Mt Piper Extension
Environmental Assessment

RESPONSES TO QUESTIONS FROM DEPARTMENT OF PLANNING

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1. Introduction

1.1. Overview

This report has been prepared to support Delta Electricity's application for the concept plan approval for the proposed Mt Piper Power Station Extension project, under Part 3A of the *Environmental Planning and Assessment (EP&A) Act 1979*.

The proposed Power station extension comprises the construction and operation of a new base-load power station and associated infrastructure with a maximum generating capacity of 2,000 megawatts (MW), fuelled either by coal, using ultra-supercritical (USC) generating technology or natural gas, using combined cycle gas turbine (CCGT) generating technology. Both options would use air cooled condensers (ACC) to minimise water usage. The new power station would be located to the west of the existing plant, generally in the area previously prepared for Units 3 and 4 when Units 1 and 2 were constructed.

1.2. Review of the Environmental Assessment

The Environmental Assessment for the Mt Piper Power Station Extension project was placed on public exhibition by the Department of Planning from 25 September to 26 October 2009. A total of 383 submissions were received by the Department. These have been addressed in a Submissions Report provided to the Department of Planning.

The Department also undertook independent reviews of the EA working papers dealing with air quality, noise and greenhouse gas assessment. In a letter dated 28 October 2009 the Department has sought response from Delta on the reviews undertaken. Our responses to those reviews are provided in the following chapters.

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2. Greenhouse Gas Assessment

2.1. Department of Planning Comment

The Department requested responses to the following:

- Section 2.2.1 of the Arup report – justification and clarification of the modelling approach implemented for Scope 1 emissions, specifically with respect to the use of an 80% capacity factor for predicting worse case emissions;
- Section 3.2 of the Arup report – further justification is required for the coal and gas fired options identified as best achievable practice considering the issues identified in the Arup report;
- Sections 4.1 – 4.2 of the Arup report – further clarification is required on further greenhouse gas offsets and/or renewable energy augmentation with consideration to the options identified by Arup (eg Biomass co-firing);
- Section 5 of the Arup report – comment on the issues raised by Arup in relation to the potential implications of the Carbon Pollution Reduction Scheme on the project.

2.2. Response

2.2.1. Section 2.2.1 of the Arup Report - Scope 1 Emissions

> Arup considers that total annual emissions for both the USC coal and CCGT options presented in the GHG Assessment are likely to be underestimates. Conservative worst case estimates by Arup suggest that the total annual emissions could be up to 20% higher than the values presented in the greenhouse gas assessment. This is due to assumptions for thermal efficiency and use of the typical rather than theoretical maximum scenario used by the Proponent which may not be appropriate for the purposes of the assessment. In practice, the annual emissions are likely to range somewhere between this worst case and the estimates provided in the GHG Assessment.
>
> Further, the annual average coal consumption implied by the annual average emissions level is inconsistent (around 20% less) with values for annual coal consumption stated elsewhere in the Environmental Assessment (Section 3.3.6 of the main body of the EA and Section 4.4.3 of the greenhouse gas assessment).

The two key factors that have the most effect on GHG emissions are:

- The fuel chosen for the project;
- The annual capacity factor of the power station over its life (capacity factor is a measure of the station's annual output and is calculated by dividing its total output over the year by its maximum potential output assuming it was generating at full output for the entire year).

Capacity factor

With regard to the second point (capacity factor), the Arup Report implies that total annual emissions should be calculated based on a 100% capacity factor which is not realistic because:

- It does not allow for planned outages, forced outages and any de-rating of the units over their lives. Planned outages for maintenance and upgrades and forced outages would typically account for an average of about 8% a year over the station's life, leaving the unit available for generation for about 92% of the time over its life. This would give a theoretical maximum capacity factor of 92% assuming it could operate at full output whenever it is available for service over its entire life, which in itself is unrealistic;
- Mt Piper Extension will operate in the competitive National Electricity Market (NEM) with an emissions trading scheme in place. Its output will depend on supply and demand for electricity and its competitiveness within the NEM over its life. It will have to bid for dispatch by AEMO (the market operator) each day. As the units age they would typically become less competitive and be partially displaced by newer technologies, especially renewable generation technologies as a result of government initiatives and reducing costs due to scale effects.

Given the above, a capacity factor of 80% over the power station's entire life is possibly optimistic, but has been used for planning purposes to give a conservatively estimate of the station's greenhouse gas emissions over its life. By way of comparison, the existing capacity factor for Mt Piper Power Station over the first 16 years of its commercial life is about 77%.

However, it is possible that the capacity factor for Mt Piper Extension could be higher than 80%, especially in the early years of its life, if it is the lowest cost producer in NSW in the competitive electricity market. The choice of 100%, as implied in the Arup Report, is not realistic from a technical perspective, though 92% could theoretically be achieved if Mt Piper Extension's cost position in the competitive NEM allowed it to operate at full output whenever it was available for service. On balance, 80% is seen to be a reasonable estimate for planning purposes, acknowledging that it could be higher or lower dependent on competitive forces.

Thermal Efficiency

With regard to fuel impacts on GHG emissions, gas has significantly lower emissions than coal as indicated in the Environmental Assessment (EA). The project provides for both fuel types in accordance with the NSW Government's Energy Reform Strategy. Having selected a fuel type, minimising GHG emissions requires the best commercially available technology to be used. In this regard, this is determined by the efficiency of converting the fuel to electricity. For coal fired, the best commercially available technology is ultra-supercritical (USC) and for gas it is combined cycle gas turbine (CCGT) as indicated in the Owens Report (2007).

The efficiency estimate used for USC is an annualised efficiency measure rather than the design efficiency claimed in the Arup report. Annualised efficiency is used because it provides a more realistic measure, taking into account the variation in ambient conditions over the course of the year which will have the effect of increasing or decreasing the design efficiency depending on atmospheric conditions. Design efficiency on the other hand is based on a single set of atmospheric conditions. For Mt Piper Extension the estimated design efficiency at the concept stage is 38.7%, whereas the annualised efficiency estimate is 39.2%.

Part load operation will reduce efficiency. The impact of this is not able to be determined accurately at this concept stage as the heat rate vs load curves and the operating profiles are not available.

Nevertheless we would expect the impact of part load operation on heat rate to be small for an average annual capacity factor of 80% as it will require the station to be near or at full load most of the time it is in-service. For example, 80% capacity equates to an output factor of 87% assuming an availability of 92% (factor 87% is 80% of 92%). Output factor measures the station's output while it is actually in-service. The heat rate curve for black coal-fired units typically tends to flatten out above 80% output. An output factor of 87% implies the units are operating in the flat region of their heat rate curve most of the time and that therefore they are near or at their design efficiency.

It is noted that Arup's argument that annual emissions should be calculated based on a 100% capacity factor contradicts the argument that part load operation should be allowed for in calculating operating efficiency.

Note: the reference on pg 30 of the Greenhouse Gas Assessment to adjusting the design efficiency for part load operation is an error......the calculations are based on correction for ambient conditions only.

The NGA Factors value of 27.0GJ/tonne is for a generic coal.

The coal consumption of 5.5Mtpa in the EA is correct and based on Cobora coal which has a specific energy of 21.7GJ/tonne as received.

2.2.2. Section 3 of the Arup Report – best achievable practice

Arup Report 3.1.2 Comparison with Best Practice

> **While the EA does not commit to any one CCGT technology, Arup considers that the 9FB gas turbine used in the analysis is not the best achievable practice for emissions intensity and thermal efficiency in gas fired generation. An H class based CCGT is achievable and has higher thermal efficiency and lower emissions intensity.**

The EA considers a number different GTs and configurations to provide an output greater than 2000MW. Of these the GE 9FB has the highest output and greenhouse emissions and was chosen for the evaluation as it has the greatest environmental impact.

The EA does not claim the GE 9FB to be best achievable practice.

An H-class based CCGT option will require only 5 units to produce an output greater than 2000MW (2164MW for GE 9H CCGT) and have lower greenhouse emissions. However, H-class GTs are essentially still at the development stage with only one manufacturer offering product at present, with resultant price impacts. However, many of the technological advances of the H-class have been adopted by manufacturers of E and F-class machines with the result that there can be little differences in performance especially when dry cooled and operating at higher elevations as is the case for Mt Piper Extension.

The final GT type, capacity, quantity and configuration will be determined by the final proponent in the project application should the gas-fired option be adopted. At the concept level a conservative approach has been adopted to give a greater GHG emissions rate than may be the case.

Arup Report 3.1.3 USC Coal

> Arup considers that there is insufficient information to determine whether the reported thermal efficiency for the USC coal option is the best achievable practice for emissions intensity and thermal efficiency in coal fired generation. Notwithstanding, the reported steam conditions for the boiler technology are comparable with existing commercial USC coal plants world wide. Therefore the thermal efficiency for the proposed USC coal option is likely to be comparable with these plants.

There is a clear distinction between "best achievable practice" proposed by Arup and "the most technologically advanced, commercially viable options currently available for the next tranche of baseload generation in New South Wales" advocated in the Owen Report. A key term in the Owen statement is "commercially viable", which is an essential aspect of any technology that has to operate in the competitive NEM.

Thermal modelling carried out indicated that an annualised efficiency (sent out) of 40.16% (as opposed to 39.2% identified in the EA) could be achieved. However, this would require additional plant at considerable cost to achieve. For example, to achieve a condenser back pressure of 10 kPa (as opposed to 15 kPa adopted for the EA), would require approximately 50% increase in the size of the air cooled condenser. Such cost increases could not be justified in the competitive NEM given the small relative improvement in thermal efficiency and GHG intensity and were accordingly judged to be not commercially viable.

Arup Report 3.2.1 Calculation of Project Emissions Intensity

> Arup considers that the emission intensities calculated for both fuel types represent likely emissions intensity at theoretical maximum capacity and therefore may underestimate emissions intensity at typical annual average operation at a reduced capacity.
>
> The materiality of the underestimate is not able to be determined without more detailed information relating to the operational efficiencies of the generators at reduced capacity.

Refer to response to 2.2.1 above.

Arup Report 3.2.2 Benchmarking

> Arup considers that use of the NSW pool co-efficient to represent the current NSW average emissions intensity of electricity generation may not be appropriate for comparative purposes.

We have not claimed that the GGAS NSW Pool Coefficient represents the current NSW average emissions intensity, but have included the comparison as GGAS is the operating greenhouse gas reduction scheme in NSW and therefore relevant.

> Arup considers that the NGA Factors emissions intensity is indicative of the average NSW emissions intensity in 2007 and may therefore be useful in providing an estimate of current emissions intensities.

We agree that the NGA Factors provides the most useful comparison and do not consider that this emissions intensity has changed materially since 2007.

> Arup considers that the GHG Assessment is likely to have under estimated average annual emission intensities of both technology options as the calculation methodology assumes that that the annual average thermal efficiency is equal to the design efficiency. Notwithstanding, the annual average emissions intensity of the USC coal option is likely to be no more than the current average emissions intensity of electricity generation in NSW.
>
> The emissions intensity of the CCGT option is likely to be significantly less than the NSW average emissions intensity at current levels and into the foreseeable future.
>
> By the time the USC coal option would be built in 2015, the average NSW emissions intensity is likely to have reduced such that the USC coal option will have an emissions intensity greater than the average NSW emissions intensity at that time.

See Section 2.2.1 with regard to response on average thermal efficiency and design efficiency.

The statement that the USC coal option is likely to have higher emissions intensity than the grid in 2015 is not reasonable. This can be illustrated as follows:

- The NGA Factors specify a NSW grid emissions intensity of 0.89tCO_2/MWh in 2007;
- The AEMO 2009 Electrical Statement of Opportunities has NSW energy in 2007 of approximately 75,000GWh and prediction for 2015 of approximately 81,000GWh;
- Allowing for new generation installed since 2007 including:
  - Condong 30MW renewable at 80% capacity factor
  - Broadwater 30MW renewable at 80% capacity factor
  - Tallawarra 400MW CCGT at 70% capacity factor
  - Uranquinty 640MW OCGT at 1% capacity factor
  - Colongra 660MW OCGT at 1% capacity factor;
- Allowing for realistic proposed generation installed/retired by 2015 including:
  - Eraring upgrade 240MW coal at 70% capacity factor
  - Munmorah retirement 600MW coal at 40% capacity factor
  - New CCGT 400MW gas at 70% capacity factor
  - New wind 453MW at 30% capacity factor.

The above additions will provide AEMO's projected additional 6,000GWh and based on typical greenhouse intensities for each technology the NSW grid intensity in 2015 would be approximately 0.84tCO_2/MWh – greater than the 0.81tCO_2/MWh for the USC coal option. The calculations are shown in Appendix A.

The above is a forecast based on current knowledge and assumed capacity factors for existing and proposed power stations. It is not possible to definitively state the emissions intensity in 2015 but the information provides a reasonable basis for forecasting it.

Arup Report 3.3 Comparison Against Total National Emissions

> Arup considers that the greenhouse gas emissions as outlined in the GHG Assessment would represent approximately 2.9% (USC coal option) or 1.6% (CCGT option) of national emissions (all sectors) over the life time (assuming the CPRS is passed with a 15% reduction target by 2020 and an emissions reduction scenario that follows the CPRS 15 forecasts from Treasury).
>
> Further, Arup considers that the total emissions from the project are nationally significant based on the indicative triggers in the Review of the EPBC Act. Further, the emissions are considered significant in terms of increasing the overall abatement which must be achieved for Australia to meet its emission reduction targets and may potentially have an increase on the cost of the CPRS to the wider community.

The Arup methodology to calculate the emissions over the lifetime is reasonable. However to put this into perspective the calculation should also be done for the “Reference” and “CPRS5” scenarios:

- Reference: USC = 1.24% and CCGT = 0.684%;
- CPRS5: USC = 2.55% and CCGT = 1.40%.

The CPRS is intended to provide the most economically efficient method for achieving GHG reduction targets given the numerous competing interests and considerations. Mt Piper Extension will operate within this competitive environment.

2.2.3. Section 4 of the Arup Report – Available offsets and renewable augmentation

Arup Report 4.1 Identification of Measures

> Arup considers that the renewable energy augmentation measures to reduce and/or offset the greenhouse emissions identified in the GHG Assessment have not been adequately explored and have not been analysed in a transparent manner. Furthermore additional mitigation options (biomass co-firing), may be available to the project proponent at the commencement and throughout the life of the project.

Solar thermal augmentation is not considered viable for Mt Piper Extension because it has never been utilised on USC plant and as such is not commercially available. There is also minimal land area available close-by for any solar array at Mt Piper, especially after allowance is made for the carbon capture plant.

Any attempt to adopt solar thermal augmentation would result in material increases in cost in the design phase (including modelling, experimentation and demonstration to prove its technical viability), in the manufacturing phase for the solar array and connecting pipe work, and in the construction and commissioning phase. Such a feature would increase the risk of the project and hence the cost of finance in addition to the material increases in the capital cost.

A small experimental solar thermal project is underway at the sub-critical Liddell Power Station in the Hunter Valley. If a system similar to that at Liddell were installed the effect on greenhouse intensity would not be material with only 4.4GWh being possible from the solar installation compared to 12,886GWh for the USC coal option.

Biomass co-firing is not considered viable for Mt Piper Extension because:

- USC boiler technology is unproven for co-fired biomass and not commercially available;
- Lack of established biomass supply for Mt Piper (quantity to make a substantial difference in emissions, plus need to transport long distances from growing regions with consequential increase in emissions from the use of diesel fuel);
- Greater risk of fuel supply disruptions with biomass due to natural disasters, droughts and other crop failures;
- Need to construct off-site biomass preparation plant (drying, grinding, and pelletising) which would add a significant extra project cost;
- Requirement for separate biomass receiving, loading, and dry storage plant to prevent fuel contamination and ensure correct handling – significant extra project cost and site area required for this;
- Unknown effects of biomass on furnace slagging behaviour at the higher heat fluxes typical in USC furnaces and the consequential need for experimentation etc prior to design (see same issue identified above for solar thermal augmentation);
- Unknown effects of biomass on co-fired ash properties; potential loss of cementitious re-use market (at least) due to higher unburned carbon in ash;
- As for solar thermal augmentation, incorporation of biomass co-firing would increase the risk of the project and hence the cost of finance in addition to the material increases in the capital cost.

In essence, the incorporation of solar thermal augmentation or biomass co-firing is not considered to be viable for Mt Piper because it is not commercially available for USC plant.

Arup Report 4.1 Carbon Capture and Storage

Arup considers that the viability of CCS for the Mt Piper Extension is uncertain and is likely to depend on the outcomes of the assessments of the Sydney-Gunnedah Basin and Darling Basin as potential storage sites.

Further, aside from allocating additional site area, the project may not be able to be made Carbon Capture Ready to significantly reduce retrofit costs at this point in time without locking in a particular capture technology (which has risks if a different, more efficient technology emerges).

No comment.

2.2.4. Section 5 of the Arup Report – implications of CPRS

Arup Report 5.1.1 Evaluation without Mitigation Measures

> Long Run Marginal Cost is a widely used method in the electricity generation sector for determining costs of investment in new electricity generation infrastructure on per unit of generation basis. LRMC is a measure made up of factors including the capital costs of building the power plant, as well as the operating, maintenance, fuel and financing costs. LRMC is used to estimate the average price the generator would need to charge for electricity over the life of the project.
>
> As such, Arup considers that LRMC is the most appropriate methodology for evaluating the commercial viability of any emissions reduction/offsetting measures.

We do not consider that a detailed Long Run Marginal Cost analysis is necessary to evaluate the viability of emissions reduction/offsetting measures. The methodology employed in the EA effectively determines incremental LRMCs in $/MWh due to the addition of CCS to the power plant or due to the CPRS cost.

We consider that improved thermal efficiency options have already been evaluated and that solar thermal augmentation and biomass co-firing are not viable for the Mt Piper USC option.

Arup Report 5.1.2 Evaluation with Mitigation Measures

> **Arup therefore considers that the CCS costs produced by McKinsey 2008 may underestimate the cost of CCS for the Mt Piper options, implying that CCS may not be viable until a higher carbon price than implied by the GHG Assessment is in place.**

The EA clearly identifies the various factors that may increase CCS costs, but presents a best case CCS cost which is still clearly greater than the CPRS cost at \$50/tCO_2.

> **Overall Arup considers that evaluation of the project under the CPRS is not technically adequate in that it does not evaluate the project under different carbon prices and only evaluates the viability of CCS. Further the methodology to assess the project without CCS under a carbon price and the methodology to assess the project with CCS are not compatible and therefore a comparison is not considered appropriate.**

We consider that while simple, the methodology employed in the EA is entirely valid. The methodology employed in the EA effectively determines incremental LRMCs in $/MWh due to the addition of CCS to the power plant or due to the CPRS cost. The comparison of the incremental LRMC of CCS to incremental LRMC of CPRS is compatible and appropriate.

The Arup report makes reference to the McKinsey study CCS cost being based on new build coal fired power plant in Europe. We would consider these costs would not be materially different in Australia especially given that two of the major power plant OEMs are European (Alstom and Siemens).

Arup considers that although the CPRS is yet to be finalised, there is enough publically available information to warrant a much more comprehensive review of the impacts of the CPRS than what is currently presented in the GHG Assessment.

We do not consider that a detailed analysis as suggested by Arup is necessary to show that the impact of CPRS on the project is less than the impact of installing CCS. In fact Arup's plots in Figures 4-6 clearly show that in all cases the addition of CCS has more impact on LRMCs than CPRS does.

The DG's requirements do not call for a comparison of the LRMCs of USC coal and CCGT, only an evaluation of the impact of CPRS costs on the project.

3. Air Quality

3.1. Department of Planning Comment

The Department requested responses to the following:

- Sections 3.1.1, 3.1.2, 3.2, 4.1.1, 4.2.3 and 4.2.4 of the Heggies Report – further justification and clarification of the modelling approach implemented considering the issues identified by Heggies with respect to meteorological data, limitations to the CALPUFF model program (in terms of simulating non-steady state conditions and predict maximum pollutant concentration levels), emission rates data, NOx to NO_2 conversion methodology and model performance with respect to predicting a range percentiles for SO_2;
- Section 4.2.1 of the Heggies Report – further clarification is required (or justification otherwise) of the predicted pollutant concentration levels and the significance of these levels at each identified sensitive receptor location;
- Sections 4.2.2 and 4.2.5 of the Heggies Report – provision of updated air quality contour plots with consideration to the issue identified by Heggies;
- Section 7 of the Heggies Report – further clarification of likely cumulative PM_{10} impacts at relevant receivers and the potential for acid deposition as a result of the project.

3.2. Response

3.2.1. Responses to Sections 3.1.1, 3.1.2, 3.2, 4.1.1, 4.2.3 and 4.2.4 of the report

Section 3.1.1 - Meteorological year selection

Dispersion modelling using meteorology from the 2004 calendar year has been undertaken to assess any differences in model results, compared to the EA. The 2004 calendar year was chosen because this year had the best data recovery (after 2001) and the wind patterns were similar to other years. It is unclear why Heggies considers 2003 to be a more representative meteorological year than 2001.

Table 3-1 shows the results for SO_2 using 2004 meteorology and for 1-hour, 24-hour and annual average ground-level concentrations. The 1-hour averages are of most interest since no other averaging time was identified for potential exceedances of ground-level concentration criteria.

The results in Table 3-1 demonstrate that the assessment using the 2001 meteorological data does not result in significantly lower predictions than for an alternative year.

- **Table 3-1 Comparison of model results for different meteorological data**

Averaging time	Highest ground-level SO_2 concentration in model domain due to the proposed Mt Piper Extension (USC) emissions ($\mu g/m^3$)	
	2001 meteorological data (EA)	2004 meteorological data
Maximum 1-hour average	1,393	1,045
Maximum 24-hour average	82	155
Annual average	2.2	2.2

Section 3.1.2 – Meteorological data assimilation

Parameters used in the CALMET modelling

A summary of the parameters used for the CALMET modelling is provided in Appendix B.

Vertical model level assimilation for meteorology

A value of eight (8) was chosen as the number of vertical model levels to assimilate each side of the nearest model level to the observed wind data provided to TAPM. This selection was based on the topography in the modelling region as well as the overall assessment approach of placing more emphasis on measured data, rather than prognostic data.

Heggies did not provide a reason why the vertical level assimilation value was inappropriate, other than “the surrounding terrain is quite complex”. Despite this further justification of SKM’s selection and approach is provided below.

The elevation of the model domain ranges from approximately 900 to 1300 m, with the Mt Piper weather station at approximately 930 m. A vertical level assimilation value of eight was chosen so that the measured wind data influenced the prognostic model (TAPM) up to around 300 m above the weather station site. In the horizontal, the measured wind data influenced model calculations out to 5,000 m. The vertical level assimilation value does not mean that TAPM will assume the 10 m winds are the same as the winds up to 300 m. The influence of the measured wind data will decrease up to 300 m and at 300 m, the influence of the measured wind data on TAPM calculations will be small. Without the assumption that winds at the bottom of the valleys had some similarities to winds higher in the valleys, the model calculations for the valleys would be dominated by coarse, synoptic-scale information, which was considered to be inappropriate for the complex terrain environment.

It is recognised that some model settings, such as the vertical level assimilation values described above, can be subjective. In general, however, the approach to the assessment was to bias the model simulations towards measured data (where available), and place less emphasis on prognostic information.

Meteorological modelling approach (CALMET)

Heggies has stated that the approach for using one surface and one upper air station as the basis for determining meteorology across the model domain is questionable, although no explanation is given as to why this approach is questionable. There is no reason why CALMET cannot accurately diagnose meteorological conditions at other locations of the model domain, given accurate information on the variations in topography and landuse.

Delta provided SKM with all their known and available meteorological data. The privately owned meteorological stations (known to Heggies) were not known to SKM, although it is clear the Mt Piper weather station collects the most relevant data for this assessment, given that the predicted impacts are close to the sources of interest. SKM questions Heggies on whether adding additional meteorological stations (at greater distances from Mt Piper) will affect the conclusions of the assessment, given that the highest impacts from Mt Piper Power Station are expected to be close to the emission sources (that is, within 1 to 2 km).

Section 3.2 – CALPUFF pollution model use

CALPUFF was selected for this assessment because it can be run from diagnostic meteorology. TAPM is a prognostic model which is driven primarily by synoptic-scale meteorology at approximately 75 km resolution. Based on these two model concepts, CALPUFF (through the CALMET meteorological processor) should in theory, make more effective use of the measured meteorological information. In CALMET, the measured meteorological conditions are used in the development of the initial guess wind-fields while in TAPM, the synoptic-scale conditions are used as the initial guess wind-fields. Both CALPUFF and TAPM are approved models for use in air quality assessments in NSW (DEC, 2005).

It is recognised that no model is perfect as none can reproduce the atmospheric conditions perfectly. This limitation applies to both CALPUFF and TAPM. However, the air quality assessment has provided information on the performance of CALPUFF for predicting measured ambient pollutant concentrations and the conclusions of the assessment have taken the outcomes of the model performance analysis into consideration.

Section 4.1.1 – Emission rates

Emission estimates were developed by Connell Wagner, and presented by Holmes Air Sciences (2005). The omission of this reference in the air quality assessment was not intentional. Emissions of HF, NO_x, PM and SO_2 were based on measurement data, while emissions of other substances were from estimates for the NPI. Hourly varying emissions were scaled from plant output data, provided by Delta.

SKM has now reviewed recent (2009) stack testing data to assess the variability of emissions at different plant loads. The results are presented in Table 3-2**.**

- **Table 3-2: Comparison of Modelled Emissions with Actual Emissions**

Duct	Date	Load (MW)	Flow (Nm^3/s)	NO_x conc (g/Nm^3)	NO_x Mass (g/s)	SO_2 conc (g/Nm^3)	SO_2 mass (g/s)
MP1b	7/07/2009	700	340	0.85	290	1.2	410
	17/06/2009	660	330	0.74	250	1.3	440
	24/03/2009	660	350	1.2	410	1.1	390
MP2a	8/07/2009	660	340	0.72	210	1.2	330
	26/05/2009	660	360	0.74	220	1.1	340
	24/03/2009	660	350	0.83	250	1.2	360
4 duct data			1380.00	0.85	**1087**	1.18	**1513**
Modelled Emissions		660	1469	0.97	**1422**	1.06	**1550**

It can be seen from Table 3-2 that there is one set of stack test data for one unit operating at 700 MW. Of particular note is that, in terms of both SO_2 and NO_X, there are mass emission rates for operations at 660 MW which are greater than those at 700 MW. Additionally, it can seen that the mass emissions used for modelling are higher for both SO_2 and NO_X than the average of 2009 stack test data which includes operations on one unit at 700 MW for one sample. For other important parameters affecting air quality (eg. stack velocity and temperature) there is no appreciable difference between 700 MW and 660 MW, as modelled.

As such it can be seen that modelling emissions for the existing Mt Piper Power Station based on a 2 x 660 MW configuration will not underestimate SO_2 and NO_X impacts when compared to operations at 2 x 700 MW. In terms of other pollutants (eg. particulates) these are governed by the bag filter pollution control devices, which will provide the same level of control at both 2 x 660 MW and 2 x 700 MW operation.

Section 4.2.3 – Transformation of NO_x to NO_2

The air quality assessment adopted 30% as the proportion of NO_2 present in the NO_x at the point of maximum impact from the power station plumes. This proportion was based on results from the air quality monitoring data. The approach to estimating NO_2 impacts has been refined following the request in the DoP/Heggies submission.

The ozone limiting method (OLM) has been applied, as per Section 8.1.2 of the *Approved Methods*. The OLM assumes that all the available ozone in the atmosphere will react with NO in the plume until either all the O_3 or all of the NO is consumed. Equation 1 shows the calculation.

Equation 1:

$$[NO_2]_{total} = \{0.1 \text{ x } [NO_x]_{pred}\} + MIN\{0.9 \text{ x } [NO_x]_{pred}, 46/48 \text{ x } [O_3]_{bkgd}\} + [NO_2]_{bkgd}$$

Where,
$[NO_2]_{total}$ is the predicted cumulative concentration of NO_2 in µg/m^3.
$[NO_x]_{pred}$ is the dispersion model prediction of ground-level NO_x in µg/m^3.
$[O_3]_{bkgd}$ is the background ambient ozone concentration in µg/m^3.
$[NO_2]_{bkgd}$ is the background ambient NO_2 in µg/m^3.

From the air quality assessment, **Equation 1** can be populated as follows:
$[NO_x]_{pred}$ = 660 µg/m^3 (maximum ground-level NO_x for USC option)
$[O_3]_{bkgd}$ = 50 ppb (107 µg/m^3) (extracted from TAPM-CTM predictions for the Project domain)
$[NO_2]_{bkgd}$ = 79 µg/m^3 (maximum 1-hour average NO_2 in 2001 at Blackmans Flat)

Therefore,
$[NO_2]_{total} = \{0.1 \times 660\} + \text{MIN}\{0.9 \times 660, 46/48 \times 107\} + 79$
$[NO_2]_{total} = 66 + 103 + 79$
$[NO_2]_{total} = 248$ µg/m^3

The predicted maximum 1-hour average NO_2 concentration is therefore 248 µg/m^3, which is essentially the same as the DECCW criterion of 246 µg/m^3 and approximately 30% lower than the 365 µg/m^3 maximum that was presented in the air quality assessment. Given that the maximum levels occur next to the power station site (Figure 11 of air quality assessment), it follows that maximum NO_2 concentrations will be below 246 µg/m^3 at all sensitive receptor locations.

The "Level 1" assessment using OLM, discussed above, is a conservative approach since maximum predicted and background levels are assumed to occur at the same time.

Section 4.2.4 – Predictions for a range of percentiles
Figure 10 in the air quality assessment provides information on the model performance for all percentiles.

3.2.2. Response to Section 4.2.1 of the Heggies Report

Section 4.2.1 – Selection of appropriate sensitive receptor locations
The conclusions of the air quality assessment were formed from model predictions for the most affected ground-level locations in the model domain. Predictions for nearest sensitive receptors will generally be lower than the impacts at the most affected ground-level location. For completeness, the nearest sensitive receptors have been identified (Figure 3-1) and model results have subsequently been determined for these locations.

- **Figure 3-1 Location of sensitive receptor locations (yellow points)**

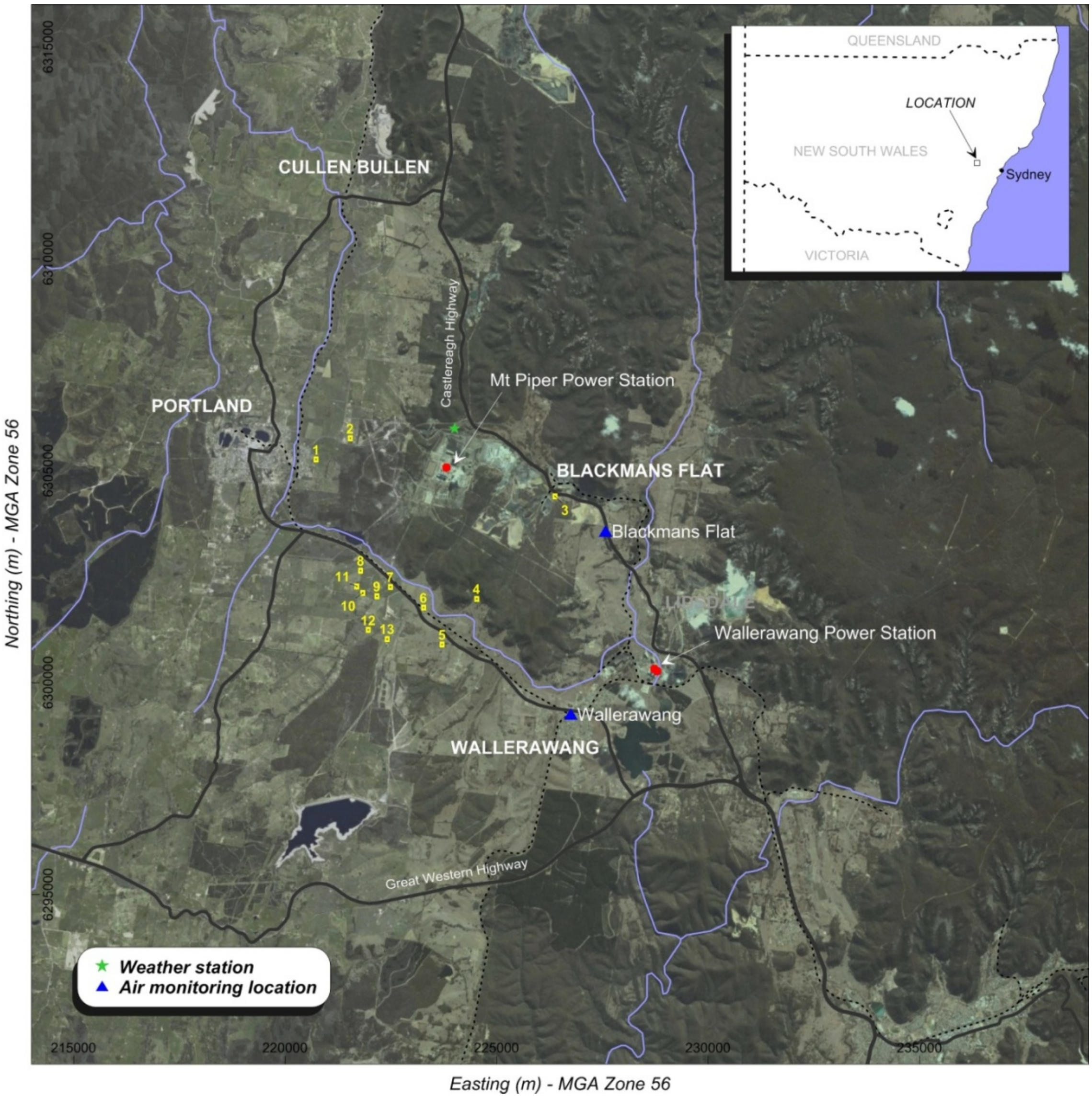


Table 3-3 shows the dispersion model results, including results for the nearest sensitive receptor locations. Some locations are predicted to experience ground-level SO_2 concentrations above relevant criteria under both the existing and proposed scenarios, although this outcome was also noted in the air quality assessment.

Subsequent analysis of the maximum 1-hour average NO_2 predictions (see earlier response to Section 4.2.3 – Transformation of NO_x to NO_2) has shown that all sensitive receptors are predicted to comply with the 246 $\mu g/m^3$ NO_2 criteria.

Table 3-3 Summary of dispersion model results including nearest sensitive receptor locations

Pollutant and averaging time	Individual contributions				Cumulative scenarios (showing the sources included)				
	MP-A	MP-Extension (USC)	MP-CCGT	Wallerawang	MP-A, Wallerawang	MP-A, MP-B (USC)	MP-A, MP-CCGT	MP-A, MP-B (USC), Wallerawang	MP-A, MP-CCGT, Wallerawang
1-hour average NO_X (µg/m^3)									
Highest GLC in model domain	829	660	334	904	919	1128	830	1218	919
Highest GLC at Blackmans Flat	135	51	162	151	167	178	162	189	173
Highest GLC at Wallerawang	98	62	117	881	881	132	117	881	881
Highest GLC at R1	200	166	121	125	200	363	216	363	218
Highest GLC at R2	265	233	170	203	268	484	289	488	297
Highest GLC at R3	176	100	106	145	191	277	176	288	195
Highest GLC at R4	525	285	192	185	563	811	545	849	583
Highest GLC at R5	413	316	99	159	452	730	430	769	469
Highest GLC at R6	396	284	150	179	426	681	427	710	457
Highest GLC at R7	221	159	150	169	249	380	264	409	287
Highest GLC at R8	168	148	112	146	213	308	211	359	221
Highest GLC at R9	203	153	146	162	228	355	244	380	267
Highest GLC at R10	166	134	121	156	200	291	204	329	225
Highest GLC at R11	154	131	109	155	194	272	193	317	210
Highest GLC at R12	226	185	104	161	249	411	252	435	276
Highest GLC at R13	280	232	100	155	307	511	304	539	331
Air quality criteria	-	-	-	-	-	-	-	-	-
1-hour average NO_2 (µg/m^3)									
Highest GLC in model domain	249	198	100	271	276	338	249	365	276
Highest GLC at Blackmans Flat	40	15	49	45	50	53	49	57	52
Highest GLC at Wallerawang	29	19	35	264	264	40	35	264	264
Highest GLC at R1	60	50	36	37	60	109	65	109	65
Highest GLC at R2	79	70	51	61	80	145	87	147	89
Highest GLC at R3	53	30	32	43	57	83	53	86	58
Highest GLC at R4	158	86	58	55	169	243	163	255	175
Highest GLC at R5	124	95	30	48	136	219	129	231	141
Highest GLC at R6	119	85	45	54	128	204	128	213	137

Pollutant and averaging time	Individual contributions				Cumulative scenarios (showing the sources included)				
	MP-A	MP-Extension (USC)	MP-CCGT	Wallerawang	MP-A, Wallerawang	MP-A, MP-B (USC)	MP-A, MP-CCGT	MP-A, MP-B (USC), Wallerawang	MP-A, MP-CCGT, Wallerawang
Highest GLC at R7	66	48	45	51	75	114	79	123	86
Highest GLC at R8	50	44	34	44	64	93	63	108	66
Highest GLC at R9	61	46	44	49	68	106	73	114	80
Highest GLC at R10	50	40	36	47	60	87	61	99	68
Highest GLC at R11	46	39	33	47	58	81	58	95	63
Highest GLC at R12	68	56	31	48	75	123	76	130	83
Highest GLC at R13	84	70	30	47	92	153	91	162	99
Air quality criteria	246	246	246	246	246	246	246	246	246
10-minute average SO_2 ($\mu g/m^3$)									
Highest GLC in model domain	1293	1993	0	2527	2527	2439	1293	2665	2527
Highest GLC at Blackmans Flat	210	155	0	421	424	340	210	481	424
Highest GLC at Wallerawang	153	187	0	2462	2462	296	153	2462	2462
Highest GLC at R1	310	500	0	348	376	806	310	807	376
Highest GLC at R2	412	703	0	567	579	1081	412	1097	579
Highest GLC at R3	275	302	0	404	430	578	275	607	430
Highest GLC at R4	819	861	0	516	920	1680	819	1784	920
Highest GLC at R5	645	955	0	445	752	1604	645	1705	752
Highest GLC at R6	617	859	0	499	700	1478	617	1561	700
Highest GLC at R7	345	480	0	471	495	824	345	905	495
Highest GLC at R8	261	446	0	408	426	696	261	840	426
Highest GLC at R9	317	460	0	454	489	776	317	845	489
Highest GLC at R10	259	404	0	437	468	650	259	754	468
Highest GLC at R11	240	394	0	434	450	614	240	741	450
Highest GLC at R12	352	558	0	451	505	911	352	976	505
Highest GLC at R13	437	699	0	434	539	1135	437	1211	539
Air quality criteria	712	712	712	712	712	712	712	712	712
1-hour average SO_2 ($\mu g/m^3$)									
Highest GLC in model domain	904	1393	0	1767	1767	1706	904	1864	1767
Highest GLC at Blackmans Flat	147	108	0	295	296	238	147	336	296
Highest GLC at Wallerawang	107	131	0	1722	1722	207	107	1722	1722

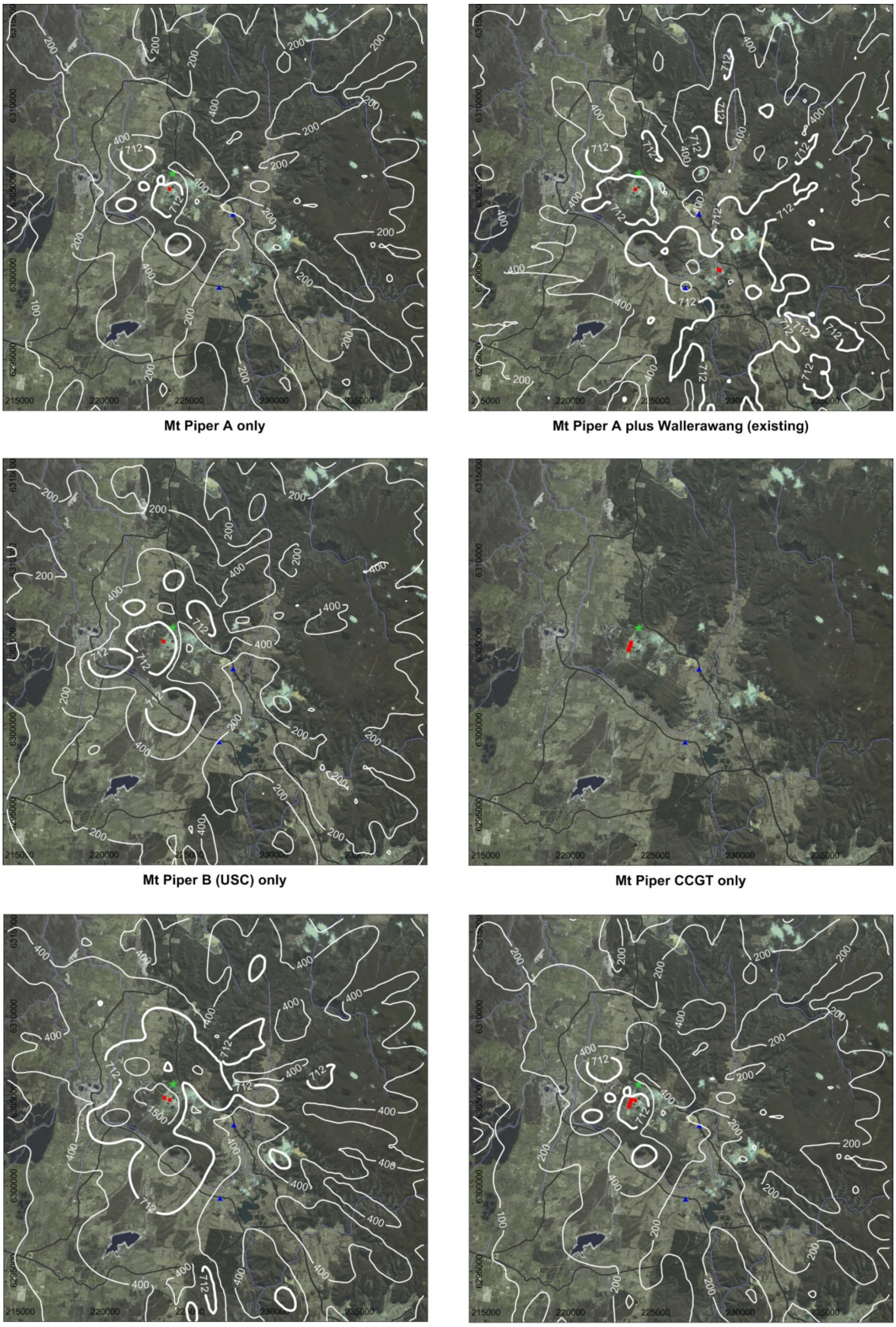
Pollutant and averaging time	Individual contributions				Cumulative scenarios (showing the sources included)				
	MP-A	MP-Extension (USC)	MP-CCGT	Wallerawang	MP-A, Wallerawang	MP-A, MP-B (USC)	MP-A, MP-CCGT	MP-A, MP-B (USC), Wallerawang	MP-A, MP-CCGT, Wallerawang
Highest GLC at R1	217	349	0	244	263	564	217	564	263
Highest GLC at R2	288	492	0	396	405	756	288	767	405
Highest GLC at R3	192	211	0	283	301	404	192	424	301
Highest GLC at R4	572	602	0	361	644	1175	572	1248	644
Highest GLC at R5	451	668	0	311	526	1122	451	1192	526
Highest GLC at R6	432	601	0	349	490	1033	432	1092	490
Highest GLC at R7	241	335	0	330	346	576	241	633	346
Highest GLC at R8	183	312	0	285	298	487	183	588	298
Highest GLC at R9	222	321	0	317	342	543	222	591	342
Highest GLC at R10	181	282	0	306	328	455	181	527	328
Highest GLC at R11	168	275	0	303	315	429	168	518	315
Highest GLC at R12	246	390	0	315	353	637	246	683	353
Highest GLC at R13	305	489	0	304	377	794	305	847	377
Air quality criteria	570	570	570	570	570	570	570	570	570

3.2.3. Responses to Sections 4.2.2 and 4.2.5 of the Heggies Report

Section 4.2.2 – Contour plots for maximum 10-minute average SO_2

Contour plots showing the spatial distribution of predicted maximum 10-minute average SO_2 concentrations are shown in Figure 3-2 below.

- **Figure 3-2 Predicted maximum 10-minute average SO_2 concentrations (µg/m^3)**



Mt Piper A only

Mt Piper A plus Wallerawang (existing)

Mt Piper B (USC) only

Mt Piper CCGT only

Mt Piper A plus Mt Piper B (USC)

Mt Piper A plus CCGT

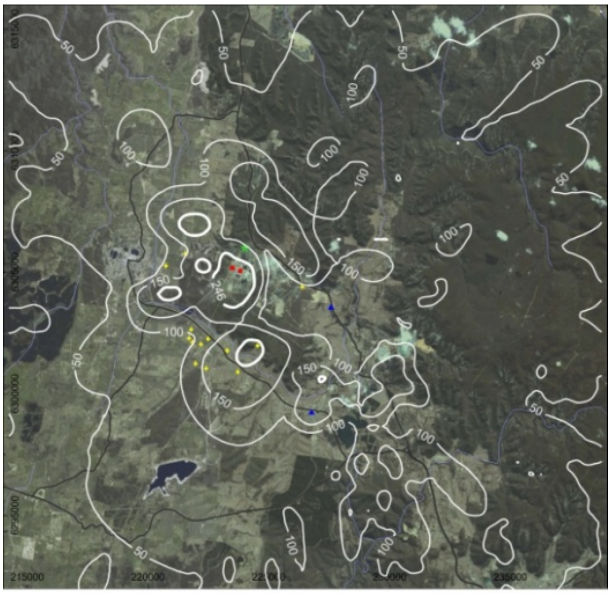
Section 4.2.5 - Contour plot presentation

Contour plot presentation

The scenarios presented in the contour plots were chosen to examine the change in impacts due to changes at Mt Piper. As noted by Heggies, the scenario with existing Mt Piper plus Wallerawang plus Mt Piper Extension is also useful for the assessment although, at the time, the results for this scenario were left in tabular form.

Figure 3-3 shows the cumulative isopleths for NO_2 for the model scenario which includes Mt Piper, Wallerawang and the proposed Mt Piper Extension (USC). These results assume that 30% of the NO_x is NO_2, at the point of maximum 1-hour average ground-level concentration. From the revised NO_2 assessment using OLM and given in the response to Section 4.2.3 above, the maximum 1-hour average NO_2 concentrations will be 248 µg/m^3 rather than the 365 µg/m^3 maximum that was presented in the air quality assessment. Therefore, the results in Figure 3-3 are higher than expected impacts and the predicted number of hours above the 246 µg/m^3 criterion will be essentially zero at sensitive receptor locations.

- **Figure 3-3 Predicted NO_2 impacts due to Mt Piper, Wallerawang and Mt Piper Extension (USC)** **(Mt Piper A = Existing Mt Piper PS; Mt Piper B = Mt Piper Extension)**



Mt Piper A plus Wallerawang plus Mt Piper B (USC)

Maximum 1-hour average concentrations (µg/m^3)(assumes 30% of the NO_x is NO_2)

Mt Piper A plus Wallerawang plus Mt Piper B (USC)

Number of hours above 246 µg/m^3 (assumes 30% of the NO_x is NO_2)

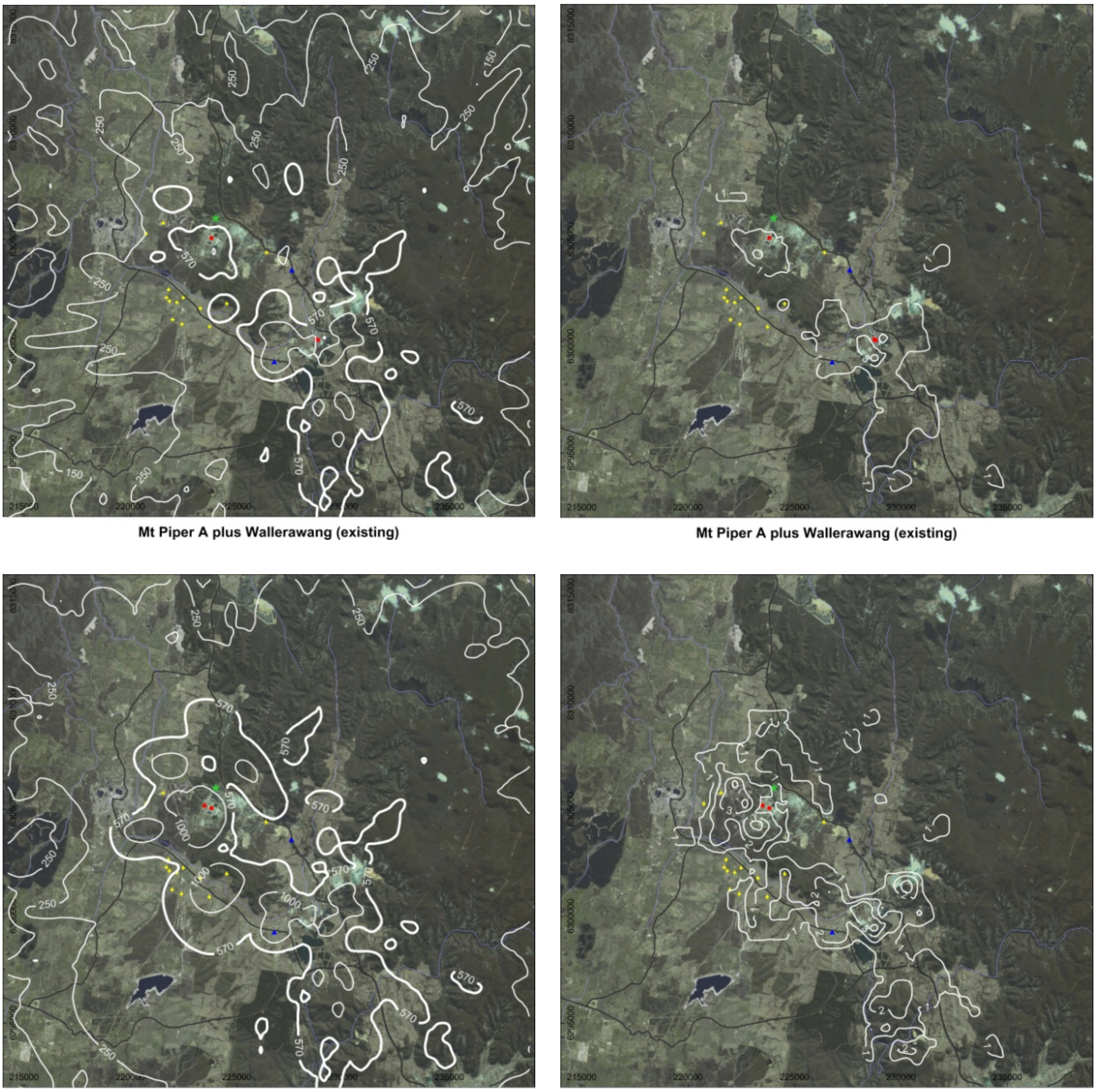
Figure 3-4 shows cumulative isopleths for SO_2 which include the following scenarios:

- Mt Piper and Wallerawang (that is, existing / base case); and
- Mt Piper, Wallerawang and the proposed Mt Piper Extension (USC).

Maximum 1-hour average SO_2 concentrations are presented, as well as the predicted number of hours above 570 µg/m^3. It can be seen from this figure that the spatial extent of maximum 1-hour average SO_2 concentrations is predicted to increase when the Mt Piper Extension source is added to the existing sources. Also, the extent of areas above the 570 µg/m^3 criterion is predicted to increase. The maximum number of hours above 570 µg/m^3 is predicted to remain unchanged at 5 per year (Table 13 of the air quality assessment). This maximum is dominated by the Wallerawang sources.

- **Figure 3-4 Predicted SO_2 impacts** **(Mt Piper A = Existing Mt Piper PS; Mt Piper B = Mt Piper Extension)**

Maximum 1-hour average concentrations (µg/m^3) | **Number of hours above 570 µg/m^3**



Mt Piper A plus Wallerawang (existing) | Mt Piper A plus Wallerawang (existing)

Mt Piper A plus Wallerawang plus Mt Piper B (USC) | Mt Piper A plus Wallerawang plus Mt Piper B (USC)

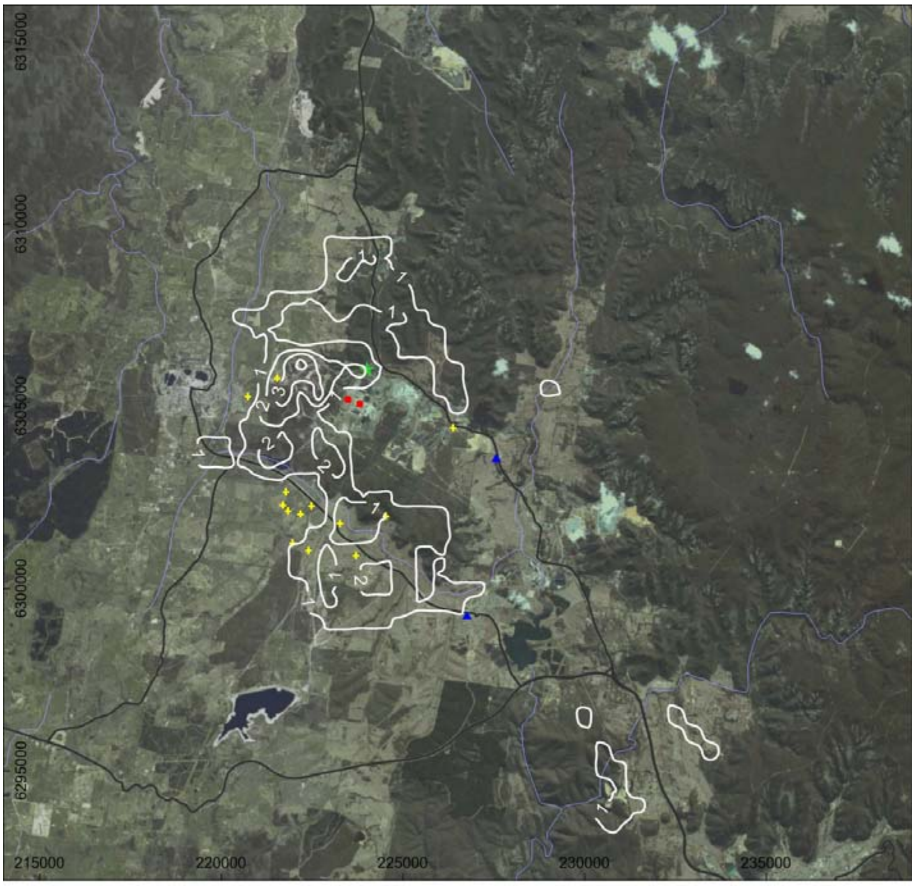
Figure 3-5 shows the predicted change in the number of hours above 570 μg/m^3, after the Mt Piper Extension (USC) source is added to the model and compared with the existing (Mt Piper and Wallerawang) scenario. Five of the identified receptor locations (yellow points) are predicted to experience an additional hour per year above the 570 μg/m^3 criterion.

It was noted in the air quality assessment that predicted maximum 1-hour average SO_2 concentrations were much higher than those which are currently, and have historically, been monitored in the region (that is, maximum predicted levels of 1,767 μg/m^3 versus 712 μg/m^3 as the maximum measured result from the past eight years). Interpretation of the results presented in this section, and in the air quality assessment, should take into consideration the likely over-prediction of maximum short-term SO_2 concentrations.

The results provided in Figure 3-4 and Figure 3-5 are consistent with the outcomes discussed in the air quality assessment.

- **Figure 3-5 Predicted change in the number of hours above 570 μg/m^3 (SO_2)**

  (Mt Piper A = Existing Mt Piper PS; Mt Piper B = Mt Piper Extension)



Mt Piper A plus Wallerawang plus Mt Piper B (USC)

The scale of the figures can be determined from the x and y-axes, which show the easting and northing in metres.

3.2.4. Response to Section 7 of the Heggies Report

Section 7 – Cumulative PM_{10} and acid deposition

Coal for the USC plant would probably be transferred via rail to the proposed coal unloader at Pipers Flat and by conveyor to a new coal stockpile. A conveyor would then transfer the coal to a new coal handling plant before combustion in the boilers.

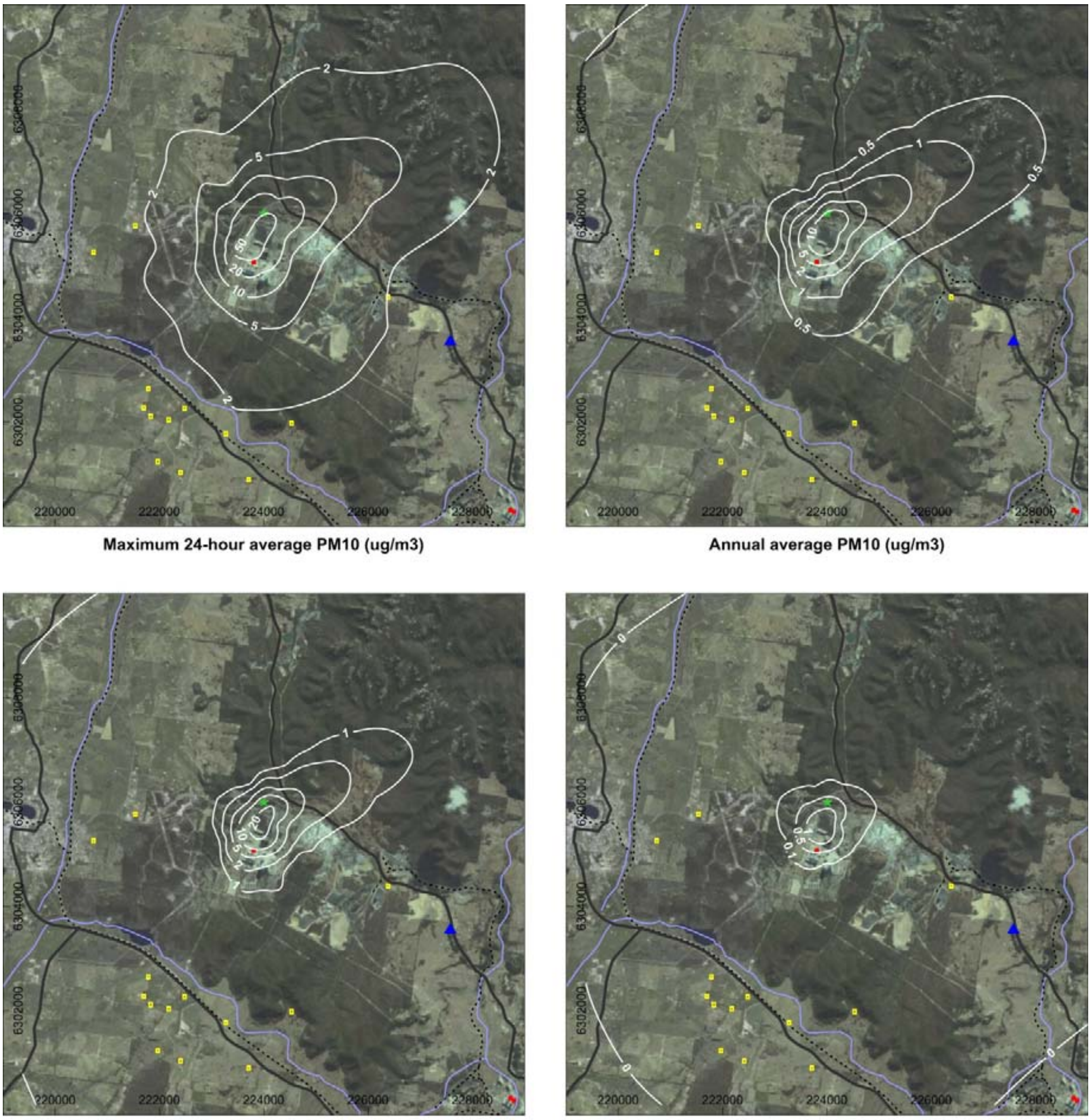
Due to the enclosed nature of the coal handling procedures, the dust generation is expected to be minimal. Nevertheless, a dispersion modelling exercise has been undertaken to quantify the potential dust impacts from the proposed coal handling activities. Dust emissions have been estimated using US EPA and NPI emission factors, with calculations shown in Table 3-4 below. Meteorological data were derived from CALMET simulation, as described in the air quality assessment, and the ISCST3 dispersion model was used. No terrain was included in the dust modelling simulations.

- **Table 3-4 Dust emission estimates for coal handling and storage activities with USC option**

Activity	TSP emission (kg/y)	Intensity	units	Emission factor	Units	Variable 1	Units	Variable 2	units	Variable 3	units
Unloading coal to stockpile from conveyor	677	5,000,000	t	0.00014	kg/t	1.088	average of (wind speed/2.2)^1.3 in m/s	10	moisture content of coal in %		
Reclaiming coal from stockpile	677	5,000,000	t	0.00014	kg/t	1.088	average of (wind speed/2.2)^1.3 in m/s	10	moisture content of coal in %		
Handling coal at CHP	677	5,000,000	t	0.00014	kg/t	1.088	average of (wind speed/2.2)^1.3 in m/s	10	moisture content of coal in %		
Dozer pushing product coal	65,528	8,760	h/y	7.5	kg/h	4	silt content in %	10	moisture content in %		
Loading product coal stockpile	677	5,000,000	t	0.00014	kg/t	1.088	average of (wind speed/2.2)^1.3 in m/s	10	moisture content of coal in %		
Coal stockpiles	7,445	12.50	ha	595.6	kg/ha/y	126	Average number of raindays	4	silt content in %	4.75	% of winds above 5.4 m/s

Predicted dust concentration and deposition results due to the coal handling and storage activities are shown below in Figure 3-6.

- **Figure 3-6 Predicted dust concentration and deposition levels due to coal handling for Mt Piper Extension**



Maximum 24-hour average PM10 (ug/m3)

Annual average PM10 (ug/m3)

Annual average TSP (ug/m3)

Annual average dust deposition (g/m2/month)

The relevant DECCW air quality criteria are as follows:

- 50 µg/m^3 for maximum 24-hour average PM_{10}
- 30 µg/m^3 for annual average PM_{10}
- 90 µg/m^3 for annual average TSP
- 4 g/m^2/month for annual average dust deposition.

The model results show that the coal handling and storage activities will contribute very little to particulate matter concentrations and deposition levels, relative to the DECCW air quality assessment criteria.

The maximum 24-hour average PM_{10} concentration is predicted to be around 2 $\mu g/m^3$ at the closest sensitive receptors, which is well below the DECCW criterion of 50 $\mu g/m^3$. This increment is unlikely to cause exceedances of the 24-hour average criterion.

While compliance is demonstrated by these results, it is possible that the DECCW criterion is exceeded from time to time due to unforseen events such as bushfires and dust-storms or from domestic heating. However, the predicted increment is sufficiently small that proposed activities are unlikely to be the cause of exceedances.

There were no specific requirements (Director General or DECCW) to assess the potential for acid deposition due to the Project.

4. Noise

4.1. Department of Planning Comment

The Department requested responses to the following:

- Sections 2 and 4.3 of the Heggies Report - further justification of the modelling approach with respect to operational noise including background noise surveys (Section 2) and clarification on whether CONCAWE meteorological categories were employed in the modelling (Section 4.3);
- Section 4.2 of the Heggies Report - further justification of the representativeness of sound power levels used in the operational noise assessment (with and without mitigation) and where necessary provision of updated predictions;
- Section 4.3 of the Heggies Report - clarification of operational noise contributions from relevant project components including the Western Rail Coal Unloader; and
- Sections 3.2, 3.3 and 3.4 of the Heggies Report - further justification of the modelling approach with respect to construction noise including construction noise scenarios and modelling assumptions.

4.2. Response

4.2.1. Sections 2 and 4.3 of the Heggies Report

In Section 2 of the Noise Impact Assessment Peer Review, the adequacy of the measured background noise levels at receiver locations has been questioned, specifically with reference to the Amenity Criteria (Ref Table 2.1 of the INP). Where incomplete or inadequate background noise level measurements are used in an assessment, there is the potential for an under or over estimation of the Project Specific Noise Levels (PSNL) in an assessment. Separately, but related to this issue the DECCW Industrial Noise Policy (INP), contains guidelines for assessing the PSNL.

Importantly, where the background noise levels are based on the amenity criteria, **and** there is a measureable noise influence from existing industrial sources, the amenity criteria is modified to account for these influences in order to limit cumulative noise impacts. For representative locations around the power station, the appropriate Amenity Area noted in the INP has been identified as "Rural", having a night time noise level criteria of 40 dB(A). For the Amenity Criteria, when considering modifications to the acceptable noise level, the minimum possible Amenity Criteria for a rural area is 40 dB(A) with an adjustment of -10 dB(A) giving a criterion value of 30 dB(A). It should be noted that this would only occur where there is a significant existing industrial noise influence.

In addition, where the PSNL are based on the Intrusiveness Criteria, **and** the background noise levels are less than 30 dB(A), the Rating Background Level (RBL) is deemed to be 30 dB(A) as a minimum. Whilst the Heggie review has questioned the monitoring data presented by SKM and recommended the use of the minimum RBL, it has failed to recognise that the SKM report has already recommended the adoption of a minimum RBL of 30-31 dB(A), resulting in PSNL of 35-36 dB(A) for the project, a fact that has been acknowledged in the DECCW review of the noise report. As these levels are the minimum criteria recognised by the DECCW, no further justification of the PSNL should be necessary.

The Heggie review did not identify the met categories used in the assessment. The noise report clearly states in Section 4.2.1:

"The noise model used CONCAWE algorithms to predict the LAeq 15 min impacts at the nearby residences for both daytime and night time scenarios. The use of the CONCAWE model allows for prediction of noise impacts from adverse weather conditions, where the INP identifies these effects must be assessed."

And in Sections 5.1 and 6.1 of the SKM noise report, the modelling scenarios identified the assessed meteorology as well as the INP default adverse meteorological values as follows:

"The assessed adverse weather conditions include an F class stability and a 1.5m/s wind from the source to the receiver. The INP default conditions include either a 3m/s wind or an F class stability with a 2m/s wind from the source to the receiver. These results have been adjusted to account for low frequency noise impacts by adding 5 dB(A) to the predicted values."

The Heggie review has also questioned the use of the CONCAWE algorithm in the SoundPLAN noise model. It is academic as to whether the SoundPLAN or ENM model is more accurate in predicting the correct noise level at a receiver location. However, both models are acknowledged for use by the DECCW and it is recognised that both models also have their limitations.

4.2.2. Section 4.2 of the Heggie Report

The Heggie review of the noise impact assessment has questioned the noise levels used to assess emissions from the power station for both the coal fired and gas fired options. Interestingly the Heggie estimates of sound power levels were identical for both options, which does not seem plausible. Section 4.2.5 of the SKM noise report provides justification of the sound power levels identified for the modelling exercise. For the existing power station, the measured levels were used in the validation of the noise model and compared to the site measurements made in and around the Mt Piper power station. The gas fired power station was also modelled on actual site measurements of an existing CCGT plant from another project, which have been separately validated.

In addition while the review report identified sound power levels used in the EA were low according to their estimates, the simple summation of levels in the table has underestimated all the sources in the noise model which total approximately 124 dB(A). Furthermore the Heggie review has expressed the opinion that the predicted levels are understated by between 4 dB(A) and 17 dB(A), although this assertion is not based on comparable modelling of the project parameters, but simply the difference between the Heggie estimated sound power levels and the calculated levels from the table in the noise report.

With respect to the Heggie statement that the levels in the EA are low, SKM recommend using measurements and validation of existing plant noise levels, which are expected to yield a more accurate result than the theoretical estimates which can under or over predict impacts depending on the level of modelling undertaken.

4.2.3. Section 4.3 of the Heggie Report

The Heggie review has identified that the WRCU has been incorporated into the noise assessment but that there are no noise levels included in the report. The assessment of the WRCU is reasonably complex but largely based on the noise from the coal train on the rail loop. The sound power levels used in the assessment the WRCU are shown in Table 4-1 below.

- **Table 4-1 WRCU Sound Power Levels**

Item	L_{Aeq} SWL
2 x Locomotives	114 dB(A)
Conveyor	77 dB(A)/ metre

4.2.4. Sections 3.2, 3.3 and 3.4 of the Heggie Report

The modelling approach was based on the limited information available regarding the proposed construction methodology. SKM has made assumptions of the quantity and location of the construction equipment required for the project, which forms the basis of the construction noise assessment. While the assumptions may not accurately reflect the final equipment list or methodology used at the site, it will provide an indication of the potential for construction noise to exceed the DECCW guidelines.

The current assessment shows that at distances of over 1.5 kilometres and with considerable intervening topographic shielding between the site and residential locations, it is highly unlikely that the construction noise levels will cause an adverse impact.

In addition, the Heggie review has incorrectly identified that the assessment has predicted levels of up to 32 dB(A). In this instance, the report states:

"Specific noisy activities such as impulsive or explosive noise emissions or night time works may require a more detailed review at the design stage however, the predicted levels indicate that construction noise would remain within the criterion of 32 dB(A) at the nearest receiver. "

It is agreed that the reassessment of the construction scenario would be necessary to complete the construction noise assessment in accordance with the new DECCW Interim construction noise guidelines however, DGR's issued on the 30/06/09 required the use of the use of "existing guidelines" with a link, directed to the ENCM, Chapter 171 requirements. The construction noise guidelines were revised on 21/07/09 to the new in the interim guidelines, noted on the website as "Interim Construction noise Guidelines".

Regardless of the methodology used to assess the construction activity for the Proposal, it would not substantially alter the outcome that, at large distances and with significant shielding and works limited to daytime hours, there would not be any exceedances of the noise guidelines.

Appendix A NSW Grid Emission Intensity

2007				
Emissions Intensity	0.89	tCO2/MWh	NGA Factors	
Energy	75,000	GWh	SOO 2009	
2015				
Energy	81,000	GWh	SOO 2009	
New Generation				
Broadwater				
Output	30	MW		
Capacity Factor	80%			
Energy	210	GWh	4%	
EI	-	tCO2/MWh		
Condong				
Output	30	MW		
Capacity Factor	80%			
Energy	210	GWh	4%	
EI	-	tCO2/MWh		
Tallawarra				
Output	400	MW		
Capacity Factor	70%			6,929 kJ/kWhr
Energy	2,453	GWh	41%	51.33 KgCO2/GJ
EI	0.36	tCO2/MWh		0.356
Uranquinty				
Output	640	MW		
Capacity Factor	1%			11,750 kJ/kWhr
Energy	56	GWh	1%	51.33 KgCO2/GJ
EI	0.60	tCO2/MWh		0.60
Colongra				
Output	660	MW		
Capacity Factor	1%			11,253 kJ/kWhr
Energy	58	GWh	1%	51.33 KgCO2/GJ
EI	0.58	tCO2/MWh		0.58

Eraring Upgrade

Output	240	MW	
Capacity Factor	70%		
Energy	1,472	GWh	25%
EI	0.91	tCO2/MWh	

New CCGT

Output	400	MW	
Capacity Factor	70%		
Energy	2,453	GWh	41%
EI	0.36	tCO2/MWh	

New Wind

Output	453	MW	
Capacity Factor	30%		
Energy	1,190	GWh	20%
EI	-	tCO2/MWh	

Munmorah Retired

Output	600	MW	
Capacity Factor	40%		
Energy	-2,102	GWh	-35%
EI	1.04	tCO2/MWh	

Total Energy	6,000	GWh	100%
Renewables			27%
CCGT			82%
OCGT			2%
Coal			-11%

Emissions Intensity	0.836	tCO2/MWh

Appendix B Calmet Model Parameters

CALMET model settings

```
CALMET.INP      2.1             Hour Start and End Times with Seconds
Mt Piper
CALMET Simulation

---------------- Run title (3 lines) ------------------------------------------

                    CALMET MODEL CONTROL FILE
                    -------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names


Subgroup (a)
------------
Default Name  Type          File Name
------------  ----          ---------
GEO.DAT       input    ! GEODAT=GEO.DAT       !
SURF.DAT      input    ! SRFDAT=SURF2001.DAT      !
CLOUD.DAT     input    * CLDDAT=            *
PRECIP.DAT    input    * PRCDAT=            *
WT.DAT        input    * WTDAT=             *

CALMET.LST    output   ! METLST=CALMET01.LST     !
CALMET.DAT    output   ! METDAT=CALMET01.DAT    !
PACOUT.DAT    output   * PACDAT=            *

All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = F !
         F = UPPER CASE

NUMBER OF UPPER AIR & OVERWATER STATIONS:

    Number of upper air stations (NUSTA)  No default     ! NUSTA =  1  !
    Number of overwater met stations
                                 (NOWSTA) No default     ! NOWSTA =  0  !

NUMBER OF PROGNOSTIC and IGF-CALMET FILEs:

    Number of MM4/MM5/3D.DAT files
                                 (NM3D) No default       ! NM3D =  0  !

    Number of IGF-CALMET.DAT files
                                 (NIGF)   No default     ! NIGF =  0  !

                       !END!
--------------------------------------------------------------------------------
Subgroup (b)
---------------------------------
Upper air files (one per station)
---------------------------------
Default Name  Type       File Name
------------  ----       ---------
UP1.DAT       input     1  ! UPDAT=UP1.DAT!    !END!
--------------------------------------------------------------------------------
Subgroup (c)
-----------------------------------------
Overwater station files (one per station)
-----------------------------------------
Default Name  Type       File Name
------------  ----       ---------
SEA1.DAT       input     1  * SEADAT=SEA_449.DAT *    *END*
--------------------------------------------------------------------------------
Subgroup (d)
------------------------------------------------
MM4/MM5/3D.DAT files (consecutive or overlapping)
------------------------------------------------
Default Name  Type       File Name
------------  ----       ---------
MM51.DAT       input     1  * M3DDAT=LSP2003.DAT *    *END*
--------------------------------------------------------------------------------
Subgroup (e)
-------------------------------------------------
IGF-CALMET.DAT files (consecutive or overlapping)
-------------------------------------------------
Default Name  Type       File Name
------------  ----       ---------
IGFn.DAT       input     1  * IGFDAT=CALMET0.DAT *    *END*
--------------------------------------------------------------------------------
Subgroup (f)
----------------
Other file names
----------------

Default Name  Type       File Name
------------  ----       ---------
DIAG.DAT      input      * DIADAT=                  *
PROG.DAT      input      * PRGDAT=                  *

TEST.PRT      output     * TSTPRT=                  *
TEST.OUT      output     * TSTOUT=                  *
TEST.KIN      output     * TSTKIN=                  *
TEST.FRD      output     * TSTFRD=                  *
TEST.SLP      output     * TSTSLP=                  *
DCST.GRD      output     * DCSTGD=                  *
```

```
--------------------------------------------------------------------------------
NOTES: (1) File/path names can be up to 70 characters in length
       (2) Subgroups (a) and (f) must have ONE 'END' (surrounded by
           delimiters) at the end of the group
       (3) Subgroups (b) through (e) are included ONLY if the corresponding
           number of files (NUSTA, NOWSTA, NM3D, NIGF) is not 0, and each must have
           an 'END' (surround by delimiters) at the end of EACH LINE

                         !END!


-------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

     Starting date:    Year   (IBYR)  --    No default   ! IBYR  =  2001  !
                       Month  (IBMO)  --    No default   ! IBMO  =  1  !
                       Day    (IBDY)  --    No default   ! IBDY  =  1  !
     Starting time:    Hour   (IBHR)  --    No default   ! IBHR  =  0  !
                       Second (IBSEC) --    No default   ! IBSEC =  0  !

     Ending date:      Year   (IEYR)  --    No default   ! IEYR  =  2001  !
                       Month  (IEMO)  --    No default   ! IEMO  =  5  !
                       Day    (IEDY)  --    No default   ! IEDY  =  1  !
     Ending time:      Hour   (IEHR)  --    No default   ! IEHR  =  0  !
                       Second (IESEC) --    No default   ! IESEC =  0  !

      UTC time zone         (ABTZ) -- No default       ! ABTZ= UTC+1000 !
         (character*8)
         PST = UTC-0800, MST = UTC-0700 , GMT = UTC-0000
         CST = UTC-0600, EST = UTC-0500

     Length of modeling time-step (seconds)
     Must divide evenly into 3600 (1 hour)
     (NSECDT)                        Default:3600     ! NSECDT =  3600  !
                                     Units: seconds

     Run type            (IRTYPE) -- Default: 1       ! IRTYPE=  1  !

        0 = Computes wind fields only
        1 = Computes wind fields and micrometeorological variables
            (u*, w*, L, zi, etc.)
        (IRTYPE must be 1 to run CALPUFF or CALGRID)

     Compute special data fields required
     by CALGRID (i.e., 3-D fields of W wind
     components and temperature)
     in additional to regular            Default: T    ! LCALGRD = T !
     fields ? (LCALGRD)
     (LCALGRD must be T to run CALGRID)

      Flag to stop run after
      SETUP phase (ITEST)             Default: 2       ! ITEST=  2   !
      (Used to allow checking
      of the model inputs, files, etc.)
      ITEST = 1 - STOPS program after SETUP phase
      ITEST = 2 - Continues with execution of
                  COMPUTATIONAL phase after SETUP


     Test options specified to see if
     they conform to regulatory
     values? (MREG)                   No Default       ! MREG =   0   !

        0 = NO checks are made
        1 = Technical options must conform to USEPA guidance
                  IMIXH    -1       Maul-Carson convective mixing height
                                    over land; OCD mixing height overwater
                  ICOARE   0        OCD deltaT method for overwater fluxes
                  THRESHL  0.0      Threshold buoyancy flux over land needed
                                    to sustain convective mixing height growth
                  ISURFT   > 0      Pick one representative station, OR
                           -2       in NOOBS mode (ITPROG=2) average all
                                    surface prognostic temperatures to get
                                    a single representative surface temp.
                  IUPT     > 0      Pick one representative station, OR
                           -2       in NOOBS mode (ITPROG>0) average all surface
                                    prognostic temperatures to get a single
                                    representative surface temp.

!END!

-------------------------------------------------------------------------------

INPUT GROUP: 2 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = UTM  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
```

```
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                   Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                  Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                  No Default      ! IUTMZN =  56   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                  Default: N      ! UTMHEM = S  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                   No Default      ! RLAT0 = -34.45N  !
     (RLON0)                   No Default      ! RLON0 = -150.88W  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                   No Default      ! XLAT1 = -30N  !
     (XLAT2)                   No Default      ! XLAT2 = -60N  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E


     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its output
     consistent with local mapping products.  The list of Datum-Regions with
     official transformation parameters is provided by the National Imagery and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)
     ------------------------------------------------------------------------------
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                   Default: WGS-84    ! DATUM = WGS-84  !


     Horizontal grid definition:
     ---------------------------

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =   50  !
            No. Y grid cells (NY)      No default     ! NY =   50  !

     Grid spacing (DGRIDKM)            No default     ! DGRIDKM = 0.5 !
                                       Units: km

     Reference grid coordinate of
     SOUTHWEST corner of grid cell (1,1)

        X coordinate (XORIGKM)         No default     ! XORIGKM = 214.000 !
        Y coordinate (YORIGKM)         No default     ! YORIGKM = 6291.000 !
                                       Units: km


     Vertical grid definition:
     -------------------------

        No. of vertical layers (NZ)    No default     ! NZ =  9  !

        Cell face heights in arbitrary
        vertical grid (ZFACE(NZ+1))    No defaults
                                       Units: m
        ! ZFACE = 0.,20.,40.,80.,160.,320.,700.,1200.,1500.,2000. !

!END!
```

```
-------------------------------------------------------------------------------

INPUT GROUP: 3 -- Output Options
--------------


    DISK OUTPUT OPTION

       Save met. fields in an unformatted
       output file ?              (LSAVE)  Default: T     ! LSAVE = T !
       (F = Do not save, T = Save)

       Type of unformatted output file:
       (IFORMO)                            Default: 1    ! IFORMO =  1  !

            1 = CALPUFF/CALGRID type file (CALMET.DAT)
            2 = MESOPUFF-II type file     (PACOUT.DAT)


    LINE PRINTER OUTPUT OPTIONS:

       Print met. fields ?  (LPRINT)       Default: F     ! LPRINT = F !
       (F = Do not print, T = Print)
       (NOTE: parameters below control which
              met. variables are printed)

       Print interval
       (IPRINF) in hours                   Default: 1     ! IPRINF =  96  !
       (Meteorological fields are printed
        every  96  hours)


       Specify which layers of U, V wind component
       to print (IUVOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T)        Defaults: NZ*0
       ! IUVOUT =  1 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !
       -----------------------


       Specify which levels of the W wind component to print
       (NOTE: W defined at TOP cell face --  9  values)
       (IWOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T & LCALGRD=T)
       -----------------------------------
                                             Defaults: NZ*0
        ! IWOUT =  1 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !


       Specify which levels of the 3-D temperature field to print
       (ITOUT(NZ)) -- NOTE: NZ values must be entered
       (0=Do not print, 1=Print)
       (used only if LPRINT=T & LCALGRD=T)
       -----------------------------------
                                             Defaults: NZ*0
        ! ITOUT =  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0 ,  0  !

       Specify which meteorological fields
       to print
       (used only if LPRINT=T)             Defaults: 0 (all variables)
       -----------------------


         Variable            Print ?
                         (0 = do not print,
                          1 = print)
         --------        ------------------

      !  STABILITY  =          1           ! - PGT stability class
      !  USTAR      =          0           ! - Friction velocity
      !  MONIN      =          0           ! - Monin-Obukhov length
      !  MIXHT      =          0           ! - Mixing height
      !  WSTAR      =          0           ! - Convective velocity scale
      !  PRECIP     =          0           ! - Precipitation rate
      !  SENSHEAT   =          0           ! - Sensible heat flux
      !  CONVZI     =          0           ! - Convective mixing ht.


       Testing and debug print options for micrometeorological module

          Print input meteorological data and
          internal variables (LDB)         Default: F       ! LDB = F !
          (F = Do not print, T = print)
          (NOTE: this option produces large amounts of output)

          First time step for which debug data
          are printed (NN1)                Default: 1       ! NN1 =  1  !

          Last time step for which debug data
          are printed (NN2)                Default: 1       ! NN2 =  2  !

          Print distance to land
          internal variables (LDBCST)      Default: F       ! LDBCST = F !
          (F = Do not print, T = print)
          (Output in .GRD file DCST.GRD, defined in input group 0)

       Testing and debug print options for wind field module
       (all of the following print options control output to
        wind field module's output files: TEST.PRT, TEST.OUT,
        TEST.KIN, TEST.FRD, and TEST.SLP)
```

```
          Control variable for writing the test/debug
          wind fields to disk files (IOUTD)
          (0=Do not write, 1=write)        Default: 0       ! IOUTD =  0  !

          Number of levels, starting at the surface,
          to print (NZPRN2)                Default: 1       ! NZPRN2 =  1  !

          Print the INTERPOLATED wind components ?
          (IPR0) (0=no, 1=yes)             Default: 0       !  IPR0 =  0  !

          Print the TERRAIN ADJUSTED surface wind
          components ?
          (IPR1) (0=no, 1=yes)             Default: 0       !  IPR1 =  0  !

          Print the SMOOTHED wind components and
          the INITIAL DIVERGENCE fields ?
          (IPR2) (0=no, 1=yes)             Default: 0       !  IPR2 =  0  !

          Print the FINAL wind speed and direction
          fields ?
          (IPR3) (0=no, 1=yes)             Default: 0       !  IPR3 =  0  !

          Print the FINAL DIVERGENCE fields ?
          (IPR4) (0=no, 1=yes)             Default: 0       !  IPR4 =  0  !

          Print the winds after KINEMATIC effects
          are added ?
          (IPR5) (0=no, 1=yes)             Default: 0       !  IPR5 =  0  !

          Print the winds after the FROUDE NUMBER
          adjustment is made ?
          (IPR6) (0=no, 1=yes)             Default: 0       !  IPR6 =  0  !

          Print the winds after SLOPE FLOWS
          are added ?
          (IPR7) (0=no, 1=yes)             Default: 0       !  IPR7 =  0  !

          Print the FINAL wind field components ?
          (IPR8) (0=no, 1=yes)             Default: 0       !  IPR8 =  0  !

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 4 -- Meteorological data options
--------------

    NO OBSERVATION MODE             (NOOBS)  Default: 0     ! NOOBS =  0   !
          0 = Use surface, overwater, and upper air stations
          1 = Use surface and overwater stations (no upper air observations)
              Use MM4/MM5/3D.DAT for upper air data
          2 = No surface, overwater, or upper air observations
              Use MM4/MM5/3D.DAT for surface, overwater, and upper air data

    NUMBER OF SURFACE & PRECIP. METEOROLOGICAL STATIONS

       Number of surface stations   (NSSTA)  No default     ! NSSTA =  1  !

       Number of precipitation stations
       (NPSTA=-1: flag for use of MM5/3D.DAT precip data)
                                    (NPSTA)  No default     ! NPSTA =  0  !

    CLOUD DATA OPTIONS
       Gridded cloud fields:
                                   (ICLOUD)  Default: 0     ! ICLOUD =  0  !
       ICLOUD = 0 - Gridded clouds not used
       ICLOUD = 1 - Gridded CLOUD.DAT generated as OUTPUT
       ICLOUD = 2 - Gridded CLOUD.DAT read as INPUT
       ICLOUD = 3 - Gridded cloud cover from Prognostic Rel. Humidity
                    at 850mb (Teixera)
       ICLOUD = 4 - Gridded cloud cover from Prognostic Rel. Humidity
                    at all levels (MM5toGrads algorithm)

    FILE FORMATS

       Surface meteorological data file format
                                   (IFORMS)  Default: 2     ! IFORMS =  2  !
       (1 = unformatted (e.g., SMERGE output))
       (2 = formatted   (free-formatted user input))

       Precipitation data file format
                                   (IFORMP)  Default: 2     ! IFORMP =  2  !
       (1 = unformatted (e.g., PMERGE output))
       (2 = formatted   (free-formatted user input))

       Cloud data file format
                                   (IFORMC)  Default: 2     ! IFORMC =  2  !
       (1 = unformatted - CALMET unformatted output)
       (2 = formatted   - free-formatted CALMET output or user input)

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 5 -- Wind Field Options and Parameters
--------------


    WIND FIELD MODEL OPTIONS
```

```
   Model selection variable (IWFCOD)     Default: 1      ! IWFCOD =  1  !
      0 = Objective analysis only
      1 = Diagnostic wind module

   Compute Froude number adjustment
   effects ? (IFRADJ)                    Default: 1      ! IFRADJ =  1  !
   (0 = NO, 1 = YES)

   Compute kinematic effects ? (IKINE)   Default: 0      ! IKINE  =  1  !
   (0 = NO, 1 = YES)

   Use O'Brien procedure for adjustment
   of the vertical velocity ? (IOBR)     Default: 0      ! IOBR =  0  !
   (0 = NO, 1 = YES)

   Compute slope flow effects ? (ISLOPE) Default: 1      ! ISLOPE  =  1  !
   (0 = NO, 1 = YES)

   Extrapolate surface wind observations
   to upper layers ? (IEXTRP)            Default: -4     ! IEXTRP = -4  !
   (1 = no extrapolation is done,
    2 = power law extrapolation used,
    3 = user input multiplicative factors
        for layers 2 - NZ used (see FEXTRP array)
    4 = similarity theory used
    -1, -2, -3, -4 = same as above except layer 1 data
        at upper air stations are ignored

   Extrapolate surface winds even
   if calm? (ICALM)                      Default: 0      ! ICALM  =  0  !
   (0 = NO, 1 = YES)

   Layer-dependent biases modifying the weights of
   surface and upper air stations (BIAS(NZ))
     -1<=BIAS<=1
   Negative BIAS reduces the weight of upper air stations
     (e.g. BIAS=-0.1 reduces the weight of upper air stations
   by 10%; BIAS= -1, reduces their weight by 100 %)
   Positive BIAS reduces the weight of surface stations
     (e.g. BIAS= 0.2 reduces the weight of surface stations
   by 20%; BIAS=1 reduces their weight by 100%)
   Zero BIAS leaves weights unchanged (1/R**2 interpolation)
   Default: NZ*0
                           ! BIAS = -1 , -.8 , -.6 , -.4 , -.2 , -.1 ,  0 ,  0 ,  0  !

   Minimum distance from nearest upper air station
   to surface station for which extrapolation
   of surface winds at surface station will be allowed
   (RMIN2: Set to -1 for IEXTRP = 4 or other situations
    where all surface stations should be extrapolated)
                                         Default: 4.     ! RMIN2 = -1.0 !

   Use gridded prognostic wind field model
   output fields as input to the diagnostic
   wind field model (IPROG)              Default: 0      ! IPROG =  0  !
   (0 = No, [IWFCOD = 0 or 1]
    1 = Yes, use CSUMM prog. winds as Step 1 field, [IWFCOD = 0]
    2 = Yes, use CSUMM prog. winds as initial guess field [IWFCOD = 1]
    3 = Yes, use winds from MM4.DAT file as Step 1 field [IWFCOD = 0]
    4 = Yes, use winds from MM4.DAT file as initial guess field [IWFCOD = 1]
    5 = Yes, use winds from MM4.DAT file as observations [IWFCOD = 1]
    13 = Yes, use winds from MM5/3D.DAT file as Step 1 field [IWFCOD = 0]
    14 = Yes, use winds from MM5/3D.DAT file as initial guess field [IWFCOD = 1]
    15 = Yes, use winds from MM5/3D.DAT file as observations [IWFCOD = 1]

   Timestep (seconds) of the prognostic
   model input data   (ISTEPPGS)         Default: 3600   ! ISTEPPGS =  3600   !

   Use coarse CALMET fields as initial guess fields (IGFMET)
   (overwrites IGF based on prognostic wind fields if any)
                                         Default: 0      ! IGFMET =  0  !

RADIUS OF INFLUENCE PARAMETERS

   Use varying radius of influence       Default: F      ! LVARY =  F!
   (if no stations are found within RMAX1,RMAX2,
    or RMAX3, then the closest station will be used)

   Maximum radius of influence over land
   in the surface layer (RMAX1)          No default      ! RMAX1 = 5. !
                                         Units: km
   Maximum radius of influence over land
   aloft (RMAX2)                         No default      ! RMAX2 = 20. !
                                         Units: km
   Maximum radius of influence over water
   (RMAX3)                               No default      ! RMAX3 = 20. !
                                         Units: km


OTHER WIND FIELD INPUT PARAMETERS

   Minimum radius of influence used in
   the wind field interpolation (RMIN)   Default: 0.1    ! RMIN = 0.1 !
                                         Units: km
   Radius of influence of terrain
   features (TERRAD)                     No default      ! TERRAD = 5. !

                                         Units: km
   Relative weighting of the first
   guess field and observations in the
   SURFACE layer (R1)                    No default      ! R1 = 0.5 !
   (R1 is the distance from an           Units: km
```

```
      observational station at which the
      observation and first guess field are
      equally weighted)

      Relative weighting of the first
      guess field and observations in the
      layers ALOFT (R2)                     No default      ! R2 = 2. !
      (R2 is applied in the upper layers    Units: km
      in the same manner as R1 is used in
      the surface layer).

      Relative weighting parameter of the
      prognostic wind field data (RPROG)    No default      ! RPROG = 0. !
      (Used only if IPROG = 1)              Units: km
      ------------------------

      Maximum acceptable divergence in the
      divergence minimization procedure
      (DIVLIM)                              Default: 5.E-6  ! DIVLIM= 5.0E-06 !

      Maximum number of iterations in the
      divergence min. procedure (NITER)     Default: 50     ! NITER =  50  !

      Number of passes in the smoothing
      procedure (NSMTH(NZ))
      NOTE: NZ values must be entered
           Default: 2,(mxnz-1)*4 ! NSMTH =
2 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4 ,  4  !

      Maximum number of stations used in
      each layer for the interpolation of
      data to a grid point (NINTR2(NZ))
      NOTE: NZ values must be entered       Default: 99.    ! NINTR2 =
99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99 ,  99  !

      Critical Froude number (CRITFN)       Default: 1.0    ! CRITFN = 1. !

      Empirical factor controlling the
      influence of kinematic effects
      (ALPHA)                               Default: 0.1    ! ALPHA = 0.1 !

      Multiplicative scaling factor for
      extrapolation of surface observations
      to upper layers (FEXTR2(NZ))          Default: NZ*0.0
      ! FEXTR2 = 0., 0., 0., 0., 0., 0., 0., 0., 0. !
      (Used only if IEXTRP = 3 or -3)


   BARRIER INFORMATION

      Number of barriers to interpolation
      of the wind fields (NBAR)             Default: 0      ! NBAR =  0  !

      Level (1 to NZ) up to which barriers
      apply (KBAR)                          Default: NZ     ! KBAR =  9  !

      THE FOLLOWING 4 VARIABLES ARE INCLUDED
      ONLY IF NBAR > 0
      NOTE: NBAR values must be entered     No defaults
            for each variable               Units: km

         X coordinate of BEGINNING
         of each barrier (XBBAR(NBAR))      ! XBBAR = 0. !
         Y coordinate of BEGINNING
         of each barrier (YBBAR(NBAR))      ! YBBAR = 0. !

         X coordinate of ENDING
         of each barrier (XEBAR(NBAR))      ! XEBAR = 0. !
         Y coordinate of ENDING
         of each barrier (YEBAR(NBAR))      ! YEBAR = 0. !


   DIAGNOSTIC MODULE DATA INPUT OPTIONS

      Surface temperature (IDIOPT1)         Default: 0      ! IDIOPT1 =  0  !
         0 = Compute internally from
             hourly surface observations or prognostic fields
         1 = Read preprocessed values from
             a data file (DIAG.DAT)

         Surface met. station to use for
         the surface temperature (ISURFT)   Default: -1    ! ISURFT =  1  !
         (Must be a value from 1 to NSSTA,
          or -1 to use 2-D spatially varying
             surface temperatures,
          or -2 to use a domain-average prognostic
             surface temperatures (only with ITPROG=2))
         (Used only if IDIOPT1 = 0)
         --------------------------

      Temperature lapse rate used in the    Default: 0     ! IDIOPT2 =  0  !
         computation of terrain-induced
         circulations (IDIOPT2)
         0 = Compute internally from (at least) twice-daily
             upper air observations or prognostic fields
         1 = Read hourly preprocessed values
             from a data file (DIAG.DAT)

         Upper air station to use for
         the domain-scale lapse rate (IUPT) Default: -1    ! IUPT   =  1  !
         (Must be a value from 1 to NUSTA,
          or -1 to use 2-D spatially varying lapse rate,
```

```
            or -2 to use a domain-average prognostic
               lapse rate (only with ITPROG>0))
           (Used only if IDIOPT2 = 0)
           -------------------------

           Depth through which the domain-scale
           lapse rate is computed (ZUPT)      Default: 200.  ! ZUPT = 200. !
           (Used only if IDIOPT2 = 0)         Units: meters
           -------------------------

        Initial Guess Field Winds
        (IDIOPT3)                             Default: 0     ! IDIOPT3 =  0  !
           0 = Compute internally from
               observations or prognostic wind fields
           1 = Read hourly preprocessed domain-average wind values
               from a data file (DIAG.DAT)

           Upper air station to use for
           the initial guess winds (IUPWND)   Default: -1    ! IUPWND = -1  !
           (Must be a value from -1 to NUSTA, with
           -1 indicating 3-D initial guess fields,
           and IUPWND>1 domain-scaled (i.e. constant) IGF)
           (Used only if IDIOPT3 = 0 and noobs=0)
           -------------------------------------

           Bottom and top of layer through
           which the domain-scale winds
           are computed
           (ZUPWND(1), ZUPWND(2))        Defaults: 1., 1000. ! ZUPWND= 1., 1000. !
           (Used only if IDIOPT3 = 0, NOOBS>0 and IUPWND>0)    Units: meters
           -------------------------

        Observed surface wind components
        for wind field module (IDIOPT4)  Default: 0     ! IDIOPT4 =  0  !
           0 = Read WS, WD from a surface
               data file (SURF.DAT)
           1 = Read hourly preprocessed U, V from
               a data file (DIAG.DAT)

        Observed upper air wind components
        for wind field module (IDIOPT5)  Default: 0     ! IDIOPT5 =  0  !
           0 = Read WS, WD from an upper
               air data file (UP1.DAT, UP2.DAT, etc.)
           1 = Read hourly preprocessed U, V from
               a data file (DIAG.DAT)

        LAKE BREEZE INFORMATION

           Use Lake Breeze Module  (LLBREZE)
                                            Default: F      ! LLBREZE = F !

            Number of lake breeze regions (NBOX)            ! NBOX =  0  !

         X Grid line 1 defining the region of interest
                                                       ! XG1 = 0. !
         X Grid line 2 defining the region of interest
                                                       ! XG2 = 0. !
         Y Grid line 1 defining the region of interest
                                                       ! YG1 = 0. !
         Y Grid line 2 defining the region of interest
                                                       ! YG2 = 0. !

          X Point defining the coastline (Straight line)
                    (XBCST)  (KM)   Default: none    ! XBCST = 0. !

          Y Point defining the coastline (Straight line)
                    (YBCST)  (KM)   Default: none    ! YBCST = 0. !

          X Point defining the coastline (Straight line)
                    (XECST)  (KM)   Default: none    ! XECST = 0. !

          Y Point defining the coastline (Straight line)
                    (YECST)  (KM)   Default: none    ! YECST = 0. !


        Number of stations in the region     Default: none ! NLB =  0 !
        (Surface stations + upper air stations)

        Station ID's  in the region   (METBXID(NLB))
        (Surface stations first, then upper air stations)
          ! METBXID =  0 !

!END!


-------------------------------------------------------------------------------

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters
--------------

    EMPIRICAL MIXING HEIGHT CONSTANTS

        Neutral, mechanical equation
        (CONSTB)                              Default: 1.41   ! CONSTB = 1.41 !
        Convective mixing ht. equation
        (CONSTE)                              Default: 0.15   ! CONSTE = 0.15 !
        Stable mixing ht. equation
        (CONSTN)                              Default: 2400.  ! CONSTN = 2400.!
        Overwater mixing ht. equation
        (CONSTW)                              Default: 0.16   ! CONSTW = 0.16 !
        Absolute value of Coriolis
        parameter (FCORIOL)                   Default: 1.E-4  ! FCORIOL = 7.8E-05!
```

```
                                         Units: (1/s)

SPATIAL AVERAGING OF MIXING HEIGHTS

   Conduct spatial averaging
   (IAVEZI)  (0=no, 1=yes)               Default: 1      ! IAVEZI =  1  !

   Max. search radius in averaging
   process (MNMDAV)                      Default: 1      ! MNMDAV =  1  !
                                         Units: Grid
                                                cells
   Half-angle of upwind looking cone
   for averaging (HAFANG)                Default: 30.    ! HAFANG = 30. !
                                         Units: deg.
   Layer of winds used in upwind
   averaging (ILEVZI)                    Default: 1      ! ILEVZI =  1  !
   (must be between 1 and NZ)


CONVECTIVE MIXING HEIGHT OPTIONS:
   Method to compute the convective
   mixing height(IMIHXH)                 Default: 1      ! IMIXH =  1  !
       1: Maul-Carson for land and water cells
      -1: Maul-Carson for land cells only -
          OCD mixing height overwater
       2: Batchvarova and Gryning for land and water cells
      -2: Batchvarova and Gryning for land cells only
          OCD mixing height overwater

   Threshold buoyancy flux required to
   sustain convective mixing height growth
   overland (THRESHL)                    Default: 0.0    ! THRESHL = 0.05 !
   (expressed as a heat flux             units: W/m3
    per meter of boundary layer)


   Threshold buoyancy flux required to
   sustain convective mixing height growth
   overwater (THRESHW)                   Default: 0.05   ! THRESHW = 0.05 !
   (expressed as a heat flux             units: W/m3
    per meter of boundary layer)


   Option for overwater lapse rates used
   in convective mixing height growth
   (ITWPROG)                             Default: 0      ! ITWPROG =  0  !
   0 : use SEA.DAT lapse rates and deltaT (or assume neutral
       conditions if missing)
   1 : use prognostic lapse rates (only if IPROG>2)
       and SEA.DAT deltaT (or neutral if missing)
   2 : use prognostic lapse rates and prognostic delta T
       (only if iprog>12 and 3D.DAT version# 2.0 or higher)

   Land Use category ocean in 3D.DAT datasets
   (ILUOC3D)                             Default: 16     ! ILUOC3D =  16  !
   Note: if 3D.DAT from MM5 version 3.0, iluoc3d = 16
         if MM4.DAT,           typically iluoc3d = 7


OTHER MIXING HEIGHT VARIABLES

   Minimum potential temperature lapse
   rate in the stable layer above the
   current convective mixing ht.         Default: 0.001  ! DPTMIN = 0.001 !
   (DPTMIN)                              Units: deg. K/m
   Depth of layer above current conv.
   mixing height through which lapse     Default: 200.   ! DZZI = 200. !
   rate is computed (DZZI)               Units: meters

   Minimum overland mixing height        Default:  50.   ! ZIMIN = 50. !
   (ZIMIN)                               Units: meters
   Maximum overland mixing height        Default: 3000.  ! ZIMAX = 2500. !
   (ZIMAX)                               Units: meters
   Minimum overwater mixing height       Default:   50.  ! ZIMINW = 50. !
   (ZIMINW) -- (Not used if observed     Units: meters
   overwater mixing hts. are used)
   Maximum overwater mixing height       Default: 3000.  ! ZIMAXW = 2500. !
   (ZIMAXW) -- (Not used if observed     Units: meters
   overwater mixing hts. are used)


OVERWATER SURFACE FLUXES METHOD and PARAMETERS
      (ICOARE)                           Default: 10      ! ICOARE =  10   !
       0: original deltaT method (OCD)
      10: COARE with no wave parameterization (jwave=0, Charnock)
      11: COARE with wave option jwave=1 (Oost et al.)
          and default wave properties
     -11: COARE with wave option jwave=1 (Oost et al.)
          and observed wave properties (must be in SEA.DAT files)
      12: COARE with wave option 2 (Taylor and Yelland)
           and default wave properties
     -12: COARE with wave option 2 (Taylor and Yelland)
          and observed wave properties (must be in SEA.DAT files)

      Note:  When ICOARE=0, similarity wind profile stability PSI functions
             based on Van Ulden and Holtslag (1985) are substituted for
             later formulations used with the COARE module, and temperatures
             used for surface layer parameters are obtained from either the
             nearest surface station temperature or prognostic model 2D
             temperatures (if ITPROG=2).
```

```
         Coastal/Shallow water length scale (DSHELF)
         (for modified z0 in shallow water)
         ( COARE fluxes only)
                                Default : 0.        ! DSHELF = 0. !
                                units: km

          COARE warm layer computation (IWARM)         ! IWARM =  0   !
          1: on - 0: off (must be off if SST measured with
          IR radiometer)                Default: 0

          COARE cool skin layer computation (ICOOL)    ! ICOOL =  0   !
          1: on - 0: off (must be off if SST measured with
          IR radiometer)                Default: 0

   RELATIVE HUMIDITY PARAMETERS

      3D relative humidity from observations or
      from prognostic data? (IRHPROG)      Default:0        ! IRHPROG =  0   !

         0 = Use RH from SURF.DAT file
             (only if NOOBS = 0,1)
         1 = Use prognostic RH
             (only if NOOBS = 0,1,2)

   TEMPERATURE PARAMETERS

      3D temperature from observations or
      from prognostic data? (ITPROG)       Default:0        ! ITPROG =  0   !

         0 = Use Surface and upper air stations
             (only if NOOBS = 0)
         1 = Use Surface stations (no upper air observations)
             Use MM5/3D.DAT for upper air data
             (only if NOOBS = 0,1)
         2 = No surface or upper air observations
             Use MM5/3D.DAT for surface and upper air data
             (only if NOOBS = 0,1,2)

      Interpolation type
      (1 = 1/R ; 2 = 1/R**2)               Default:1         ! IRAD =  1  !

      Radius of influence for temperature
      interpolation (TRADKM)               Default: 500.     ! TRADKM = 10. !
                                           Units: km

      Maximum Number of stations to include
      in temperature interpolation (NUMTS) Default: 5        ! NUMTS = 4  !

      Conduct spatial averaging of temp-
      eratures (IAVET)  (0=no, 1=yes)      Default: 1        ! IAVET =  1  !
      (will use mixing ht MNMDAV,HAFANG
       so make sure they are correct)

      Default temperature gradient         Default: -.0098   ! TGDEFB = -0.0098 !
      below the mixing height over         Units: K/m
      water (TGDEFB)

      Default temperature gradient         Default: -.0045   ! TGDEFA = -0.0045 !
      above the mixing height over         Units: K/m
      water (TGDEFA)

      Beginning (JWAT1) and ending (JWAT2)
      land use categories for temperature                   ! JWAT1 =  999  !
      interpolation over water -- Make                      ! JWAT2 =  999  !
      bigger than largest land use to disable

  PRECIP INTERPOLATION PARAMETERS

      Method of interpolation (NFLAGP)     Default: 2       ! NFLAGP =  2  !
       (1=1/R,2=1/R**2,3=EXP/R**2)
      Radius of Influence  (SIGMAP)        Default: 100.0   ! SIGMAP = 100. !
       (0.0 => use half dist. btwn         Units: km
        nearest stns w & w/out
        precip when NFLAGP = 3)
      Minimum Precip. Rate Cutoff (CUTP)   Default: 0.01    ! CUTP = 0.01 !
       (values < CUTP = 0.0 mm/hr)         Units: mm/hr
!END!


-------------------------------------------------------------------------------

INPUT GROUP: 7 -- Surface meteorological station parameters
--------------

     SURFACE STATION VARIABLES
     (One record per station --  1  records in all)


             1     2
         Name   ID           X coord.   Y coord.   Time   Anem.
                              (km)       (km)      zone   Ht.(m)
      ----------------------------------------------------------
! SS1  ='MTP'        1       224.125     6305.825   -10    10  !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Six digit integer for station ID

!END!
```

```
-------------------------------------------------------------------------------

INPUT GROUP: 8 -- Upper air meteorological station parameters
--------------

     UPPER AIR STATION VARIABLES
     (One record per station --  1  records in all)

             1     2
         Name    ID      X coord.   Y coord.  Time zone
                           (km)       (km)
        -----------------------------------------------
! US1  ='TAPM'   54321    224.125   6305.825   -10  !
-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Five digit integer for station ID

!END!

-------------------------------------------------------------------------------

INPUT GROUP: 9 -- Precipitation station parameters
--------------

     PRECIPITATION STATION VARIABLES
     (One record per station --  0  records in all)
     (NOT INCLUDED IF NPSTA = 0)

            1          2
         Name   Station    X coord.  Y coord.
                  Code       (km)      (km)
         ------------------------------------


-------------------
      1
        Four character string for station name
        (MUST START IN COLUMN 9)

      2
        Six digit station code composed of state
        code (first 2 digits) and station ID (last
        4 digits)

!END!
```