Air Quality Assessment

- Aurecon 2009 Report
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Appendix E

Air Quality Assessment Munmorah Rehabilitation Works

Delta Electricity

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Executive summary

An air quality impact assessment was carried out on behalf of Delta Electricity for the proposed rehabilitation works for Munmorah Power Station. This air quality assessment has examined the current air quality in the locality and considered the changes that are predicted to occur as a result of the rehabilitation. The effects of the continuing operation of Munmorah on local, regional and inter regional air quality following the rehabilitation have been examined through a consideration of relevant peer reviewed and technical literature and a dispersion modelling study.

Based on an examination of the records from air quality monitoring stations at Wyee and Lake Munmorah Public School, which are suitably located to monitor the effects of Munmorah, the existing air quality in the region has been shown to be very good and significantly lower than established air quality goals. Analysis of the air quality data has shown that only a very small percentage of data is elevated above are above close to very low “baseline” values. It is demonstrated that these short term elevated records would generally not be due to Munmorah Power Station.

An assessment of air pollutants from Munmorah Power Station has been undertaken in accordance with the Approved methods for the modelling and assessment of air pollutants in NSW document (DEC, 2005) (the Approved Methods) in order to quantify the nature and extent of potential worst case ground level concentrations of emissions. The dispersion modelling assessed the air quality impact on the local scale of emissions of oxides of nitrogen, sulfur dioxide, fine particulates and other pollutants (including trace elements, volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs)).

The assessment was able to demonstrate that the air emissions from the plant would not contribute to any further exceedances in the guideline limits for all pollutants with the exception of SO_2. The modelling predicted an exceedance in guideline limits under worst case operating assumptions for sulfur dioxide for the 10 min and hourly averaged parameters.

The report concludes that these predicted worst case exceedances are unlikely to occur given the conservative nature of the methodology adopted in representing cumulative air quality impacts for this pollutant. The possible use of natural gas would further reduce the likelihood of these exceedances.

The air quality impacts on the regional and interregional basis were assessed based on a literature review of air quality studies conducted by a range of specialists including the CSIRO (as referenced within the document). Based on this literature review it is concluded that there would be little to no discernible impacts upon regional air quality through this region – in terms of reduced incidence of neither peak ozone concentrations nor NO_2 ground level concentrations. This conclusion is based on the evidence which suggests that there is already surplus NO_x in the regional atmosphere available to react with the low levels of anthropogenic volatile organic compound sources that exist.

The assessment has demonstrated that there is likely to be a largely negligible change in the air quality impacts with respect to the emissions of other pollutants these pollutants following the plant rehabilitation. Trace elements (including lead (Pb) and other trace elements), CO, VOCs and subset groups including PAHs, are already compliant with Group 6 emission standards and world’s best practice Best Available Techniques (BATs).

The report also considered the Munmorah plant rehabilitation program in terms of the best available emission control measures. As Munmorah is an operating power station that has been subject to continual improvement through its life, practicable BATs, such as the installation of fabric filter technology for improved dist extraction have already been implemented. A consideration of the best available techniques (BAT) in the context of the Munmorah facility has demonstrated that the plant has already implemented as many of the BAT measures as is justifiable; when additional measures are considered on the basis of the marginal environmental benefit that might result.

The report also assessed the adequacy of the current ambient air monitoring network and stack emissions monitoring plan to represent the plant’s ongoing performance. The modelling results were able to demonstrate that the Lake Munmorah Primary School air monitoring station is well located to monitor the worst case impacts of Munmorah. The assessment of pollutant contours developed as part of the Holmes Air Sciences study also found that the worst case impact of air emissions from the yet to be commissioned Colongra gas turbine development will be in the same locality. The report noted that while the current emissions monitoring program is adequate, some modification of the stack emissions monitoring is required in order to meet current requirements. These would be included in the rehabilitation works

The assessment concludes that rehabilitation of Munmorah Power Station would not result in unacceptable impacts on air quality.

1. Introduction

1.1 Background

Delta Electricity's Munmorah Power station, located on the NSW Central Coast near Doyalson was constructed as a 1,400MW four unit coal fired power station in 1967. Units one and two ceased operating in the early 1990s, while units three and four have continued to generate electricity for sale in the National Electricity Market (NEM).

The location of the Munmorah power station in relation to the other major industrial and diffuse air emission sources in the area is provided in Figure 1.1. Delta Electricity is proposing to rehabilitate units three and four in the plant to replace worn and obsolete components with current technology.

The purpose of this rehabilitation project is to improve the reliability and efficiency of the generating units, returning unit output to the original 350MW such that they are able to continue to generate electricity for the NEM in the short to medium term (up to 20 years) while reducing the carbon dioxide emission per unit of electricity generated.

The project proposal is being assessed under Part 3A of the EP&A Act. This assessment has been prepared to satisfy the air quality assessment requirements of the Director General of Planning as specified in the project DGRs issued on 19 June 2009.

Figure 1.1 Munmorah power station in relation to other major industrial and diffuse (traffic) air emission sources on the NSW Central Coast

1.2 Air quality assessment aims

The aims of this assessment are to understand the potential implications of the proposed rehabilitation upon air quality through this region. This air quality assessment is based on numerical dispersion modelling and the analysis of the significant volume of technical literature studying the behaviour of atmospheric air pollutants through this region to date.

The aims of the desktop modelling assessment are to understand the cumulative impacts of the rehabilitated facility in the local geographical setting.

The available literature is in the form of assessments considering the regional scale impact of the emissions of oxides of nitrogen (NO_x) from the various industrial and diffuse air emission sources (Nelson et. al., 2002 and Cope et. al., 2005) as well as local scale impact assessments (Holmes Air Sciences, 2005). In addition to this the study will also analyse the ambient air monitoring data collected at the Wyee and Lake Munmorah Primary School (LMPS) sites since 1994 to discern the trends in observed air quality.

The historical data does not include the additional air quality impacts that could be expected by the concurrent operation of the Colongra gas turbine facility and Munmorah power station. The additional impact of the former project was assessed and approved by the Department of Planning in July 2006. This air quality assessment included Munmorah Power Station operating as a two unit base load power station.

The following report examines the outcomes of existing technical studies to describe the implications of the Munmorah rehabilitation project for local and regional air quality and to enable the regulatory bodies to make an informed decision, based on:

- the technical design studies involved in developing the rehabilitation plan for the Munmorah facility (Aurecon, SKM, Worley Parsons, 2009);
- the historical ambient air monitoring studies;
- local scale air dispersion modelling based on the CSIRO developed TAPM model;
- the technical air quality reports considering the dispersion of air pollutants through this region authored by the Atmospheric Sciences division of the CSIRO (Cope et. al. 2005), Holmes Air Sciences, Hugh Malfroy (2007) and others; and
- relevant peer-reviewed scientific literature;

As referenced in text throughout the document and populated in detail within the reference list at the end of this report.

1.2.1 Scope of assessment

On the basis of the DGRs the following scope was adopted:

- Review of air emission concentrations predicted for the rehabilitated Munmorah Power Station and compare against the relevant emission standards in the PoEO Act;
- Assess of the potential local, regional and inter-regional impacts from the proposed facility using the:
  - Approved desktop meteorological and air dispersion modelling in accordance with the Approved methods for the modelling and assessment of air pollutants in NSW document (DEC, 2005) (the Approved Methods)
  - Literature survey incorporating but not limited to the following studies:
    - Colongra gas turbines study (Holmes Air Sciences, Cope et. al., 2005),
    - Inter regional transport of air pollutants study (Nelson et. al., 2002),
    - Central coast air quality data (Wyee, Lake Munmorah Primary School),
    - Munmorah power station – An evaluation of factors relevant to an application for the revision of the Environment Protection Licence (Malfroy, c.2007);
- Assess all necessary mitigation programs that may be needed to limit exceedances of the relevant criteria as stipulated under Section 7 of the Approved Methods.

The modelling assessment primarily focuses on the emissions of sulfur dioxide (SO_2) and oxides of nitrogen (NO_x), and local impacts with respect to air quality guideline limits (see Section 5 and 6).

Other pollutants including fine particulate matter (PM_{10}), fluoride compounds (modelled as hydrogen fluoride), trace elements including cadmium (Cd) and mercury (Hg) and dioxins and furans (PCDD/F) are also considered.

2. Regulations and Guidelines

2.1 Protection of the Environment Operations (Clean Air) Regulation 2002 (POEO)

Munmorah Power Station is classified as Scheduled Premises under the POEO Act. Part 4 of the POEO (Clean Air) Regulation establishes six emission limit groups for scheduled premises based on the age of the plant

Munmorah Power Station currently belongs to the Group 2 emission standard. the Group 2 emission standards of concentration for scheduled premises are due to be phased out by 1 January 2012 following which it will be required to be compliant with Group 5 emission standards as a minimum, unless a variation is approved under Clause 24 of the Regulation.

In addition the EPA license for Munmorah Power Station (EPL759) includes a clause (U2) under Pollution Studies and Reduction Programmes which indicates that Munmorah Power Station should achieve Group 6 emission limits for NO_x beyond January 2012.

The standards of concentration for air impurities in relation to ‘Electricity Generation’ prescribed in Schedule 3 of the Regulation are listed in the following table.

Munmorah Power Station is currently compliant with all Group 6 emission standards, with the exception of NO_x (Table 2.1). The rehabilitation program aims to address this issue.

2.2 Ambient air quality guidelines

The guidelines that are used to assess ambient air quality have been stipulated by both the NSW DECC and within the Ambient Air Quality and Air Toxics National Environment Protection Measures (NEPM). The air quality standards/goals for the various pollutants outlined by these organisations are listed in Table 2.1.

Table 2.1 Concentration limits for Munmorah Power Station and Groups 2, 5 and 6

Numbers in bold indicate Munmorah limits are equivalent to either Group 5 or 6 limits

Pollutant	Units of Measure (1)	Munmorah Limits (2)	Group 2	Group 5 limits	Group 6 limits
Cadmium	mg/m^3	**1**	-	**1**	0.2
Chlorine (3)	mg/m^3	**200**	200	**200**	**200**
Mercury	mg/m^3	**1**	-	**1**	0.2
NO_2 or NO or both expressed as NO_2 equivalent	mg/m^3	2,500	2,500	800	500
Flourine, as HF equivalent	mg/m^3	**50**	50	**50**	**50**
Hydrogen chloride (3)	mg/m^3	400	400	100	100
Total solid particles	mg/m^3	**100**	250	**100**	50
Smoke emissions	% opacity (ringelmann)				
Approved circumstance (4)		-	60 (3)	60 (3)	60 (3)
Other circumstances		-	20 (1)	20 (1)	20 (1)
Sulfuric acid mist and sulfur trioxide (as SO_3)	mg/m^3	200	100	100	100
Type 1 and type 2 substances in aggregate (5)	mg/m^3	**5**	-	**5**	1
VOCs as n-propane equivalent	ng/m^3	-	-	-	0.1
Hydrogen sulphide (3)	mg/m^3	-	5	5	5

Source: POEO Regulation Schedule 3 Standards of concentration for scheduled premises: activities and plant used for specific purposes

NOTE:
(1) 100 percentile concentration limit
(2) Munmorah Power Station EPL 759 – 24 August 2009
(3) Source: POEO Regulation Schedule 4: Standards of concentration for scheduled premises: general activities and plant
(4) Approved circumstance (a) smoke is emitted as a result of blowing soot from a boiler, for a period of no more than 10 minutes per 8 hours, and (b) that all practicable means are employed to prevent or minimise the emission of smoke during that period.
(5) Type 1: antimony, arsenic, cadmium, lead or mercury. Type 2: Beryllium, chromium, cobalt, manganese, nickel, selenium, tin and vanadium. Type 1 included in Group 2 and Type 1 and Type 2 included in Group 5.

Table 2.2 Air quality goals/standards as stipulated by the DEC (2005) and as part of the NEPM (2003)

Pollutant	Goal	Averaging period	Reference
Nitrogen dioxide (NO_2)	120 ppb (246 µg/m^3) 30 ppb (62 µg/m^3)	1-hour Annual	NSW DEC, NEPM
Photochemical oxidants as Ozone (O_3)	100 ppb (214 µg/m^3) 80 ppb (171 µg/m^3)	1-hour 4-hour	NEPM
Sulfur dioxide (SO_2)	25 pphm* (712 µg/m^3) 200 ppb (570 µg/m^3) 80 ppb (228 µg/m^3) 20 ppb (60 µg/m^3)	10-minute 1-hour Daily Annual	NSW DECC NSW DECC, NEPM
Particulate matter of aerodynamic diameter <10µm (PM_{10})	50 µg/m^3 30 µg/m^3	Daily Annual	NSW DECC, NEPM NSW DECC
Particulate matter of aerodynamic diameter < 2.5µm ($PM_{2.5}$)^	25 µg/m^3 8 µg/m^3	Daily Annual	NEPM
Fluoride (as HF)	1.5 µg/m^3 0.8 µg/m^3 0.4 µg/m^3 0.25 µg/m^3	Daily 7-day 30-day 90-day	NSW DECC
Cadmium (Cd)	0.018 µg/m^3	1-hour	
Mercury (Hg)	1.8 µg/m^3	1-hour	
Dioxins and furans (PCDD/F)	2.0 pg/m^3 [#]	1-hour	

* pphm – parts per hundred million

^ Advisory reporting standard.

[#] pg/m^3 – pico grams per metre cubed of ambient air (pico – 10^{-12}) TEQ

Table 2.3 NEPM air toxics (2004) – monitoring investigation levels.

Pollutant	Goal	Averaging period
Benzene	0.0003 ppm	Annual
Formaldehyde	0.04 ppm	Annual
Toluene	1 ppm 0.1 ppm	Daily Annual
Xylene	0.25 ppm 0.20 ppm	Daily Annual
Polycyclic aromatic hydrocarbons (PAH)	0.30 ng/m^3	Annual

3. Existing environment

3.1 Ambient air monitoring

This section examines the ambient air quality based on data collected from the two compliance air monitoring stations for Munmorah Power Station located at Wyee and near the Pacific Highway at Lake Munmorah Primary School (LMPS).

In addition to examining current air quality, these monitoring stations have been used to characterise background air quality in this region

The background air quality in this region is affected by major industrial sources (Munmorah, Vales Point and Eraring Power Stations) and fugitive emission sources (i.e. road traffic), as highlighted in Figure 3.2. It is noted that the emissions from the Colongra Gas Turbine facility (currently undergoing commissioning testing) are not reflected in the historical air quality data.

It is noted that the emissions from the Colongra Gas Turbine facility (currently undergoing commissioning testing) and recently approved additional generation from Eraring Power Station are not reflected in the historical air quality data. The contribution of Munmorah to ambient air quality between 1999 and 2009 is shown in the following Figure.

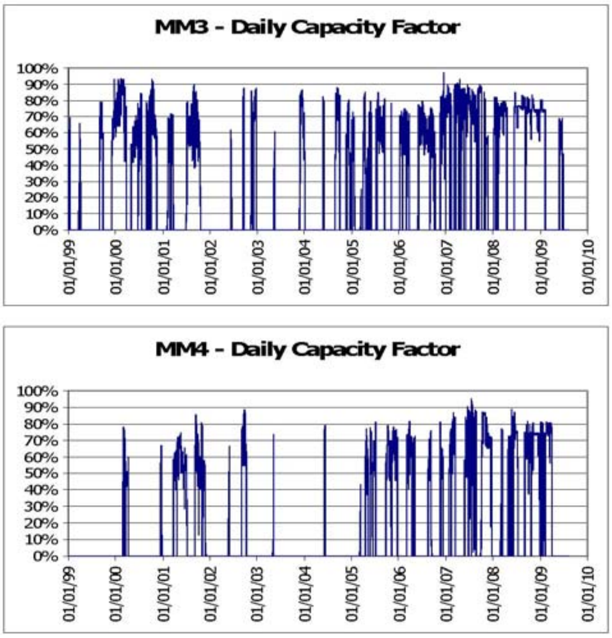

Figure 3.1 Munmorah Power Station capacity factor for 1999 to 2009

3.1.1 Sulfur dioxide (SO_2)

The following analysis of ambient SO_2records from Wyee and LMPS air monitoring stations for encompasses the period from 1994-2008 and examines annual average, daily, one hour and ten minute ambient SO_2 air quality. The analysis demonstrates that annual average, daily and one hour ambient concentrations have been significantly below the relevant air quality goals.

Annual Average

The profile of annual average ground level concentrations is presented in Figure 3.2.

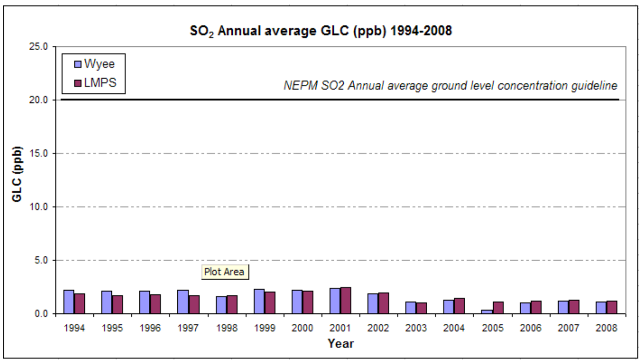

Figure 3.2 Observed annual averaged SO_2 concentrations, from 1994 to 2008 at the Wyee and Lake Munmorah Primary school air monitoring stations

This above profile of annual average statistics shows that the observed annual average ambient SO2 concentrations are low, close to an order of magnitude below the regulated NEPM and NSW DEC air quality limits.

Hourly Average

Peak and percentile SO_2 ground level concentrations observed at Wyee (Figure 3.3) and LMPS (Figure 3.4) air monitoring stations from 1994 to 2008 are presented in this section.

An examination of the frequency distribution of the observed data shows that for more than 99% of the hours in any given year the observed data are below < 20 ppb (17% of the air quality goal)

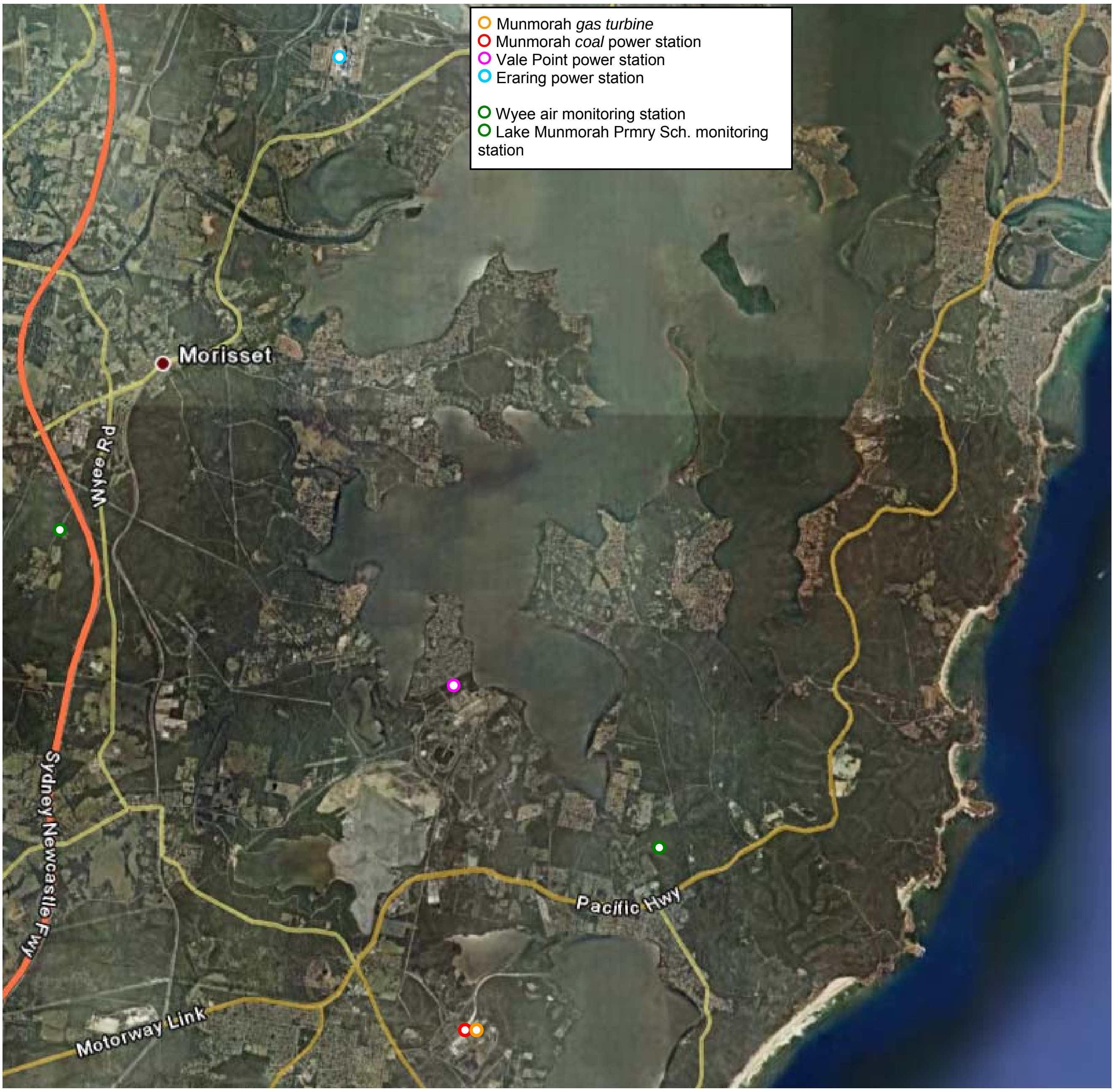

Figure 3.3 Major local industrial air emission sources proposed (approved) and existing and compliance air monitoring stations

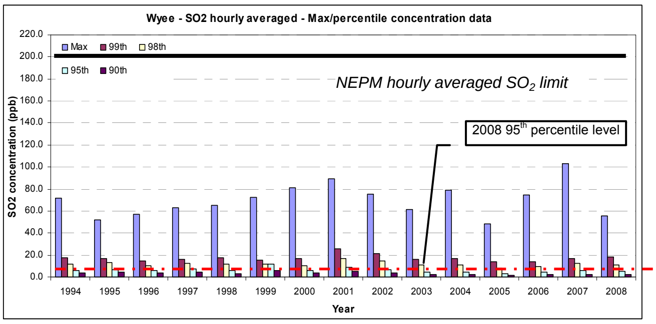

Figure 3.4 Observed hourly averaged SO_2 concentrations, from 1994 to 2008 at Wyee air quality monitoring station

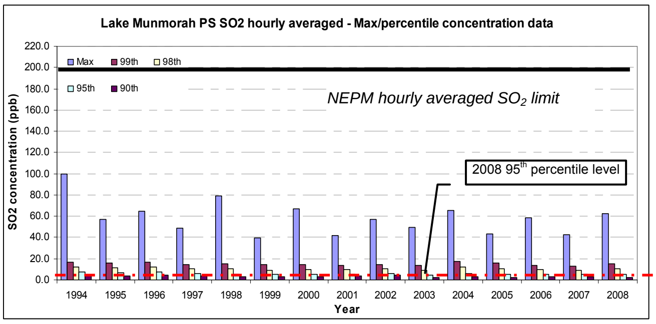

Figure 3.5 Observed hourly averaged SO_2 concentrations, from 1994 to 2008 at LMPS air quality monitoring station.

The following Figure 3.5 and Figure 3.6 show the hourly averaged SO_2 ground level concentrations observed at the Wyee and LMPS in 2004 (the reference year for subsequent modelling). The figures also identify the directions from which Munmorah, Vales Point and Eraring Power Stations are directly downwind from the air monitoring stations.

As the power stations are the only major source of SO_2 in the region, the peaks from certain wind directions most likely represent the effect of emissions from the upwind power station. The peaks suggest that the contribution by Munmorah Power Station to SO_2 levels is much lower than contributions from other sources.

The analysis also illustrates the low likelihood that the maximum SO_2 impact from Munmorah would coincide with the maximum impact with the other sources.

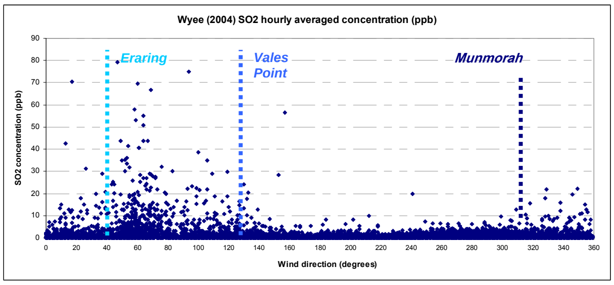

Figure 3.6 Observed hourly averaged SO_2 concentrations against contemporaneous wind directions at Wyee

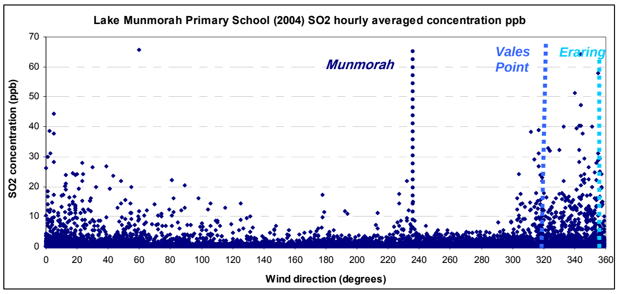

Figure 3.7 Observed hourly averaged SO_2 concentrations against contemporaneous wind directions at LMPS. 10 Minute average

The peak 10 minute averaged levels over the last 3 years have been observed to reach up to 400 µg/m3 (Limit = 712 µg/m3). An in depth analysis of SO2 impacts carried out by Holmes Air Sciences (2005) demonstrated the negligible nature of observed air quality impacts over the most monitoring period.

3.1.2 Nitrogen dioxide (NO_2)

The following analysis of ambient NO_2 records from Wyee and LMPS air monitoring stations encompasses the period from 1994-2008 and examines annual average, daily, one hour and ten minute ambient NO_2 air quality. The analysis demonstrates that annual average, daily and one hour ambient concentrations have been significantly below the relevant air quality goals.

Annual Average

The following profile of annual average ground level concentrations examines the observed data from Wyee and LMPS air monitoring stations during the period from 1994-2008. This profile of annual average statistics demonstrates that the observations are less than a third of the regulated NEPM and NSW Dec air quality limits. A downward trend in annual average NO_2 concentrations is observed over the period. This data indicates that air quality through this region is good.

Hourly average

A summary of the hourly average records of NO_2 concentration from the Wyee and LMPS monitoring stations for the period from 1994 to 2005 is provided in Figure 3.5 and Figure 3.6. The 2008 95th percentile level is provided as a reference (dotted line) to assist with the following interpretation.

Wyee

It is observed that the maximum observed NO_2 concentrations are significantly less than half the hourly average limit of 120 ppb.

While concentrations have remained relatively steady over the 15 year period the maximum concentrations recorded have been more variable.

This variability in peak concentrations may be attributed to variability in worst case meteorological conditions from year to year.

LMPS

The summary data of NO_2 concentrations recorded at the LMPS air monitoring station from 1994 to 2008 shows that there has not been a single exceedance in the guideline limit over the period examined. The maximum concentration recorded in 2008 (< 40 ppb) was less than a third of the hourly averaged limit.

The NO_2 concentration in 95% of the records examined are less than one fifth of the NEPM limit. The temporal differences in the observed 99th, 98th, 95th and 90th percentile levels are all largely negligible as the dotted reference line illustrates.

A similar variability in peak concentrations recorded over the period was observed with the worst case levels being observed in 2000 and 2005.

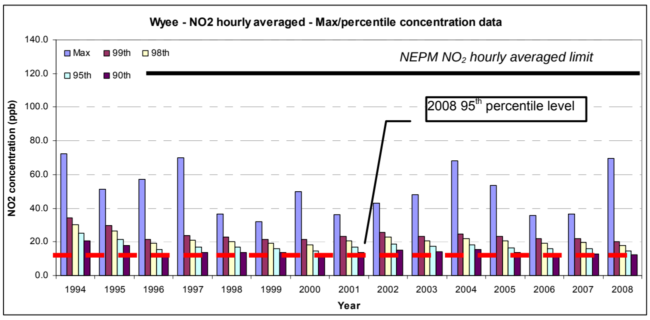

Figure 3.8 Summary of NO_2 percentile and peak hourly averaged ground level concentrations (ppb) 1994-2008 at (a) Wyee and (b) Lake Munmorah Primary School air monitoring data.

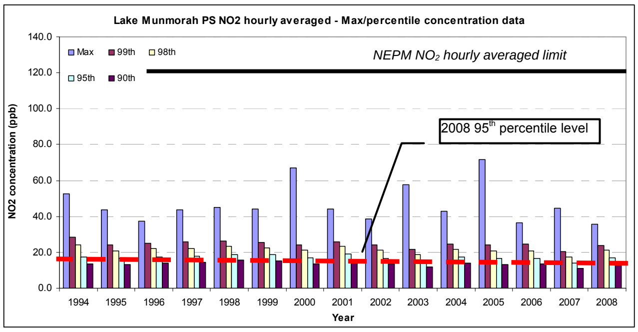

Figure 3.9 Summary of NO_2 percentile and peak hourly averaged ground level concentrations (ppb) 1994-2008 at (a) Wyee and (b) Lake Munmorah Primary School air monitoring data.

Discussion

The observed NO_2data indicates that the air quality in the region is very good. The 99th percentile NO_2 concentration recorded at Wyee and LMPS indicates that the peak concentrations are well below the NEPM hourly averaged limit and that they occur as isolated events through the year.

The 2008, 95th percentile of the observed hourly averaged NO_2 concentrations during the period analysed is less than one fifth of the NEPM NO_2 limit.

As confirmed by in reported dispersion studies (See Chapter 4, Holmes Air Sciences 2005), the Wyee and LMPS ambient monitoring stations are located in areas where peak NO_2 concentrations resulting from the operation of Munmorah Power Station are expected to occur.

It is noted that the two compliance air monitoring stations for Munmorah are located near the Sydney-Newcastle Fwy (> 40,000 veh/day) at Wyee (~ 500 m to edge of carriageway) and near the Pacific Hwy (20-40,000 veh/day) at Lake Munmorah Primary School (LMPS) (~ 100 m to edge of carriageway) (RTA, 2006).

An analysis of the ten highest NO_2 concentrations observed at Wyee air monitoring station through 2004 (refer Table 3.8) shows that, the peak levels correspond to evening traffic flow peaks on weekdays between 6 and 7 pm.

The ten highest NO_2 concentrations also coincide with low SO_2 concentrations (< 10 ppb), which supports the suggestion that power stations emissions are not the main cause of the observed NO_2 air quality impact through this region.

While the highest NO_2 ground level concentration observed at Wyee does not correspond with expected peak traffic volumes, and corresponds with the wind direction when Wyee is immediately downwind of any emissions from Munmorah, it is believed that emissions from Munmorah Power Station could not have been responsible, given corresponding low levels of SO_2 observed, through the hours and days either side of this statistic.

The low levels of SO_2 observed through these periods suggest that emissions from motor vehicles as opposed to those from a power station plume provide the main contribution to these higher records.

A similar analysis of the ten highest NO_2 concentrations observed at LMPS monitoring station (refer Figure 3.9) also illustrates that emissions from motor vehicles as opposed to the emissions from the power station are more likely to contribute to peak NO_2 events in this region.

Seven of the ten highest levels occur through periods that correspond to morning and evening traffic flow peaks. Three of these events coincide with higher SO_2 levels, however the corresponding wind directions do not place Munmorah down wind of the site.

Table 3.1 Ten highest NO_2 ground level concentrations (ppb) observed at Wyee through reference year 2004.

Date/time	NO_2	SO_2	Wind direction
2/03/2004 11:00	68.3	ND	131
26/03/2004 19:00	35.0	1.0	282
1/04/2004 18:00	37.3	1.0	311
27/08/2004 4:00	32.3	1.3	291
17/09/2004 19:00	31.8	1.8	348
27/09/2004 20:00	32.8	1.0	305
12/10/2004 18:00	32.8	1.3	300
13/10/2004 18:00	35.8	0.7	339
14/10/2004 0:00	33.7	9.7	354
30/11/2004 19:00	32.2	0.7	313

Table 3.2 Ten highest NO_2 ground level concentrations (ppb) observed at Lake Munmorah Primary School through reference year 2004.

Date/time	NO_2	SO_2	Wind direction
7/05/2004 17:00	42.8	3.2	132
9/03/2004 13:00	37.7	51.3	340
1/04/2004 19:00	37.3	2.8	253
7/05/2004 16:00	37.2	2.8	130
16/05/2004 17:00	36.7	1.7	122
20/12/2004 1:00	35.7	0.0	192
9/03/2004 12:00	35.5	47.2	344
7/05/2004 18:00	35.2	2.7	55
8/05/2004 18:00	34.3	3.3	92
11/05/2004 17:00	33.5	5.5	31

3.1.3 Fine particulate matter (PM_{10})

The observed levels of fine particulate matter (PM_{10}) in this region were analysed using the DECC Ambient Air Monitoring Reports for 2004. The levels observed by the TEOM particulate monitor at the air monitoring stations in the Lower Hunter being Beresfield, and Wallsend, were used to represent the background level of PM_{10} at this facility, to enable a reasonable representation of cumulative air quality impacts.

Table 3.3 Monthly PM_{10} maxima at DECC monitoring stations at Beresfield and Wallsend.

PM_{10} daily averaged (µg/m^3)	Beresfield	Wallsend
Jan	33	19
Feb	44	43
Mar	40	34
Apr	48	34
May	44	38
Jun	34	20
Jul	38	25
Aug	33	29
Sept	30	29
Oct	49	43
Nov	38	36
Dec	56*	53*

* Single exceedance in the NEPM PM_{10} daily averaged guideline limit of 50 µg/m^3 through the month of December at both DECC Air monitoring sites.

Exceedances in the daily averaged NEPM ambient air quality guideline for PM_{10} was observed at both of these stations through the month of December through the reference year (2004).

The majority of the exceedances in PM_{10} air quality goals through this region through the summer months (as in this case) can be attributed to local dust events, and/or bushfires events which enable the transport of large amounts of particulate matter over large distances. In this instance the relatively minor exceedance in the guideline through December is indicative of a local dust event. The data disseminated also indicates that the maximum daily averaged levels observed at Beresfield are consistently higher than those observed at the Wallsend air monitoring station.

3.2 Reference background conditions

The background conditions adopted for the pollutants that will be considered as part of the local air quality impact assessment are discussed in this section.

The adopted background conditions for NO_2, SO_2, PM_{10} and O_3 are provided in Table 3. The NO_2 and SO_2 background levels were adopted from the contemporaneous (2004) LMPS and Wyee datasets. The 2004 dataset was considered in this case as this was the reference year for the meteorological and air dispersion modelling carried out for the local air quality impact assessment. The selection of 2004 as an appropriate reference year is discussed in Section 5.1, as well as being based upon consideration of studies by the CSIRO the latter indicating that the worst case impact through this local region has been assessed to be through this reference year.

The DECCW prefers the 100th percentile background level to be adopted in considering cumulative air quality impacts. In the case of Munmorah, which is an existing operating facility, this is considered to be overtly conservative given it leads to the inclusion of the existing emissions from the Munmorah in any judgment of future air quality impacts, this leads to a double accounting effect.

Table 3.4 Summary of adopted background conditions from representative ambient NSW DECC campaign and Delta air quality monitoring stations (Wyee and LMPS)

Pollutant	Averaging period	Background level ppb (µg/m^3)	Notes
SO_2	10 min	113 (334)	Peak level observed at Wyee ambient air monitoring station through reference year 2004.
	1 hour	79.2 (226)	
	Daily	9.5 (27.2)	
	Annual	1.3 (3.7)	
NO_2	Hourly	37.7 (77.3)	Refer discussion in Section 3.1.2
	Annual	8.3 (17)	Annual average level observed through 2004.
O_3	Hourly	87.8 (188)	Average of the maximum hourly averaged ground level concentrations recorded at all NSW DECC air monitoring stations in the Lower Hunter region (Beresfield, Wallsend and Newcastle) over the period from 2003-2008. (note discussion in Section 6.1)
PM_{10}	Daily	56 µg/m^3	Peak PM_{10} daily averaged ground level concentration observed through 2004 at Beresfield air monitoring station.
	Annual	25 µg/m^3	

4. Effect of Rehabilitation on Power Station Emissions to the Atmosphere

4.1 Introduction

The objective the rehabilitation of Munmorah is to improve the efficiency of the power station by generating more electricity form the same input of energy (the same coal equivalent input). In this regard the rehabilitation is not predicted to result in any significant changes to the fundamental operation of the current power station. Minor changes to the plant and the proposed provision for gas firing, would result in a number of changes that affect the emissions characteristics of the existing power station. The most significant change in relation to coal firing is the provision of low NO_x burners which will reduce NO_x emissions.

Comprehensive technical investigations of the effects of the rehabilitation have been conducted (Aurecon 2009). The results of these investigations have been summarised in this section for the purpose of highlighting the nature and significance of any changes to emission s to the atmosphere that will occur. This information is provided in the following sections.

4.2 Technical Investigations

The technical investigations were conducted to provide the necessary inputs to the assessment of the potential environmental effects of the rehabilitation.

A significant aspect of the technical investigation was the prediction of unit performance over a range of gas firing scenarios. The predicted thermal performance levels were then used to estimate emissions of sulfur dioxides, nitrogen oxides, particulates and carbon dioxide. The investigations also addressed stack exit conditions.

PROATES (PROcess Analysis for Thermal Energy Systems), a whole plant modelling package for analysing and improving power plant steady state thermal performance was used for the modelling of the plant. It contains modules representing the physical processes of individual plant components, linked together to make a mathematical model. The software is proprietary to E.ON (UK) (formerly Power Gen) and has been under continuous development since 1979. E.ON has extensively validated the software against real plant data. A more detailed discussion of this modelling is provided in Appendix C of the main EA for this proposal.

4.3 Performance, Efficiency and Emissions

The original design performance and performance test results during the life of the power station are summarised in Table 4.1. The 1969 test results show that when the plant was new, the design performance levels were not achieved. The December 2006 test results show that a further deterioration in performance occurred over the intervening decades.

A significant reason for the reduced performance levels is the change in turbine heat rate - a 14% higher heat rate was measured in 2006 compared to the original design.

Table 4.2 summarises the predicted thermal performance for the range of possible boiler firing scenarios from 100% coal up to 75% gas firing of the boilers (Aurecon 2009)

Table 4.1 Original design and estimated test performance

Parameter	Units	Original Design	Test 5S 9 Sep 69	WP Test 13 Dec 06
Unit load	MW-Gen	350	348	290
Coal input energy	%	100	100	100
Main steam T.	°C	566	561	-
Hot reheat steam T	°C	538	540	-
Coal flow	kg/s	40	43	39
Coal rate	t/GWh-Gen	416	442	488
Flue gas O_2	%	3.2	3.2	3.2
Boiler efficiency	%	88.9	88.8	88.8
Turbine heat rate	kJ/kWh	8109	8563	9244
Turbine efficiency	%	44.4	42.0	38.9
Unit efficiency (gen)	%	39.5	37.3	34.6

Table 4.2 Predicted performance for proposed rehabilitated Units

Parameter	Units	Predicted Performance			
Target load	MW-Gen	350	350	350	350
Gas input energy	%	0	25	50	75
Coal input energy	%	100	75	50	25
Natural gas flow	kg/s	0.0	4.3	8.6	13.1
Coal flow	kg/s	40	31	21	10
Coal rate	t/GWh-gen	416	316	214	108
Flue gas O2	%	3.2	2.4	2.4	2.4
Boiler efficiency	%	88.9	88.8	88.3	87.7
Turbine heat rate	kJ/kWh	8109	8109	8109	8109
Turbine efficiency	%	44.4	44.4	44.4	44.4
Unit efficiency - gen	%	39.5	39.4	39.2	38.9

The predicted performance assumes full load operation and as new condition. In making these predictions the following assumptions were made:

- From the results in Table 3.2 it can be seen that here is a slight reduction in boiler efficiency with increasing gas proportion. This is due to the greater hydrogen content of natural gas and increased losses due to moisture in flue gas.
- The key parameter for the estimation of emissions is the fuel flow rates for the different configurations.

4.4 Changes to Stack Exit Conditions and Emission Characteristics

4.4.1 Stack Exit Conditions

The stack exit conditions were estimated based on data obtained from the PROATES modelling and a report delivered by Howden ("Munmorah Unit 3-4: Draught and Fabric Filter Dust Collection Plant Study", 11 May 2009) to provide input to plume dispersion modelling. The stack gas exit temperature and velocity was calculated for the 100% coal case only, with both Units operating at 350 MW (Aurecon 2009).

Table 4.3 Exhaust stack exit temperatures

Location	Howden Temperature Data	Estimated Temperatures
Ambient	20°C	20°C
Air heater gas inlet	320°C	327°C [1]
Stack outlet	**144°C**	**137°C**

1. PROATES modelling result

The volumetric flow rate of the flue gas is highly reliant on the gas density, and therefore gas temperature. The density of the gas flow was calculated at specific locations between the air heater inlet and the stack exit based on temperature changes between these sections. The volumetric flow rate was calculated from the flue gas mass flow rate as provided by the PROATES modelling. (Aurecon 2009). The flue gas exit velocity is calculated using the final volumetric flow rate and the exhaust stack exit dimensions.

The predicted flue gas stack exit velocity for the proposed Munmorah upgrade is summarised in Table 4.4.

Table 4.4 Exhaust stack exit velocity

Location	Parameter	Value
Stack outlet conditions for 2 Units	Volumetric flow rate	465 m^3/s
	Stack exit velocity	**19.0 m/s**

PROATES modelling result

A comparison between the historical and the predicted conditions for the rehabilitated plant is provided in the following table.

Table 4.5 Comparison of stack exit conditions in the historical case and the predicted conditions for the rehabilitated plant

Munmorah stack exit conditions (Stack ø7.9 m)	Average volumetric flow (Am^3/s)	Exit velocity (m/s)	Stack exit temperature (K)
Historical plant	892	18.2	403
Rehabilitated plant (2009 PROATE Modelling)	951	19.4	426
Percentage change	+6.6%		+5.7%

4.4.2 Emission Characteristics

NO_x Emissions

All fossil fuels produce NO_x during the combustion process. Nitrogen oxide production is a function of the boiler and burner design, operating conditions and fuel properties. As part of the plant rehabilitation, low NO_x coal burners are proposed.

The NO_x emissions with the new burners will be less than 500mg/Nm^3(SKM 2009). The use of gas will require new burners, which may also be specified as 'low NO_x', with a limit on emissions consistent with the new coal burners. The use of gas will therefore not impact NO_x missions compared to the 100% coal case.

NO_x emissions will meet the concentration limits for Munmorah Power Station emissions provided in Section 2.1. The existing records vs load and expected change in the NO_x emissions following rehabilitation are shown in the following attached figures.

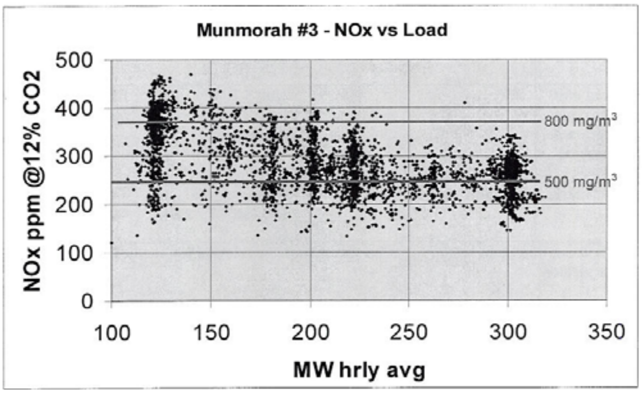

Figure 4.1 Current plant performance: NO_x emissions concentrations versus plant load (Malfroy, c2007) (Original source: PPI (2000))

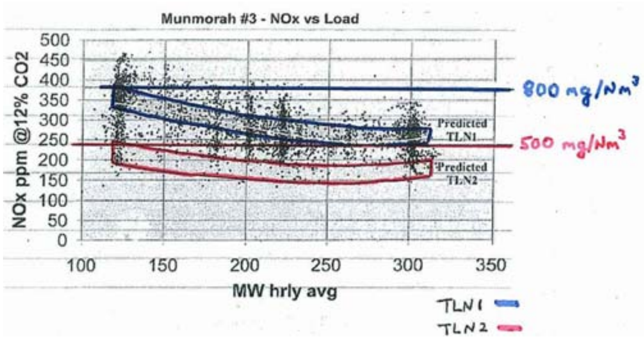

Figure 4.2 Rehabilitated (red line predicted:TLN2) NO_x performance versus plant load overlaid with current NO_x performance scatter plot (Worley Parsons, 2008).

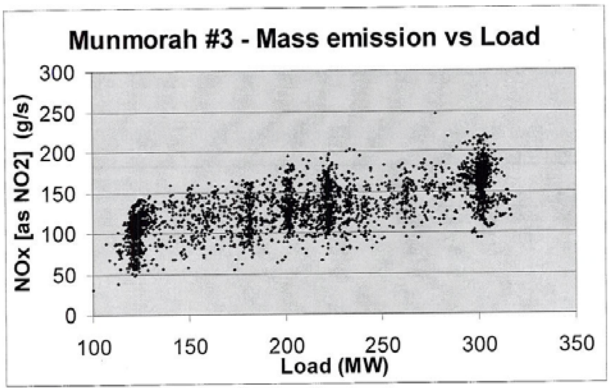

Figure 4.3 NO_x mass emission rates versus plant load (Malfroy, c2007) (Original source: PPI (2000))

SO_x Emissions

The stack SO_x emissions have been predicted based on typical coal qualities provided by Delta Electricity and the assumption that all sulfur in the fired coal is converted to sulfur dioxide (SO_2). It is also assumed that natural gas does not contain any sulfur. The SO_2 emissions have been calculated using Aurecon's boiler efficiency model, which has been verified and refined over a number of years (Aurecon 2009).

The key inputs to the model include the fuel composition on an "as received" basis and the oxygen (O_2) levels in flue gas. The coal properties are the same as used in the PROATES modelling.

The SO_2 concentrations have been calculated using the reference conditions as outlined in the "Protection of the Environment Operations (Clean Air) Regulation 2002". Schedule 5 of this regulation states reference O_2 levels of 7% are to be used for SO_x emissions for coal boilers.

The SO_2 concentration was calculated for the 100% coal case, and subsequently scaled for each gas option based on the percentage of coal fuel used. The results of the SO_2 emission concentration calculations for wet flue gas are summarised in Table 3.7

Table 4.5 Predicted SO2 emissions from proposed Munmorah upgrade

	100% Coal	25% Gas	50% Gas	75% Gas
SO_2 (ppm v/v)	341	256	171	85

In order to reduce the potential for Munmorah to contribute to short term (10 minute) ambient SO_2 exceedances, Delta Electricity is proposing to reduce the fuel quality limit at Munmorah to a maximum average monthly concentration of 0.7% sulfur in coal (Rae, et. al. 2008), 0.3 % down from the current 1%.

The sulfur emission rate based on this worst case ~0.7% sulfur grade coal is used in the air quality assessment. This emission rate is some 30% higher than the emissions that result from the from typical coal currently consumed at the station.

The co-combustion of low sulfur coal with natural gas would reduce emissions rates from the base case scenario. As can be seen from Table 4.5, SO_2 emissions significantly reduce as the proportion of gas firing increases.

Table 4.6 SO_2 flue gas emissions equivalent to a coal quality level of 0.7% S in coal

Coal: 0.7% S	100% coal fired
SO_2 (ppm v/v)	582

Monitoring of SO_2 and sulfuric acid mist and sulfur trioxide (as SO_3) from the existing power station has indicated that levels are well If it is assumed that there is a direct relationship between SO_2 and Sulfuric acid mist and sulfur trioxide (as SO_3) the proposed reduction of maximum coal quality should result in a 30% reduction in the maximum values recorded.

Particulate Emissions

It is not expected that the proposed Munmorah rehabilitation would change plant characteristics that in relation to particulate emissions. The volumetric flow of the flue gas will be largely unchanged for all options, and the dust burden in the flue gas will vary with the amount of natural gas firing.

The more gas firing that takes place, the lower the inlet dust burden of the fabric filter plant. Reduced inlet dust burden levels may assist in lowering fabric filter dPs and lengthening fabric filter bag cleaning cycles.

The precise impact of the gas firing on particulate emissions is unclear, as the combustion process may result in varying ash particle size distributions. If the combustion process results in a larger amount of finer ash, then the particulate emissions may increase relative to the amount of coal burnt. However the reverse case is also true, in that a smaller amount of finer ash will improve the particulate emissions.

4.5 Review of Munmorah emissions

A review of air emissions concentrations for the relevant pollutants stipulated under Schedule 3 of the POEO (Clean Air) Act 2002 has been provided by Delta Electricity (Malfroy 2007).

The emission concentrations from Munmorah Power Station are based on historical performance data undertaken in accordance with the Approved methods for the sampling and analysis of air pollutants in NSW (DEC, 2005). Comment on the effects of the rehabilitation is also provided in the following table.

Existing monitoring has shown that emissions over the period 2004-2006 comply with the current licensed emission requirements and that they are generally compliant with Group 6 emission standards.

With the introduction of low NO$_x$ burners, as part of the rehabilitation works, NO$_x$ emissions will be compliant with Group 6 emission standards under normal operating conditions, following the implementation of the rehabilitation works.

Table 4.7 Assessment of Emission against Group 6 emission limits

Substance	Limit	Averaging time	Munmorah 2004-2006 performance	Comment – data source	Expected Change Due to Rehabilitation	
					100% Coal Fired	With Gas Firing
Solid particles	50 **mg/m^3**	**(1)**	Unit 3: 11.5-51.6 Average 29.6 Unit 4: 3.4-13.6 Average 5.6	EPL – annual batch sample	No change	No expected change
NO$_2$ or NO or both expressed as NO$_2$ equivalent	500 **mg/m^3**	1 hour block	900 (~650@full load)	EPL – CEMS	Reduction to < 500 with low NO$_x$ burner retrofit	
Fluorine, as HF equivalent	50 **mg/m^3**	**(1)**	Unit 3: 1.7-8.7 Average 4.1 Unit 4: 02-14.5 Average 5.6	EPL – annual batch sample	No change	Reduction in proportion to % gas
Type 1 and Type 2 substances in aggregate **(2)**	1 **mg/m^3**	**(1)**	Unit 3: 0.003-0.11 Average 0.05 Unit 4: 0.02-0.11 Average 0.06	EPL – annual batch sample (most results for individual metals <LOD. For calculations results assumed to equal the LOD.	No change	Reduction in proportion to % gas

Substance	Limit	Averaging time	Munmorah 2004-2006 performance	Comment – data source	Expected Change Due to Rehabilitation	
Cd or Hg individually	0.2 **mg/m**^{3}	**(1)**	<u>Cd Unit 3 &4</u>: <0.00007-0.002 Average 0.00132 <u>Hg Unit 3 & 4</u>: <0.00007-0.004 Average 0.00030	EPL – annual batch sample. See comment above.	No change	Reduction in proportion to % gas
VOCs as n propane	40 VOC or 125 CO **mg/m**^{3}	1 hour rolling	Unit 3 & 4 2006 <5 No VOC peak detected	EPL – batch (measurement of CO not required by EPL)	No change	Increase in proportion to % gas
Smoke **(3)**	Ringlemann 3 or 60% opacity (Note 6) or Ringlemann 1 or 20% opacity (Note 7)	6 minutes rolling	<10% (4)	EPL – CEMS for *"undifferentiated particles"*	No change	No change
Hydrogen chloride	100 **mg/m**^{3}	**(1)**	<u>Unit 3 and 4</u> 0.2-4.5 Average: 4.1	EPL – annual batch sample	No change	Reduction in proportion to % gas
Chlorine (Cl_2)	200 **mg/m**^{3}	1 hour block	<u>Unit 3 and 4</u>: 0.005-0.4 Average: 0.16	EPL- annual batch sample	No change	No change
Hydrogen sulphide	5 **mg/m**^{3}	1 hour block	Below level of detection (5)	Testing not required by EPL	No change	No change
Sulfuric acid mist or SO_3 or both expressed as SO_3 equivalent	100 **mg/m**^{3}	**(1)**	<u>Unit 3 & 4</u>: 0.9-2.1 Average: 1.4	EPL – annual batch sample	No change	Reduction in proportion to % gas
Dioxin or furans **(8)**	0.1ng/m^3		0.0013 ng/m3 (average of 2 tests)**(5)**	Testing not required by EPL	No change	Reduction in proportion to % gas

NOTE:

1. 1 hour, or minimum sampling period specified in the relevant test method, whichever is the greater.
2. <u>Type 1</u>: antimony, arsenic, cadmium, lead or mercury
   <u>Type 2</u>: Beryllium, chromium, cobalt, manganese, nickel, selenium, tin and vanadium
3. <u>Approved circumstances</u> – as applicable to Munmorah;
   For a period of not more than 20 minutes per 24hours after lighting a boiler or incinerator for cold, being the period that the boiler or incinerator is brought up to normal operation and that all practical means are employed to prevent or minimise the emission or smoke during that period.
4. Opacity us bit recorded at Munmorah. Instruments output data in mg/m$^{3.}$ Opacity data have been sourced form Vales Point Unit 6 which is now equipped with pulse jet bad filters and should be indicative of opacity in Munmorah ducts.
5. Based on measurements at Vales Point Power Station. Stephenson and Associates 1999.
6. In approved circumstances:
7. In other circumstances:
8. <u>Dioxins or furans limit of 0.1ng/m^3</u>, only applies to non-standard fuels containing precursors of dioxin or furan formation.

4.5.1 Particulate emissions (PM)

The Munmorah Rehabilitation - Technical Investigation Report s3.5 p13 (Aurecon 2009) provides a succinct description of the dependency of PM emissions upon fly ash conditions and percentage of gas combusted. A comparison of historical levels (2004-06) against the Group 6 guidelines shows that the emission concentrations are generally well below the Group 6 standard of 50 mg/m^3 (Unit 3 ~ 8 mg/m^3 and Unit 4 ~29 mg/m^3 - see Attachement A), this is likely to remain largely unchanged.

The report noted that the volumetric flow of the flue gas will be largely unchanged for all options, and the dust burden in the flue gas will vary with the amount of natural gas firing.

The more gas firing that takes place, the lower the inlet dust burden of the fabric filter plant. Reduced inlet dust burden levels may assist in lowering fabric filter dPs and lengthening fabric filter bag cleaning cycles. However, the precise impact of the gas firing on particulate emissions is unclear, as the combustion process may result in varying ash particle size distributions.

The emission of fine particles from fabric filters is a function of the bag condition and the effective management of the bag system rather than the load on them. The efficient maintenance and operation of fabric filters will lead to high levels of emissions control being achieved and particulate emissions levels being kept below regulated limits.

4.5.2 Other pollutants

Although the specifics of the proportions of coal and gas that will be co-fired is unknown at this stage, any reduction in the proportion of coal burnt will lead to a significant decrease in emissions of fine particulates. Proportional decreases in emissions of particulate bound pollutants including PAHs, persistent organic pollutants and trace metals would also occur.

Other pollutants include but are not limited to the emissions of trace elements including Type 1[1], Type 2[1] pollutants and Cd, Hg specifically), volatile organic compounds (VOCs) and subset groups including dioxins and furans. The comparison of Munmorah's historical emissions performance against the Group 6 standards demonstrates compliance, prior to plant rehabilitation. The plant is expected to be compliant. While some changes in emissions could occur, as noted in Table 4.8, the plant is predicted to remain compliant with emissions standards.

4.5.3 Stack exit conditions

The characteristics of the flow at the stack exit in terms of velocity were determined through the PROATES combustion modelling introduced in the previous sections (Aurecon, 2009). A comparison is made between the stack exit conditions assumed in historical air quality assessments (Cox, J., 2009 per comm.) and what is expected post rehabilitation.

The PROATES modelling outcomes demonstrate a small increase in the final stack exit velocity which equates to approximately 6% increase in the volumetric flow rate in comparison to that used in previous air quality modelling studies.

4.5.4 Discussion

A goal of the rehabilitation works at Munmorah Power Station is to achieve compliance with Group 6 emission standards. The shift from inefficient coal burners to rehabilitated low NO_x coal and gas burners (separate entities) will lead to a decrease in NO_x emission rates (g/s), when compared with historical conditions. As shown in Table 4.2, the PROATE modelling results have demonstrated that the improved thermal performance of the system will provide increased generation capacity as well as result in decreased NO_x emissions overall. That is, greater thermal efficiencies leads to greater generation efficiency i.e. a reduction in coal burnt per MW output.

The marginal change in the stack exit temperature and exit velocities will not have a significant impact upon the dispersion of air pollutants as they exit the stack tip. This is largely due to the relatively small increase in the respective parameters as compared to the historical levels. The expected air quality impacts on the local and regional atmospheric environments are shown to be acceptable and, with the exception of reduced NO_x emissions are not predicted to change substantially from current operations.

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[1] Type 1: antimony, arsenic, cadmium, lead or mercury; Type 2: beryllium, chromium, cobalt, magnesium, nickel, selenium, tin and vanadium.

5. Air dispersion modelling inputs

5.1 Introduction

The preceding analysis of ambient air quality data has provided an indication of the good air quality experienced in the region, which includes the effects of the currently operating Munmorah Power Station. However, the DGRs also require an assessment of air pollutants in accordance with the Approved methods for the modelling and assessment of air pollutants in NSW document (DEC, 2005) (the Approved Methods) in order to quantify the nature and extent of potential worst case ground level concentrations of emissions.

TAPM (The Air Pollution Model) developed by the CSIRO has been used for this purpose. The TAPM model produces the input meteorological data and using the predicted emissions data for the sources calculates the resultant hourly ground level concentration of emissions. The model is described further in Section 5.2.2.

This input emissions data for the modelling has been described in the previous section. In addition, the modelling requires representative meteorology in order to predict the worst case impacts.

Following a description of the meteorology developed as input to the modelling, this section documents the outcome of the modelling in accordance with the DECCW requirements and discusses the results.

5.2 Meteorology

The ground-level concentrations resulting from emissions from a stationary source, such as Munmorah Power Station vary according to the emission characteristics of the facility and the weather (particularly the wind) conditions at the time.

The meteorology is the primary factor determining the diluting effect of the atmosphere. Therefore, it is important that meteorology is carefully considered when modelling plume dispersion.

In addition to the characteristics of the emissions, plume rise at the release point is affected by ambient temperature and relative humidity. The subsequent dispersion of the plume from the source is affected by:

- Wind speed, profile and turbulence intensity;
- Buoyancy affected by the temperature gradient which is determined from *atmospheric stability* and;
- *Mixing height* which is the depth of the atmospheric boundary layer.

5.2.1 Observed meteorological conditions

Selection of reference year

2004 was selected as the reference year for the analysis on the basis of a comparative analysis of average temperature and wind speed conditions for this year with long term average conditions.

The observed meteorological conditions through the reference year are discussed in this section.

Temperature distribution

Minimum temperature is a good indicator of the frequency of calm stable conditions which inhibit the dispersion of emissions. The analysis of mean minimum temperature through 2004, shown in Figure 5.1 illustrates a good correlation with the long term average conditions.

The congruence of the yearly mean minimum temperature with the long term average supports the selection of 2004 as an appropriate reference year.

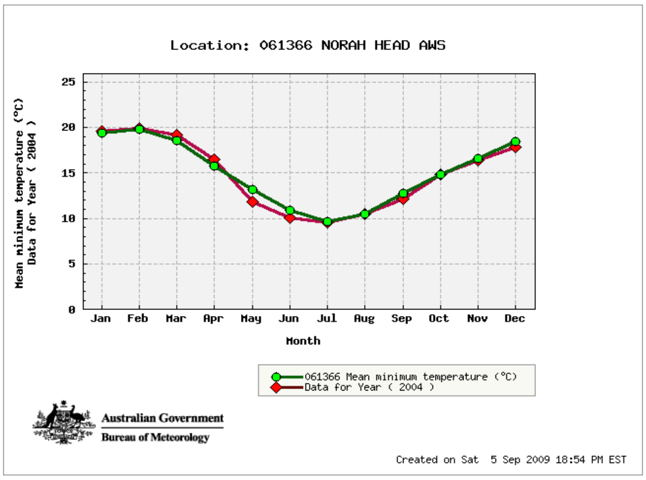

Figure 5.1 2004 mean minimum temperature compared to the long term average figures at Norah Head AWS (BoM, 2009)

Wind speeds

The 2004 mean 9 am and 3 pm wind speed conditions at the Bureau of Meteorology automatic weather station (AWS) at Norah Heads also correlated well with the long term average wind conditions through this region (refer Figure 5.2).

Observed wind speed data were also obtained from the Delta air monitoring stations at Munmorah, Lake Munmorah Primary School (LMPS) and Wyee. The data from these stations were assimilated into a prognostic numerical meteorological model (TAPM) to predict more complex meteorological parameters that feed into the air dispersion model. This assimilation process allowed for a more robust assessment of wind speed conditions through this region.

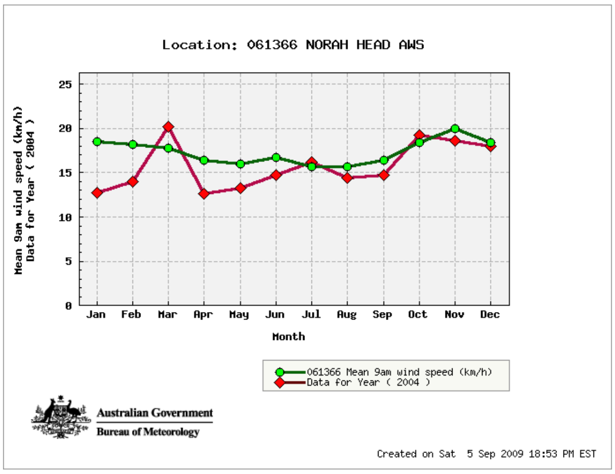

Figure 5.2 2004 average (a) 9 am wind speed conditions compared to the long term average figures at Parafield Airport AWS (BoM, 2009)

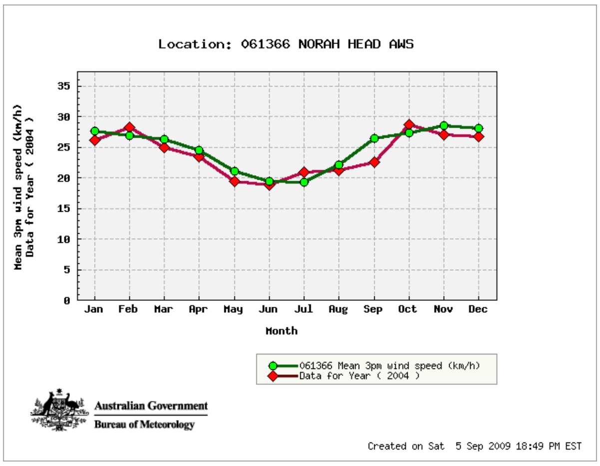

Figure 5.3 2004 average 3 pm wind speed conditions compared to the long term average figures at Parafield Airport AWS (BoM, 2009)

Local Winds

The wind roses developed from the observed datasets for the Munmorah, LMPS and Wyee stations are shown Figure 5.4, 5.5 and 5.6 respectively. The wind roses illustrate the local variability in wind speed and directionality characteristics within the region.

The Munmorah Power Station wind rose (Figure 5.4) shows that winds from the south west being dominant through the year, although there is good representation of wind from all other directions, with the exception of easterly winds.

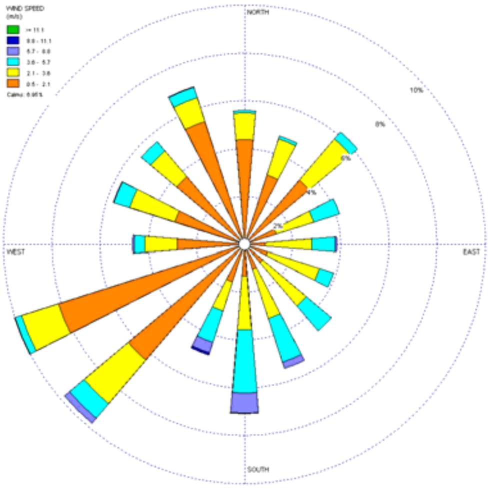

Figure 5.4 Observed wind roses from Delta air monitoring stations at Munmorah

The wind rose for LMPS (Figure 5.5) , illustrates that winds at this site are dominated largely from the North and South.

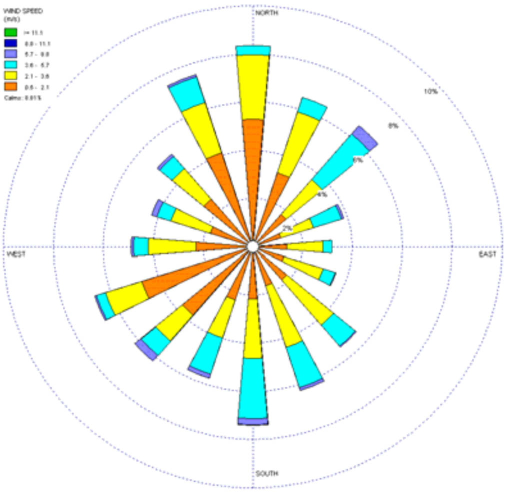

Figure 5.5 Observed wind roses from Delta air monitoring stations at LMPS

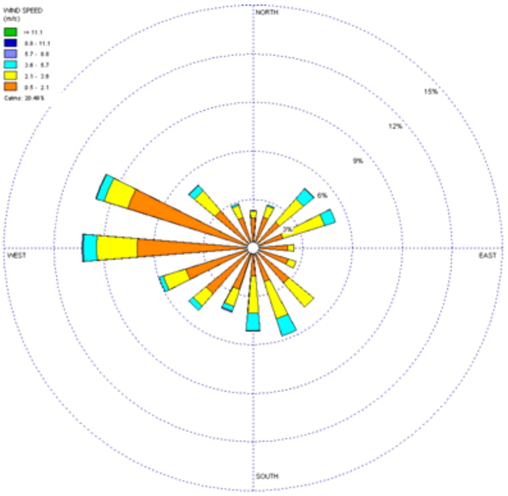

Figure 5.6 Observed wind roses from Delta air monitoring stations at Wyee.

The Wyee observed wind rose for Wyee Figure 5.6, shows that winds from the west are highly dominant with all other directions being poorly represented. The figure also shows that nearly all winds are below 5.7 m/s in magnitude, whereas higher wind speeds, i.e. those greater than 5.7m/s occur at Munmorah and LMPS.

5.2.2 Predicted meteorological conditions

TAPM – The Air Pollution Model v3.0

TAPM (The Air Pollution Model) a CSIRO developed prognostic meteorological and air dispersion model was used to develop the pre-processing spatially varying hourly meteorological data for this region. Previous studies of available models have shown that this model performs well for the range of conditions experienced on the Central Coast, although it has a tendency to over-predict the highest concentrations on occasions (Lilley et al 2007).

The TAPM model produces meteorological data, upper air information and temperature profiles for the simulation period in three dimensions for all the grid points across the domain. The gridded meteorological data generated by TAPM is calculated from the synoptic information determined from the six hour interval limited area prediction system (LAPS) (Puri K et al 1998).This final meteorological data is representative of the local topography, land use, surface roughness and temperature effects caused by water bodies.

The TAPM nesting grid or mesh was determined for this model via the consideration of the required terrain resolution in the radius of influence (approximately 20 km). Due to the gentle, ‘rolling’ gradient of the hills the required terrain resolution was achieved via the use of nested grid with a minimum spacing of 1,000 m The dispersion grid was modelled with still smaller a grid spacing (500 m) to resolve the impacts at near field sensitive receptors. When running the TAPM in the dispersion modelling mode the Eulerian computational option was selected.

A basic summary of the data and parameters used in both the meteorological and dispersion parts of the TAPM model is shown in Table 5.1. The pollutants were modelled as tracers in the absence of any chemical transformations or deposition.

Thus the cumulative impact (background plus contribution of Munmorah) of the rehabilitated Munmorah Power Station facility will be considered based on the analysis of the existing environment; considered in Section 3.

Table 5.1 TAPM input parameters

	Meteorology	Dispersion
Centre	33° 12′ 30″ **S** 151° 32′ 30″ **E** Easting: 364183 m Northing: 6324290 m	
Dates	2004 (GMT +10.1)	
Grid	25 x 25 x 20 (nx x ny x nz)	41 x 41 (nx x ny)
Nesting	30 – 10 – 3.0 – 1.0 km	15 – 5.0 – 1.5 – 0.5 km
Meteorology assimilation	Hourly wind speed/direction data from Munmorah climatic, Wyee and Lake Munmorah Primary School ambient air monitoring stations.	
Dispersion computation	Tracer mode emissions (no chemistry or deposition) - Eulerian grid approach	

Predicted wind speeds

The predicted wind rose and the frequency distribution of the modelled wind classes are provided in Figure 5.7 to 5.9 and Figure 5.10 to 5.12 respectively.

A comparison between the observed wind roses of Figure 5.4 to 5.6 to the wind roses based on the predicted dataset in Figure 5.7 to Figure 5.9 enables an assessment of the directionality characteristics of the predicted dataset against what was observed.

An analysis of the Munmorah and LMPS wind roses shows that there is a relatively even distribution of wind directionality classes across the range from 0-359°, although the westerly winds dominate both the observed and predicted Munmorah datasets. The LMPS predicted dataset seems to have over predicted the frequency of westerly winds, the observed dataset showing dominance by northerly and southerly wind directions. There is quite a good degree of similarity however between the Wyee observed and predicted wind roses with westerly wind conditions dominating both datasets. Although there has been some compromise in the accuracy of the LMPS predicted dataset, overall there is relatively good agreeability in the directionality of the predicted wind conditions. This analysis follows the predicted meteorological dataset being nudged towards observed levels through assimilation of the contemporaneous dataset (refer Table 5.1).

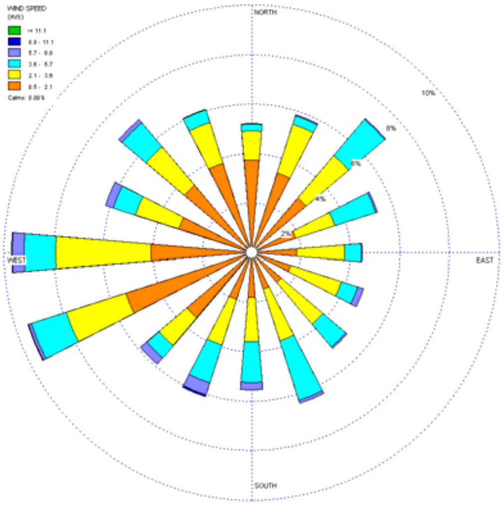

Figure 5.7 Predicted wind roses from Delta Electricity air monitoring stations at (a) Munmorah, (b) Lake Munmorah Primary School and (c) Wyee.

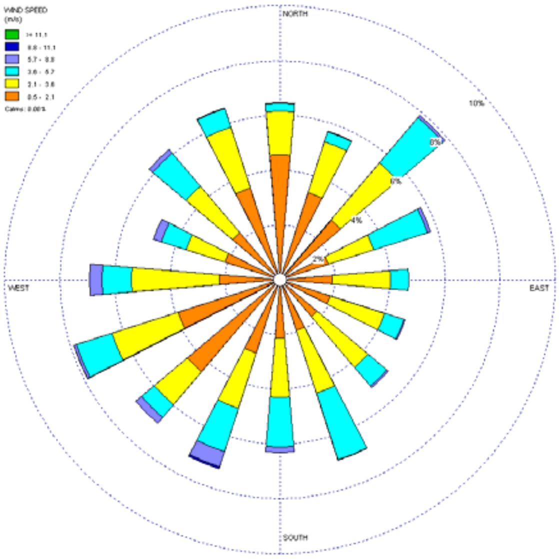

Figure 5.8 Predicted wind roses from Delta Electricity air monitoring stations at (a) Munmorah, (b) Lake Munmorah Primary School and (c) Wyee.

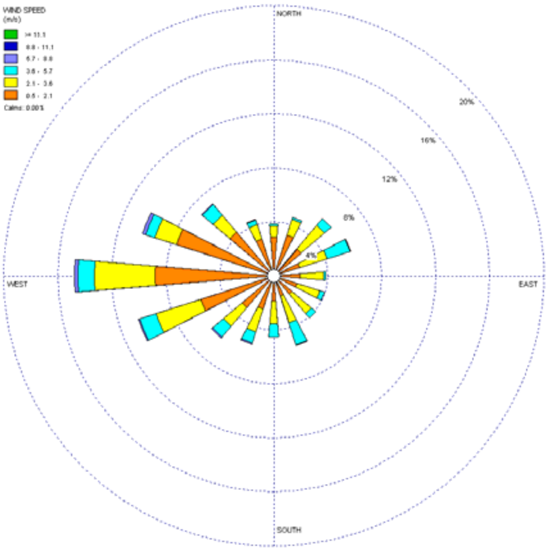

Figure 5.9 Predicted wind roses from Delta Electricity air monitoring stations at (a) Munmorah, (b) Lake Munmorah Primary School and (c) Wyee.

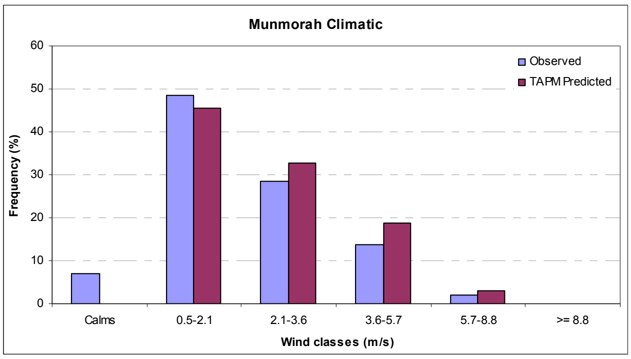

Figure 5.10 Comparative histograms of predicted against observed wind class frequency distributions for Munmorah weather station

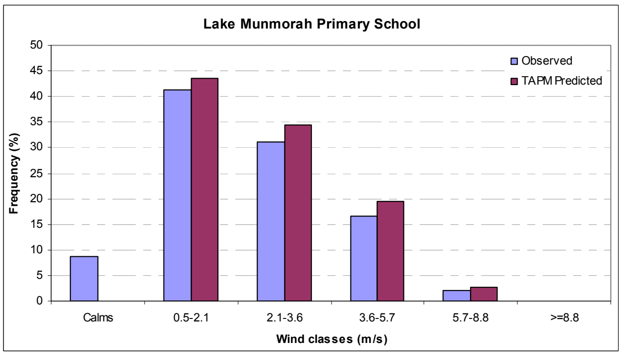

Figure 5.11 Comparative histograms of predicted against observed wind class frequency distributions for LMPS air monitoring station

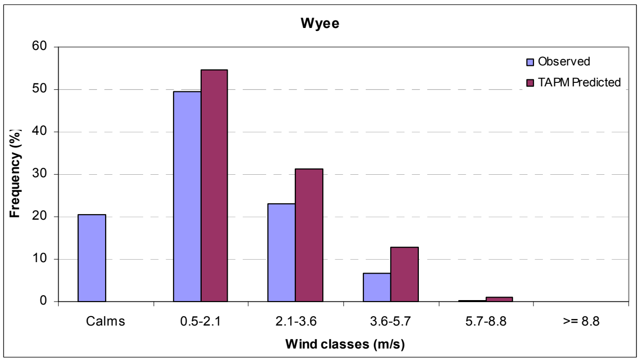

Figure 5.12 Comparative histograms of predicted against observed wind class frequency distributions for Wyee air monitoring station

The wind class frequency distributions shown in Figure 5.10 to 5.12 illustrate that the bulk of winds through this region are less than 6 m/s. The TAPM simulation has been unable to accurately represent calm conditions but has represented all other wind classes including high wind speed classes (i.e. > 9 m/s) accurately. The assimilation of the observed datasets into the TAPM simulation illustrates some skew towards the lower wind classes in the frequency distribution. However this being the case the model will tend to over prediction of air quality impacts.

Atmospheric stability

The degree of stability in the atmosphere will affect the dispersion of emissions from a source. The Pasquill-Gifford (P-G) stability category scheme is used to denote atmospheric stability. Stability class under this scheme is designated a letter from A-F (and sometimes G), ranging from highly unstable to extremely stable. The TAPM model simulates this atmospheric stability through turbulence intensity.

Atmospheric movement is characterised by four basic conditions that describe the general stability of the atmosphere. In stable conditions, vertical movement is discouraged, whereas in unstable conditions the “air parcel” tends to move upward or downward and to continue that movement. When conditions neither encourage nor discourage vertical movement, beyond the rate of adiabatic heating or cooling, they are considered neutral.

When conditions are extremely stable, cooler air near the surface becomes trapped by a layer of warmer air above it. Under these conditions, called an inversion, virtually no vertical air motion occurs.

Table 5.2, illustrates how the amount of incoming solar radiation affects stability, as does wind speed. The frequency distribution of stability class with wind speed classes (Table 5.3) shows that neutral conditions occur through all wind speeds but stable and unstable conditions only occur through the lower wind speed ranges (predominantly those below 6 m/s). This is consistent with what is expected for this region and the empirical expectations described in Table 5.2.

The stability class frequency distribution for the reference year (2004) in the predictive modelling for Munmorah is shown in Table 5.2. These results demonstrate the high frequency of unstable meteorological conditions during the day time and neutral to stable conditions being prevalent during the night. This is as expected as mixing is enhanced during the day time due to solar irradiation as well as mechanical mixing by the wind. However during the night, mixing only occurs through mechanical means i.e. wind, which is less pronounced in comparison to day time hours. This leads to more stable meteorological conditions being observed.

Table 5.2 Atmospheric stability categories

Wind speed (m/s)	Solar irradiation (mW/cm^2)				Time after sunset or before sunrise	Night-time cloud cover (octas)		
	>60	30-60	<30	Overcast		0-3	4-7	8
< 1.5	A	A-B	B	C	D	F or G[b]	F	D
2.0 – 2.5	A-B	B	C	C	D	F	E	D
3.0 – 4.5	B	B-C	C	C	D	E	D	D
5.0 – 6.0	C	C-D	D	D	D	D	D	D
> 6.0	D	D	D	D	D	D	D	D

[a] Wind speed is measured to the nearest 0.5m/s.

[b] Category G is restricted to night-time with less than 1 octa of cloud and a wind speed less than 0.5m/s.

Table 5.3 Stability class frequency distribution with respect to wind speed classes.

Speed (m/s)	A	B	C	D	E	F
0.5 - 2.0	65	220	220	1367	889	706
2.1 – 4.0	105	723	723	858	212	1307
4.1 – 6.0	0	268	268	459	264	0
6.0 – 8.0	0	0	0	166	0	0
> 8.0	0	0	0	27	0	0

Table 5.4 Stability class frequency distribution with respect to time of day

Hour of day	A	B	C	D	E	F
1	0	0	0	77	118	171
2	0	0	0	68	129	169
3	0	0	0	76	128	162
4	0	0	0	91	127	148
5	0	0	0	110	117	139
6	0	0	0	209	71	86
7	0	0	8	306	16	36
8	0	2	106	258	0	0
9	0	64	145	157	0	0
10	7	144	136	79	0	0
11	17	171	113	65	0	0
12	35	178	86	67	0	0
13	44	167	92	63	0	0
14	33	166	97	70	0	0
15	22	144	109	91	0	0
16	12	113	96	145	0	0
17	0	61	103	202	0	0
18	0	1	57	249	18	41
19	0	0	0	200	59	107
20	0	0	0	52	122	192
21	0	0	0	50	127	189
22	0	0	0	64	101	201
23	0	0	0	61	115	190
24	0	0	0	67	117	182

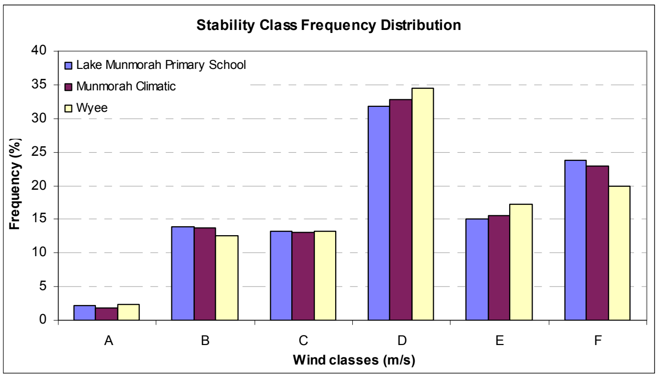

Figure 5.13 Annual stability class frequency distribution at Lake Munmorah Primary School, Munmorah and Wyee

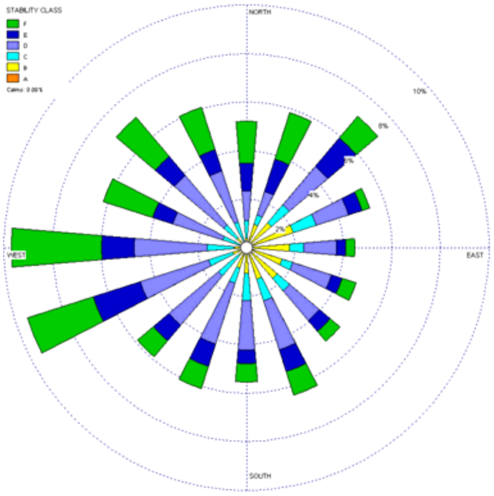

Figure 5.14 Stability class rose at Munmorah.

Mixing Height

The mixing height is the height of the turbulent (boundary) layer of air near the earth's surface, into which ground level emissions will be rapidly mixed. A plume emitted above this height will remain isolated from the ground until the mixing height reaches the height of the plume. A plume emitted below this height will be mixed subject to the stability class and wind climate. The height of the mixing layer is controlled by convection (resulting from solar heating of the ground during the day), by mechanically generated turbulence as the wind blows over 'rough' ground and also presence or absence of higher level subsidence.

The mixing height at Munmorah was estimated using gridded surface and upper air meteorological data that was generated by TAPM. TAPM is able to generate meteorological data up to a level of 8 km above sea level. Hence with this data the mixing height can be estimated. The hourly mixing height profile (average, 2nd and 99th percentiles) for the reference year is provided in Figure 5.15

The estimated mixing height for this site rises very quickly in the early morning from just after sunrise until mid afternoon, at which point the mixing height remains at a relatively stable value until returning to a lower level early in the evening. This diurnal variation in the atmospheric structure is consistent with that found at similar sites. Large values for mixing height occur in the summer months as expected due to the greater convective effects. The main change throughout the year is the length of the period of strong convection and wind variation.

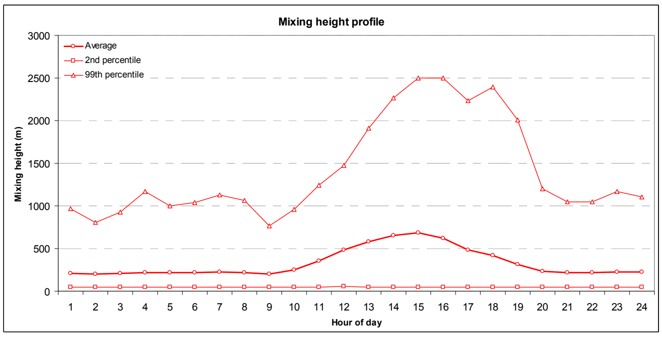

Figure 5.15 Hourly mixing height profile at Munmorah, as predicted by the TAPM prognostic meteorological simulation

5.3 Air dispersion - pollutant modelling

The pollutant emissions modelled as part of the local air quality impact assessment were assessed based on the guaranteed emission limits provided by the proponent. The guaranteed limits are largely set to be equal to the Group 6 emission standards as stipulated by the POEO (Clean Air) Act. Maximum pollutant emission rates for the rehabilitated plant configuration are tabulated in Table 5.5. Based on measured data (refer Section 4) an emission limit lower than the Group 6 standard has been used for fluoride and cadmium compounds in order to better reflect the potential ambient air quality impacts.

As discussed in Section 4 Delta Electricity proposes to adopt a limit of 0.7% sulfur coal in order to further limit contributions from Munmorah to exceedances of short term sulfur dioxide ambient air quality goals, (i.e. in terms of ground level concentrations) over the 10 min and 1 hour averaging periods.

The parameters that were used to represent the Munmorah Power Station source in the TAPM air dispersion model are summarised in Table 5.1 and Table 5.6. The data was sourced from the PROATES modelling results summarised in Section (and per Cox J (2009)) along with consideration of emissions examined in Chapter 4.

Table 5.5 Emission limits and rates for pollutants modelled as part of the local air quality impact assessment

Pollutant	PoEO Regulation Group 6 limits	Guaranteed emissions limit (mg/Nm^3 unless stated otherwise)	Munmorah rehabilitated emission rates (g/s)*
Sulfur dioxide (SO_2)	-	1663#	1014
Oxides of nitrogen (NO_x)	500	500	305
Fine particulates (PM_{10})	50	50	30.5
Fluoride (modelled as HF – hydrogen fluoride)	50	10	6.1
Cadmium (Cd)	0.2	0.002	0.0012
Mercury (Hg)	0.2	0.2	0.122
Dioxins and furans (PCDD/F)	0.1	0.1 ng/Nm^3	6.09×10^{-8}

SO_2 - emission concentration at 0.7% sulfur coal

* Emission rates are reported at standard conditions (0°, dry gas, 1 atm pressure, 7% O_2) Normalised volumetric flow rate – 604.3 Nm^3/s was used to determine specific pollutant air emissions.

Table 5.6 Stack exit parameters included in air dispersion model

Stack exit conditions	
Stack - height - base elevation	150 m 15 m
Diameter	7.9 m
Exit temperature	426 K
Exit velocity	19.4 m/s
Average volumetric flow rate at exit	951 m^3/s

6. Local air quality impacts

This section seeks to assess the air quality impacts of the rehabilitation of this Munmorah Power Station. The dispersion modelling study modelled the Munmorah facility using the parameters tabulated in Table 5.1, Table 5.5 and Table 5.6.

Cumulative impacts are assessed by considering the predicted impact of Munmorah Power Station in addition to the background air quality currently as well as the predicted impact from the nearby Colongra gas turbine, which is currently being commissioned.

In addition the changing nature to the air environment following resulting from recent approvals to increase the capacity of Vales Point and Eraring Power Stations requires consideration.

Vales Point and Eraring Power were not explicitly modelled as it is believed that their influence is adequately reflected in the maximum observed ambient air quality concentrations through 2004 for both NO_2 and SO_2.

It is noted that both Eraring and Vales Point Power Stations have a significant influence on the observed ambient air quality at Wyee and LMPS monitoring stations. Furthermore, these levels do not take into account the planned upgrade the Eraring Power Station from a 4 x 600 MW facility to a 4 x 750 MW facility.

The worst case impacts from the Eraring facility have been noted to occur to the North and North west of the Eraring Power Station (Rae et. al. (2007)).

A further consideration is low the probability of coincidental worst case impacts from both Munmorah and Eraring Power Stations, due to their separation. The observed wind at any point would have to shift in direction by more than a quadrant (90 degrees) for the impacts from both facilities impacts to be coincidental,.

Finally, while Eraring Power Station has been shown to have a more significant influence upon observations at Wyee than the LMPS monitoring site, the emissions from Munmorah have the converse range of influence.

The worst case impacts for Munmorah are observed near or close to the Lake Munmorah region with much lower impacts through Wyee and surrounding regions.

The existing (background) air quality was discussed in Section 3. Section 6.1 outlines the methodology adopted to represent cumulative impacts for NO_2. The cumulative impacts for all other pollutants are considered by a simple summation of the worst case impact derived from the modelling program and the level that is deemed to adequately represent background air quality through this region. A summary of these background levels was provided in Table 3.4.

6.1 Cumulative NO_2 impacts – Ozone limiting method (OLM)

The explicit analysis of atmospheric chemistry in air dispersion modelling is not always necessary to accurately determine the amount of NO and NO_2 within the plume at any time, because simpler methods have been found to be adequate in most situations. The most conservative approach is to assume that all of the NO_x emitted from the power plant is NO_2. This is unlikely to ever occur for an extended period of time in practice.

The ozone limiting method developed by the US EPA assumes that all available atmospheric ozone will react with NO in the plume until either O_3 or NO is completely exhausted. One limitation of this method is that the atmospheric reaction is assumed to be instantaneous, but in reality these reactions take place over several hours.

In order to calculate total NO_2 concentrations from the OLM method the background levels of O_3 and NO_2, have to be assumed and the maximum NO_x concentration in the atmosphere must be predicted. This can be done through simulation. Equation 1 describes the calculation of ground level NO_2 concentrations using the OLM method.

Ozone background

Assuming a background level of ozone based on the 2004 dataset alone does not enable a reasonable characterisation of the changing nature of the air environment through this region. It is important to characterise this changing nature of the air environment given the influence of VOC and NO_x emission reduction strategies implemented by the DECCW over the past decade on ozone concentrations.

In addition to this the ozone levels in this region are heavily influenced by other year specific summer period events such as bushfires.

Equation 1

$$[NO_2]_{total} = \{0.1 \times [NO_x]_{pred.}\} + MIN\{(0.9) \times [NO_x]_{pred.}\ or\ (46/48) \times [O_3]_{bkgd.}\} + [NO_2]_{bkgd.}$$

(*pred.* – predicted; *bkgd.* – background)

Table 6.1 Parameterisation of OLM calculation.

Parameter	Value (ppb)
Predicted NO_x levels	
- Munmorah	TAPM dispersion modelling result for each grid point within domain
- Colongra gas turbine	34*
Ozone background $[O_3]_{bkgd}$	88
NO_2 background $[NO_2]_{bkgd}$	37.7
i.e. for NO_2: 1 ppb = 2.05 µg/m^3	

Bushfires lead to significant emissions, (over and above those from industrial and diffuse sources) of NO_x and VOCs and have contributed to ozone events that exceed the NEPM limit through the NSW Lower Hunter and Central Coast regions.

An average of the maximum levels recorded over the period from 2003-2008 at the DECCW air monitoring stations through the Lower Hunter has been used to adequately represent the ozone background. The data considered DECCW station reports for Beresfield, Newcastle and Wallsend specifically.

Colongra gas turbine

The study that was carried out as part of the Environmental Assessment for the Colongra gas turbine facility (Holmes Air Sciences 2005) has been used to represent the contribution of this facility to the local atmospheric NO_x load in the worst case scenario. The impact through normal operations using distillate has been assessed by adding the contribution provided in Table 6.1 to the predicted level of NO_x that was predicted for Munmorah through the dispersion modelling carried out as part of this assessment.

A summary of the parameterisation of the OLM calculation for the Munmorah Power Station is provided in Table 6.1.

6.2 Cumulative air quality impacts - Dispersion modelling results

The cumulative air quality impacts for the pollutants, SO_2, NO_2, and PM_{10} are provided in Table 6.2, Table 6.3 and Table 6.4 respectively. A dispersion modelling assessment with respect to the existing configuration was not carried out as the discussion in Section 3 satisfies this purpose in a much more robust fashion.

The conservative nature of the methodology adopted as part of this assessment provides a robust characterisation of the worst case air quality impact through this region with the operation of all the facilities.

6.2.1 Sulfur dioxide

The cumulative impact for SO_2 ground level concentrations in this region is provided on an annual, daily, hourly and over ten minute averaging periods.

The cumulative SO_2 impacts for annual, daily, hourly and ten minute averaging periods outlined in Table 6.2, explicitly illustrates compliance with annual and daily averaged guideline limits even with emissions continuously at worst case levels throughout the year.

Further analysis of the time series of the predicted data through the modelled reference year; illustrates that the 4th highest cumulative hourly averaged ground level concentration will not exceed the NSW DEC or AAQ NEPM short term air quality limits at the nearest sensitive receptor. The second highest cumulative ground level concentration was predicted to be 212 ppb, which is 46% lower than the peak cumulative level predicted.

A previous analysis by Lilley et. al. (2007) has reported that the highest predictions of air quality models can over estimate impacts by as much as 50%. The large difference between the first and second highest cumulative predicted ground level concentrations indicates that there could be some level of over prediction. Evidence to this effect is supported by the *difference* between the first (42.8 ppb) and second highest (37.7 ppb) observed SO_2 levels at the LMPS monitoring station – approximately 13.5%.

In addition to this the background level to assess cumulative impacts in this instance is considered to be conservative because the peak level observed through 2004 at Wyee was used.

This is important when considering the potential impact of Munmorah because the emissions from both Vales Point and Eraring Power Stations have a greater influence upon the levels observed at Wyee air monitoring station as opposed to levels observed at LMPS, refer Section 3.1.1.

In addition to this the dispersion modelling isopleths illustrate that the maximum predicted concentrations from Munmorah are expected to occur in the region that can be described to be within the vicinity of the LMPS air monitoring station (refer Attachment B).

Given the explicit prediction of ten minute average ground level concentrations is not possible, using TAPM, a power law function based on historical data (Rae (et. al.) (2008)) was used to predict the worst case 10 minute averaged ground level concentration. This function is represented by the equation below.

$$C_{10\,\min} = C_{60\,\min}\left(\frac{60}{10}\right)^{0.38}$$

i.e. peak 10 minute average concentrations are on average twice the hourly averaged ground level concentration: $C_{10\,\min} = 1.98C_{60\,\min}$. However a more recent assessment of air quality impacts on the Central Coast (Rae et. al., 2008) shows that an assumption of such a relationship may in fact significantly over estimate the 10 minute average concentrations.

The assessment by Rae (et. al.) (2008) suggests that, as hourly averaged concentrations are maximised the ratio of 10 min average concentrations to hourly average concentrations *tends* towards unity.

i.e. $\frac{C_{10\,\min}}{C_{60\,\min}} \to 1;$ as $C_{60\,\min}$ = peak

The analysis of 10 min to hourly averaged (peak to mean) SO_2 ratios for the LMPS and Wyee datasets for the 2004 reference year (Holmes Air Sciences 2005) is included in Attachment C. This profile illustrates the point above in a graphical form. Here it is important to understand that 10 minute average concentrations are maximised when the mean level is also at its peak. The more standard power law conversion equation is used to understand the potential for impacts through the ten minute averaging period.

$$C_{10\,\min} = C_{60\,\min}\left(\frac{60}{10}\right)^{0.2}$$

The use of this methodology predicts exceedances in the guideline figure; however, it is also important to consider the likelihood that exceedance impacts would be coincident with sensitive land uses.

An assessment that considers the maximum predicted level in respect of contemporaneous time series observations of the same figure at LMPS was considered to yield a more appropriate analysis of actual worst case hourly averaged impacts.

This methodology is in line with the DECC Approved Methods Level 2 assessment methodology. The LMPS dataset was considered to be more appropriate than the Wyee as the maximum predicted ground level concentrations from Munmorah alone are populated largely around this region and do not extent to the areas that can be classified as being within the region of influence of the Wyee ambient air monitoring station.

The peak SO_2 concentration in this instance occurs when the background level is approximately 17.7 ppb. This additional level of assessment shows that cumulative SO_2 levels will exceed the hourly averaged guidelines at most on two occasions in any given year. However this has to be considered in light of the fact that these events if they do occur are predicted to be through non-sensitive regions as highlighted in Figure 6.2.

Based on the preceding discussion, it is suggested that exceedances of the air quality goals in the ten minute averaging period limits will coincide with the exceedances in the hourly averaged criterion. By association with the exceedances in the hourly averaged limit, the exceedances in the ten minute averaged guidelines are also predicted to occur on non-sensitive land uses as highlighted in Figure 6.2

Table 6.2 Predicted highest SO_2 cumulative ground level concentrations through proposed upgrade scenario at emissions equivalent to the firing of 0.7% sulfur grade coal

Pollutant concentrations (ppb)	SO_2 ~ 0.7% Sulphur coal				
Averaging period	10 min	1 hr		24 hr	Annual
Method		Method 1	Method 2		
Predicted cumulative impact	455	318	257	60	16.7
Background air quality	113	79	17.7	9.5	1.3
Prediction with Munmorah alone	342	239	239	50	15.4
Air quality limit	*250**	*200*	*80*	*20*	

* NSW DEC guideline limit.

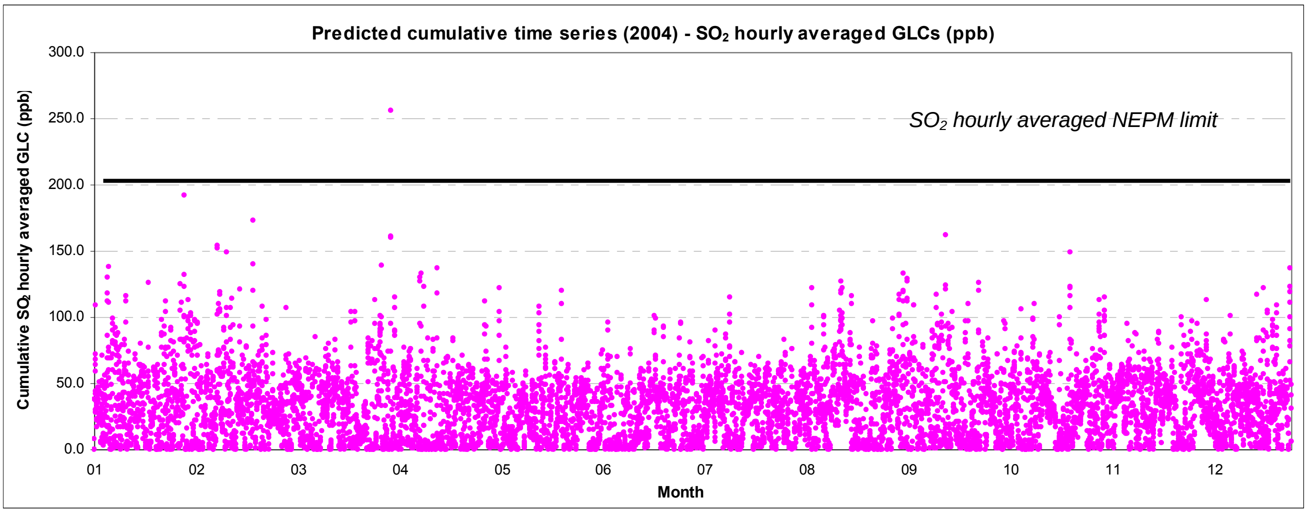

Figure 6.1 Time series of cumulative predicted SO_2 hourly averaged ground level concentrations (ppb).

It is important to note that the purpose of the pollutant contours for SO_2 across the various time averaging periods does not appropriately represent the actual levels of impact that are expected but is a graphical representation of the locations through which the worst case impacts are likely to occur.

The reason behind this proposition can be understood by assessing the maximum impacts as they are presented in the isopleths with those represented in Figure 6.1 and 6.2. Furthermore the preference for the use of the contemporaneous observed Lake Munmorah Primary school dataset over that observed at Wyee is contended to be appropriate given the predicted results illustrate that the worst case impacts from Munmorah are within the region of influence of Lake Munmorah Primary school as opposed to Wyee. The impacts of emissions from Munmorah in the regions surrounding the Wyee air monitoring station are significantly reduced in comparison to those observed near Lake Munmorah.

Figure 6.2 Locations of potential exceedance in SO_2 guideline limits in respect of nearest sensitive receiver groups as highlighted and the highest predicted NO_2 level that is within the bounds of a sensitive receiver group but the predicted level is below the regulated limit. .

6.2.2 Nitrogen dioxide

The cumulative impact data summarised in Table 6.3 shows that the predicted impacts comply with the annual averaged NO2 NEPM limit; however at first sight it also shows an exceedances in the National Environment Protection Measures and the air quality goals of the NSW DECC. However one only has to look at the monitoring record over the past 15 years and consider the proposal in this light to understand that exceedance of the NO_2 hourly averaged criterion are most unlikely.

The hourly averaged predicted level is considered to be a highly conservative representation of the probable air quality impact for this pollutant into the future and has to be considered in this context. This is in light of the reasons outlined in the discussion relating to the apparent nature of TAPM over predicting peak levels (Section 6.2.1). A similar trend is depicted in this case also, following the analysis of the first and second highest levels of NO_x predicted. The difference in these two statistics corresponds to the 46% figure that was assessed in the discussion pertaining to short-term SO_2 impacts.

Furthermore the cumulative level is also based on the assumption that Munmorah's operation at peak output being contemporaneous with worst case meteorological conditions, the Colongra gas turbine operating at worst case emissions and generally high background levels of NO_x in the environment (from other industrial and fugitive air emissions sources in this region). A consideration of the likelihood of these events being coincident in light of the predicted worst case air quality impacts represented in Table 6.3 stands as evidence in favour of the proposition that any exceedances in the hourly average NO_2 limit being highly unlikely.

An assessment that considers the maximum predicted level in respect of contemporaneous time series observations of the same figure at Lake Munmorah Primary School was considered to yield a more appropriate analysis of actual worst case impacts. This methodology is in line with the DECC Approved Methods Level 2 OLM methodology. However it is important to note that in this instance the assessment has not been populated by contemporaneous ozone measurements, but only contemporaneous NO_2 observations. The Lake Munmorah Primary School dataset was considered to be more appropriate than the Wyee as the maximum predicted ground level concentrations from Munmorah alone are populated largely around this region and do not extend to the areas that can be classified as being within the region of influence of the Wyee ambient air monitoring station.

The peak NO_2 concentration in this instance occurs when the background level is approximately 26.7 ppb, and the predicted level of NO_x is approximately 55.4 ppb (referenced to NO_2), all other parameters remain constant as per Table 6.1. This additional level of assessment shows that cumulative hourly averaged NO_2 levels will be compliant with the stipulated guideline limits.

The cumulative predictions of NO_2, as is represented in Table 6.3is conservative because it considers that the worst case operating conditions from Colongra will always coincide with the emissions from Munmorah throughout the year.

This is considered to be a conservative assessment of cumulative impacts, as emissions from Colongra would have generally formed a part of the adopted background level of air quality. Thus it is believed that the highest concentration predicted (116.1 ppb) is nonetheless a conservative representation of the cumulative impact that is more representative of reality, even though the method adopted in determining this figure is conservative also.

The contention discussed in the previous sections in respect of the disparity between the maximum impact represented in the hourly averaged NO_2 contours published and that depicted in the time series profile of Figure 6.3 is also relevant. The contours are created from the levels predicted using the initial screening methodology (Method 1), which is considered to be a conservative representation of the likely cumulative air quality impacts. Thus the sole purpose of the published contours is to represent the areas through which cumulative concentrations are expected to occur.

Figure 6.3 Illustrates the region through which the highest NO_2 hourly averaged NO_2 concentration is expected to occur. Although this is within the bounds of a group of sensitive receivers (residential land), the inherent conservatism in the methodology adopted enables confidence in attesting that the worst case cumulative prediction of 116 ppb will not be exceeded.

Table 6.3 Predicted NO_2 first highest cumulative ground level concentrations through proposed upgrade scenario.

Pollutant concentrations (ppb)	**NO_2**		
Averaging period	**1 hour**		**Annual**
OLM Method	**Method 1**	**Method 2**	
Predicted cumulative impact (NO_2)	**139**	**116**	**14.8**
Background air quality (**NO_2**)^	37.7	26.7	8.3
Munmorah power station contribution (**NO_x**)	100	55.3	6.5
Colongra gas turbine contribution (**NO_x**)*	34.1	34.1	0.1
Air quality limit	*120*		*30*

^ Background air quality represents emissions from Vales Point, Eraring Power Stations and background levels from other fugitive sources (including motor vehicle emissions).

* Worst case operation assumed to be contemporaneous with worst case impact from Munmorah power station.

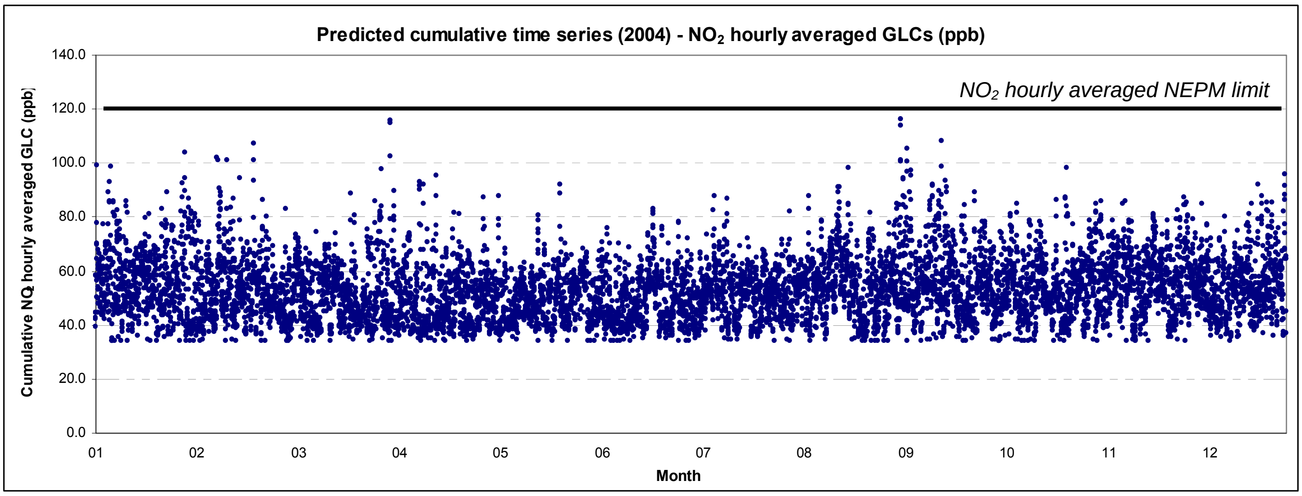

Figure 6.3 Time series of predicted cumulative NO_2 hourly averaged ground level concentrations (ppb).

6.2.3 Fine particulates (PM_{10})

The background level of PM_{10}, the Munmorah contribution and the cumulative daily averaged PM_{10} levels are summarised in Table 6.4. The analysis predicts an exceedance in the daily averaged NEPM goal. An assessment of the background levels outlined in Table 4.2 shows that there will be an exceedance of the guideline limit when the background level is greater than (50 minus the Munmorah contribution (4.3)); The background level through Beresfield and Wallsend air monitoring stations is above this level through the months of April, October and December.

The modelling predicts that following rehabilitation, the operation of Munmorah may contribute to two additional exceedances in the NEPM Ambient Air Quality guidelines in any given year, leading to a total of three exceedances. This is below the allowance of five exceedances per year stipulated within the NEPM ambient air quality guidelines.

Although the cumulative peak predicted level is shown to exceed the NEPM and DEC guideline limits, this has to be considered in the context of the contribution the Munmorah facility makes to the pre-existing background level in the ambient air environment.

The background level already exceeds the AAQ NEPM. The peak contribution of emissions from Munmorah shown in Table 6.4 shows the minor contribution Munmorah makes to the cumulative impact (<10% of the peak background level).

Furthermore the emissions from Munmorah assumed the Group 6 guideline limit of 50 mg/Nm^3.

The observed emissions from the facility through 2002-2004 varied between 3.4 -13.6 mg/m^3 (Unit 3) and 11.5 – 51.6 mg/Nm^3 (Unit 4). This suggests that emissions of PM_{10} compounds from Munmorah will generally be well below the Group 6 limit. This being the case Munmorah Power Station would be expected to make a negligible contribution to peak events or exceedances of the PM_{10} limit through this region.

The majority of exceedances of the PM_{10} limit will be associated with local wind blown dust events through the summer months. The number of exceedances however will still be below the allowable number of exceedances per year of five stipulated within the NEPM ambient air quality guidelines. Although this method of assessment has not been explicitly stated in the Approved methods guidelines (DEC, 2005); it is important to consider the allowable number of exceedances in the PM_{10} guideline per year in the regulation of air quality as nearly all exceedances in the guideline can be attributed to wind blown dust events or accumulation of fugitive emissions as opposed to emissions from industrial facilities.

6.2.4 Other Pollutants

The ambient air quality impacts for all other pollutants (Fluoride compounds, Cd, Hg and dioxins and furans) have been prescribed on a non-cumulative basis, given the absence of any ambient air monitoring data to represent the background level of these pollutants. This is considered to be reasonable in light of the conservative approach that has been taken in assessing the likely impact for the pollutants listed in Table 6.4.

A comparison of the emission rates used in predicting the impacts for these pollutants to those recorded over the historical period from for the Munmorah facility (refer Table 4.8 and Table 6.6) supports the view that the assessment is conservative. Average levels observed between 2004 and 2006 are at a level that is either half or up to an order of magnitude below the modelled levels.

The performance data in Attachment A also shows peaks in the observed data over the same period.,

Further improvements in motor vehicle fuel quality and combustion and emissions control technology will also contribute towards general improvements in the level of these pollutants in the ambient air.

Taking all of the above into account in the assessment of the predicted impact noted in Table 6.5 it is concluded that the predicted levels of Cd, Hg, dioxins and furans are several orders of magnitude below the ambient air quality limit as prescribed by the NSW DECC.

The sensitive land use surrounding the Munmorah power station facility is largely composed of residential receivers with regions dominated by agricultural industry that incorporates the growing of grape vines or stone fruit being nonexistent. Thus the limits used to assess the incremental impact from Munmorah power station represent the nature of the surrounding land.

Although the levels of fluorides in the ambient environment are predicted to fall to levels that are half the limit prescribed over the daily averaging period, and well below the limit for the weekly and 30 day averaging periods. However the impact predicted for the 90 day averaging period is shown to be equal to the NSW DEC guideline limit. However this is considered to be a highly conservative representation of the 90 day incremental impact as the assessment methodology assumes emissions at the worst case level throughout the monitoring period. This is contended to be an overtly conservative representation of the likely emissions profile over a random 90 day plant operating period.

Table 6.4 Predicted PM_{10} first highest cumulative ground level concentrations through proposed upgrade scenario.

Pollutant concentrations (µg/m^3)	PM_{10}	
Averaging period	**24 hr**	**Annual**
Number of exceedances through reference year	3	*none*
Predicted cumulative impact	**60**	22.1
Prediction with Munmorah alone	4.3	1.3
Background air quality	56	20.8
Air quality limit	*50*	*30*
Allowable exceedances per year	*5*	*none*

Table 6.5 Predicted first highest cumulative ground level concentrations through proposed upgrade scenario for cadmium, mercury, dioxins and furans (PCDD/F) and Hydrogen fluoride.

Pollutant concentrations (µg/m^3)	Cadmium	Mercury	PCDD/F*	Fluorides (as hydrogen fluoride (HF))			
Averaging period	**1 hour**	**1 hour**	**1 hour**	**24 hr**	**7 days**	**30 days**	**90 days**
Predicted cumulative impact	0.001	0.082	4.1×10^{-8}	1.2	0.84	0.64	0.50
Air quality limit	0.018	1.8	2.0×10^{-6}	2.9	1.7	0.84	0.5
* Polychlorinated dibenzo-dioxin and dibenzo-furans							

Table 6.6 Comparison of modelled versus actual performance data (Malfroy, 2007) for Fluoride (HF), Cd, Hg compounds and total toxic equivalent dioxins and furans

Pollutant (mg/m^3 unless stated otherwise)	Modelled emissions concentration	Munmorah performance (2004-2006) (Malfroy, 2007)
Fluoride compounds (modelled as hydrogen fluoride)	14.5	Unit 3: Average = 4.1 Unit 4: Average = 5.6 Maximum Recorded = 14.5
Cadmium compounds (Cd)	0.002	Unit 3 & 4: Average = 0.00132 Maximum recorded = 200
Mercury compounds (Hg)	0.2	Unit 3 & 4: Average = 0.00030
Dioxins and furans (PCDD/F)	0.1 ng/m^3	Unit 3 & 4: Average = 0.0013 ng/m^3

6.3 Acid deposition impacts

Depletion of NO_x and SO_2 from the atmosphere through oxidisation by dry and wet deposition processes is assessed in a qualitative manner in this report.

The regional atmospheric NO_x load is formed through a combination of diffuse and industrial source air emissions; the diffuse sources are a far more significant contributor to this effect than the industrial sources in this region.

Typically, the deposition of large amounts of NO_x and SO_2 will lead to some of level of acidification of natural and man made water bodies as well as acidification of soils over time, which is especially important for regions dominated by agricultural or horticultural land use. While not a serious threat, this may lead to loss of crop productivity unless limestone is applied to correct this acidification. This is a normal practice in agriculture in high rainfall areas, and in areas of high productivity, where acidification is a natural process or a consequence of agricultural production activities.

As a result of plant rehabilitation cumulative NO_x emissions would reduce by up to 20% over the proposed 20 year lifespan of the plant. In addition to this a marginal increase in the level of gross SO_2 emissions over a period of time may be observed, however it is not expected the average quality of the coal that is combusted would be represented by the 0.7% sulfur grade upper limit. Furthermore the emissions of sulfur dioxide would decrease if the plant is co-fired with gas. This would be expected to have a beneficial effect on the potential for acid deposition from the operation of Munmorah.

7. Regional and Inter-Regional Impacts

The regions broadly described as the NSW Central Coast and Sydney Greater Metropolitan are densely populated with numerous fugitive and industrial NO_x and anthropogenic/biogenic volatile organic compound (A/BVOC) emission sources, which are precursors to ozone formation and photochemical smog.

The discussions in this section outline a decrease in the intensity of NO_x emission concentrations following the rehabilitation of Munmorah Power Station. However an increase in mass emissions of NO_x is predicted given the increased capacity factor for the plant .

The formation of NO_2 and ozone in the lower atmosphere is dependant upon numerous other factors, relating to the interaction of various organic and inorganic reagents, meteorological conditions, and the local/regional atmospheric NO_x load.

The photochemical smog study for the yet to be commissioned Colongra Gas Turbine (Cope et. al. 2005) examined the impact of the open cycle gas turbine facility, a new significant NO_x emission source in this region. The following sections provide an assessment of the likely impact of the rehabilitated Munmorah Power Station on regional and inter-regional air quality, considering the probable NO_2 and O_3 impacts separately.

7.1 Ozone

The Colongra assessment over several historically high ozone concentration days showed that the Colongra Gas Turbine would have a negligible impact upon exceedances of the criterion stipulated by the NSW DECC over the one hour averaging period for both NO_2 and O_3. This assessment included Munmorah Power Station operating two units at 600MW (same emissions as the rehabilitated 700MW station) .

The isopleths shown in Figure 7.1 are for hourly averaged ozone ground level concentrations over the period 11-13 March 1998 (Cope et. al., 2005). The plot on the left is the overall predicted ozone concentration, the plot on the right being the difference between the baseline, which includes Munmorah Power Station emissions, and the test case (Colongra Gas Turbine emissions included).

The highlighted plots show that the highest increase in predicted concentration, once the Colongra gas turbine commences operating, is expected to occur over sparsely populated but densely forested regions north of Lithgow. These predicted increases in ozone, with Munmorah operating, were accepted and the Colongra Gas Turbine project was approved in July 2006

The results from this study (Cope et. al., 2005) indicate that the formation of ozone through this region is not limited by the availability of NO_x in the atmosphere but rather on the availability of AVOC and BVOC (Nelson et. al., 2002). A similar trend is observed when the results for the other historical ozone event days considered within this study are analysed. This trend was first outlined by Nelson (et. al.) (2002) (IRTAPS).

The proposed rehabilitation of Munmorah Power Station is unlikely to be a major contributor to any exceedances of regulated ozone criterion in the Central coast region of NSW or in the Greater Metropolitan Region of Sydney.

It is reasonable to assume that the initiatives introduced by the NSW DECC over the last decade has had some effect in limiting VOC emissions therefore assisting in creating low VOC/NO_x mixing ratios which are less conducive to ozone formation. Low VOC/NO_x ratios have been shown to have a greater effect however over shorter term i.e. one hour averaging periods in urban environments (Jin, L, et. al. 2008).

The control of industrial NO_x emissions through more efficient burner systems in the plant is therefore will not result in any discernable adverse photochemical impacts represented by hourly averaged ozone concentrations. However there is some potential for the control of NO_x emissions of the nature proposed for Munmorah Power Station to have a significantly more suppressive effect on photochemical smog impacts defined in terms of four hour averaged ozone concentration (Jin, L, et. al. 2008).

A sensitivity analysis carried out by Jin (2008) assessed the effect of variations in NO_x and VOC emissions upon the formation of ozone in the San Joaquin Valley, California. While there are similarities in terms of the urban environments between the California study and the NSW Central Coast region, there are also geographical differences. Nonetheless, the results of the study are still relevant as it showed the effect of NO_x and VOC controls on ozone concentrations over different averaging periods in an urban setting populated with numerous fugitive and industrial emission sources.

The California study confirmed the trend that in an AVOC limited environment NO_x emissions control is more effective at reducing ozone impacts over longer time averaging periods (specifically eight hour averaged ozone concentrations in the case of the California study). Although the regulated time averaging periods in New South Wales are one and four hours, a reasonable inference can be drawn as to a potential beneficial impact upon observed four hour averaged ozone, following the rehabilitation of the Munmorah Power Station.

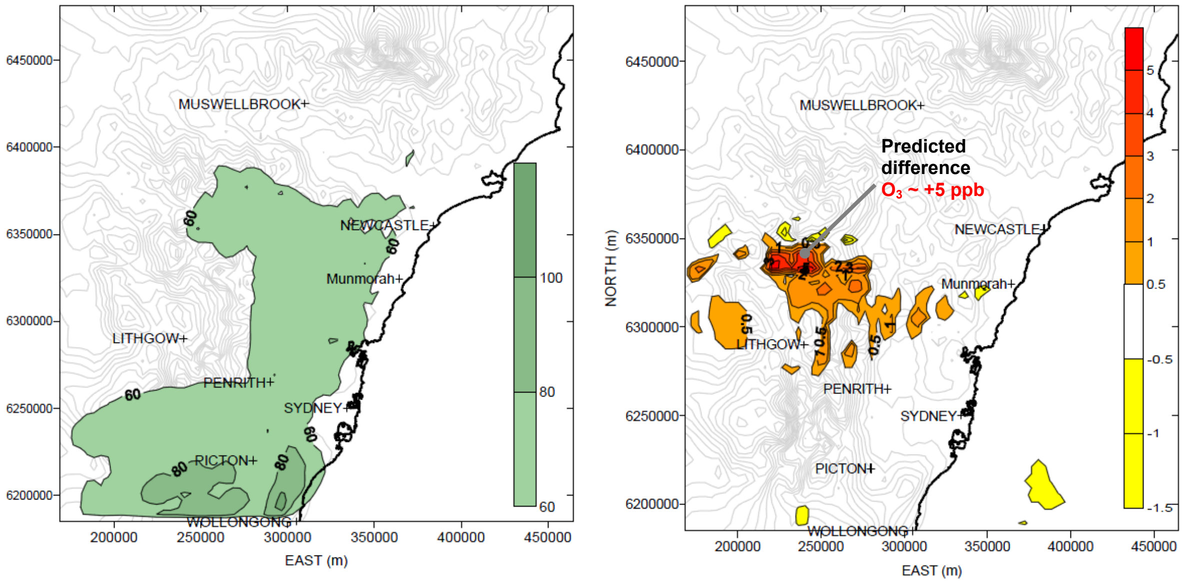

Figure 7.1 Hourly averaged O_3 ground level concentrations (ppb) – Baseline case (left) and test case (with Munmorah gas turbine) (right) (Cope et. al., 2005).

7.2 Nitrogen dioxide

The assessment of the effect of the Colongra gas turbine facility upon NO_2 impacts in the regional setting included Munmorah Power station (two Units) operating at full load. This information has been used to infer the likely air quality impacts following the rehabilitation of Munmorah Power station.

The hourly averaged NO_2 concentration isopleths in Figure 7.2 show that a significant addition to the atmospheric NO_x load in the form of emissions from Colongra gas turbine is not expected to lead to appreciable air quality impacts in the urbanised regions along the coast. Instead it has transpired to increased NO_2 concentrations in NO_x limited but BVOC (B - biogenic) rich environments north west of the facility in this scenario (photochemical smog event day – 11-13 Mar 1998). The increased NO_2 concentrations through these areas are not of a significant nature given the absence of any

A relatively minor change in the temporal anthropogenic NO_x emissions profile through this region following the proposed rehabilitation program and the operation of Colongra Gas Turbine is not likely to have any appreciable adverse impacts upon either regional or inter-regional air quality.

The predicted impacts of both Munmorah Power Station and Colongra Gas Turbine operating were assessed and approved by the Department of Planning in consultation with the DECC (DOP 2006).

The rehabilitation of the Munmorah plant will decrease the intensity of NO_x emissions from the plant. The effect of this change will decrease regional NO_2 or O_3 concentrations over an hourly averaged time period. The effect of a change in atmospheric mixing ratios (VOC/NO_x) varies significantly through diurnal, seasonal and weekday-weekend basis, with motor vehicle emissions being the primary driver of this system. This complexity cannot be simplified in terms of a single figure.

The Colongra analysis (Cope et al 2005) also showed that chemical transport model based simulations often yield results, which raise questions of statistical significance. The qualitative assessment of existing relevant work demonstrates that there will be no adverse impacts upon the regional and/or inter-regional atmospheric environments following the reduction of NO$_x$ emissions through the rehabilitation of Munmorah..

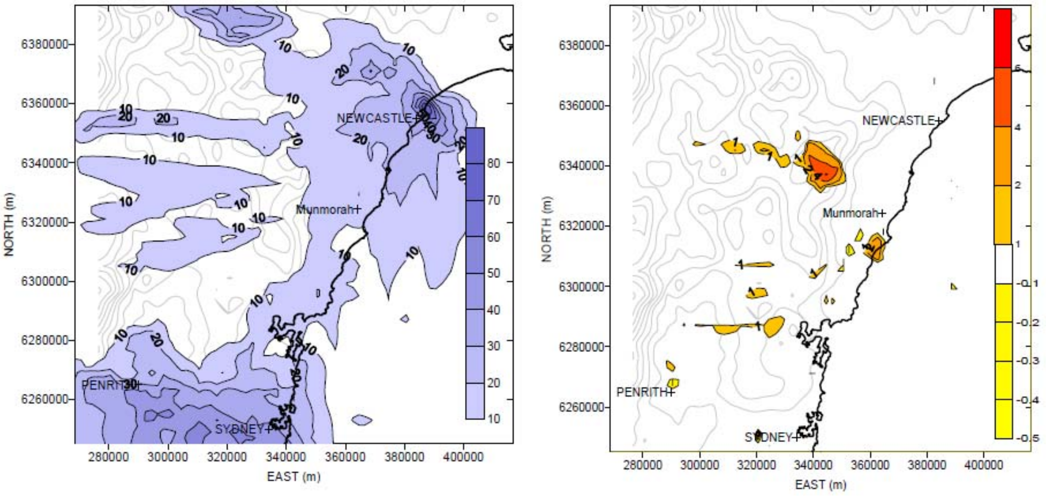

Figure 7.2 Hourly averaged NO$_2$ ground level concentrations – Baseline case (left) and test case (with Munmorah gas turbine) (right) (Cope et. al., 2005).

8. Mitigation and control measures

8.1 International Best Available Techniques (BAT)

The European Council under Article 16(2) of Council Directive 96/61/EC required the Commission to organise '*an exchange of information between Member States and the industries concerned on best available techniques, associated monitoring and developments in them*', and to publish the results of the exchange.

The 'Large Combustion Plants' Best Available Techniques Reference (LCP BREF) is a document produced under this Directive. The LCP BREF covers all nature of large combustion plants and includes specific BATs applicable to coal only (no lignite) combustion plants.

The BREF is provided for comparison against the requirements made by the NSW DECCW.

8.1.1 Sulfur dioxide

Removal of SO_2 from coal fired power stations can be achieved by the implementation of the following measures (DTI, 2000).

Fuel switching

This could include switching to coal sources with lower sulfur content or making a switch to natural gas. Delta Electricity is proposing to reduce the limit of sulfur in coal from 1% to 0.7% and in addition, co-firing with natural gas would also reduce the SO_2 emissions further.

Desulfurisation technologies

The following desulfurisation options are available:

- Pre-combustion: this involves removing sulfur with chemical cleaning processes; however this is not practised on a commercial scale. Gasification could be considered a pre-combustion technology (IGCC). Although commercially available, this technology is still not fully mature and is not considered feasible in the short to medium term due to high construction costs (See Section 2.3.3.).
- During combustion: this involves the addition of sorbents eg lime or limestone to the furnace during combustion. Although this technology has been used in pulverised fuel boilers, it is more applicable to fluidised bed combustion where higher residence times (between the SO_2 and sorbent) can be achieved.
- Post-combustion: this is the most common method of achieving sulfur emission reductions from conventional coal fired power stations. Flue gas desulfurisation (FGD) technologies include limestone gypsum wet scrubbing, sea water scrubbing, combined de-SO_x and de-NO_x technologies, ammonia scrubbing etc. FGD technologies generally require high levels of auxiliary power and quite often the significant energy penalty is not balanced by the relatively minor benefit in additional emission control that can be achieved.

Implementation of the BAT enables the attainment of SO_2 emission limits outlined in Table 8.1. As discussed in Section 7 Delta Electricity has proposed a lower sulfur level in the fuel to mitigate air quality impacts.

The prevailing system would not achieve a maximum emissions level that is compliant with world's best practice systems. This is primarily due to the issues associated with the physical constraints involved with the design of a system such as this. These design constraints are discussed further in Section 8.1.4.

Table 8.1 Directive 96/61/EC – SO_2 emissions associated with coal combustion BAT (existing plants)

Fuel	Combustion techniques	Emission control techniques	SO_2 emission level associated with BAT (mg/Nm^3)
Coal Capacity > 300 MW$_{th}$	Pulverised/ bubbling/circulating fluidised bed combustion	Low sulfur fuel, pulverised combustion. Wet/dry (sorbent injection) flue-gas desulfuration Seawater scrubbing Combined techniques for the reduction of NO_x and SO_2.	20-200(1) mg/Nm^3
	Bubbling/pressurised fluidised bed combustion	Low sulfur fuel Limestone injection	100-200(2) mg/Nm^3
	Bubbling fluidised bed combustion	Low sulfur fuel Wet flue-gas desulfurisation	20-200(3) mg/Nm^3

(1) Upper level of 400 mg/Nm^3

(2), (3) Upper level of 300 mg/Nm^3

These levels are proposed by Industry (EU) because they claim that better takes into account the fuel characteristics, the inlet flue-gas SO_2 concentration affects the BAT achievable levels considering the agreed wet scrubber SO_2 removal efficiencies of 85 – 98 %, the high energy consumption of such a wet scrubber system in relation with the net unit efficiency requirements, and because an optimisation is necessary between emission control technique performance (low emission levels) and related energy consumption (energy penalty).

Table 8.2 Directive 96/61/EC - NO_x emissions associated with coal and gas combustion BAT (existing plants)

Fuel	Combustion technique	NO_x emission level associated with BAT (mg/Nm^3)
Coal Capacity > 300 MW$_{th}$	Pulverised combustion. Combination of primary measures to reduce NO_x (incl. air and fuel staging, low NO_x burners, reburning etc.) in combination with selective catalytic reduction or combined techniques	90-200(1) mg/Nm^3
Gas (new and existing gas-fired boilers) O_2 reference level – 3%	Low NO_x burners, selective catalytic and non-catalytic reduction.	50-100 mg/Nm^3 (upper limit – 120 mg/Nm^3)

(1) The document states that for the European scenario a strict target of 150 mg/Nm^3 can be achieved in a cost effective way by a system of NO_x emission trading, this infrastructure is not available to Australian operators. However, to have maximum flexibility in the system of NO_x emission trading, a Member State explained that for the oldest combustion plants, a range of 100 – 650 mg/Nm^3 for existing plants over 300 MW was more practicable.

Table 8.3 Best available techniques emission limits for the control of dust from large existing coal fired combustion plants.

Type of fuel	Rated thermal input (MW$_{th}$)	Emission limit values (mg/Nm^3)
Solid	≥ 500	50*
	< 500	100

* A limit value of 100 mg/Nm^3 may be applied to plants with a rated thermal input greater than or equal to 500 MW$_{th}$ burning solid fuel with a heat content of less than 5,800 kJ/kg (net calorific value), a moisture content greater than 45 % by weight, a combined moisture and ash content greater than 60% by weight and a calcium oxide content greater than 10%.

8.1.2 Oxides of nitrogen

Nitrogen bound in the coal, and nitrogen present in air contributes to the formation of NO_x during combustion. The following mechanisms contribute to the formation of NO_x:

- Thermal NO_x results from the presence of nitrogen in combustion air reacting with oxygen at high temperatures (5-25% of total NO_x formed).
- Fuel NO_x results from the oxidation of the nitrogen in the fuel (70-80% of total NO_x formed)
- Prompt NO_x is formed at the flame front (<5% of total NO_x formed).

Investigations have shown that optimisation of the boiler can achieve up to 20% reduction in NO_x emissions. Optimisation can be achieved through balancing fuel and air flows, reducing excess air levels etc (DTI, 1997).

Combustion modification technologies include the following:

- installation of low NO_x burners: these burners aim to reduce the temperature and oxygen availability in the flame by various means;
- air and fuel staging: this technology aims to stage the supply of combustion air and fuel through the burners with ~70-90% air being supplied to the burners and the remaining 10-30% being injected above the burners (referred to as 'overfire' air);
- reburning: this involves the staged supply of fuel and combustion air in the furnace. Stage 1 includes the primary zone where coal is burnt with excess air to produce NO_x. Stage 2 involves the addition of a secondary fuel, either natural gas, coal or oil, which is injected above the burner to create the reburn zone reducing the NO_x formed in the Stage 1 to molecular nitrogen. Stage 3 involves the injection of the remaining combustion air to ensure complete combustion. Up to 70% NO_x reduction can be achieved using this mechanism.

These are relevantly inexpensive modifications which can achieve up to 50% NO_x reduction when applied individually (DTI, 1997).

A number of flue gas NO_x reduction systems are available commercially. These include:

- selective catalytic reduction (SCR) – 90% reduction achievable
- Non-selective catalytic reduction (NSCR) – 50% reduction achievable
- combined NO_x/SO_x control (DTI, 1997)

Flue gas treatment is more expensive due to high capital, operating and maintenance costs and only countries with stringent NO_x emission limits, as indicated in Table 8.2, will these technologies be feasible.

It is proposed that tangential low NO_x burners with separate overfire air technology (TLN2) be installed during the rehabilitation. These burners will provide significant reductions and are likely to meet, or be very close to Group 6 limits (500 mg/Nm^3). This emission will be achieved at a modest cost compared to the costs associated with the installation of catalytic or non-catalytic de-NO_x.

The BAT emissions guideline for the NO_x emissions achievable by coal and/or gas combustion within existing plants is provided in Section 8.1. Although the proposed facility will not be compliant with the BAT guidelines stipulated, it is within the practicable range for the oldest of the existing combustion plants with thermal capacity > 300 MW as outlined by the European Member state.

Furthermore due to the lack of any infrastructure representing emission trading systems for NO_x, nor the onerous responsibilities placed upon European member states to reduce industrial source NO_x emissions to mitigate the large diffuse NO_x load (as a result of the extent of industrialisation); the most stringent BAT recommendations are not relevant to the Australian air environment. Further to this the very low levels of ambient NO_2 in the local atmosphere recorded over the past decade (see Section 5.1) demonstrate that further control measures are unnecessary. High quality low NO_x burners will provide significant reductions and are expected to meet Group 6 limits. The additional costs of catalytic or non-catalytic de-NO_x is not justified given the low ambient impacts.

The overall benefit is defined qualitatively as the marginal environmental gain over and above the requirements stipulated by the NSW DECCW as a function of the marginal economic costs.

8.1.3 Fine particulates, Persistent organic and non-organic pollutants

The best available techniques for controlling the emissions of dust, and in particular particulate bound trace elements and VOCs are stipulated in the LCP BREF document (referred to above with the achievable emission limits summarised in Table 8.3).

It is known that trace metals including mercury preferentially adsorb onto smaller particles i.e. those with aerodynamic diameter < 2.5µm. Thus it is important to apply best available techniques for controlling these fine particles and adsorbed pollutants that not only include metals but also persistent organic pollutants (POPs) (including polycyclic aromatic hydrocarbons). These POP subset group have a tendency to accumulate for extended periods of time in the natural environment; i.e. they bioaccumulate.

The main technologies used for the removal of fly ash from coal fired power stations include:

- electrostatic precipitation;
- electrostatic precipitation with sulfur trioxide (SO_3) conditioning;
- fabric filters.

The LCP BREF document states that the BATs for large coal combustion plants in this instance is the use of fabric filters as they are highly efficient at controlling small particles; i.e. more so than electrostatic precipitators.

Fabric filters replaced the older electrostatic precipitator technology at Munmorah Power Station in the late 1980s. The importance of greater efficiency in controlling fine particles has been stated in the previous paragraphs given the tendency of some of the persistent organic and non-organic pollutants to be bound to fine particles (i.e. $PM_{0.1\text{-}2.5\mu m}$).

The implementation of effective management strategies is also important in maintaining the high particulate control efficiencies associated with a fabric filter emissions control system. Baghouse fabric filters management strategies are stipulated to ensure that they do not become clogged with particulate matter and include;

- monitoring of pressure differentials (dPs) across the fabric filters in the baghouse,
- ensuring that the actuators shaking the dust off the fabric filters are operating properly,
- ensuring the availability of spare sections through the baghouse which can be brought in to service in the event of a tear in the fabric filters in another section of the bag house.

The limits that are achievable through application of the BATs are provided in Table 8.3. The particulate limit applicable to Munmorah Power Station is 50 mg/Nm^3, this limit coincides with the NSW DECC Group 6 emission standards as well as BAT limits. The assessment by Malfroy (2007) (refer relevant extract in Attachment A), reported the levels recorded over the period from 2004-2006 being within this guideline: Unit 3 ~ 8 mg/m^3 and Unit 4 – 29 mg/m^3.

The emissions of persistent organic pollutants such as mercury (Hg) and polychlorinated dibenzodioxin and dibenzofuran (PCDD/F) can be further controlled where emission levels are unacceptable. Additional control of organic compounds and trace elements can be achieved through the adoption of sorbent injection techniques. However the significant economic costs of this type of infrastructure significantly outweighs any potential environmental benefits that arise from its application.

8.1.4 Design constraints

The primary constraint in regards to the implementation of the described BAT arises from a problem of optimisation. The various pieces of plant in a typical facility such as Munmorah are highly interrelated and operate in a manner that requires cross optimisation to enable the greatest efficiency in heat throughput and emissions control. It is thus important to note that in this instance only the burners are being replaced given they contribute most significantly to combustion inefficiencies and high air emissions.

The physical constraints associated with the design of this system do not allow for the optimisation of the entire boiler system for the specific temperatures and pressure of flow created by the new burner technology. Following on as a corollary to this is, the addition of any emissions control system will lead to further inefficiencies, as this piece of plant effectively acts as a flow restriction device through the power plant system. The primary penalty that is associated with additional non-optimised pieces of plant is decreased generation efficiency, and will potentially also lead to the non-attainment of the maximum level of emissions control. This decreased electrical generation efficiency is also associated with a greenhouse gas penalty. Thus further emissions control entails a significant economic cost with minimal environmental benefits. Nonetheless, the plant is still operational using some worlds' best practice emissions control technology; that is in the form of the baghouse fabric filters, and low NO_x burners to minimise air emissions.

8.2 Compliance monitoring program

8.2.1 Ambient air monitoring network

The preceding analysis of observed local air quality records for the Wyee and LMPS have shown that the existing air quality is well below current guidelines. The period of historical records include years when Munmorah Power Station has operated as a two unit power station.

The predicted worst case impact pollutant isopleths in Attachment B as well as the historical analysis by Holmes air sciences (2005) illustrate that the LMPS air monitoring station is sited appropriately in light of the requirement for this compliance monitoring station to capture worst case impacts. The pollutant isopleths illustrate that peak concentrations are expected to occur to the north east of the facility, through an area proximate to where the Lake Munmorah Primary School air monitoring station is currently located (refer Attachment B for pollutant contours generated as part of the modelling study undertaken for this project). However it is important to note that the pollutant contours also show that peak concentrations from these facilities are not likely to be captured by the observations at the Wyee air monitoring station.

8.2.2 Stack emissions monitoring

Delta will continue to carry out continuous and manual in stack emissions monitoring, as it has done so historically, for all the relevant regulated pollutants stipulated within the PoEO (Clean Air) Act to monitor compliance with the regulated emission limits. This will provide confidence as to the extent of the improvements realised through the rehabilitation works proposed for this facility.

Delta has been in discussion with the DECC regarding improvements in stack sampling methods necessary to meet current stack emission sampling requirements. It is expected that the rehabilitation will include a requirement to upgrade sampling to include in-stack sampling to meet the updated requirements. This will improve the quality of data as well as confidence in the performance of the combustion and associated emissions control systems.