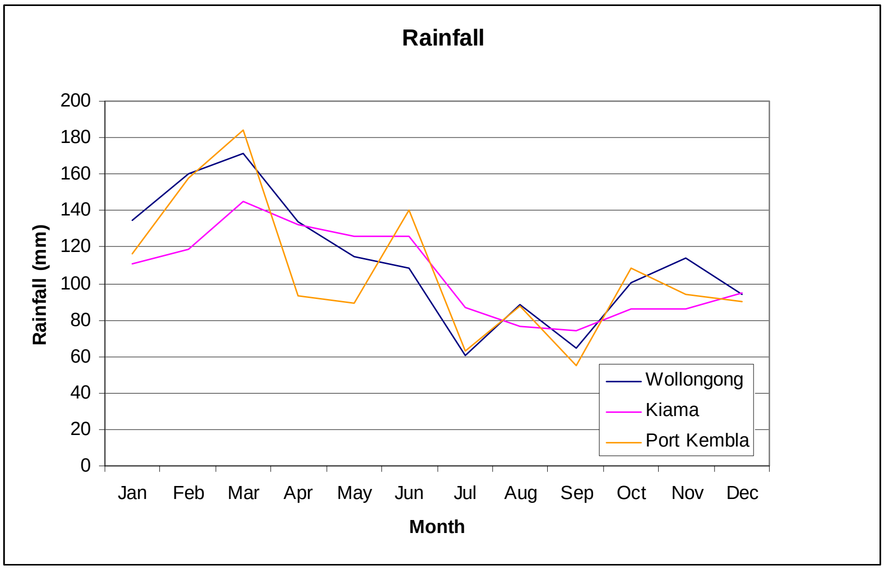
3.2.3. Rainfall

Figure 3-6 and **Figure 3-7** show the distribution of monthly average rainfall and rain days in the Illawarra. Rainfall data show that March is the wettest month of the year, receiving a mean monthly rainfall of 183.7 mm at Port Kembla. The driest month of the year in terms of mean monthly rainfall is September, recording 55 mm at Port Kembla. Kiama records the lowest variability in rainfall, receiving an annual average of 1,262 mm spread across 127 days.

- **Figure 3-6: Mean Number of Rainy Days in the Illawarra**



- **Figure 3-7 Mean Rainfall in the Illawarra**



3.3. Dispersion Meteorology

This section examines first, the dispersion meteorology of the Illawarra region, which is influenced strongly by north-easterly sea breezes and the alignment of the western escarpment (as noted above, refer to **Section 2.3.3**, **Figure 2-1** and **Section 3.2**); and second, the performance of the model in representing local data and the terrain effects on air flows. Meteorology data for the year 2002 was selected for modelling the local scale air pollution impacts of Tallawarra power station given that, first, higher background air pollution concentrations were recorded in the Illawarra during that year (refer to **Section 3.4**); and second wind data during 2002 strongly represented the average wind data for 2001-2005 (refer to **Section 3.3.1**).

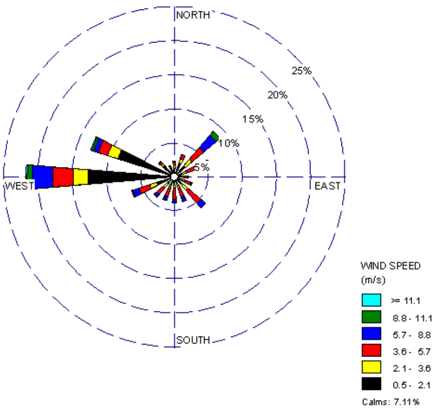
The following discussion describes:

- The averaged wind data recorded during 2001 to 2005 at Kembla Grange, the DECC meteorology and air quality monitoring site located closest to the site of Tallawarra Power Station (refer to **Section 3.3.1)**.
- The observed wind data for 2002, compared with modelled wind data in order to demonstrate the performance of TAPM in predicting local wind data at the four DECC monitoring sites (Kembla Grange, refer to **Section 3.3.2**; Warrawong, refer to **Section 3.3.3**; Wollongong refer to **Section 3.3.4**; and Albion Park refer to **Section 3.3.5**.
- Modelled wind data predicted for the Tallawarra power station site, identifying comparisons with observations recorded at Kembla Grange and Warrawong during 2002 (refer to **Section 3.3.6**).
- The overall performance of TAPM in predicting local wind data (refer to **Section 3.3.7**), and
- The performance of TAPM in predicting terrain effects on air flows (refer to **Section 3.3.8**).

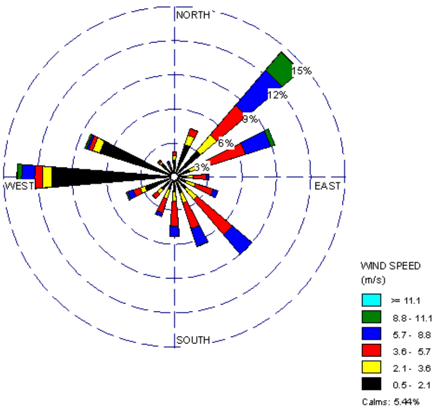
3.3.1. Kembla Grange Observed Wind Data 2001-2005

Observed wind data for 2002 strongly represents the average wind data for 2001 to 2005 (refer to **Figure 3-8** and **Figure 3-9**). On an average annual basis, west and north-west winds generally prevail (approximately 40 percent). Compared with wind data averaged over 2001 to 2005, annual wind data for 2002 indicates a very small increase in the proportion of westerly winds and a decrease in the proportion of southerly winds (approximately 1 percent). Considering seasonal variability in observed wind speed and direction, generally, west and north-west winds prevail throughout autumn, winter and spring, with autumn bringing lower wind speeds than winter and spring. In summer and spring, wind directions show more variability, with more frequent north-easterlies and south-easterlies in addition to the westerly winds. Seasonal windroses for 2002 compare closely with the average seasonal windroses for 2001 to 2005. Summer 2002 recorded slightly weaker northeast (approximately 2 percent) and southeast components (approximately 2 percent) and a slightly stronger westerly component (approximately 4 percent) compared to the 2001 to 2005 average.

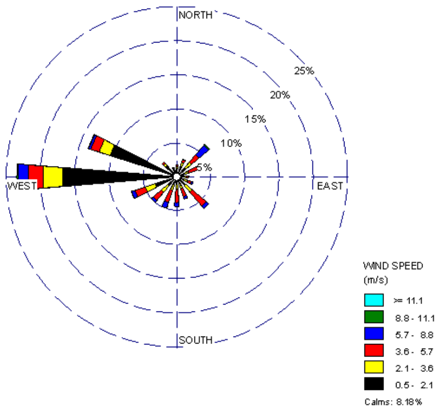
- **Figure 3-8: Kembla Grange Windroses Observations 2001-2005**



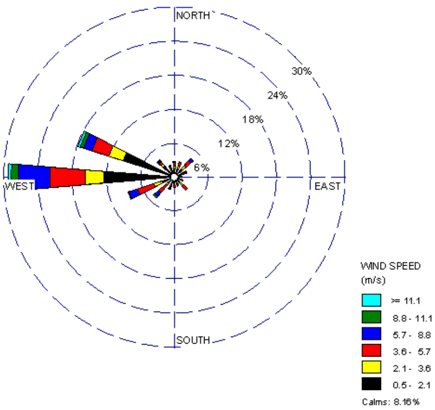
Annual



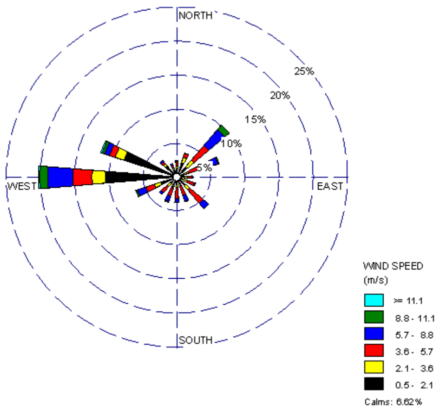
Summer



Autumn



Winter



Spring

- **Figure 3-9: Kembla Grange Windroses Observations 2002**

3.3.2. Kembla Grange Observed and Modelled Wind Data 2002

In general, TAPM predicted the observed annual and seasonal wind patterns, showing the dominant westerly wind directions (refer to **Figure 3-10**).

In terms of annual average wind data:

- TAPM predicted the dominant flow of winds from the western quadrants (approximately 60 percent for TAPM compared with 58 percent for observations), although slightly over predicted the frequency of the NNW and SW components;
- TAPM predicted an average annual wind speed of 2.4 m/s compared to observed 3.1 m/s;
- TAPM predicted 52 percent of wind speeds to be less than 2.1 m/s, which is the same percentage as observed;
- TAPM predicted no calms, in contrast to 7 percent observed calms;
- TAPM predicted 47% of winds to be between 2.1 m/s and 5.7 m/s, compared to 33 percent observed; and
- TAPM under estimated the frequency of wind speeds greater than 5.7 m/s, predicting 1 percent, compared to 16 percent observed.

In terms of predicting seasonal variability:

- In spring and summer, TAPM generally predicted the seasonal influence of easterly winds (approximately 32 percent and 48 percent for TAPM, compared with 41 percent and 46 percent of observations for spring and summer, respectively) and the frequency of low wind speeds, less than 2.1 m/s (approximately 48 percent and 50 percent TAPM compared to 50 percent to 45 percent observations), however TAPM slightly over predicted the frequency of the SW component; and
- Similarly, in autumn and winter, TAPM generally predicted the frequency of winds from the western quadrants (approximately 66 percent and 78 percent TAPM, compared with 58 percent and 68 percent observations) and the frequency of wind speeds less than 2.1 m/s (approximately 61 percent and 49 percent TAPM, compared with 61 percent and 49 percent observations in autumn and winter, respectively).

- **Figure 3-10: Kembla Grange Windroses Modelled**

3.3.3. Warrawong Observed and Modelled Wind Data 2002

TAPM predicted the annual and seasonal wind patterns observed at Warrawong, indicating typically stronger intensities and greater southerly and easterly components, due to a more coastal (easterly) location than Kembla Grange (refer to **Figure 3-11** and **Figure 3-12**).

In terms of the average annual wind data:

- TAPM predicted an average annual wind speed of 2.6m/s compared to the 3.3m/s observed;
- TAPM predicted the westerly component at approximately 59 percent compared with the 54 percent observed;
- TAPM predicted winds from the east quadrants at 31 percent compared to the 33 percent observed;
- Wind speeds greater than 5.7 m/s were slightly over predicted, 3 percent, compared to the 2 percent observed;
- TAPM predicted 50 percent of winds to be between 2.1 m/s and 5.7 m/s, compared to 51 percent observed;
- TAPM predicted 48 percent of wind speeds to be less than 2.1 m/s, compared to 33 percent observed; and
- TAPM predicted no calm periods, in contrast to 1 percent observed calms.

In terms of seasonal variability:

- TAPM predicted the seasonal influence of easterly winds in spring, summer and autumn (approximately 37 percent, 46 percent and 29 percent TAPM, compared with 44 percent, 45 percent and 29 percent observed in spring, summer and autumn, respectively); and
- Similarly, TAPM predicted the dominant westerly winds in winter (approximately 75 percent TAPM compared with 76 percent observations).

■ **Figure 3-11: - Warrawong Windroses Observations 2002**

▪ Figure 3-12: Warrawong Windroses Modelled 2002

3.3.4. Wollongong Observed and Modelled Wind Data 2002

TAPM predicted the southwest and northeast component in the general annual and seasonal wind patterns observed at Wollongong, typically influenced by the location of the site on a narrow coastal plain (refer to **Figure 3-13** and **Figure 3-14**). The adjacent western escarpment, aligned southwest to northeast, is relatively closer to the coast, compared with the other Illawarra sites.

In relation to the annual average wind data observations:

- TAPM slightly under predicted the dominance of the SW component, 30 percent compared with 33 percent observed and consequently slightly over predicted the direct westerly component and the components in the other quadrants;
- TAPM slightly over predicted the frequency of wind speeds between 2.1m/s and 5.7 m/s, 46 percent, compared with 41 percent observations; and
- TAPM predicted no calms, compared with 11 percent observed calms, and slightly under predicted the frequency of wind speeds less than 2.1m/s at 53 percent, compared with observed winds, combined with calms, at 57 percent.

In terms of the seasonal variation in wind data:

- TAPM predicted the dominance of the south westerly component in winter, 32 percent, compared with 38 percent observed. However, TAPM under predicted the dominance of the direct westerly component in winter. TAPM predicted the direct westerly component in spring, summer and autumn to be 49 percent, 41 percent and 63 percent respectively compared with 43 percent, 41 percent and 59 percent observed;
- TAPM generally predicted the northeast component in summer, 25 percent, compared with 26 percent observed and the frequency of wind speeds between 2.1m/s and 5.7m/s, at 53 percent, compared with 49 percent observed; and
- TAPM slightly under predicted the intensity of the northeast component in summer, predicting no wind speeds over 5.7 m/s, compared with approximately 2 percent observed (potentially under estimating the transport of pollution from Wollongong to the Tallawarra area).

▪ Figure 3-13: Wollongong Windroses Observations 2002

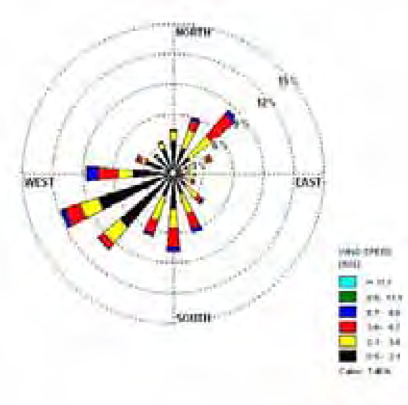
- **Figure 3-14: Wollongong Windroses Modelled 2002**

3.3.5. Albion Park Observed and Modelled Wind Data 2002

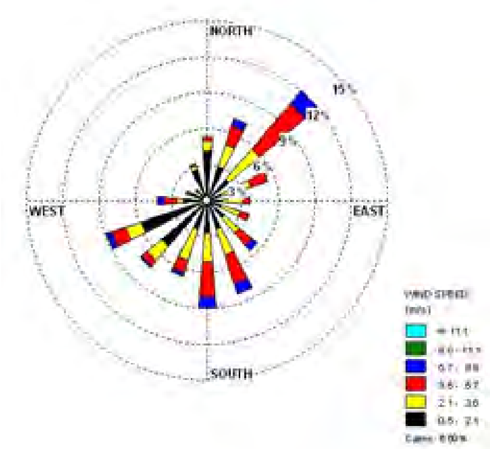
At the Albion Park monitoring site, approximately 3 km south of Lake Illawarra, maintenance by EPA during 2002 resulted in data gaps, with 64 percent data availability annually (15 percent in winter, 40 percent in autumn, 17 percent in spring and 40 percent in summer). Consequently, the TAPM predictions compare more closely with observed wind data in summer and autumn, rather than winter and spring. Wind roses indicate the seasonal influence of north easterlies in summer and southerlies in summer as well as autumn (refer to **Figure 3-15** and **Figure 3-16**).

Wind roses of observed annual and seasonal wind data suggest that records missed the westerly component typically experienced in the Illawarra region during spring.

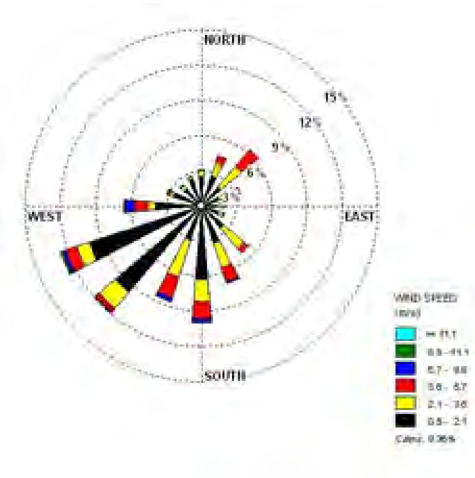
- **Figure 3-15: - Albion Park Windroses Observations 2002**



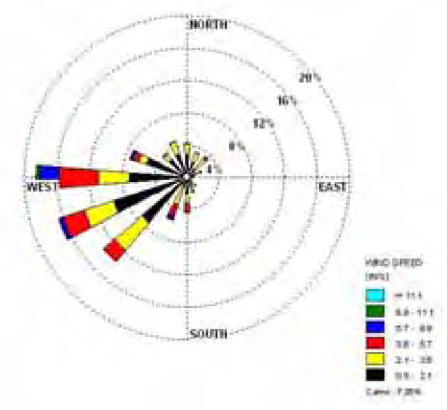
Annual



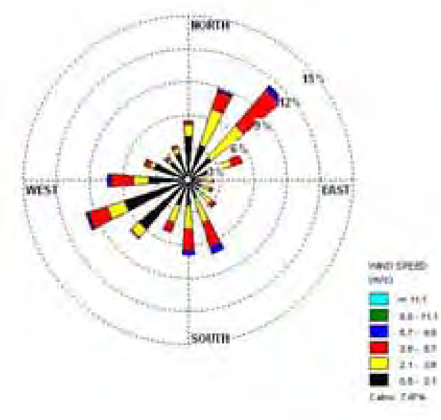
Summer



Autumn

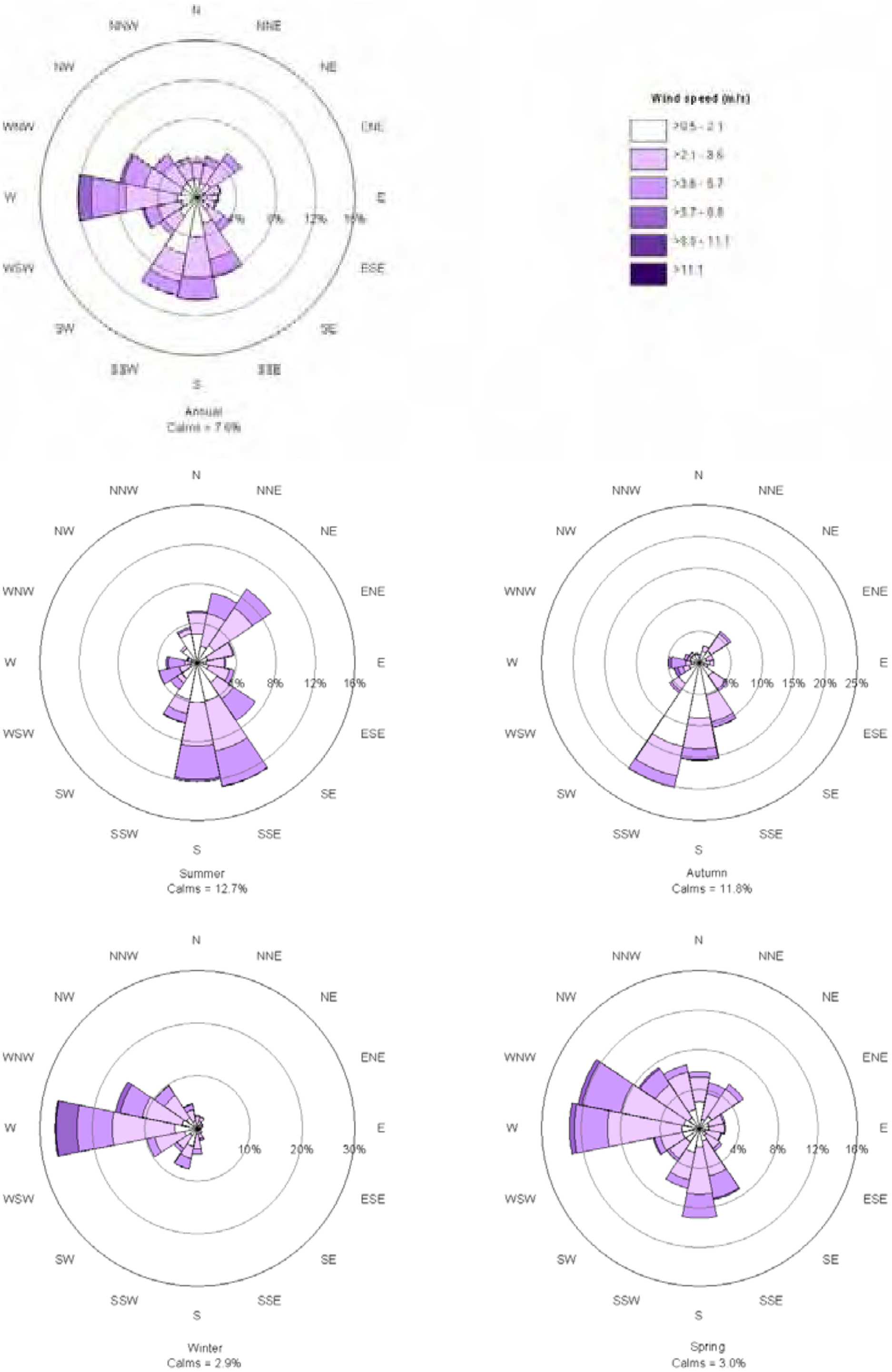


Winter



Spring

- **Figure 3-16: Albion Park Windroses Modelled 2002**



3.3.6. Tallawarra Power Station Modelled Wind Data 2002

The Tallawarra site is located on the western shore of Lake Illawarra, approximately 7 km east of the Illawarra escarpment, 7 km south of Kembla Grange and 9 km south west of Warrawong (refer to **Figure 3-17**).

The wind data pattern predicted by TAPM for Tallawarra, for 2002, indicates a similar pattern to the general patterns experienced at the Kembla Grange and Warrawong sites (refer to **Figure 3-10** and **Figure 3-12**).

In terms of annual wind data at Tallawarra, TAPM predicted the following (refer to **Figure 3-17**):

- an annual average wind speed of 2.5 m/s, with higher wind speeds reaching a maximum of 8.8 m/s from all directions and with a total frequency of approximately 4 percent for winds from 5.5 m/s to 8.8 m/s;
- approximately 47 percent of winds between 2.1 m/s and 5.7 m/s ;
- approximately 45 percent of winds less than 2.1 m/s;
- a dominant westerly flow with a frequency of about 52 percent, maybe due to the more open location of the site relative to the western escarpment; and
- other components, at approximately 16 percent north-easterly and south-easterly components at 13 percent.

In terms of seasonal variability (refer to **Figure 3-17**):

- TAPM predicted the seasonal influence of easterly winds in spring and summer (approximately 35 percent and 47 percent), which compared similarly with predictions for Kembla Grange (approximately 32 percent and 48 percent). However, at Tallawarra, TAPM predicted a slightly greater frequency of wind speeds greater than 2.1 m/s (58 percent and 53 percent in spring and summer, compared to 52 percent and 50 percent at Kembla Grange). This result suggests that TAPM potentially may tend to predict effective dispersion of air pollution towards the southwest of the Tallawarra site, in spring and summer; and
- TAPM predicted the influence of westerly winds in autumn and winter (approximately 52 percent and 77 percent), which is similar to the dominance of westerly flows at Kembla Grange (66 percent and 78 percent). This result suggests that TAPM is likely to predict effective dispersion of air pollution, east-ward of the Tallawarra site, in autumn and winter.

- **Figure 3-17: Tallawarra Power Station Windroses Modelled 2002**

3.3.7. Overall TAPM Performance in Predicting Wind Data

TAPM predicts local meteorology across a study area by interpolating Bureau of Meteorology synoptic scale data, down to the local scale. The data assimilation facility in TAPM allows local wind measurements to influence the interpolation process, thereby weighting the prediction of local meteorology towards local observations recorded during the modelling period. Wind data observed at four DECC monitoring sites during 2002 were assimilated into the TAPM predictions for local meteorology and air pollution dispersion.

Assuming that wind flows assist the dispersion of air pollution, then potentially an under prediction of higher wind speeds by the model may result in an over prediction of ground level concentrations of air pollutants and conversely, an over prediction of higher wind speeds may result in an under prediction of ground level concentrations.

In summary, TAPM performed well in predicting the general wind patterns in the Illawarra, namely the dominant westerly flows due to the alignment of the western escarpment and with the addition of easterly components in spring and summer. TAPM also predicted the small local variations in the dominant westerly flows resulting from the location of the Illawarra sites relative to the coast and the escarpment.

Although TAPM failed to predict calm periods, the model’s good performance in predicting the lower wind speeds (< 2.1 m/s) is most likely due to the incorporation of local wind data observations. That is, the data assimilation facility seems to have improved the model’s general capacity to predict lower wind speeds (evident from preliminary modelling in tracer mode not reported here). In this study, the tendency for TAPM to under predict wind speeds greater than 5.7 m/s at the DECC sites may result in:

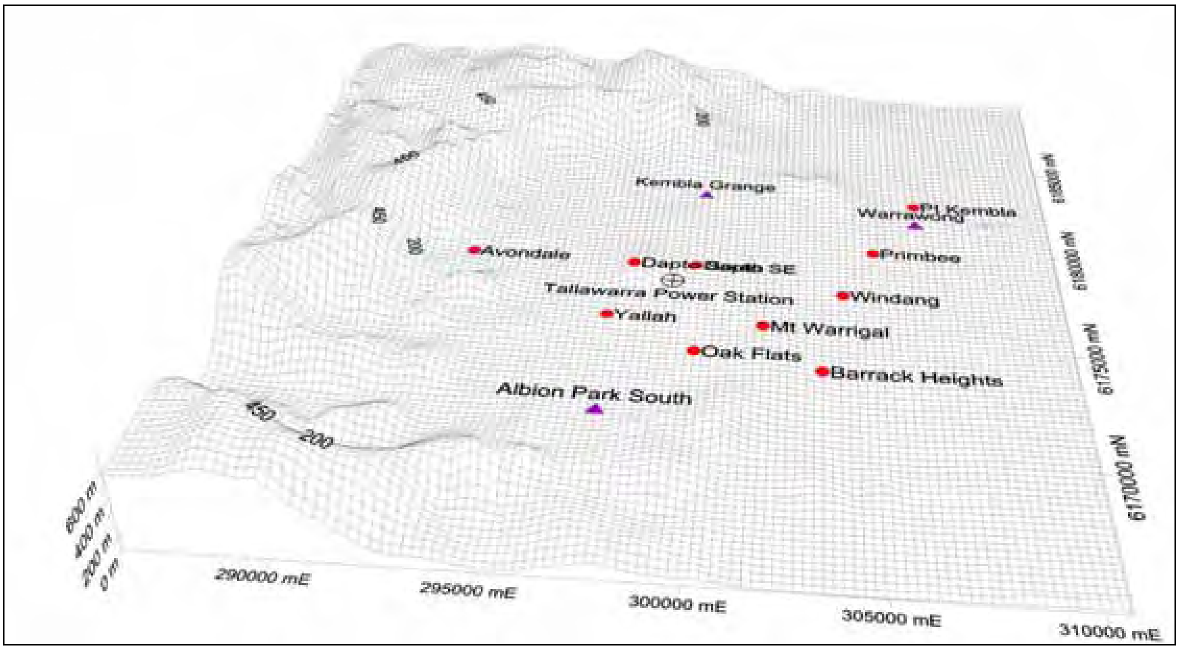
- The potential to slightly over predict local air pollution concentrations during periods of observed higher wind intensity (> 5.7 m/s). However, this result may be unlikely, given that winds with speeds greater than 5.7 m/s represent a relatively small proportion of all observed wind flows (up to approximately 16 percent).
- As relevant to the regional photochemical smog assessment, there is a small potential to under predict the transport of air pollutants during periods of observed high wind intensity. For example, the under predicted intensity of summer north-easterly winds at Wollongong may result in TAPM under estimating the transport of air pollutants into the Tallawarra area and consequently under estimating the background concentrations which mix with air emissions from Tallawarra.
- It is not expected that these small variations in TAPM predictions would be of any consequence to the overall modelling assessment at the local or regional scales.

3.3.8. Terrain Effects

The effects of airflows over terrain have been incorporated in the air pollution dispersion modelling process by incorporating a 250 m resolution digital elevation model (DEM) (data provided by SKM GIS section).

The three-dimensional 'wireframe' plot illustrates how the DEM represents the terrain of the locality, indicating the Illawarra escarpment in the west and land-water contrasts to the east (refer to **Figure 3-18**).

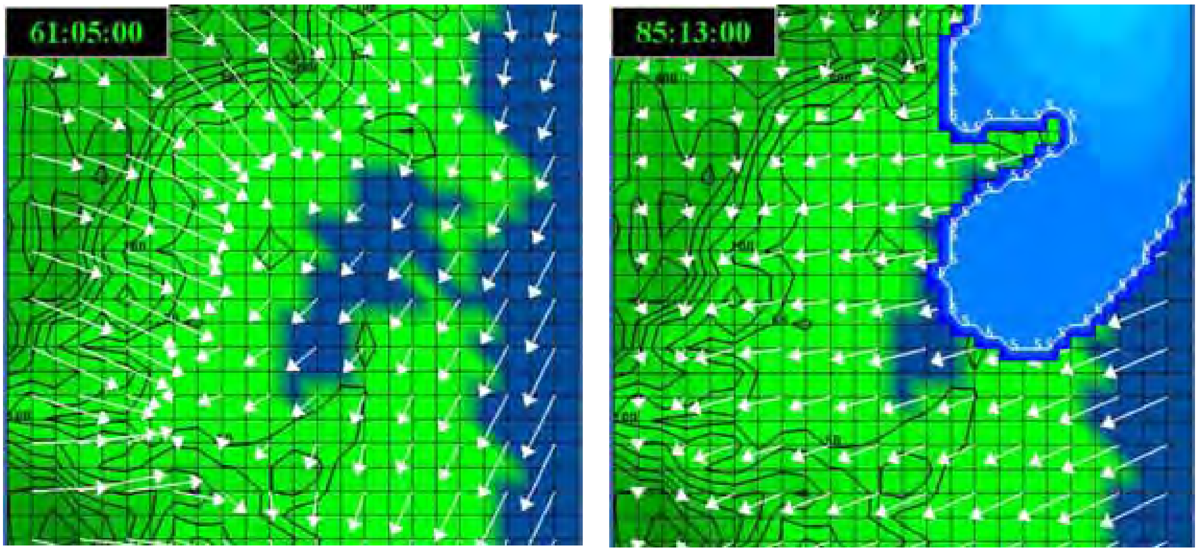
- **Figure 3-18: Terrain Model of Illawarra Region used in TAPM**



TAPM output graphics indicate that the modelling of both air flows and concentrations are influenced by the local terrain effects such as the coastal line and the Illawarra escarpment. **Figure 3-19** illustrates the interaction of terrain, wind speed and direction and transport of ozone from the Sydney metropolitan area to the Illawarra region.

In summary, the northeast-southwest alignment of the Illawarra escarpment and the land-water contrasts of Lake Illawarra and the coastal plain dominate the terrain of the study area. The figures above and the discussion of observed and modelled wind data demonstrate that TAPM has accounted for local terrain in the process of simulating air flows and predicting ground level pollution concentrations (refer to **Section 3.3.7**).

- **Figure 3-19: Terrain Effects Illustrated by TAPM-GRS Output**



Notes
TAPM output graphics (using generic reaction set [GRS] for photochemical modelling) for model simulation Day 61 05:00 hours (31st December 2003, 5:00am) and Day 85 13:00 hours (24th January 2004, 1:00am)
Lake Illawarra is shown in blue, terrain as black contour lines and wind speed and direction as white arrows.
Ozone plume transported from Sydney region shown in light blue, units in parts per billion (ppb), background ozone not included in modelling in this preliminary model run. However background ozone 20 ppb was included in photochemical modelling discussed in Appendix C and Appendix D.

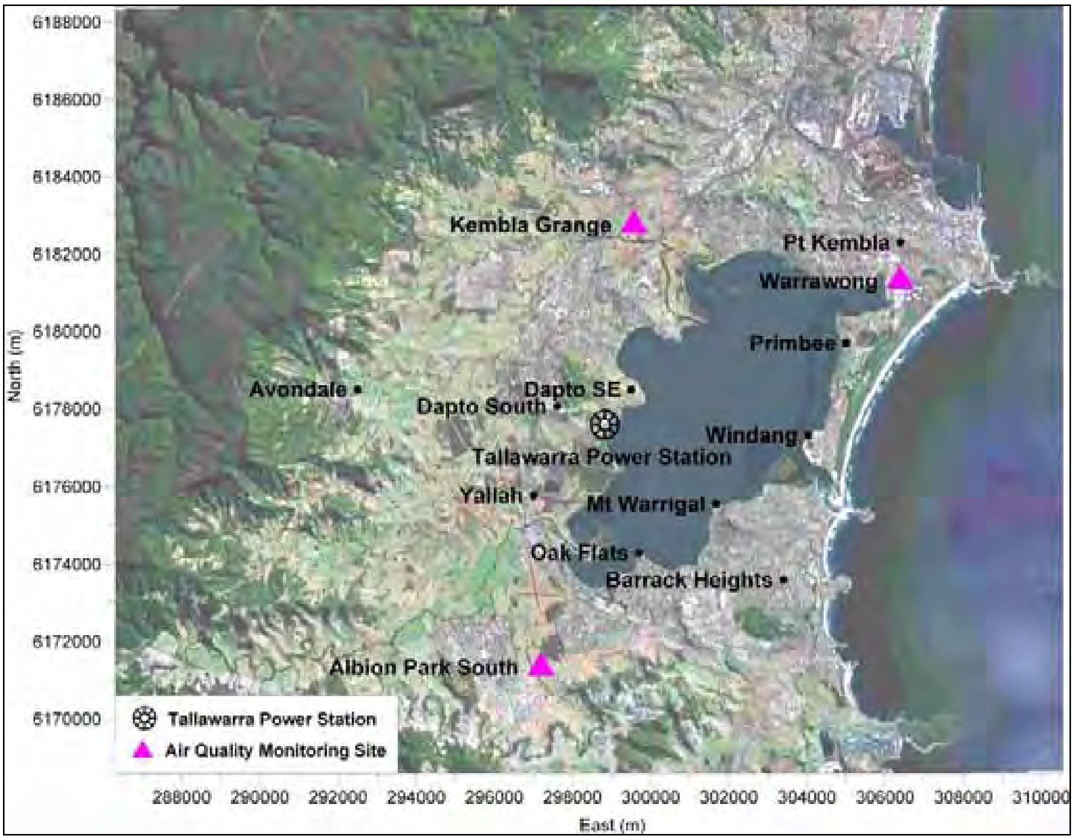
3.4. Existing Air Quality

The Illawarra has two dominant types of air pollution - photochemical smog and particulates. The major sources of air pollution in the Illawarra airshed include motor vehicles, iron and steel production and primary metallurgical works (NSW EPA, 2002). In addition, transport of air pollution has been observed between the Sydney and Illawarra regions, most often travelling south from Sydney to the Illawarra (NSW EPA, 2002).

3.4.1. Ambient Air Quality Monitoring Data

DECC conducts air quality monitoring at numerous sites in the Illawarra Region, as illustrated in **Figure 3-20**.

▪ **Figure 3-20: Illawarra Region Ambient Air Quality Monitoring Sites**



Air quality data recorded Kembla Grange was identified as providing representative background air pollution data for the purpose of modelling and analysis model outputs, based on the following:

- The proximity of Kembla Grange 5.5 km north of Tallawarra power station;
- The northerly location of Kembla Grange, relative to Tallawarra, provides a conservative estimate for background air pollution transported from the Sydney airshed; and
- Relatively higher concentrations of NO_2 and O_3 were recorded at Kembla Grange during 2002 (refer to **Sections 3.4.2**and **3.4.3).**

Background concentrations recorded at Kembla Grange during 2002 are summarised as:

- Maximum NO_2 1-hour average concentration: 145 $\mu g/m^3$, representing 59 percent of the NEPM standard (246 $\mu g/m^3$).
- Maximum O_3 1-hour average concentrations of 212 $\mu g/m^3$ (9.9 pphm), slightly below the NEPM standard (respectively, 214 $\mu g/m^3$ or 10 pphm)

The following discussion presents long term summary data for NO_2 and O_3 concentrations in the Illawarra.

3.4.2. Nitrogen Dioxide

Long term air quality data shows that annual average and maximum 1-hour NO_2 concentrations recorded in the Illawarra were within the respective NSW DECC criteria of 62 µg/m^3 and 246µg/m^3 during the period 2001 to 2005 (refer to **Figure 3-21** and **Figure 3-22**).

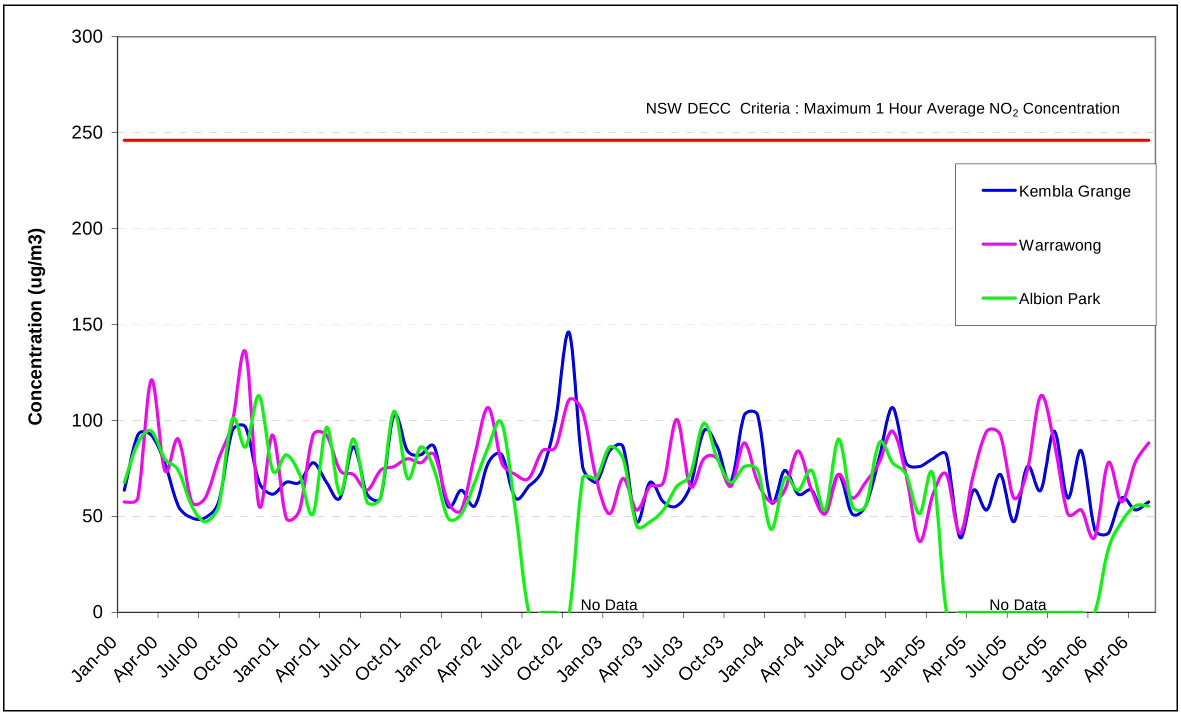
Figure 3-21 shows a slight downward trend in peak 1-hour NO_2 concentrations from January 2000 to June 2006. As noted above, the highest 1-hour NO_2 concentration during the period, 145 µg/m^3 occurred at Kembla Grange in 2002. The monthly average NO_2 concentrations follow a seasonal pattern with generally higher concentrations in winter months compared to summer months (refer to **Figure 3-22**).

Kembla Grange recorded a similar long-term pattern of NO_2 concentrations to the ambient air monitoring sites of Warrawong and Albion Park. Concentrations at Kembla Grange generally ranged between levels recorded at Warrawong and Albion Park.

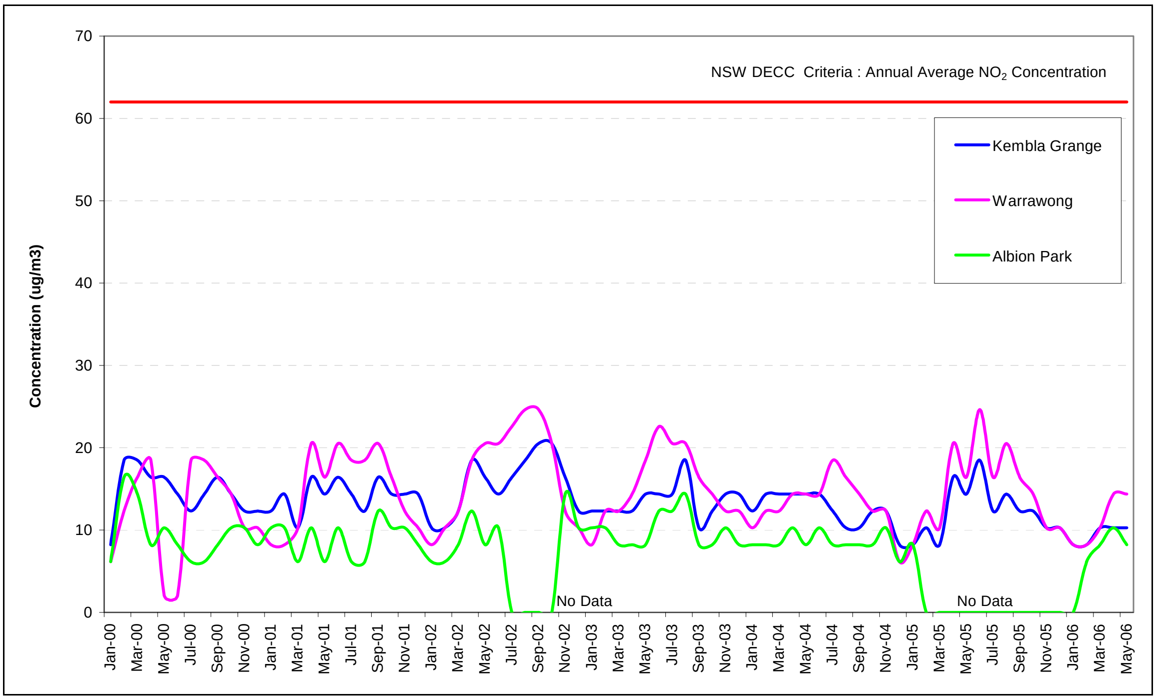
Figure 3-23 and **Figure 3-24** illustrate that during 2002, Kembla Grange recorded higher monthly average concentrations and the highest 1-hour concentration, compared with other years. As noted above, these data identified 2002 meteorological conditions as appropriate for the modelling year and air quality records at Kembla Grange during 2002 as providing appropriate background data for analysing model outputs (refer to **Section 5.5.4**).

Background NO_2 concentrations adopted for the purpose of this assessment are the maximum 1-hour average concentration, 146 µg/m^3 and the annual average concentration, 15 µg/m^3, recorded at Kembla Grange during 2002.

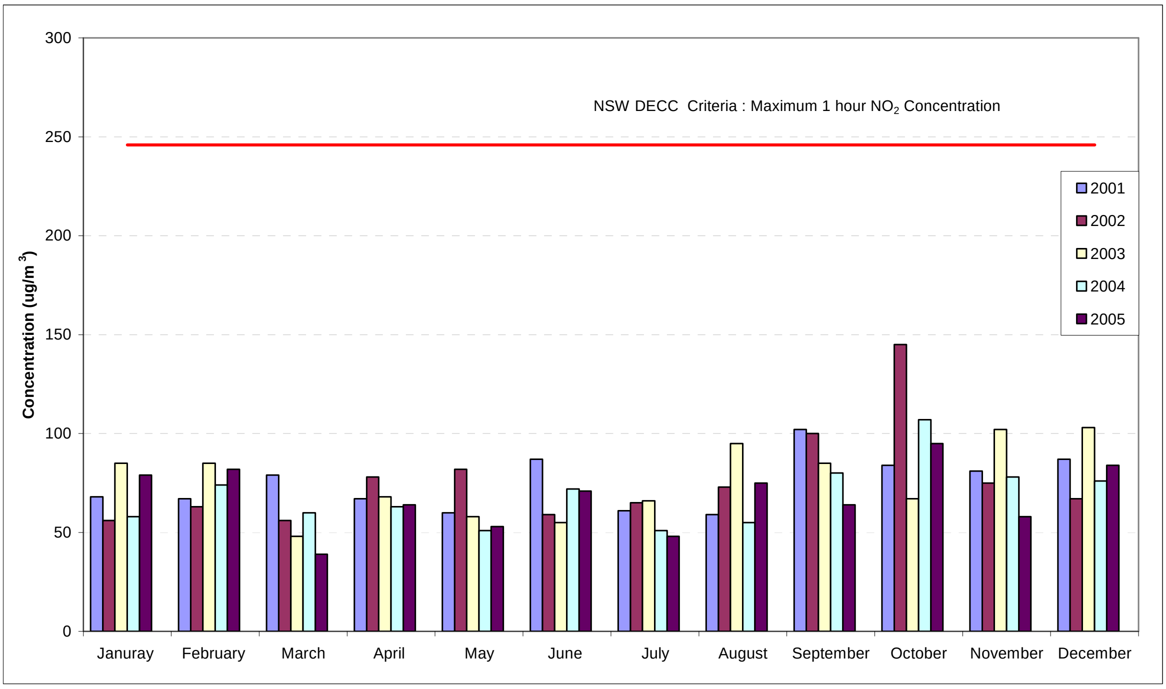
- **Figure 3-21: Illawarra Region Maximum 1-hour Average NO_2 Concentrations (Jan 2000- June 2006)**



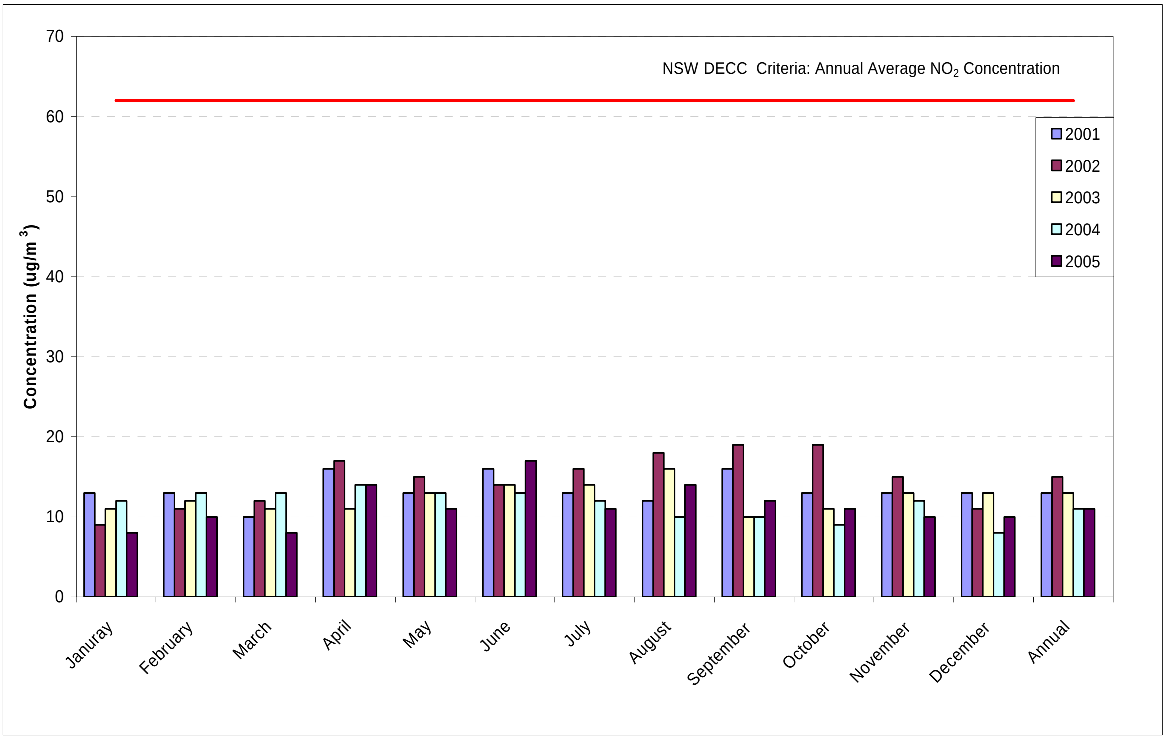
- **Figure 3-22: Illawarra Region Monthly Average NO_2 Concentrations (Jan 2000- June 2006)**



- **Figure 3-23: Kembla Grange Maximum 1-hour NO_2 Concentrations (2001- 2002)**



- **Figure 3-24: Kembla Grange Annual Average NO_2 Concentrations (2001- 2005)**



3.4.3. Ozone

On numerous occasions during the summer months of 1994 to 2004, O_3 concentrations in the Illawarra Region have exceeded the NSW DECC criteria for the 1-hour average (214 µg/m^3 or 10 pphm and the 4-hour average (171 µg/m^3 or 8 pphm) (refer to **Figure 3-25**, **Figure 3-26** and **Figure 3-27**).

Table 3-1 presents the peak concentrations and exceedences of the 1-hour and 4-hour average standards. The greatest number of exceedences occurred at Kembla Grange, with 18 days recording exceedences of one-hour criterion and 26 days recording exceedences of the four-hour criterion. Albion Park, the station furthest downwind of NO_X and VOCs sources, recorded the second highest number of exceedences with 14 days recording exceedences of the one hour criterion and 22 days exceeding the four hour criterion. Kembla Grange and Albion Park recorded a highest one-hour ozone concentration of 14 pphm. Warrawong recorded the fewest exceedences, with 6 days exceeding the one-hour standard and 12 days exceeding the four-hour standard. All sites except Wollongong recorded the maximum four-hour concentration of 12 pphm (DECC, 2007).

DECC (2007) suggested that the spatial pattern of peak ozone concentrations in the Illawarra demonstrates the regional distribution of interacting cycles of ozone formation and titration. The SOKAQIR (DECC 2007) noted that ozone concentrations may be reduced on a local scale in proximity to NO_X emissions sources, in the process of titration, whereby O_3 loses an oxygen atom to become O_2 and to make NO_2 from NO. The comparatively low number of exceedences at Warrawong may be explained by localised titration of O_3 to O_2, in proximity to NO_X emissions from Port Kembla steelworks. The formation of ozone in the NO_X plume, downwind of the steelworks while north-easterly winds frequently prevail, may explain the higher number of exceedences at Albion (DECC, 2007)

- **Table 3-1 Number of Exceedence Days of O_3 Criteria at Illawarra Sites (1994-2004)**

Site	Number of Exceedence Days 1-Hour Criteria (10 pphm)	Maximum 1-Hour O_3 Concentration (pphm)	Number of Exceedence Days 4-Hour Criteria (8 pphm)	Maximum 4-Hour O_3 Concentration (pphm)
Wollongong	12	12	17	11
Kembla Grange	18	14	26	12
Warrawong	6	13	12	12
Albion Park	14	14	22	12
No. of Station Days	50		77	
No. of Distinct Days	30		40	

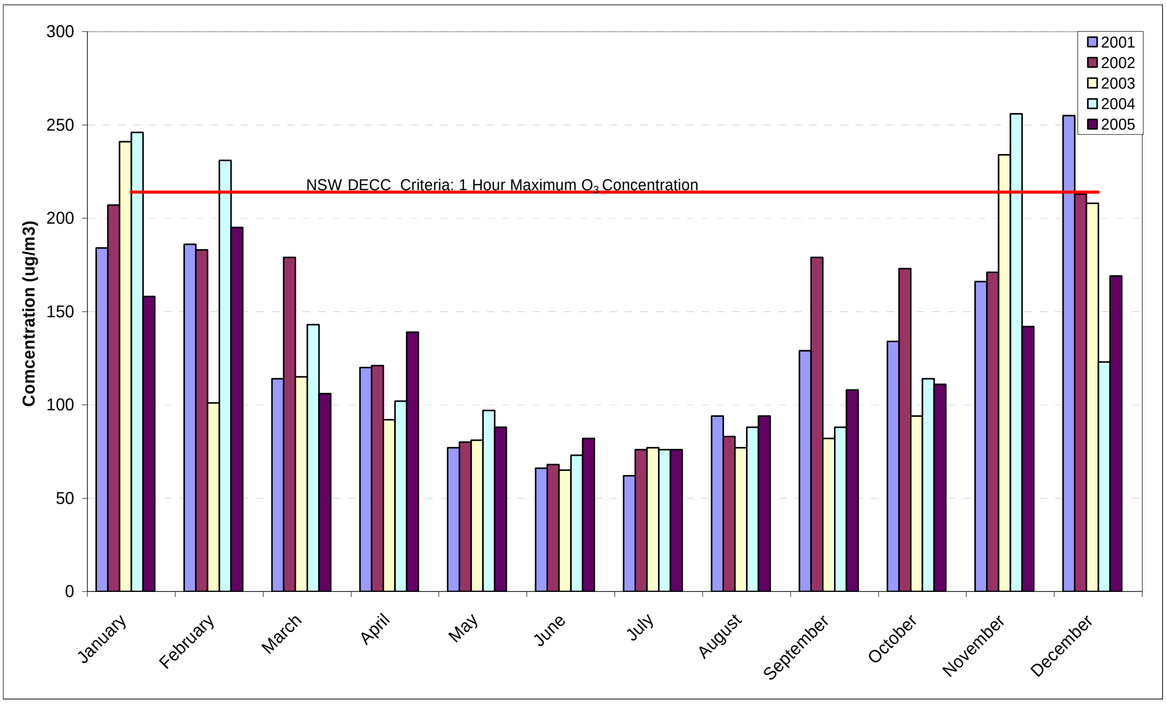
Source: DECC, 2007

The National Environmental Protection Measure for Ambient Air

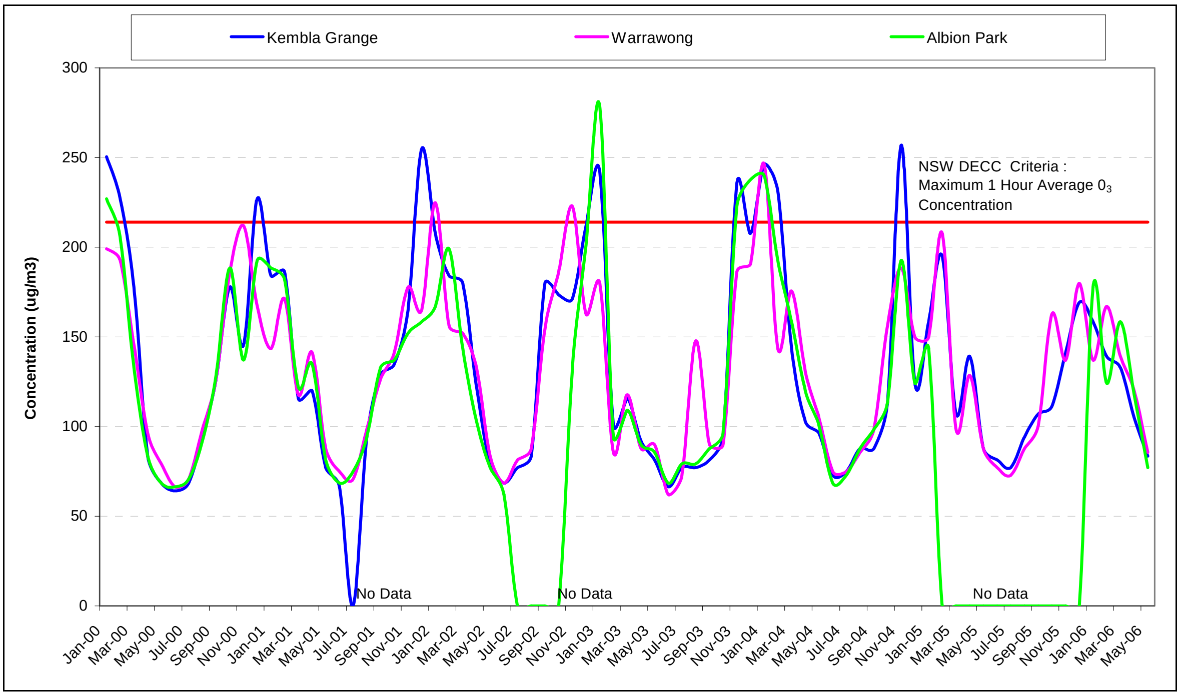
The national goal for ozone is to maintain ozone concentrations below the standards (0.10 ppm for the one-hour and 0.08 ppm for the four-hour), with a goal that the maximum concentration is exceeded on no more than one day a year by 2008 for each standard (NEPC, 1998). The number of days when ozone standards are exceeded in any given year is strongly dependent on the meteorological conditions experienced in that year. The impacts of a cooler and wetter summer (1995-96) and a hotter, drier summer (1997-98 and 2001) are evident. The years with the lowest number of exceedences were 1995, 1996 and 1999 at all sites in the Illawarra. This is consistent with the results for Sydney and the meteorological conditions in those years. During the period 1994 to 2005, the maximum number of exceedence-days in one year at one site was 5 days at Albion Park in 1997 for the one-hour standard and 6 days at Kembla Grange in 1998 for the four-hour standard. Recent data for 2004 show exceedences of up to 3 days a year at a site for both standards (DECC, 2007)

These data indicate that the Illawarra region fails to comply with the NEPM goal of no more than one exceedence day a year at a specific site.

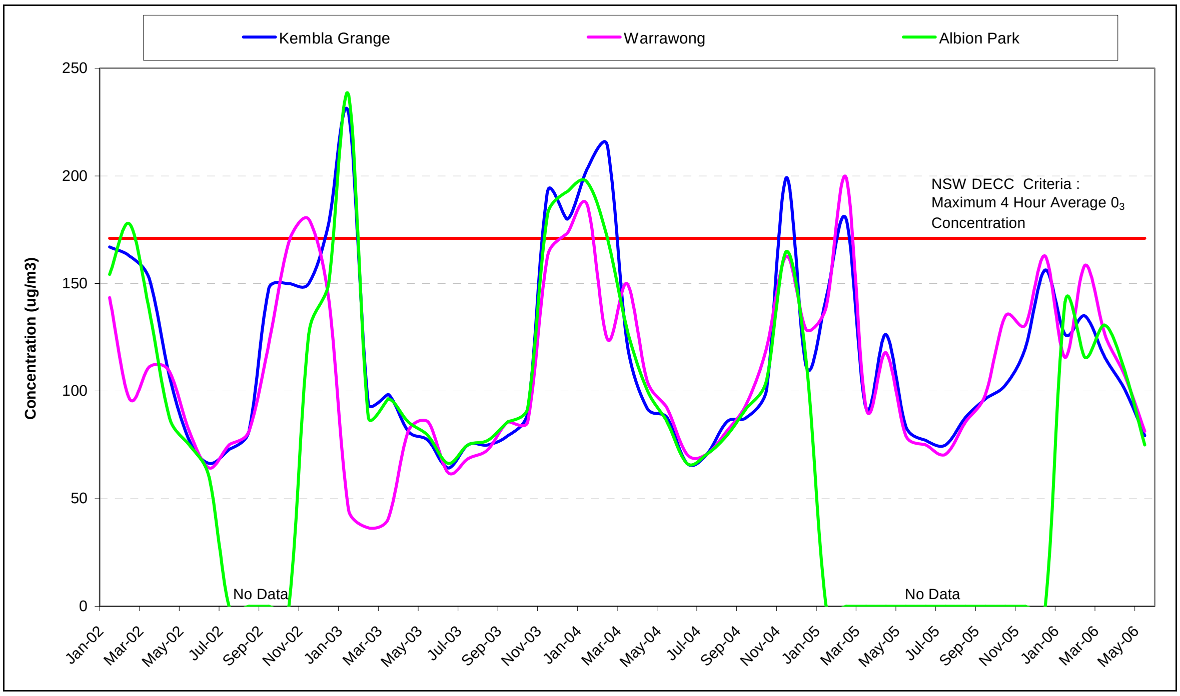
- **Figure 3-25: 1-hour Maximum O_3 Concentrations (2001 - 2005)**



- **Figure 3-26: Illawarra Region Maximum 1-hour Average O_3 Concentrations (Jan 2000-June 2006)**



- **Figure 3-27: Illawarra Region Maximum 4-hour Average O_3 Concentrations (Jan 2002-June 2006)**



4. Air Quality Objectives

4.1. Overview

This section of the report sets out the effects of air pollution and air quality objectives (criteria) relevant to the power station operations.

4.2. Air Emission Standards and Ambient Objectives

Relevant air quality standards and objectives to Tallawarra power station are as follows:

- Protection of the Environment Operations (Clean Air) Regulation (NSW DEC 2002);
- NSW DEC Impact Assessment Criteria (NSW DEC 2005); and
- National Environment Protection Measure (NEPM) for Ambient Air Quality (NEPC 1998).

4.2.1. Air Emission Standards

The *Protection of the Environment Operations (Clean Air) Regulation 2002* (NSW 2002) sets maximum limits on emissions from activities and plant for a number of substances, including acid gases such as NO_X.

Schedule 3 of the Regulation (NSW 2002) provides standards of concentration for emissions from activities including plant used for electricity generation. The Tallawarra power station belongs to Group 6, that is, plants that operate after 1 September 2005. The relevant standards are provided in **Table 4-1**.

Table 4-1 Relevant Emission Limits (Clean Air Regulation)

Electricity Generation		
Air Impurity	**Activity or Plant**	**Standard of Concentration**
Nitrogen dioxide (NO_2) or nitric oxide (NO) or both, as NO_2 equivalent	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 (35 ppmv)
	Any turbine operating on a fuel other than gas, being a turbine used in connection with an electricity generating system with a capacity of 30 MW or more	90 mg/m^3 (45 ppmv)

The proposed OCGT or CCGT plant will meet the above stated emission limits, and the proposed Dry Low NO_X (DLN) technology will provide for NO_X emissions in the order of 25 ppm during natural gas firing. For the OCGT plant, water injection into the gas turbine exhaust under diesel firing will provide for NO_X emission rates in the order of 42 parts per million by volume (ppmv).

4.2.2. Ambient Air Quality Objectives

The National Environmental Protection Measures (NEPM) for Ambient Air Quality (Air NEPM) provides uniform standards for ambient air quality (NEPC, 1998). The NSW DECC impact assessment criteria are based on NEPM guidelines. The NEPM / NSW DECC objectives relevant to ambient air quality in the Illawarra airshed are listed in **Table 4-2**.

Table 4-2 Ambient Air Quality Objectives

Pollutant	Averaging Period	Maximum Concentration		Source
		ppm	$\mu g/m^3$	
Nitrogen Dioxide (NO_2)	1 hour	0.12	246	NEPC 1998
	Annual	0.03	62	NEPC 1998
Photochemical oxidants (such as ozone, O_3)	1 hour	0.10	214	NEPC 1998
	4 hours	0.08	171	NEPC 1998
Particulates (as PM_{10})	24 hours		50	NEPC 1998
	Annual		30	NSW EPA 1998
Sulphur Dioxide (SO_2)	10 minutes	0.25	712	NEPC 1998
	1 hour	0.20	570	NEPC 1998
	24 hours	0.02	228	NEPC 1998
		ppm	mg/m^3	
Carbon Monoxide (CO)	15 minutes	87	100	WHO 2000
	1 hour	25	30	WHO 2000
	8 hours	9	25	NEPC 1998

4.3. Project Specific DECC Requirements

The Department of Environment and Climate Change (DECC) in a letter to the Department of Planning (DoP) dated 25 October 2007 set out their expectations for the air quality assessment of the project. These requirements are reflected in the Director-General Requirements (DGRs) for the project dated 16 October 2007.

The key pollutant of concern for the proposed development will be nitrogen oxides (NO_X) and the possible impact of the new emissions source in relation to the NSW State Plan clean air target. State Plan priority E3 for clean air is for NSW to meet the National Environmental Protection Measures (NEPM) for Ambient Air Quality (Air NEPM) goals (refer to **Table 4-2**). The Illawarra region has exceeded the ozone goal for eight of the past 13 years (DECC correspondence 25/10/07). The Air NEPM goal allows for one exceedence day per year, for the maximum one-hour and four-hour averaged ozone concentration (NEPC, 1998). The Illawarra region will not achieve ongoing compliance with the Air NEPM ozone goal by the compliance date of 2008. The DECC recognises that although there are advantages in extending Tallawarra Power Station, a new source of NO_X emissions may compromise timely and cost-effective achievement of the State Plan clean air target.

To maintain the capacity to meet the State Plan, the DECC requires that the Environmental Assessment for Tallawarra address the following:

a) Demonstrate that the proposed Tallawarra Stage B development is either NO_X neutral or incorporates best available control technology (BACT) to reduce NO_X emissions

The development consent for the Tallawarra Stage A CCGT included a consent limit for NO_X emissions of 900 tonnes per annum (tpa). The DECC requires that the combined emissions of Stage A and Stage B would be below the 900 tpa consent limit. This may be achieved by:

- The proponent implementing BACT to reduce emissions from either Stage A or Stage B to achieve a NO_X emission concentration of 10 $\mu g/m^3$ as a three hour rolling average; or
- The proponent undertaking off site projects in the Illawarra airshed to off-set NO_X emissions from the Stage B development.

b) Air quality impact assessment in accordance with the *Approved Methods for Modelling and Assessment of Air Pollutants in NSW*, NSW DEC, 2005)

Since the original consent was granted for Tallawarra A, new residential and industrial developments have been approved in the vicinity of the power station. The DECC requires that the air quality assessment applies a methodology consistent with the *Approved Methods* (NSW DEC 2005), including consideration of the following:

- Emissions from new industrial NO_X sources, such as the BlueScope Limited (BSL) ore preparation upgrade which was accompanied by a NO_X emission limit of 8,085 tpa (NB: DECC subsequently advised that this is not required);
- High NO_X emission scenarios associated with start up, shut down and part load operations at the power station;
- The impact of the power station operations within the context of recent land use changes, such as known and likely population centres; and
- The impact of NO_X emissions on ozone formation in the Illawarra airshed, taking into account days conducive to photochemical smog formation and the extent, duration and size of regional NO_X and ozone exposure. The proponent may wish to consult with the DECC on the assessment methodology (refer to **Section 5.6**).

4.4. POEO Act - Green Offsets

An option is being explored for TRUenergy to undertake NO_X offset activities in the Illawarra. If such an option is undertaken, the specific details of the relevant activities would be approved in accordance with the appropriate sections of the *Protection of the Environment Operations Act 1997* (POEO Act).

The sections of the POEO Act which are relevant to NO_X offsets are sections 69 and 295M. These extracts are presented below:

Protection of the Environment Operations Act 1997 No 156

69 Conditions relating to tradable emission schemes, green offsets and other schemes involving economic measures

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The conditions of a licence may implement or otherwise relate to:
(a) tradable emission schemes, or
(b) green offset schemes or works, or
(c) other schemes involving economic measures,
as referred to in Part 9.3, 9.3A or 9.3B.
Note. Conditions relating to tradable emission schemes or green offset schemes or works may also be attached to licences by the regulations (see Parts 9.3A and 9.3B).

Part 9.3B Green offsets
295M Definitions
In this Part:
licensed activity *means an activity authorised or controlled by a licence.*
participant *in a green offset scheme means:*
(a) a person who holds a green offset credit created under the scheme, or
(b) a person who holds a licence that is subject to a condition that requires or authorises the person to participate in or contribute to the scheme, or a licence of a prescribed kind, or
(c) a person (other than the holder of a licence) who arranges, implements or manages the scheme.
participant *in green offset works means:*
(a) a person who holds a licence that is subject to a condition that requires or authorises the person to implement or arrange the works, or
(b) a person (other than the holder of a licence) who implements or manages the works.

295N Licence conditions

(1) A condition of a licence may be imposed in relation to a green offset scheme or work even though:

(a) the scheme or work does not relate to the licensed premises, or

(b) the scheme or work does not relate to harm arising from the activity authorised or controlled by the licence,

so long as the harm arises from the same kind of licensed activities and relates to the same types of pollutants or impacts that arise from the activity authorised or controlled by the licence.

(2) The appropriate regulatory authority may not impose any such condition on a licence unless it is satisfied of the following:

(a) that the pollutants or impacts of the activity may not be otherwise prevented, controlled, abated or mitigated in a cost effective way by other measures under the licence,

(b) that the proposed green offset scheme or work is likely to result in at least the same or a more beneficial effect on the environment than the use of such other measures,

(c) that the effects and benefits of the proposed green offset scheme or work may be reliably estimated or ascertained by the authority,

(d) that the effects of the proposed green offset scheme or work are likely to occur wholly or partly in an area affected by the pollutants or impacts that arise from the activity,

(e) that the effects and benefits of the proposed green offset scheme or work are likely to last at least until the relevant impact of the activity is offset.

(3) The regulations may, for the purpose of giving effect to a green offset scheme or works, impose conditions on licences.

(4) Conditions of a licence that are imposed by the regulations for the purposes of this Part cannot be substituted, omitted, amended or revoked by a regulatory authority.

(5) This section does not prevent a condition from being attached to a licence by an appropriate regulatory authority in the manner provided by Chapter 3.

***Note**. Under section 69, conditions may be imposed on licences implementing or otherwise relating to green offset schemes and green offset works.*

4.5. Requirement for Project NO_X Offsets

The approval conditions for Tallawarra Stage A require NO_X emission concentrations not to exceed 25 ppmv with a mass load limit of 900 tonnes per annum (tpa).

The Tallawarra A plant has recently entered commercial operation and as anticipated, at full load NO_X emissions are in the order of 12.5 ppmv. Assuming an annual capacity factor of 96 percent, the actual NO_X mass load will be somewhat lower than 900 tpa, more like 450 tpa. As such to achieve a NO_X neutral scenario for Tallawarra B in light of the approved conditions for Tallawarra A, this could be done where the Tallawarra B NO_X emissions were able to be limited to less than 450 tpa (900 tpa – 450 tpa).

Tallawarra B, configured as a CCGT plant similar to Tallawarra A, will also achieve NO_X emissions no greater than 12.5 ppmv and 450 tpa. Therefore it follows that the total NO_X load from Tallawarra A and B will be within the site load limit of 900 tpa. Based on this analysis it is clear that NO_X offsets will not be required for Tallawarra B configured as a CCGT plant.

The exact configuration of the Tallawarra B power station configured as an OCGT gas turbine plant is yet to be decided, with the final decision being based on a combination of technical and commercial outcomes. This air quality assessment assumes for the OCGT option, two gas turbines with total capacity up to 400 MW, with NO_X emission rates for gas firing at 25 ppmv of the order of 72.5 kg/hour and diesel firing at 42 ppmv of the order of 135 kg/hour. Assuming diesel firing at a rate of 1 percent of all operating hours, the annualised NO_X emissions assuming full load operations of the two turbines could be limited to approximately 3,000 hours per year or an annual capacity factor of 35 percent to keep the annual NO_X tonnage below the calculated 450 tpa for B station and 900 tpa for both A and B stations. Therefore it can be seen that NO_X offsets are not required for Tallawarra B as an OCGT plant operating up to 35 % capacity factor.

The actual operating regimes for both A and B stations will largely be driven by the electricity market (NEMMCO). Annual capacity factors of 96 percent for the base load CCGT A station and 35 percent for the peak load B station may seem conservative at this stage. However, future electricity demand may require additional generation, particularly the B OCGT station, where there is a significant opportunity to increase annual electricity outputs, beyond the 35 percent estimated to maintain total site emissions within 900 tpa. TRUenergy would assess this scenario and the need for NO_X offsets on an as required basis.

TRUenergy propose to install and operate a continuous NO_X monitoring system at the site. The continuous emissions monitoring system data will provide for a real-time NO_X emission load calculation to be carried out so TRUenergy can track their actual emission load against the site NO_X load limit and therefore the potential need for any NO_X offset.

It should be noted that while the exact operating regime of Tallawarra A and B is not known, the air dispersion modelling undertaken assumes a worst-case situation where the plant is assumed to operate at 100 percent load on a continuous basis with NO_X emission concentrations at 25 ppmv. Where air quality impacts are shown to comply with relevant criteria under this worst-case scenario it follows that impacts will also be acceptable under any operating regime less than 100 percent load on a continuous basis.

4.5.1. Gas Turbine NO_x Emission Control

Further on-site opportunities for fitting Tallawarra A and B stations NO_X emissions within the existing 900 tpa load largely depend on the ability of the OCGT plant to achieve NO_X emission concentrations lower than 25 ppmv. It is noted that in the Australian environment 25 ppmv as achieved by DLN technology has been considered "Best Practice" for large industrial gas turbines, and is lower than the 35 ppmv required by the POEO Act Clean Air Regulations, 2002. It is noted that recently approved gas turbine projects at Munmorah on the NSW Central Coast and Bamerang near Nowra immediately south of the Illawarra region were both approved with 25 ppmv NO_X limits.

To guarantee NO_X emissions lower than 25 ppmv for OCGT or CCGT plant under gas firing would require the introduction of technology above and beyond that which can be achieved by DLN, such as Selective Catalytic Reduction (SCR). A discussion of the feasibility of applying SCR technology to large industrial gas turbines within the Australian environment is discussed as follows.

A detailed assessment of Best Available Control technology (BACT) was completed for the Tallawarra B project as either an open or combined cycle gas turbine power station. In general, Selective Catalytic Reduction (SCR) was identified as the only technical measure of providing significant reductions in NOx emission concentrations compared with more standard control technologies like Dry Low NOx (DLN).

SCR works by selectively reducing NOx by combining ammonia (NH3) and oxygen (O2) with NOx in the turbine exhaust gas in the presence of a catalyst to form molecular nitrogen (N2) and water (H2O). The primary chemical reactions are:

- $4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$
- $2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$

With SCR, NOx reduction of 80 to 95 percent can be achieved, although the higher the reduction level, the more catalyst is required and system capital and O&M costs increase.

An important consideration in the design of a SCR system is the exhaust gas temperature. The catalysts normally only operate within a defined temperature range. Typical ranges for catalyst types are presented in **Table 4-3**.

Table 4-3 Typical Operating Temperatures for SCR Catalysts

Catalyst	Temperature Range (°C)
Platinum	175 to 260
Vanadium	300 to 450
Zeolite	510 to 590

Keeping the exhaust gas temperature within these ranges is important. If it drops below the range, the reaction efficiency becomes too low and increased amounts of NOx and unreacted ammonia will be released. If the reaction temperature gets too high, the catalyst may begin to decompose or be destroyed. In some cases, dilution air is added to the exhaust gas stream to control the air temperature upstream of the catalyst.

Most SCR systems have been installed in CCGT and cogeneration applications in an area within the heat recovery steam generator (HRSG), where the gas temperature has given up heat to the steam cycle and so is cooled to be within the reaction range of the catalyst. SCR systems have been installed in open cycle plants, though the bulk of these have been behind aeroderivative GTs. (Typically, aeroderivative GTs have lower exhaust gas temperatures than industrial GTs – in the order of 450°C rather than approximately 550°C from industrial GTs.) Even in some of the aeroderivative applications the exhaust gas temperature must be reduced by using tempering air to protect the catalyst.

The literature suggests there are few industrial OCGT installations with what can be called hot SCR systems. Whilst there have been operational problems with these systems, SKM understand the bulk of the problems have been due to system mechanical design rather than with the process or catalyst performance.

SCR systems themselves have considerable resource requirements and potential safety and environmental impacts. Large quantities of ammonia must be stored on site. It appears common practice now is to use aqueous ammonia rather that the more dangerous anhydrous ammonia.

"Ammonia slip" occurs when ammonia injected into the exhaust fails to react in the exhaust gas stream causing ammonia to be released into the atmosphere. This can normally be controlled to approximately 5ppm NH3.

Spent catalyst must be disposed of. In the United States, it appears the norm is for the catalyst supplier to take back the catalyst for regeneration. It is not known if this type of service would be readily available in Australia. The catalyst must be washed occasionally and the associated waste stream normally requires neutralisation and may be considered hazardous.

The SCR system increases the backpressure on the GT, reducing overall output and efficiency. Additional parasitic losses would be incurred if tempering air fans are required to reduce the exhaust gas temperature to protect the catalyst, reducing net plant output and efficiency further.

While SCR has been identified as the only technically feasible means of reducing NO_X further at Tallawarra B, the costs estimates determined for its implementation would render the project not feasible. This is based on current and future cost estimates for peak load electricity and the fact that recently approved and expected future approvals of other NSW peak load OCGT plants without SCR would make Tallawarra B uncompetitive with these other lower cost operators.

4.6. Offsite Project Opportunities for NO_X Offsets and International Context

4.6.1. Project Opportunities for NO_X Offsets

The DECC has identified a range of offsite project opportunities in the Illawarra which may be considered by TRUenergy for the purpose of achieving NO_X offsets, if required (refer to **Table 4-4**).

- **Table 4-4 Potential NO_X Offset Opportunities in the Illawarra**

Source	Program	Description	Reduction (approximate tpa)
Buses	Replacement of buses. E.g. Euro 1 or 3 with Euro 5	Contribute to government replacement program (505 Program) or approach private company directly	1 -2 tonnes per bus per year at \$550k per bus
Service stations	Install VR 2 Install VR 1 (however limited abatement timeframe)	Installation of this technology where it is otherwise not required	65 tonnes per year per midsized service station at ~ \$100,000 + per service station. Possible abatement for up to 30 yrs if service station only recently refurbished.
Third party provider of offset services.	NO_x offset scheme	Contribute to offset program provided by 3rd party. Specialist 3rd party to identify, document and broker offset opportunities.	Variable Market not yet developed.
Lawn Mowers	Replace 2 stroke mowers with 4 stroke.	Buy back or replacement program	5 kg per year per mower (0.005 tonnes)
Small to medium sized enterprises	Targeted industry sector program	Work with group of businesses to identify offsets across an industry sector	Unknown

Source: DECC (personal communication, 18/01/08)

Further detail relating to specific programs may be obtained from recent DECC publications (NSW DECC 2007b, 2007c).

4.6.2. The International Context

While the introduction of NO_X offset activities in NSW is forthcoming, such programs have been operating in the United States of America since 1990. The US offset Credit Market for Emission Reduction was created as part of the *Clean Air Act Amendments 1990* under the US EPA to allow certain new or significantly modified sources of air pollution to be built in an air shed that does not meet national air quality standards without further affecting the region's air quality. Any new source, or major modification causing a significant increase in emissions in the air shed, requires the operator to buy offset credits from an existing source. Individual States have developed unique requirements and procedures tailored for the air quality needs of each area while complying with the EPA's federal requirements. Common features of offset programs are outlined below:

- **Interpollutant trade -** Emission reduction credits of NO_X may be used to offset increased emissions of other pollutants such as VOCs. US States which allow interpollutant trading to take place include California, Louisiana and Maine.
- **Shutdowns -** The most commonly used form of offset is permanent shutdowns. For example, the High Desert Power Plant in California achieved an offset to the power plant's NO_X emissions by obtaining and trading the VOC emission reduction credits achieved from the closure of the George Air Force Base. Other states in which shutdowns are used to offset new stationary sources include Colorado, Pennsylvania, New York and New Hampshire. In New Hampshire, the credits generated by shutdowns are not to be used for trade and must be used by the source.
- **Mobile emission credits -** Offsets may be generated by mobile emission sources such as scrapping high-emitting vehicles or switching vehicles to alternate fuel sources. Illinois instituted a program in which pre-1980 automobiles were bought, their tailpipe emissions and fuel evaporation rates were recorded and then the vehicles were scrapped. The credit generated was proportional to the total amount of emissions removed from the air by permanently removing the vehicles from the road. In Georgia, owners of fleet vehicles can earn credits by purchasing clean-fuelled vehicles. In Illinois, Louisiana and Delaware, stationary sources operating in areas that violate national air quality standards may purchase mobile emission source credits to offset their emissions.

Using California as an example the Air Resources Board (ARB) makes available emission reduction credits (ERCs) to peaking power plants that need emission offsets in order to add new or expanded peaking capacity. A number of power plants in California have used ERCs to comply with legislation in order to add new or expanded peaking capacity including the Delta Energy Centre and

Sutter Power Plant. ERCs are valid for a three year period. Prior to their expiration the applicant must secure emission reductions for the remaining life of the plant.

In 1993, about 93 percent of ERCs came from stationary (area) sources, about 7 percent of these were from agricultural sources and less than 10 percent came from mobile sources (motor vehicles, lawn mowers). For example:

- **Area (stationary) sources -** Offsets may be generated by encouraging emission reductions and technology advancement for retrofitting of older, higher emitting equipment. The area source providing the emission reduction (such as a diesel generator) must comply with all applicable EPA, ARB and district rules and regulations.
- **Agricultural Pumps -** NO_X emissions may be offset from a stationary source through the electrification of agricultural pumps. Diesel-fuelled engines used to power such pumps must be replaced with an electric motor. Each modified agricultural pump is located within the district.
- **Clean lawn and gardening equipment -** ERCs can be acquired by purchasing low-polluting equipment and early retirement of older, high polluting equipment. To generate the offset, existing lawn and gardening equipment must be scrapped and replaced with equipment which meets emission standards or replaced with new low or zero emission equipment.
- **Clean On-road vehicles and Off-road Mobile Equipment -** Offsets may be generated by emission reductions created by the operation of low or zero-emission on-road vehicles, including heavy-duty vehicles or off-road equipment, which is registered and operated in the district. Off-road equipment includes; bulldozers, loaders, tractors, scrapers, graders, off-highway trucks, forklifts and utility service vehicles. In order to generate an offset, the changes must result in exhaust, evaporative or marketing loss emission reductions, in addition to reductions required by ARB, District and EPA regulations.
- **Old-vehicle scrapping and repair of on-road motor vehicles -** ERCs can be achieved by reducing motor vehicle exhaust emissions through the scrapping of old, high emitting vehicles. Procurement of old vehicles may be accomplished by persons voluntarily giving up their vehicle for scrapping upon receiving an incentive payment. To be a valid offset, old vehicles must have, on average, at least three years useful remaining life prior to scrapping. Recycling and resale of parts from the retired vehicle are permitted for non-emission related and non-drive train parts. ERCs can be generated by reducing the emissions of high-emitting vehicles through the repair of emissions related components. Emission reductions must be surplus to regulatory requirements.
- **Truck stops and Truck Refrigeration Units-** NO_X offsets may be achieved through the use of electrical power for trucks in lieu of the operation of diesel-powered engines. This involves turning off the diesel engine while the truck is parked in the truck stop and providing electric power to operate on-board electrical systems including heating, ventilation and air conditioning to truck cabs.

- **Marine Vessels and Hotelling Operations** - Diesel fuelled captive marine vessels operated within the district waters may be re-powered or have their engine remanufactured to achieve emissions at or below a specified emission standard. Opportunities to generate offsets may also arise from the use of electric power or fuel cell technology in lieu of diesel-fuelled auxiliary engines during hotelling operations (wharf side).

4.7. Vapour Recovery at Service Stations

As per **Table 4-4**, petrol station vapour recovery (VR1 and VR2) appears to be the most effective offset available to TRUenergy for the Tallawarra power station. Details on the offsite project opportunity regarding the installation of petrol station vapour recovery technology are detailed below.

The use of vapour-recovery technology at service stations is one of the single most important actions available in NSW today to substantially reduce VOC levels and deliver both regional and local air quality benefits.

Stage 1 vapour recovery (VR1) controls emissions from underground storage tanks while the tanks are being filled from road tankers. Stage 2 vapour recovery (VR2) controls emissions from vehicle tanks during refuelling at petrol bowsers.

In both cases additional piping is needed for the vapour transfer. This involves underground excavation to install pipework to the storage tanks. VR1 requires additional pipework and connections on the road tanker, whereas VR2 generally requires a vapour pump to return the vapour from the vehicle’s petrol tank to the underground storage tank.

4.7.1. Costs and Benefits

The economic study found the cost of implementing both VR1 and VR2 to be between $15,000 and $290,000 per service station, depending on the size of the service station and the timing of refurbishment. This includes the equipment’s capital and installation costs, business disruption costs during refurbishment, and compliance costs. If not already present, VR1 would need to be implemented along with VR2 to ensure that vapour collected while vehicles were being filling was not vented when the tanker refilled the underground tank.

VR1 Proposal

It is estimated that expanding the VR1 area to include Newcastle, the Central Coast, Wollongong and currently excluded outlying Local Government Areas (LGAs) in the Sydney region would reduce VOC emissions by up to 850 tonnes a year (tpa). Emission reductions expected to be attributed to expanded vapour recovery in the Illawarra region are up to 177 tpa.

Analysis of survey data collected for DECC's 2006 emissions inventory identified 2,100 service stations in the GMR, including 83 in the Illawarra region.

4.7.2. Sources of Vapour

VOC emissions arise from a number of sources at petrol stations, including the vapour expelled from a vehicle's petrol tank as the tank is filled; drips from the filling nozzle; leaks from hoses and gaskets, and vapour expelled from underground storage tanks as they are refilled by road tankers.

4.7.3. Principles of Vapour Recovery

The implementation of VR1 and VR2 is considered best management practice for vapours at petrol stations. The equipment modifications required in both cases consist of additional piping for the vapour transfer.

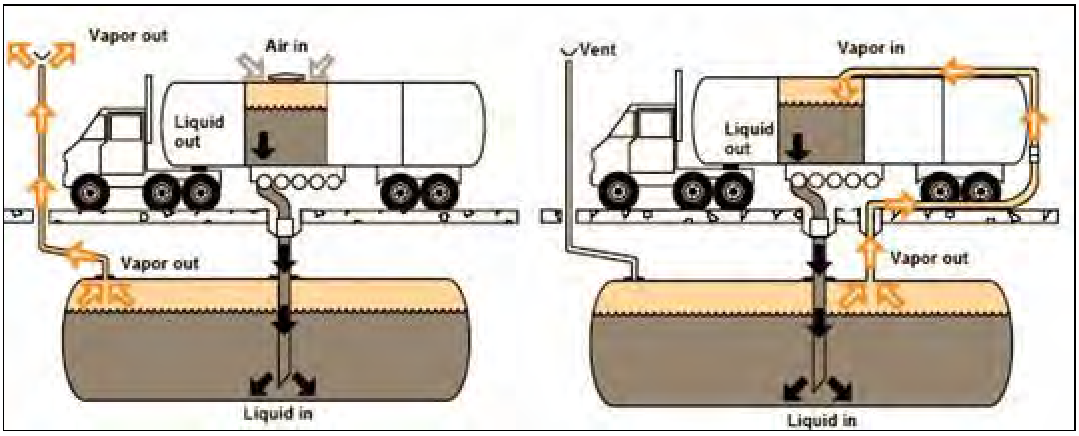
Principles of VR1

VR1 controls the emissions from underground storage tanks as the tanks are filled by road tankers. VR1 involves the collection of the vapour occupying the empty space in the underground petrol storage tank while the tank is being filled by the road tanker. The vapour displaced by the rising liquid level is fed into the vapour space of the tanker as the liquid level in the tanker. This provides a closed loop of liquid and vapour transfer between the tank and tanker (refer to **Figure 4-1**).

When the tanker returns to the terminal for refilling, the vapour displaced from the tanker is collected through the gantry and returned to the terminal tank storage via a vapour recovery unit that condenses the vapour into a liquid. Condensers and/or activated carbon beds commonly control vapour release from the storage tanks at the refinery or terminal.

VR1 involves underground excavation to install pipework to the storage tank and additional pipework and connections on the road tanker.

Figure 4-1: Uncontrolled and Controlled Stage 1 Vapour Recovery (VR1)

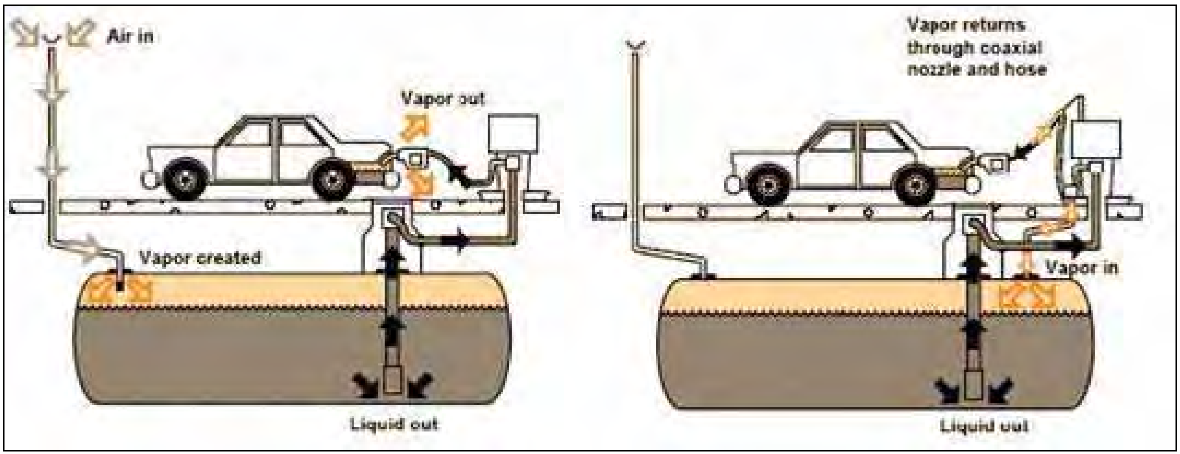


Principles of VR2

VR2 controls the emissions from filling vehicle tanks. VR2 operates on the same principle as VR1 to capture petrol vapours at the petrol pump when motor vehicles refuel. VR2 involves collection of the vapour in the vehicle's fuel tank as it is refuelled and the transfer of these vapours to the underground storage tank, preventing their release into the atmosphere (refer to **Figure 4-2**).

In addition to the vapour piping system in VR2, a pumping system is required to create suction to return the vapour from the vehicle's petrol tank to the underground tank, ensuring that no vapour escapes from the space around the nozzle. This pumping system is calibrated to capture at least 95 percent of petrol vapour.

Figure 4-2: Uncontrolled and Controlled Stage 2 Vapour Recovery (VR1)



4.7.4. Onboard Refuelling Vapour Recovery (ORVR)

Onboard refuelling vapour recovery (ORVR) is an emission-control system that utilises a large activated carbon canister to capture fuel vapours from the vehicle's petrol tank during refuelling. ORVR is an alternative approach to VR2 for capturing fuel vapours.

The petrol tank and filling pipe of an ORVR-equipped vehicle are designed so that when the vehicle is refuelled, petrol vapours in the petrol tank are directed to a carbon canister, which adsorbs the vapour, preventing the vapours from venting out the filling pipe to the atmosphere. When in operation, the engine draws upon the petrol vapours from the carbon canister to be used as fuel.

The adoption of ORVR for the Sydney region is not a feasible alternative approach. It would require new Australian Design Rules (ADRs) for light passenger vehicles and would take at least 20 years to become sufficiently widespread across the vehicle fleet to make a significant impact on VOC emissions. It would also be difficult to justify imposing a cost on all vehicles sold in the Australian market to mitigate air pollution in the Sydney region alone.

4.7.5. NSW Regulation and Proposed Approach to Extending VR

Part 5 of the POEO (Clean Air) Regulation 2002 requires facilities that handle petrol to have vapour-recovery systems to reduce VOC emissions. Under the Regulation, VR1 is required in the Sydney region but not in other metropolitan areas of the NSW Greater Metropolitan Region (GMR). DECC proposes to:

- Extend the area of coverage of VR1 to include all petrol stations in metropolitan Newcastle, Wollongong, Central Coast and Sydney. This would reduce VOC emissions by up to 850 tonnes a year ; and
- Introduce VR2 to all petrol stations in the Sydney region that have fuel throughputs of 3 million litres or more a year. This would reduce VOC emissions by up to 4300 tonnes a year.

In relation to the timing of implementation DECC proposes:

- VR1 full implementation to be required by 2010; and
- VR2 implementation be staged to 2016.

4.7.6. Benefits of Vapour Recovery

The complex nature of the chemistry that causes ozone concentrations to form makes it difficult to model future ozone levels. However, a broad indication of the benefits of reducing VOCs can be drawn from estimates of the ozone-related health costs of VOC emissions in Europe (A$2,650 a tonne) and the USA (A$2,200 per ton). These cost estimates are relevant to Sydney, where ozone concentrations and population density are comparable to those in the USA and Europe. The current proposal will reduce VOC emissions by up to 5,100 tonnes a year for the whole NSW GMR. There is currently a debate as to whether or not there is a no-effect threshold for human exposure to ozone. If there is no threshold, the potential benefits of implementing VOC controls are likely to be much higher.

5. Methodology for Air Quality Assessment

5.1. Overview

The methodology for the air quality assessment is consistent with the environmental assessment requirements under Part 3A of the *Environmental Planning and Assessment Act 1979* and Department of Planning Director General's requirements for the project dated 16 October 2007.

This section describes the methods undertaken to meet the DECC requirements for the assessment of NO_2 and O_3, consistent with the *Approved Methods* (NSW DEC 2005) and the project specific DECC requirements (noted in **Section 4.3)**, as follows:

- High NO_X emission scenarios associated with start up, shut down and part load operations at the power station (refer to **Section 5.4**);
- The impact of the power station operations within the context of recent land use changes, such as known and likely population centres (refer to **Section 5.5.3**); and
- The impact of NO_X emissions on ozone formation in the Illawarra airshed, taking into account days conducive to photochemical smog formation and the extent, duration and size of regional NO_X and ozone exposure (refer to **Section 5.6 and Appendix D.1**).

Air pollution modelling for local and regional impact assessment was conducted using The Air Pollution Model (TAPM, Hurley, 2005a, 2005b), developed by CSIRO Atmospheric Research (refer to **Section 5.2**).

The TAPM applications involved two approaches:

1. Local area impacts of NO_X/NO_2, PM_{10}, and SO_2 were conducted using TAPM in tracer mode (refer to **Section 5.5**).
2. Regional scale photochemical modelling also was undertaken using a methodology set by the DECC (refer to **Section 5.6**).

5.2. Brief Description of The Air Pollution Model (TAPM)

TAPM consists of coupled components for modelling prognostic meteorology and air pollution concentrations. TAPM has been designed to eliminate the need to have site-specific meteorological observations for the area of interest, although the inclusion of local measurements of wind data by a data assimilation option can be beneficial in assisting TAPM to model local wind data more realistically (2005a, 2005b, Hurley *et al.* 2005).

TAPM is more complex than the Gaussian models, such as AUSPLUME, in that the fundamental fluid dynamics and scalar transport equations are solved to predict meteorology and pollutant concentrations. The model predicts the flows important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses (Hurley *et al*. 2005).

The standard version of TAPM (v.3.0.7) was applied in tracer mode to assess the impacts of Tallawarra power station on local scale concentrations of NO_X/NO_2, PM_{10} and SO_2 (refer to **Section 5.5**). TAPM (v.3.0.1) also includes a photochemistry option to calculate the prediction of ground level concentrations of NO_2 and O_3 resulting from emissions of pre-cursor pollutants such as NO_X and VOCs. The chemistry in the model is described by a set of interactions known as the general reaction series (GRS, Azzi, *et al*., 2002). Hence, the reference to the application of TAPM-GRS, DECC's preferred mode for the assessment of photochemical smog in the Illawarra (refer to **Section 5.6**).

Recently, TAPM has been developed to feature a more comprehensive photochemistry option, the chemical transport module (CTM), a component designed for the Australian air pollution forecasting system (Cope *et al.,* 2004). In this assessment, modelling of NO_2 and O_3 with TAPM-CTM was undertaken by SKM, with CSIRO support, for a known elevated ozone event in the Illawarra region (refer to **Appendix D**).

5.2.1. Meteorological Component

The meteorological component of TAPM is an incompressible, optionally non-hydrostatic, primitive equation model with a terrain following vertical coordinate for three-dimensional situations. It predicts winds, temperature, pressure, water vapour, cloud/rain water and turbulence. The model also includes urban/vegetation canopy, soil effects and radiative fluxes (Hurley, 2002).

The model is driven by six-hourly analysis fields of wind, temperature and specific humidity from the Bureau of Meteorology Limited Area Prediction System (LAPS) model, which account for the larger-scale synoptic variability (Hurley 2005a, 2005b, Hurley *et al.* 2005).

5.2.2. Air Pollution Component

The air pollution component of TAPM consists of a nested Eulerian grid-based set of prognostic equations for pollutant concentration. A Lagrangian Particle Module (LPM) can also be used to represent near-source dispersion more accurately for point sources. The photochemistry mode includes gas-phase photochemical reactions for NO_X and O_3 and gas-phase and aqueous phase chemical reactions for sulphur dioxide and particles. Included in the model are dry and wet deposition processes, plume buoyancy, momentum and building wake effect for point sources (Hurley 2005a, 2005b, Hurley *et al.* 2005).

5.3. Stack Characteristics and Emission Scenarios

The stack characteristics of the Tallawarra power station and the various emissions scenarios are described below:

- **Tallawarra Stack A** (CCGT), location MGA Zone 56 [298,826 (mE), 6,177,714 (mN)], stack height 60m, radius 2.75m
- **Tallawarra Stacks B1 & B2** (OCGT), locations [298,876 (mE), 6,177,792 (mN)] and [298,892 (mE), 6,177,777 mN], stack height 40m, radius 3m
- **Tallawarra Stack B** (CCGT), locations [298,884 (mE), 6,177,784 (mN)], stack height 60m, radius 2.75m

5.4. Emission Scenarios

This section of the report provides emission release parameters for numerous operating scenarios relevant to Tallawarra A and B, with Stage B configured as either an OCGT or CCGT power station, consistent with DECC requirements.

Emission parameters have been generated with the gas turbine software GTPro to provide worst case emissions for a range of normal operating regimes as well as start-up and part load operations on natural gas and diesel fuels. **Table 5-1** to **Table 5-3** summarise the parameters of the respective emissions scenarios under full load conditions as well as various scenarios of start-up load operations. A more detailed analysis of full load and start load emissions is presented in **Appendix A**. It is noted that shut-down emissions are considered equivalent to start-up emissions.

Gas turbine power stations have different starting regimes and for the CCGT plant there are three different starts, broadly defined as follows:

- **Cold Start –** this start occurs when the plant is first started or after an indefinite period of shut-down, where the HRSG would be cold and the start occurs over a longer period of time, to bring both the gas and steam turbine plant up to base load. During a cold start the gas turbine would be below 30 percent load for about 100 minutes where the NO_X emission concentration may be above 25 ppm;
- **Warm Start** – this start occurs after a period of about 36 hours shut-down and the gas turbine would be below 30 percent load for about 60 minutes where the NO_X emission concentration may be above 25 ppm; and
- **Hot Start** – this start occurs after a period of less than 36 hours shut-down and the gas turbine would be below 30 percent load for about 20 minutes where the NO_X emission concentration may be above 25.

Tallawarra A CCGT emission parameters, presented in **Table 5-1**, are consistent with emissions assessed as part of the original approval for Tallawarra A.

Table 5-1 Tallawarra A Air Emission Scenarios

Modelling Scenario	Stack	Velocity (m/s)	Temp (°C)	NO_2 Emission Conc. ppm	Emission Rate NO_X per unit g/s	Emission Rate PM_{10} per unit g/s	Emission Rate SO_2 per unit g/s
Full Load	A	26	78	25	29.4	2.3	1.9
Hot Start Hour 1	A	19.0	80	32	22.9	-	-
Warm Start Hour 1	A	12.4	70	87	41.7	-	-
Warm Start Hour 2	A	21.8	80	30	24.8	-	-
Cold Start Hour 1	A	12.4	40	92	48.4	-	-
Cold Start Hour 2	A	13.1	60	81	42.4	-	-
Cold Start Hour 3	A	25.9	60	31	29.9	-	-

Emission scenarios for Tallawarra A CCGT in combination with the Tallawarra B OCGT assume that the start-up emissions for Tallawarra A are based on "hot-starts" (refer to **Table 5-2**).

For the OCGT plant, the only applicable starts are "normal starts" and "fast starts". During a "normal start" emissions would be above 25 ppm up to approximately 30 percent load, and this will usually be for the first 20 minutes of starting. The start-up modelling for the Tallawarra B OCGT plant is based on "normal starts". During a "fast start" emissions would be above 25 ppm for a shorter period of time and hence maximum NO_X emissions for the first hour of starting would be lower than those for a "normal start".

Where Tallawarra A and B both operate as CCGT plants, operational scenarios as outlined in **Table 5-3** have been assessed. These three start load scenarios cover a range of expected high NO_X emission operations. It is noted that the Tallawarra A cold start and Tallawarra B cold start scenario has not been modelled. The results of modelling suggest that it is possible for this scenario to exceed the DECC criteria on the existing conservative emissions data. Therefore, to avoid exceedence of the DECC criteria, TRUenergy propose not to cold start both the Tallawarra A and B plants simultaneously unless later information proves that this scenario will not lead to an exceedence.

Table 5-2 Tallawarra A and B (OCGT) (Diesel Fired) Emission Scenarios

Modelling Scenario	Stack	Velocity (m/s)	Temp (°C)	NO_2 Emission Conc. ppm	Emission Rate NO_X per unit g/s	Emission Rate PM_{10} per unit g/s	Emission Rate SO_2 per unit g/s
Full Load Stacks A, B1&B2	A	26	78	25	29.4	2.3	1.9
	B1	41.7	526	45	37.5	4.2	12.1
	B2	41.7	526	45	37.5	4.2	12.1
Stack A Start Stacks B1&B2 Full Load	A	19.0	80	32	22.9	-	-
	B1	41.7	526	45	37.5	-	-
	B2	41.7	526	45	37.5	-	-
Stack A Full Load Stacks B1&B2 Start Load	A	26	78	25	29.4	-	-
	B1	38	500	94	66	-	-
	B2	38	500	94	66	-	-
Start Stacks A, B1&B2	A	19.0	80	32	22.9	-	-
	B1	38	500	94	66	-	-
	B2	38	500	94	66	-	-
Stack A Full Load Stacks B1&B2 Part Load 50%	A	26	78	25	29.4	-	-
	B1	31.9	497	45	27	-	-
	B2	31.9	497	45	27	-	-

Table 5-3 Tallawarra A and B (CCGT) Emission Scenarios

Modelling Scenario	Stack	Velocity (m/s)	Temp (°C)	NO_2 Emission Conc. ppm	Emission Rate NO_X per unit g/s	Emission Rate PM_{10} per unit g/s	Emission Rate SO_2 per unit g/s
Full Load Stacks A &B	A	26	78	25	29.4	-	-
	B	26	78	25	29.4	-	-
Stack A Full Load Stack B Cold Start Hour 1	A	26	78	25	29.4	-	-
	B	12.4	40	92	48.3	-	-
Stack A Full Load Stack B Warm Start Hour 1	A	26	78	25	29.4	-	-
	B	12.4	70	87	41.7	-	-
Stack A Warm Start Hour 1 Stack B Cold Start Hour 1	A	12.4	70	87	41.7	-	-
	B	12.4	40	92	48.3	-	-

5.5. Modelling of Local Scale Impacts of Tallawarra Power Station

The air quality impacts of the Tallawarra power station were modelled using the following method.

5.5.1. Meteorological Configuration

TAPM was configured to simulate meteorological conditions for the year 2002. (A survey of air quality monitoring data indicated that the Illawarra region experienced elevated pollution levels in 2002). TAPM (v.3.0.7) was set to run for the period 1/1/2002 to 31/12/2002 and configured with four nested grids of 25 x 25 horizontal points with grid spacings of 30 km, 10 km, 3 km and 1 km for meteorology and 25 vertical levels. The grids were centred at 34.°31.5'S and 150°48.5'N (which also indicates the stack location). Default model options were used for soil parameters and the main land use type around the power stations is urban. The terrain data used was obtained from Geoscience Australia at nine-second grid spacing (approximately 0.3 km) and edited manually to resemble more closely the coastal area including Lake Illawarra.

Modelling was conducted using meteorology produced by TAPM, as well as with assimilation of observed wind data. The assimilation of wind data allows the model predictions for wind parameters to reflect more closely the locally observed wind conditions. Observations of wind speed and wind direction for the purpose of wind data assimilation were taken from the four DECC weather stations at Wollongong, Kembla Grange, Warrawong and Albion Park (refer to **Figure 3-1**).

5.5.2. Pollution Configuration

The pollution grid was configured with a finer resolution of 49 by 49 horizontal points, allowing analysis at 500 m over the inner grid domain. Emissions from the power station stacks were modelled as point sources. TAPM was applied in tracer mode, with background concentrations levels set at zero.

5.5.3. Sensitive Receptor Locations

The location of the nearest urban areas surrounding Tallawarra power station and Lake Illawarra and locations with the potential for urban development, such as Avondale in the hinterland, guided the identification of ten sensitive receptor locations at which to assess local impacts of emission from the power station (refer to **Figure 3-1** and **Table 5-4)**. Model outputs were extracted at the nearest grid point relative to each of these ten existing and potential urban areas.

Table 5-4 Sensitive Receptor Locations Relative to Tallawarra Stage B

Sensitive Receptor	Easting (m)	Northing (m)	Distance to Tallawarra B (m)	Direction from Tallawarra B
SE Dapto	299500	6178500	945	NNE
South Dapto	297604	6178064	1310	WNW
Avondale	292500	6178500	6424	WNW
Yallah	297000	6175785	2747	SW
Oak Flats	299699	6174298	3580	SSE
Mt Warrigal	301663	6175568	3554	SE
Windang	304029	6177337	5164	ESE
Barrack Heights	303400	6173600	6156	SE
Primbee	305000	6179700	6409	ENE
Pt Kembla	306388	6182309	8763	NE

5.5.4. NOx Analysis Using the Ozone Limiting Method

The *Approved Methods* (NSW DEC 2005) identifies various methods to assess the oxidation of NO to NO_2 in the atmosphere. The analyses require assumptions to be made regarding the percentage of NO_2 concentrations in the mix of ambient air arriving at the sensitive receptor locations. An adequate assumption for minor sources of NO_X and VOC may be that 100 percent of emissions arriving at the sensitive receptors as been converted to NO_2. Larger emission sources proposed for locations with high background pollutant concentrations may require more detailed assessment.

NO_X emissions from the power station are produced during the combustion process by the oxidation of nitrogen in the fuel and nitrogen in the air. The high-temperature process forms a variety of NO_X including nitric oxide (NO) and nitrogen dioxide (NO_2). At the point of emission, the NO generally comprises about 90 percent of NO_X and the remaining 10 percent mostly NO_2. As the NO_X emissions disperse, all NO eventually is oxidised to NO_2 and higher oxides of nitrogen. As noted in **Section 2.3**, the rate at which this oxidation takes place depends on prevailing atmospheric conditions including temperature, humidity and the presence of other pollutants such as ozone. If the rate of oxidation is rapid and the dispersion slow, then high maximum ground level concentrations of NO_2 may occur.

This assessment of Tallawarra power station analyses NO_X impacts using the USEPA Ozone Limiting Method (OLM) (NSW DEC, 2005; Cole and Summerhays, 1979; Tikvart, 1996). The method assumes that the amount of NO that is converted to NO_2 is limited by the ambient ozone concentration. The DECC Level 2 assessment was used which required analysis of the TAPM-predicted 1-hour average ground level concentrations of NO_X and the contemporaneous (same hour)

1-hour average ambient measurements of NO_2 and O_3 recorded at Kembla Grange in 2002, the same period as the modelling year.

The OLM method assumes that 10 percent of the NO_x in the exhaust is NO_2. The remaining 90 percent of the NO_x emissions is assumed to be nitric oxide (NO). As noted above, in **Section 2.3**, the exhaust leaves the stack and mixes with the ambient air, the NO reacts with ambient ozone (O_3) to form NO_2 and molecular oxygen (O_2):

$$NO + O_3 \Longrightarrow NO_2 + O_2 \qquad \text{Oxidation of NO by ambient } O_3$$

The OLM assumes that at any given receptor location, the amount of NO that is converted to NO_2 by this reaction is proportional to the ambient O_3 concentration. If the O_3 concentration is less than the NO concentration, then the amount of NO_2 formed by this reaction is limited. If the O_3 concentration is greater than or equal to the NO concentration, all available NO is assumed to be converted to NO_2. **Figure 5-1** presents the equation used in the OLM for conversion of NO to NO_2, with all concentrations in mass units (NSW DEC 2005).

- **Figure 5-1: Equation Applied in the Ozone Limiting Method for Conversion of Nitrogen Oxide to Nitrogen Dioxide**

Equation 1: $[NO_2]_{tot} = \{(0.1) \times [NO_x]_{pred}\} + MIN\{(0.9) \times [NO_x]_{pred}, \text{ or } (46/48) \times [O_3]_{bkgd}\} + [NO_2]_{bkgd}$

where

$[NO_2]_{tot}$	is the predicted total NO_2 concentration
$[NO_x]_{pred}$	is the model predicted NO_x concentration
MIN	means the minimum of the two quantities within the brackets
$[O_3]_{bkgd}$	is the ambient O_3 concentration
(46/48)	is the molecular weight of NO_2 divided by the molecular weight of O_3
$[NO_2]_{bkgd}$	is the background concentration of NO_2

In **Equation 1**, the predicted NO_x concentration is multiplied by 10 to account for the assumed in-stack thermal conversion of NO_x to NO_2. The remaining 90 percent of the modelled NO_x (assumed to be NO) reacts with the background O_3 concentration to determine the quantity of NO that is converted to NO_2. The background concentration of NO_2 is then added to this concentration to give the total predicted NO_2 value.

A worked example of applying **Equation 1** to convert NO to NO_2 is presented below in **Table 5-5**.

Table 5-5 Applying the Ozone Limiting Method Equation for the Conversion of Nitrogen Oxide to Nitrogen Dioxide

A	B	C	D	E	F	G	H	I	J	K	L	M
DATE	HOUR	TIME	Point Source NOx Increment [TAPM Tracer MAX CONC (ug/m3)]	90% of NOX=NO	10% of NOX=NO2	O3 Background (ug/m3) (made from DECC file)	46/48 * O3 Bkgd (ug/m3) (OLM method)	New NOX to NO2 (ug/m3) [Min(ColE, ColH)]	Calc OLM NO2 Point Source Increment	NO2 Background ug/m3 (made from DECC file)	Final NO2 Cumulative Impact (ug/m3)	Ratio Calculated OLM NO2 / TAPM MAX NOX
20020804	5	5165	279.2	251.3	27.9	62.5	59.9	59.9	87.8	0.4	88.3	31%

- In the example above, the TAPM-predicted point source NO_x concentration (279.2 µg/m^3, Column D), is multiplied by 10 percent to account for the assumed in-stack thermal conversion of NO_x to NO_2 (27.9 µg/m^3, Column F)
- The remaining 90 percent of the modelled NO_x, assumed to be NO (251.3 µg/m^3, Column E) reacts with the background O_3 concentration (62.5 µg/m^3, Column G) to determine the quantity of NO that is converted to NO_2 (59.9 µg/m^3, Column H, where '46/48' is the molecular weight of NO_2 divided by the molecular weight of O_3. Column I (59.9 µg/m^3) takes the minimum of the two quantities in Columns E (251.3 µg/m^3) and H (59.9 µg/m^3).
- The total predicted NO_2 point source increment, resulting from the OLM (87.8 µg/m^3, Column J), is the sum of the in-stack NO_2 concentration (27.9 µg/m^3, Column F) and the quantity of NO that is converted to NO_2 beyond the stack (59.9 µg/m^3, Column I).
- The background concentration of NO_2 for the same hour (0.4 µg/m^3, Column K) is added to this concentration (87.8 µg/m^3, Column J) to give the predicted final NO_2 cumulative impact (88.3 C µg/m^3, Column L).
- In this example, considering the predicted point source impacts only, the ratio of the NO_2 concentration calculated by the OLM method (87.8 µg/m^3, Column J) compared to the TAPM output NO_X concentration (279.2 µg/m^3, Column D) was 31% (Column M).

5.6. Modelling Regional Scale Impacts of Photochemical Air Pollution

Modelling with TAPM-GRS was used to assess the impact of photochemical smog levels in the Illawarra area. A base case emission scenario modelled the impact of the emissions of anthropogenic and biogenic emissions from the whole of the GMR, excluding the Tallawarra power station. The test case emission scenario modelled the impact of all base case emissions in combination with full load emissions from Tallawarra A CCGT and Tallawarra B1 and B2 OCGT.

The methodology has been prescribed by the DECC and requires the application of TAPM in the photochemistry mode, which uses a generic reaction set of atmospheric photochemical transformations (Azzi *et al*., 1992, referred to in this report as TAPM-GRS).

5.6.1. Model Configuration

Table 5-6 shows the TAPM options and inputs for the regional scale modelling.

- **Table 5-6 Setup for TAPM-GRS modelling of regional scale air quality**

Model	TAPM version 3.0.7
Mode	GRS (APM, NO_x, NO_2 and O_3 with chemistry and deposition)
Centre coordinates	151 deg 11.5 min E, 33 deg 33.5 min S (0,0 model grid coordinates)
Number of grids	3
Grid dimensions	60 x 80 x 30
Grid spacing	10 km, 6 km and 3 km
Terrain database	AUSLIG 9 second DEM
Simulation periods	Four (1 Nov to 31 Mar for 2000/2001, 2003/2004, 2004/2005 and 2005/2006)
Met data assimilation	22 sites with wind data for each summer period (provided by DECC)
Gridded surface emissions	.gse file provided by DECC to apply for all four modelling periods
Point source emissions	.pse file provided by DECC to apply for all four modelling periods
Background ozone level	2 pphm
Monitoring site locations (with respect to model centre coordinates) (m)	Albion Park: -34792, -113908 Kembla Grange: -32422, -102298 Warrawong: -25592, -103848 Wollongong: -26222, -95758

5.6.2. Method for Regional Ozone Assessment

The method investigates hourly average ozone concentrations recorded on selected study days and hours at the four Illawarra monitoring sites for four summer periods. The selected study days are identified according to the following criteria:

- Days displaying hours during which the observed hourly average concentrations recorded at the monitoring sites were > 60 ppb, and within 20 ppb of TAPM Base Case concentration predicted for the same hour at the relevant site.

The steps in the analysis are listed as follows:

1. Run TAPM-GRS with wind data assimilation for 4 summers (November to March for 2000-01, 2003-04, 2003-4 and 2005-6).
2. Run base case emissions and compare with ambient concentrations at four Illawarra air quality monitoring sites.
3. Consider days when observed ozone concentrations were greater than 6 parts per hundred million (pphm) (that is, 60 parts per billion, ppb, the units used by TAPM);
4. Compare base case run with ambient concentrations and select days where the difference between the base case run and the ambient concentration is less than 2 pphm (20 ppb).
5. Once those days have been identified, re-run TAPM-GRS with emissions from the Tallawarra power station added to the inventory.
6. Compare the change, if any, in ozone concentration on those days identified in Step 4.
7. Count the number of events and compare the difference between the base case and the base case plus power station run and note increases or decreases in ozone concentrations.
8. Comment on any change in the duration of the ozone plume.

It is noted that the emissions inventory for the GMR was provided by DECC in TAPM format. The DECC also provided details for model configuration and ambient air quality data for the modelling periods.

The following outputs are of interest from this modelling method:

1. Comparisons of ambient measurements and model outputs for each complete summer period (1^{st} November to 31^{st} March).
2. Summary table of results from 1 (refer to **Table 7-1**).
3. Plots of selected days compared with the base case run (refer to **Appendix C**).
4. Summary table of results from 3 (refer to **Table 7-2**).
5. Comparison plots of base case run emissions inventory with base case plus additional source (power station) for each complete summer (refer to **Appendix C**).
6. Summary table of results from 5 (refer to **Table 7-2**).

7. Comparison plots of selected days and base case run with extra source (power station) added (refer to **Appendix C**).
8. Summary table of results from Step 7 (refer to **Table 7-2**).
9. The predicted counts for the change in ozone concentrations as described in Step 6 above (refer to **Table 7-2**).
10. Comments on any chance in the duration of the plume (refer to **Table 7-3**).

The results are summarised in **Section 7** and more detailed outputs are presented in **Appendix C**.

6. Air Quality Impact Assessment: Local Scale

6.1. Overview

The following sections examine the air quality impacts of the range of modelling approaches described previously in **Section 5**. Local scale impacts of NO_2, SO_2 and particulate matter (as PM_{10}) were investigated using TAPM (Hurley 2005a, 2005b) in tracer mode. Regional scale photochemical impacts of individual O_3 events were investigated using the photochemistry module TAPM-GRS (Hurley 2005a, 2005b).

The statistics presented in this air quality assessment are the maximum hourly NO_2 and SO_2 concentrations, maximum 24 hourly concentrations of PM_{10} and annual average concentrations for NO_2, SO_2 and PM_{10}. Relevant NSW DECC criteria for air quality impact assessment are given in **Table 4-2**.

Sections 6.3 and **6.4** present the results for NO_2, the air pollutant identified as causing the highest impact at the local scale, with respect to the criteria. **Section 6.3.3** presents impacts of SO_2 and PM_{10}, which are very low relative to the NSW DECC criteria. The predicted patterns of SO_2 and PM_{10} dispersion are presented in **Appendix B**. Regional photochemical impacts using TAPM-GRS are summarised in **Section 7** and presented in further detail in **Appendix C**. A summary discussion of results is presented in **Section 8.**

6.2. Tallawarra A CCGT Plant

The maximum cumulative NO_2 impacts across the study area, resulting from Tallawarra A, are predicted to meet the DECC criteria for the hourly-average concentration (246 $\mu g/m^3$) and the annual average concentration (62 $\mu g/m^3$) for all the modelled emission scenarios in this assessment.

As noted in **Section 5.5.4**, the modelled NO_X ground level concentrations were analysed using the OLM to determine NO_2 ground level concentrations. Level 1 and Level 2 assessments were undertaken as required by DECC (NSW DEC 2005:42, 43). At the sensitive receptors, the highest incremental NO_2 1-hour impact of Tallawarra A, by the OLM, was predicted to be 157 $\mu g/m^3$ at Dapto South during the first hour of cold start operations (refer to **Table 6-1**). By the Level 1 assessment, the incremental impact, 157 $\mu g/m^3$, combined with the maximum background concentration, 145 $\mu g/m^3$, would result in a cumulative impact which would exceed the DECC 1-hour criterion of 246 $\mu g/m^3$ by about 12 percent. Further analysis was undertaken using the Level 2 assessment method.

Table 6-1, **Table 6-2, Table 6-3** and **Figure 6-1** present the results of applying the Level 2 OLM assessment to analyse the impacts of Tallawarra A for full load (base load) operations and a range of start-load conditions, as required by DECC (2005:53). **Table 6-1** shows the total predicted concentration at the hour of the highest predicted 1-hour incremental concentration. **Table 6-2** shows the total predicted concentration at the hour with the highest background concentration. In addition to the tables required by the DECC Level 2 assessment (**Table 6-1** and **Table 6-2**), **Table 6-3** provides an example of the maximum cumulative concentration impacts for the emission scenario of Tallawarra A during the first hour of cold start operations. **Table 6-3** illustrates that the maximum cumulative concentration may comprise a specific incremental impact by the OLM combined with a contemporaneous background concentration in instances when neither the increment nor the background are at maxima.

Figure 6-1 presents the results in **Table 6-1** as well as the maximum cumulative impact at the sensitive receptors and for any point across the grid, displayed as shaded bars.

The results of the OLM analysis are discussed in further detail in the following subsections. The overall impacts for Tallawarra A CCGT are summarised in **Section 8.1**

Figure 6-2 to **Figure 6-15** show the predicted horizontal pattern of incremental NO_X ground level concentrations, due to the plume from the power station, for full load and the range of modelled start load emissions scenarios. It is emphasised that the concentrations in these plots represent the raw model outputs for NO_X, prior to OLM analysis.

Table 6-1 Highest Predicted NO_2 1-Hour Average Impacts and Contemporaneous Background Concentration (µg/m^3) Tallawarra A CCGT

Scenario	Full Load			Hot Start Hour 1			Warm Start Hour 1			Warm Start Hour 2			Cold Start Hour 1			Cold Start Hour 2			Cold Start Hour 3		
Sensitive Receptor Location	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact
SE Dapto	37	4	41	34	5	39	73	3	77	31	5	36	80	12	92	74	3	77	33	5	37
Dapto South	33	2	35	21	7	28	72	11	83	20	19	39	157	24	180	67	9	76	22	5	27
Avondale	31	3	34	33	22	55	66	22	87	33	22	55	102	25	128	65	22	87	35	22	57
Yallah	49	5	53	20	7	27	58	10	68	18	7	25	87	19	107	57	6	63	19	19	38
Oak Flats	30	6	36	17	11	29	38	11	50	19	11	30	57	11	68	44	11	56	22	6	27
Mt Warrigal	31	36	67	25	18	42	56	16	73	24	16	41	69	38	107	57	16	73	27	18	45
Windang	23	33	57	30	3	33	74	3	77	33	3	36	90	3	94	78	5	83	34	5	40
Barrack Hts	25	6	31	26	46	72	43	19	62	26	46	72	52	3	56	47	19	67	31	46	77
Primbee	16	1	18	32	2	34	55	2	57	31	2	33	76	2	78	63	2	65	36	2	38
Pt Kembla	13	13	26	17	4	21	34	4	38	18	4	22	38	2	41	33	4	37	20	4	24
Average	29		40	26		38	57		67	25		39	81		95	59		68	28		41

■ **Table 6-2 Highest Background Concentration and Contemporaneous Predicted NO_2 1-Hour Average Impacts (µg/m^3) Tallawarra A CCGT**

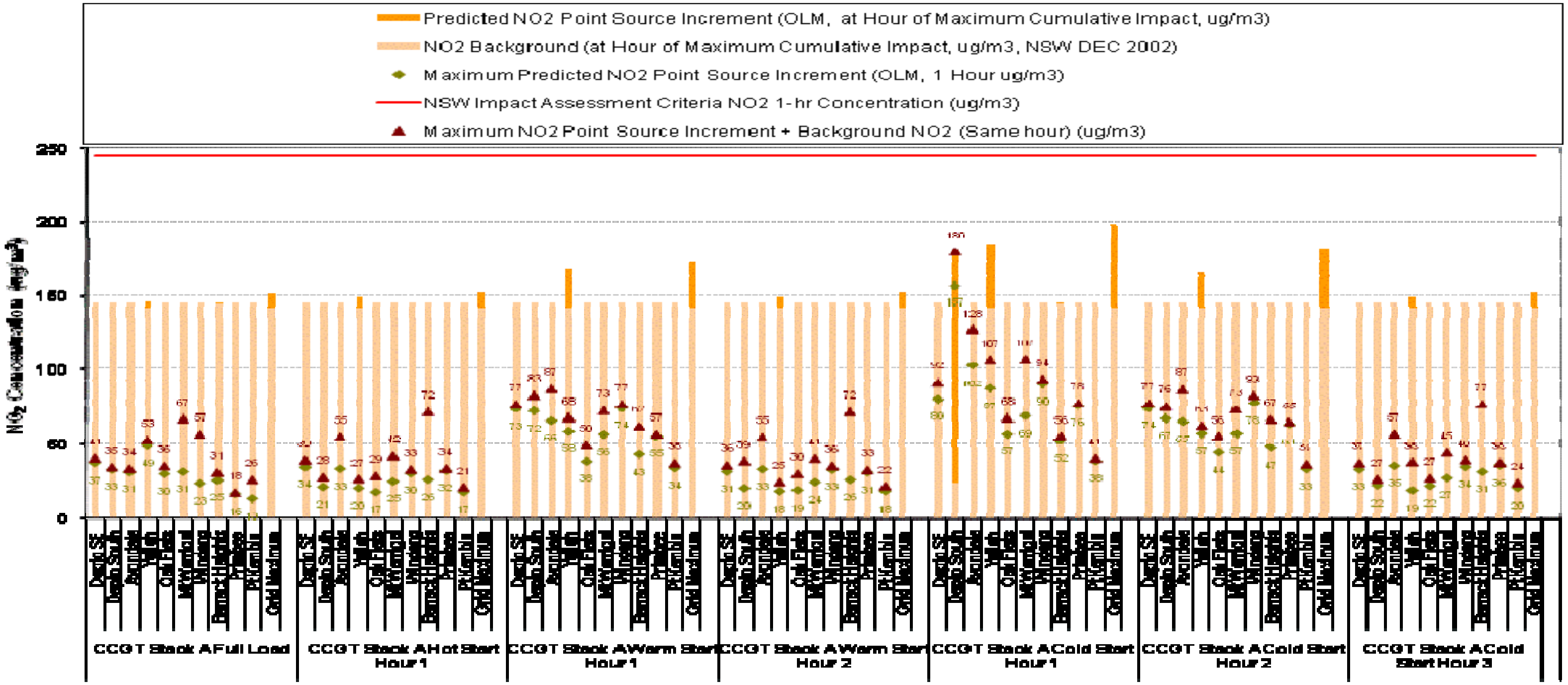
Scenario	Full Load			Hot Start Hour 1			Warm Start Hour 1			Warm Start Hour 2			Cold Start Hour 1			Cold Start Hour 2			Cold Start Hour 3		
Sensitive Receptor Location	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO_2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO_2 by OLM	Background Concentration (same hour)	Cumulative Impact
SE Dapto	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Dapto South	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Avondale	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Yallah	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Oak Flats	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Mt Warrigal	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Windang	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Barrack Hts	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Primbee	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Pt Kembla	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Grid Maximum	3	145	148	0	145	145	1	145	146	0	145	145	12	145	157	1	145	146	0	145	145

Table 6-3 Example Highest Cumulative Concentrations for Tallawarra A CCGT Showing Contemporaneous Predicted NO_2 1-Hour Average Impacts and Background Concentration

Cold Start Hour 1	Total NO_2 Point Source Increment By OLM (ug/m3)	NO_2 Background (DECC Kembla Grange same hour) (ug/m3)	Total NO_2 Cumulative Impact (same hour) (ug/m3)
Yallah			
20021004	42	142	184
20021030	0	145	145
20021007	54	70	123
20021007	65	51	116
20021007	74	40	113
20021007	82	31	112
20021004	46	66	112
20021030	0	108	108
20021007	60	48	108
20021007	65	42	107
At Any Point Across the Grid			
20021004	57	142	199
20021216	157	24	180
20020104	160	14	173
20021004	83	84	167
20021222	139	25	165
20021216	152	12	164
20021030	77	84	161
20021030	12	145	157
20021125	116	40	156
20020411	94	62	156

Note: The maximum cumulative impact may occur when neither the incremental impact nor the background are at maximum concentration.

Figure 6-1: Summary 1-Hour Average NO_2 Results for Tallawarra A CCGT Plant, Predicted Maximum Incremental Impacts and Cumulative Concentrations (µg/m³)



Note:

The shaded bars illustrate that the highest cumulative impacts generally resulted from the high 1-hr average background NO_2 concentrations, combined with relative low predicted incremental impacts of the plume from the power station, in the corresponding hour.

6.2.1. Full Load Operation of Tallawarra A CCGT

Results of the OLM analysis of raw NO_X model outputs indicated that during full load operations at Tallawarra A CCGT plant, the highest cumulative concentration associated with a maximum incremental NO_2 impact of the plume, at any of the sensitive receptor sites, was predicted to occur at Mt Warrigal. The OLM analysis of the raw modelled NO_X outputs at Mt Warringal produced a maximum 1-hour incremental NO_2 impact of 31 µg/m^3 (due to the power station), which was associated with a background concentration of 36 µg/m^3 (recorded at Kembla Grange in the same hour), resulting in cumulative concentration of 67 µg/m^3 (refer to **Table 6-1** and **Figure 6-1**), which represents about 27 percent of the DECC 1-hour criterion (246 µg/m^3).

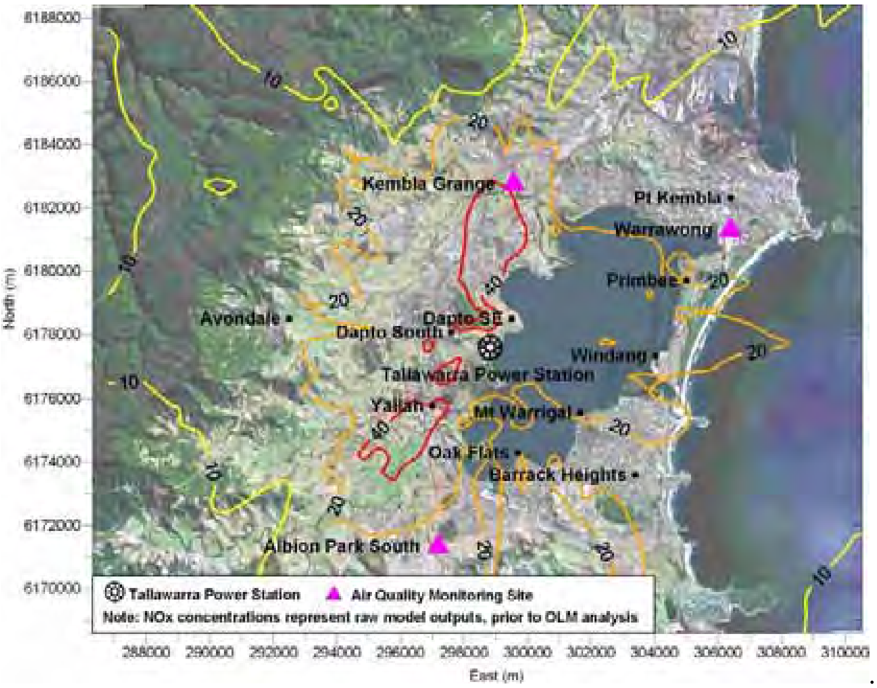
The highest incremental 1-hour NO_2 impact at sensitive receptor sites due to the plume from the power station was predicted to reach 49 µg/m^3 at Yallah. This incremental impact, combined with the low background NO_2 concentration, 5 µg/m^3 (recorded at Kembla Grange in the same hour), resulted in a cumulative impact of 53 µg/m^3 (refer to **Table 6-1** and **Figure 6-1**) which represents about 22 percent of the DECC 1-hour criterion (246 µg/m^3).

At the hour of the maximum cumulative NO_2 concentration across the grid, 151 µg/m^3, calculated by the OLM analysis, the background concentration was 142 µg/m^3 and the incremental impact due to the plume was 9 µg/m^3. Consequently, the maximum cumulative concentration across the grid, 151 µg/m, which represents about 61 percent of the DECC criterion (246 µg/m^3), resulted from the high background concentration combined with a relatively very low incremental impact due to the power station (refer to shaded bars for grid maximum in **Figure 6-1**). Similarly, the maximum cumulative concentrations at the sensitive receptor sites, resulting from the OLM analysis, comprised high background concentrations which coincided with very low or near-zero incremental impacts due to the power station (refer to shaded bars **Figure 6-1**).

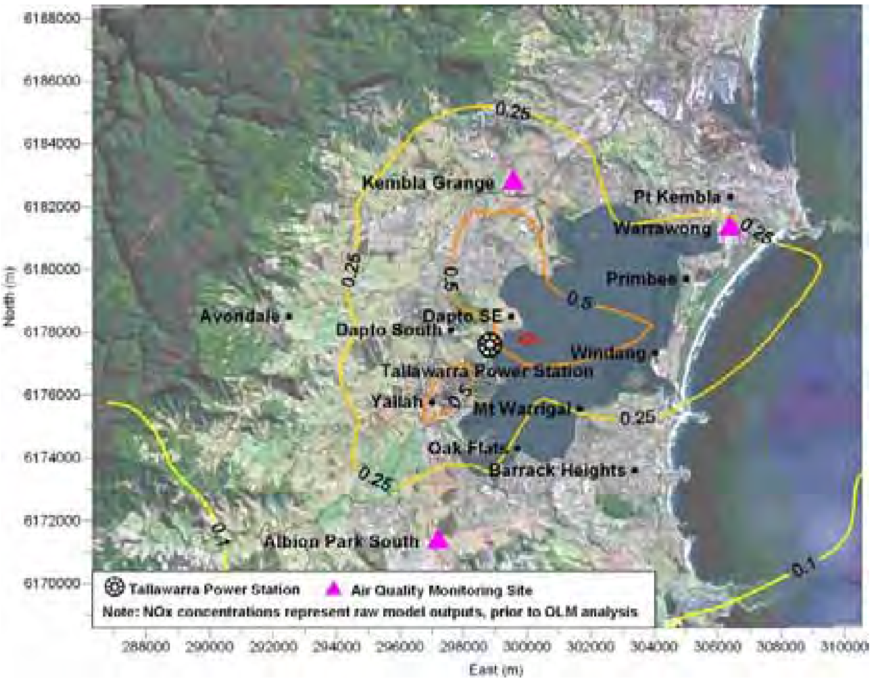
Table 6-2 shows the predicted horizontal pattern of 1-hour maximum NO_X concentrations due to the plume from the power station for the full load emission scenario. Locations predicted to be most affected, by incremental increases of 40 µg/m^3 to 67 µg/m^3, extend north of Tallawarra A towards Kembla Grange and south-west beyond the general vicinity of Yallah.

Figure 6-3 indicates that the location predicted to receive the highest increment in annual average NO_X concentrations extends east of the power station over Lake Illawarra. Incremental increases in the annual average NO_X concentration were predicted to range from less than 0.1 µg/m^3 to 1.067 µg/m^3. If the maximum increment in the annual average NO_2 concentration, due to Tallawarra A operating at full load, was assumed conservatively to be 1 µg/m^3, then combined with a background annual average concentration of 15 µg/m^3 (refer to **Section 3.4.2**), the cumulative annual average concentration would be 16 µg/m^3, which represents about 26 percent of the DECC annual average NO_2 criterion (62 µg/m^3).

- **Figure 6-2: Tallawarra A Full Load Incremental NO_X Maximum 1 hr Concentrations ($\mu g/m^3$)**



- **Figure 6-3: Tallawarra A Full Load Incremental NO_X Annual Average Concentrations ($\mu g/m^3$)**



6.2.2. Start Load Operations of Tallawarra A CCGT

Considering the range of modelled emission scenarios for start load operations, the highest cumulative NO_2 concentrations at sensitive receptor sites (due to the maximum incremental impact of the plume from the power station combined with the background concentration recorded at Kembla Grange in the same hour), met the DECC 1-hour criterion, 246 µg/m^3. Results were as follows (refer to **Table 6-1** and **Figure 6-1)**:

- Cold Start Hour One - 180 µg/m^3 at Dapto South, 73% of DECC 1-hour criterion
- Cold Start Hour Two - 87 µg/m^3 at Avondale, 35% of DECC 1-hour criterion
- Warm Start Hour One - 87 at Avondale, 35% of the DECC 1-hour criterion
- Cold Start Hour Three - 77 µg/m^3 at Barrack Heights, 31% of DECC 1-hour criterion
- Warm Start Hour Two - 72 µg/m^3 at Barrack Heights, 31% of DECC 1-hour criterion
- Hot Start Hour One - 72 µg/m^3 at Barrack Heights, 73% of the DECC 1-hour criteria.

During the first hour of cold start operations the highest cumulative 1-hour NO_2 concentration at any sensitive receptor, associated with a maximum incremental impact of the plume, occurred at Dapto South, where 180 µg/m^3 resulted from an incremental impact of 157 µg/m^3, due to the power station, combined with a background concentration of 24 µg/m^3 recorded at Kembla Grange in the same hour (refer to **Table 6-1** and **Figure 6-1**).

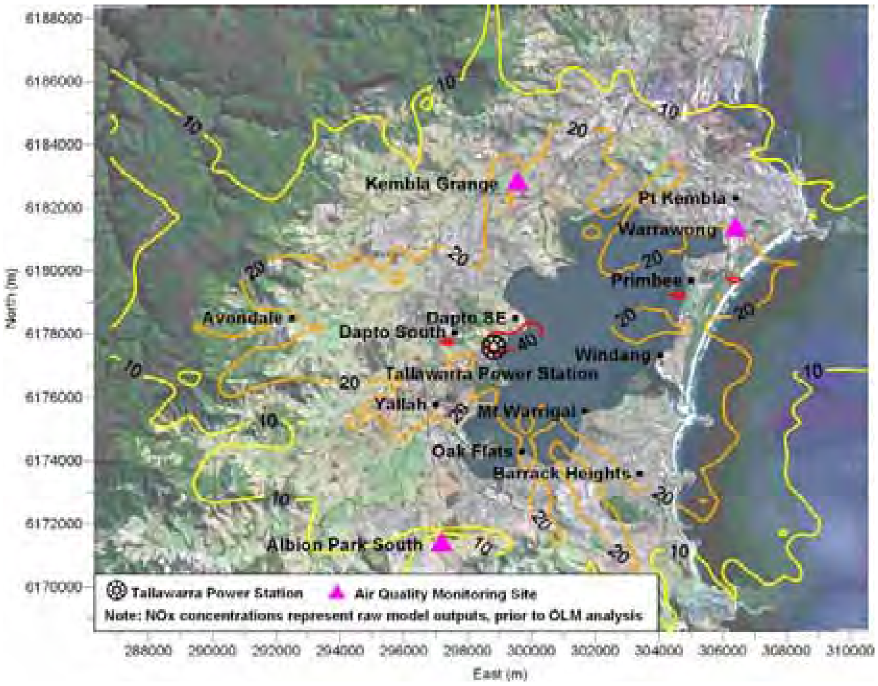
Also during cold start hour one operations, the maximum cumulative concentration at any sensitive receptor occurred at Yallah, where 184 µg/m^3 resulted from an incremental impact of 42 µg/m^3, due to the power station, combined with a background concentration of 142 µg/m^3 (refer to **Table 6-3** shaded bars for grid maximum in cold start hour 1 **Figure 6-1**).

The maximum cumulative NO_2 concentration across the grid, during the first hour of cold start operations, 199 µg/m^3, resulted from an incremental impact of 57 µg/m^3, due to the plume, and a background concentration, 142 µg/m^3 in the same hour. Thus, the maximum cumulative concentration across the grid, 199 µg/m^3, which represents about 81 percent of the DECC 1-hour criterion (246 µg/m^3), resulted from the high background concentration combined with the relatively low incremental impact due to the plume (refer to **Table 6-3** and shaded bars for grid maximum in cold start hour 1 in **Figure 6-1**).

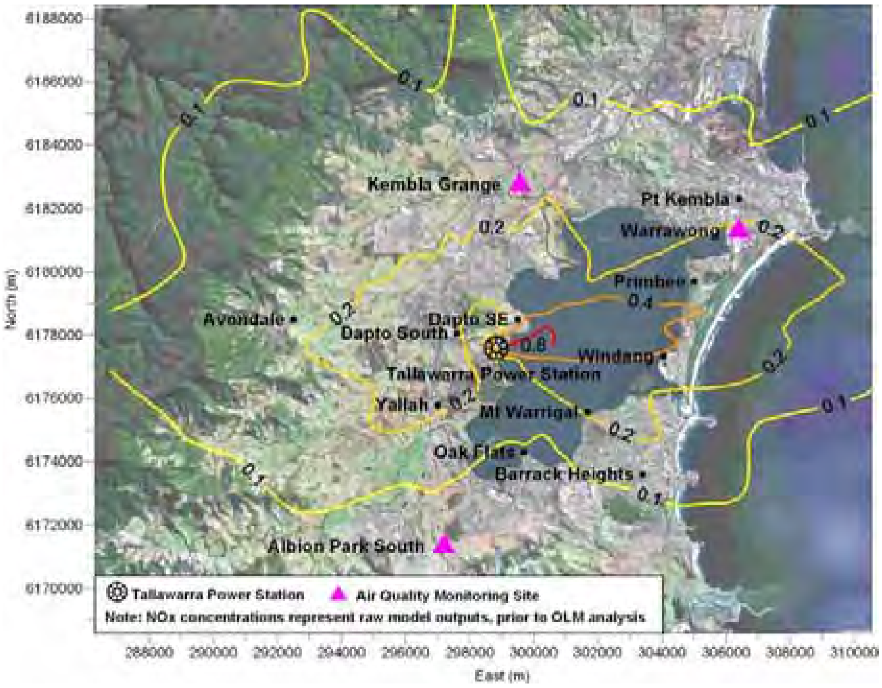
Figure 6-10 and **Figure 6-11** illustrate the modelled extent of incremental NO_X concentrations due to the plume in the first hour of cold start operations. Locations in the vicinity of Dapto are predicted to experience maximum increases in 1-hour average concentration of 160 µg/m^3 to 279 µg/m^3. It is emphasised that the concentrations in these plots represent the raw model outputs for NO_X, prior to OLM analysis, which indicated that the maximum cumulative 1-hour NO2 impact met the criterion.

Figure 6-11 shows that the highest incremental increases in the annual average NO_X concentration associated with the first hour of cold start operations were predicted to occur in the vicinity of Dapto and to be less than 4 $\mu g/m^3$. Assuming conservatively that the highest increment in the annual average NO_2 concentration is 4 $\mu g/m^3$ and that the background annual average NO_2 concentration is 15 $\mu g/m^3$ (refer to **Section 3.4.2**), then the maximum cumulative annual average concentration would be 19 $\mu g/m^3$, which represents about 31 percent of the DECC annual average NO_2 criterion (62 $\mu g/m^3$).

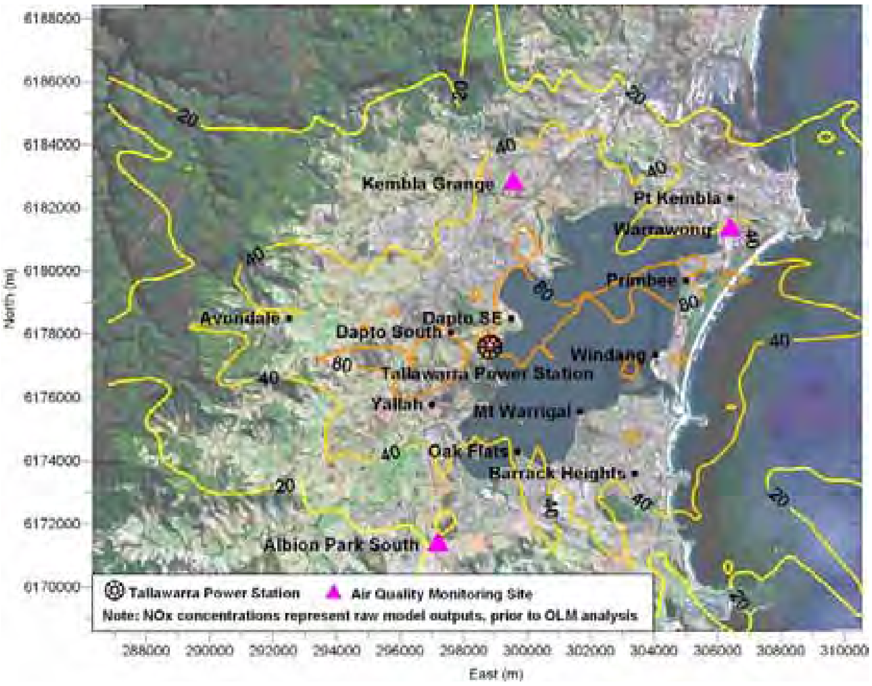
- **Figure 6-4: Tallawarra A Hot Start Hour 1 Incremental NO_X Maximum 1 hr Concentrations ($\mu g/m^3$)**



- **Figure 6-5: Tallawarra A Hot Start Hour 1 Incremental NO_X Annual Average Concentrations ($\mu g/m^3$)**

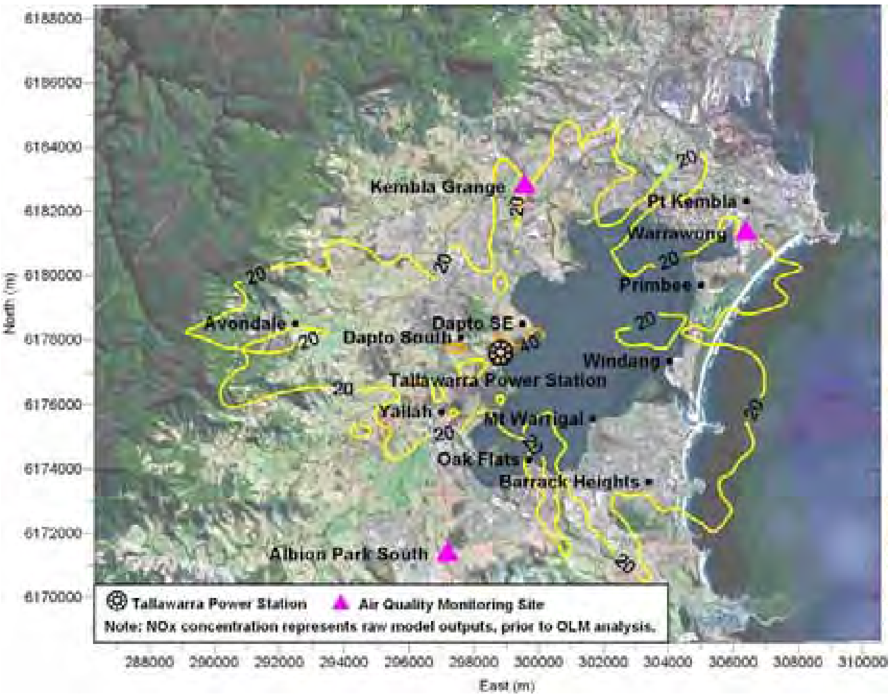


- **Figure 6-6: Tallawarra A Warm Start Hour 1 Incremental NO_X Maximum 1 hr Concentrations (μg/m^3)**

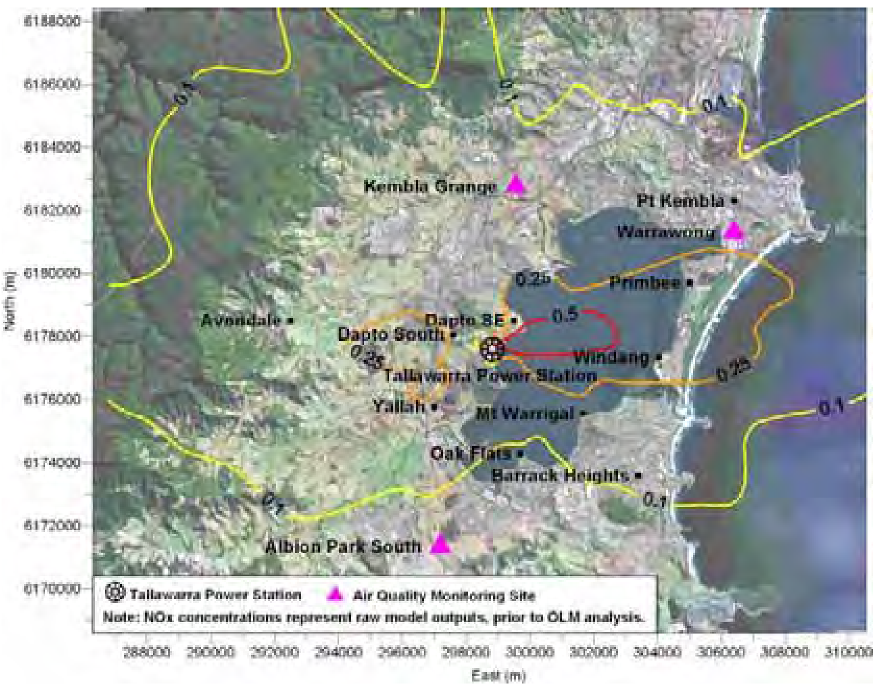


- **Figure 6-7: Tallawarra A Warm Start Hour 1 Incremental NO_X Annual Average Concentrations (μg/m^3)**

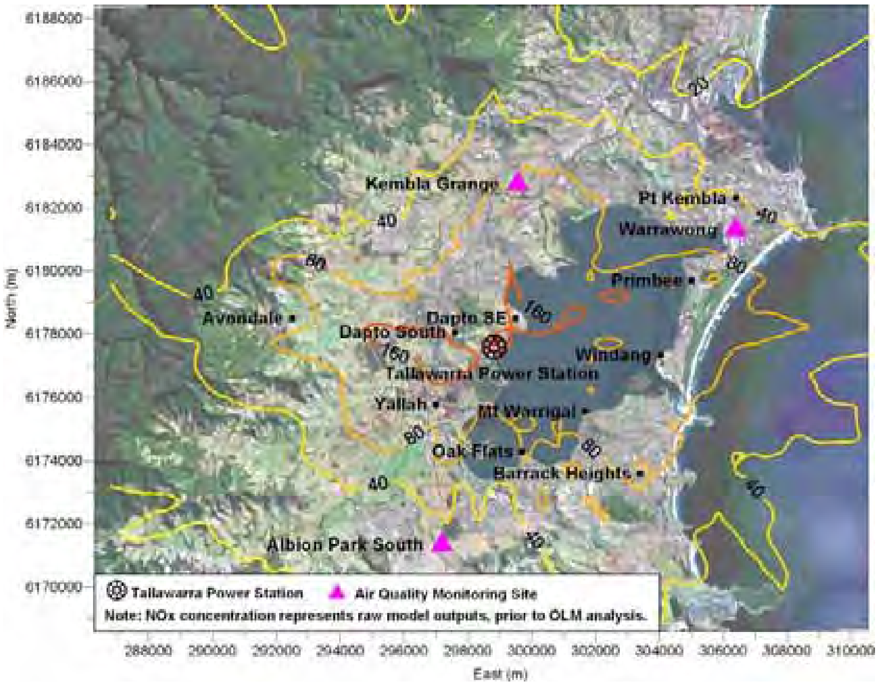
- **Figure 6-8: Tallawarra A Warm Start Hour 2 Incremental NO_X Maximum 1 hr Concentrations (µg/m³)**



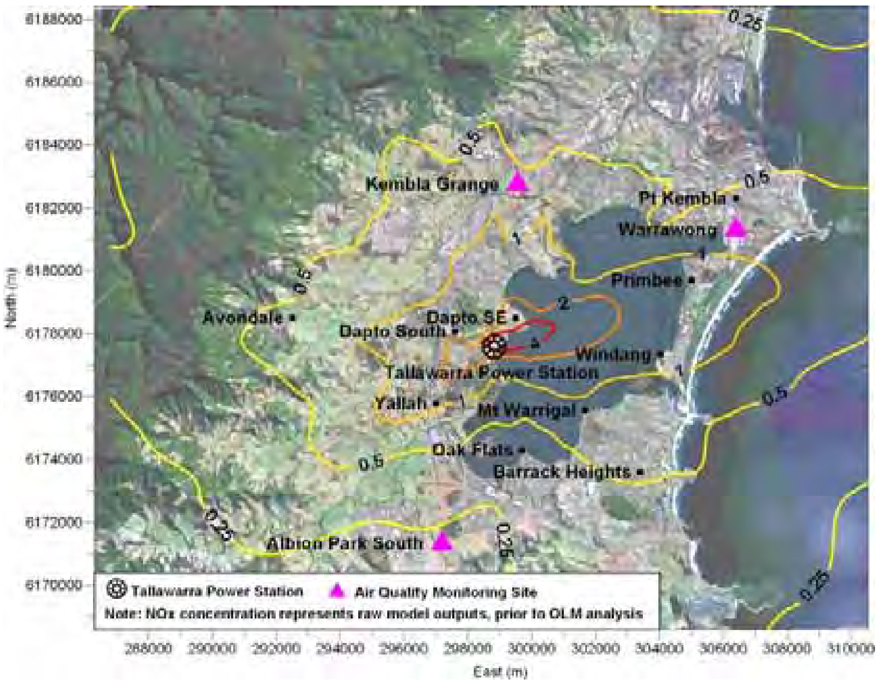
- **Figure 6-9: Tallawarra A Warm Start Hour 2 Incremental NO_X Annual Average Concentrations (µg/m³)**



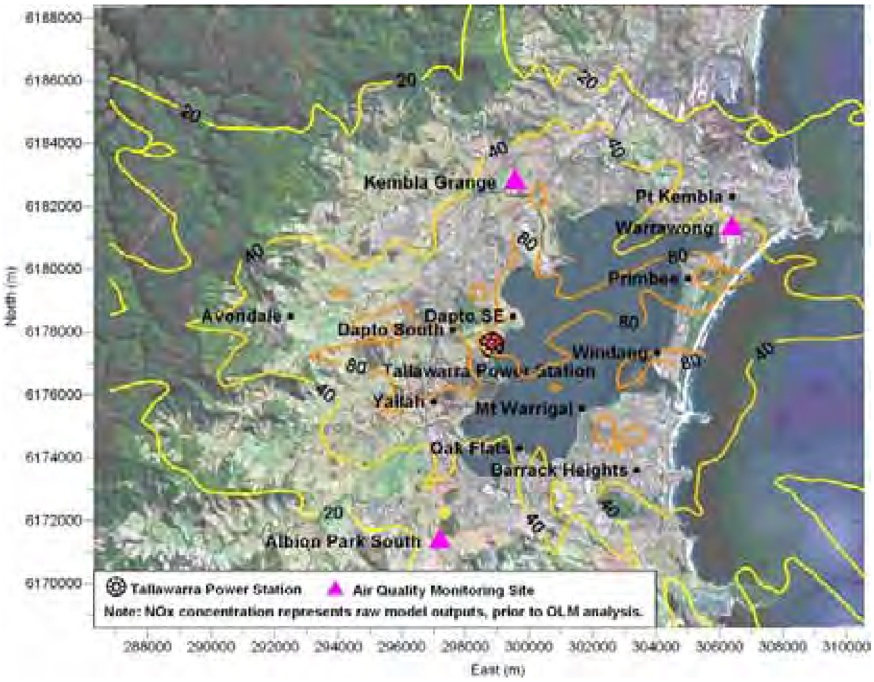
- **Figure 6-10: Tallawarra A Cold Start Hour 1 Incremental NO_X Maximum 1 hr Concentrations (µg/m³)**



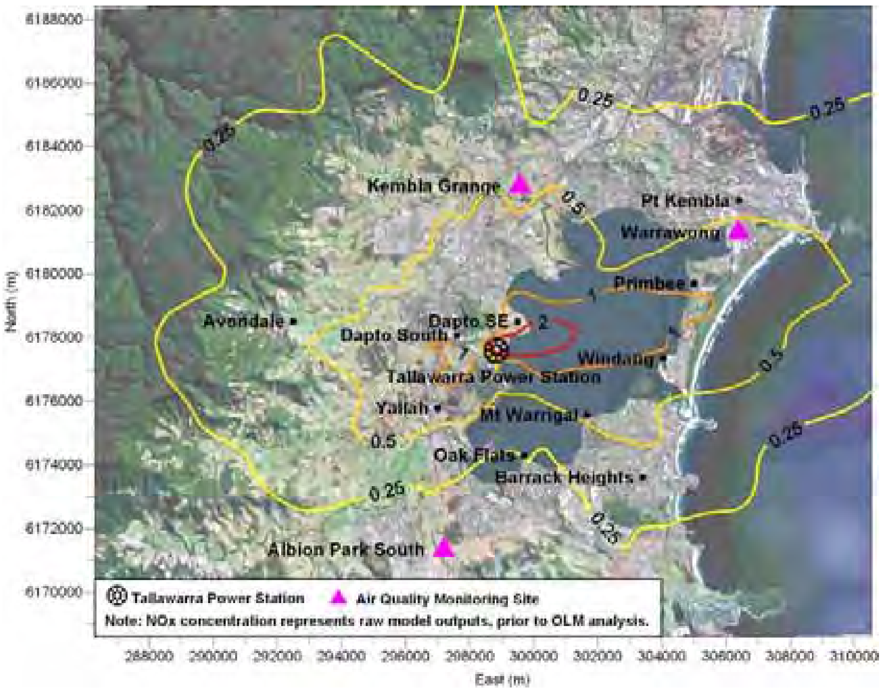
- **Figure 6-11: Tallawarra A Cold Start Hour 1 Incremental NO_X Annual Average Concentrations (µg/m³)**



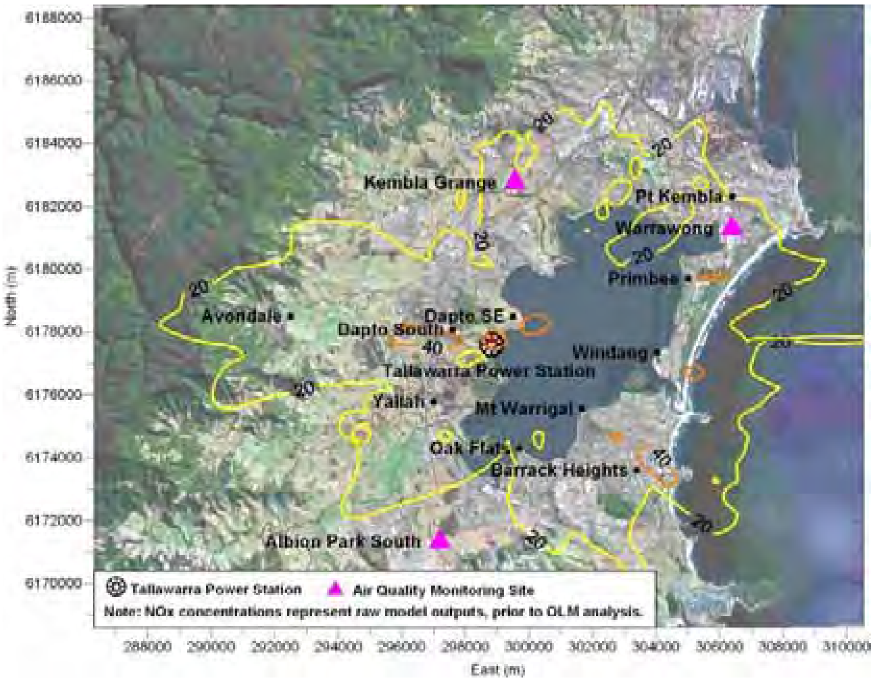
- **Figure 6-12: Tallawarra A Cold Start Hour 2 Incremental NO_X Maximum 1 hr Concentrations (µg/m³)**



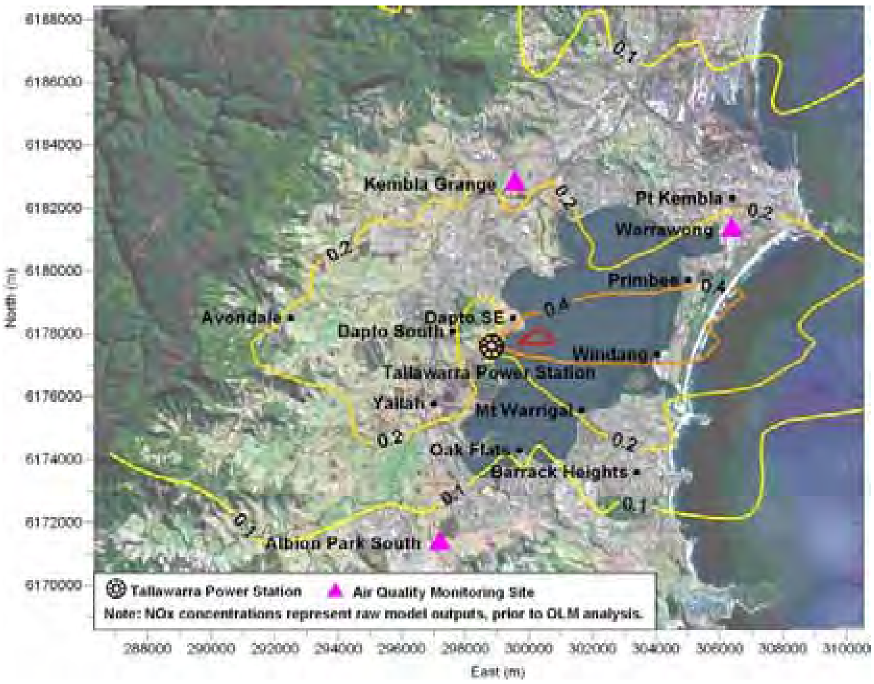
- **Figure 6-13: Tallawarra A Cold Start Hour 2 Incremental NO_X Annual Average Concentrations (µg/m³)**



- **Figure 6-14: Tallawarra A Cold Start Hour 3 Incremental NO_X Maximum 1 hr Concentrations ($\mu g/m^3$)**



- **Figure 6-15: Tallawarra A Cold Start Hour 3 Incremental NO_X Annual Average Concentrations ($\mu g/m^3$)**



6.3. Tallawarra A and Tallawarra B OCGT Plant (Diesel Fired)

Results indicate that the impact on NO_2 concentrations, resulting from the Tallawarra A CCGT plant in combination with the Tallawarra B1 and B2 OCGT plant (diesel fired) under normal operating conditions, as well as a set of start-up and part load operating conditions, would be within the DECC criteria set for NO_2 1-hour average concentration (246 µg/m^3) and the annual average concentration (62 µg/m^3).

For the Stage B OCGT air quality assessment, NOx impacts have been investigated for start-up operations and at base load as per the Director-General requirements. For an OCGT plant, there are two types of start: a “normal “start and a “fast” start. During a normal start it will take a 150 MW gas turbine in the order of 20 minutes to reach 50 – 60 percent load, the point at which NO_X emissions concentrations reduce to below 25 ppmv. On a fast start, 50 – 60 percent load and NO_X emissions less than 25 ppmv can be achieved within approximately 12 minutes of starting. Based on these results it can be seen that in the starting hour of an OCGT plant the mass emission rate of NO_X will be higher for a “normal” start, where it will take almost twice as long for the gas turbine NO_X emission concentration to reduce below 25 ppmv than for a “fast” start. When considering exhaust temperature and flow rate (velocity) which are also important for air quality impacts, the average temperature and flow rate will be lower in the first hour of a “normal ”start compared to a ”fast” start. In summary, with higher NO_X emissions and lower temperatures and velocities for a “normal” start, it is clear that air quality impacts will be higher for “normal” starts than is the case for “fast” starts.

The modelled NO_X ground level concentrations were analysed using the OLM to determine NO_2 ground level concentrations (refer to **Section 5.5.4**). At the sensitive receptors, the highest incremental NO_2 1-hour impact of Tallawarra A combined with Tallawarra B OCGT, was predicted to be 75 µg/m^3 at Dapto South, for the set of modelled emission scenarios (refer to **Table 6-1**). By the Level 1 assessment (NSW DEC 2005:42), the cumulative impact 220, resulting from the incremental impact, 78 µg/m^3, combined with the maximum background concentration, 145 µg/m^3, would represent about 89 percent of the DECC 1-hour criterion of 246 µg/m^3. As such, no additional assessment is required according to the approved methods, however, for the purpose of comparison with Tallawarra B as CCGT, the Level 2 assessment was undertaken (NSW DECC, 2005:43).

Table 6-4 , Table 6-5 and **Figure 6-16** present the results of applying the Level 2 OLM assessment to analyse the impacts of Tallawarra A for full load (base load) operations and a range of start-load conditions. **Table 6-4** shows the total predicted concentration at the hour of the highest predicted 1-hour incremental concentration. **Table 6-5** shows the total predicted concentration at the hour with the highest background concentration.

Table 6-6 demonstrates that the maximum cumulative concentration may comprise a specific incremental impact by the OLM combined with a contemporaneous background concentration in instances when neither the increment nor the background are at maximum. **Figure 6-16** presents the results **in Table 6-4** as well as the maximum cumulative impacts, displayed as shaded bars.

Figure 6-17 to **Figure 6-26** show contour plots of the incremental hourly-averaged NO_2 ground level concentrations for full load and the range of start load and part emissions scenarios (refer to **Table 5-2** for emission rates). As noted in **Section 6**, the concentration values on the contour plots are raw model outputs, prior to OLM analysis and thereby assume that the composition of NO_X in the ground level concentrations is 100 percent NO_2.

Results are discussed in the following subsections and summarised in **Section 8.2**

Table 6-4 Highest Predicted NO_2 1-Hour Average Impacts and Contemporaneous Background Concentration (µg/m³) Tallawarra A CCGT (Gas Fired) and Tallawarra B OCGT (Diesel Fired)

Scenario	Tallawarra A Full Load + Tallawarra B1 and B2 Full Load			Tallawarra A Full Load + Tallawarra B1 and B2 Start Load			Tallawarra A Start Load + Tallawarra B1 and B2 Full Load			Tallawarra A Start Load + Tallawarra B1 and B2 Start Load			Tallawarra A Full Load + Tallawarra B1 and B2 Part Load 50%		
Sensitive Receptor Location	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact
SE Dapto	44	4	48	32	3	35	27	5	32	53	4	57	30	3	33
Dapto South	75	3	78	75	3	78	75	3	78	75	3	78	75	3	78
Avondale	45	3	48	63	5	68	49	9	58	61	3	64	41	9	50
Yallah	46	5	51	25	19	44	22	7	28	56	5	60	21	5	27
Oak Flats	30	6	36	42	11	53	33	11	45	30	6	36	27	10	37
Mt Warrigal	37	3	40	55	20	75	48	18	66	52	3	55	38	18	55
Windang	57	0	57	70	3	72	47	0	47	73	0	73	38	0	38
Barrack Hts	31	6	36	54	7	61	40	5	45	37	42	80	34	5	39
Primbee	30	7	37	55	0	56	38	2	40	46	3	49	35	2	37
Pt Kembla	28	7	35	54	3	57	42	3	45	43	7	49	35	3	38
Average	42		47	53		60	42		48	53		60	37		43

■ Table 6-5 Highest Background Concentration and Contemporaneous Predicted NO_2 1-Hour Average Impacts ($\mu g/m^3$) for Tallawarra A CCGT (Gas Fired) and Tallawarra B OCGT (Diesel Fired)

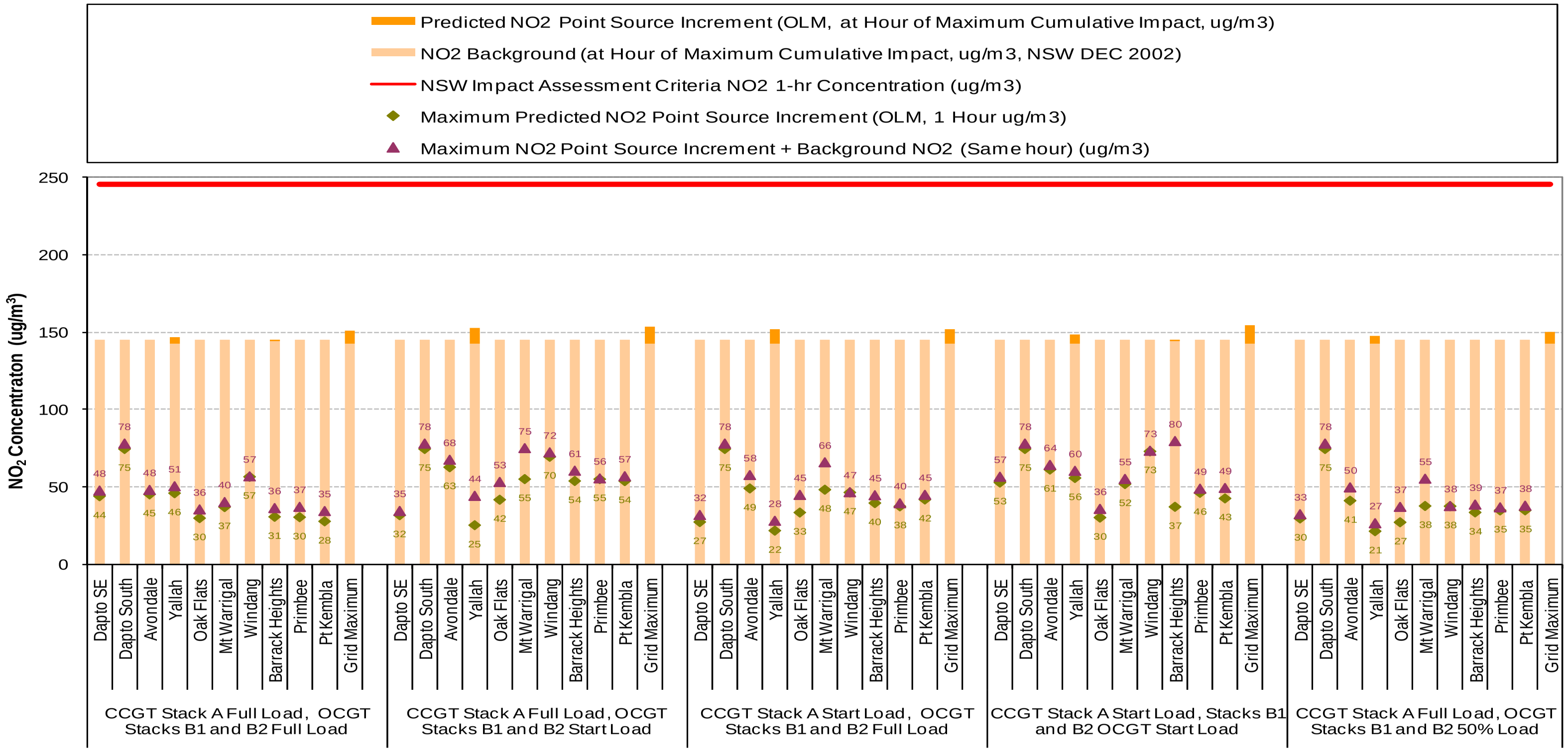
Scenario	Tallawarra A Full Load + Tallawarra B1 and B2 Full Load			Tallawarra A Full Load + Tallawarra B1 and B2 Start Load			Tallawarra A Start Load + Tallawarra B1 and B2 Full Load			Tallawarra A Start Load + Tallawarra B1 and B2 Start Load			Tallawarra A Full Load + Tallawarra B1 and B2 Part Load 50%		
Sensitive Receptor Location	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact
SE Dapto	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Dapto South	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Avondale	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Yallah	0	145	145	0	145	145	9	142	152	0	145	145	0	145	145
Oak Flats	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Mt Warrigal	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Windang	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Barrack Hts	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Primbee	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Pt Kembla	0	145	145	0	145	145	0	145	145	0	145	145	0	145	145
Grid Maximum	3	145	147	0	145	145	10	142	152	4	145	148	0	145	145

Table 6-6 Example Highest Cumulative Concentrations for Tallawarra A CCGT and Tallawarra B OCGT Showing Contemporaneous Predicted NO_2 1-Hour Average Impacts and Background Concentration

Tallawarra A Start Load + Tallawarra B1 and B2 Start Load	Total NO_2 Point Source Increment By OLM (ug/m3)	NO_2 Background (DECC Kembla Grange same hour) (ug/m3)	Total NO_2 Cumulative Impact (same hour) (ug/m3)
Yallah			
20021004	6	142	148
20021030	0	145	145
20021016	30	82	113
20021030	0	108	108
20021016	11	91	102
20021030	0	101	101
20020924	0	100	100
20020924	0	99	99
20021016	29	68	97
20020924	1	89	90
At Any Point Across the Grid			
20021004	13	142	155
20021030	4	145	148
20021016	34	82	116
20021030	4	108	112
20020924	7	100	108
20021030	6	101	107
20021007	37	70	107
20020411	37	70	107
20021016	12	91	103
20020924	3	99	101

Note: The maximum cumulative impact may occur when neither the incremental impact nor the background are at maximum concentration

Figure 6-16 Tallawarra A CCGT Plant and Tallawarra B OCGT Plant (Diesel Fired) Summary 1-Hour Average NO_2 Results



Note:

The shaded bars illustrate that the highest cumulative impacts generally resulted from the high 1-hr average background NO_2 concentrations, combined with relative low predicted incremental impacts of the plume from the power station, in the corresponding hour.

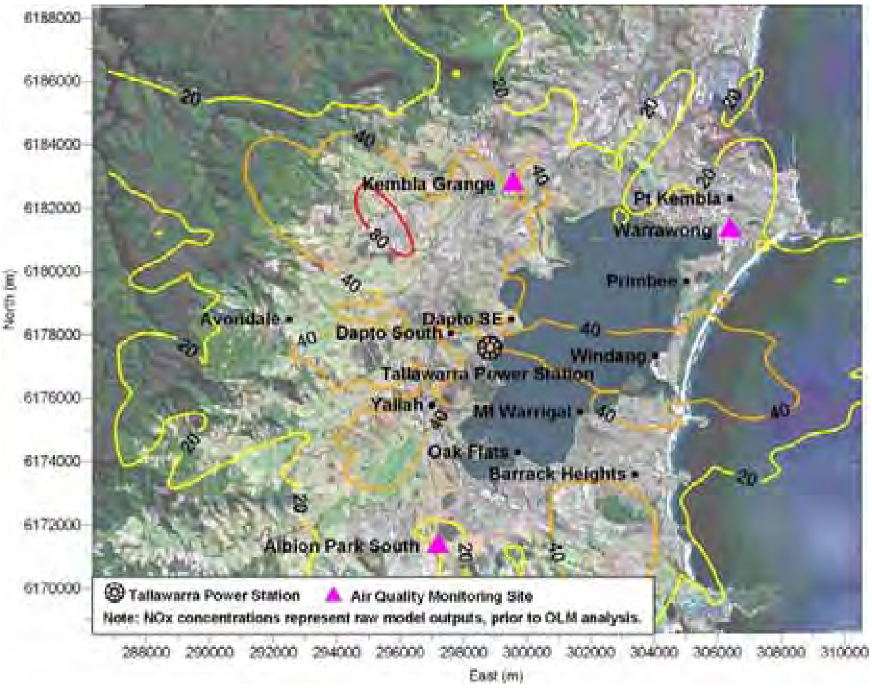
6.3.1. Full Load Operations

The highest incremental NO_2 impact produced by OLM analysis of raw NO_X model outputs for full load operations of Tallawarra A CCGT and B1 and B2 OCGT, at the sensitive receptor sites, was predicted to reach 75 $\mu g/m^3$ at Dapto South. Combined with the low background NO_2 concentration, 3 $\mu g/m^3$ (recorded at Kembla Grange in the same hour), the cumulative impact of 78 $\mu g/m^3$ (refer to **Table 6-4** and **Figure 6-16**), represents about 31 percent of the DECC 1-hour criterion (246 $\mu g/m^3$). Compared with Tallawarra A at full load operations, the addition of Tallawarra B OCGT at full load resulted in an increase of 11 $\mu g/m^3$ (or 4 percent of the DECC 1-hour criterion) for the highest cumulative concentration which occurred in association with a maximum incremental NO_2 plume impact at any of the sensitive receptor sites (i.e. The cumulative concentration at Mt Warrigal was predicted to be 67 $\mu g/m^3$ due to Tallawarra A at full load, refer to **Table 6-1** and to be 78 $\mu g/m^3$ at Dapto South with the addition of Tallawarra B OCGT at full load, refer to **Table 6-4**.)

The maximum cumulative concentration across the grid, 151 $\mu g/m^3$ represents about 61 percent of the DECC 1-hour criterion (246 $\mu g/m^3$) and resulted from the high background concentration, 142 $\mu g/m^3$, combined with a relatively very low incremental impact, 9 $\mu g/m^{3,}$ due to the power station (refer to **Figure 6-16,** shaded bars**)** . The addition of Tallawarra B1 and B2 OCGT at full load, compared with Tallawarra A at full load, resulted in no major change in the maximum cumulative concentration across the grid. In both cases, the high background concentrations combined with low plume impacts in the corresponding hours. The maximum cumulative concentrations across the grid, in both emission scenarios represent about 61 percent of the DECC 1-hour criterion, 246 $\mu g/m^3$ (i.e. Tallawarra A full load, 151 $\mu g/m^3$, refer to **Figure 6-1** and Tallawarra A full load plus B OCGT, 151 $\mu g/m^3$, refer to **Figure 6-16**)

Figure 6-17 shows the predicted horizontal pattern of 1-hour maximum NO_X concentrations due to the plumes from Tallawarra A CCGT and B OCGT for the full load emission scenario. Locations predicted to be most affected by incremental increases of 80 $\mu g/m^3$ to 90 $\mu g/m^3$, extend northwest of the Tallawarra power station site. **Figure 6-18** indicates that the location predicted to receive the highest increment in annual average NO_X concentrations extends east of the power station over Lake Illawarra. The incremental increases in the annual average concentration were predicted to range from 0.1 $\mu g/m^3$ to 1.8 $\mu g/m^3$. Assuming conservatively that the maximum increment in the annual average NO_2 concentration, due to Tallawarra A CCGT and Tallawarra B OCGT, both operating at full load, was 2 $\mu g/m^3$, then combined with a background annual average concentration of 15 $\mu g/m^3$ (refer to **Section 3.4.2)**, the cumulative annual average concentration would be 17 $\mu g/m^3$, which represents about 27 percent of the DECC annual average NO_2 criterion (62 $\mu g/m^3$).Compared with Tallawarra A operating at full load, the incremental increase in the annual average NO_X concentration resulting from the addition of Tallawarra B OCGT at full load was about 1 percent.

- **Figure 6-17: Tallawarra A CCGT Full Load and Tallawarra B1 and B2 OCGT Full Load (Diesel Fired) Incremental NO_X Maximum 1 hr Concentrations (µg/m³)**



- **Figure 6-18: Tallawarra A CCGT Full Load and Tallawarra B1 and B2 OCGT Full Load (Diesel Fired) Incremental NO_X Annual Average 1 hr Concentrations (µg/m³)**

6.3.2. Start Load and Part Load Operations

Results of the OLM analysis of raw NO_X model outputs indicated that for all start and part load scenarios considered, the highest cumulative NO_2 concentrations (due to maximum incremental impacts of the plume at any of the sensitive receptors) were predicted to be meet the DECC 1-hour criterion, 246 $\mu g/m^3$.

In all modelled scenarios for start and part load operations (refer to **Section 5.4**) the highest cumulative NO_2 concentrations of 78 $\mu g/m^3$ resulted from incremental impacts of 75 $\mu g/m^3$, due to the impact of the plumes, combined with corresponding background concentrations of 3 $\mu g/m^3$, recorded at Kembla Grange during the same hour (refer to **Table 6-4** and **Figure 6-16**).

Further, compared with the impacts of full load operations at Tallawarra A CCGT and B1 and B2 OCGT, there was no difference in the highest cumulative NO_2 concentrations at sensitive receptors for start and part load operations. The highest cumulative NO_2 concentrations, 78 $\mu g/m^3$ resulting from maximum incremental impacts of the plume all scenarios at represented 31 percent of the DECC 1-hour criterion, 246 $\mu g/m^3$ and occurred at Dapto South.

The maximum cumulative concentration across the grid in the start and part load scenarios compared to the impacts of full load operations (151 $\mu g/m^3$) were as follows:

- A Hot Start + B1&B2 Normal Start - 154 $\mu g/m^3$, 63% of DECC 1-hour criterion
- A Full Load + B1&B2 Normal Start - 153 $\mu g/m^3$, 62% of DECC 1-hour criterion
- A Hot Start + B1&B2 Full Load - 152 $\mu g/m^3$, 62% of DECC 1-hour criterion
- A Full Load + B1&B2 50% Load - 150 $\mu g/m^3$, 61% of DECC 1-hour criterion

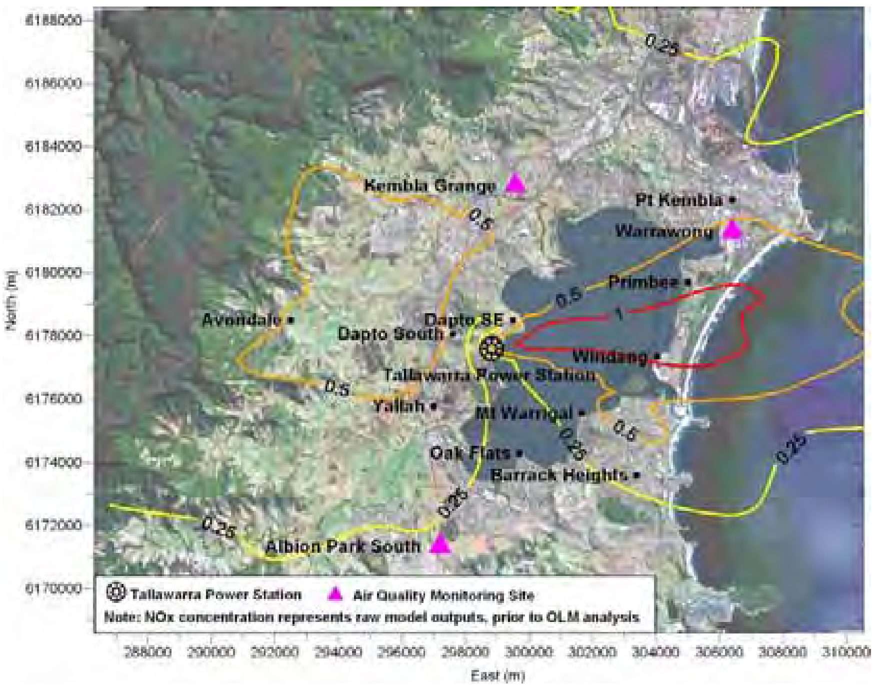
As discussed in previous scenarios, the maximum cumulative concentration across the grid resulted from the high background concentration combined with a relatively low incremental impact due to the power station (refer **Table 6-6** and to shaded bars **Figure 6-16**). For example, during start load operation of Tallawarra A CCGT and B OCGT, the highest cumulative concentration at any sensitive receptor occurred at Yallah, 148 $\mu g/m^3$ comprising an incremental impact 6 $\mu g/m^3$ due to the plume and a contemporaneous background concentration of 142 $\mu g/m^3$. The maximum cumulative concentration across the grid, 155 $\mu g/m^3$ resulted from an incremental impact 13 $\mu g/m^3$ due to eh plume and a contemporaneous background concentration of 142 $\mu g/m^3$ (refer to **Table 6-6**).

Figure 6-19 to **Figure 6-26** show the predicted horizontal pattern of incremental NO_X ground level concentrations, due to the plume from the power station, for the range of modelled start and part load emissions scenarios. It is emphasised that the concentrations in these plots represent the raw model outputs for NO_X, prior to OLM analysis. Locations most affected by the plumes are located generally west-north-west of the power station and across Lake Illawarra to the east-south-east. OLM analysis of NO_X, outputs described above indicates that NO_2 impacts meet the DECC 1-hour criterion.

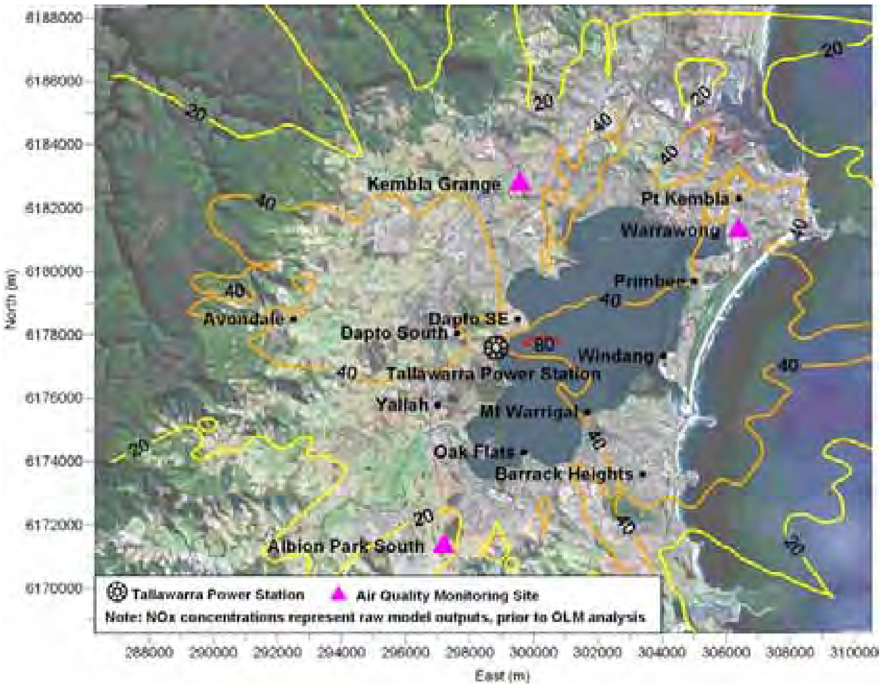
Assuming conservatively that the maximum increment in the annual average NO_2 concentration, due to the modelled start and part load scenarios for Tallawarra A CCGT and Tallawarra B1 and B2 OCGT, both operating at full load, was 3 µg/m^3 (the result for Tallawarra A hot start hour 1 and Tallawarra B1 and B2 normal start, refer to **Figure 6-24**) then combined with a background annual average concentration of 15 µg/m^3 (refer to **Section 3.4.2)**, the cumulative annual average concentration would be 18 µg/m^3, which represents about 29 percent of the DECC annual average NO_2 criterion (62 µg/m^3).

- **Figure 6-19: Tallawarra A CCGT Full Load and Tallawarra B1 and B2 OCGT Start Load (Diesel Fired) Incremental NO_X Maximum 1 hr Concentrations (µg/m³)**

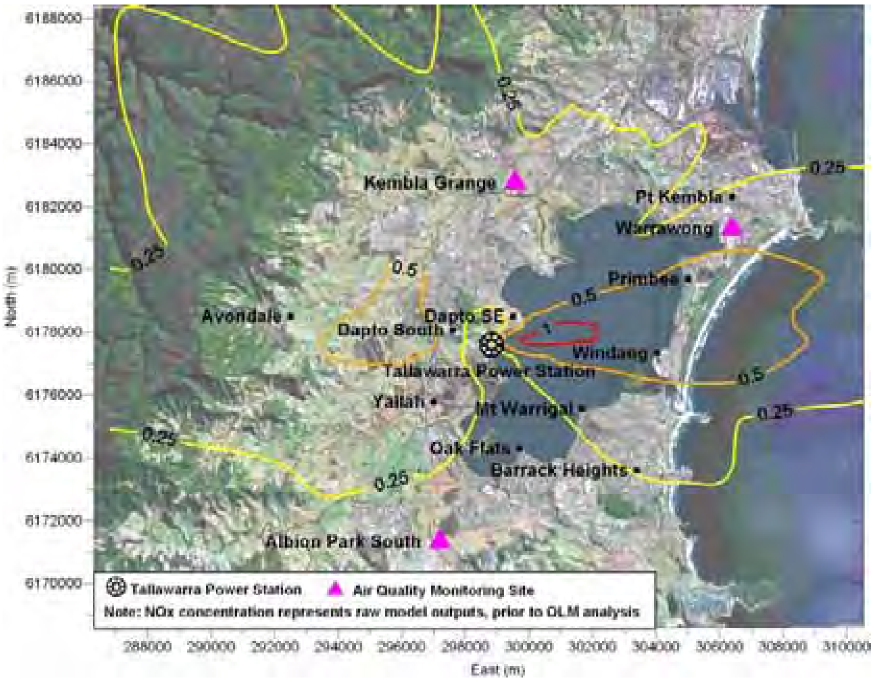
- **Figure 6-20 Tallawarra A CCGT Full Load and Tallawarra B1 and B2 OCGT Start Load (Diesel Fired) Incremental NO_X Annual Average 1 hr Concentrations (µg/m³)**



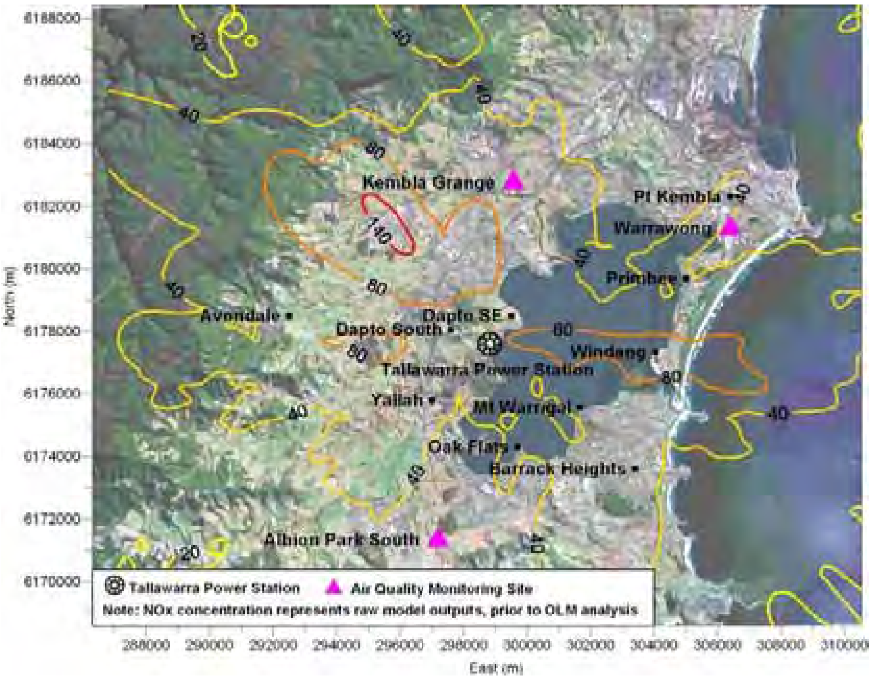
- **Figure 6-21: Tallawarra A CCGT Start Load and Tallawarra B1 and B2 OCGT Full Load (Diesel Fired) Incremental NO_X Maximum 1 hr Concentrations (µg/m³)**



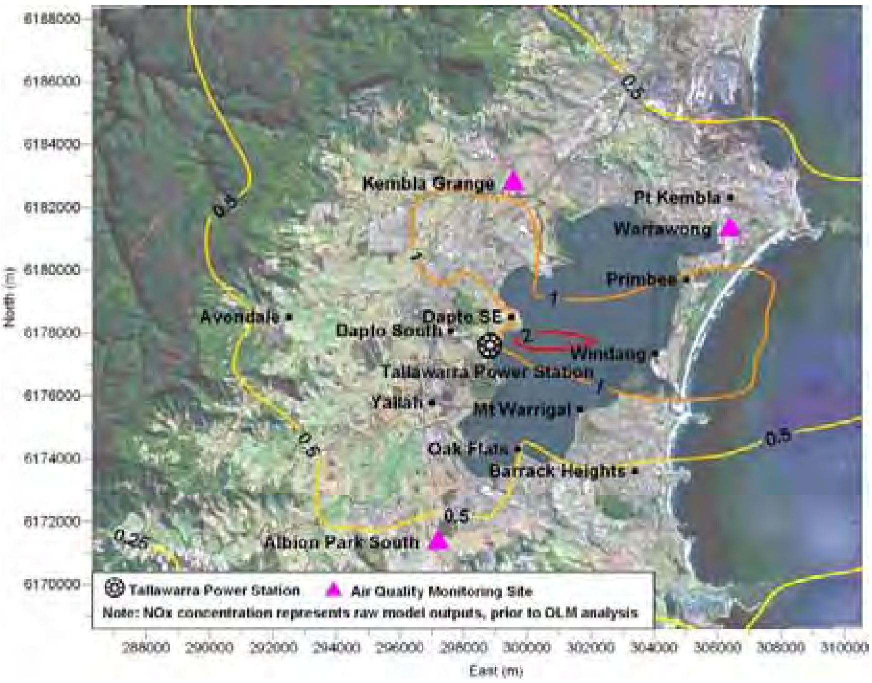
- **Figure 6-22 Tallawarra A CCGT Start Load and Tallawarra B1 and B2 OCGT Full Load (Diesel Fired) Incremental NO_X Annual Average 1 hr Concentrations (µg/m³)**



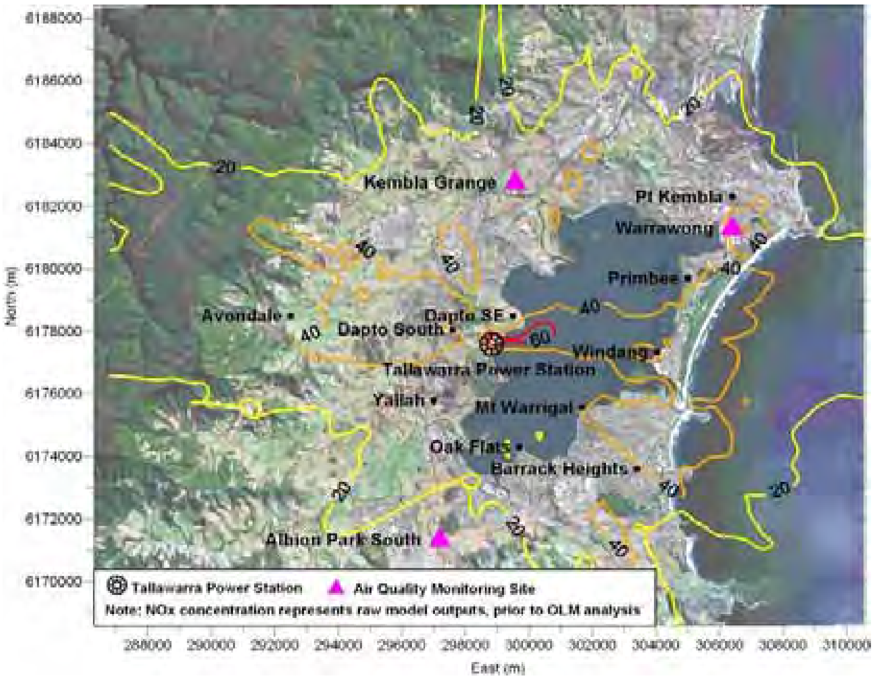
- **Figure 6-23: Tallawarra A CCGT Start Load and Tallawarra B1 and B2 OCGT Start Load (Diesel Fired) Incremental NO_X Maximum 1 hr Concentrations (µg/m^3)**



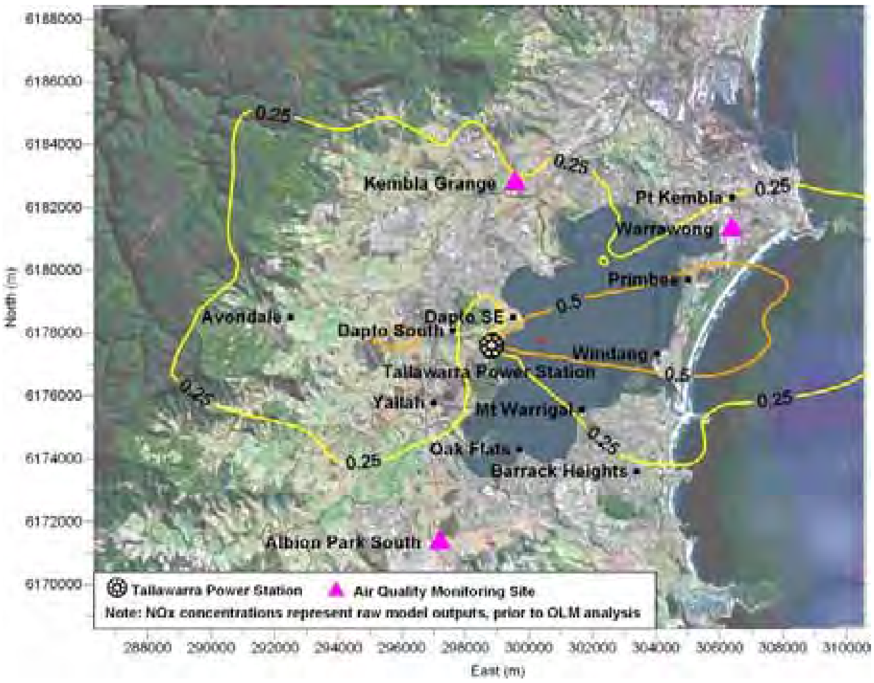
- **Figure 6-24 Tallawarra A CCGT Start Load and Tallawarra B1 and B2 OCGT Start Load (Diesel Fired) Incremental NO_X Annual Average 1 hr Concentrations (µg/m^3)**



- **Figure 6-25: Tallawarra A CCGT Full Load and Tallawarra B1 and B2 OCGT (Part Load 50% Diesel Fired) Incremental NO_X Maximum 1 hr Concentrations (µg/m^3)**



- **Figure 6-26 Tallawarra A CCGT Full Load and Tallawarra B1 and B2 OCGT Part Load (50%) (Diesel Fired) Incremental NO_X Annual Average 1 hr Concentrations (µg/m^3)**



6.3.3. SO_2 and PM_{10} Impacts of Tallawarra A and Tallawarra B OCGT (Diesel Fired)

Modelling results predicted for the Tallawarra A CCGT plant operating alone under normal operating conditions in combination with the Tallawarra B OCGT plant (diesel fired) indicated that SO_2 and PM_{10} concentrations would be very low and within the criteria set by the NSW DECC.

A summary of results is presented **Table 6-7**. The predicted patterns of average concentrations across the modelling domain are presented in **Appendix B**.

Table 6-7 Summary of Incremental SO_2 and PM_{10} Results for Tallawarra A CCGT Plant (Gas Fired) and Tallawarra B OCGT Plant (Diesel Fired)

Air Pollutant	Averaging Period	NSW DEC Criteria	Min Conc.	Max Conc.		Conc. at Sensitive Receptors	
		($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)	% of Criteria	($\mu g/m^3$) approx	% of Criteria
Tallawarra A CCGT Plant							
SO2	1 Hour	570	0.28	4.30	<1	2	<1
	Annual	60	0.06	1.33	<3	0.02	<1
PM10	24 Hour	50	0.08	1.6	<4	0.08	<1
	Annual	30	0.004	0.106	<1	0.04	<1
Tallawarra A CCGT Plant Combined with Tallawarra B OGCT Plant							
SO2	1 Hour	570	1.59	26	<5	5-8	1-2
	Annual	60	0.02	0.23	<1	<0.2	<1
PM10	24 Hour	50	0.16	3.99	<8	<2	<5
	Annual	30	0.009	0.152	<1	<0.1	<1

6.4. Tallawarra A and B CCGT Plants

The assessment of Tallawarra A CCGT plant in combination with Tallawarra B CCGT plant assumes that the stack parameters of Tallawarra B CCGT plant are identical to Tallawarra A CCGT. Emission scenarios include normal operating conditions as well as a set of start-up and part load operating conditions.

The results show that the impacts across the study area meet the DECC criteria of for NO_2 1-hour average concentration (246 µg/m^3) and the annual average concentration (62 µg/m^3) for all hours during full load operations the start load emission scenarios considered in this assessment (refer to **Table 6-8**, **Table 6-9** and **Figure 6-27**).

The modelled NO_X ground level concentrations were analysed using the OLM to determine NO_2 ground level concentrations (refer to **Section 5.5.4**). At the sensitive receptors, the highest incremental NO_2 1-hour impact of Tallawarra A, by the OLM, was predicted to be 118 µg/m^3 at Yallah, during the Tallawarra A full load and Tallawarra B cold start hour 1 (refer to **Table 6-8**). By the Level 1 assessment (NSW DEC 2005:42), the incremental impact, 118 µg/m^3, combined with the maximum background concentration, 145 µg/m^3, would result in a cumulative impact which would exceed the DECC 1-hour criterion of 246 µg/m^3 by about 7 percent. Further analysis was undertaken using the Level 2 assessment method (NSW DECC, 2005:43).

Table 6-8, **Table 6-9** and **Figure 6-27** present the results of applying the Level 2 OLM assessment to analyse the impacts of Tallawarra A and B CCGT for full load operations and start-load conditions. **Table 6-8** shows the total predicted concentration at the hour of the highest predicted 1-hour incremental concentration.

Table 6-10 demonstrates that the maximum cumulative concentration may comprise the highest background concentration and the contemporaneous incremental impact of the plume or vice versa. **Figure 6-27** presents the results in **Table 6-8** as well as the maximum cumulative impacts, displayed as shaded bars.

Figure 6-28 to **Figure 6-33** show contour plots of the incremental NO_X ground level concentrations for the range of full load and start load emissions scenarios. As noted in **Section 6**, the concentration values on the contour plots are raw model outputs prior to OLM analysis.

Results are summarised in **Section 8.3**.

Table 6-8 Highest Predicted NO_2 1-Hour Average Impacts and Contemporaneous Background Concentration ($\mu g/m^3$) Tallawarra A CCGT (Gas Fired) and Tallawarra B CCGT (Diesel Fired)

Scenario	Tallawarra A Full Load + Tallawarra B Full Load			Tallawarra A Full Load + Tallawarra B Cold Start Hour 1			Tallawarra A Full Load + Tallawarra B Warm Start Hour 1			Tallawarra A Warm Start Hour 1 + Tallawarra B Cold Start Hour 1		
Sensitive Receptor Location	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Max Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact
SE Dapto	54	4	57	75	4	79	70	5	75	85	7	92
South Dapto	65	18	83	97	5	102	75	3	78	92	5	97
Avondale	58	3	61	75	4	79	72	4	76	78	4	82
Yallah	68	5	73	116	10	127	97	17	113	86	5	90
Oak Flats	47	6	53	55	19	74	45	19	64	57	19	76
Mt Warrigal	45	5	50	93	5	98	69	5	74	93	5	98
Windang	50	1	51	68	1	69	67	1	68	71	2	73
Barrack Hts	40	6	46	46	10	56	42	10	52	52	10	63
Primbee	46	3	49	57	3	59	54	3	57	58	12	70
Pt Kembla	22	13	35	32	1	33	28	14	42	48	1	49
Average	50		56	71		78	62		70	72		79

- **Table 6-9 Highest Background Concentration and Contemporaneous Predicted NO_2 1-Hour Average Impacts ($\mu g/m^3$) for Tallawarra A CCGT (Gas Fired) and Tallawarra B OCGT (Diesel Fired)**

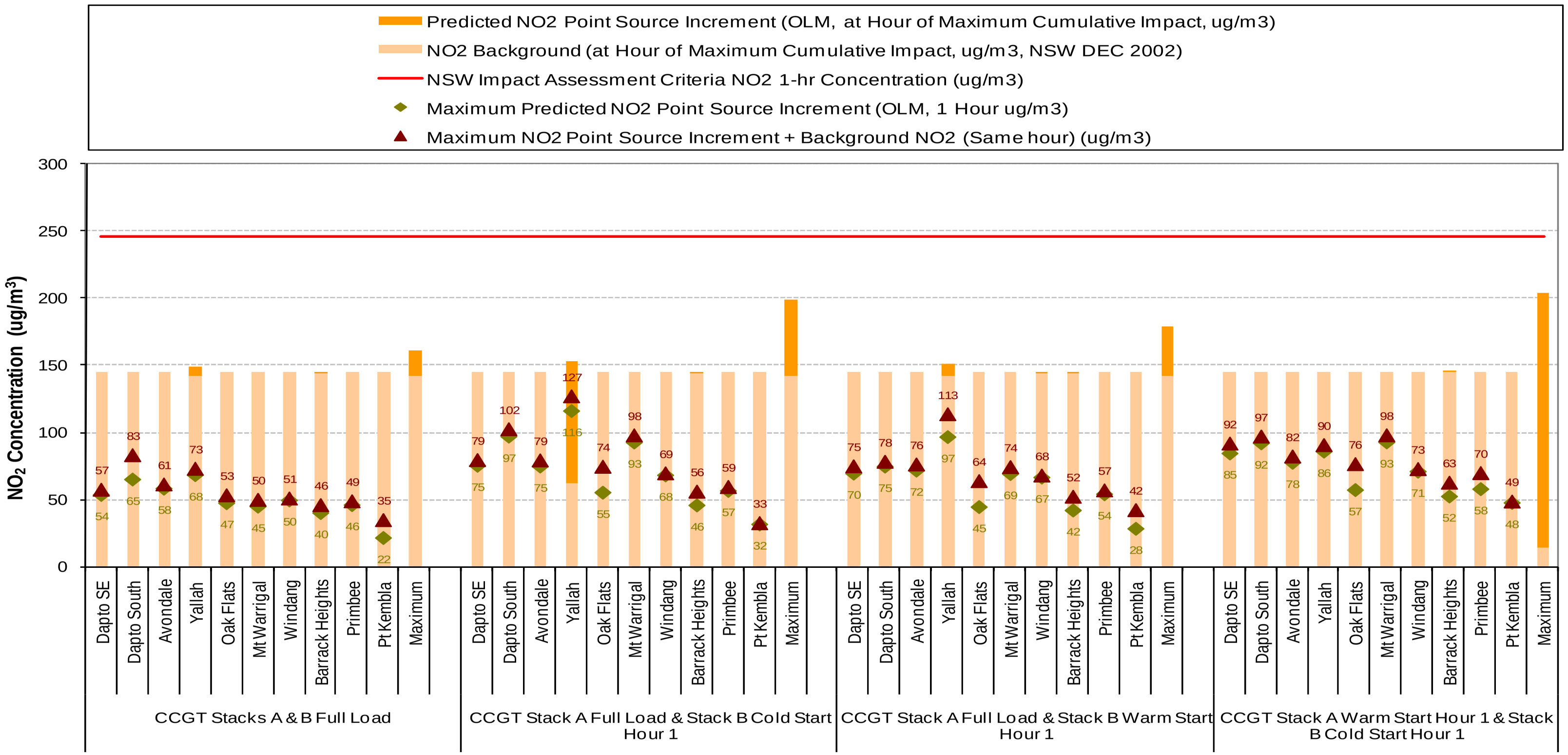
Scenario	Tallawarra A Full Load + Tallawarra B Full Load			Tallawarra A Full Load + Tallawarra B Cold Start Hour 1			Tallawarra A Full Load + Tallawarra B Warm Start Hour 1			Tallawarra A Warm Start Hour 1 + Tallawarra B Cold Start Hour 1		
Sensitive Receptor Location	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact	Predicted Incremental NO2 by OLM	Background Concentration (same hour)	Cumulative Impact
SE Dapto	0	145	145	0	145	145	0	145	145	0	145	145
South Dapto	0	145	145	0	145	145	0	145	145	0	145	145
Avondale	0	145	145	0	145	145	0	145	145	0	145	145
Yallah	0	145	145	0	145	145	9	142	151	0	145	145
Oak Flats	0	145	145	0	145	145	0	145	145	0	145	145
Mt Warrigal	0	145	145	0	145	145	0	145	145	0	145	145
Windang	0	145	145	0	145	145	0	145	145	0	145	145
Barrack Hts	0	145	145	0	145	145	0	145	145	1	145	146
Primbee	0	145	145	0	145	145	0	145	145	0	145	145
Pt Kembla	0	145	145	0	145	145	0	145	145	0	145	145
Grid Maximum	5	145	150	14	145	158	4	145	148	22	145	167

Table 6-10 Example Highest Cumulative Concentrations for Tallawarra A and B CCGT Showing Contemporaneous Predicted NO_2 1-Hour Average Impacts and Background Concentration

Tallawarra A Warm Start Hour 1 + Tallawarra B1 Cold Start Hour 1	Total NO_2 Point Source Increment By OLM (µg/m^3)	NO_2 Background (DECC Kembla Grange same hour) (µg/m^3)	Total NO_2 Cumulative Impact (same hour) (µg/m^3)
Dapto South			
20021030	0	145	145
20021004	0	142	142
20021004	29	81	110
20021030	0	108	108
20021030	0	101	101
20020924	0	100	100
20020924	0	99	99
20021207	92	5	97
20020822	64	31	95
20020923	71	22	93
At Any Point Across the Grid			
20020104	191	14	205
20021004	57	142	199
20021222	172	24	196
20021216	167	24	190
20021222	155	25	181
20020104	160	19	179
20021216	149	28	177
20020104	162	11	173
20021004	85	84	169
20021030	22	145	167

Note: In this example, the maximum cumulative concentration at the sensitive receiver resulted from the highest background concentration combined with a near –zero incremental impact. At any point across the grid, the maximum cumulative concentration resulted from the maximum incremental impact, due to the plume, combined with a relatively low background concentration.

Figure 6-27 Summary 1-Hour Average NO_2 Results for Tallawarra A and B CCGT Plants (Gas Fired) Predicted Maximum Incremental Impacts and Cumulative Concentrations



Note:

The shaded bars illustrate that the highest cumulative impacts generally resulted from the maximum 1-hr average background NO_2 concentration, 146 µg/m^3, combined with a relative low incremental impact of the plume from the power station, in the corresponding hour..

6.4.1. Full Load Operations

The highest cumulative NO_2 impact produced by OLM analysis of raw NO_X model outputs for full load operations of Tallawarra A and B CCGT, at the sensitive receptor sites, was predicted to reach 83 µg/m^3 at Dapto South, representing 34 percent of the DECC 1-hour criterion. This impact resulted from incremental impact of the plumes, 65 µg/m^3, combined with a background NO_2 concentration, 18 µg/m^3 recorded at Kembla Grange in the same hour (refer to **Table 6-8** and **Figure 6-27**).

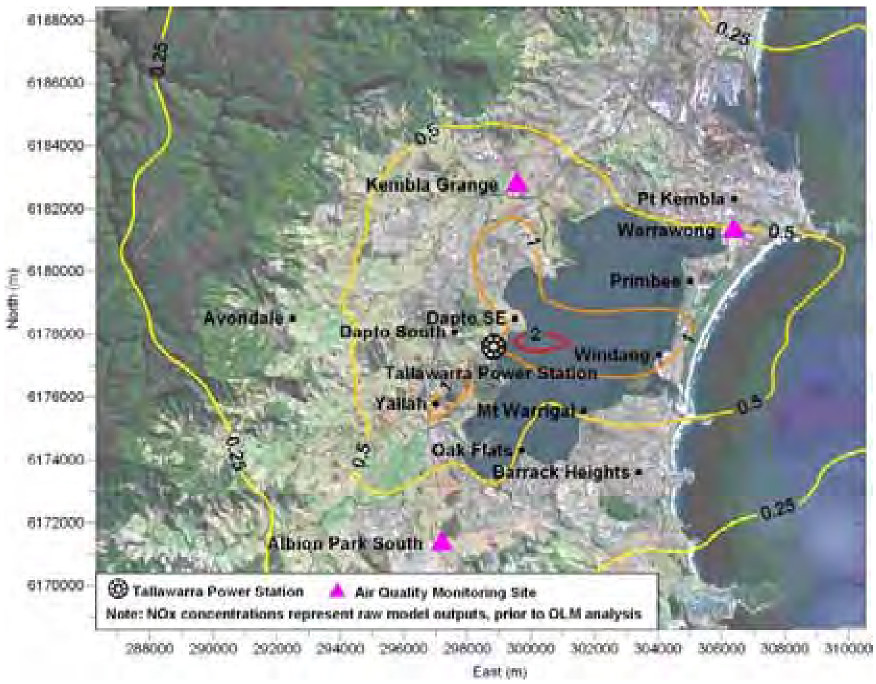
Although the average incremental NO_2 impact of the plumes was higher in the case of Tallawarra A and B CCGT plants (50 µg/m^3), compared with Tallawarra A CCGT and B1 and B2 OCGT at full load (42 µg/m^3), the background concentration influences the resulting cumulative concentration (refer to **Table 6-1** and **Table 6-8).**

Figure 6-28 shows the predicted horizontal pattern of 1-hour maximum NO_X concentrations due to the plumes from Tallawarra A and B CCGT for the full load emission scenario. Locations predicted to be most affected by incremental increases of 80 µg/m3 to 109 µg/m3, extend north-northwest and south-west of the Tallawarra power station site.

Figure 6-29 indicates that the location predicted to receive the highest increment in annual average NOX concentrations extends east of the power station over Lake Illawarra. The incremental increases in the annual average concentration were predicted to range from 0.1 µg/$m^3$to 2.6 µg/m^3. Assuming conservatively that the maximum increment in the annual average NO_2 concentration, due to Tallawarra A and B CCGT, both operating at full load, was 3 µg/m3, then combined with a background annual average concentration of 15 µg/m3 (refer to Section 3.4.2), the cumulative annual average concentration would be 18 µg/m3, which represents about 27 percent of the DECC annual average NO_2 criterion (62 µg/m3).Compared with Tallawarra A CCGT and Tallawarra B1 and B2 OCGT at full load, the incremental increase in the annual average NOX concentration was about 1 percent.

- **Figure 6-28: Tallawarra A and B CCGT Full Load Incremental NO_X Maximum 1 hr Concentrations (µg/m^3)**

- **Figure 6-29: Tallawarra A and B CCGT Full Load Incremental NO_X Annual Average Concentrations (µg/m^3)**



6.4.2. Start Load Operations

Results of the OLM analysis of raw NO_X model outputs for modelled start load scenarios indicate that the highest cumulative NO_2 concentrations (due to maximum incremental impacts of the plume at any of the sensitive receptors) were predicted meet the DECC 1-hour criterion, 246 µg/m^3, and to be as follows (refer to **Table 6-8** and **Figure 6-27)**:

- A Full Load + B Cold Start Hour 1 - 127 µg/m^3 at Yallah, 52 % of DECC 1-hour criterion
- A Full Load + B Warm Start Hour 1 - 113 µg/m^3 at Yallah, 46% of DECC 1-hour criterion
- A Warm Start Hour 1 + B Cold Start Hour 1 - 98 µg/m^3, 40% of DECC 1-hour criterion

Considering the modelled start load scenarios, while the highest maximum incremental impact of the plumes, 116 µg/m^3 occurred during Tallawarra A Full Load plus B Cold Start Hour 1, the average incremental NO_2 impact due Tallawarra A Warm Start Hour 1 combined with Tallawarra B Cold Start Hour 1 to the plumes, was higher by one percent (72 µg/m^3 compared to 71 µg/m^3, refer to **Table 6-8).**

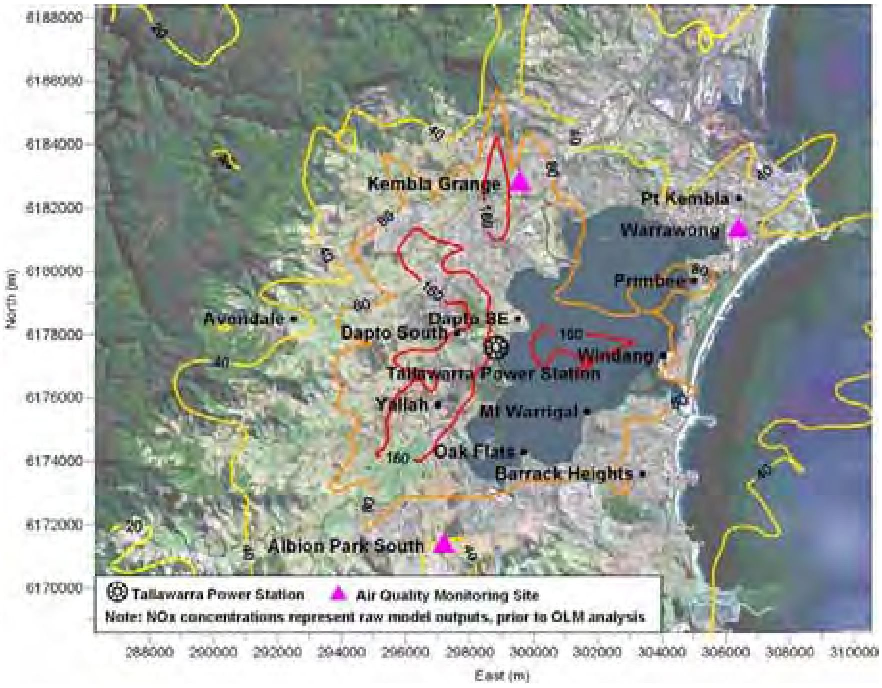
The maximum cumulative concentration across the grid, 205 µg/m^3, representing 83% of the DECC 1-hour criterion (246 µg/m^3), was predicted to occur in the scenario of Tallawarra A Warm Start Hour 1 + B Cold Start Hour 1, resulting from an incremental impact of 191 µg/m^3 due to the plumes combined with a background concentration of 14 µg/m^3 at Kembla Grange for the same hour (refer **Table 6-10** to shaded bars **Figure 6-27)**.

In contrast, the maximum cumulative concentration across the grid in the scenario of Tallawarra A Full Load + B Cold Start Hour 1, 199 µg/m^3, representing 81% of the DECC 1-hour criterion resulted from an incremental impact of 57 µg/m^3 due to the plumes combined with a background concentration of 142 µg/m^3 at Kembla Grange for the same hour (refer to shaded bars **Figure 6-27)**

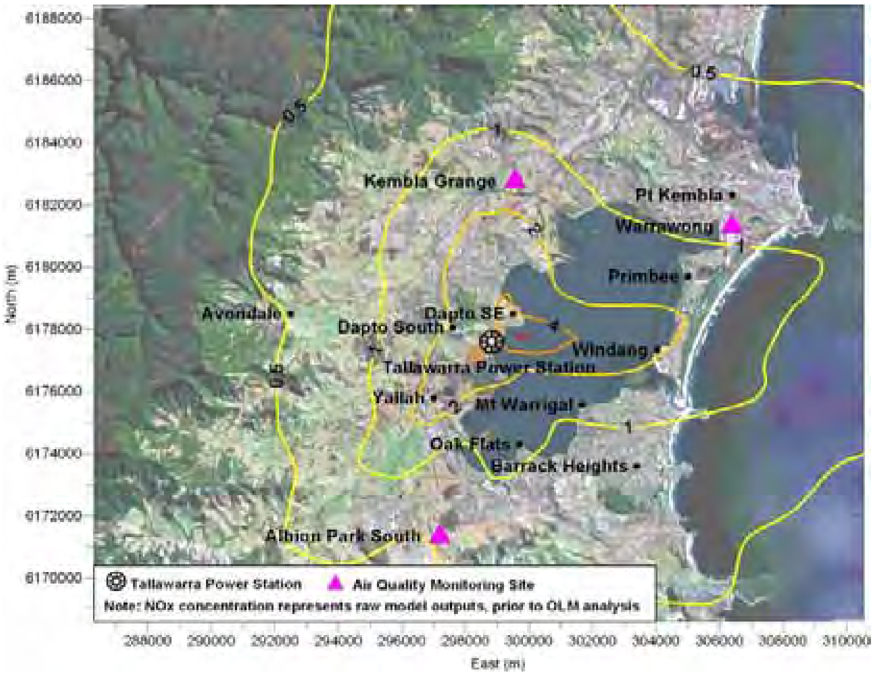
Figure 6-30 to **Figure 6-35** show the predicted horizontal pattern of incremental NO_X ground level concentrations, due to the plume from the power station, for the range of modelled start load emissions scenarios. As noted previously, the concentrations in these plots represent the raw model outputs for NO_X, prior to OLM analysis. Locations most affected by the plumes are located generally north-north-west and south-west of the power station. OLM analysis of NO_X, outputs described above indicates that NO_2 impacts meet the DECC 1-hour criterion.

Assuming conservatively that the worst case maximum increment in the annual average NO2 concentration, due Tallawarra A Warm Start Hour 1 combined with Tallawarra B Cold Start Hour 1 was 5 µg/m^3 (refer to **Figure 6-35**), then combined with a background annual average concentration of 15 µg/m^3 (refer to **Section 3.4.2**), the cumulative annual average concentration would be 20 µg/m^3, which represents about 32 percent of the DECC annual average NO2 criterion (62 µg/m^3).

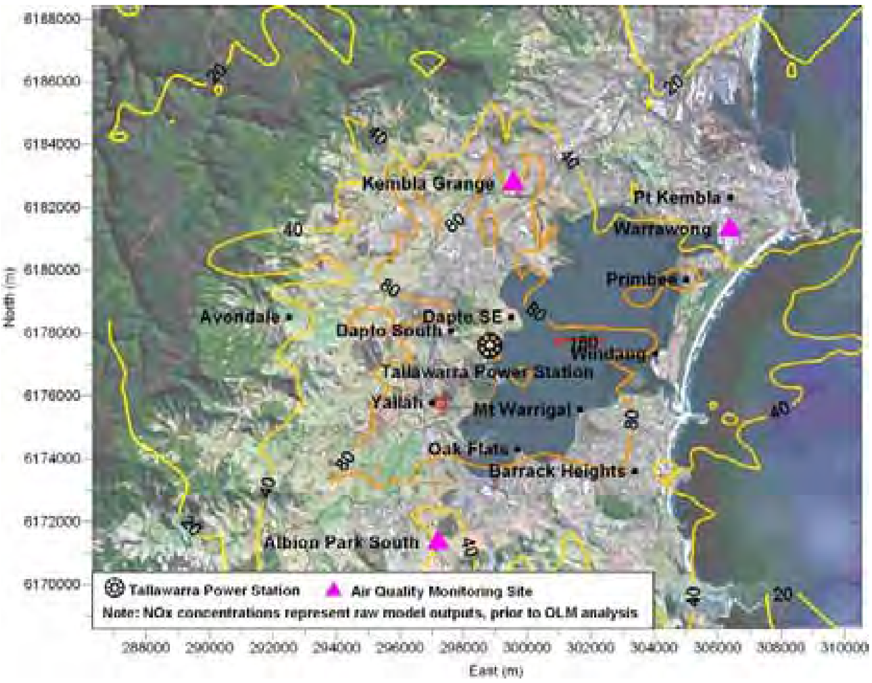
- **Figure 6-30: Tallawarra A Full Load and B CCGT Cold Start Hour 1 Incremental NO_X Maximum 1 hr Concentrations (µg/m³)**



- **Figure 6-31: Tallawarra A Full Load and B CCGT Cold Start Hour 1 Incremental NO_X Annual Average Concentrations (µg/m³)**

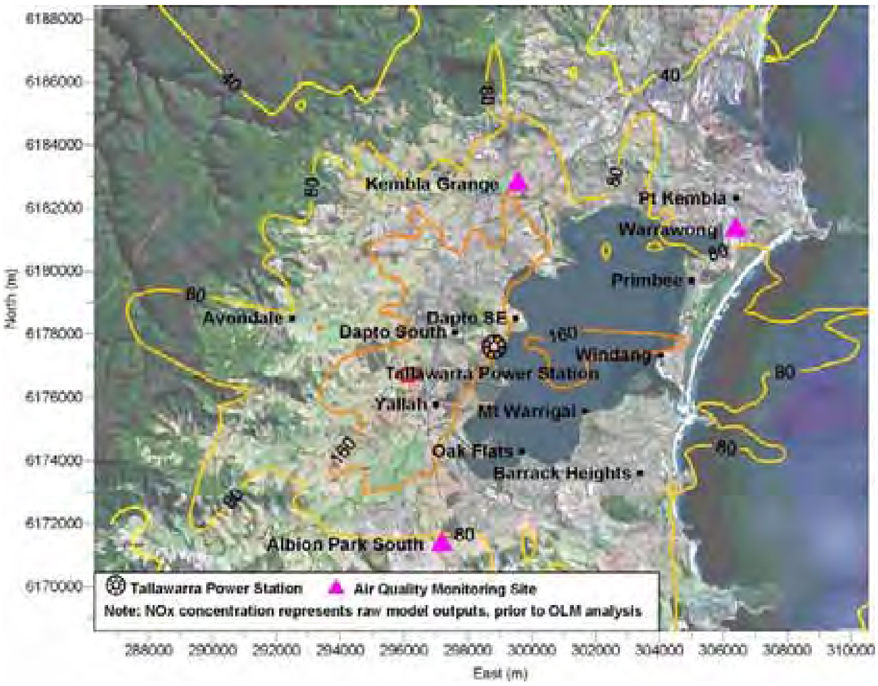


- **Figure 6-32: Tallawarra A Full Load and B CCGT Warm Start Hour 1 Incremental NO_X Maximum 1 hr Concentrations (µg/m³)**

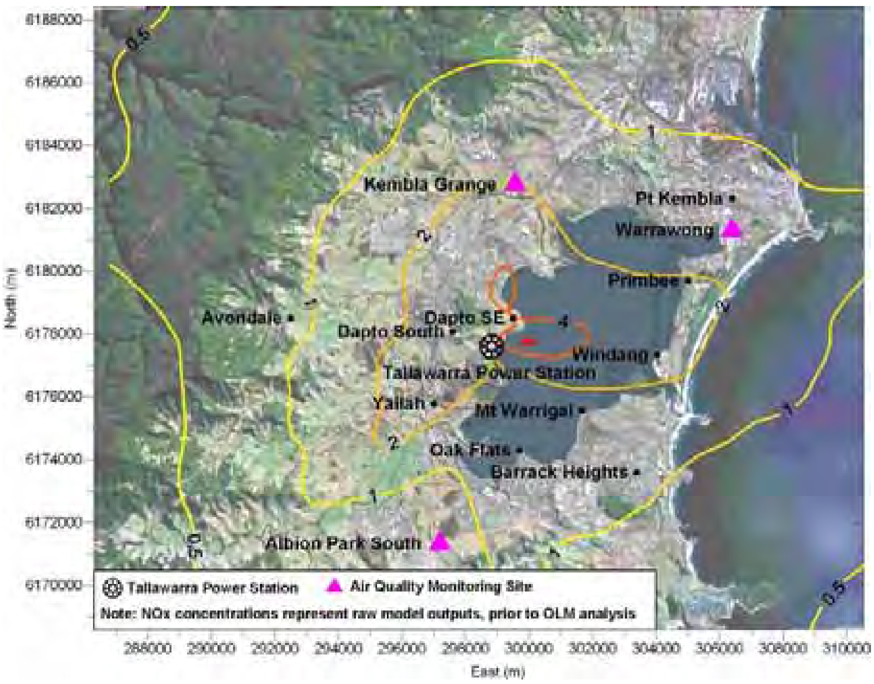


- **Figure 6-33: Tallawarra A Full Load and B CCGT Warm Start Hour 1 Incremental NO_X Annual Average Concentrations (µg/m³)**

- **Figure 6-34: Tallawarra A Warm Start Hour 1 and B CCGT Cold Start Hour 1 Incremental NO_X Maximum 1 hr Concentrations (µg/m³)**



- **Figure 6-35: Tallawarra A Warm Start Hour 1 and B CCGT Cold Start Hour 1 Incremental NO_X Annual Average Concentrations (µg/m³)**



7. Air Quality Impact Assessment - Regional Scale

In this section, O_3 concentrations are presented in terms of parts per billion (ppb) which are the units used by TAPM-GRS. In these terms, the DECC air quality criteria for 1-hour O_3 is 100 ppb.

This analysis investigated the impact of the Tallawarra power station on ozone concentrations at air quality monitoring sites in the Illawarra region, during the four summer periods (November to March) for the years 2000-01, 2003-04, 2004-05 and 2005-06. As described in **Section 5.6**, site-study days were selected according to the following criteria:

- Days displaying hours during which the observed hourly average concentrations recorded at the monitoring sites were > 60 ppb, and
- Within 20 ppb of TAPM base case concentration predicted for same hour at the relevant site.

Appendix C presents detailed results as comparisons of time-series plots for each summer period and selected days, showing ozone observations and predicted base case and test case concentrations.

The assessment has identified the following:

- 19 study days over the four summer periods with hours that met the criteria;
- 53 time-specific one-hour-events, that is, hours which met the criteria at one or more of the four monitoring sites. For example, on the study day 30th November 2000, three hours met the criteria at one or more sites; and
- 67 site-specific one-hour events. For example, on the study day 30th November 2000, five site-specific one-hour events occurred, namely, two one-hour events at Warrawong (12:00 and 15:00) and three at Wollongong (11:00, 12:00 and 15:00)

Table 7-1 provides a summary of the measured and predicted ozone concentrations at the four DECC monitoring locations for the four summer periods of interest. The test case included the Tallawarra power station. In summary, the analysis predicted there would be no significant increase (at most 2 ppb) to the average ozone concentrations as a result of Tallawarra power station (A and B). Increases to maximum ozone concentrations were predicted for 11 of the 16 statistical instances. At all sites, the predicted average and maximum ozone concentrations were greater than the measured concentrations.

Hourly average measured and predicted ozone concentrations are provided in **Appendix C**.

Table 7-1 Summary of measured and predicted ozone concentrations using TAPM-GRS

	Ozone (ppb)											
	Albion Park			Kembla Grange			Warrawong			Wollongong		
	Measured	Base case	Test case	Measured	Base case	Test case	Measured	Base case	Test case	Measured	Base case	Test case
Nov 2000 to Mar 2001												
Average	20	29	29	18	28	26	20	27	27	17	31	30
Maximum	90	290	363	106	479	687	99	464	505	87	1070	1063
Nov 2003 to Mar 2004												
Average	21	28	28	20	27	25	22	27	27	20	29	29
Maximum	112	269	299	115	388	494	115	883	1002	103	458	398
Nov 2004 to Mar 2005												
Average	20	25	25	19	24	21	20	25	24	18	26	25
Maximum	90	235	305	120	581	455	97	646	617	102	407	397
Nov 2005 to Mar 2006												
Average	18	26	26	19	25	23	20	25	24	18	27	27
Maximum	83	218	236	79	250	341	84	417	448	83	426	430

Table 7-2 provides information on the measured and predicted ozone concentrations for hours where the observation was above 60 ppb and the prediction was within 20 ppb of the observation, for at least one of the four monitoring locations.

Over the four summer periods, there was a total of 19 days which contained high ozone events that were reproduced well by TAPM-GRS. Daily time-series plots for each of these days, for each site are provided in **Appendix C**. These plots can be used to identify the occasions when the power station source is predicted to change the ozone concentrations at each site.

It could be said that any changes from the base case to the test case are a result of the new emission sources, since the modelled meteorology remain unchanged.

From the results from **Table 7-2** it was deduced that there were:

- 1 hour of decreased ozone, 10 hours of increased ozone and 2 hours of no change in ozone concentrations for well reproduced hours at Albion Park.
- 4 hours of decreased ozone, 5 hours of increased ozone and zero hours of no change in ozone concentrations for well reproduced hours at Kembla Grange.
- 6 hours of decreased ozone, 16 hours of increased ozone and 1 hour of no change in ozone concentrations for well reproduced hours at Warrawong.
- 9 hours of decreased ozone, 5 hours of increased ozone and 8 hours of no change in ozone concentrations for well reproduced hours at Wollongong.

Also, of the hours when modelled base case ozone concentrations exceeded 100 ppb, it was noted that no hours were predicted to increase under the test case.

There was one hour in the four summer modelling periods when test case ozone concentrations were predicted to result in an additional exceedance of the air quality criteria. This hour was hour 15 (3 pm) on 30 November 2000 when the following was predicted:

- An increase from the base case to the test case of 84 to 144 ppb at the Warrawong site.
- An increase from the base case to the test case of 78 to 249 ppb at the Wollongong site.

Table 7-2 Measured and predicted ozone concentrations for hours that were reproduced well by TAPM-GRS

Date and time	Albion Park					Kembla Grange					Warrawong					Wollongong				
	Measured	Base case	Test case	Difference	Change	Measured	Base case	Test case	Difference	Change	Measured	Base case	Test case	Difference	Change	Measured	Base case	Test case	Difference	Change
30/11/2000 11:00																66	67	58	-9	Decrease
30/11/2000 12:00											78	58	67	9	Increase	82	98	94	-4	Decrease
30/11/2000 15:00											69	84	144	60	Increase	64	78	249	171	Increase
12/12/2000 9:00											61	46	54	8	Increase					
12/12/2000 15:00																67	52	50	-2	Decrease
15/01/2001 14:00																64	69	58	-11	Decrease
15/11/2003 12:00						77	90	94	4	Increase										
15/11/2003 13:00						100	83	88	5	Increase										
15/11/2003 14:00	104	90	90	0	No change															
4/12/2003 13:00																62	44	44	0	No change
4/12/2003 14:00																81	73	78	5	Increase
4/12/2003 15:00											87	92	88	-4	Decrease	90	96	96	0	No change
4/12/2003 16:00	78	86	85	-1	Decrease	97	111	108	-3	Decrease	86	101	98	-3	Decrease	76	96	96	0	No change
4/12/2003 17:00	76	83	83	0	No change															
11/12/2003 14:00	61	41	42	1	Increase						75	63	70	7	Increase					
11/12/2003 15:00						67	70	78	8	Increase	70	77	88	11	Increase					
11/12/2003 16:00	67	64	72	8	Increase						66	52	62	10	Increase					
11/12/2003 17:00	71	57	65	8	Increase															
11/12/2003 18:00	61	68	79	11	Increase															
19/12/2003 11:00	62	54	56	2	Increase															
19/12/2003 15:00											89	75	72	-3	Decrease					
25/12/2004 12:00											64	74	76	2	Increase					
25/12/2004 13:00											74	55	57	2	Increase					

Date and time	Albion Park					Kembla Grange					Warrawong					Wollongong				
	Measured	Base case	Test case	Difference	Change	Measured	Base case	Test case	Difference	Change	Measured	Base case	Test case	Difference	Change	Measured	Base case	Test case	Difference	Change
10/01/2004 12:00											61	78	78	0	No change	69	65	64	-1	Decrease
10/01/2004 13:00	72	58	63	5	Increase	70	80	79	-1	Decrease										
10/01/2004 14:00						80	87	89	2	Increase										
10/01/2004 18:00											62	73	74	1	Increase					
21/01/2004 12:00						61	58	56	-2	Decrease	65	64	66	2	Increase					
21/01/2004 13:00	72	81	86	5	Increase															
21/01/2004 15:00																73	77	87	10	Increase
9/03/2004 13:00											73	93	101	8	Increase					
9/03/2004 15:00																60	60	60	0	No change
18/11/2004 13:00											62	53	54	1	Increase					
18/11/2004 15:00											63	71	76	5	Increase					
27/11/2004 11:00																67	59	58	-1	Decrease
27/11/2004 12:00																73	91	91	0	No change
30/11/2004 12:00																72	50	47	-3	Decrease
30/11/2004 13:00	77	88	112	24	Increase	82	69	72	3	Increase										
30/11/2004 14:00	90	84	102	18	Increase															
30/11/2004 23:00											69	52	48	-4	Decrease					
1/12/2004 0:00											70	51	48	-3	Decrease					
8/02/2005 12:00											66	82	83	1	Increase	73	66	64	-2	Decrease
8/02/2005 18:00						71	76	75	-1	Decrease										
15/02/2005 13:00																65	51	50	-1	Decrease
15/02/2005 14:00																65	61	65	4	Increase
21/12/2005 13:00																67	51	51	0	No change
21/12/2005 16:00																72	60	60	0	No change
21/12/2005 17:00																79	67	67	0	No change
14/01/2006 14:00											60	74	72	-2	Decrease					
14/01/2006 15:00	70	83	85	2	Increase															

Date and time	Albion Park					Kembla Grange					Warrawong					Wollongong				
	Measured	Base case	Test case	Difference	Change	Measured	Base case	Test case	Difference	Change	Measured	Base case	Test case	Difference	Change	Measured	Base case	Test case	Difference	Change
17/02/2006 15:00											68	87	95	8	Increase					
17/02/2006 18:00																72	73	78	5	Increase
17/02/2006 19:00											73	54	55	1	Increase					

Note: Ozone concentrations in parts per billion (ppb)

Table 7-3 presents a summary of the predicted change in plume duration (in hours) from the base case to the test case. In this assessment, the duration of the plume was defined as the number of hours in the day when the predicted ozone concentrations were above 60 ppb.

The analysis identified that as a result of the Tallawarra power station (A and B), the duration of the high ozone plume events increased on 13 occasions (where a change in the number of hours at one site represented one occasion), decreased on 8 and was unchanged on the remaining 55 occasions.

- **Table 7-3 Predicted Change in Plume Duration for Base Case and Test Case**

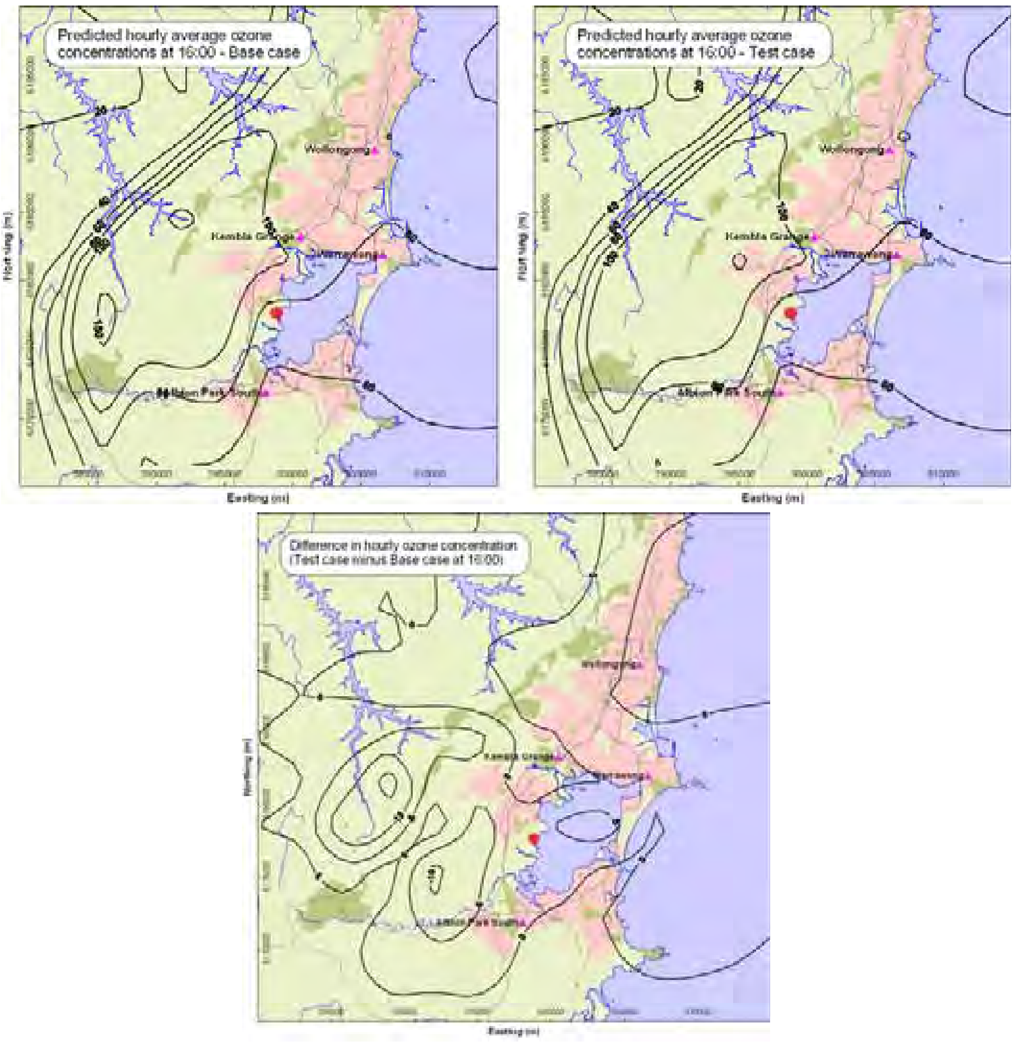
Date	Number of hours											
	Albion Park			Kembla Grange			Warrawong			Wollongong		
	Base case	Test case	Change in plume duration	Base case	Test case	Change in plume duration	Base case	Test case	Change in plume duration	Base case	Test case	Change in plume duration
30-Nov-00	5	5	0	4	4	0	6	7	1	5	4	-1
12-Dec-00	0	1	1	1	3	2	1	1	0	3	3	0
15-Jan-01	8	7	-1	8	8	0	9	10	1	8	6	-2
15-Nov-03	12	12	0	11	11	0	11	11	0	4	4	0
4-Dec-03	10	10	0	9	8	-1	10	9	-1	9	9	0
11-Dec-03	2	4	2	4	5	1	7	8	1	0	0	0
19-Dec-03	4	4	0	3	4	1	6	6	0	2	2	0
25-Dec-03	5	5	0	6	6	0	15	15	0	2	2	0
10-Jan-04	8	9	1	9	10	1	10	9	-1	5	5	0
21-Jan-04	7	7	0	7	7	0	8	8	0	4	4	0
9-Mar-04	2	2	0	2	2	0	4	4	0	0	0	0
18-Nov-04	2	2	0	0	0	0	5	5	0	0	0	0
27-Nov-04	12	12	0	11	11	0	10	10	0	8	8	0
30-Nov-04	12	11	-1	14	14	0	14	14	0	6	6	0
8-Feb-05	10	10	0	10	10	0	10	11	1	6	6	0
15-Feb-05	2	2	0	7	6	-1	11	11	0	6	6	0
21-Dec-05	8	8	0	8	9	1	12	12	0	3	4	1
14-Jan-06	7	7	0	8	8	0	8	8	0	8	8	0
17-Feb-06	7	7	0	10	10	0	10	10	0	8	8	0

From the results in **Table 7-2** there was only one hour in the four modelling periods where high ozone levels were reproduced well at all four monitoring sites simultaneously. This hour was at 4 pm (16:00) on 4 December 2003. There were no other hours in the modelling simulations in which measured concentrations exceeded 60 ppb and the TAPM base case model prediction was within 20 ppb at all four monitoring locations.

Further, there were no hours in the model simulations where high ozone levels were reproduced well (by the DECC model method) at three sites simultaneously. Seven days had hours which satisfied the model method simultaneously at two sites simultaneously; 30 Nov 2000, 4 Dec 2003, 11 Dec 2003, 10 Jan 2004, 21 Jan 2004, 30 Nov 2004 and 8 Dec 2005. The limited number of hours where the criteria was met at more than one site simultaneously suggests that the spatial variation in ozone levels has not been consistently well represented by the model.

Contour plots for 4 December 2003 are shown below in **Figure 7-1**. The contour plots show the spatial variation in ozone concentrations for 4 December 2003, hour 16. It can be seen that ozone levels were predicted to exceed the 100 ppb criteria in many parts of the study area at this time. Actual measured ozone concentrations at this time ranged between 76 and 97 ppb.

Also shown in **Figure 7-1** is a plot showing the difference between the test case and base case (test case minus base case). The difference plot shows that ozone concentrations are predominantly lower for the test case at this time, with decreases of up to approximately 10 ppb in some areas. This hour was found to be reproduced well by the model at the four monitoring locations, however, it is not known whether the model is also performing well at other locations.



■ **Figure 7-1: Predicted ozone concentrations on 4 December 2003 (ppb)**

8. Summary of Results

This section provides a summary of the modelling results in order to capture the worst case impacts hours for each scenario. It is noted that while the actual operating regime of Tallawarra A and B currently is unknown, the air dispersion modelling undertaken assumes a worst-case situation where the plant is assumed to operate at 100 percent load on a continuous basis with NO_X emission concentrations at 25 ppmv. Where air quality impacts are shown to comply with relevant criteria under this worst-case scenario, it follows that impacts will also be acceptable under any operating regime less than 100 percent load on a continuous basis.

In summary, the modelling results show that, at the sensitive receptor locations, the cumulative impacts of the extension to Tallawarra A power station, as either Tallawarra B1 and B2 OCGT plant or as Tallawarra B CCGT plant, are predicted to be within the DECC criteria for nitrogen dioxide (NO_2), ozone (O_3) as a measure of photochemical smog, sulphur dioxide (SO_2), and particulate matter (as PM_{10}). These results are discussed in further detail below.

8.1. Tallawarra A CCGT

The maximum cumulative NO_2 impacts across the study area, resulting from Tallawarra A, are predicted to meet the DECC criteria for the hourly-average concentration (246 μg/m^3) and the annual average concentration (62 μg/m^3) for all the modelled emission scenarios in this assessment (refer to **Table 8-1**.)

Table 8-1 Tallawarra A CCGT and B OCGT Summary Modelling Results

Air Pollutant	Emission Scenario - Worst Case Conditions	NSW DECC Criteria μg/m3	Maximum Incremental Concentration at Sensitive Receptors (Due to the Power Station)		Maximum Cumulative Concentration at Sensitive Receptor		Maximum Cumulative Concentration across Modelling Domain	
			Conc. μg/m3	% of Criteria	Conc. μg/m3	% of Criteria	Conc.	% of Criteria
NO_2 (1-Hr)	Full Load	246	49 Yallah	20%	67 Mt Warrigal	27%	151	61%
NO_2 (Annual)	Full Load	62					16	26%
NO_2 (1-Hr)	Cold Start Hr 1	246	102 Avondale	41%	180 Dapto South	73%	199	81%
NO_2 (Annual)	Cold Start Hr 1	62					21	34%
SO_2 (1-Hr)	Full Load	570	2 (increment)	< 1%	2 (increment)	< 1%	4 (increment)	< 1%
SO_2 (Annual)	Full Load	60					0.1 (increment)	< 1%

Air Pollutant	Emission Scenario - Worst Case Conditions	NSW DECC Criteria µg/m3	Maximum Incremental Concentration at Sensitive Receptors (Due to the Power Station)		Maximum Cumulative Concentration at Sensitive Receptor		Maximum Cumulative Concentration across Modelling Domain	
			Conc. µg/m3	% of Criteria	Conc. µg/m3	% of Criteria	Conc.	% of Criteria
PM_{10} (24-Hr)	Full Load	50	0.1 (increment)	< 1%	0.1 (increment)	< 1%	2 (increment)	< 4%
PM_{10} (Annual)	Full Load	30					0.1 (increment)	< 1%

Note that in **Table 8-1**, the cumulative concentrations for 1-hour impacts at sensitive receptors were derived by adding the highest NO_2 increment due to the plume (resulting from OLM analysis of raw model NOx outputs) and background NO_2 concentration recorded for the corresponding hour at Kembla Grange in corresponding year, modelling year 2002. Annual impacts for NO2 were derived by adding the highest incremental annual average concentration across the modelling domain due to the plume (assuming conservatively that all NOx output is NO_2) and the annual average concentration of 15 $\mu g/m^3$ recorded at Kembla Grange for the monitoring year 2002.

8.1.1. Comparison of Results with the Tallawarra CCGT Environmental Impact Assessment

This following discussion summarises the air dispersion modelling results, prepared as part of the Environmental Impact Statement for the CCGT Plant (EIS, Azzi, *et al.* 1998), and compares the modelling results with the results of the current assessment, referred to as Tallawarra A (Full Load).

In the EIS (Azzi, *et al.* 1998), Section 2 of the air quality assessment describes the impacts on ground level concentrations of air pollutants which were predicted to result from the plumes emitted from the (then-proposed) Tallawarra CCGT chimney. In summary, the report concluded that the total ground level concentrations resulting from the impact of the Tallawarra CCGT would meet the relevant criteria.

The EIS assumed that the ratios NO_2:NO_X at the point of maximum ground-level concentration were less than 0.25 for night time conditions and 0.5 for daytime conditions (Azzi *et al.* 1998). The EIS reported that Tallawarra CCGT full load operations would result in maximum ground level concentrations of NO_X ranging from 0.5 pphm (10 $\mu g/m^3$) to 4.1 pphm (84 $\mu g/m^3$) and NO_2 concentrations ranging from 0.12 pphm (3 $\mu g/m^3$) to 1.02 pphm (21 $\mu g/m^3$) (Azzi *et al.* 1998, Tables 4 and 6).

A comparison between the modelling results from the EIS (Azzi *et al.* 1998) and this assessment is limited by the difference in the modelling procedures. The plume dispersion modelling for the EIS, conducted by a CSIRO photochemical smog team, based at North Ryde (Azzi *et al.* 1998), used two dispersion models to investigate near-field dispersion of various types of meteorological conditions and emission scenarios: namely the United States Environmental Protection Agency Industrial Source Complex dispersion model (ISC3, USEPA 1995) and a semi-empirical dispersion model developed for investigation of power station emission in Queensland and NSW, by Lunney and Best (1992). The current modelling assessment has used TAPM, the most recent dispersion model developed by CSIRO. Vast improvements in computing capacity has allowed TAPM to provide a more complex and scientifically accurate simulation of biophysical processes affecting air flows and pollution dispersion, compared with models applied in the EIS (Azzi *et al.* 1998). The differences are demonstrated by a comparison of the spatial dispersion patterns of ground level concentrations output by the respective models (see Azzi *et al.* 1998 and the current report).

Nevertheless, the NO_X results from the EIS (Azzi *et al.* 1998) are compared most appropriately with the NO_2 predictions for Tallawarra A in the current assessment when the analysis assumes that the NO_2 component of modelled maximum ground level concentrations represents 100 percent of the NO_X impact. Based on this assumption, the current study predicts maximum hourly concentrations of 81 $\mu g/m^3$ (3.9 pphm) which compares well with maximum hourly concentrations of 84 $\mu g/m^3$ (4.1 pphm) predicted by the EIS (Azzi *et al.* 1998).

This review concludes that, although a comparison between the results of the EIS and the current assessment is limited by the differences in the modelling applications, the results of modelling Tallawarra A CCGT plant (full load, using TAPM in tracer mode and assuming that the NO_2 component of modelled maximum ground level concentrations represents 100 percent of the NO_X impact), compare well with the air dispersion modelling results for the CCGT presented in the EIS (Azzi, *et al.* 1998).

8.2. Tallawarra A CCGT and Tallawarra B OCGT

Results indicate that the impact on NO_2 concentrations, resulting from the Tallawarra A CCGT plant in combination with the Tallawarra B1 and B2 OCGT plant (diesel fired) under normal operating conditions, as well as a set of start-up and part load operating conditions, would be within the DECC criteria set for NO_2 1-hour average concentration (246 µg/m^3) and the annual average concentration (62 µg/m^3) (refer to **Table 8-2**).

- **Table 8-2 Tallawarra A CCGT and B CCGT Summary Modelling Results**

Air Pollutant	Emission Scenario - Worst Case Conditions	NSW DECC Criteria µg/m3	Maximum Incremental Concentration at Sensitive Receptors (Due to the Power Station)		Maximum Cumulative Concentration at Sensitive Receptors		Maximum Cumulative Concentration across Modelling Domain	
			Conc µg/m3	% of Criteria	Conc µg/m3	% of Criteria	Conc µg/m3	% of Criteria
NO_2 (1-Hr)	Full Load	246	75 Dapto South	30%	78 Dapto South	31%	151	61%
NO_2 (Annual)	Full Load	62					17	27%
NO_2 (1-Hr)	A Full Load B1&B2 Startup	246	75 Dapto South	30%	78 Dapto South	31%	153	62%
NO_2 (Annual)	A Full Load B1&B2 Startup	62					16	26%
NO_2 (1-Hr)	A Hot Start B1&B2 Startup	246	75 Dapto South	30%	78 Dapto South	31%	155	63%
NO_2 (Annual)	A Hot Start B1&B2 Startup	62					18	29%
SO_2 (1-Hr)	Full Load	570			8	2%	26 (increment)	< 5%
SO_2 (Annual)	Full Load	60					0.2 (increment)	< 1%
PM_{10} (24-Hr)	Full Load	50			2	< 5%	4 (increment)	< 8%
PM_{10} (Annual)	Full Load						0.2 (increment)	< 1%

Modelling results predicted for the Tallawarra A CCGT plant operating alone under normal operating conditions in combination with the Tallawarra B OCGT plant (diesel fired) indicated that SO_2 and PM_{10} concentrations would be very low and within the criteria set by the NSW DECC.

Note in **Table 8-2**, the cumulative concentrations for 1-hour impacts at sensitive receptors were derived by adding the highest NO_2 increment due to the plume (resulting from OLM analysis of raw model NOx outputs) and background NO_2 concentration recorded for the corresponding hour at Kembla Grange in corresponding year, modelling year 2002. Annual impacts for NO2 were derived by adding the highest incremental annual average concentration across the modelling domain due to the plume (assuming conservatively that all NOx output is NO_2) and the annual average concentration of 15 $\mu g/m^3$ recorded at Kembla Grange for the monitoring year 2002.

8.3. Tallawarra A CCGT and B CCGT

The assessment of Tallawarra A CCGT plant in combination with Tallawarra B CCGT plant assumes that the stack parameters of Tallawarra B CCGT plant are identical to Tallawarra A CCGT. Emission scenarios include normal operating conditions as well as a set of start-up and part load operating conditions (refer to **Table 8-3**).

- **Table 8-3 Tallawarra A CCGT and B CCGT Summary Modelling Results**

Air Pollutant	Emission Scenario - Worst Case Conditions	NSW DECC Criteria µg/m3	Maximum Incremental Concentration at Sensitive Receptors (Due to the Power Station)		Maximum Cumulative Concentration at Sensitive Receptors		Maximum Cumulative Concentration across Modelling Domain	
			Conc µg/m3	% of Criteria	Conc µg/m3	% of Criteria	Units	% of Criteria
NO_2 (1-Hr)	Full Load	246	68 Avondale	28%	83 Dapto South	34%	161	65%
NO_2 (Annual)		62					18	29%
NO_2 (1-Hr)	A Full Load + B Cold Start Hr 1	246	116 Yallah	47%	127 Yallah	62%	199	81%
NO_2 (Annual)		62					23	37%
NO_2 (1-Hr)	A Warm Start Hr 1 + B Cold Start Hr 1	246	93 Mt Warrigal	40%	98 Mt Warrigal	40%	205	83%
NO_2 (Annual)		62					20	32%

Note in **Table 8-3**, the cumulative concentrations for 1-hour impacts at sensitive receptors were derived by adding the highest NO_2 increment due to the plume (resulting from OLM analysis of raw model NOx outputs) and background NO_2 concentration recorded for the corresponding hour at Kembla Grange in corresponding year, modelling year 2002. Annual impacts for NO2 were derived by adding the highest incremental annual average concentration across the modelling domain due to the plume (assuming conservatively that all NOx output is NO_2) and the annual average concentration of 15 $\mu g/m^3$ recorded at Kembla Grange for the monitoring year 2002.

8.4. Regional Photochemical Impacts of Tallawarra A CCGT and B OCGT using TAPM-GRS

This assessment methodology, prescribed by the DECC, used photochemical modelling to evaluate a base case impact in the Illawarra of existing emissions of NO_X and VOCs from the whole of the Sydney GMR (excluding Tallawarra power station) and compared modelled results with ozone concentrations at the four DECC air quality monitoring sites in the Illawarra region. Site-study days were selected according to the following criteria:

- Days displaying hours during which the observed hourly average concentrations recorded at the monitoring sites were > 60 ppb and within 20 ppb of TAPM Base Case concentration predicted for same hour at the relevant site.

This screening of modelled and observed ozone concentrations at the four Illawarra air quality monitoring sites during the months of November to March, inclusive, for the four summer periods 2000-2001, 2003-2004 and 2005-2006 identified 19 days where high ozone concentration events were reproduced well by TAPM-GRS.

Secondly, test case modelling investigated the impact on ozone concentrations resulting from the additional NO_X emissions from Tallawarra A CCGT and Tallawarra B1 and B2 OGCT. The analysis compared modelled base case and test case ozone impacts for the site-study hours as well as the duration of modelled ozone concentrations over 60 ppb.

For days which contained high ozone concentration hours that were reproduced well, the analysis showed that, as a result of the Tallawarra power station (A and B), the duration of the high ozone plume events increased on 13 occasions, decreased on 8 and was unchanged on the remaining 55 occasions.

This assessment methodology, prescribed by the DECC, allowed analysis of the change in individual ozone events. However, it was shown (**Table 7-1**) that TAPM-GRS over-predicted the average and maximum ozone concentrations at each DECC monitoring location. Nevertheless, the relative difference in the ozone concentrations in the modelled base case compared to the test case provides quantified evidence that the change in the risk of ozone exposure in populated areas due to NO_X emissions from Tallawarra A and B is minimal.

9. Conclusions

TRUenergy has recently commissioned a 400 MW combined cycle gas turbine (CCGT) power plant (Tallawarra A), on the site of the former Tallawarra coal-fired power station on Lake Illawarra. TRUenergy is proposing an extension to the power station (Tallawarra B).

This assessment has applied the CSIRO air pollution dispersion model, TAPM, to investigate the air quality impacts of a range of emission scenarios for Tallawarra A and Tallawarra B operating at full load conditions as well as under a selected range of start up and part load conditions.

The air pollutants investigated are:

- Nitrogen dioxide (NO_2);
- Ozone (O_3) as a measure of photochemical smog;
- Sulphur dioxide (SO_2); and
- Particulate matter (as PM_{10}, particles with diameters less than 10 micrometers, $\mu g/m^3$).

Analysis of the modelling results, by the ozone limiting method (NSW DEC, 2005), shows that the maximum cumulative concentrations, at the sensitive receptor locations resulting from the extension to Tallawarra power station, as either Tallawarra B OCGT plant or as Tallawarra B CCGT plant, are predicted to be within the DECC criteria for nitrogen dioxide (NO_2), ozone (O_3) as a measure of photochemical smog, sulphur dioxide (SO_2), and particulate matter (as PM_{10}).

For both options for Tallawarra B, either OCGT or CCGT, the maximum NO_2 cumulative ground level concentrations are predicted to occur during hours of relatively low incremental impacts from the power station, combined with high background concentrations. The highest incremental impacts of the power station are predicted to occur during hours of relatively low background concentrations.

Analysis of individual ozone events, during five-month periods over four summers predicted that the additional emissions from Tallawarra A and B OCGT would result in predominantly no change in high ozone plume duration events. There were a small number of hours with predicted increased or decreased duration of high ozone plume concentration events.

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Appendix A – Tallawarra A–Start Up Emissions

A.1 Tallawarra A – GT26 (CCGT)

Table A-1 – Cold Start

Event	Time	Load	Duration	Duration	Emission Rate	Emissions	Flow	Temp
	mins	%	m	H	kg/h	Kg	m3/s	C
Turning gear	0						0	
Ignition	10	0	10	0.167	0.0	0.0	295	
Synch	16	0	6	0.1	209.2	20.9	295	40
Hold	22	5	6	0.1	209.2	20.9	295	40
Hold	27	5	5	0.083	209.2	17.4	295	40
Loading	30	5	3	0.05	209.2	10.5	295	40
Hold	36	5	6	0.1	209.2	20.9	295	40
Hold	42	5	6	0.1	209.2	20.9	295	40
Hold	48	5	6	0.1	209.2	20.9	295	40
Hold	54	5	6	0.1	209.2	20.9	295	40
Hold	60	5	6	0.1	209.2	20.9	295	40
Hold	66	5	6	0.1	209.2	20.9	295	60
Hold	72	5	6	0.1	209.2	20.9	295	60
Hold	78	5	6	0.1	209.2	20.9	295	60
Hold	84	5	6	0.1	209.2	20.9	295	60
Hold	90	5	6	0.1	209.2	20.9	295	60
Hold	96	5	6	0.1	209.2	20.9	295	60
Hold	98	5	2	0.033	209.2	7.0	295	60
Loading	101	30	3	0.05	49.2	2.5	315	60
Hold	107	30	6	0.1	49.2	4.9	315	60
Hold	113	30	6	0.1	49.2	4.9	315	60
Loading	115	40	2	0.033	57.8	1.9	356	60
Loading	117	50	2	0.033	65.7	2.2	389	60
Loading	120	60	3	0.05	74.0	3.7	426	60
Loading	122	70	2	0.033	82.4	2.7	464	80
Loading	124	80	2	0.033	90.9	3.0	509	80
Loading	126	90	2	0.033	99.4	3.3	570	80
Loading	128	100	2	0.033	109.5	3.7	625	80
Hold	134	100	6	0.1	109.5	11.0	625	80
Hold	140	100	6	0.1	109.5	11.0	625	80
Hold	146	100	6	0.1	109.5	11.0	625	80
Hold	152	100	6	0.1	109.5	11.0	625	80
Hold	158	100	6	0.1	109.5	11.0	625	80
Hold	164	100	6	0.1	109.5	11.0	625	80
Hold	170	100	6	0.1	109.5	11.0	625	80
Hold	176	100	6	0.1	109.5	11.0	625	80
Hold	180	100	4	0.067	109.5	7.3	625	80
Total			**180**	**3**		**434.6**		

Table A-2 – Warm Start

Event	Time	Load	Duration	Duration	Emission Rate	Emissions	Flow	Temp
	mins	%	m	H	kg/h	Kg	m3/s	C
Turning gear	0							
Ignition	10	0	10	0.167			295	
Synch	16	0	6	0.1	180.3	18.0	295	70
Hold	21	5	5	0.083	180.3	15.0	295	70
Hold	27	5	6	0.1	180.3	18.0	295	70
Loading	30	15	3	0.05	180.3	9.0	295	70
Hold	36	15	6	0.1	180.3	18.0	295	70
Hold	42	15	6	0.1	180.3	18.0	315	70
Hold	48	15	6	0.1	180.3	18.0	315	70
Hold	54	15	6	0.1	180.3	18.0	356	70
Hold	60	15	6	0.1	180.3	18.0	389	70
Loading	63	30	3	0.05	49.2	2.5	315	80
Hold	68	30	5	0.083	49.2	4.1	315	80
Hold	73	30	5	0.083	49.2	4.1	315	80
Loading	75	40	2	0.033	57.8	1.9	356	80
Loading	77	50	2	0.033	65.7	2.2	389	80
Loading	80	60	3	0.05	74.0	3.7	426	80
Loading	82	70	2	0.033	82.4	2.7	464	80
Loading	85	80	3	0.05	90.9	4.5	509	80
Loading	88	90	3	0.05	99.4	5.0	570	80
Loading	91	100	3	0.05	109.5	5.5	625	80
Hold	98	100	7	0.117	109.5	12.8	625	80
Hold	104	100	6	0.1	109.5	11.0	625	80
Hold	110	100	6	0.1	109.5	11.0	625	80
Hold	116	100	6	0.1	109.5	11.0	625	80
Hold	120	100	4	0.067	109.5	7.3	625	80
Total			**120**	**2**	**0.0**	**239.4**		

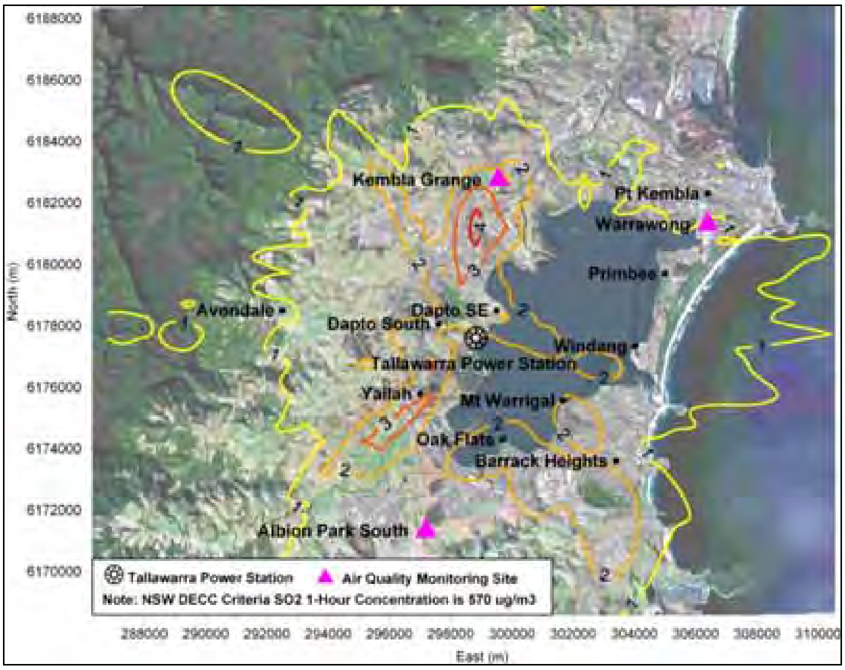
Table A-3 – Hot Start

Event	Time	Load	Duration	Duration	Emission Rate	Emissions	Flow	Temp
	mins	%	m	H	kg/h	Kg	m3/s	C
Turning gear	0						0	
Ignition	10	0	10	0.1667	0		295	
Synch	16	0	6	0.1	136.8	13.7	295	80
Loading	19	15	3	0.05	136.8	6.8	295	80
Loading	20	20	1	0.0167	22.80	0.4	295	80
Loading	23.5	30	3.5	0.0583	49.2	2.9	315	80
Loading	24	40	0.5	0.0083	57.8	0.5	356	80
Loading	27	50	3	0.05	65.7	3.3	389	80
Loading	28	60	1	0.0167	74.0	1.2	426	80
Loading	31	70	3	0.05	82.4	4.1	464	80
Hold	34	70	3	0.05	82.4	4.1	464	80
Loading	38	80	4	0.067	90.9	6.1	509	80
Loading	42.5	90	4.5	0.075	99.4	7.5	570	80
Loading	47	100	4.5	0.075	109.5	8.2	625	80
Loading	52	100	5	0.083	109.5	9.1	625	80
Hold	57	100	5	0.083	109.5	9.1	625	80
Hold	60	100	3	0.05	109.5	5.5	625	80
Total			**60**	**1**		**82.5**		

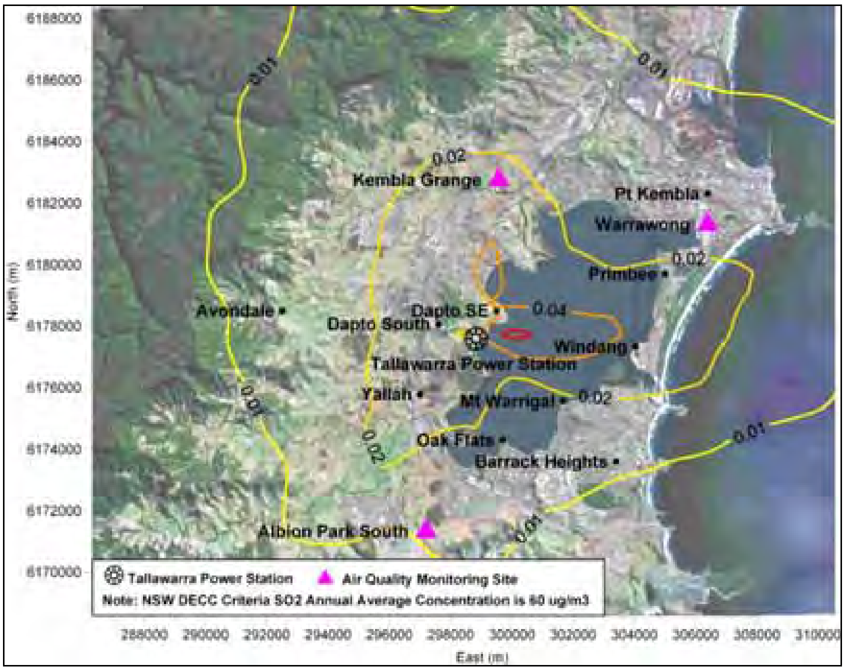
Appendix B – TAPM Results for SO_2 and PM_{10}

B.1 Incremental SO_2 Results for CCGT (Case #1)

B.1.1 SO_2 Maximum 1 hr Concentrations (µg/m^3)

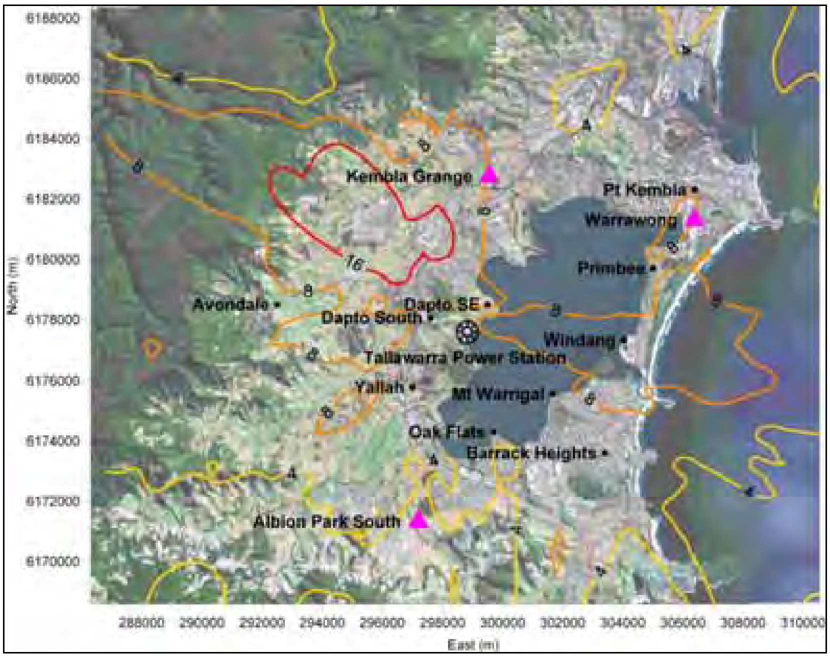


B.1.2 SO_2 Annual Average Concentrations (µg/m^3)

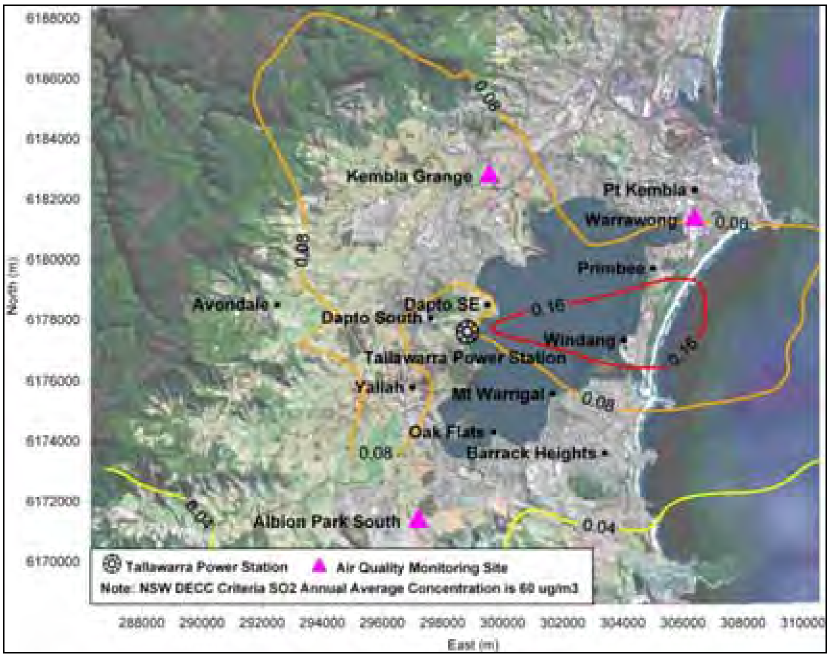


B.2 Incremental SO_2 Results for CCGT and OGCT (Case #2)

B.2.1 SO_2 Maximum 1 hr Concentrations (µg/m^3)

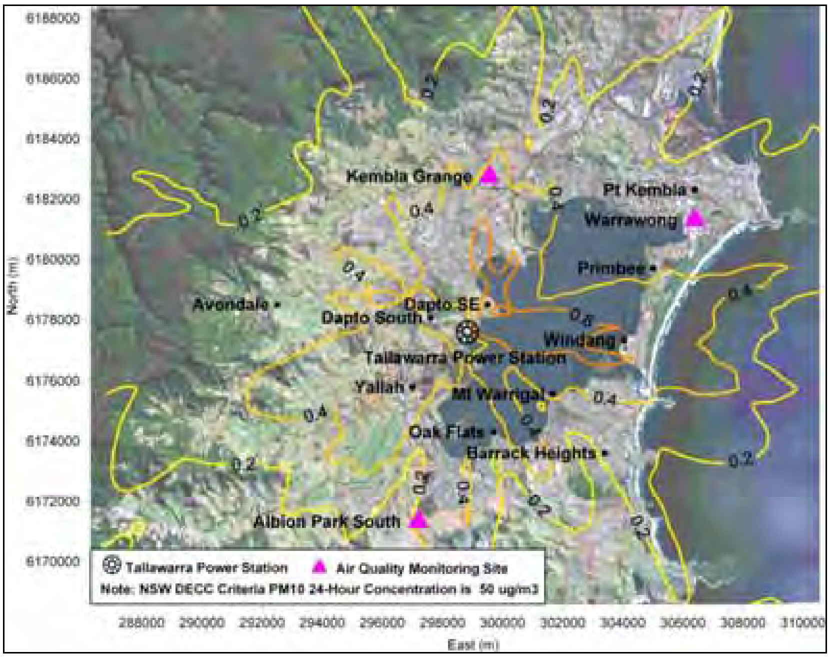


B.2.2 SO_2 Annual Average Concentrations (µg/m^3)



B.3 Incremental PM_{10} Results for CCGT (Case #1)

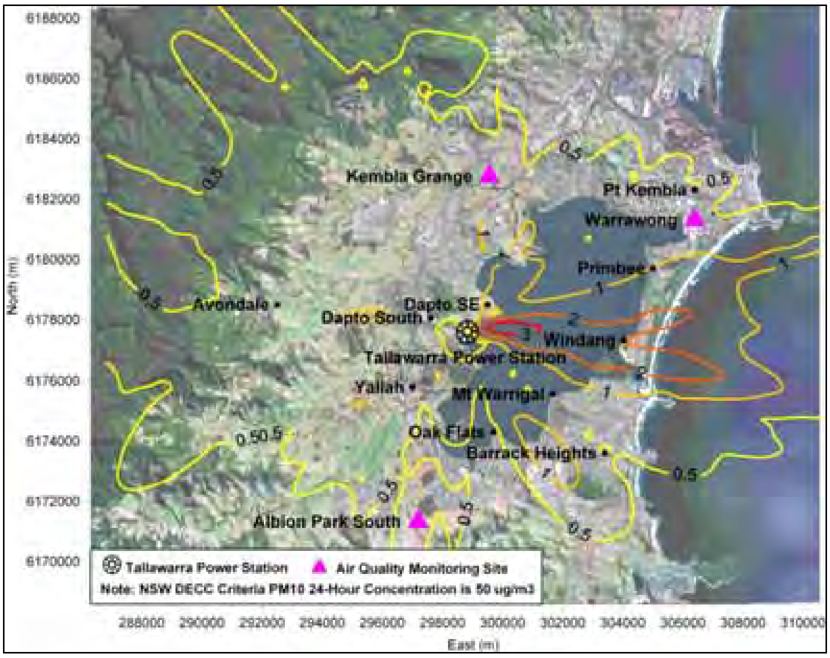
B.3.1 PM_{10} Maximum 24 hr Concentrations (µg/m³)



B.3.2 PM_{10} Annual Average Concentrations (µg/m³)

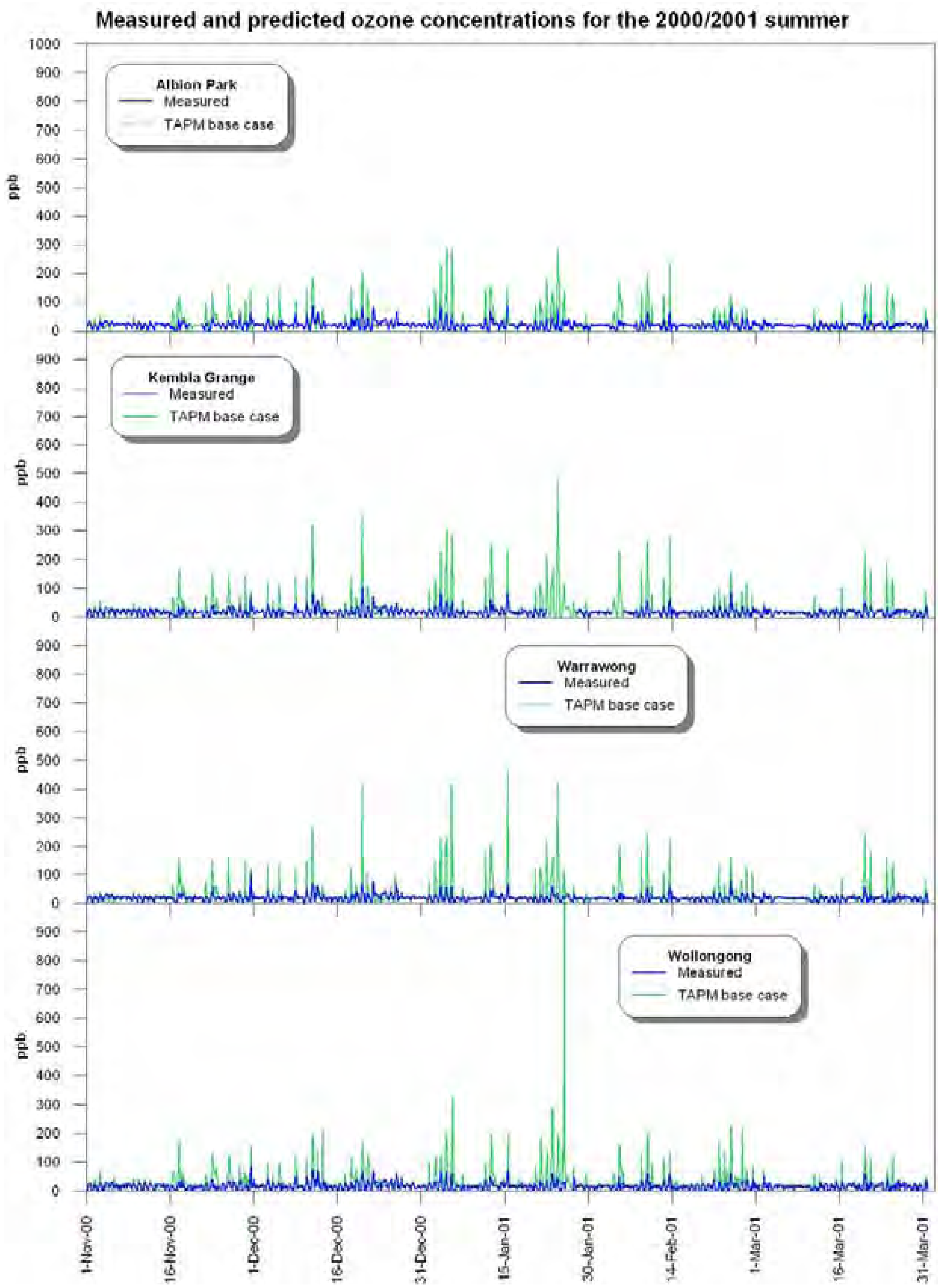
B.4 Incremental PM_{10} Results for CCGT and OCGT (Case #2)

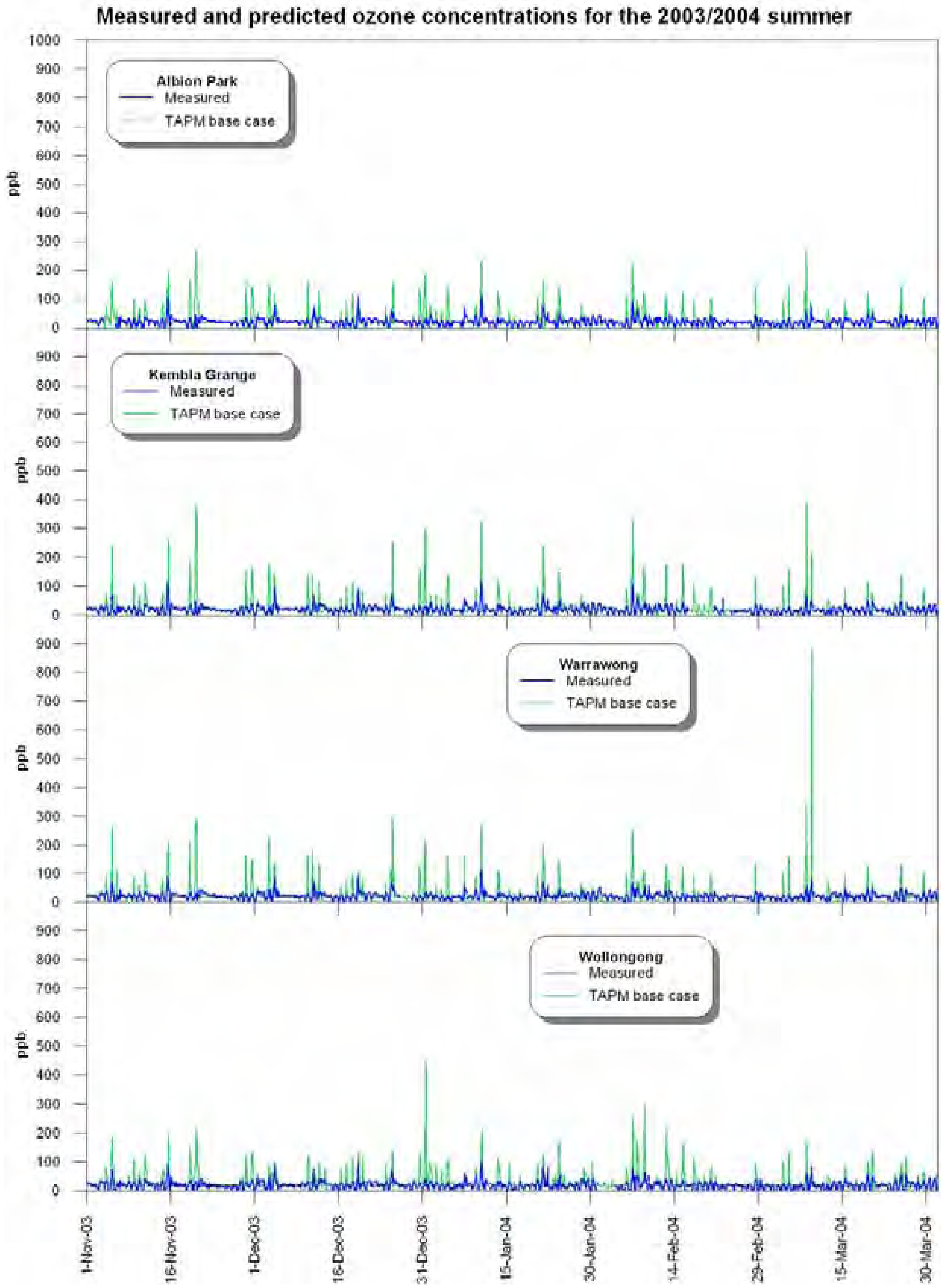
B.4.1 PM_{10} Maximum 24 hr Concentrations (µg/m$_3$)

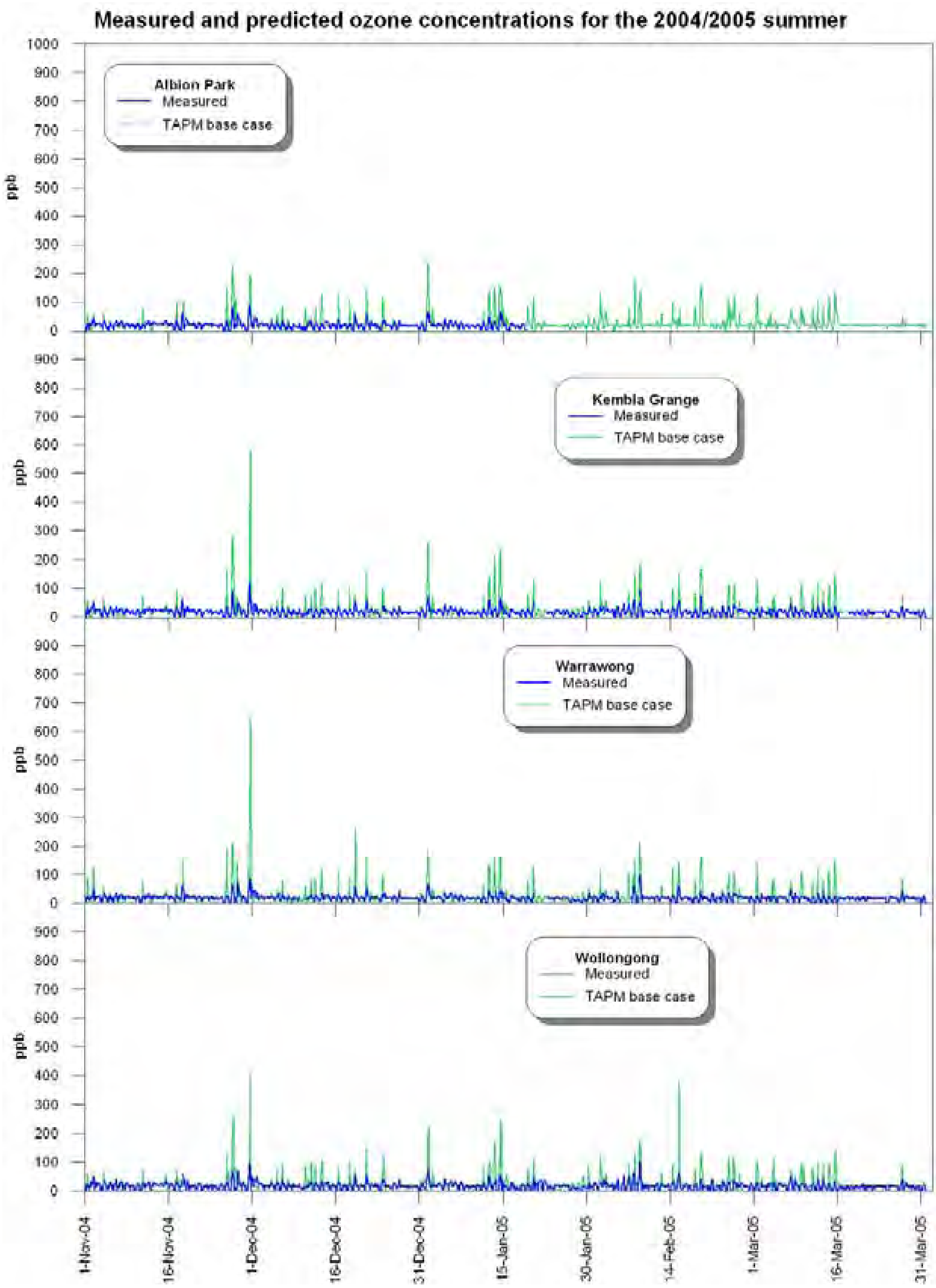


B.4.2 PM_{10} Annual Average Concentrations (µg/m^3)

Appendix C Regional Photochemical Modelling with TAPM-GRS


Measured and predicted ozone concentrations for the 2000/2001 summer
Albion Park
Measured
TAPM base case
Kembla Grange
Measured
TAPM base case
Warrawong
Measured
TAPM base case
Wollongong
Measured
TAPM base case
ppb
1-Nov-00
16-Nov-00
1-Dec-00
16-Dec-00
31-Dec-00
15-Jan-01
30-Jan-01
14-Feb-01
1-Mar-01
16-Mar-01
31-Mar-01


Measured and predicted ozone concentrations for the 2003/2004 summer
Albion Park
Measured
TAPM base case
Kembla Grange
Measured
TAPM base case
Warrawong
Measured
TAPM base case
Wollongong
Measured
TAPM base case
ppb
1000
900
800
700
600
500
400
300
200
100
0
1-Nov-03
16-Nov-03
1-Dec-03
16-Dec-03
31-Dec-03
15-Jan-04
30-Jan-04
14-Feb-04
29-Feb-04
15-Mar-04
30-Mar-04


Measured and predicted ozone concentrations for the 2004/2005 summer
Albion Park
Measured
TAPM base case
Kembla Grange
Measured
TAPM base case
Warrawong
Measured
TAPM base case
Wollongong
Measured
TAPM base case
ppb
1-Nov-04
16-Nov-04
1-Dec-04
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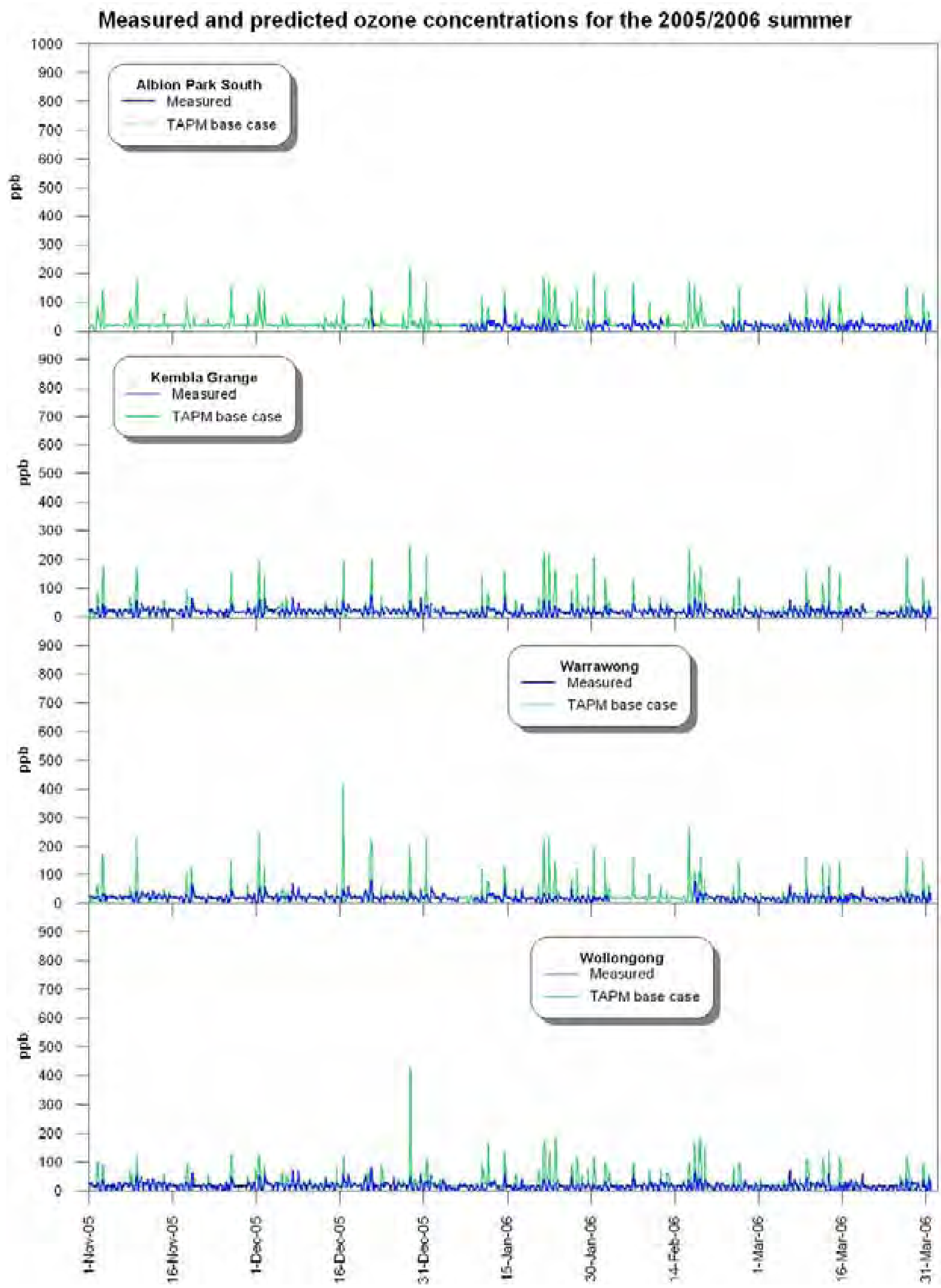
16-Mar-05
31-Mar-05


Measured and predicted ozone concentrations for the 2005/2006 summer
Albion Park South
Measured
TAPM base case
Kembla Grange
Measured
TAPM base case
Warrawong
Measured
TAPM base case
Wollongong
Measured
TAPM base case
ppb
1-Nov-05
16-Nov-05
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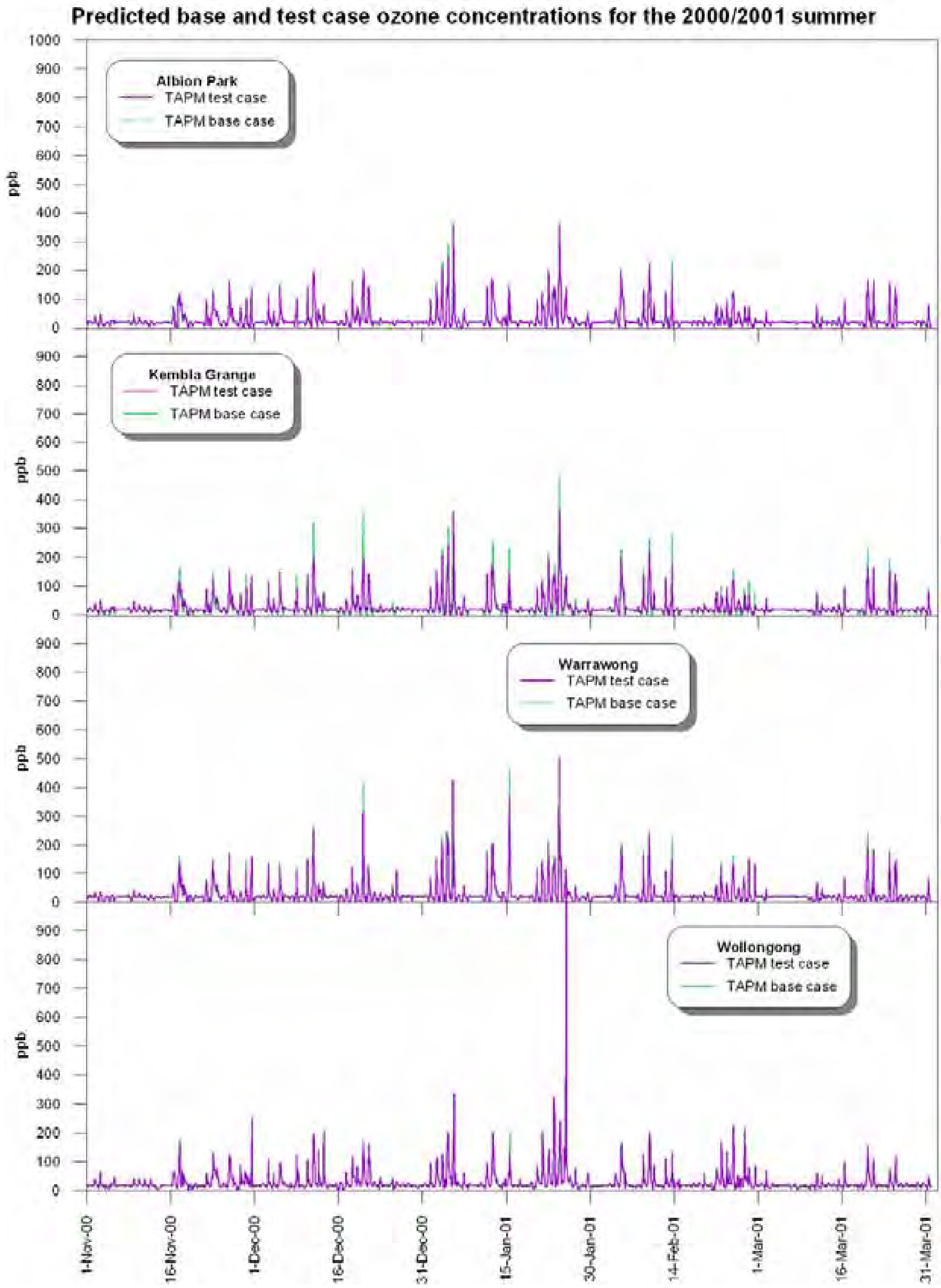
16-Mar-06
31-Mar-06


Predicted base and test case ozone concentrations for the 2000/2001 summer
Albion Park
TAPM test case
TAPM base case
Kembla Grange
TAPM test case
TAPM base case
Warrawong
TAPM test case
TAPM base case
Wollongong
TAPM test case
TAPM base case
ppb
1000
900
800
700
600
500
400
300
200
100
0
1-Nov-00
16-Nov-00
1-Dec-00
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30-Jan-01
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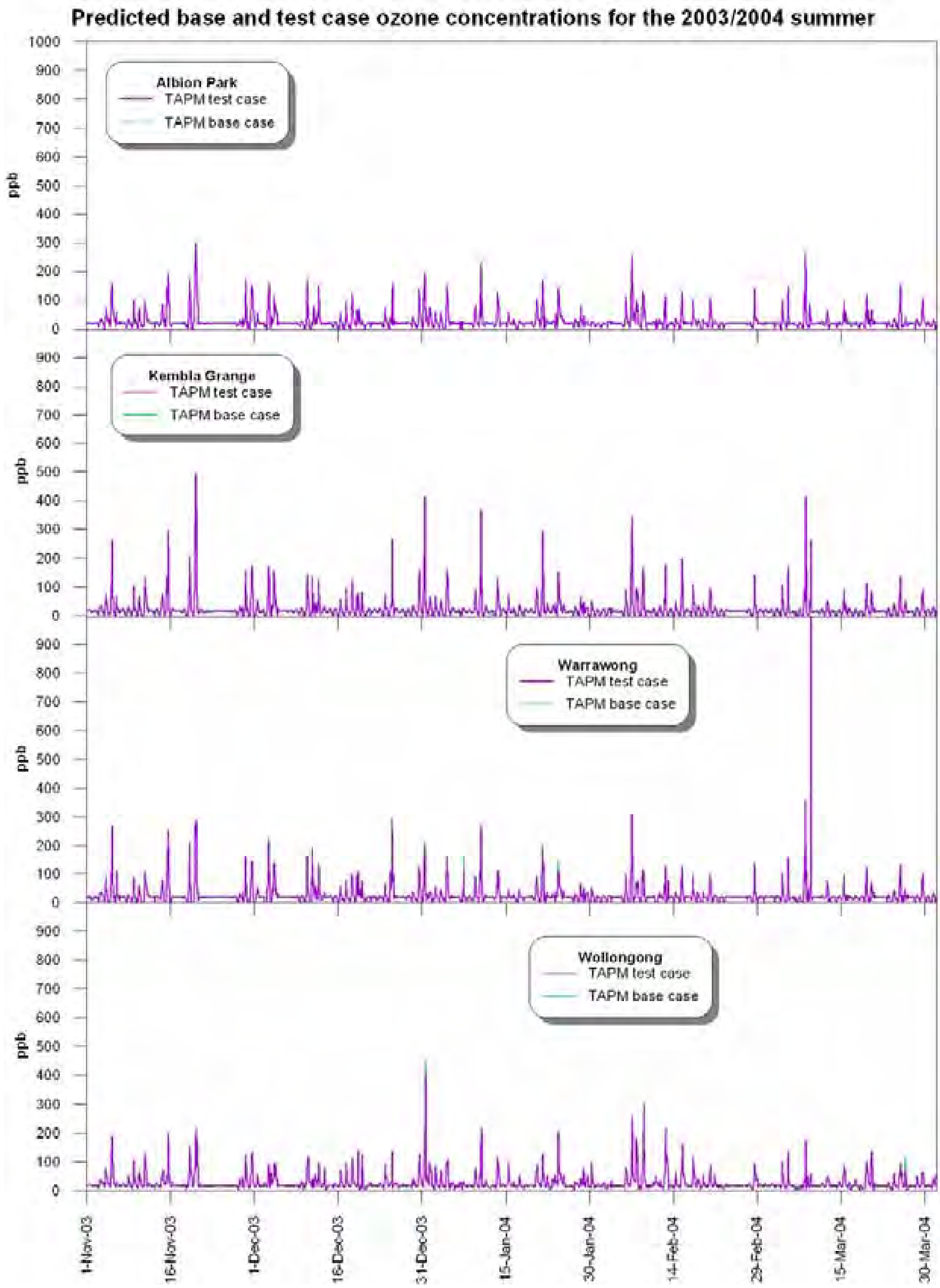
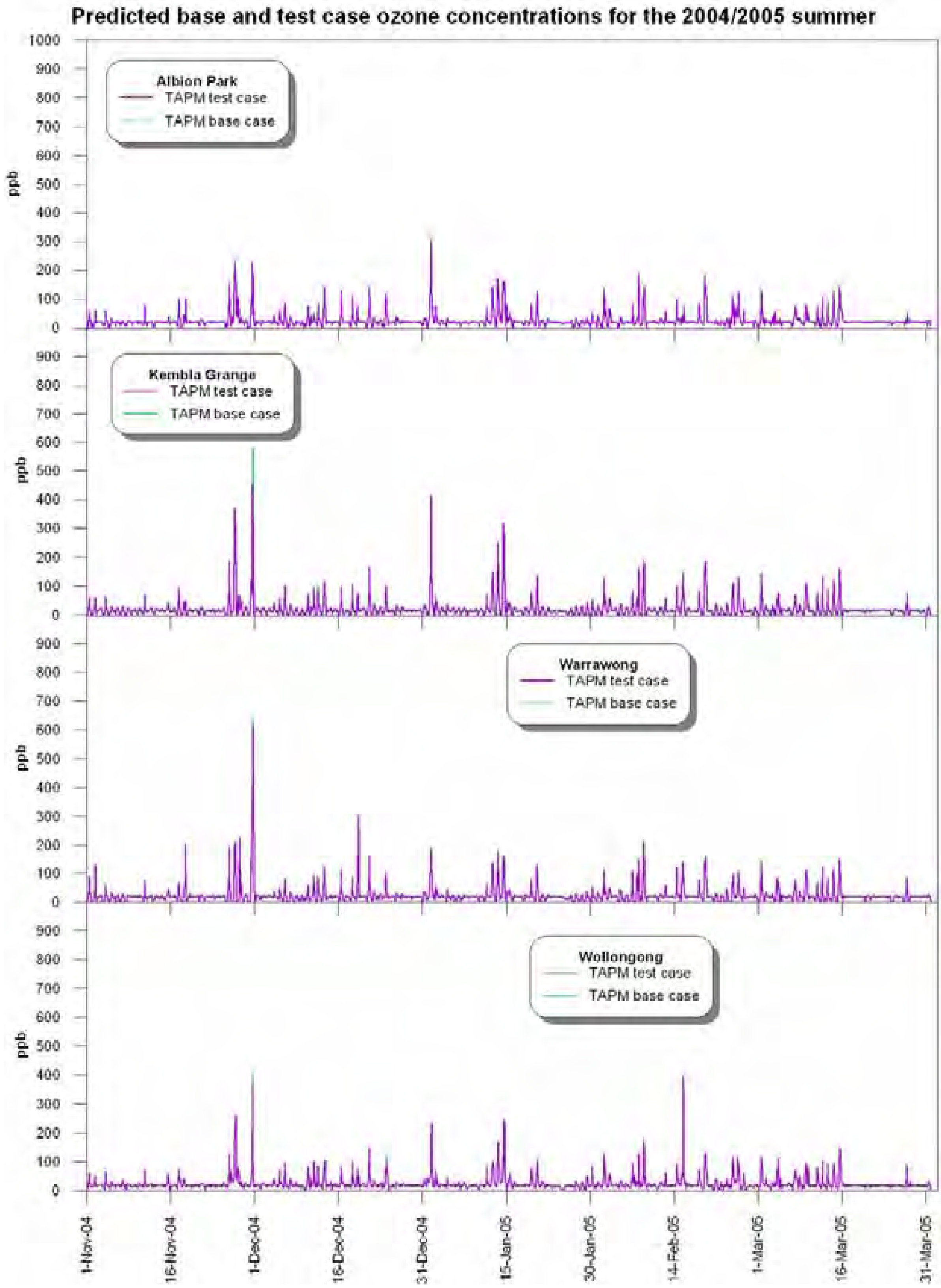
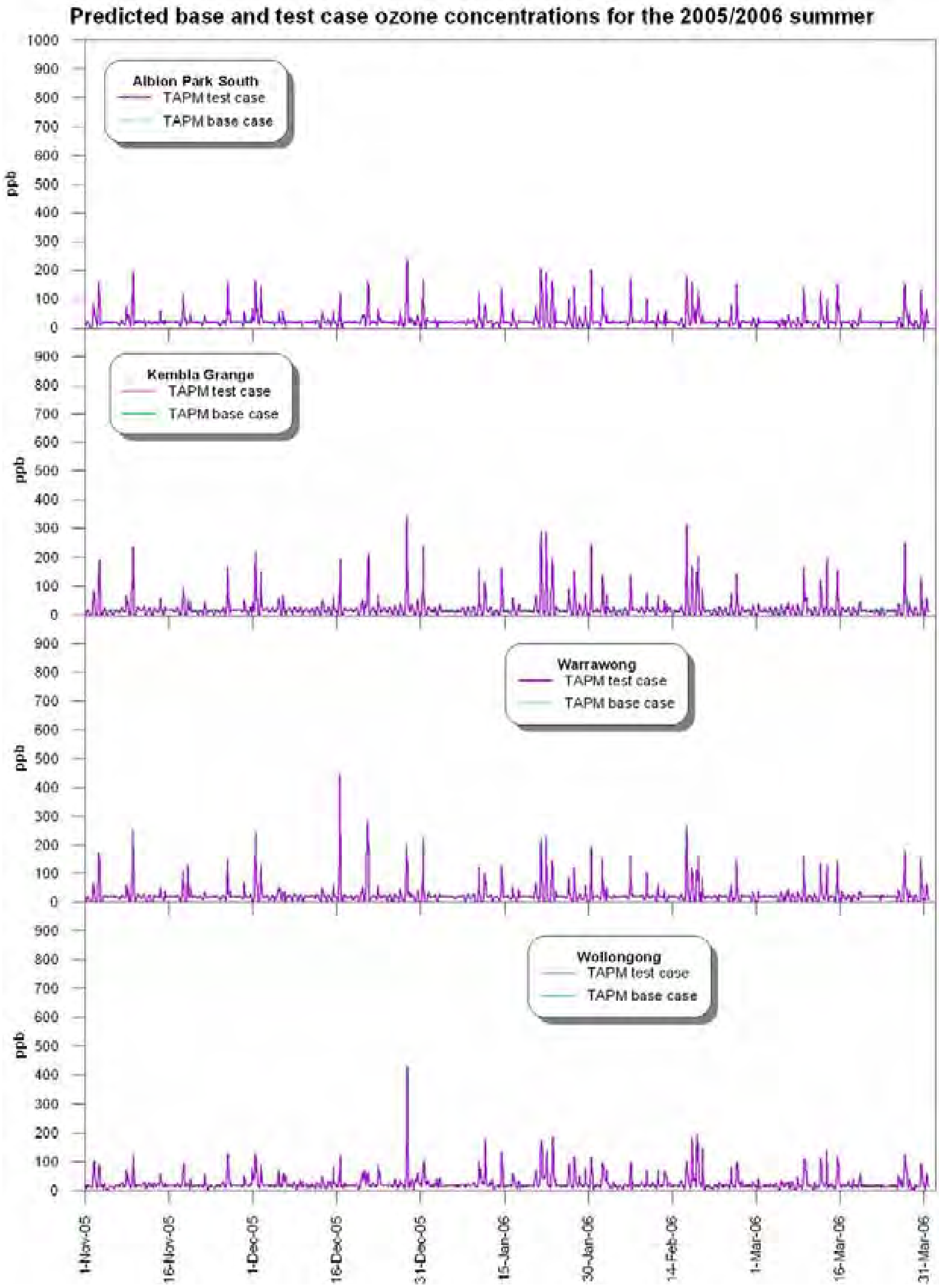
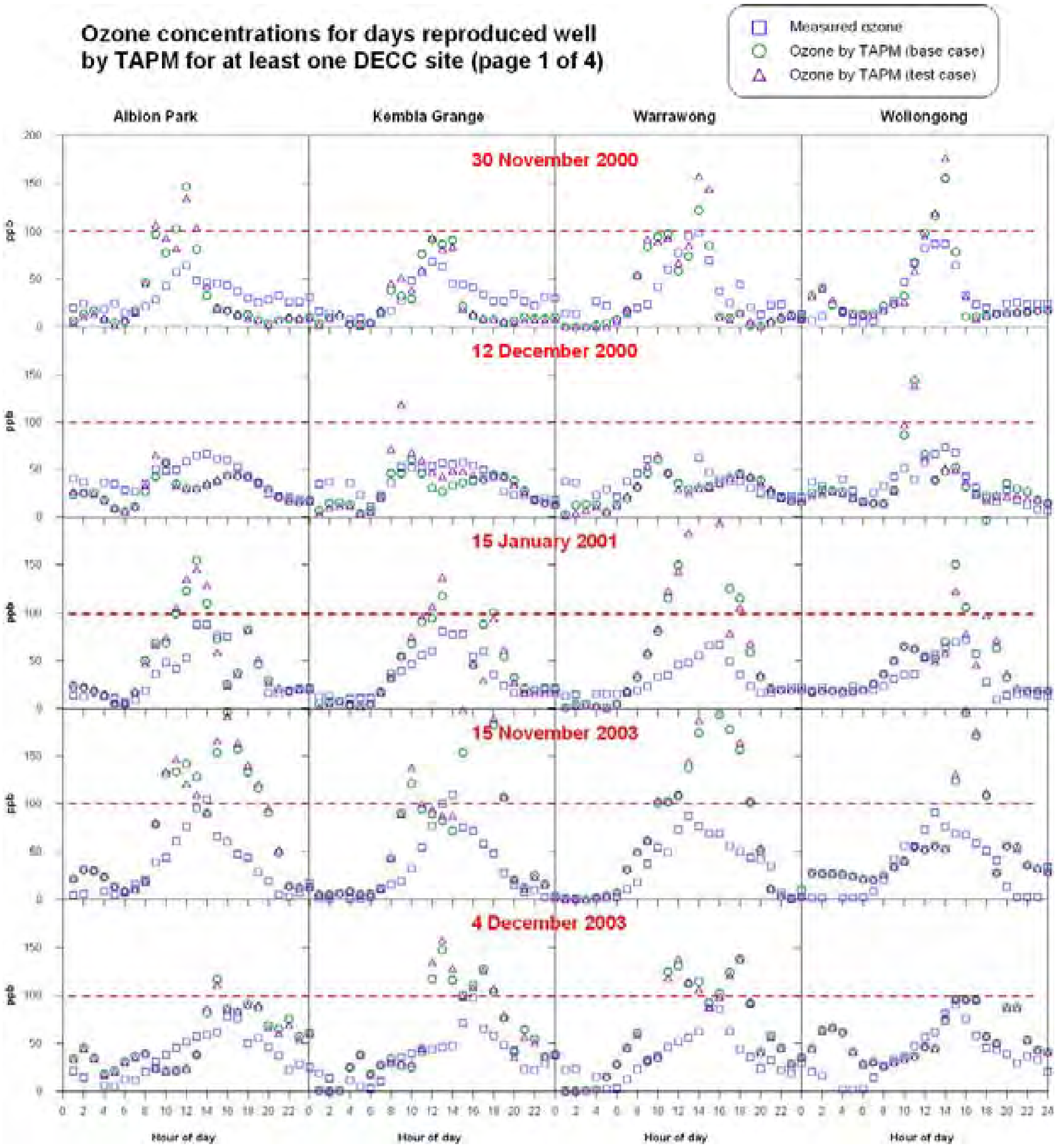
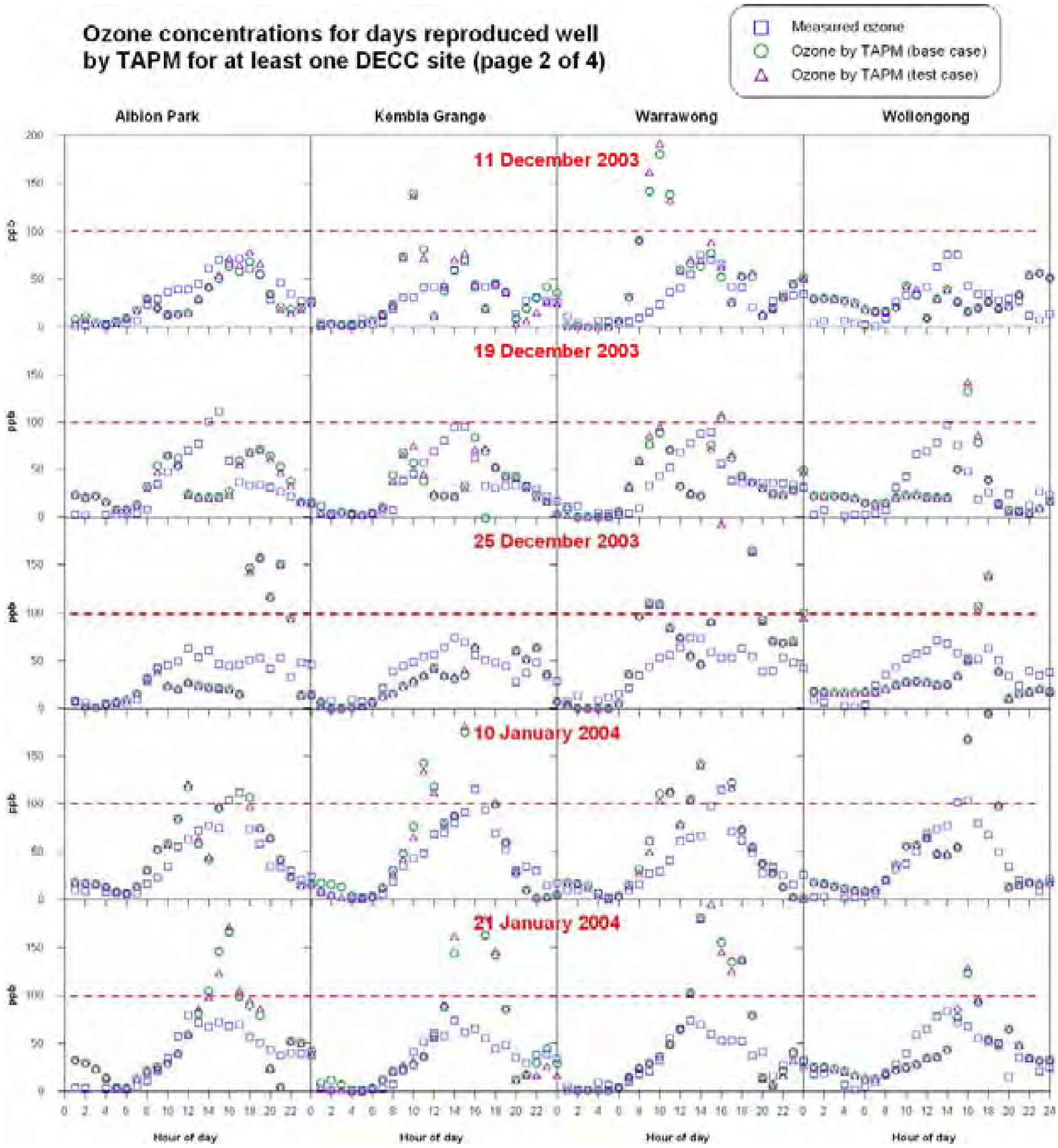
1-Mar-01
16-Mar-01
31-Mar-01

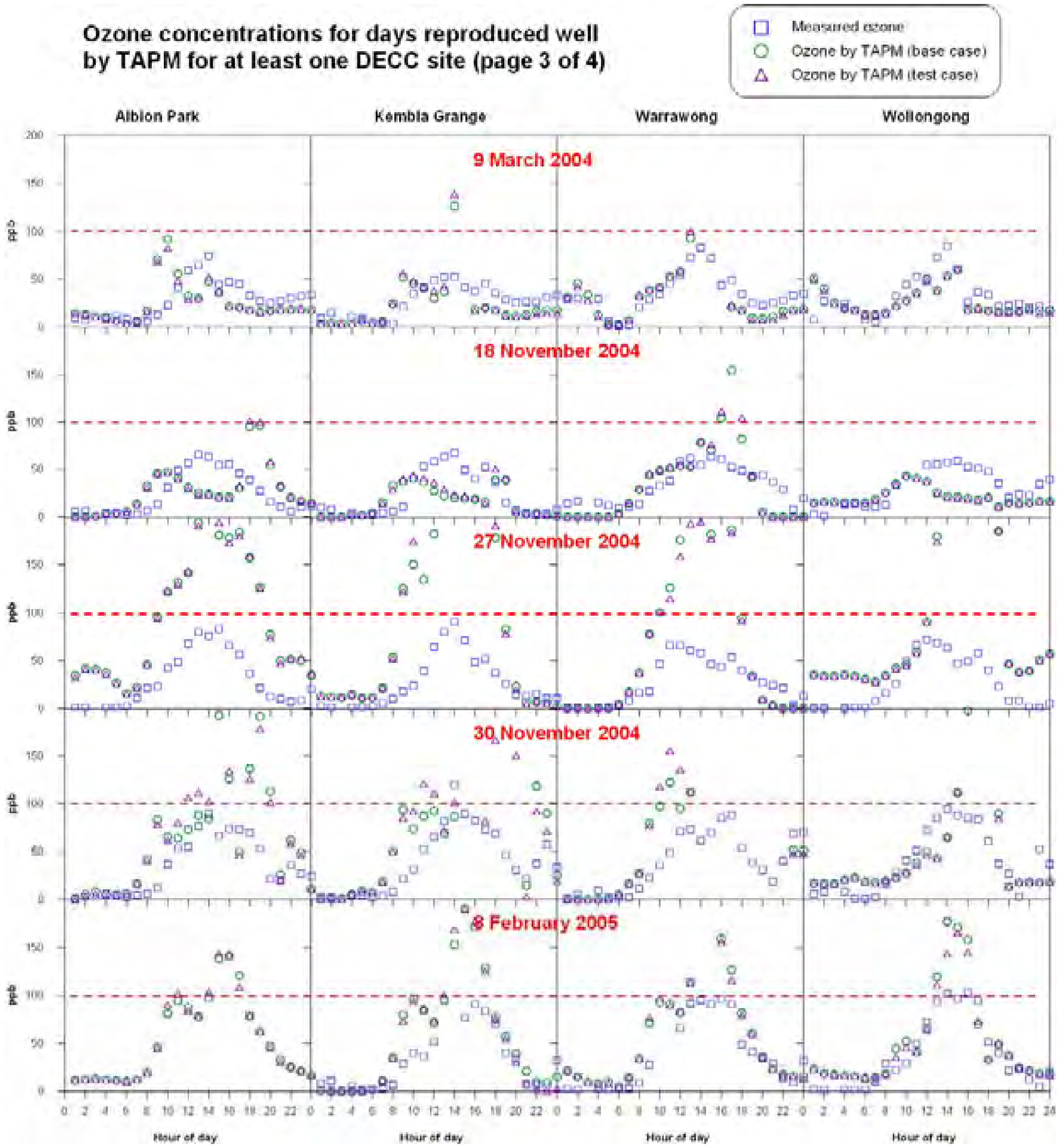

Predicted base and test case ozone concentrations for the 2003/2004 summer
Albion Park
TAPM test case
TAPM base case
Kembla Grange
TAPM test case
TAPM base case
Warrawong
TAPM test case
TAPM base case
Wollongong
TAPM test case
TAPM base case
ppb
1-Nov-03
16-Nov-03
1-Dec-03
16-Dec-03
31-Dec-03
15-Jan-04
30-Jan-04
14-Feb-04
29-Feb-04
15-Mar-04
30-Mar-04

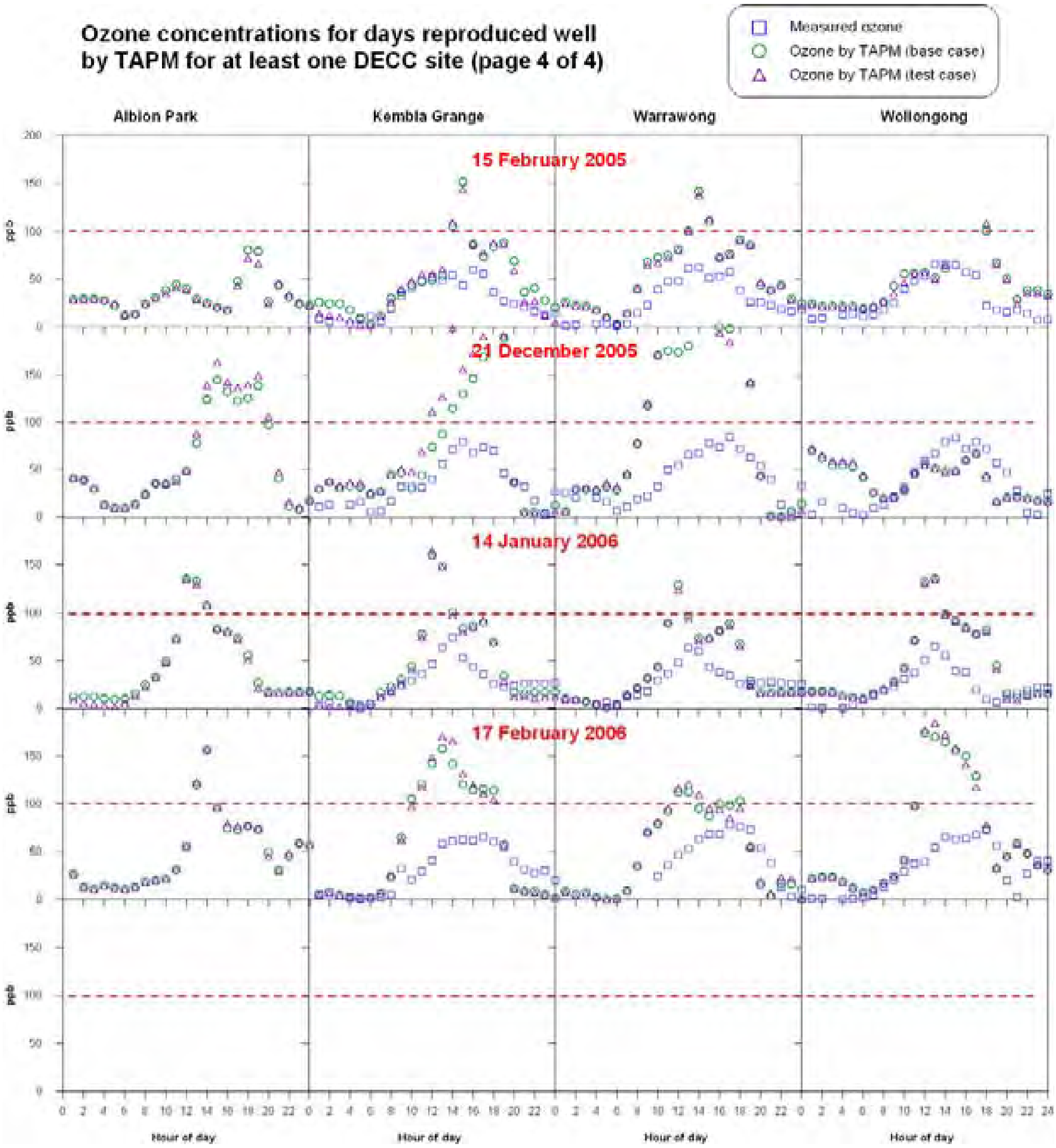

Predicted base and test case ozone concentrations for the 2004/2005 summer
Albion Park
TAPM test case
TAPM base case
Kembla Grange
TAPM test case
TAPM base case
Warrawong
TAPM test case
TAPM base case
Wollongong
TAPM test case
TAPM base case
ppb
1-Nov-04
16-Nov-04
1-Dec-04
16-Dec-04
31-Dec-04
15-Jan-05
30-Jan-05
14-Feb-05
1-Mar-05
16-Mar-05
31-Mar-05


Predicted base and test case ozone concentrations for the 2005/2006 summer
Albion Park South
TAPM test case
TAPM base case
Kembla Grange
TAPM test case
TAPM base case
Warrawong
TAPM test case
TAPM base case
Wollongong
TAPM test case
TAPM base case
ppb
1-Nov-05
16-Nov-05
1-Dec-05
16-Dec-05
31-Dec-05
15-Jan-06
30-Jan-06
14-Feb-06
1-Mar-06
16-Mar-06
31-Mar-06


Ozone concentrations for days reproduced well by TAPM for at least one DECC site (page 1 of 4)
Measured ozone
Ozone by TAPM (base case)
Ozone by TAPM (test case)
Albion Park
Kembla Grange
Warrawong
Wollongong
30 November 2000
12 December 2000
15 January 2001
15 November 2003
4 December 2003
ppb
Hour of day


Ozone concentrations for days reproduced well by TAPM for at least one DECC site (page 2 of 4)
Measured ozone
Ozone by TAPM (base case)
Ozone by TAPM (test case)
Albion Park
Kembla Grange
Warrawong
Wollongong
11 December 2003
19 December 2003
25 December 2003
10 January 2004
21 January 2004
ppb
Hour of day


Ozone concentrations for days reproduced well by TAPM for at least one DECC site (page 3 of 4)
Measured ozone
Ozone by TAPM (base case)
Ozone by TAPM (test case)
Albion Park
Kembla Grange
Warrawong
Wollongong
9 March 2004
18 November 2004
27 November 2004
30 November 2004
8 February 2005
ppb
Hour of day


Ozone concentrations for days reproduced well by TAPM for at least one DECC site (page 4 of 4)
Measured ozone
Ozone by TAPM (base case)
Ozone by TAPM (test case)
Albion Park
Kembla Grange
Warrawong
Wollongong
15 February 2005
21 December 2005
14 January 2006
17 February 2006
ppb
Hour of day

Appendix D Regional Photochemical Modelling with TAPM-CTM

D.1 TAPM-CTM Method

A recent development of TAPM is the chemical transport module, referred to as TAPM-CTM (Hurley 2005, Cope *et al.,* 2004). The modelling system involves three major components:

- A numerical weather prediction system, TAPM Version 3.3 (Hurley, 2005) which has been used for the prediction of meteorological fields including wind velocity, temperature, mixing ratio, radiation and turbulence.
- Chemical Transport Model CTM Version 1.7 (Cope et al., 2004) for modelling photochemical transformation.
- A comprehensive emissions inventory for the GMR provided by CSIRO.

TAPM-CTM was run in nested mode, with two 60 x 70 grid point modelling domains with grid spacings of 6 km for meteorology and 3 km for both meteorology and air quality. Local wind observations for 142 sites across the GMR were assimilated into TAPM predictions for meteorology.

The air quality impact has been assessed by comparing modelled O_3 concentrations from a base case emissions scenario (i.e. all existing sources in the GMR excluding Tallawarra) and a test case scenario (i.e. all base case sources plus Tallawarra A and Tallawarra B1&B2). This assessment has been undertaken for a 7-day photochemical smog episode observed in GMR which includes the Illawarra region during summer 2003-2004.

Emissions

CSIRO provided a comprehensive air emissions inventory for TAPM-CTM. Air emissions files included industrial point source emissions and area or grid-based emissions from anthropogenic and biogenic sources. The emissions were derived from the Sydney Metropolitan Air Quality (MAQS) emission inventory (Carnovale *et al.*, 1996) and recent updates, as follows:

- Commercial-domestic emissions from the MAQS inventory (Carnovale *et al*. 1997);
- Motor vehicle emissions updated from MAQS (Carnovale *et al*. 1997) for 2002 (Xu, NSW EPA, 2002);
- Industrial emissions from the MAQS inventory (Carnovale *et al*. 1997) updated by CSIRO to include major industrial NO_X emitters in the Sydney GMR, incorporating the Hunter, Central Coast and Western Coalfields (Nelson *et al.,* 2002); and
- Biogenic emissions incorporating natural sources of VOCs (CSIRO 2002).

Background concentrations were set as follows in parts per billion (ppb, the units required by TAPM):

- 20 ppb for ozone (i.e. 20 ppb = 2 parts per hundred million);
- 0.5 ppb for rsmog (i.e. rsmog units measure the reactive component in volatile organic compounds); and
- Zero for $NO_{X.}$

Photochemical Event Days

Selected days for examining the trajectories of ozone events were identified by referring to CSIRO modelling studies of photochemical events across the Sydney GMR (Cope, M, personal communication, July 2007). Also, observed ozone concentrations in the Illawarra region were examined. The three Illawarra monitoring sites of Kembla Grange, Warrawong and Albion Park experienced high ozone concentrations during the summer period November 2003 to March 2004.

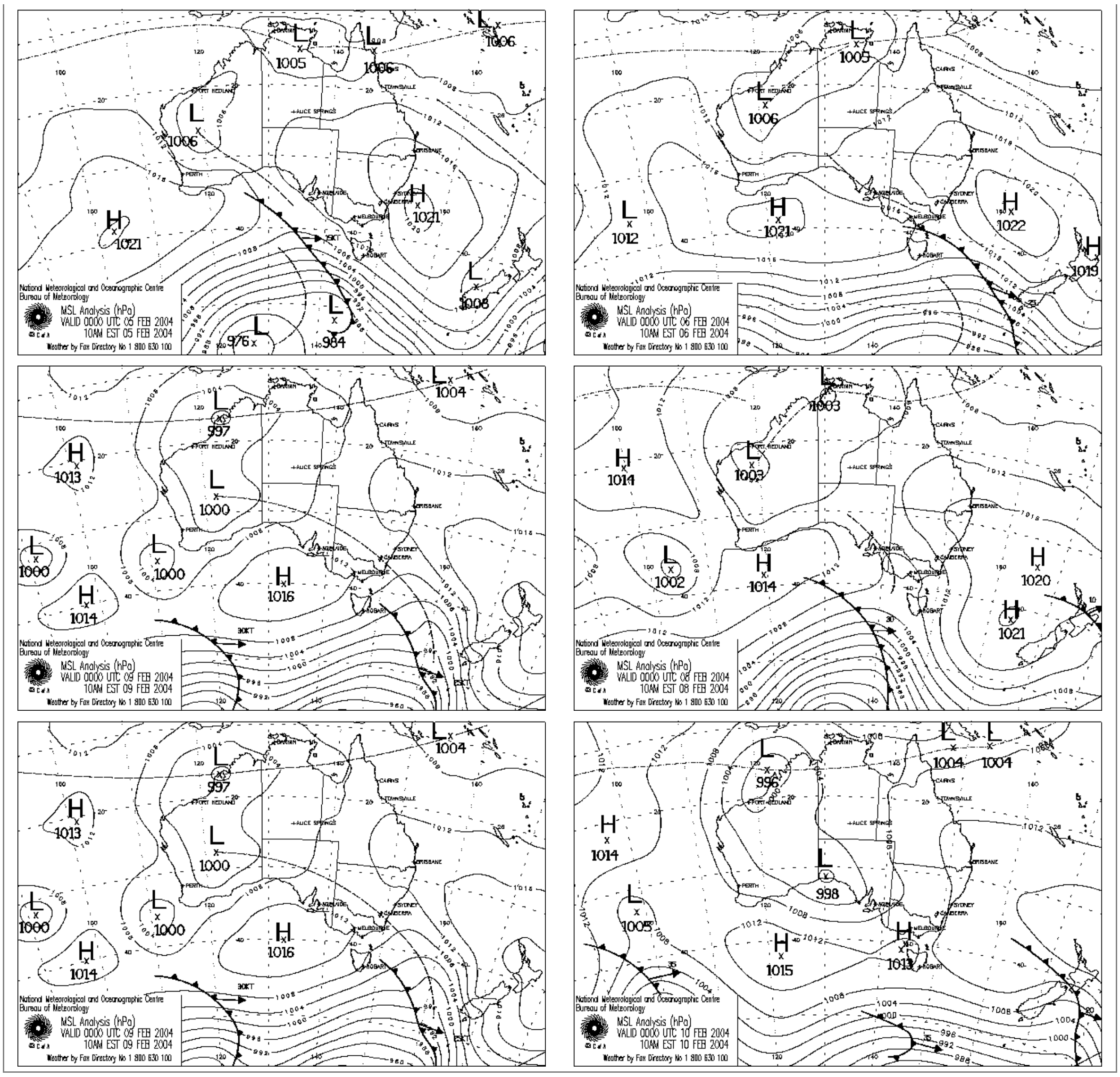
D.2 TAPM-CTM Results

In this section, NO_2 and O_3 concentrations are presented in terms of ppb, which are the units used by TAPM-CTM. In these terms, the DECC air quality criteria for 1-hour NO_2 is 120 ppb and for 1-hour O_3 is 100 ppb.

4th – 10th February 2004

The period 4th to 10th February 2004 was selected for modelling on the basis that it was a significant ozone event in Sydney and meteorological conditions favoured transport of ozone from the Sydney basin to the Illawarra (refer to **Figure D-2.1** and **Figure D-2.2**. The mean sea-level pressure charts for the period show a high pressure system in the Tasman Sea and north-westerly winds prevailing across south-eastern Australia (refer to **Figure D-2.1**).

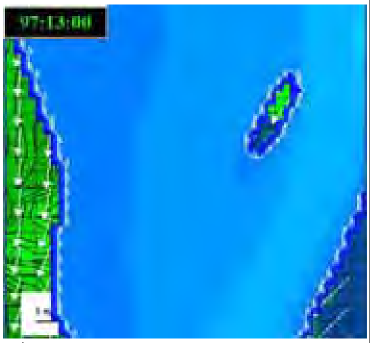
- **Figure D-2.1 Mean Sea-Level Pressure Charts for 5thto 10th February 2004, Illustrating North-Westerly Winds over South-Eastern Australia**



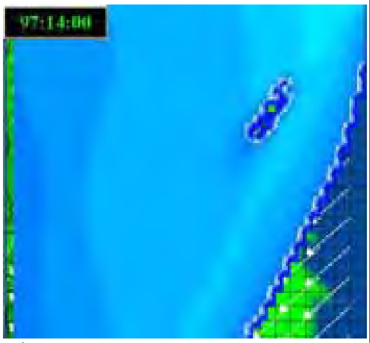
The screening run of TAPM-GRS simulated the afternoon north-easterly sea breezes prevailing at the regional and local scale. The model output graphics presented in **Figure D-2.2** illustrate the afternoon transport ozone from the GMR into the Illawarra region during 5th and 6th February 2002 (days 97 and 98 of the screening TAPM-GRS simulation). During this period, maximum observed concentrations were 108 ppb at Kembla Grange, 90 ppb at Albion Park, 67 ppb at Warrawong and 72 ppb at Wollongong (NSW DECC air quality monitoring records).

- **Figure D-2.2 Transport of Ozone by Afternoon North-Easterly Sea Breezes over Illawarra Region, 5th – 6th February 2004, as illustrated by TAPM-GRS Screening Run**

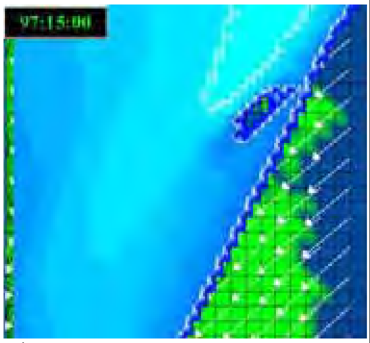
Note: In this preliminary model run, ozone was modelled with zero background concentration.



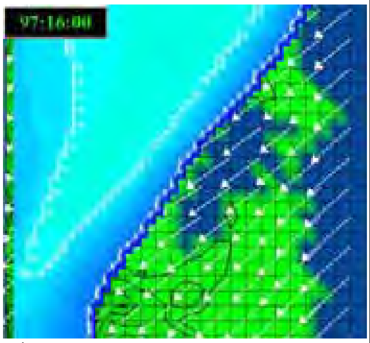
5th February 2004 1:00pm



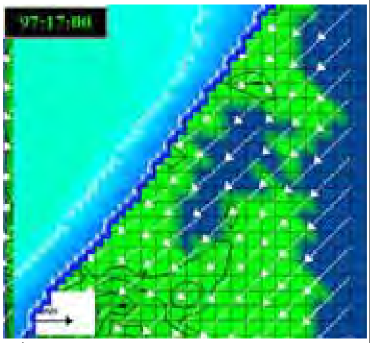
5th February 2004 2:00pm



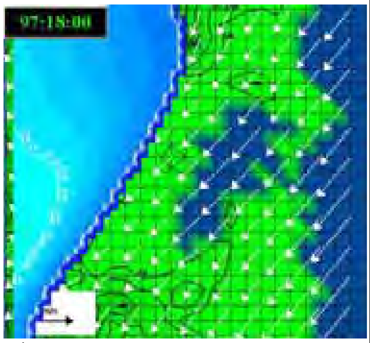
5th February 2004 3:00pm



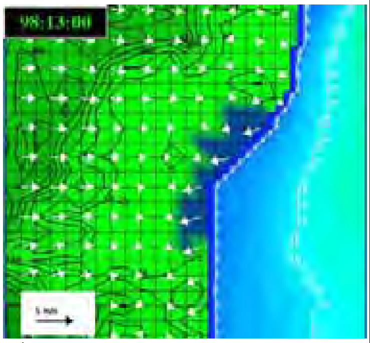
5th February 2004 4:00pm



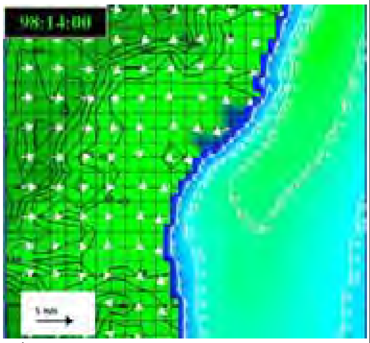
5th February 2004 4:00pm



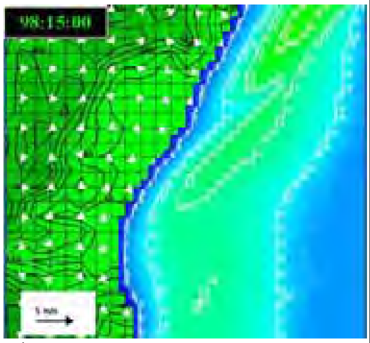
5th February 2004 4:00pm



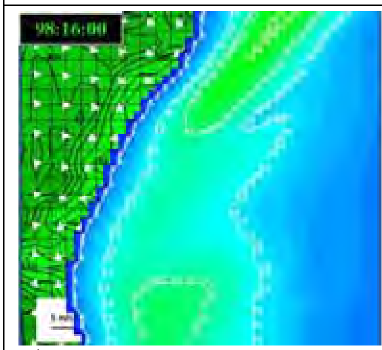
6th February 2004 1:00pm



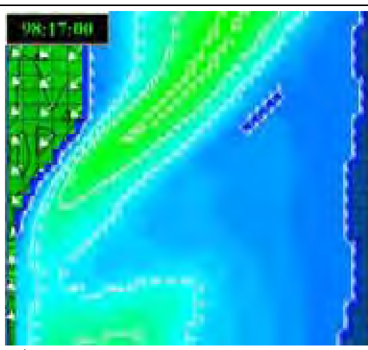
6th February 2004 2:00pm



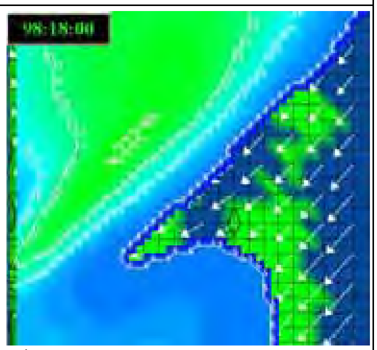
6th February 2004 3:00pm



6th February 2004 4:00pm



6th February 2004 4:00pm



6th February 2004 4:00pm

During the period 4th to 10th February 2004, maximum hourly averages observed at Kembla Grange were 36 ppb for NO_2 and 108 ppb for O_3. Observed exceedences in the Illawarra region of the ozone standard occurred at Kembla Grange on 6th February (108 ppb at 4:00 pm and 5:00 pm).

D.2.1 Summary Results for Nitrogen Dioxide and Ozone

The modelling results for the selected event show that the impact on maximum hourly NO_2 and O_3 concentrations is negligible as summarised in the following table and discussed in further detail below.

- **Table D-2.1 Summary Results of TAPM-CTM Modelled Base Case and Test Case 4-10 February 2004**

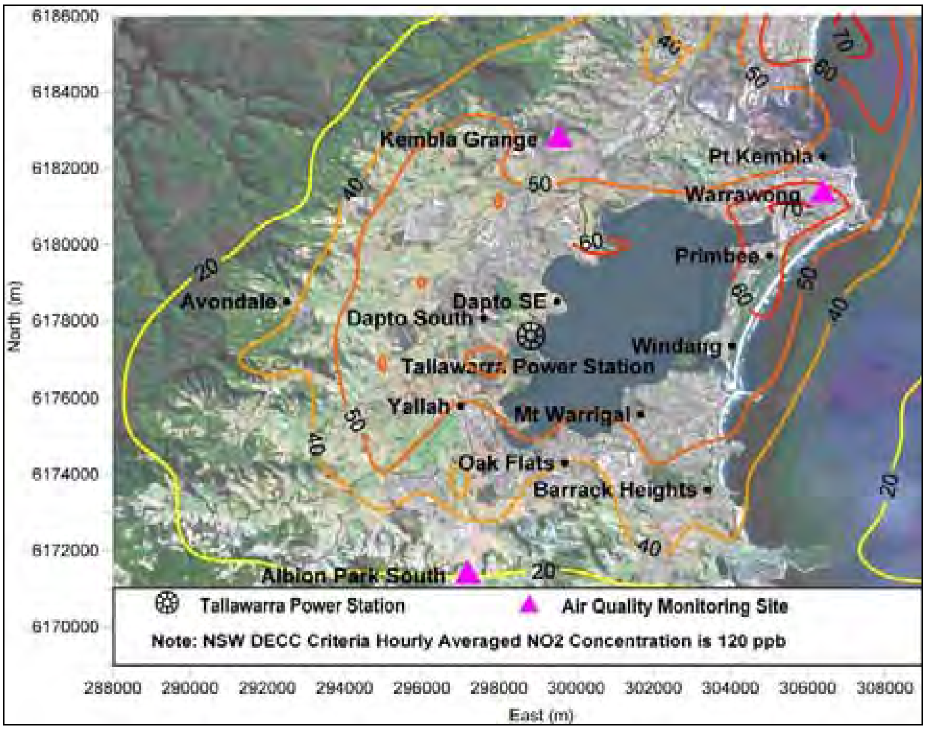
Selected Event	NO_2 1-Hour Average Concentration (ppb)		O_3 1-Hour Average Concentration (ppb)	
	Base	Test	Base	Test
Grid Maximum	71.45	71.52	93.16	93.15
Kembla Grange Maximum	42.71	42.72	61.50	61.50

D.2.2 Results for Nitrogen Dioxide

Results indicate that emissions from Tallawarra A CCGT and Tallawarra B1&B2 OCGT increased the highest regional 1-hour NO_2 concentration by only 0.07 ppb, from 71.45 ppb to 71.52 ppb. The highest concentration at Kembla Grange increased by only 0.01 ppb, from 42.71 ppb to 42.72 ppb.

Figure D-2.3 and **Figure D-2.4** show the contour plots for the maximum hourly average NO_2 ground level concentrations for the base case and test case for 4th – 10th February 2004. Results showed that the base case highest NO_2 concentrations, of up to 71.45 ppb, occurred northeast of the Tallawarra site in the area between Warrawong and Primbee and off-shore approximately 5 km north of Port Kembla. Test case results showed that the highest concentration (71.52 ppb) occurred in the same location as the base case.

- **Figure D-2.3 Base Case NO_2 Maximum Hourly-Averaged Concentrations (ppb) 4-10 February 2004**



- **Figure D-2.4 Test Case NO_2 Maximum Hourly-Averaged Concentrations (ppb) 4-10 February 2004**

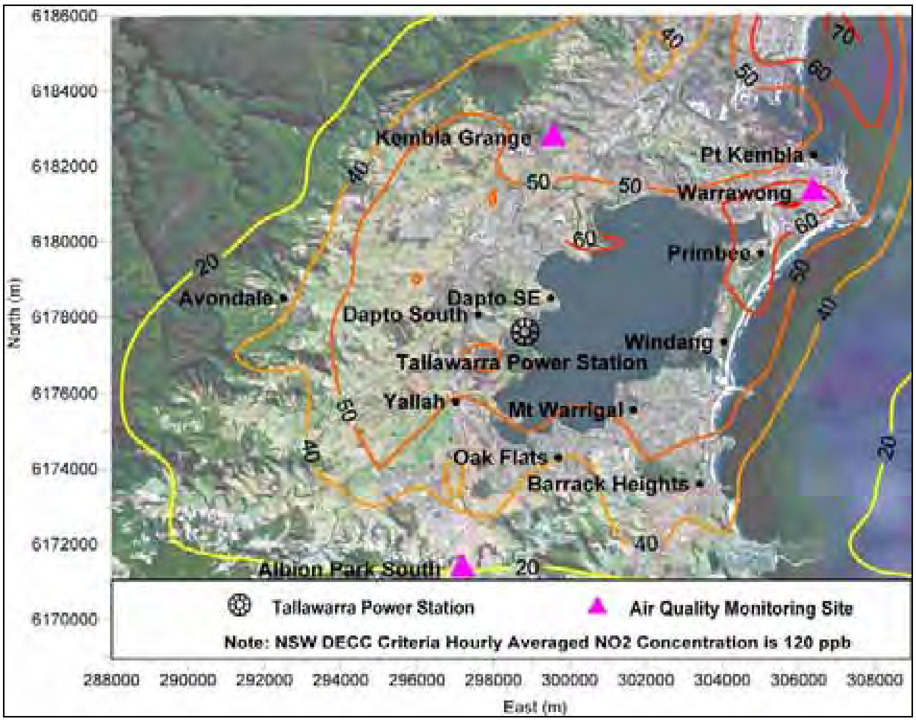
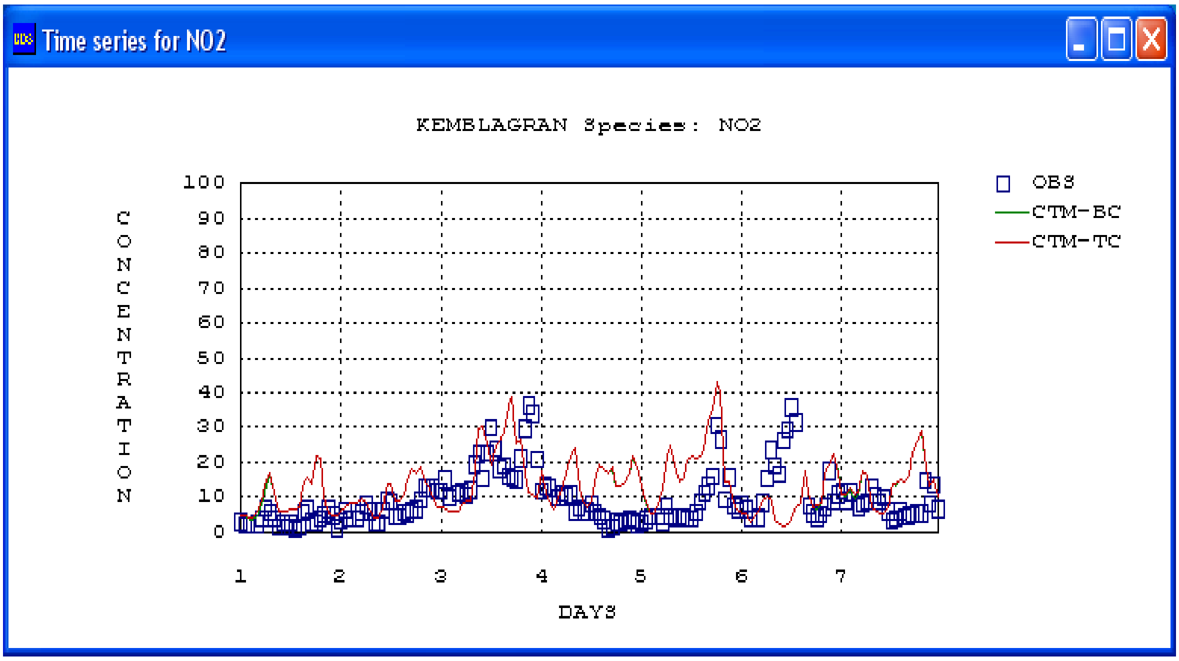


Figure D-2.5 shows the time-series plot of the observed NO2 concentrations compared with modelled base case and test case concentrations at Kembla Grange for the 7-day period. Although the model under-estimated the impacts, these results indicate that the model performed well compared with similar TAPM-CTM applications (Physick *et al*, 2007).

- **Figure D 2.5 Observed (OBS), Modelled Base Case (CTM-BC) and Test Case (CTM-TC) Hourly Averaged Concentrations for NO_2 (ppb) at Kembla Grange 4-10 February 2004**



Note: Test Case time series plot CTM-TC overlays Base Case time series plot CTM-B. Hence, Base Case plot is not visible

Figure D-2.6 shows the contour plot of the difference between the test case and base case maximum ground level concentrations (ppb) for NO_2, that is, the difference due to the power station. These results indicate that the greatest impact of the power station (0.3 ppb) occurs approximately 2 kilometres south of Oak Flats where base case concentrations are low (approximately 40 ppb) and well away from the regional maximum concentration (71.45 ppb) between Primbee and Warrawong (refer to **Figure D-2.3** and **Figure D-2.4**).

- **Figure D-2.6 Difference Test Case and Maximum Base Case NO_2 Maximum Hourly-Averaged Concentrations (ppb) 4-10 February 2004**

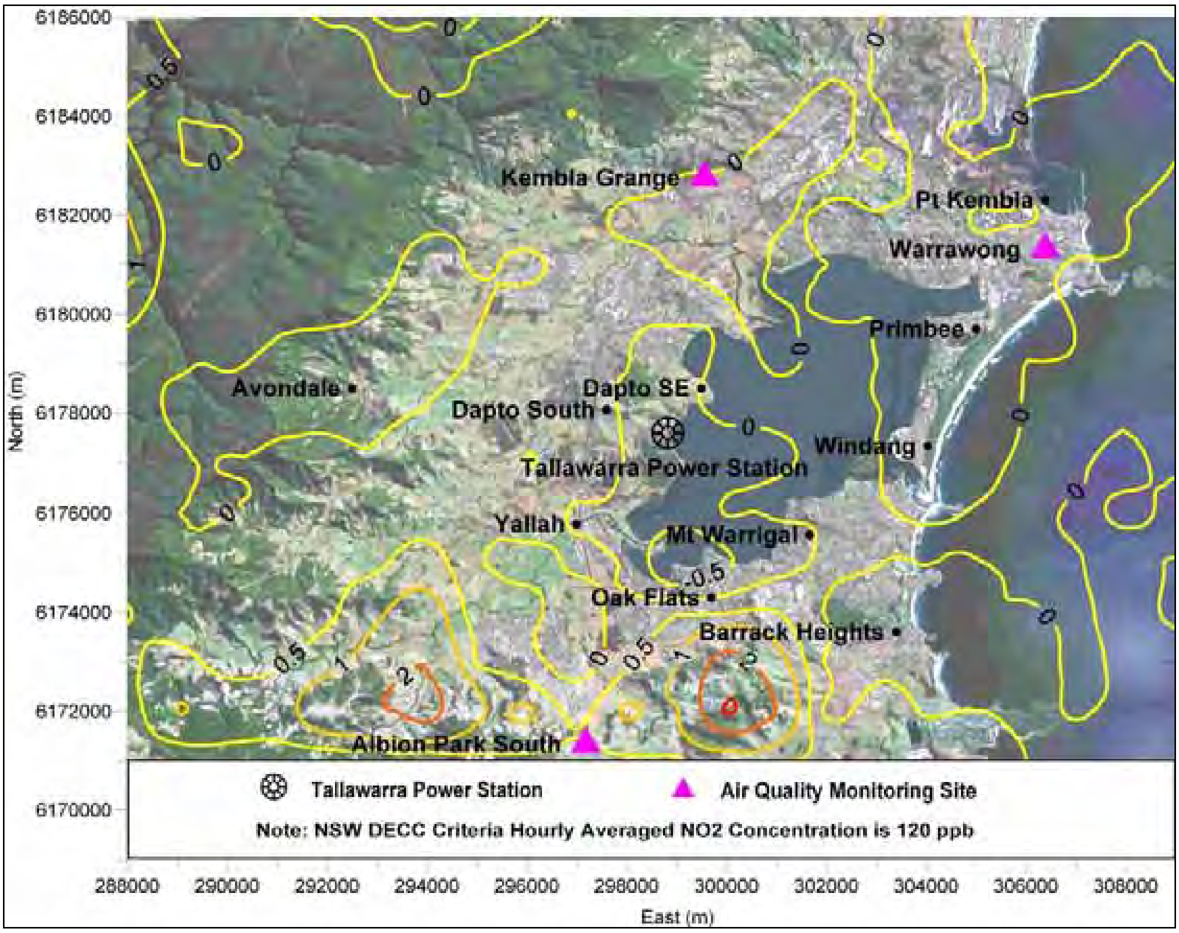
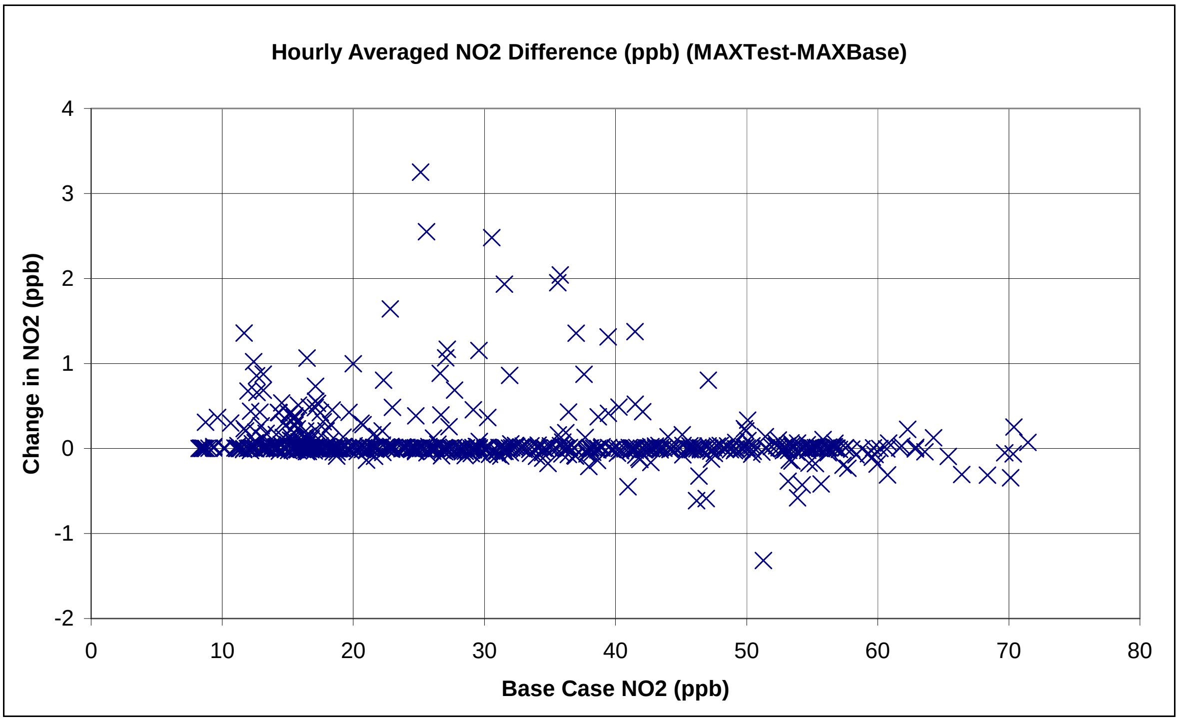


Figure D-2.7 shows a scatter plot for the difference between the test case and the base case versus the maximum base-case NO_2 concentration for hourly-averaged pollutants for each grid point. At most points, NO_2 concentrations show little change. The largest increases (up to 3.3 ppb) occurring in areas where the base case concentrations are less than 40 ppb.

- **Figure D-2.7 Difference Between Test Case and Base Case Maximum Ground Level Concentrations Compared to Base Case Maximum Ground Level Concentrations at all Grid Points in the 1-km Modelling Domain for Hourly-Averaged NO_2 Concentrations, 4-10 February 2004**

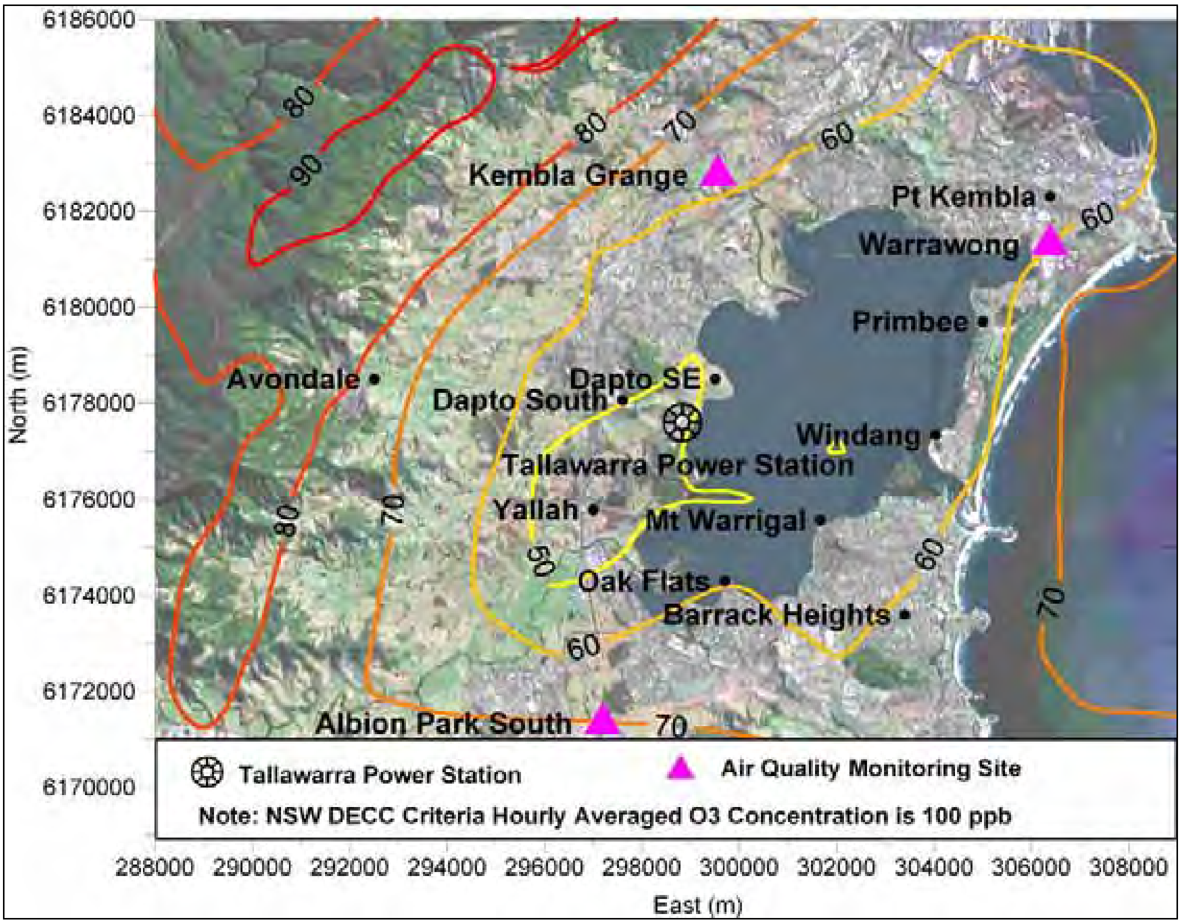


D.2.3 Results for Ozone

Results indicate that emissions from Tallawarra A CCGT and Tallawarra B1 and B2 OCGT decreased the highest regional 1-hour O_3 concentration by 0.01 ppb, from 96.16 ppb to 96.15 ppb. The highest concentration at Kembla Grange remained unchanged at 61.50 ppb (refer to **Table D-2.1**).

Figure D-2.8 and **Figure D-2.9** show the contour plots for the maximum hourly average O_3 ground level concentrations for the base case and test case. The highest O_3 concentrations (up to 96.16 ppb base case and 96.15 ppb test case) occurred approximately 10 km northwest of the Tallawarra site, well away from the sensitive receptors and urban-rural areas.

- **Figure D-2.8 Base-Case O_3 Maximum Hourly-Averaged Concentrations (ppb) 4-10 February 2004**



- **Figure D 2.9 Test-Case O_3 Maximum Hourly-Averaged Concentrations (ppb) 4-10 February 2004**

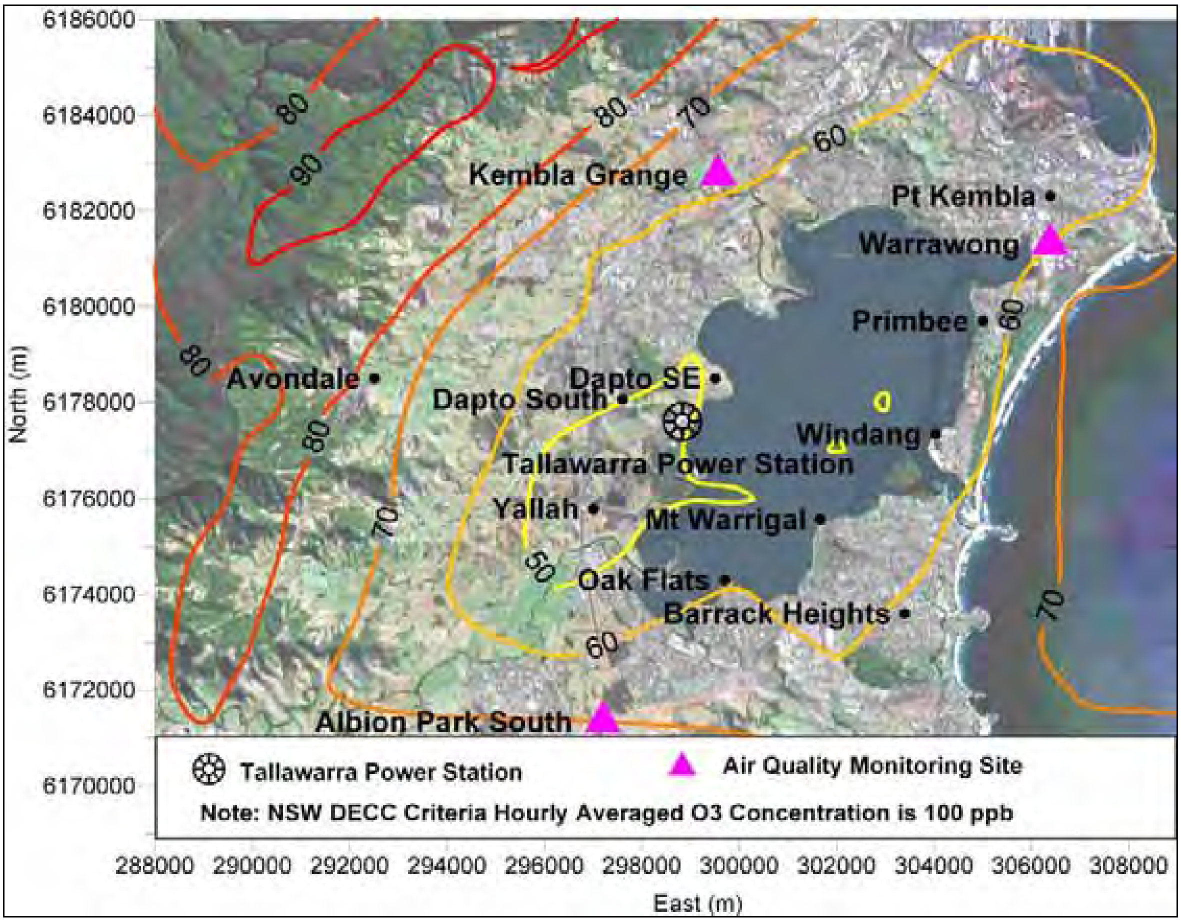
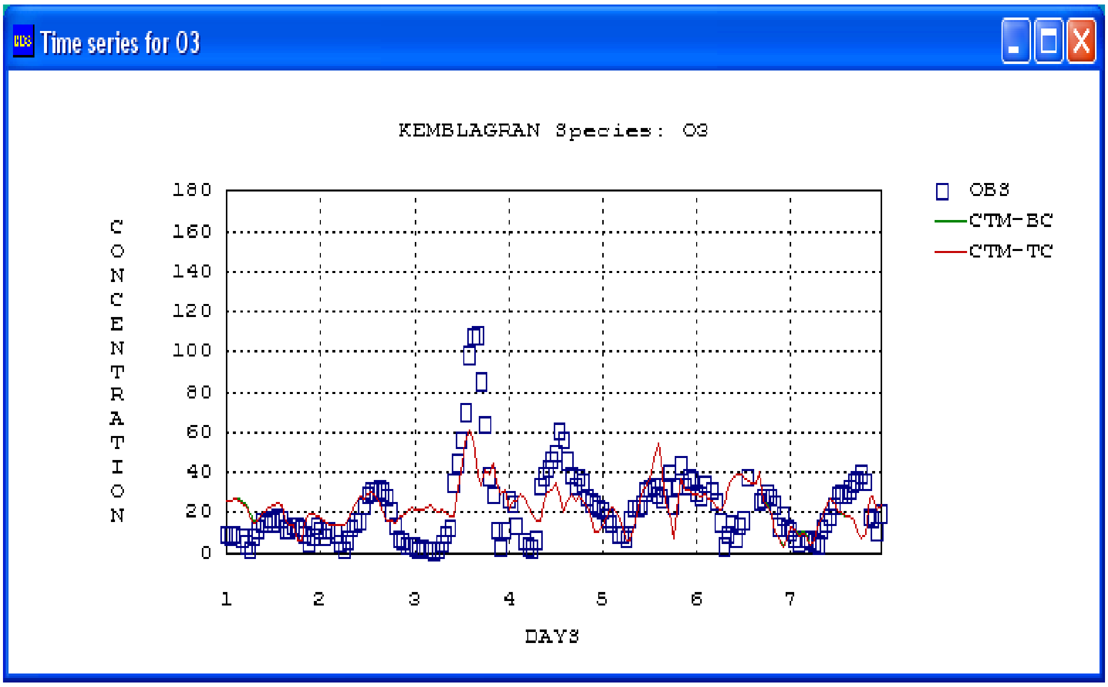


Figure D-2.10 shows the time series of observed O_3 concentrations compared with modelled base case and test case concentrations at Kembla Grange for the 7-day period. These results indicate that the model predicted the general trends in the maximum hourly concentrations; however, the peaks were under-predicted. The model may be considered to have performed reasonably well as judged by similar TAPM-CTM studies (Cope, M., CSIRO, personal communication, 24/01/08). The reason for the under-prediction may be related to the emission and/or the meteorological inputs to the model (Cope, M., CSIRO, personal communication, 24/01/08). Further investigation of the model's performance was beyond the scope of this assessment.

- **Figure D-2.10 Observed (OBS), Modelled Base-case (CTM_BC) and Test Case (CTM-TC) Hourly Averaged O_3 Concentrations (ppb) at Kembla Grange 4-10 February 2004**



Note: Test Case time series plot CTM-TC overlays Base Case time series plot CTM-B. Hence, Base Case plot is not visible

Figure D-2.11 shows the contour plot of the change in the maximum ground level concentrations for points in the 1 km grid modelling domain. The highest increase (0.05 ppb) occurred approximately 4 km west of the Tallawarra site in an area well away from urban-rural areas and where base case O_3 concentrations were less than 70 ppb. As noted above, in the area 10 km northwest of the power station, where the maximum base-case concentrations occur for this event, the impact of the power station is predicted to be close to 0 ppb.

- **Figure D-2.11 Difference Between Maximum Test Case and Maximum Base Case O_3 Maximum Hourly-Averaged Concentrations (ppb) 4-10 February 2004**

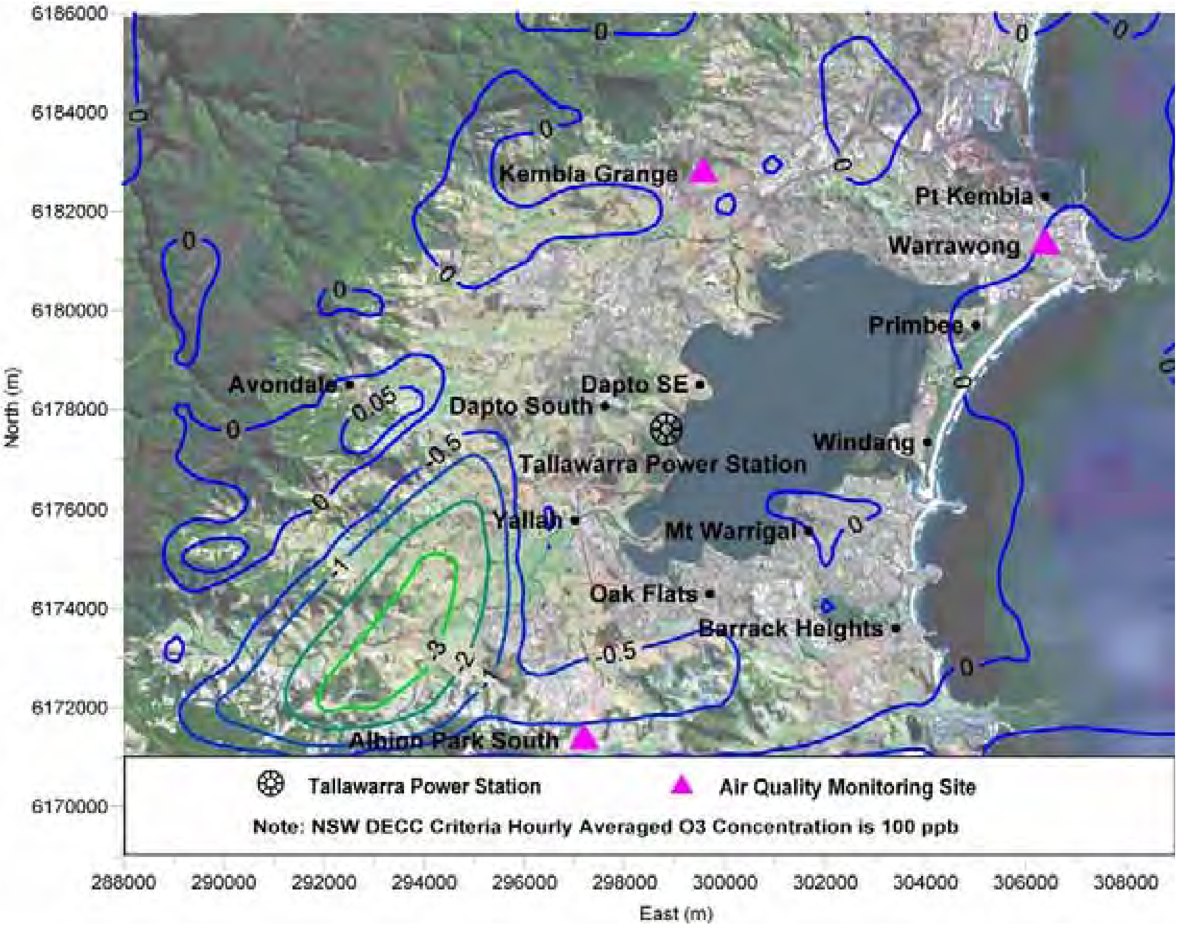
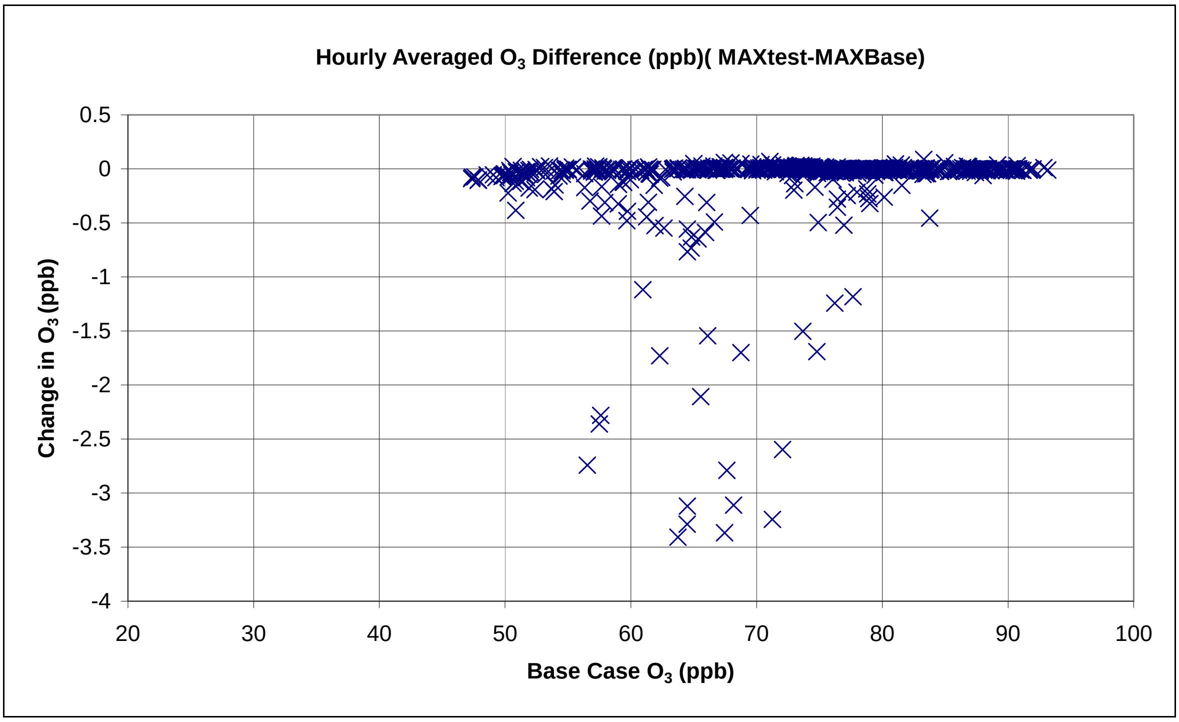


Figure D-2.12 shows a scatter plot of the difference between the test case and the base case versus the maximum base case concentration for hourly-averaged O_3 concentrations. At most points, the impact of the power station is close to 0 ppb, especially at the lowest and the higher concentrations. Many points with base case concentrations between 55 ppb and 80 ppb are predicted to experience a decrease in the maximum hourly-average concentration of up to 3.3 ppb.

- **Figure D-2.12 The Difference Between Test-Case and Base-Case Maximum Ground Level Concentrations Compared to Base-Case Maximum Ground Level Concentrations at all grid points of the 1-km Modelling Domain for the Hourly-Averaged Concentrations for NO_2 and O_3, 4-10 February 2004**



D.3 Discussion of Results - Regional Photochemical Impacts of Tallawarra A CCGT and B OCGT using TAPM-CTM

This methodology used the photochemical transport model, TAPM-CTM, to model an ozone event in the Illawarra during 4th -10th February 2004. A base case scenario in the Illawarra (existing emissions of NO_X and VOCs from the Sydney GMR, excluding Tallawarra power station) was compared with a test case (base case plus NO_X emissions from Tallawarra A CCGT and B OCGT).

The modelling results for the ozone event show that the impact of emissions from Tallawarra power station would be:

- an increase in the regional maximum hourly averaged NO_2 concentration of 0.07 ppb;
- an increase in the maximum hourly averaged NO_2 concentration at Kembla Grange of 0.01 ppb;
- a decrease in the regional maximum hourly averaged O_3 concentration of 0.01 ppb; and
- no change in the maximum hourly averaged O_3 concentration at Kembla Grange.

Generally, at most points across the modelling domain, NO_2 concentrations were unaffected by the addition of Tallawarra power station. That is, at most points, the predicted O_3 impact of the power station is close to 0 ppb, especially at the lowest and the higher concentrations. The largest increases (up to 3.3 ppb) were predicted to occur in areas where the base-case concentrations are less than 40 ppb. Many points, with base case concentrations between 55 ppb and 80 ppb, are predicted to experience a decrease in the maximum hourly-average concentration of up to 3.3 ppb.

In summary, the emission from Tallawarra A CCGT and B OCGT are predicted to have no adverse effects on regional concentrations of NO_2 and O_3 and to result in no additional exceedences of DECC air quality criteria.