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AGL Leafs Gully Power Project Environmental Assessment

MP 08_0077

Appendix F

Regional Air Quality Assessment (300 MW)

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PRELIMINARY ASSESSMENT OF THE IMPACT OF NO_x EMISSIONS FROM A PROPOSED APPIN GAS FIRED POWER STATION ON PHOTOCHEMICAL SMOG IN THE SYDNEY REGION

By

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Chief of Division	1
Client	2
Project Manager	1
Other CSIRO Staff	4
This is copy number	of 8

TABLE OF CONTENTS

1. INTRODUCTION

In June 2004, The Australian Gas Company, AGL requested CSIRO to undertake a preliminary study to assess the potential impact on photochemical smog formation of emissions from a proposed gas fired power station to be sited at Appin in the south west of Sydney basin (Figure 1).

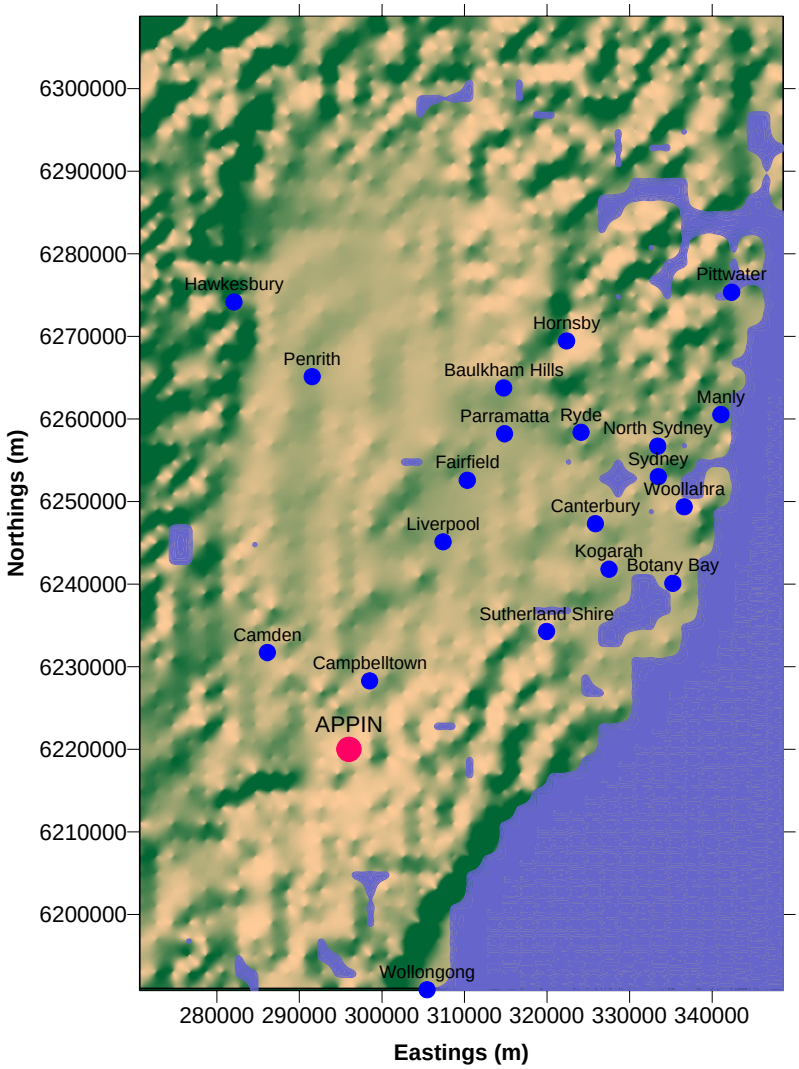


Figure 1: Location of the proposed 300 MW Appin gas fired power station

Any additional oxides of nitrogen (NO_x) emissions within the Sydney airshed must satisfy an air quality analysis to demonstrate that their addition does not deteriorate the existing air quality and does not significantly contribute to an exceedance of the National Environment Protection Measures (NEPM) guidelines applicable in NSW.

This report only documents the outcomes of a screening study which considers potential changes to photochemical smog production within the Sydney airshed as a result of the proposed Appin gas fired power station NO_x emissions.

The impact assessment has been undertaken using a three dimensional modelling system and the selected emission scenario representative of potential operating condition for the proposed power station as supplied by AGL.

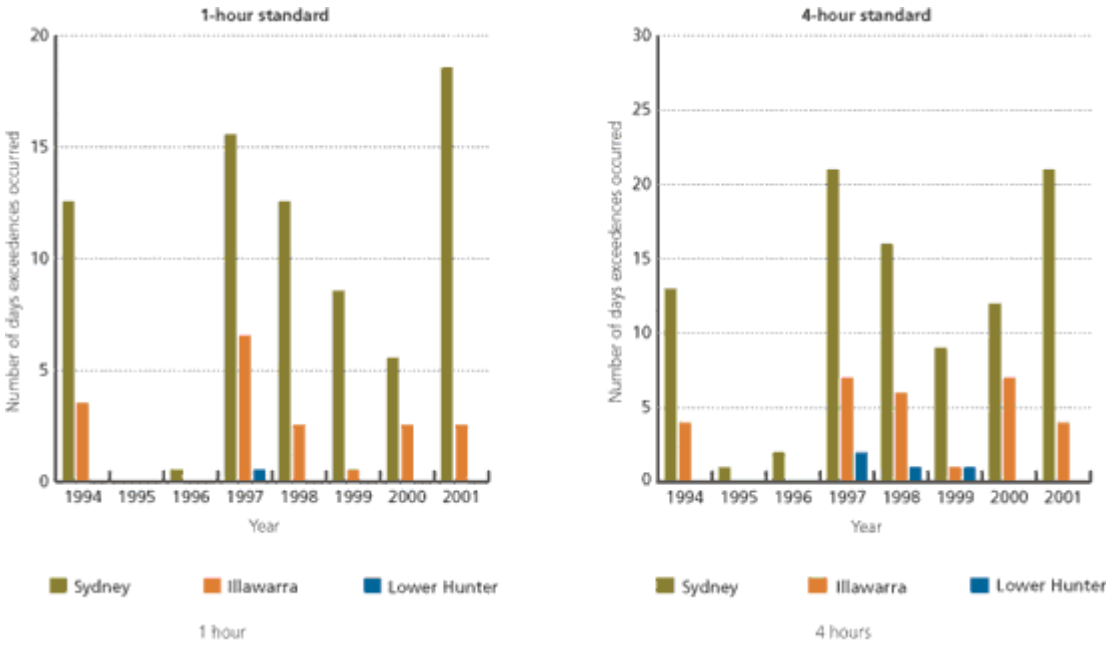
2. BRIEF DESCRIPTION OF PHOTOCHEMICAL SMOG FORMATION

Emissions of NO_x have been associated with photochemical smog formation in the lower troposphere. The term photochemical smog refers to a family of secondary gaseous and aerosol species which are generated by complex chemical reactions of NO_x, and volatile organic compounds (VOCs) in the presence of heat and sunlight. In NSW the principle component of photochemical smog is ozone (O_3). Other components of interest include nitrogen dioxide (NO_2), hydrogen peroxide (H_2O_2), peroxyacetylnitrate (PAN), formaldehyde and aerosol nitrates.

Ozone is of particular concern in NSW because the NSW Environment Protection Authority (NSW–EPA) has observed breaches of the 1–hour and 4–hour National Environment Protection Measures (NEPM) of 100 ppb and 80 ppb respectively for many years (Figure 2). Breaches of the 4–hour NEPM (80 ppb) in particular show little downward trend over recent years (NSW–EPA, 2002).

NO_x and VOCs are the principal precursors to ozone formation. The highest ozone concentrations are produced when both VOCs and NO_x emissions are present in significant quantities on clear summer days. The role of VOCs in photochemical smog production is to generate radical species which in turn can oxidise nitric oxide (NO) to nitrogen dioxide (NO_2). It should be noted that NO comprises the major proportion (> 90 % on a molar basis) of the NO_x emitted from high temperature combustion processes. Subsequently, the photolysis of NO_2 by sunlight and reaction with molecular oxygen is the only significant ozone production pathway under tropospheric conditions. In turn NO_x

is steadily consumed by the photochemical production process while, to some degree, radicals generated from primary and secondary VOCs are recycled.



Source EPA data, as at 2002

Figure 2: Exceedences of the 1-hour and 4-hour standards for ozone, GMR (Source NSW SOE 2003)

NO_x also plays an additional role in photochemical smog chemistry. The nitric oxide component which generally dominates in fresh NO_x emissions rapidly reacts with ozone to form nitrogen dioxide (the time scale is a few minutes). Thus ozone concentrations immediately downwind of a NO_x source such as a power station will be suppressed relative to concentrations in adjacent areas.

Under low NO_x conditions (VOC-rich i.e. the VOC:NO_x ratio exceeds 10, see Figure 3) ozone production will occur rapidly depending on the reactivity of VOCs and peak ozone concentrations will be controlled by the availability of NO_x. For these conditions, the addition of NO_x into the system (i.e. from a new power station) may cause peak ozone concentrations to increase.

Under conditions of high NO_x (NO_x-rich i.e. the VOC:NO_x ratio is less than 5) and relatively low VOC levels, NO_x forms inorganic nitrates but relatively little ozone.

Under these conditions, VOC reductions are effective in reducing ozone, but NO_x reductions can actually increase local ozone under certain circumstances. The addition of NO_x will delay photochemical production and peak ozone concentrations may be reduced.

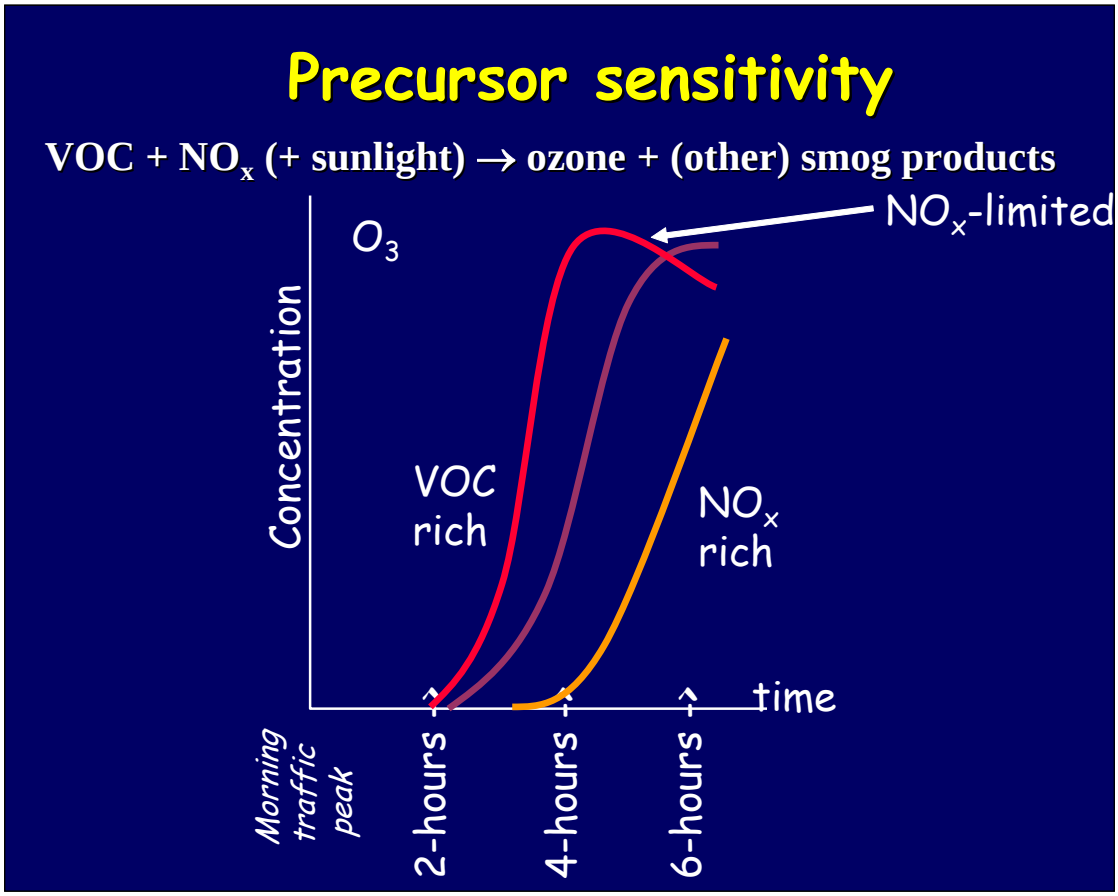


Figure 3: Schematic diagram illustrating how ozone production will vary with the proportions of VOC and NO_x

3. METHODOLOGY

The highly sensitive non-linear nature of photochemical smog formation makes it necessary to assess the air quality impacts of the entire Sydney airshed when considering the impacts from additional sources such as the proposed Appin gas fired power station. Hence, the CSIRO's three dimensional air pollution modelling system TAPM v2.5 (Hurley 1998), was used to assess the impact of NO_x emissions from the proposed 300 MW Appin gas fired power station on photochemical smog production in the Sydney airshed. It should be noted that the assessment is not intended to investigate the nature of ozone events that may occur due to the additional NO_x within the Sydney airshed.

The model couples prognostic meteorological and air pollution concentration components. The model consists of the following:

- Meteorological module. The model relies on large-scale synoptic meteorology to provide the baseline climatology for predictions of local scale flows important to air pollution formation such as sea breezes and terrain induced flows.

- Chemistry module. The simplified Generic Reaction Set (GRS) (Azzi, M. et al., 1992) photochemistry is embedded into TAPM for modelling photochemical transformation.

- Emission inventory module. The current application utilises the MAQS emissions inventory (Carnovale et al., 1996) for industrial, commercial and residential emissions with 2002 updates for the motor vehicle component (Charles Xu; NSW–EPA). Biogenic emissions are provided by the latest emission methodology developed by CSIRO, 2002.

Meteorology was solved on a series of nested grids with spacing 18km, 6 km and 2 km. All domains were solved with 40 nodes in the easterly direction, 60 nodes in the northerly direction and 25 nodes in the vertical direction. Vertical layers were concentrated within

the boundary layer to better capture local meteorological events. Each domain was centered at the AMG coordinate of 309623 east, 6249784 north.

The air emissions from the proposed gas fired power station primarily consist of common contaminants such NO_x, carbon monoxide (CO) and carbon dioxide (CO_2). There are practically no emissions of sulphur dioxide (SO_2) and VOC's.

Table 1 summarises the estimated emission rates of these contaminants at the maximum sustained generation rate as supplied by the proponent. Also shown in Table 1 are emission totals for major anthropogenic source groups in MAQSR. Motor vehicles and industrial sources are the major contributors to NO_x emissions while motor vehicle and commercial and domestic sources are the major sources of VOC.

Table 1: Daily emission rates (NO_x, SO_2, CO and VOC) and stack characteristics for the proposed 300 MW gas-fired Appin power station. Also shown for comparison are emission rates from other anthropogenic sources in the MAQS study region. H_S release height; D_s stack diameter; V_s plume exit velocity; T_s plume temperature.

	Daily emissions					Stack characteristics			
	NO_x (tonne)	**SO_2 (tonne)**	**CO (tonne)**	**VOC (tonne)**		**H_s (m)**	**D_s (m)**	**V_s (m s^{-1})**	**T_s (°C)**
Scenario 1	3.35	0	3.98	0		35	6	40	532
MAQS									
Motor vehicles	208.5		1056.5	154.9					
Commercial and domestic	18.20		37.2	166.5					
Industrial	371.3		837.4	78.2					

The impact assessment has been undertaken by modelling the change in NO_x, NO_2 and ozone concentrations resulting from the specified gas fired Appin power station emission scenario shown in Table 1. The study has been undertaken for the year 2002 assuming that the plant will be operating at full capacity continuously for the 12 month period. The facility would not normally run continuously at maximum sustained generation rate for a

one year period. Thus, the emissions listed in Table 1 represent a conservative estimate of emission rates.

4. PREDICTED IMPACTS

The potential impact of emissions from the proposed gas fired Appin power station have been assessed by comparing modelled NO_x, NO_2 and ozone concentrations for test-case scenario with the concentrations predicted for the base-case emissions scenario in which the power station emissions have been omitted.

The difference between the test-case scenario and base-case scenario was calculated for the hourly maximum and annual averages of NO_x, NO_2 and ozone concentrations at each grid cell of the modelling domain during 2002.

4.1 Nitrogen Oxides

The maximum difference of the predicted maximum hourly concentration of NO_x illustrated in Figure 4 is 0.4 ppb occurring to the west of the proposed plant near Camden. Differences in the maximum hourly concentration are also observed in the central western and southern regions with predicted differences of around 0.3 ppb. These results exhibit the importance of the temporal and seasonal effects on the plume dispersion where the type of meteorological conditions prevailing over the Sydney basin dictate the plume trajectory and the location and the magnitude of the impact.

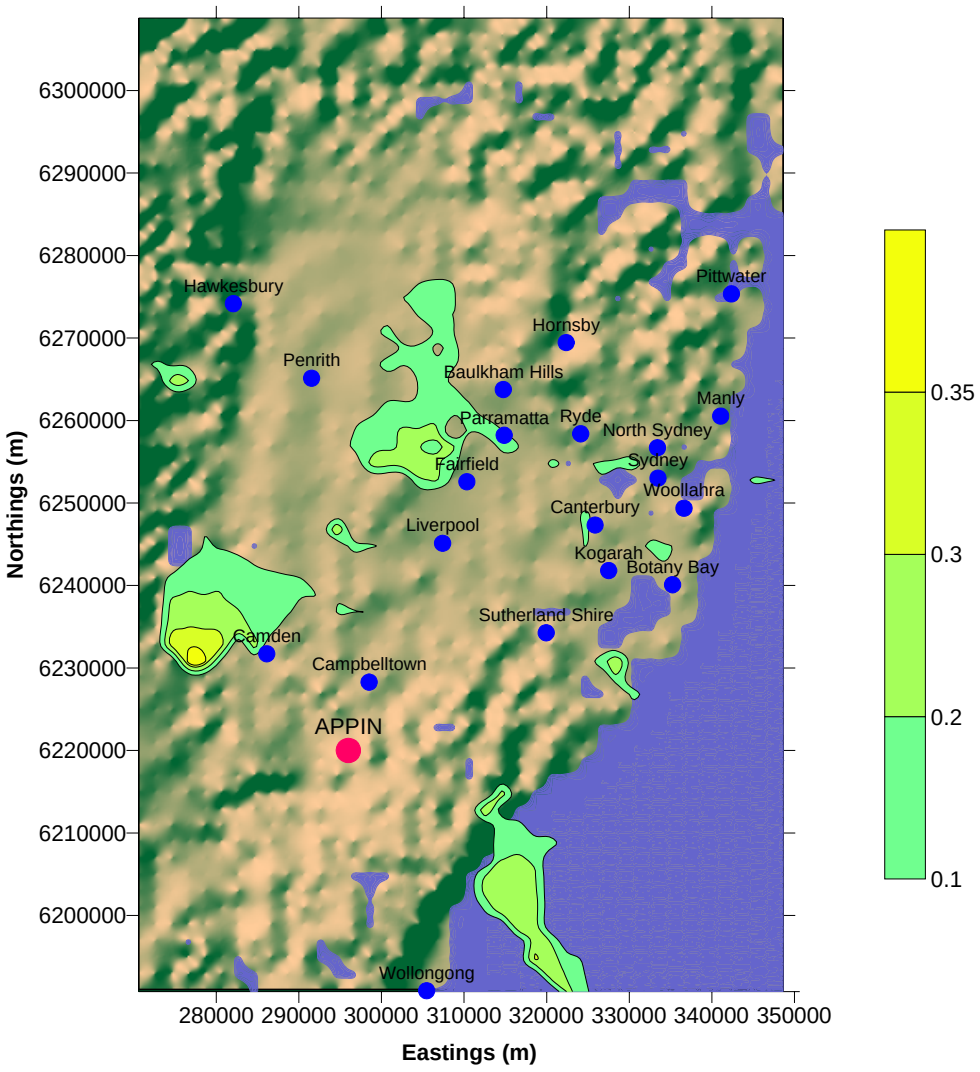


Figure 4: Predicted differences (scenario – basecase) of maximum hourly NO_x concentrations due to the proposed Appin gas-fired power plant.

It can be concluded from the magnitude of the predicted NOx concentration differences, that the additional NO_x emissions from the 300 MW proposed gas fired power station do not significantly add to existing levels (less than 0.05%).

4.2 Nitrogen Dioxide

The results of the modelling indicate a maximum difference in the maximum hourly NO_2 concentration of 3.7 ppb near Penrith as illustrated in Figure 5. This concentration change represents an addition of 3% of the 1-hour average NEPM guideline (120 ppb). Maximum differences in the predicted annual average were less significant, accounting for 0.2% of 30 ppb NEPM Guideline. The large variation in the ratio of the differences between NO_x

and NO_2 clearly indicates a complex meteorology and chemical interaction between the Appin plume and the lower level emissions for the event corresponding to this change in maximum hourly concentration. Such an event merits further investigation but is outside the scope of this preliminary screening analysis.

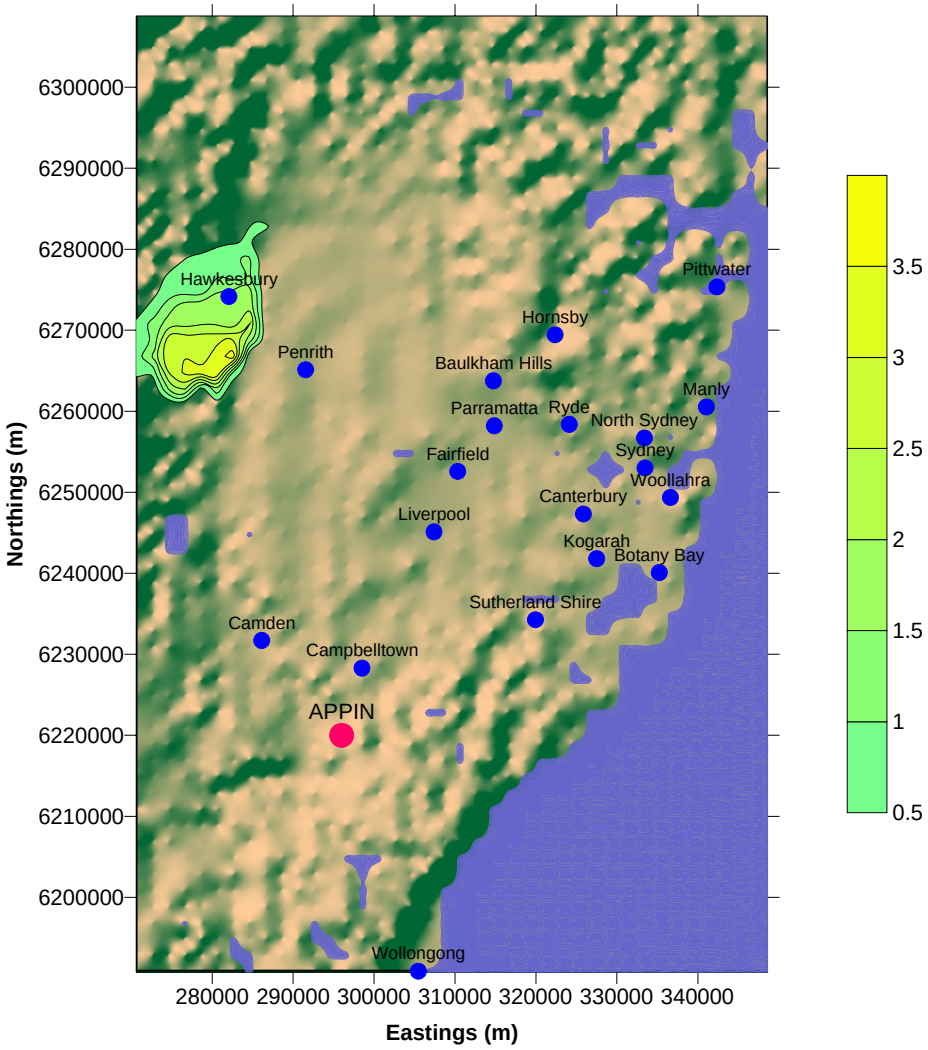


Figure 5: Predicted differences (scenario – basecase) of maximum hourly NO_2 concentrations due to the proposed Appin gas fired power plant.

4.3 Ozone

The maximum predicted difference of the maximum hourly concentration of ozone illustrated in Figure 6 shows that the additional NOx has both positive and negative impacts on ozone formation within the modelled domain. The maximum difference of 1.9 ppb occurs in a narrow region to the west of the source and equates to the addition of

1.9% of the NEPM air quality guidelines for ozone of 100ppb. In conjunction the minimum difference associated with ozone suppression of 4ppb is observed in a region over the coast, east of the proposed plant.

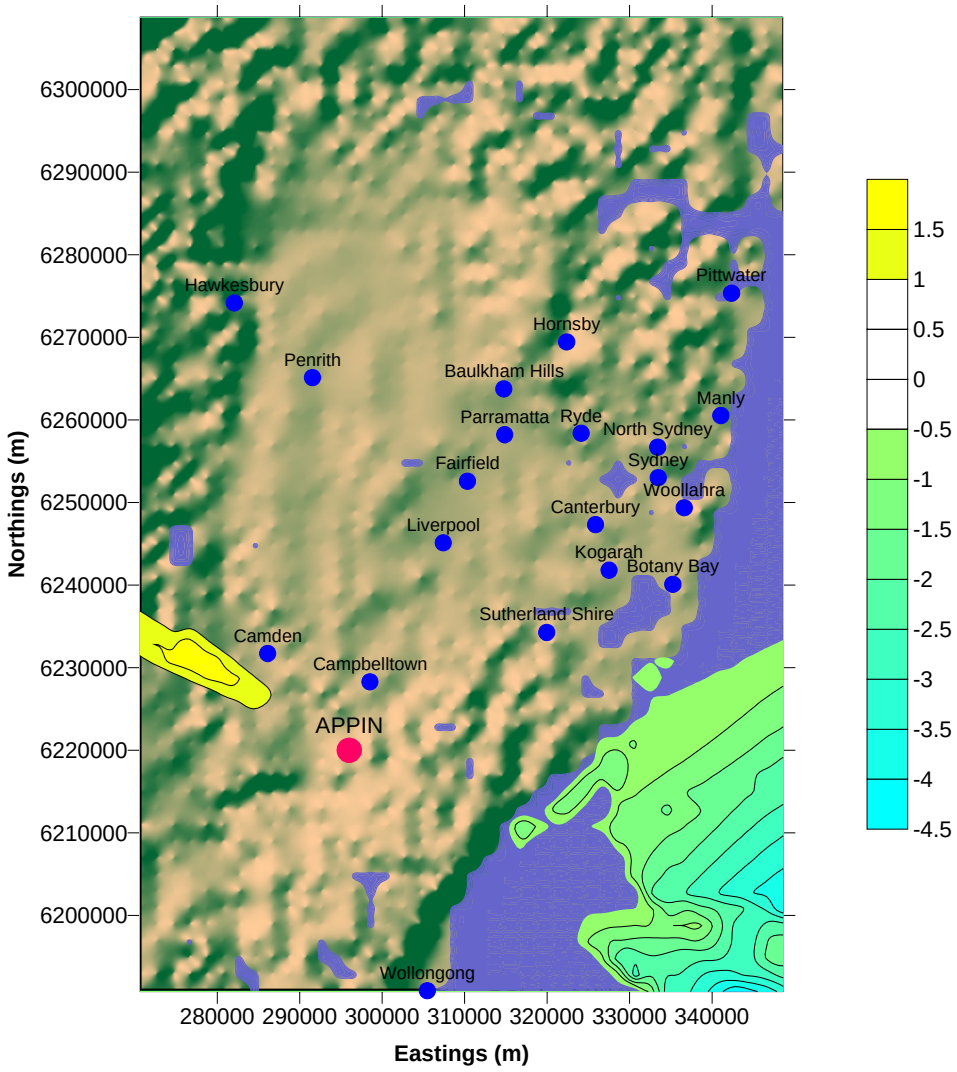


Figure 6: Predicted differences (scenario – basecase) of maximum hourly O_3 concentrations due to the proposed Appin gas fired power plant.

The calculated difference for the maximum 4-hour average ozone concentration presented in Figure 7 shows the existence of a narrow zone with a maximum value of 1.8 ppb located to the north west of the proposed Appin plant near Camden. The NEPM guideline for 4-hour average for ozone is 80 ppb. A zone of net decrease up to 3ppb is observed east of the proposed plant over the sea.

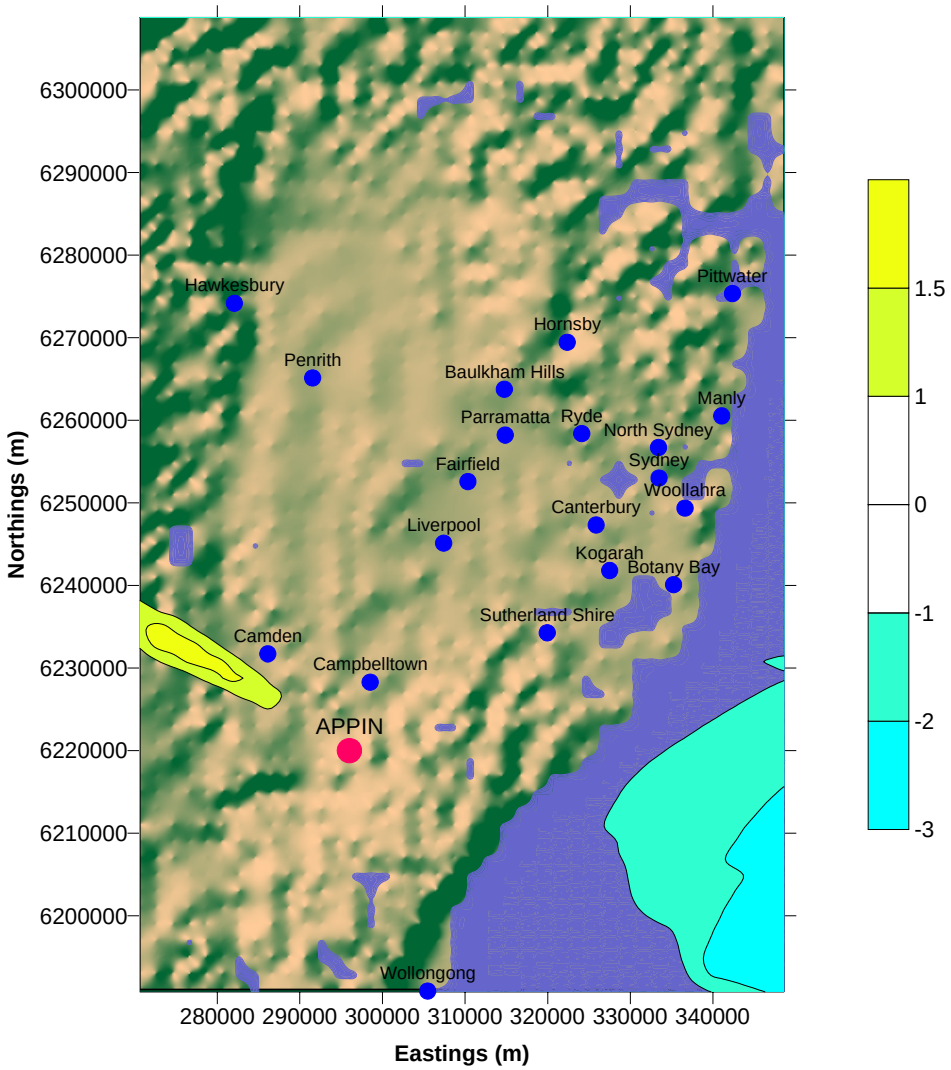


Figure 7: Predicted differences (scenario – basecase) of maximum 4hr average O_3 concentrations due to the proposed Appin gas fired power plant.

5. CONCLUSIONS

The current assessment is a screening analysis used to assess the potential impact of emissions from the Appin gas fired power station on photochemical smog formation in the region. The modelling addresses emissions from proposed routine plant operations.

The modelling results of the proposed 300 MW gas fired power station showed the following:

- The additional NO_x is predicted to increase on average the maximum 1-hour NO_x concentration by up to 0.4 ppb. The extent of this increase is limited and equates to less than 0.05% of the maximum hourly NO_x within the domain
- An increase of the 1-hour NO_2 concentration by a maximum of 3.7 ppb over a small area near Penrith.
- An increase of the maximum 1-hour O_3 concentration by up to 1.9 ppb and a potential for decrease from titration of ozone with the power station nitric oxide of up to 4 ppb.
- A similar pattern for the maximum 4hr average O3 with an increase up to 1.8 ppb in the west and suppression of up to 3ppb in the east over the sea .

In general, predicted values of NO_x, NO_2 and O_3 ground level concentrations due to the additional NOx emissions from the proposed 300 MW Appin gas fired plant are not significantly increased from the existing concentration levels.

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