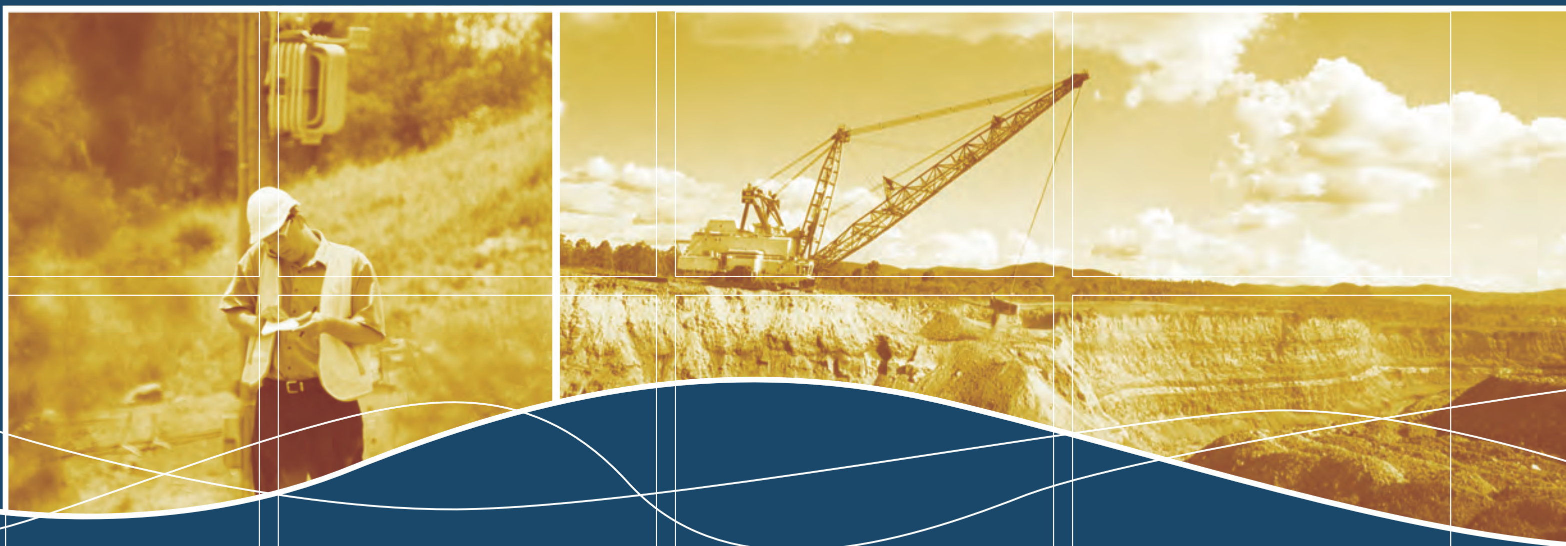
HUNTER VALLEY OPERATIONS

West Pit Extension and Minor Modifications



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Hunter Valley Operations
West Pit Extension and Minor Modifications

Technical Reports

for

Coal & Allied Operations

October 2003

COAL & ALLIED

A Rio Tinto Group Company

CONTENTS

PART I

air quality study

AIR QUALITY ASSESSMENT:
WEST PIT EXTENSION AND MINOR MODIFICATIONS

FINAL 1 October 2003

Prepared for
ERM (Australia) Pty Limited

by

Holmes Air Sciences
Suite 2B, 14 Glen Street
Eastwood NSW
ACN 003 741 035
ABN 79 003 741 035

Phone (02) 9874 8644
Fax (02) 9874 8904
Email Nigel.Holmes@holmair.com.au

GLOSSARY

CAN	Coal & Allied
HVO	Hunter Valley Operations
HVCPP	Hunter Valley Coal Preparation Plant
HVLP	Hunter Valley Loading Point
NLP	Newdell Loading Point
RCT	Ravensworth Coal Terminal
WPCPP	West Pit Coal Preparation Plant

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EXECUTIVE SUMMARY

Introduction

Coal & Allied (CNA) own and operate Hunter Valley Operations (HVO), an open cut coal mine in the Upper Hunter Valley. HVO consists of a number of open cut pits and is dissected by the Hunter River. HVO's activities north of the Hunter River include West Pit, Carrington, the Alluvial Lands and North Pit and the associated coal preparation plants (CPPs) at Hunter Valley (HVCPP) and West Pit (WPCPP) and rail loading facilities at the Hunter Valley Loading Point (HVLP), Newdell Loading Point (NLP) and the Ravensworth Coal Terminal (RCT). This report examines air quality effects due to defined HVO operations north of the Hunter River. At present, these mines operate under separate consents. The assessment considers an integrated operation with a view to developing a single consent that applies to all operations at HVO north of the Hunter River.

Local Setting, Description of The Operation And Identification of Issues

Terrain in the area is gently undulating and for the most part cleared. Open cut coal mining is currently the predominant land use having progressively replaced grazing and dairy farming over the past forty years or so. Agriculture grazing and dairy farming are important land uses on and beyond the boundaries of the mining area. Isolated rural residences associated with these agricultural enterprises are the most important land uses as far as air quality assessment is concerned. The town of Jerrys Plains is the largest population centre in the area.

Figure 1 shows the location and extent of HVO north of the Hunter River and identifies key infrastructure components.

To ensure that this infrastructure is used as efficiently as possible it is desirable to incorporate flexibility in the way in which the infrastructure will be used. In particular, it is desirable for the Proposal to be able to process coal in either of the two coal preparation plants and to haul coal from any pit to any plant and from any plant to any of the loading facilities.

The air quality assessment has been undertaken for five operating periods in the 21-year life of the proposal and considers operating modes that give a conservative assessment of the impacts. To ensure that the assessment covers all contingencies that are required for flexible operations the assessment is necessarily based on some conservative assumptions. The basic assumptions are listed below.

- Production at Carrington is increased from 6 to 10 Mtpa.
- Haulage of ROM coal from mines south of the River to HVCPP is increased from 8 to 16 Mtpa.
- The capacity of the HVCPP is increased from 13 to 20 Mtpa.
- Coal from West Pit can be sent from WPCPP to the Bayswater Power Station by conveyor with the balance being sent from the WPCPP to HVLP and NLP along Pikes Gully Road, or West Pit can send the balance to HVCPP by truck. The beneficiated coal will then be transferred to HVLP by conveyor or intermittent haulage. The most conservative assumption in terms of dust emissions is to assume that the coal is processed by HVCPP.
- Coal is also able to be transferred between the HVLP, NLP and RCT.

It can be seen that these assumptions would lead to the conclusion that HVCPP is to handle 26 Mtpa of ROM coal. In practice, HVCPP will not handle more than 20 Mtpa. The additional 6 Mtpa is to ensure that the assessment covers all contingencies for the haulage of ROM coal.

In addition the Proposal will give rise to emissions of greenhouse gases such as methane from the exposed coal and emissions of carbon dioxide from fuel used by earth moving equipment, blasting and indirectly from electricity usage. An assessment of greenhouse gas emissions is also provided in this report.

In summary the issues dealt with in the assessment are:

1. The impacts likely to arise from emissions of particulate matter (PM) from HVO north of the Hunter River;
2. The impacts likely to arise from emissions of PM from the Proposal including open cut mines at nearby mining operations including Wambo, Ravensworth-Narama and HVO south of the Hunter River, and;
3. Greenhouse emissions from the Proposal.

Air Quality Assessment Methods and Criteria
The air quality assessment has been carried out following the NSW EPA's guidelines for the assessment of air quality using dispersion modelling. This involves the following:

- Reviewing ambient air quality monitoring data to establish existing air quality
- Identifying ambient air quality criteria for assessing impacts
- Developing representative meteorological data files for use in the modelling
- Analysing the Proposal to develop estimates of dust emissions for five representative periods in the life of the development taking account of the flexibility required by CNA for operational reasons
- Using an approved dispersion model, with local meteorological data and estimated emissions, predict the concentration and deposition levels of dust due to emissions from the:

(i) Proposal, and

(ii) the Proposal plus all other sources in the area expected to be affected by the emissions from the Proposal

- Assessing the predicted concentration and deposition levels by comparing them with the assessment criteria.

Existing Air Quality
Data from monitoring programs operated by CNA provide measurements of 24-hour average concentrations of TSP and PM_{10} on a six-day cycle and monthly averages of dust fallout levels. Deposition data are available from a network of gauges (see **Figure 2**) and concentration data are available from the following sites:

- Cornfield TSP from 4 April 1998 to 26 December 2001
- Cheshunt TSP from 4 April 1998 to 25 June 2003
- Wandewoi TSP from 2 January 2002 to 25 June 2003

- Warkworth PM_{10} and TSP from 8 January 2003 to 25 June 2003

These data are reviewed in **Section 4**.

When interpreting the data it should be noted that they include the effects of existing mining operations. The data cannot be used directly to determine the background levels that should be added to predicted concentrations of TSP and PM_{10} that arise from the Proposal. This is because the Proposal includes activities that are already occurring and thus adding predicted Proposal concentrations to monitored levels would double count the effects of existing emissions.

The annual average concentrations at the Cornfield and Wandewoi monitoring sites have been below the 90 $\mu g/m^3$ annual criterion. Annual average concentrations of TSP at the Cheshunt monitor have exceeded the EPA criterion of 90 $\mu g/m^3$ on four out of the past six years and air quality at this site is clearly affected by emissions from the Cheshunt open cut, which is only a few hundred metres to the east. The data are not representative of the wider area where most non-mine residences are located.

The first few months of these measurements were collected at the end of one of the most severe droughts in NSW over the past 100 years and were affected by smoke from bushfires associated with the dry period. The data suggest that the annual average PM_{10} criterion of 30 $\mu g/m^3$ will be exceeded at Warkworth Village. The most recent data show extremely high TSP and PM_{10} concentrations (see 8 April and 8 May 2003). On 8 April, winds were generally from the northwest with speeds mostly in the range 0 to 6 m/s. On 8 May, the wind direction was similar and wind speeds were lower in the range 0 to 4 m/s. The other monitoring site did not record extreme concentrations. This suggests that the source of PM was local and located to the northwest of the monitor.

Many of the dust deposition gauges are located within the mining lease close to areas where active mining is taking place. The data from these gauges can be used to show the rate at which dust deposition levels decrease with distance from actively mined areas.

Monitoring data from gauges D5, D9, D112 and D102 to D104 provide data that is representative of conditions near residential areas.

Inspection of the data indicates that rural residential areas that are not already substantially affected by mining operations could accommodate an increment of annual dust deposition of 2 g/m^2/month without causing the EPA's 4 g/m^2/month criterion to be exceeded.

It should be noted that these data include the effect of existing mining operations and are unlikely to experience a significant change as a result of the continuation of mining.

Climate And Meteorology

Meteorological data are available from a number of different sites including a meteorological station operated by CNA near the HVCPP. A total of 8,736 hours of data were available for 2002. This corresponds to 99.7% of the data potentially available in a year. As discussed below, the distribution of winds for this year of data was consistent with long-term patterns observed in the central parts of the Hunter Valley. The data were therefore considered to be representative of dispersion conditions at the site and in the area covered by the modelling.

Climatic data have been taken from records collected since 1884 by the Bureau of Meteorology at Jerrys Plains.

Estimated Emissions Of Particulate Matter
Estimates of dust emissions from Carrington have been taken from the Carrington EIS (Year 5). The estimates have been increased by the factor 10/6 to account for the fact that Carrington may produce up to 10 Mtpa ROM coal compared with the 6 Mtpa assumed in the EIS. Carrington emissions have been included in the model runs for Years 1 and 3, but operation will have concluded by Year 8 and so emissions are not included in Year 8 or later years. However, an alternative for Year 8 has also been analysed with Carrington mine still operating.

The mining plans for Years 1, 3, 8, 8 (alternative), 14 and 20 have been analysed and detailed emissions inventories have been prepared for each of these years. The inventories include both estimated emissions from all HVO operations north of the river and emissions from other nearby mines, namely Wambo, Ravensworth-Narama, Riverview and Cheshunt.

Appendix C provides details as to how dust emissions from each dust producing activity have been calculated including the effect of dust controls and the assumptions that have been made in estimating these emissions. **Table 12** summarises the estimated TSP emission rates.

Other mines and other sources, in addition to those identified above, will of course contribute to $PM_{2.5}$, PM_{10}, TSP concentrations and to dust deposition. In the past the annual average quantum of particulate matter contributed by these more distant sources has been set at 5 $\mu g/m^3$ for PM_{10}, 10 $\mu g/m^3$ for TSP and 0.5 g/m^2/month for deposited dust.

Assessment Methodology
The assessment methodology follows the EPA guidelines. The report however provides a more comprehensive discussion of relevant issues that arise when the EPA methodology is applied to this type of assessment.

Assessment Of Impacts – Particulate Matter
The report provides isopleth diagrams showing the following for each of the five operational periods assessed.

1. The predicted maximum 24-hour average PM_{10} concentration for the Proposal alone;
2. The predicted maximum 24-hour average PM_{10} concentration for the Proposal with other sources of PM;
3. The predicted annual average PM_{10} concentration for the Proposal;
4. The predicted annual average PM_{10} concentration for the Proposal with other sources of PM;
5. The predicted annual average TSP concentration for the Proposal;
6. The predicted annual average TSP concentration for the Proposal with other sources of PM;
7. The predicted annual average dust deposition for the Proposal, and;
8. The predicted annual average dust deposition for the Proposal with other sources of PM.

Similar predictions for 24-hour and annual average $PM_{2.5}$ concentrations for the Proposal by itself and the Proposal considered with the effects of other mines are provided in **Appendix A**.

The air quality criteria used for deciding which properties are likely to experience air quality impacts above those specified in the EPA's modelling guidelines as interpreted by recent conditions of consent for mines in the Hunter Valley are:

- 50 µg/m³ for 24-hour PM_{10} for the Proposal considered alone;
- 150 µg/m³ for 24-hour PM_{10} for the Proposal considered with the contributions of other sources;
- 30 µg/m³ for annual average PM_{10} due to the Proposal and other sources;
- 90 µg/m³ for annual TSP concentrations due to the Proposal and other sources;
- 2 g/m²/month for annual average deposition (insoluble solids) due to the Proposal considered alone; and
- 4 g/m²/month for annual predicted cumulative deposition (insoluble solids) due to the Proposal and other sources.

Following practice established in recent conditions of consent, with the exception of the 2 g/m²/month goal and the 24-hour PM_{10}, the standards/goals are interpreted to be cumulative standards/goals.

The 24-hour PM_{10} criterion of 50 µg/m³ is interpreted as being applicable to the Proposal when considered in isolation and the US EPA 24-hour PM_{10} standard of 150 µg/m³ has been taken to be the cumulative criterion.

Rather than provide a detailed discussion of each isopleth figure, the results have been summarised in tabular form for each year showing the residences located in the area and highlighting those that are predicted to experience particulate matter deposition or concentration levels above the EPA's assessment criteria. Four residences are predicted to experience concentrations or deposition levels above the EPA assessment criteria. All of the residences are either owned by mining companies, are within an existing zone of affectation, or are subject to agreements between mining companies and the owners.

Greenhouse Gases

The report provides estimates of greenhouse gas emissions from the Proposal.

Ecologically Sustainable Development (ESD)

The consequences of the Proposal for ESD principles are discussed and it is concluded that although mining has important implications for ESD principles, in the context of the narrow topic of air quality, ESD principles would be complied with.

Conclusions

This report has developed emissions inventories for integrated operations of HVO mining north of the Hunter River for five representative operational periods in the next 21 Years. These have been used with local meteorological data and the US EPA's ISCST3 model to predict the maximum 24-hour PM_{10}, annual average PM_{10}, annual average TSP and annual average dust deposition (insoluble solids) over an area extending approximately 14 km (east-west) and 21 km (north-south). The modelling has been undertaken to show both the effects of HVO mining north of the Hunter River and the effects of these operations taking into account the effects of emissions from neighbouring mines and other sources of dust.

It is concluded that four residences will be impacted by dust levels exceeding the EPA assessment criteria. These residences are already within an existing zone of affectation or have private agreements in place either with CNA or with other mining companies.

1 INTRODUCTION

Coal & Allied (CNA) own and operate Hunter Valley Operations (HVO), an open cut coal mine in the Upper Hunter Valley. HVO consists of a number of open cut pits and is dissected by the Hunter River. This report examines air quality effects due to defined HVO operations north of the Hunter River. At present, these pits operate under separate consents. The assessment considers an integrated operation with a view to developing a single consent that applies to all operations at HVO north of the Hunter River.

2 LOCAL SETTING, DESCRIPTION OF THE OPERATION AND IDENTIFICATION OF ISSUES

Terrain in the area is gently undulating and for the most part cleared. Open cut coal mining is currently the predominant land use having progressively replaced grazing and dairy farming over the past forty years or so. Agriculture grazing and dairy farming are important land uses on and beyond the boundaries of the mining area. Isolated rural residences associated with these agricultural enterprises are the most important land uses as far as air quality assessment is concerned. The town of Jerrys Plains is the largest population centre in the area.

Figure 1 shows the location and extent of HVO north of the Hunter River and identifies key infrastructure components. Apart from the open cut pits labelled West Pit, Carrington, Alluvial Lands and North Pit with their associated haul roads these include:

- West Pit Coal Preparation Plant (WPCPP);
- Hunter Valley Coal Preparation Plant (HVCPP);
- Newdell stockpiles and rail loading point (NLP);
- Hunter Valley stockpiles and loading point (HVLP)
- Ravensworth Coal Terminal (RCT);
- Conveyor from HVCPP to HVLP;
- Conveyor to Bayswater Power Station from WPCPP;
- Pikes Gully Road coal transport route, and;
- Belt Line Road intermittently used as haul road from HVCPP to HVLP.

To ensure that all the infrastructure is used as efficiently as possible to meet market requirements and other unpredictable circumstances, it is desirable to incorporate flexibility in the way in which the infrastructure will be used. In particular, it is desirable for the Proposal to be able to process coal in either of the two coal preparation plants and to haul coal from any pit to any plant and from any plant to any of the loading facilities. The Proposal will require some flexibility in the consent conditions to achieve this. The air quality assessment has been undertaken for six operational periods in the 21-year life of the mine and considers operating modes that give a conservative assessment of the impacts. In practice, as will be shown later, those activities that are required to provide the Proposal with flexibility, namely the haulage of coal over different routes, are not critical to the air quality impacts and will not significantly affect the development of conditions of consent for the .

To ensure that the assessment covers all contingencies that are required for flexible operations the assessment is necessarily based on some conservative assumptions. The basic assumptions are listed below.

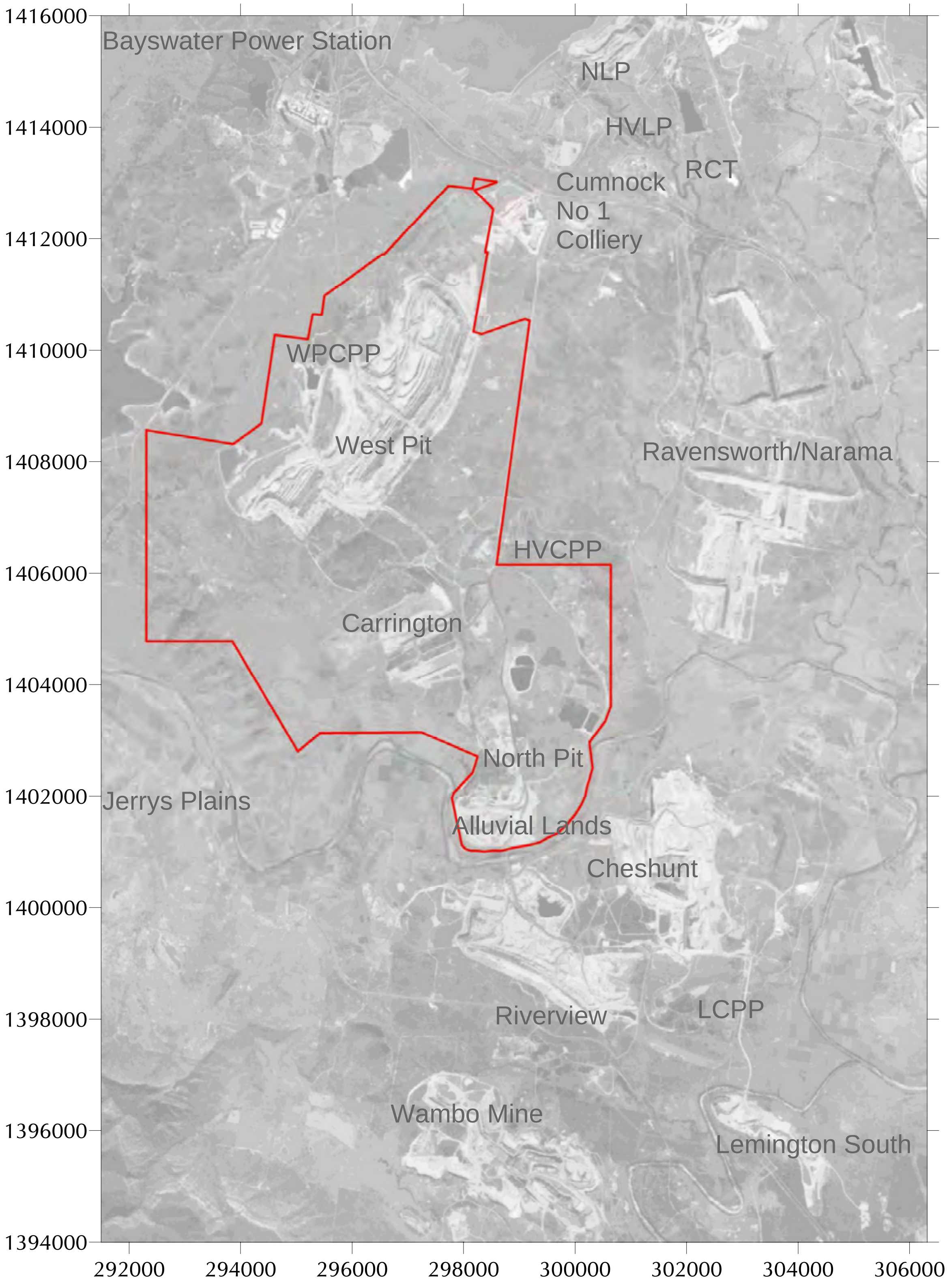
- Production at Carrington increased from 6 to 10 Mtpa.
- Haulage of ROM coal from mines south of the River to HVCPP is increased from 8 to 16 Mtpa.
- The capacity of the HVCPP is increased from 13 to 20 Mtpa.
- Coal from West Pit can be sent from WPCPP to the Bayswater Power Station by conveyor with the balance being sent from the WPCPP to HVLP and NLP along Pikes Gully Road, or West Pit can send the balance to HVCPP by truck. The beneficiated coal will then be transferred to HVLP by conveyor or intermittent haulage. The most conservative assumption in terms of dust emissions is to assume that the coal is processed by HVCPP.
- Coal is also able to be transferred between the HVLP, NLP and RCT.

In practice, the HVCPP will not handle more than 20 Mtpa of ROM coal. However, from the assumptions above it would appear that the HVCPP would be required to handle more than this amount. The additional tonnage is to ensure that the assessment covers all contingencies for the haulage of ROM coal.

In addition the Proposal will give rise to emissions of greenhouse gases such as methane from the exposed coal and emissions of carbon dioxide from fuel used by earth moving equipment, blasting and indirectly from electricity usage. An assessment of greenhouse gas emissions is provided in **Section 11**.

In summary the issues dealt with in the assessment are:

1. The impacts likely to arise from emissions of particulate matter (PM) from HVO north of the Hunter River;
2. The impacts likely to arise from emissions of PM from the Proposal including open cut mines at nearby mining operations including Wambo, Ravensworth-Narama and HVO operations south of the Hunter River, and;
3. Greenhouse emissions from the Proposal.



Location of study area

Figure 1

3 AIR QUALITY ASSESSMENT METHODS AND CRITERIA

In its guidelines (**NSW EPA, 2001**) the EPA specifies air quality assessment criteria relevant for assessing impacts from mining. These are summarised in **Tables 1**, **2** and **3**.

These criteria are consistent with the National Environment Protection Measures for Ambient Air Quality (referred to as the Ambient Air-NEPMs (see **NEPC, 1998**)). However, the EPA's criteria include averaging periods which are not included in the Air-NEPMs and references to other measures of air quality, namely dust deposition and total suspended particulate matter (TSP), which are also not part of the Air-NEPMs.

Table 1: NSW EPA Impact assessment criteria for pollutants (for use in modelling)

Pollutant	Averaging period	Concentration	
		pphm	**μg/m^3**
PM_{10}	1-day annual	- -	50* 30
SO_2	10 minutes 1-hour 1-day 1-year	25 20 8 2	712 570 228 60
NO_2	1-hour 1-year	12 3	246 62
		ppm	**mg/m^3**
CO	15 minutes 1-hour 8-hours	87 25 9	100 30 10

* Non Cumulative for purposes of impact assessment (refer Section 4.1)

In addition, the guidelines provide the criteria for TSP (see **Table 2**) and for the insoluble component of deposited dust (see **Table 3**).

Table 2: NSW EPA amenity based criteria for dust fallout

Pollutant	Averaging period	Concentration
TSP	Annual	90 μg/m^3

Table 3: NSW EPA amenity based criteria for dust fallout

Pollutant	Averaging period	Maximum increase in deposited	Maximum total dust deposition
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

The National Environmental Protection Council (NEPC) has recently published an advisory National Environmental Protection Measure (NEPM) for $PM_{2.5}$ (**NEPC, 2002**). The numerical values for $PM_{2.5}$ NEPM are:

1. 8 μg/m^3 – annual average
2. 25 μg/m^3 – maximum 1-day average.

At this stage, the proposed advisory $PM_{2.5}$ standard is not part of the NSW Environmental Protection Authority (EPA) assessment criteria and while predictions have been made as to the likely contribution that emissions from the mine will make to ambient $PM_{2.5}$ concentrations, these predictions have not been used to assess impacts against the proposed advisory standard. Predictions of $PM_{2.5}$ concentrations are provided in **Appendix A**.

The sulphur content of Australian diesel is too low and mining equipment is too widely dispersed over mine sites to cause sulphur dioxide (SO_2) goals to be exceeded even in mines that use large quantities of diesel. For this reason, no detailed study is required to demonstrate that emissions of SO_2 from the mine will not significantly affect ambient SO_2 concentrations. In addition, NO_x and CO emissions are too small and too widely dispersed to require a detailed modelling assessment.

Thus, the focus of the study is on the potential effects of PM emissions. PM has the capacity to affect human health and to cause nuisance effects.

To assist in interpreting the significance of predicted concentration and deposition levels some background discussion on the potential harmful effects is provided below.

PM can be categorised by size and/or by chemical composition. The potential harmful effects depend on both.

The human respiratory system has in-built defensive systems that prevent particles larger than approximately 10 µm from reaching the more sensitive parts of the respiratory system. Particles with aerodynamic diameters less than 10 µm are referred to as PM_{10}. Particles larger than 10 µm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason air quality goals make reference to measures of the total mass of all particles suspended in the air. This is referred to as TSP. In practice, particles larger than 30 to 50 µm settle out of the atmosphere too quickly to be regarded as air pollutants. The upper size range for TSP is usually taken to be 30 µm. TSP includes PM_{10}.

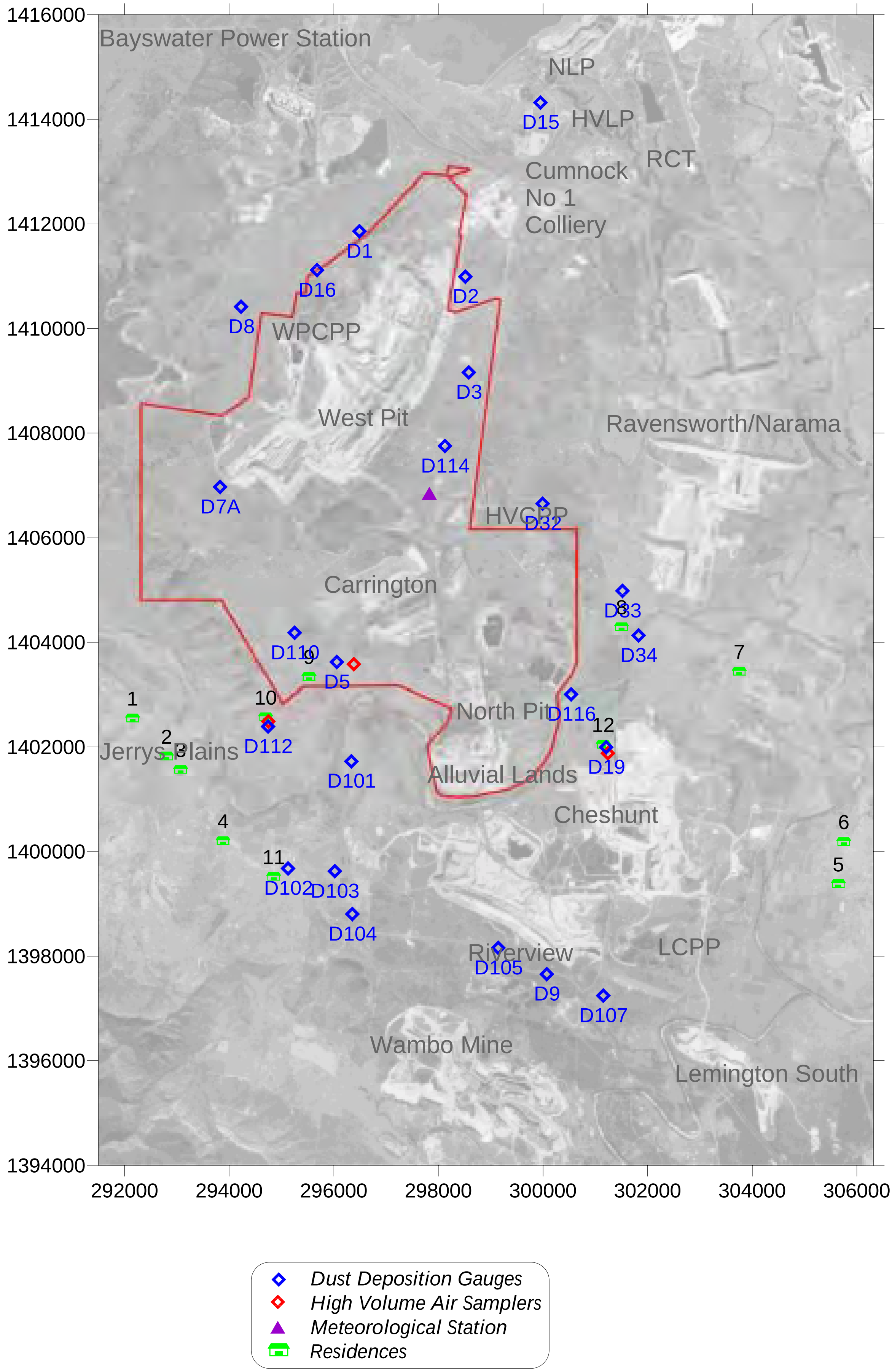
The suite of ambient air quality criteria used in the assessment is comprehensive and would be expected to protect against all harmful effects of the emissions from the Proposal including health and nuisance effects.

4 EXISTING AIR QUALITY

Emissions from the Proposal and criteria for assessment were discussed in **Section 3**. They comprise PM_{10}, TSP and deposited PM. In addition, there will be emissions of carbon monoxide (CO) and small quantities of nitrogen dioxide (NO_2) from diesel equipment and blasting and trace amounts of SO_2. As discussed before, in practice, the sources of CO, NO_2 and SO_2 in mining operations are too small and too widely dispersed to give rise to significant concentrations of these pollutants and these are not discussed in any detail in this report.

Data from monitoring programs operated by CNA provide measurements of 24-hour average concentrations of TSP and PM_{10} on a six-day cycle and monthly averages of dust fallout levels. The locations of the relevant monitoring sites are shown in **Figure 2**.

Data from these networks are reviewed below.



Location of dust and meteorological monitoring sites and residences **Figure 2**

4.1 PM Concentrations (TSP and PM_{10})

Twenty-four hour average concentrations of TSP and PM_{10} (on a six-day cycle) have been measured over various periods at the four sites; Cornfield, Cheshunt, Warkworth, and Wandewoi (see **Figure 2)**. The available data are summarised below:

- Cornfield TSP from 4 April 1998 to 26 December 2001
- Cheshunt TSP from 4 April 1998 to 25 June 2003
- Wandewoi TSP from 2 January 2002 to 25 June 2003
- Warkworth PM_{10} and TSP from 8 January 2003 to 25 June 2003

When interpreting the data it should be noted that they include the effects of existing mining operations. As a result the data cannot be used directly to determine the background levels that should be added to predicted concentrations of TSP and PM_{10} that arise from the Proposal. This is because the Proposal includes activities that are already occurring and thus adding predicted Proposal concentrations to monitored levels would double count the effects of existing emissions.

Figures 3a to **3e** show the TSP data as time series plots. **Tables 4** to **8** summarise the data showing the annual average, maximum 24-hour, minimum 24-hour and number of observations for each year.

Table 4: Concentrations of TSP measured at Cornfield 1998 to 2002

Year	Annual average TSP ($\mu g/m^3$)	Maximum TSP ($\mu g/m^3$)	Minimum TSP ($\mu g/m^3$)	Number of samples
1998	27.9	64.4	2.4	39
1999	38.2	84.2	6.8	52
2000	38.2	85.3	3.9	54
2001	32.9	91.8	5.2	47
2002	Site discontinued			

Table 5: Concentrations of TSP measured at Cheshunt 1998 to 2003

Year	Annual average TSP ($\mu g/m^3$)	Maximum TSP ($\mu g/m^3$)	Minimum TSP ($\mu g/m^3$)	Number of samples
1998	105.3	230.0	6.5	41
1999	110.7	361.6	25.1	60
2000	86.6	189.9	21.1	59
2001	82.4	217.8	17.3	60
2002	149.2	390.2	26.2	61
2003 (to 25 June)	190.4	478.8	21.9	30

Table 6: Concentrations of TSP measured at Wandewoi 2002 to 2003				
Year	**Annual average TSP (µg/m³)**	**Maximum TSP (µg/m³)**	**Minimum TSP (µg/m³)**	**Number of samples**
2002	54.5	148.9	5.7	62
2003 (to 25 June)	52.5	132.2	11.1	30

Table 7: Concentrations of TSP measured at Warkworth 2003				
Year	**Annual average TSP (µg/m³)**	**Maximum TSP (µg/m³)**	**Minimum TSP (µg/m³)**	**Number of samples**
2003 (to 25 June)	193.1	2,781.7	24.6	29

Table 8: Concentrations of PM_{10} measured at Warkworth 2003				
Year	**"Period" average PM_{10} (µg/m³)**	**Maximum TSP (µg/m³)**	**Minimum TSP (µg/m³)**	**Number of samples**
2003 (to 25 June)	40.4	337.5	4.2	29

The annual average concentrations at the Cornfield and Wandewoi monitoring sites have been below the 90 µg/m³ annual criterion. The highest concentrations recorded at these sites occur in the summer period when winds are most likely to blow from the southeast. This indicates the extent to which mining is contributing to the TSP concentrations at these sites. Annual average concentrations of TSP at the Cheshunt monitor have exceeded the EPA criterion of 90 µg/m³ on four out of the past six years and air quality at this site is clearly affected by emissions from the Cheshunt open cut, which is only a few hundred metres to the east. The data are not representative of the wider area where most non-mine residences are located.

Information on concentrations of TSP and PM_{10} are available for the Warkworth area. At this stage 29, 24-hour average concentrations are available. The first few months of these measurements were collected at the end of one of the most severe droughts in NSW over the past 100 years and were affected by smoke from bushfires associated with the dry period. The data suggest that the annual average PM_{10} criterion of 30 µg/m³ will be exceeded at Warkworth Village. The most recent data show extremely high TSP and PM_{10} concentrations (see 8 April and 8 May 2003). On 8 April winds were generally from the northwest with speeds mostly in the range 0 to 6 m/s. On 8 May the wind direction was similar and wind speeds were lower in the range 0 to 4 m/s. The other monitoring site did not record extreme concentrations. This suggests that the source of PM was local and located to the northwest of the monitor.

4.2 Deposition

The locations of relevant dust deposition gauges operated by CNA are shown in **Figure 2**. **Table 9** shows the monthly average deposition levels and summarises the annual averages since 1998. Many of the gauges (see **Figure 2**) are located within the mining lease close to areas where active mining is taking place. The data from these gauges can be used to show the rate at which dust deposition levels decrease with distance from actively mined areas.

Monitoring data from gauges D5, D19, D112 and D102 to D104 provide data that is representative of conditions near residential areas, although D19 and D5 are also located very close to mining operations.

Inspection of **Table 9** indicates that:

- D5 has recorded annual average deposition levels of insoluble solids in the range 2.0 to 6.5 g/m^2/month
- D19 has recorded annual average deposition levels of insoluble solids in the range 2.7 to 5.2 g/m^2/month
- D112 has recorded annual average deposition levels of insoluble solids in the range 0.7 to 1.8 g/m^2/month
- D102 to D104 have recorded annual average deposition levels of insoluble solids in the range 0.7 to 2.5 g/m^2/month

These suggest that rural residential areas that are not already substantially affected by mining operations could accommodate an increment of annual dust deposition of 2 g/m^2/month without causing the EPA's 4 g/m^2/month criterion to be exceeded.

It should be noted that these data include the effect of existing mining operations and are unlikely to experience a significant change as a result of a similar level of dust emission from the continuing mining.

Table 9: Dust (insoluble solids) deposition data for relevant gauges - g/m^2/month

	Total Insoluble Matter g/m2/mth																		
Sample Date	**D1**	**D2**	**D3**	**D5**	**D7**	**D7A**	**D8**	**D9**	**D15**	**D16**	**D19**	**D30**	**D31**	**D32**	**D33**	**D34**	**D38**	**D39**	**D43**
May-98					3.5			1.9			3.8	2.45	2.2	3.15	4.55	2.5	1.6	2.8	2
Jun-98					2.1			3.3			2.9	3.2	3.2	1	1.8	3.1	1.6	1.1	1.3
Jul-98					2.1			2.5			2.8	1.4	1.3	2.1	1.2	1.5	0.8	1.2	0.6
Aug-98					0.7			1.4			0.7	2	1	1.4	Ns	1.9	0.9	2.7	0.4
Sep-98					12.8			1.8			2.9	2.3	2.6	2.2	2.9	2.6	1.9	1.7	1
Oct-98					4.3			0.7			3.4	3.7	2.3	2.6	2.9	1.5	1.4	1.1	1
Nov-98					3.6			1.8			4.2	3.3	4	2.8	2.4	2	2.8	1.6	2
Dec-98					4.4			1.6			0.9	3.3	6.3	2.7	4.1	2.7	2.6	4	2.9
Average 1998					**4.2**			**1.9**			**2.7**	**2.7**	**2.9**	**2.2**	**2.8**	**2.2**	**1.7**	**2.0**	**1.4**
Jan-99					1.2			1.2			1.8	5	1.9	1.2	0.9	1.1	0.9	1.1	2.7
Feb-99					3.2			2.2			5.5	2.3	5.3	1.5	1	1.1	2	1.5	1.8
Mar-99					3.3			1.3			2.7	2.6	2.6	2.1	2.3	2.6	8.3	2.4	1.7
Apr-99					3.1			0.7			3.1	2.1	2.6	2.3	1.7	1.9	1.5	1.8	0.9
May-99					3.9			0.6			3.1	2.9	2.8	2.2	2.1	2.5	2.3	2.5	0.7
Jun-99					5.1			7.7			4.4	4.3	2.8	3.3	4.6	4	1.7	4	0.6
Jul-99					4.3			3.1			3.8	2	1.2	0.9	1.4	1.3	3.3	1.3	0.5
Aug-99					5.4			2			3.4	3	2.7	2.5	1.8	1.9	1.8	2.3	0.9
Sep-99					4.2			2.3			3	2.8	2.4	2.2	1.9	2.4	1.6	2.1	1.2
Oct-99					2.3			1.1			2.4	3.1	2.9	2.9	1.3	2.2	2.8	2.5	2.6
Nov-99					5.3			1.4			4.8	1.9	1.2	1.4	3.2	1.6	0.9	1.7	1.2
Dec-99																			
Average 1999					**3.8**			**2.0**			**3.5**	**2.9**	**2.6**	**2.0**	**2.0**	**2.1**	**2.5**	**2.1**	**1.3**
Jan-00					5			2.7			3.3	2.8	2.4	1.5	1.1	3.7	1.8	4.1	2.9
Feb-00					11.1			1.2			9.5	2.8	2.8	2.1	3.2	1.1	2	2.6	2.7
Mar-00					15.5			4.3			5.3	9.8	12.5	1.3	6.2	4.7	0.6	9	2.7
Apr-00					3.1			1.2			2	2.4	2.4	2.8	2.8	4.7	1.6	2.3	1.8
May-00					1.6			3.2			3.2	1.3	2.2	1.6	5.2	1.5	1.2	1.3	0.5
Jun-00					4.6			2.3			4.1	0.9	2.2	2.1	248.7	2.1	2	3.1	0.6
Jul-00					4.5			2.3			3	1.3	1.9	2.5	4.3	2.2	2	3.8	0.6
Aug-00					3.9			2.3			2.4	1.8	2	2.2	2.5	2.1	1.8	2.9	0.7
Sep-00					3.4			1.8			3.4	2.7	1.9	2.2	1.6	1.7	1.6	1	0.9
Oct-00					4			1.3			3.5	2.4	2.3	1.5	2.9	3.6	1.9	2.7	1.1
Nov-00	4.5	1.2	7.3	7.3	2.5	6.1	5.9	1.8	5.3	3.5	2.4	2.3		2.8	3.1	3.3	4.7	2.9	0.9
Dec-00	4.7	3.1	9.9	5.7	4.6	4.4	3.9	4.6	5.2	4.6	3.5	7.3		3	3	4.5	3.3	9	1.2
Average 2000	**4.6**	2.2	**8.6**	**6.5**	**5.3**	**5.3**	**4.9**	**2.3**	**5.3**	**4.1**	**3.8**	**3.2**	**3.3**	**2.1**	**23.7**	**2.9**	**2.0**	**3.7**	**1.4**
Jan-01	4.8	1.6	1.5	2.3	4.5	0.9		0.8	1.4	1.6	1.1	1.8		2	0.5	1.3	3.3	3.3	2.3
Feb-01	3.4	6.9	2.7	3.5		2.7	2.2	1.5	1.7	3.3	3.2	3.7		1	2.1	2	1.9	3.7	0.5
Mar-01	3.7	3.3	1.1	1.1		0.8	3.5	1.4	3.2	1.6	3.5	1.7		0.2	4.1	3.3	0.3	0.4	0.7
Apr-01	2.6	2.2	1.5	6.3		1.5	1.5	2	1.5	4.5	2.1			1	3.6	2			1.7
May-01	1.7	1.8	1.9	15.7		1.6	2.4	0.7	1.4	3.1	1.3			1.3	2.9	1.8			0.6
Jun-01	2.3	1.9	4.2	4.9		1	2.9	2	2.9	2.2	1.9			2.2	4	1.6			0.7
Jul-01	1.0	4.1	4.7	1.9		1.1	2.2	1	2.1	2.5	2			1.9	3.5	2			0.5
Aug-01	2.6	4.5	2.4	2.6		2.2	1.4	0.9	4.5	10.8	5.2			3.1	7.4	1.9			0.8
Sep-01	1.4	2.5	2.4	1.6		1	1.6	1.8	2.1	2.8	3.2			1.9	4.2	3.6			3.9
Oct-01	4.0	2.4	4.4	2.2		2	4	1.3	2.2	19.1	2.6			2.4	3.8	2.3			1.2
Nov-01	1.0	5.2	4.3	3.2		1.5	4.3	3.7	1.9	8.1	2.4			3	7.7	2.6			1.4
Dec-01	4.0	4.4	5	4		2.3	3.6	3.3	1.8	4.2	4.2			3.2	30.5	3.2			2
Average 2001	**2.7**	**3.4**	**3.0**	**4.1**	**4.5**	**1.6**	**2.9**	**2.0**	**2.2**	**5.3**	**2.7**	**2.4**		**1.9**	**6.2**	**2.3**	**1.8**	**2.5**	**1.4**
Jan-02	2.6	3.8	4.5	1.9		3.7	1.2	1.7	2.7	1.9	3.4			2.6	1.7	2			1.2
Feb-02	5.1	1.8	2.2	3.3		2.7	5.8	1.7	2.9	4	6.8			4.2	7.4	2.3			3
Mar-02	3.0	1.8	1.9	1.4		3.5	3	2.6	1.8	8	6.1			1.1	8.1	2.5			1.2
Apr-02	2.2	1.3	2.5	1.4		1.7	2.1	1.6	2.3	9.5	5			1.6	1.4	1.1			0.7
May-02	2.3	3	3.2	1.3		2.1	1.3	1.9	2.1	34.4	5.4			2.9	2.1	2.5			1.4
Jun-02	1.4	2.2	3.4	1.5		1.1	1	2.2	2.5	5.2	3.4			2	1.3	2.4			0.7
Jul-02	1.1	1.1	2.3	0.7		0.8	1.1	2.6	1.5	1.5	3.9			5.2	2.1	3.1			1
Aug-02	1.9	2.9	4.8	3.1		1.5	1.1	4.6	7.4	5.4	4.3			3.9	3.7	3.3			1.4
Sep-02	1.8	2.3	4	1.9		1.6	2.1	3.4	10.8	3.5	3.5			2.6	2.4	6.4			1.5
Oct-02	2.7	5.7	3.1	4.6		2.3	1.5	3.2	2.2	1.3	4.1			2.7	2.5	3.2			1.3
Nov-02	4.4	4.9	3.7	0.3		3.3	2.7	4.7	3.7	10.6	4.4			3.5	2.1	2.8			3.3
Dec-02	5.4	4.5	5.6	2.6		3.7	5.3	3.3	4.4	4.5	12.2			3.5	3.8	4			0.7
Average 2002	**2.8**	**2.9**	**3.4**	2		**2.3**	**2.4**	**2.8**	**3.7**	**7.5**	**5.2**			**3.0**	**3.2**	**3.0**			**1.5**
Jan-03	3.6	2.5	3.8	5		3.2	2.3	3.2	1.9	5.9	4.4			3.1	1.4	5.3			4.1
Feb-03	4.8	4.3	3.9	3.7		1.7	3.1	2.7	2.9	3.7	4			1.5	2.1	1.3			1
Mar-03	4.2		4.3	5.6		2.1	3.1	3.4	2.4	4.1	5.5			3.3	2.1	4			
Apr-03	1.8		2.1	7.2		1.8	15	4.1	1.9	4.3	3.5			3.6	2.6	2			
May-03	2.6		3.7	2		1.7	2.5	2.2	2.6	4.5	3.1			3.2		1.7			
Jun-03	1.9			2.2		0.8	3.6	2.7	3		3.2				3.1	2.6			
Average 2003	**3.2**	**3.4**	**3.6**	**4.3**		**1.9**	**5.0**	**3.1**	**2.5**	**4.5**	**4.0**			**2.9**	**2.3**	**2.8**			**2.6**

Table 9: Dust (insoluble solids) deposition data for relevant gauges - g/m^2/month *continued*

	Total Insoluble Matter g/m2/mth													
Sample Date	**D101**	**D102**	**D103**	**D104**	**D105**	**D107**	**D109**	**D110**	**D112**	**D113**	**D114**	**D115**	**D116**	**DCL**
May-98	2	2	2	2	2	2	2	2	2	2	2	2	2	
Jun-98	1.3	0.9	0.7	0.8	7.1	4.5	15	0.6	2.5	0.7	2.7	54.8	4	
Jul-98	0.6	0.3	0.3	0.5	1.4	4.2	2.6	0.4	1.8	0.6	3	2.7	4.2	
Aug-98	0.4	0.3	0.3	0.5	9	0.9	0.9	0.4	0.3	1.4	2.6	1.4	4.1	
Sep-98	1	1	0.8	1.3	3.7	1	2.3	0.8	0.9	6.5	6	2.9	4.3	
Oct-98	1	0.9	2	1.1	1.3	2.5	3.7	2.1	1.2	1.1	4.6	2.4	7.1	
Nov-98	2	0.7	0.7	0.7	1.2	11.5	3.4	0.6	1	2.7	2.1	1.9	3.6	
Dec-98	2.9	0.9	1.5	1.1	3.7	23.9	3.7	1.8	1.4	4.1	2.2	3.1	6.5	
Average 1998	**1.4**	**0.9**	**1.0**	**1.0**	**3.7**	**6.3**	**4.2**	**1.1**	**1.4**	**2.4**	**3.2**	**8.9**	**4.5**	
Jan-99	2.7	1.3	1.2	3.8	3	4.9	2.4	0.2	0.5	0.2	1.1	1	3.2	
Feb-99	1.8	0.5	1.7	2	18.6	1.7	3.6	1	0.4	1.6	1.5	4.8	4.7	
Mar-99	1.7	0.5	-	3.1	8.7	2.1	4.4	1.8	0.8	7.3	4.2	3.2	5.6	
Apr-99	0.9	0.6	0.8	2	3	1.4	2.4	1.4	1.2	2	2.7	4.6	4.4	
May-99	0.7	0.5	0.9	1.7	4.1	0.9		0.7	0.3	2.1	2.5	1.4	6.1	
Jun-99	0.6	0.3	0.2	0.7	2	5.1	11.1	0.7	0.5	1.5	3.6	1.1	7.1	
Jul-99	0.5	0.4	0.5	0.4	2.7	2.1	2.7	0.9	0.3	0.7	4	0.7	2.5	
Aug-99	0.9	0.5	0.5	0.9	2.9	4.3	3.2	0.9	0.4	1.3	5.6	1.1	4.2	
Sep-99	1.2	0.9	1.3	8.3	3.2	3.6	2.8	1.6	1.1	15.7	5.4	1.1	6.5	
Oct-99	2.6	2.2	2.3	1.9	1.3	19	2.6	3.3	1.3	5.1	3.1	2.2	3.9	
Nov-99	1.2	0.8	1.1	0.9	2	5.4	2	2.4	0.6	1.9	2.1	3.4	2.4	
Dec-99														
Average 1999	**1.3**	**0.8**	**1.1**	**2.3**	**4.7**	**4.6**	**3.7**	**1.4**	**0.7**	**3.6**	**3.3**	**2.2**	**4.6**	
Jan-00	2.9	1	5.4	1.4	1.4	4.7	2.2	5.1	0.9	1.6	9.3	3	3	
Feb-00	2.7	0.6	0.6	1.1	2.4	4.7	3.5	0.8	0.9	2.8	5.8	1.4	2.7	
Mar-00	2.7	2.4	1.2	14.1	3.7	4.2	0.7	9.3	2.3	8.1	11.7	18.6	10.7	
Apr-00	1.8	2.9	1.2	2.4	6	1.2	3.7	0.9	0.5	2.2	4.9	1.5	2.3	
May-00	0.5	0.8	0.6	0.6	2.2	1.6	13.8	0.4	0.8	2	2.9	1	2.7	
Jun-00	0.6	1	0.4	0.6	1.6	2.5	2.2	0.4	0.7	1.3	1.6	1	3.5	
Jul-00	0.6	0.6	0.5	0.5	1.2	3.1	1.7	0.2	0.3	1.5	1.7	6.5	3.8	
Aug-00	0.7	2.1	1	0.4	3.7	6.5	2.6	0.6	1	1.1	4.3	2.2	7.9	
Sep-00	0.9	0.9	1.4	2.1	0.8	2.7	3.2	0.7	0.8	1.5	3.1	2.5	3.3	
Oct-00	1.1	0.9	6	0.7	1.9	4.5	3	2.5	1.1	4.6	3	2.4	6.4	
Nov-00	0.9	0.8	0.7	1	2.6	1.4	6.4	2.3	1		4.9		4.2	
Dec-00	1.2	2.8	1.2	4.8	3.1	3.7	9.7	3.3	1.4		3.1		3.1	
Average 2000	**1.4**	**1.4**	**1.7**	**2.5**	**2.6**	**3.4**	**4.4**	**2.2**	**1.0**	**2.7**	**4.7**	**4.0**	**4.5**	
Jan-01	2.3	0.5	0.2	1.8	2.1	1.4	1.6	1.2	0.6		1.4		1.9	
Feb-01	0.5	0.3	0.5	1.1	2.3	2.4	1.1	0.8	2.5		2.6		3.7	
Mar-01	0.7	0.9	0.9	1.2	3.2	4.4	1.4	0.3	1.7		3.2		3.1	
Apr-01	1.7	0.5	0.9	0.7	4.2	11.7		1.5			3.2		3.6	6
May-01	0.6	0.2	0.5	0.4	2.4	5.7	**1.4**	0.6	0.2		2		1.8	3.1
Jun-01	0.7	1.3	0.4	0.3	2	10.5		0.5	0.5		2.6		4.6	3.1
Jul-01	0.5	0.7	0.5	0.4	1.8	1.7		0.3	0.3		2.8		3.7	3.2
Aug-01	0.8	1.1	0.5	0.6	2.5	3.7		0.8	0.6		2.4		2.8	4.8
Sep-01	3.9	0.6	0.6	0.5	2.8	2.5		2.1	1.1		3.2		5.7	1.7
Oct-01	1.2	0.9	1.1	1.9	1.3	2		1.1	1		3.9		4.9	3.1
Nov-01	1.4	1	0.8	0.7	2.8	2.6		1.3	1.3		2.6		4.1	8
Dec-01	2	1.1	1.6	3.3	5.2	6.3		2.3	1.9		3		2.3	6.1
Average 2001	**1.4**	**0.8**	**0.7**	**1.1**	**2.7**	**4.6**	**2.1**	**1.1**	**1.1**		**2.7**		**3.5**	**4.3**
Jan-02	1.2	0.9	0.4	3.9	2.5	7.6		2	2		3.3		4.9	8.9
Feb-02	3	1.6	1.8	3.7	7.8	2.2		1.7	1.9		3		6.2	8.5
Mar-02	1.2	0.8	1.4	2.6	9.9	1.8		1.3	0.8		3.5		6.5	1.2
Apr-02	0.7	0.6	1.2	0.5	1.6	1.5		1.4	1.5		1.6		3.6	3.6
May-02	1.4	0.9	1.4	0.8	2.5	8.2		1.2	0.6		3.3		2.9	2.9
Jun-02	0.7	1.1	0.7	0.4	2.1	11.6		0.8	0.6				3	3.7
Jul-02	1	0.6	0.8	0.9	1.2	7.4		0.4	0.4		2.4		5.3	1
Aug-02	1.4	1.1	1.2	1.2	5.2	9.5		1.2	3.9		2.5		4.2	4.6
Sep-02	1.5	1	1.6	1.9	3.2	8.4		1.4	1.6		2.5		9.7	2
Oct-02	1.3	1.6	2.3	2.5	1.8	11.6		2.9	1.1		2.5		3.3	4.1
Nov-02	3.3	2.4	2.6	3.5	4.2	13.2		4.3	4.1		6		7.6	12
Dec-02	0.7	0.9	1	1.1	1.6	38.1		3.5	2.5		3.7		6	2.5
Average 2002	**1.5**	**1.1**	**1.4**	**1.9**	**3.6**	**10.1**		**1.8**	**1.8**		**3.1**		**5.3**	**4.6**
Jan-03	4.1	1.6	2.2	2.9	3.7	3.8		2	2		2.4		4	3.6
Feb-03	1	0.8	1.1	1.4	2.6	2.4		2.9	1.9		2.4		5.6	4.5
Mar-03		1.1	3	3.7	3.8	2.4		2.2	1.8		4		5.5	1.7
Apr-03		0.7	1.1	2.6	2.8	3		1	0.8		2.9		3.3	8.7
May-03		0.4	2.1	0.8	2.6	42.9		1.4	0.6		4		3.7	6.7
Jun-03		2.7	3.8	0.9	3.3			1.1	1		4		3.9	
Average 2003	**2.6**	**1.2**	**2.2**	**2.1**	**3.1**	**10.9**		**1.8**	**1.4**		**3.3**		**4.3**	**5.0**

Annual running average and 24-hour average TSP concentrations for Cornfield

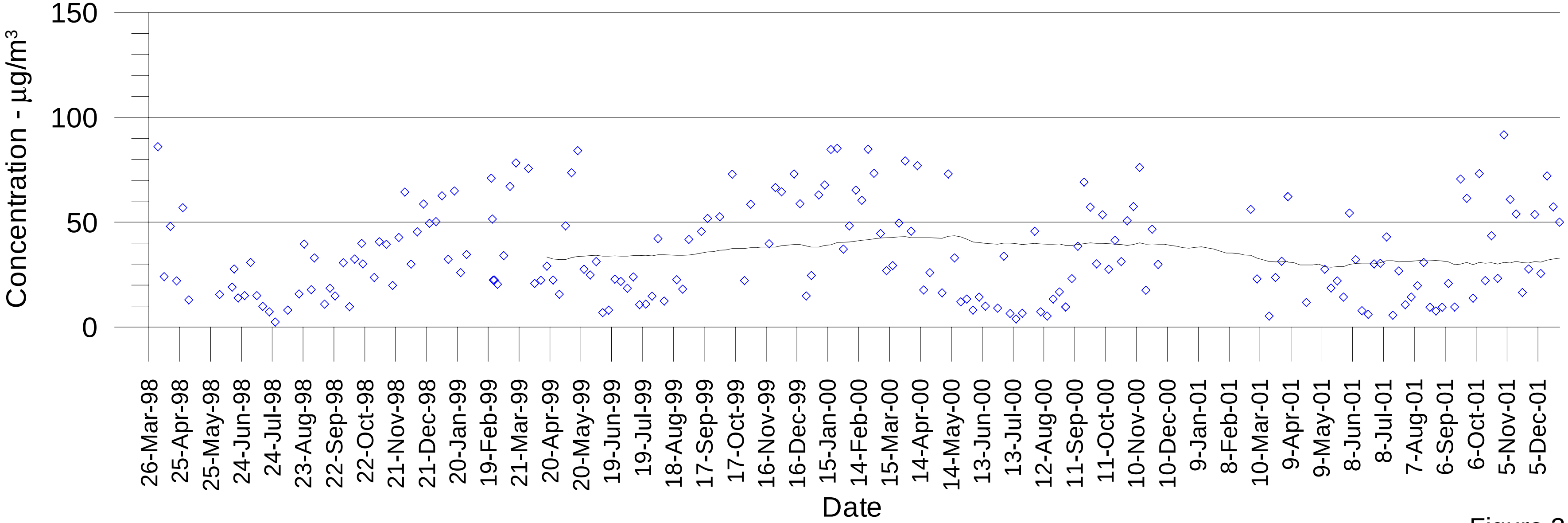


Figure 3a

Annual running average and 24-hour average TSP concentrations for Cheshunt

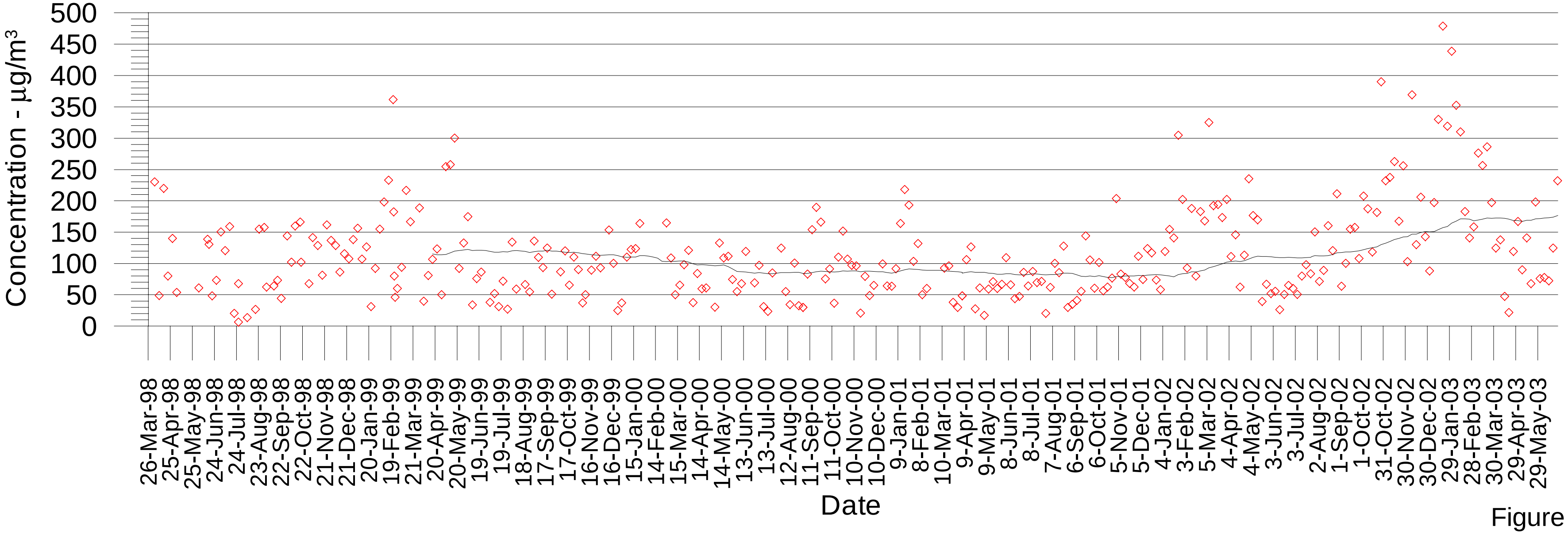


Figure 3b

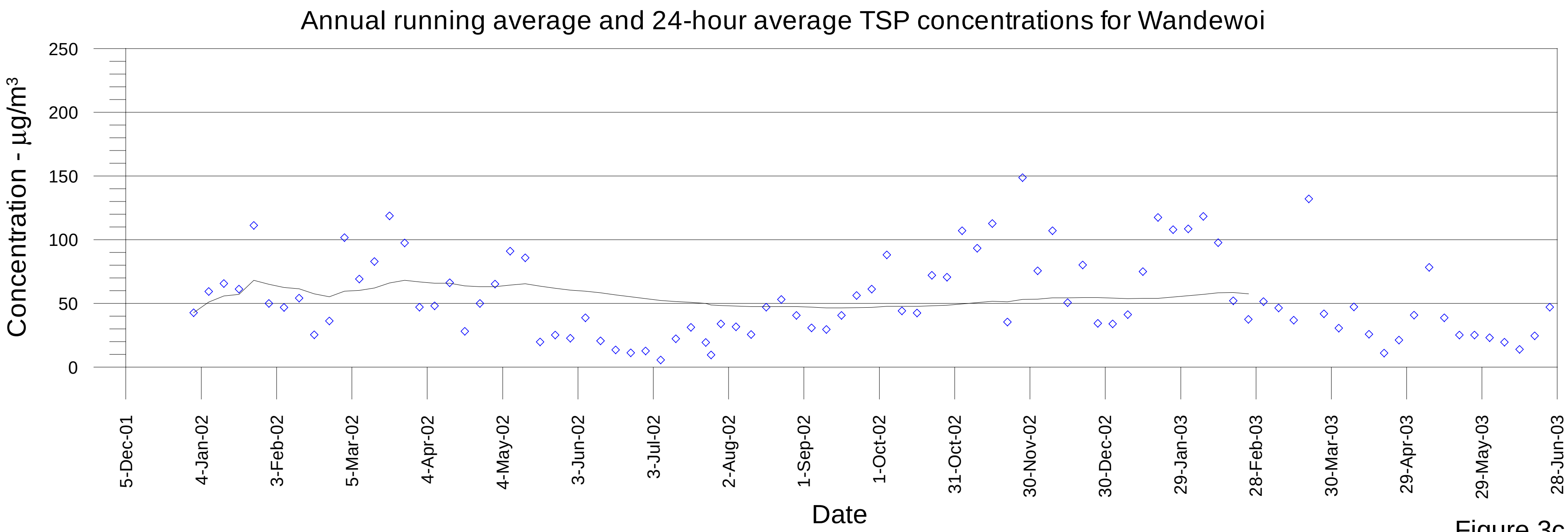


Figure 3c

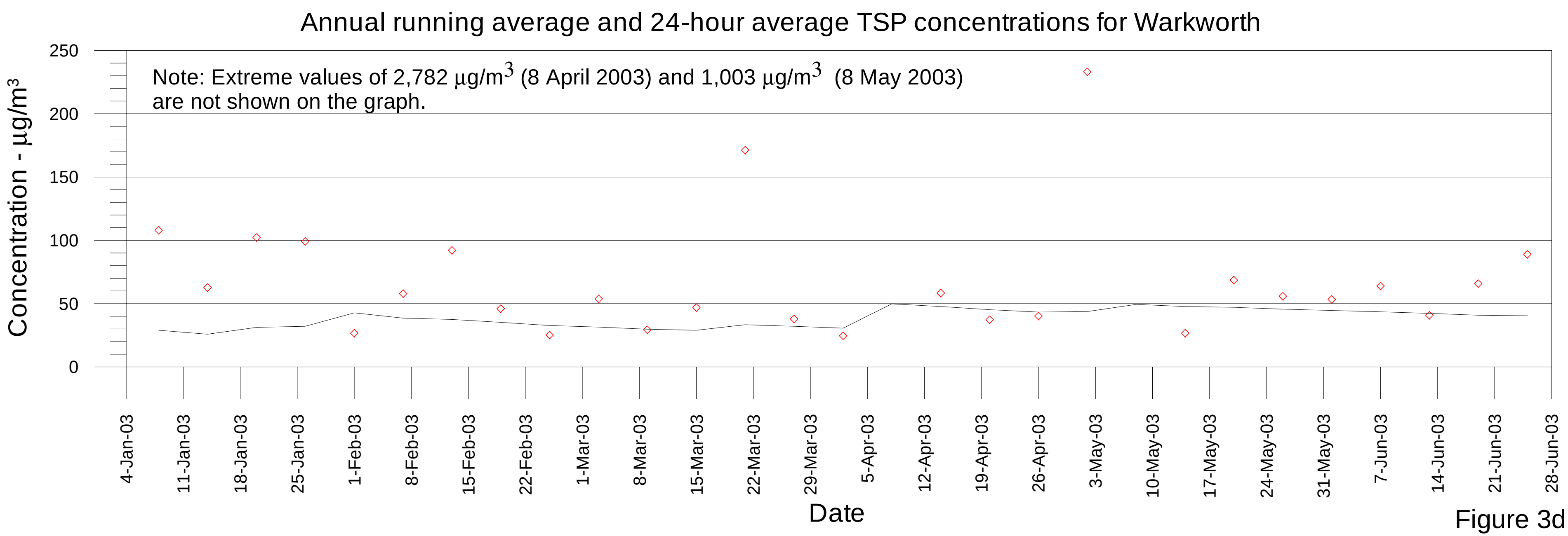
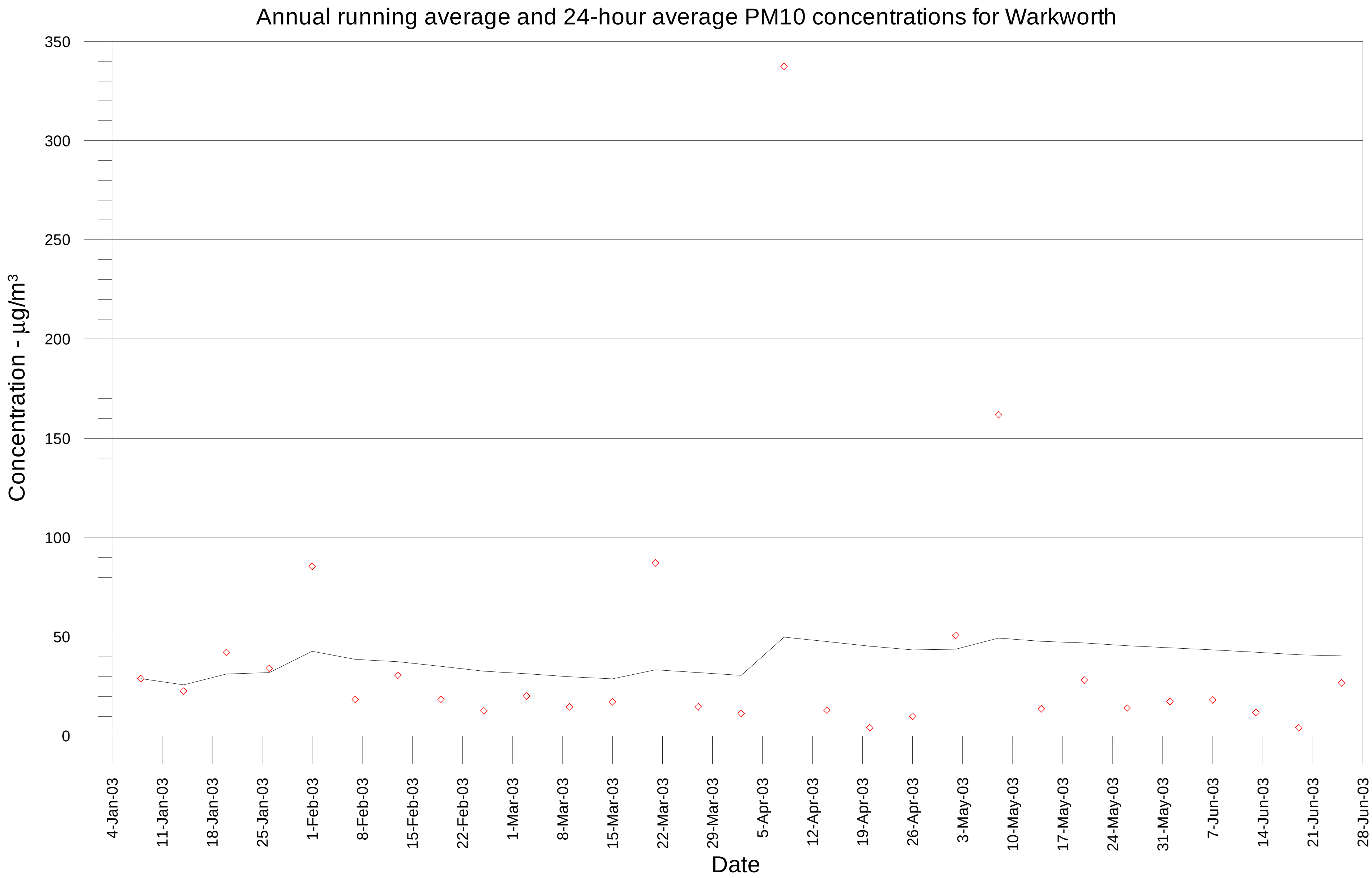


Figure 3d



Annual running average and 24-hour average PM10 concentrations for Warkworth
Concentration - µg/m³
350
300
250
200
150
100
50
0
4-Jan-03
11-Jan-03
18-Jan-03
25-Jan-03
1-Feb-03
8-Feb-03
15-Feb-03
22-Feb-03
1-Mar-03
8-Mar-03
15-Mar-03
22-Mar-03
29-Mar-03
5-Apr-03
12-Apr-03
19-Apr-03
26-Apr-03
3-May-03
10-May-03
17-May-03
24-May-03
31-May-03
7-Jun-03
14-Jun-03
21-Jun-03
28-Jun-03
Date

Figure 3e

5 CLIMATE AND METEOROLOGY

5.1 Dispersion Meteorology

The computer-based dispersion models ISCST3 has been used in this study to assess the dispersion of PM.

Data are available from a number of different sites including a meteorological station operated by Coal and Allied at the site shown in **Figure 2**. Data representative of the area and covering the twelve-month period 1 January 2002 to 31 December 2002 have been used for the current study. A total of 8,736 hours of data were available for this period. This corresponds to 99.7% of the data potentially available in a year. As discussed below, the distribution of winds for this year of data was consistent with long-term patterns observed in the central parts of the Hunter Valley. The data were therefore considered to be representative of dispersion conditions at the site and in the area covered by the modelling.

The data provide hourly information on wind speed, wind direction, and other parameters required for dispersion modelling. **Figure 4** shows annual and seasonal wind roses prepared from the data.

The data show a pattern of seasonal winds that is typical of central regions of the Hunter Valley where, over a year, winds are generally aligned along a northwest-southeast axis.

In summer, winds are generally from the southeast and in winter from the northwest.

Appendix B summarises the statistics of the meteorological data set, showing "Joint wind speed-wind direction and stability class tables". The mean annual wind speed is 3.01 m/s.

5.2 Temperature and Humidity

Temperature and humidity data for the local area, Jerrys Plains, are presented in **Table 10**. These data were obtained from the Bureau of Meteorology's weather station operated at the Jerrys Plains Post Office, which has collected data since 1884 and thus provides a useful historical record over the longer term. January is the warmest month experiencing a mean monthly maximum temperature of 31.7 ^{o}C. July is the coolest month experiencing a mean monthly minimum temperature of 3.7 ^{o}C.

Annual average relative humidity at 9 am is 69%. Annual average 3 pm humidity is 47%.

5.3 Rainfall and Evaporation

Rainfall data are presented in **Table 10**. Mean annual rainfall has been 640.2 mm. January is the wettest months (in terms of average, but not median rainfall amounts) and August is the month with lowest average rainfall. Jerrys Plains records 86 rain days per year.

Evaporation data are available from the "Climatic Atlas of Australia" (**Bureau of Meteorology, 1988B**). Evaporation rates for Singleton for January, April, July and October are approximately 225, 125, 75, and 175 mm respectively. Thus, evaporation is well above the expected rainfall amount for all the months of the year.

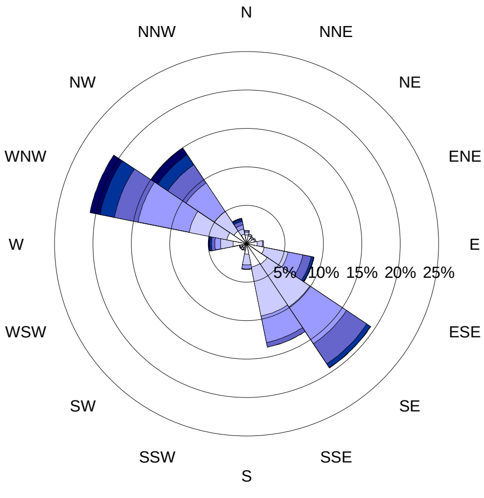
Table 10: Climate averages for Station: 061086 JERRYS PLAINS POST OFFICE
Commenced: 1884; Last record: 2001; Latitude (degS):-32.4983; Longitude (degE): 150.9083; State: NSW (Source: Bureau of Meteorology web site)

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.	No. of years	%complete
Mean daily maximum temperature - deg C	31.7	30.9	29	25.3	21.2	17.9	17.3	19.4	22.8	26.2	29.3	31.4	25.2	89.5	95
Mean no. of days where Max Temp >= 40.0 deg C	1.3	0.6	0.1	0	0	0	0	0	0	0	0.4	0.9	3.3	39.8	90
Mean no. of days where Max Temp >= 35.0 deg C	6.9	4.2	2	0.1	0	0	0	0	0.1	0.6	3.3	6.3	23.4	39.8	90
Mean no. of days where Max Temp >= 30.0 deg C	16.7	13.3	10	2.9	0	0	0	0.1	1.1	4.8	10.4	16.4	75.8	39.8	90
Highest daily Max Temp - deg C	44.4	45.3	42.8	38.9	30	26.1	25.6	31	36.2	38	44.9	45.6	45.6	39.9	90
Mean daily minimum temperature - deg C	17.1	17	15	10.8	7.3	5.2	3.7	4.4	6.9	10.2	13.1	15.7	10.5	89.8	95
Mean no. of days where Min Temp <= 2.0 °C	0	0	0	0.2	1.8	6.2	11.4	8.9	2.3	0.1	0	0	30.9	39.9	90
Mean no. of days where Min Temp <= 0.0 °C	0	0	0	0	0.4	1.8	5.2	2.9	0.3	0	0	0	10.5	39.9	90
Lowest daily Min Temp - deg C	7.8	8.7	4.5	0.6	-1.6	-2.8	-4.5	-3	-0.6	1	4.4	5	-4.5	39.9	90
Mean 9am air temp - deg C	23.3	22.7	21.4	17.9	13.5	10.5	9.2	11.2	15	18.8	21.1	23.1	17.3	57.4	95
Mean 9am wet bulb temp - deg C	19.2	19.3	17.9	14.8	11.5	8.9	7.5	8.9	11.7	14.4	16.2	18	13.9	52.8	87
Mean 9am dew point - deg C	16.7	17.2	15.5	12.5	9.5	7	5.4	6.2	8.1	10.7	12.4	14.5	11.3	37	84
Mean 9am relative humidity - %	67	72	71	71	77	79	78	72	65	60	59	60	69	51.8	85
Mean 9am wind speed - km/h	10.5	9.7	9.6	9.3	9.4	9.8	11.2	11.3	12.3	11.5	11	10.5	10.5	39.7	90
Mean 3pm air temp - deg C	29.5	28.8	27.1	24.2	20	17	16.3	18.1	20.9	23.8	26.7	28.9	23.4	42.8	96
Mean 3pm wet bulb temp - deg C	21	21	19.6	17	14.5	12.1	11	12	13.9	16.1	17.8	19.5	16.2	38.1	85
Mean 3pm dew point - deg C	15.5	16.2	14.3	11.2	9.2	7	5.2	5.3	6.8	9.5	10.7	12.9	10.3	37.9	86
Mean 3pm relative humidity - %	47	50	50	47	52	54	50	45	43	44	41	42	47	37.3	85
Mean 3pm wind speed - km/h	14.1	14	13.3	12.3	12.1	12	14	14.9	15.6	14.6	15.2	14.8	13.9	39.6	89
Mean monthly rainfall - mm	78.9	70	58.6	45.3	41.6	46.2	44.7	36.5	41.8	51.9	57.9	66.8	640.2	115.5	99
Median (5th decile) monthly rainfall - mm	65.6	43.6	46	32.6	28.7	30.7	37.2	30.6	33.8	47.2	48.6	54.7	643.9	113	
9th decile of monthly rainfall - mm	160.9	177.9	121	101	88.9	100.8	95.4	73.2	86.2	97.3	118.9	137.7	825.8	113	

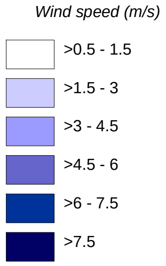
Table 10: Climate averages for Station: 061086 JERRYS PLAINS POST OFFICE ***continued***														
Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.	No. of years	%complete
1st decile of monthly rainfall - mm	24.1	6.3	8.7	4.8	5.5	8.8	8.1	6.3	8.6	10.4	10.9	15.1	418.2	113	
Mean no. of raindays	7.9	7.2	7.3	6.3	6.5	7.4	7	7	6.6	7.5	7.6	7.5	86	115.3	99
Highest monthly rainfall – mm	226.3	340.4	264.3	172.2	314.3	288.4	231.6	206.9	156.1	170	217.8	233.1		115.5	99
Lowest monthly rainfall - mm	0	0	0	0	0	2.3	0.3	0	0	1.4	1	0		115.5	99
Highest recorded daily rainfall – mm	97.3	139.7	132.1	86.6	99.1	190.8	137.2	65.3	67.3	68.6	67.1	108	190.8	115.3	99
Mean no. of clear days	7	5.4	7.3	9.3	8.6	8.4	10.7	12	10.5	8.2	7.2	7.8	102.3	42.2	95
Mean no. of cloudy days	12.3	12.2	11.4	9.7	11	11.4	8.7	8.4	8.6	11.4	11.2	11.7	128	42.2	95

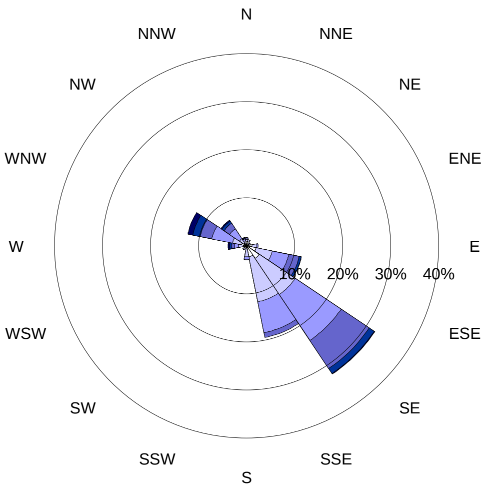
Source: Bureau of Meteorology (2003)

Annual and Seasonal Windroses for Westpit 2002

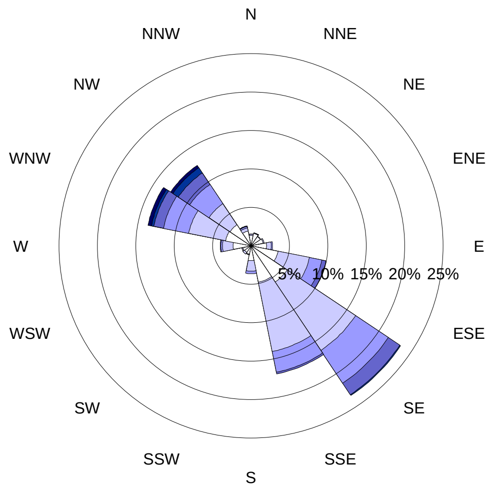


Annual

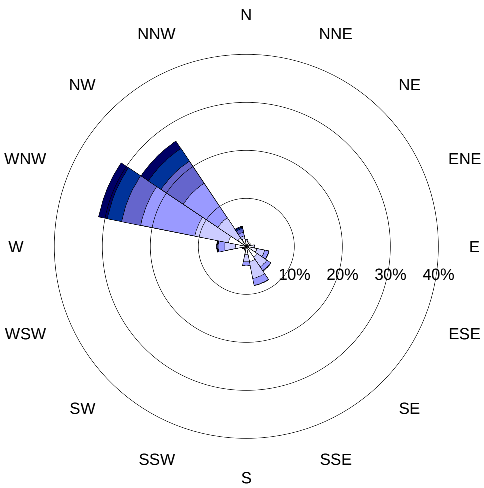




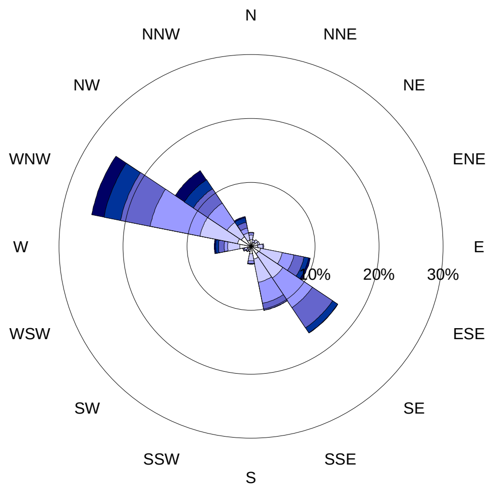
Summer



Autumn



Winter



Spring

Figure 4

5.4 *Mixing-height and stability class*

Information on hourly mixing height and stability class are required as input to the dispersion model. Intensive sonde[1] studies of the upper atmosphere around the Liddell Power Station have been undertaken on behalf of the Electricity Commission of NSW (now Pacific Power) by **Malfroy (1989)** and **Malfroy (1992)**. However, no long-term direct measurements on mixing height are available for the area and theoretically derived values have been used. The theoretical values in the day have been estimated by assuming that the maximum mixing height reached during the day was 1500 m, 1200 m, 1000 m and 1200 m for summer, autumn, winter and spring respectively. At night theoretical values based on wind speed and stability have been derived. These give mixing height values which are consistent with the values reported by Malfroy.

Stability class is used by dispersion models to determine the rate at which the plume grows by the process of turbulent mixing. Each stability class is associated with a dispersion curve, which is used by the model to calculate the plume dimension and dust concentration at points downwind of the source. In the model used here, the Pasquill-Gifford dispersion curves have been used.

The frequency of occurrence of particular stability classes in the 2002 HVO meteorological station data set, which was used in the dispersion model, is shown in **Table 11.**

Table 11: Frequency of occurrence of stability classes for HVO Meteorological Station data 2002

Stability	Frequency of occurrence
A	12.6%
B	8.1%
C	12.7%
D	40.9%
E	13.3%
F	12.3%

Note: the stability classes presented vary slightly from those reported in the noise study as F and G classes are combined for air quality studies.

6 ESTIMATED EMISSIONS OF PARTICULATE MATTER

6.1 *Carrington*

Estimates of dust emissions from Carrington have been taken from the Carrington EIS (Year 5) **(ERM, 1999).** The estimates have been increased by the factor 10/6 to account for the fact that Carrington may produce up to 10 Mtpa ROM coal compared with the 6 Mtpa assumed in the EIS. Carrington emissions have been included in the model runs for Years 1 and 3. It is expected that Carrington operations will have concluded by Year 8 and therefore two scenarios have been run for this year, Year 8 (without Carrington) and Year 8 - alternative (with Carrington). Carrington operations are not included in the scenarios for Year 14 or Year 20.

[1] A sonde in this context is a package of instruments that are carried aloft by balloon and transmit information about temperature, humidity and pressure back to the ground.

Because the emissions from Carrington have been taken from the EIS no detailed calculations of the emissions are presented in **Appendix C**. However, estimated emissions due to hauling ROM coal from Carrington to HVCCP and emissions due to wind erosion have been calculated separately.

6.2 Other HVO mines North of the River

The mining plans for Years 1, 3, 8, 8 (alternative), 14 and 20 have been analysed and detailed emissions inventories have been prepared for each of these years. The inventories include both estimated emissions from all HVO operations north of the river and emissions from other nearby mines, namely Wambo, Ravensworth-Narama, Riverview and Cheshunt.

Appendix C provides details as to how dust emissions from each dust producing activity have been calculated including the effect of dust controls and the assumptions that have been made in estimating these emissions. **Table 12** summarises the estimated TSP emission rates.

Table 12: Summary of estimated TSP dust emission from HVO North of the River (kg/y)						
ACTIVITY	**Year 1**	**Year 3**	**Year 8**	**Year 8 (alternative)**	**Year 14**	**Year 20**
	TSP emissions kg/year					
Stripping top-soil - West Pit	17,920	17,920	17,920	17,920	17,920	17,920
Drilling O/B - West Pit	24,179	29,553	18,344	18,344	29,607	5,955
Blasting coal - West Pit	75,993	95,588	96,994	96,994	121,604	39,693
Shovel/Excavators/FELs Loading O/B - West Pit	85,267	108,623	110,318	110,318	151,277	70,588
Hauling O/B to emplacement area - West Pit	548,900	699,257	710,169	710,169	973,843	454,408
- From North Pit to Alluvial Lands	25,000	25,000	25,000	25,000	-	-
- From south of river to Alluvial Lands	25,000	25,000	25,000	25,000	-	-
Emplacing O/B at dumps - West Pit	85,267	108,623	110,318	110,318	151,277	70,588
- Alluvial Lands	7,767	7,767	7,767	7,767	-	-
Dozers on O/B - West Pit	214,770	273,058	275,268	275,268	358,098	128,074
Dragline - West Pit	708,625	868,599	892,533	892,533	911,865	-
Drilling coal - West Pit	2,753	3,465	2,156	2,156	4,075	612
Blasting coal - West Pit	18,272	18,111	11,268	11,268	27,044	3,199
Dozers ripping coal - West Pit	256,532	326,154	328,794	328,794	427,730	152,978
Loading ROM Coal to trucks - West Pit	332,867	431,169	438,529	438,529	643,843	156,936
Hauling ROM coal to dump hopper - West Pit to HVCPP	150,249	179,422	183,053	183,053	284,363	44,105
- West Pit to WPCPP	113,333	116,667	113,333	113,333	113,333	113,333
- S of River to HVCPP	666,667	666,667	666,667	666,667	666,667	666,667
Unloading ROM coal at hopper/stockpile - WPCPP	34,000	35,000	34,000	34,000	34,000	34,000
- HVCPP	305,075	313,826	214,916	314,916	245,309	173,231
Re-handle ROM at hoppers - WPCPP	1,700	1,750	1,750	1,750	1,750	912
- HVCPP	4,507	5,383	5,492	5,492	8,531	1,323
Transport product coal to user/loadout point - WPCPP to NLP	54,181	59,674	54,181	54,181	54,181	54,181
- HVCPP to HVLP	7,200	7,200	7,200	7,200	7,200	7,200
- HVLP to RCT	25,200	1,800	1,800	1,800	1,800	1,800
- HVLP to NLP	17,400	17,400	17,400	17,400	17,400	17,400

Table 12: Summary of estimated TSP dust emission from HVO North of the River (kg/y) *continued*

ACTIVITY	Year 1	Year 3	Year 8	Year 8 (alternative)	Year 14	Year 20
	TSP emissions kg/year					
Unloading coal from conveyors or trucks - Bayswater Power Station	25,000	25,000	25,000	25,000	25,000	25,000
- HVLP	140,000	140,000	140,000	140,000	140,000	140,000
- NLP	42,576	44,864	42,576	42,576	42,576	42,576
Loading trains - HVLP	3,903	3,903	3,903	3,903	3,903	3,903
- NLP	1,187	1,251	1,187	1,187	1,187	1,187
Handling coal at CHPP - WPCPP	51,379	66,553	67,689	67,689	99,380	24,224
- HVCPP	318,106	327,232	224,096	328,368	255,787	180,631
Wind erosion - West Pit	184,796	165,587	165,587	165,587	165,587	165,587
- Alluvial Lands Pit	18,480	16,559	16,559	16,559	-	-
- West Pit pit O/B	184,796	165,587	165,587	165,587	165,587	165,587
- Alluvial Lands O/B	18,480	16,559	16,559	16,559	-	-
Graders - Grading all roads	61,547	61,547	61,547	61,547	61,547	61,547
SUM WEST PIT	**4,858,871**	**5,477,316**	**5,300,461**	**5,504,732**	**6,213,271**	**3,025,345**
Mitchell Pit ALL OPERATIONS	-	-	-	-	4,982,400	9,004,700
Carrington REST OF OPERATIONS	6,114,923	6,114,923	-	6,114,923	-	-
Haulage of ROM coal -Carrington to HVCPP	250,000	250,000	-	250,000	-	-
Wind erosion - Carrington pit	68,374	68,374	-	68,374	-	-
- Carrington pit O/B	68,374	68,374	-	68,374	-	-
Ravensworth-Narama ALL OPERATIONS	2,028,000	2,028,000	1,248,000	1,248,000	1,248,000	1,248,000
Wambo ALL OPERATIONS	3,969,329	3,969,329	5,122,771	5,122,771	5,139,243	5,139,243
Cheshunt ALL OPERATIONS	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000
Riverview ALL Operations	1,560,000	1,560,000	1,560,000	1,560,000	1,560,000	1,560,000
United Colliery ALL OPERATIONS	1,026,264	1,026,264	1,026,264	1,026,264	1,026,264	1,026,264

6.3 *Estimated emissions from other local mines not included in modelling*

Other mines and other sources, in addition to those identified above, will of course contribute to $PM_{2.5}$, PM_{10}, TSP concentrations and to dust deposition. In the past, the annual average concentration of particulate matter contributed by these more distant sources has been set at 5 $\mu g/m^3$ for PM_{10}, 10 $\mu g/m^3$ for TSP and 0.5 g/m^2/month for deposited dust.

Some monitoring of $PM_{2.5}$ concentrations has been undertaken by the Australian Nuclear Science and Technology Organisation (ANSTO) on behalf of the Muswellbrook Council and as part of an (Australian Coal Association Research Program) ACARP funded study. The data suggest that long-term average $PM_{2.5}$ concentrations in the Muswellbrook area are approximately 7 $\mu g/m^3$. This level includes the effect of existing mining. At this stage there is insufficient experience with $PM_{2.5}$ concentrations in the Hunter Valley to provide a reliable estimate of background $PM_{2.5}$ concentrations in the area around the Proposal. No allowance for non-mining $PM_{2.5}$ background has been added to model predictions and predictions of concentrations of $PM_{2.5}$ are provided for information rather than as a key component of the assessment (**Appendix A**).

In the cumulative modelling work each neighbouring mine has been treated as a number of volume sources. These have been located at the apparent points of major emission as estimated from the known locations of the pits and/or major dust sources on the mine or facility.

Sources have been considered in three classes:

1. Wind erosion sources where emissions vary with the hourly average wind speed according to the cube of the wind speed;
2. Loading and dumping operations where emissions vary as wind speed raised to the power 1.3; and
3. All other sources where emissions are assumed to be independent of wind speed.

For neighbouring mines the proportions of emissions in each of these categories has been assumed to be the same as applies at the Proposal, namely:

- 0.732 for emissions independent of wind speed;
- 0.135 for emissions that depend on wind speed (such as loading and dumping); and
- 0.133 for wind erosion sources.

7 ASSESSMENT METHODOLOGY

7.1 *Modelling approach*

The short-term industrial source complex model (ISC3-ST - Version 02035) has been used in this study. The model is an advanced Gaussian dispersion model approved by the US EPA for use in regulatory assessments undertaken within the US. It is one of the most widely used regulatory models in the world. The model is accepted by the NSW EPA for assessing the dispersion of dust. A complete description of the model is provided in US EPA publications (**US EPA 1995A** and **1995B**). These two volumes provide user instructions (Volume 1) and a comprehensive technical description of the algorithms used in the model (Volume 2). For convenience, a very brief description of the model is provided below.

The model uses the Gaussian dispersion equation to simulate the dispersion of a plume from either point area or volume sources. The model takes account of dry and wet deposition and includes algorithms to account for retention of dust within an open pit and includes mechanisms for determining the effect of terrain on plume dispersion. The model works on an hourly time step. This means that it requires a meteorological file that provides wind speed, wind direction and other dispersion parameters on an hourly basis. For each hour the dispersion of plumes is determined using the conventional Gaussian model assumptions. These model assumptions have some limitations and it is worth noting some of these at this point.

One of the most significant limitations of the Gaussian model is that it assumes that a steady state dispersion condition is reached instantaneously. That is, if one were to imagine that the plume is simulating for a particular hour, one would see each source of dust producing a plume that extends indefinitely in the downwind direction to the edge of the prediction grid. In reality, under very light wind conditions, this is an inappropriate assumption.

Consider for example a condition where the wind speed is 0.5 m/s. At the end of one hour any emission that occurred at the beginning of the hour will have travelled approximately 1.8 km from the source (0.5 m/s x 3,600 s). Thus, under these light wind conditions, the dust will have travelled 1.8 km from the source. The model assumes the dust will have travelled to the edge of the prediction grid that in this case may be up to 10 km from the source. In the next hour the meteorological conditions may remain the same or, more likely, the wind direction will change and the light wind condition may still persist. The model then assumes that a new equilibrium is established instantaneously and the plume travels in the new downwind direction at the new wind speed.

Because for surface sources the worst-case dispersion conditions are associated with light winds, the model has the potential to significantly overstate impacts at long distances downwind from the source. Since this problem leads to an overstatement of impacts rather than an understatement of impacts, this does not create a significant problem for environmental impact assessment. However, it should be borne in mind that there is a potential to overstate impacts at more distant receptors.

7.2 Assessing worst-case 24-hour PM_{10} concentrations

The ISC model also has the capacity to take into account emissions that vary in time, or with meteorological conditions. This has proved particularly useful for simulating emissions on mining operations where wind speed is an important factor in determining the rate at which dust is generated.

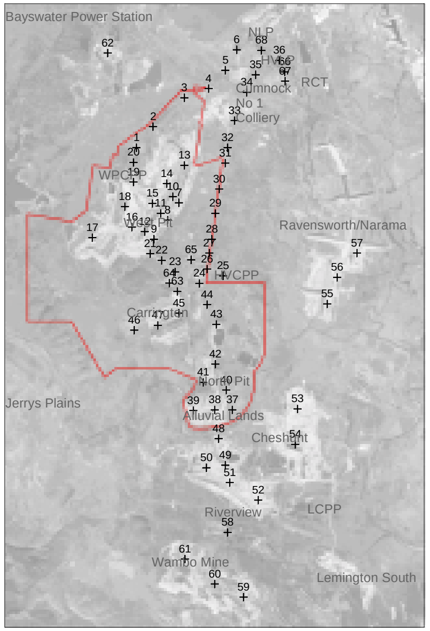
For the current study the mine was represented by a series of between 68 and 73 volume sources depending on which year is being simulated. **Figure 5** shows the location of these sources for each year. Each volume source was a combination of all dust emissions from activities in the general area. Estimates of emissions for each volume were developed on an hourly time step. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of mining activity and the wind speed. It is important to do this in the ISC model to ensure that long-term average emission rates are not combined with worst-case dispersion conditions which are associated with light winds. Light winds in a mining area correspond with periods of low dust generation (because wind erosion and other wind dependent emissions rates will be low) and also correspond with periods of poor dispersion. If these measures are not taken into account then the model has the potential to significantly overstate impacts.

A calibration study was undertaken as part of the Warkworth EIS (**Holmes Air Sciences, 2002**). This was done by comparing the predicted maximum 24-hour average PM_{10} concentrations in the period 1 November 2000 to 31 October 2001 at the Warkworth Mine monitors at HV1 and HV2 and at the Mount Thorley Operations monitors at Lot 543 and Bulga. The maximum measured PM_{10} concentration at the Bulga monitoring site and the maximum measured TSP concentrations at all four sites over the same period were then determined by inspection of the monitoring data records. (Note, PM_{10} concentrations are only measured at the Bulga monitoring site, the other sites measure TSP only). The TSP concentrations have been converted to equivalent PM_{10} concentrations assuming that PM_{10} constitutes 40% of the TSP in this area. The results are shown in **Table 13.**

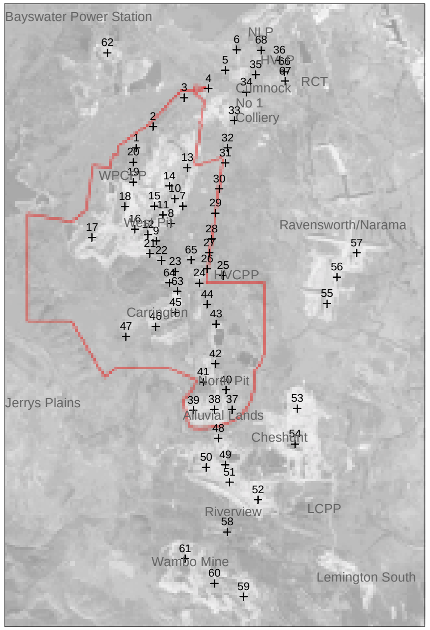
Table 13: Comparison of maximum measured (or inferred) and maximum predicted 24-hour PM_{10} concentrations (1 Nov 2000 to 31 Oct 2001) - Warkworth

Site	Maximum predicted 24-hour PM_{10} - $\mu g/m^3$	Maximum measured or inferred 24-hour PM_{10} - $\mu g/m^3$	Ratio of predicted to measured concentration
HV1	100	170 x 0.4 = 68	1.5
HV2	140	140 x 0.4 = 56	2.5
Bulga PM_{10}	160	44 (direct measurement)	3.6
Bulga TSP	160	102 x 0.4 = 41	3.9
Lot 543	95	138 x 0.4 = 55	1.7
Average			2.6

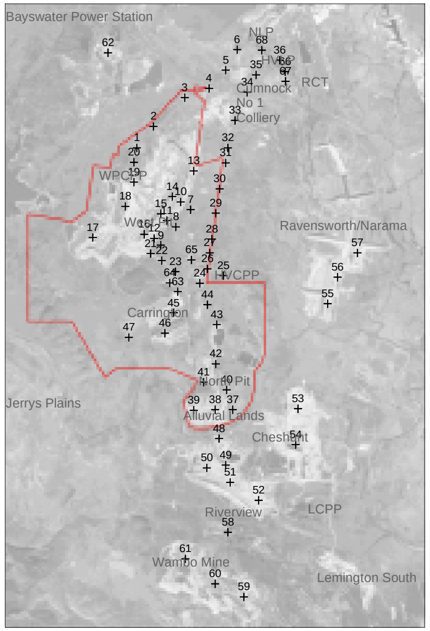
The average extent of over prediction was a factor of 2.6, that is, unadjusted model predictions appear to over predict 24-hour PM_{10} concentrations by 260%. This factor was used to adjust the model predictions for the Warkworth EIS downwards to obtain a calibrated prediction of the worst-case 24-hour PM_{10} concentrations for all five years that were assessed. This same factor has been used for the current assessment.



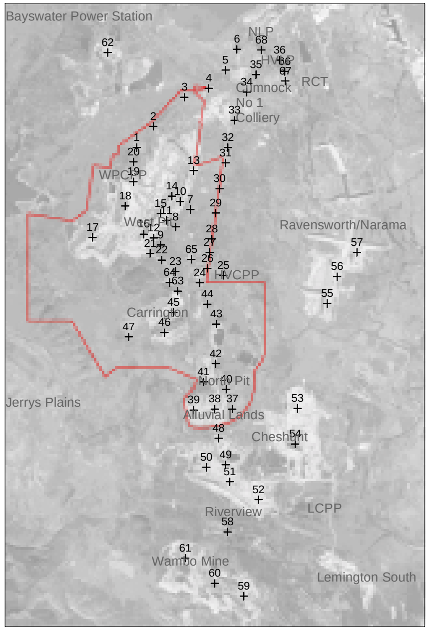
Year 1



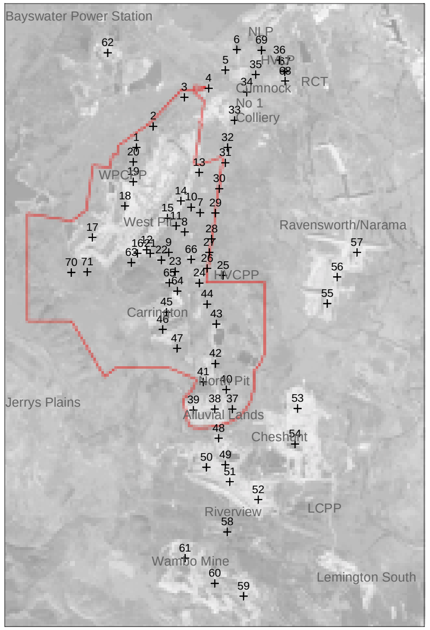
Year 3



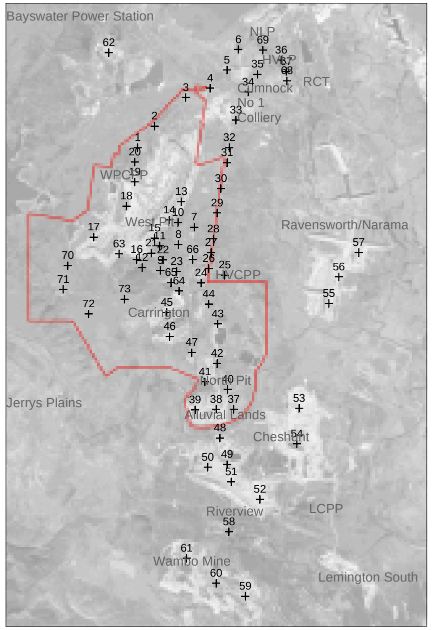
Year 8



Year 8 (alternative option)



Year 14



Year 20

Assumed source locations

Figure 5

8 ASSESSMENT OF IMPACTS – PARTICULATE MATTER

8.1 Introduction

Dispersion model simulations have been undertaken for Years 1, 3, 8, 8 (alternative), 14, and 20. This section provides an interpretation of the predicted contours of dust concentration (PM_{10}, and TSP) and dust deposition produced by these simulations. In presenting the assessment, contours firstly have been provided showing the predicted effects of the Proposal considered in isolation. In this context the Proposal is taken to be the all HVO operations north of the Hunter River. These predictions are then followed by predictions that represent the Proposal considered with other neighbouring mines including an allowance for remote mines and non-mining sources of dust. Thus for each of the five years, isopleth diagrams have been produced showing the following:

1. The predicted maximum 24-hour average PM_{10} concentration for the Proposal alone;
2. The predicted maximum 24-hour average PM_{10} concentration for the Proposal with other sources of PM;
3. The predicted annual average PM_{10} concentration for the Proposal;
4. The predicted annual average PM_{10} concentration for the Proposal with other sources of PM;
5. The predicted annual average TSP concentration for the Proposal;
6. The predicted annual average TSP concentration for the Proposal with other sources of PM;
7. The predicted annual average dust deposition for the Proposal, and;
8. The predicted annual average dust deposition for the Proposal with other sources of PM.

Similar predictions for 24-hour and annual average $PM_{2.5}$ concentrations for the Proposal by itself and the Proposal considered with the effects of other mines are provided in **Appendix A**.

8.2 Assessment criteria

The air quality criteria used for deciding which properties are likely to experience air quality impacts are those specified in the EPA's modelling guidelines as interpreted by recent conditions of consent for mines in the Hunter Valley (see **Table 1**, **2**, and **3** and the discussion below). The criteria are:

- 50 $\mu g/m^3$ for 24-hour PM_{10} for the Proposal considered alone;
- 150 $\mu g/m^3$ for 24-hour PM_{10} for the Proposal considered with the contributions of other sources;
- 30 $\mu g/m^3$ for annual average PM_{10} due to the Proposal and other sources;
- 90 $\mu g/m^3$ for annual TSP concentrations due to the Proposal and other sources;
- 2 g/m^2/month for annual average deposition (insoluble solids) due to the Proposal considered alone; and
- 4 g/m^2/month for annual predicted cumulative deposition (insoluble solids) due to the Proposal and other source levels.

Following practice established in recent conditions of consent, with the exception of the 2 g/m^2/month goal and the 24-hour PM_{10}, the standards/goals are interpreted to be cumulative standards/goals.

The 24-hour PM_{10} criterion of 50 $\mu g/m^3$ is interpreted as being applicable to the Proposal when considered in isolation and the US EPA 24-hour PM_{10} standard of 150 $\mu g/m^3$ has been taken to be the cumulative criterion.

In assessing impacts the approach has been to first show the predicted effects for the Proposal considered in isolation and then to consider the effects of the Proposal with other sources. It is useful to bear in mind, that because of the prevailing winds, the main areas where impacts would be expected are to the southeast and northwest, which are generally associated with the active mining areas. In most cases impacts are the consequence of several sources of dust including other mines and non-mining sources, but in most cases one source can be seen to be responsible for the majority of the effect.

Rather than provide a detailed discussion of each isopleth figure the results have been summarised in tabular form for each year showing the residences located in the area and highlighting those that are predicted to experience particulate matter deposition or concentration levels above the EPA's assessment criteria.

8.3 Assessment locations

The contour plots of dust concentrations and deposition levels show the areas of land that are affected by dust at different levels. However, concentration and deposition levels at residences are of particular interest. The locations of neighbouring residences are shown in **Figure 2**.

Table 14 shows the same information about the locations of residences and reference sites as does **Figure 1** and identifies those residences that are currently within an existing zone of affectation or under a negotiated agreement concerning environmental impacts.

Table 14: Locations of neighbouring residences and other reference sites			
Residence ID (see Figure 1)	**ISG Easting (m)**	**ISG Northing (m)**	**Zone of Affectation or negotiated agreements**
1	292153	1402554	
2	292801	1401825	
3	293074	1401571	
4	293884	1400207	
5	305645	1399385	
6	305748	1400194	
7	303750	1403450	Agreement with Xstrata
8	301500	1404300	Ravensworth West Zone of Affectation & agreement with CNA
9	295525	1403350	Carrington Zone of Affectation
10	294700	1402575	Carrington Zone of Affectation
11	294850	1399525	Agreement with CNA
12	301150	1402050	Cheshunt Zone of Affectation & agreement with CNA

8.4 Year 1

Figures 6 to **13** show the predicted model results for Year 1. This includes the cumulative effect including the emissions from HVO north of the Hunter River, Riverview, Cheshunt, Wambo, United, Ravensworth-Narama and an allowance for remote mines and non-mining sources. For convenience, **Table 15** summarises the results highlighting those residences that are predicted to experience exceedances of any of the assessment criteria.

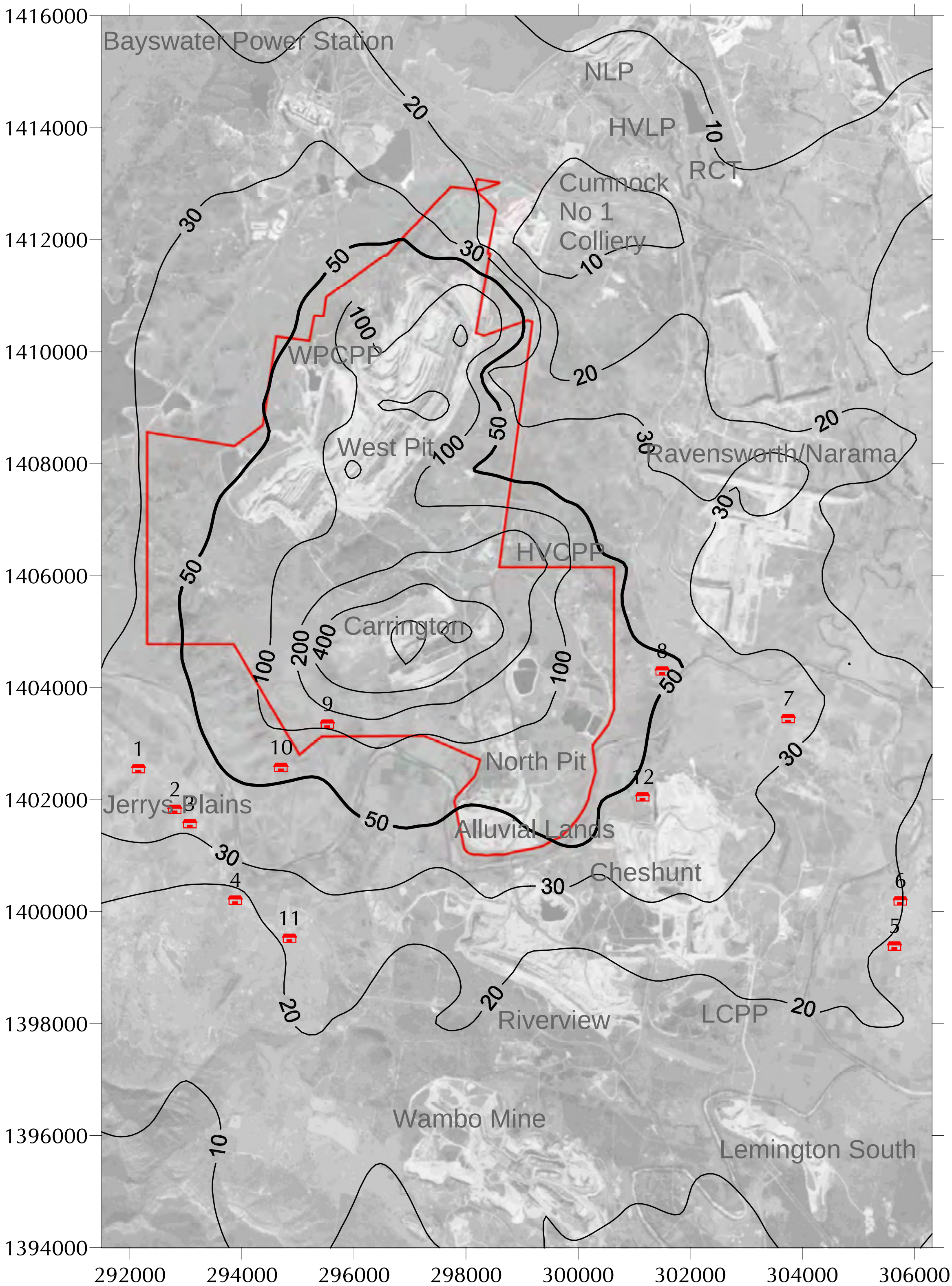
The table shows that Residences 8, 9 and 10 are predicted to experience exceedances of the EPA's 50 $\mu g/m^3$ 24-hour PM_{10} criterion due to emissions from the HVO north of the Hunter River. These residences are already within an existing zone of affectation or have agreements with mining companies.

With the Proposal and other sources, Residence 12 is predicted to experience 24-hour average PM_{10} concentrations above the US EPA's assessment criterion of 150 $\mu g/m^3$ and Residence 9 and 12 are predicted to experience annual average PM_{10} concentrations above the EPA's assessment criterion of 30 $\mu g/m^3$. In addition, Residence 12 is predicted to experience exceedances of EPA's assessment criteria for annual average TSP and dust deposition. The contribution the HVO north of the Hunter River makes to these exceedances is small.

Table 15: Summary of affected residences for Year 1

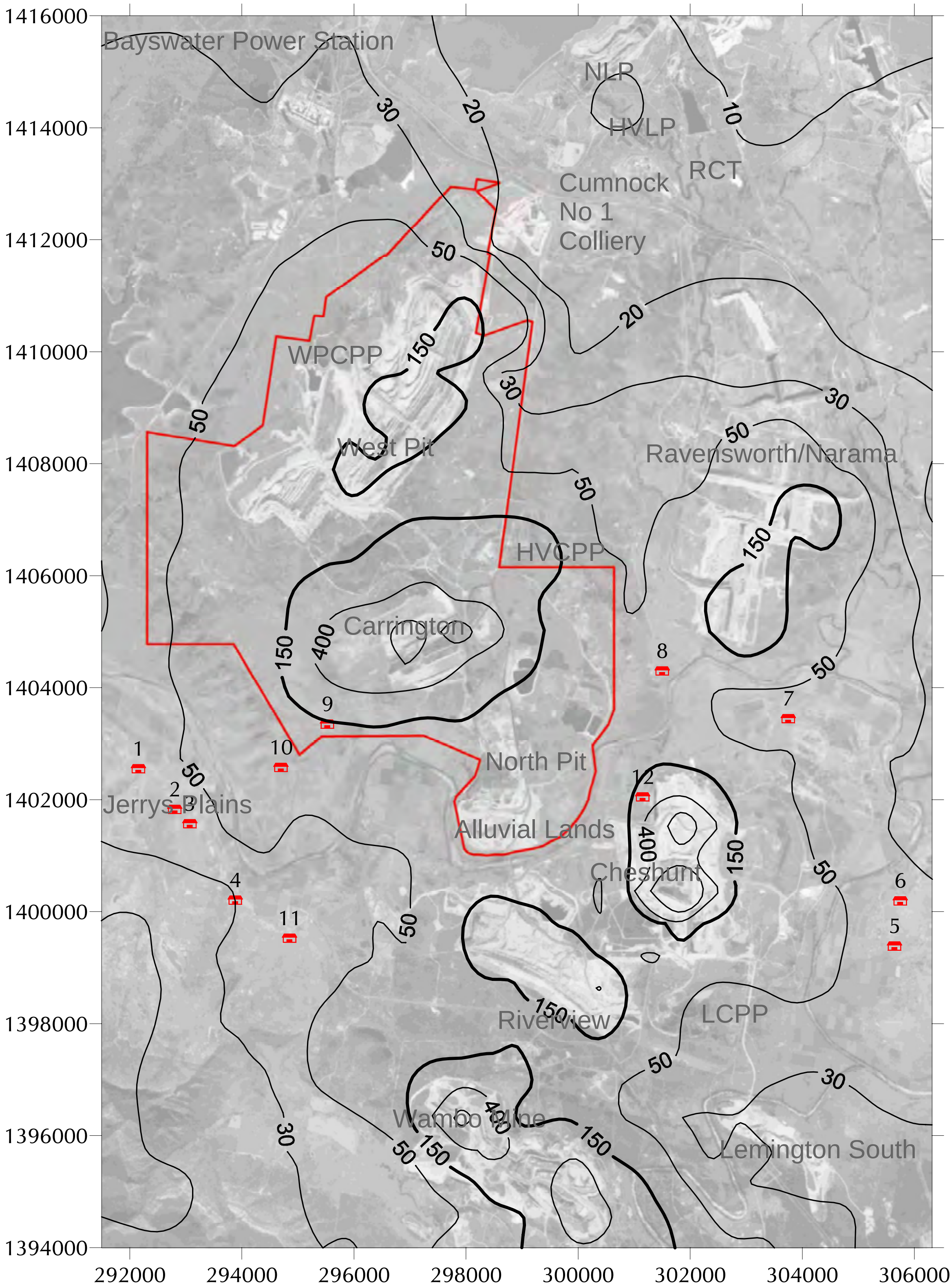
ID	Proposal in isolation in Year-1				Proposal with other sources in Year-1			
	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year
	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	g/m^2/month	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	g/m^2/month
Goal	*50*	*30*	*90*	*2*	*150*[(a)]	*30*	*90*	*4*
1	39.0	3.2	3.4	0.03	45.0	9.9	10.9	0.18
2	34.8	3.4	3.6	0.03	42.6	11.0	12.1	0.21
3	32.4	3.0	3.2	0.03	43.1	10.9	12.1	0.22
4	18.1	3.0	3.1	0.02	30.5	13.0	14.4	0.27
5	19.6	7.6	8.9	0.33	42.0	18.8	22.1	0.86
6	20.1	8.3	9.7	0.36	36.2	17.8	20.8	0.72
7	32.2	11.9	13.8	0.49	43.7	19.3	21.9	0.64
8	**52.6**	17.6	21.0	0.85	58.1	29.9	34.1	1.05
9	**123.8**	20.5	23.3	0.00	133.7	**34.4**	38.4	0.65
10	**58.9**	6.7	6.9	0.00	69.5	19.9	21.4	0.31
11	23.3	3.4	3.5	0.03	37.2	16.5	18.5	0.38
12	47.0	20.3	24.5	1.17	**226.5**	**115.0**	**154.6**	**6.91**

(a) US EPA 24-hr ambient air quality standard (99th percentile over 3 years)



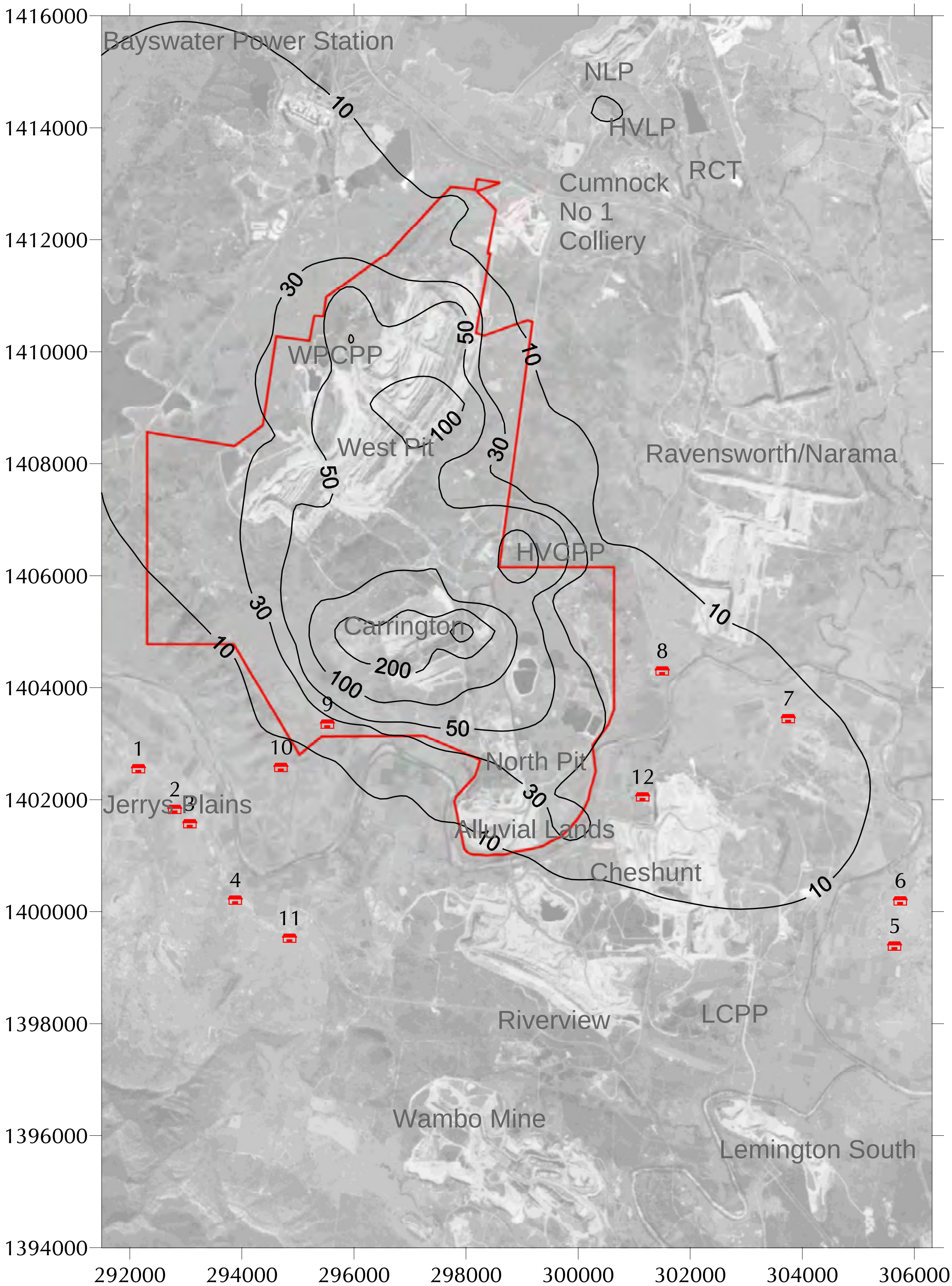
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal in Year 1 ($\mu g/m^3$)

Figure 6



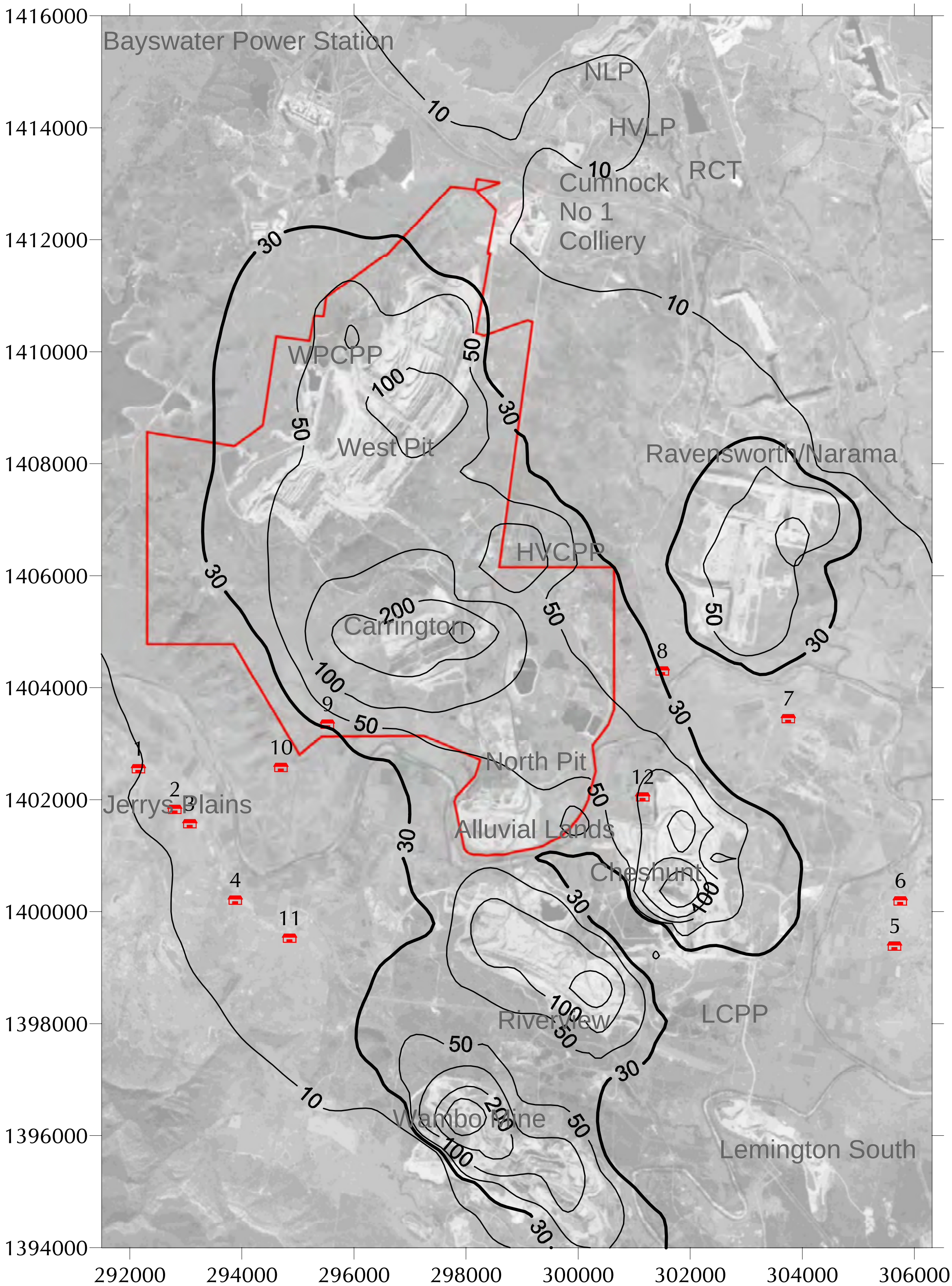
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal and other sources in Year 1 ($\mu g/m^3$)

Figure 7



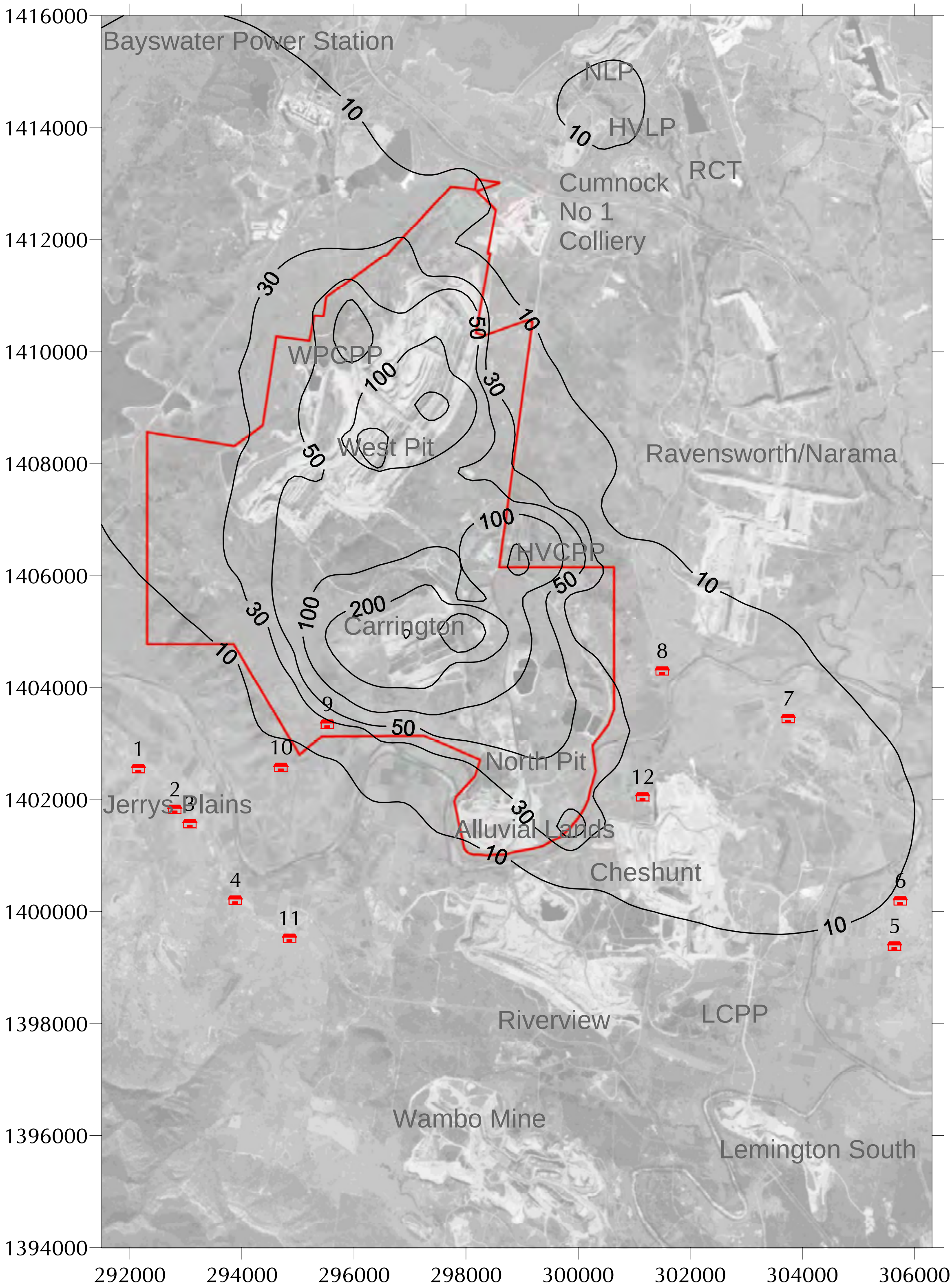
Predicted annual average PM_{10} concentrations due to emissions from the Proposal in Year 1 ($\mu g/m^3$)

Figure 8



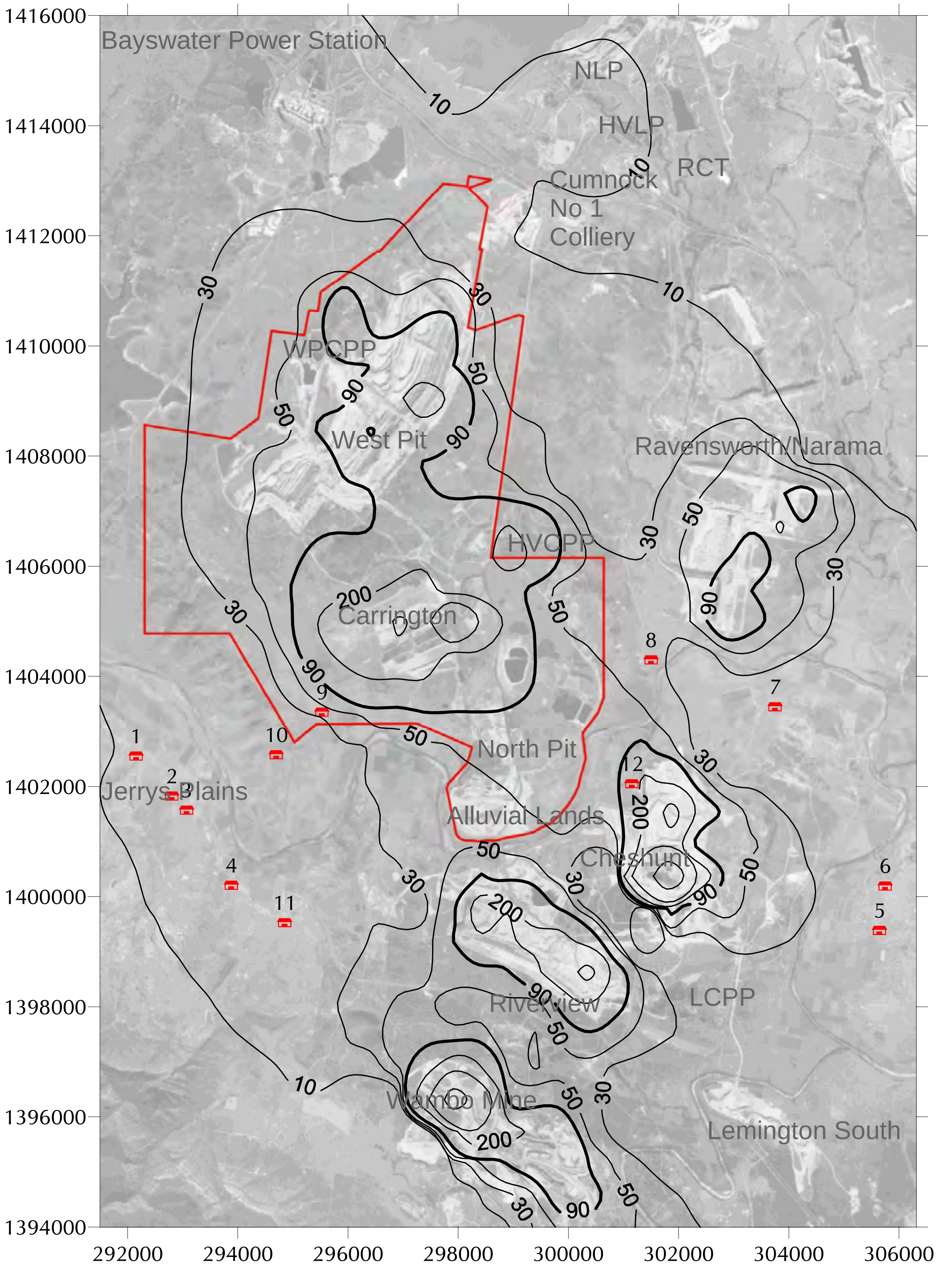
Predicted annual average PM_{10} concentrations due to emissions from the Proposal and other sources in Year 1 ($\mu g/m^3$)

Figure 9



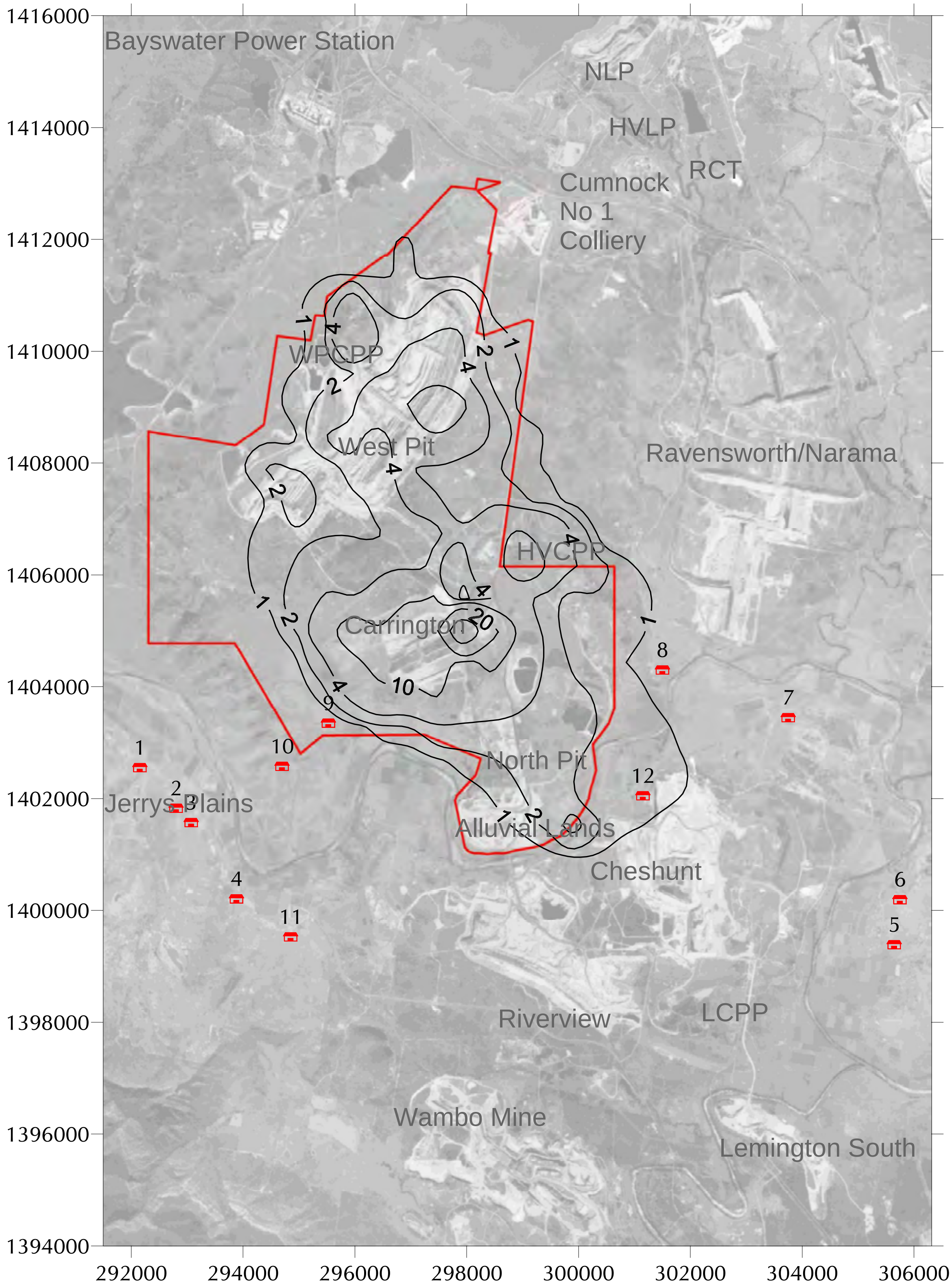
Predicted annual average TSP concentrations
due to emissions from the Proposal in Year 1 ($\mu g/m^3$)

Figure 10



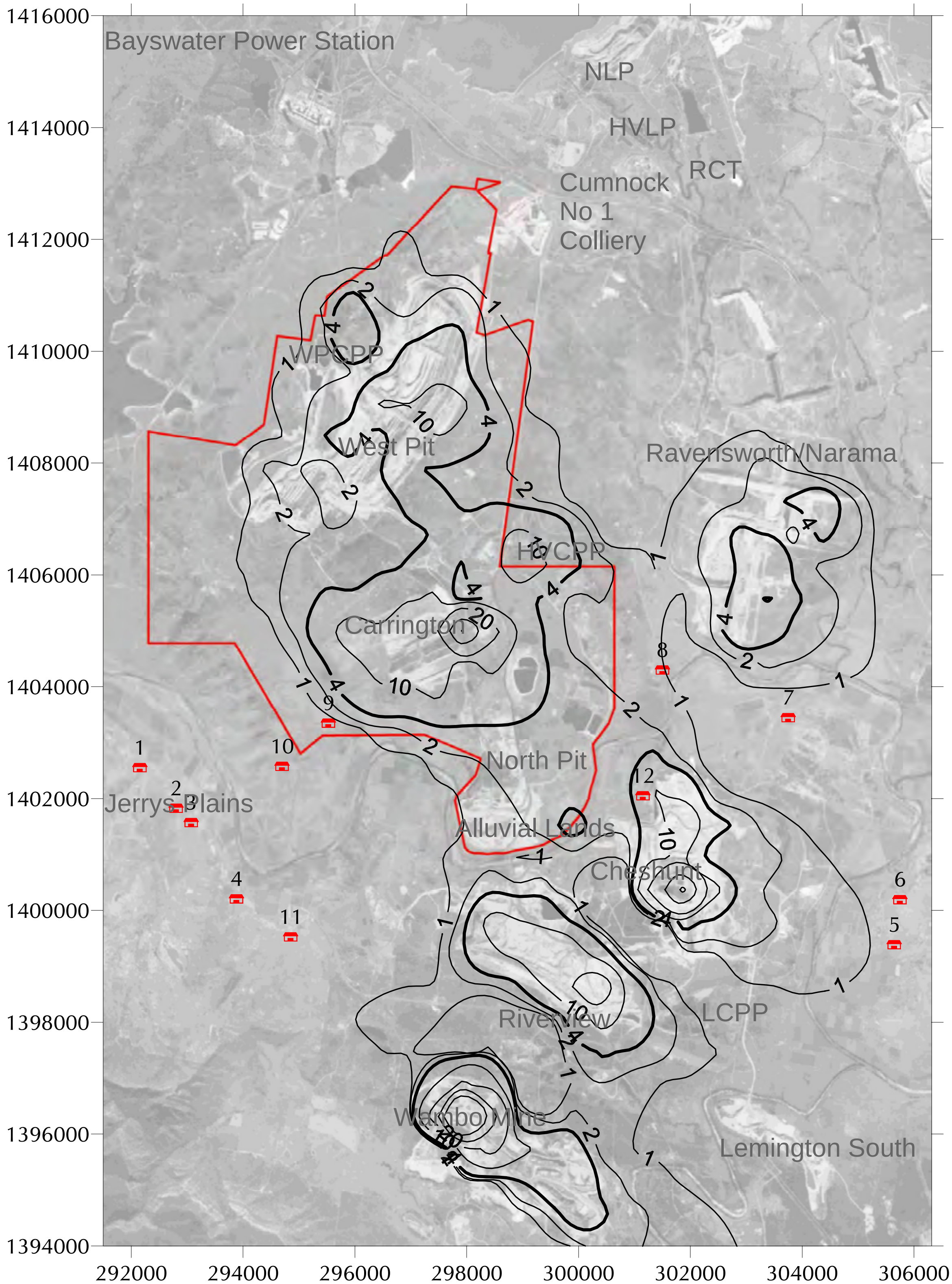
Predicted annual average TSP concentrations
due to emissions from the Proposal and other sources in Year 1 (μg/m^3)

Figure 11



Predicted annual average dust deposition
due to emissions from the Proposal in Year 1 (g/m^2/month)

Figure 12



Predicted annual average dust deposition due to emissions from the Proposal and other sources in Year 1 (g/m²/month)

Figure 13

8.5 *Year 3*

Figures 14 to **21** show the predicted model results for Year 3.

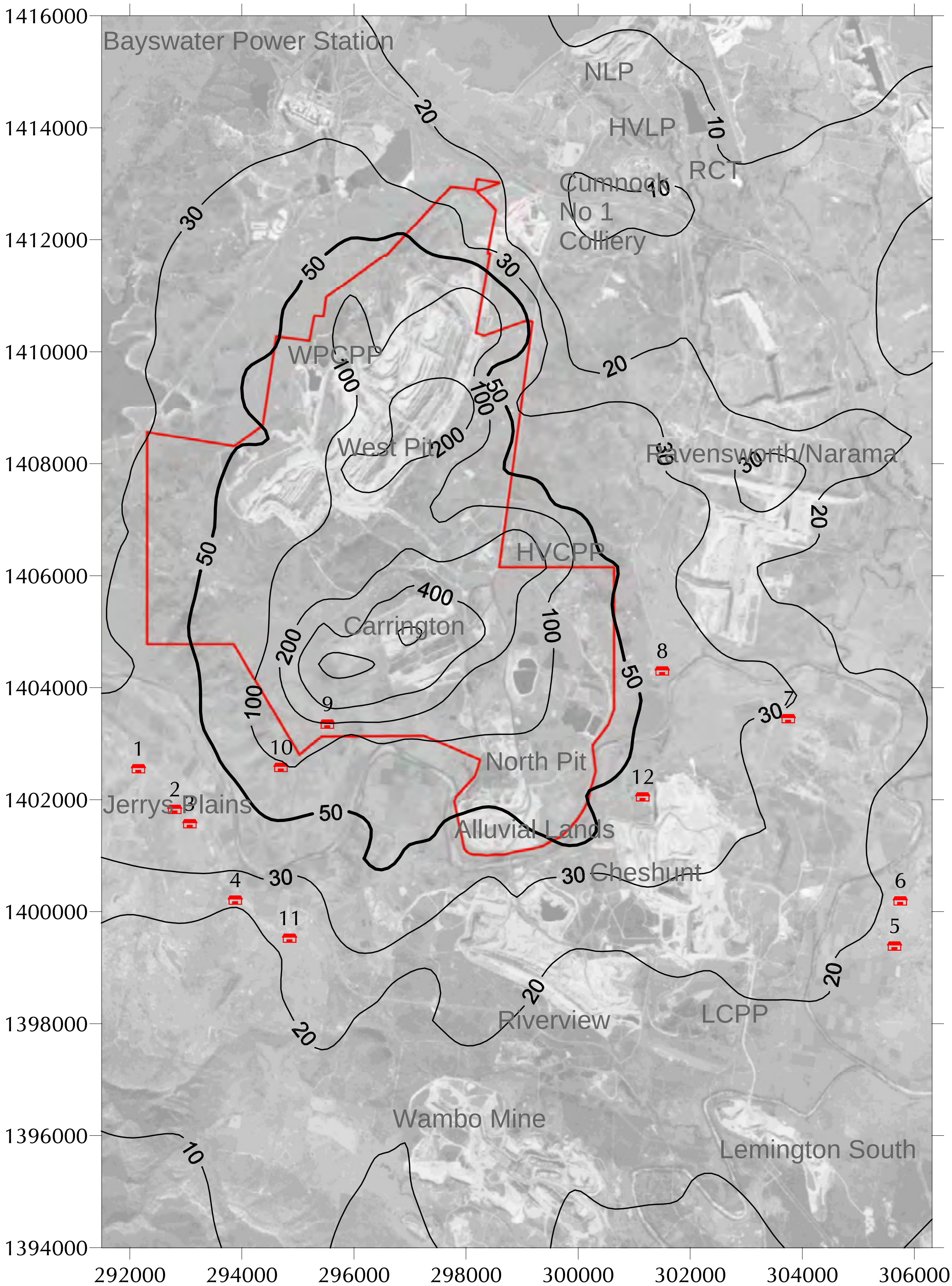
Table 16 summarises the results for Year 3. Residences 9 and 10 are predicted to experience exceedances of the EPA's 50 $\mu g/m^3$ 24-hour PM_{10} assessment criterion due to emissions from HVO north of the Hunter River. Residence 9 is also predicted to experience annual average concentrations of PM_{10} above the EPA's assessment criterion of 30 $\mu g/m^3$. As discussed before, these residences are already within an existing zone of affectation or have agreements with mining companies.

With the Proposal and other sources, Residences 9 and 12 are predicted to experience 24-hour average PM_{10} concentrations above the US EPA's assessment criterion of 150 $\mu g/m^3$ and Residences 9 and 12 are also predicted to experience annual average PM_{10} concentrations above the EPA's assessment criterion of 30 $\mu g/m^3$. In addition, Residence 12 is predicted to experience exceedances of EPA's assessment criteria for annual average TSP and dust deposition. The contribution the HVO north of the Hunter River makes to these exceedances is small.

Table 16: Summary of affected residences for Year 3

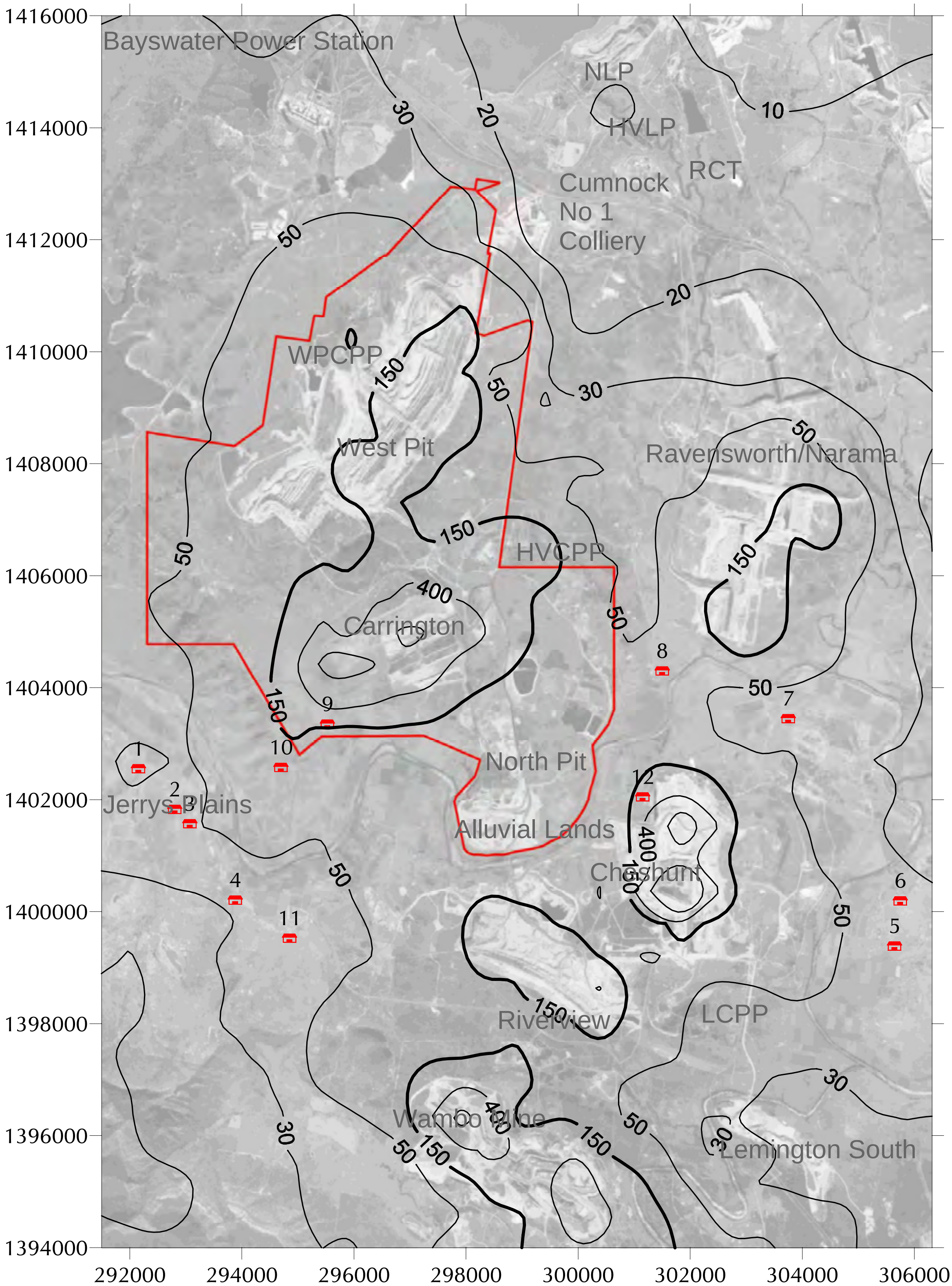
	Proposal in isolation in Year-3				Proposal with other sources in Year-3			
	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year
ID	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	g/m^2/month	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	g/m^2/month
Goal	*50*	*30*	*90*	*2*	*150*[(a)]	*30*	*90*	*4*
1	45.6	3.5	3.6	0.03	52.1	10.2	11.2	0.18
2	39.1	3.6	3.8	0.03	46.3	11.2	12.3	0.21
3	38.1	3.2	3.4	0.03	48.6	11.1	12.3	0.22
4	21.6	3.2	3.4	0.03	32.1	13.2	14.7	0.28
5	18.4	7.7	9.0	0.33	41.2	18.9	22.2	0.86
6	18.7	8.4	9.7	0.35	36.0	17.9	20.8	0.71
7	29.1	12.0	14.0	0.50	42.0	19.5	22.2	0.66
8	46.4	17.4	20.8	0.86	55.4	29.7	33.9	1.06
9	**186.7**	**41.3**	52.7	1.70	**192.1**	**55.2**	67.8	1.97
10	**93.0**	7.7	0.0	0.00	102.1	20.9	22.1	0.00
11	22.9	3.5	3.6	0.03	35.6	16.7	18.7	0.39
12	42.7	20.2	24.4	1.12	**226.7**	**114.9**	**154.5**	**6.86**

(a) US EPA 24-hr ambient air quality standard (99th percentile over 3 years)



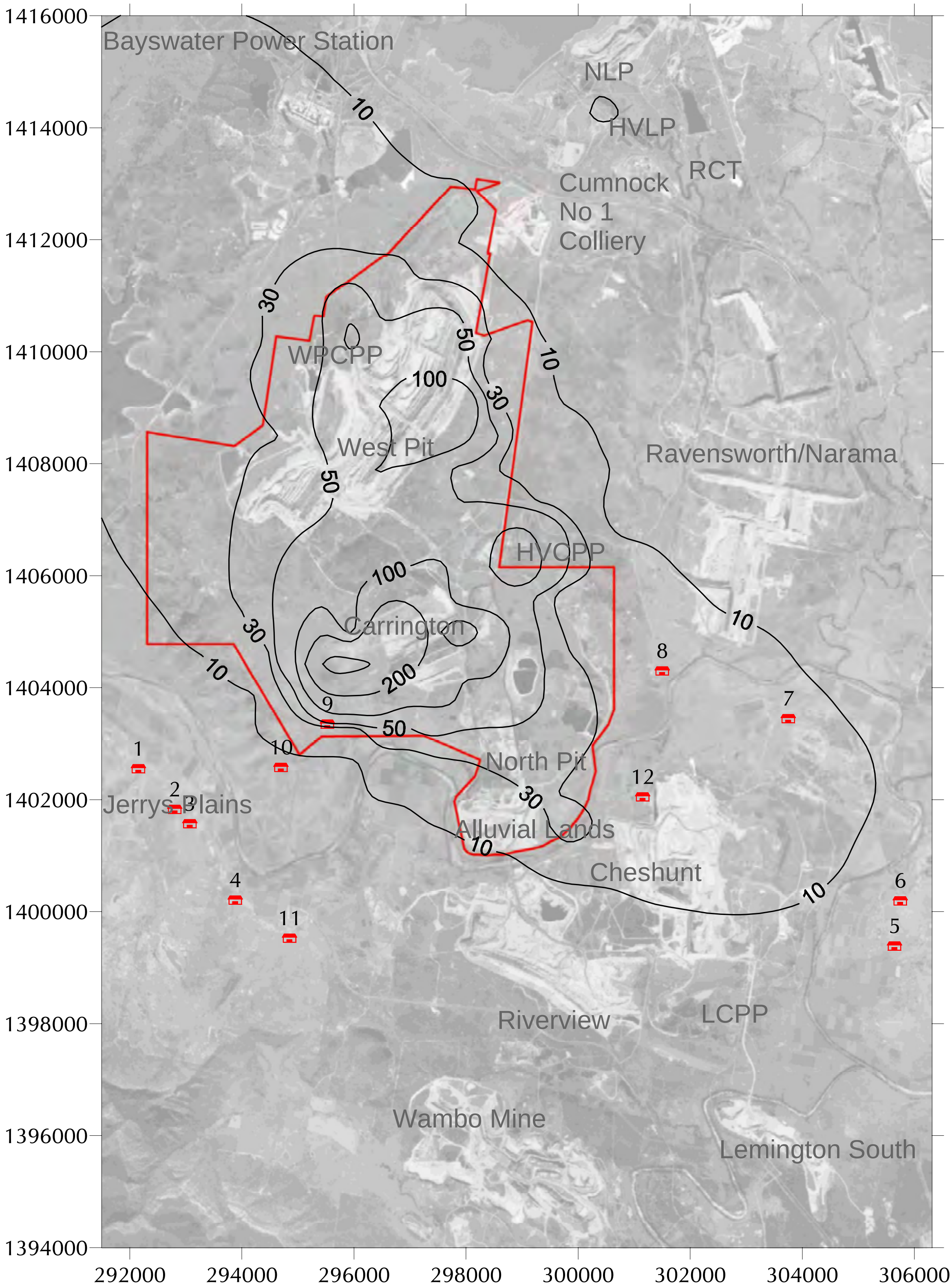
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal in Year 3 ($\mu g/m^3$)

Figure 14



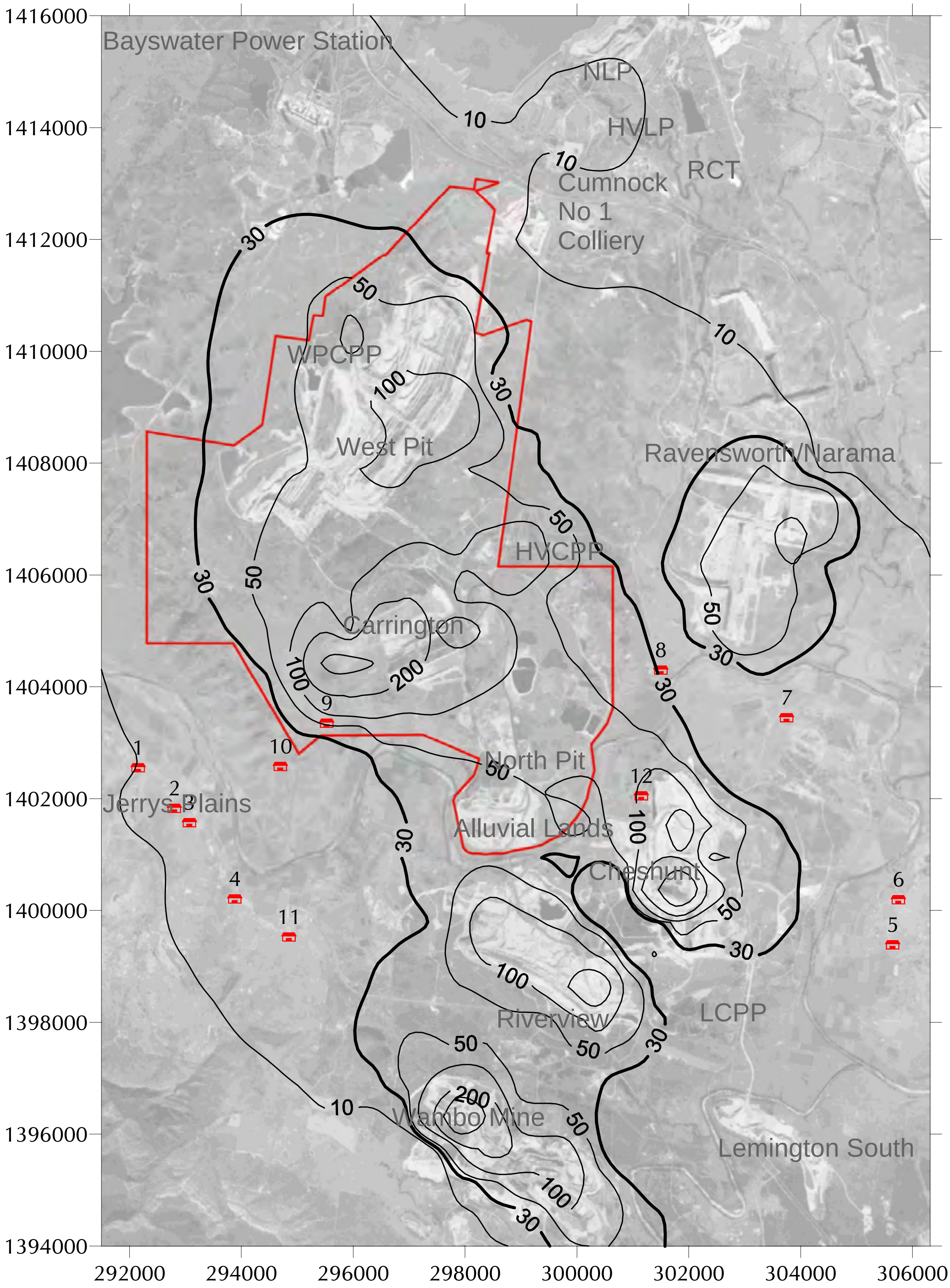
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal and other sources in Year 3 ($\mu g/m^3$)

Figure 15



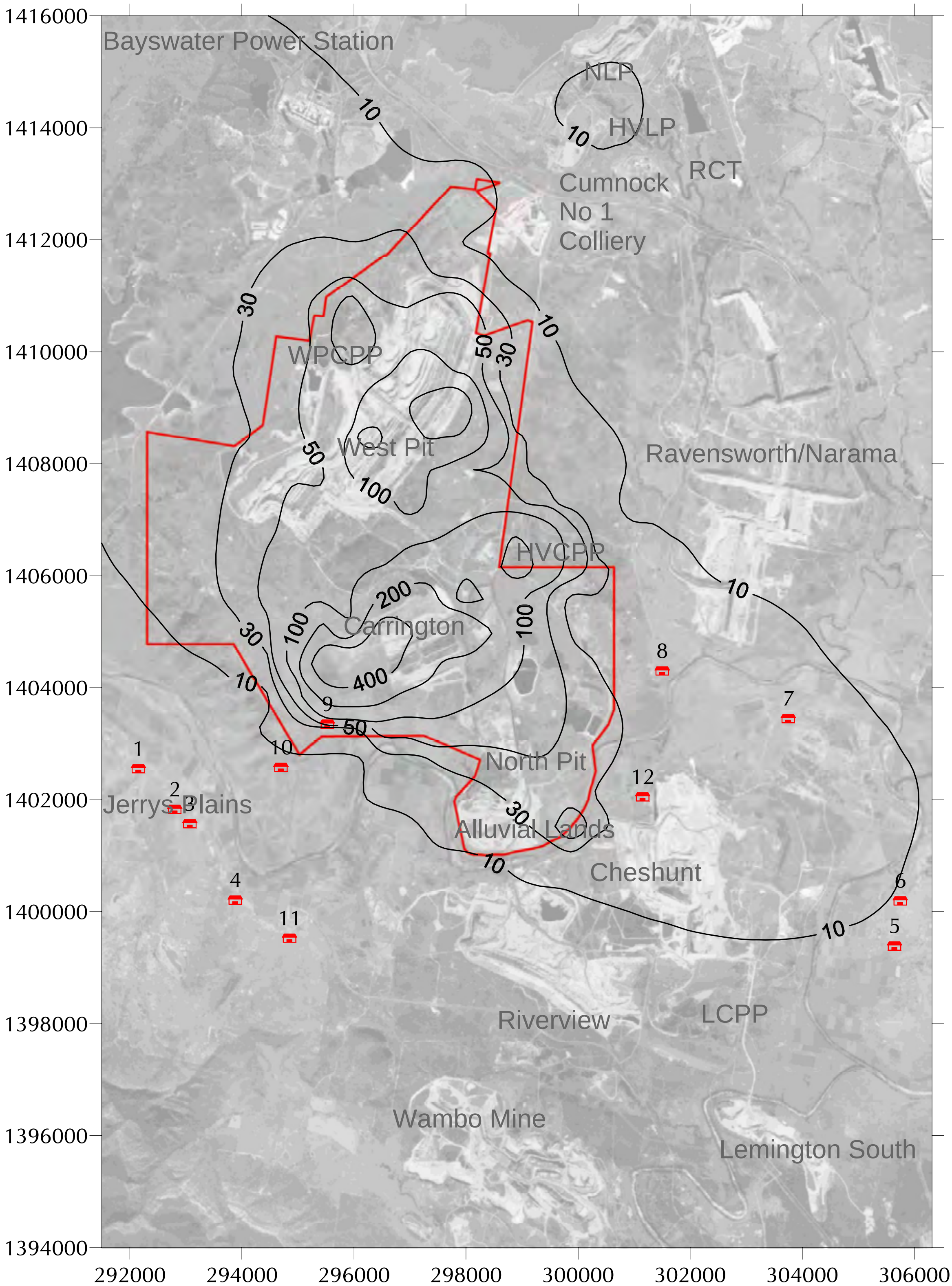
Predicted annual average PM_{10} concentrations due to emissions from the Proposal in Year 3 ($\mu g/m^3$)

Figure 16



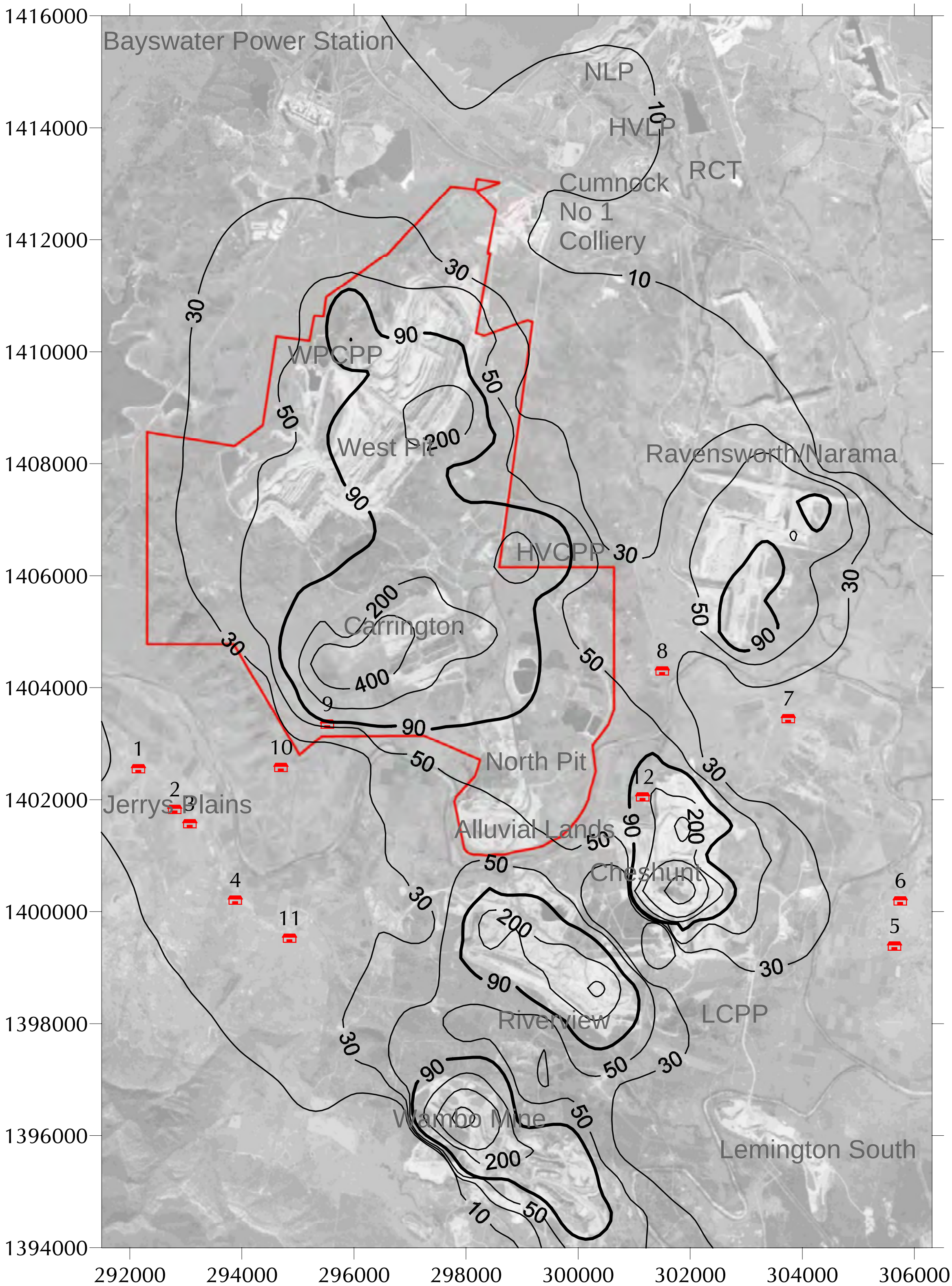
Predicted annual average PM_{10} concentrations due to emissions from the Proposal and other sources in Year 3 ($\mu g/m^3$)

Figure 17



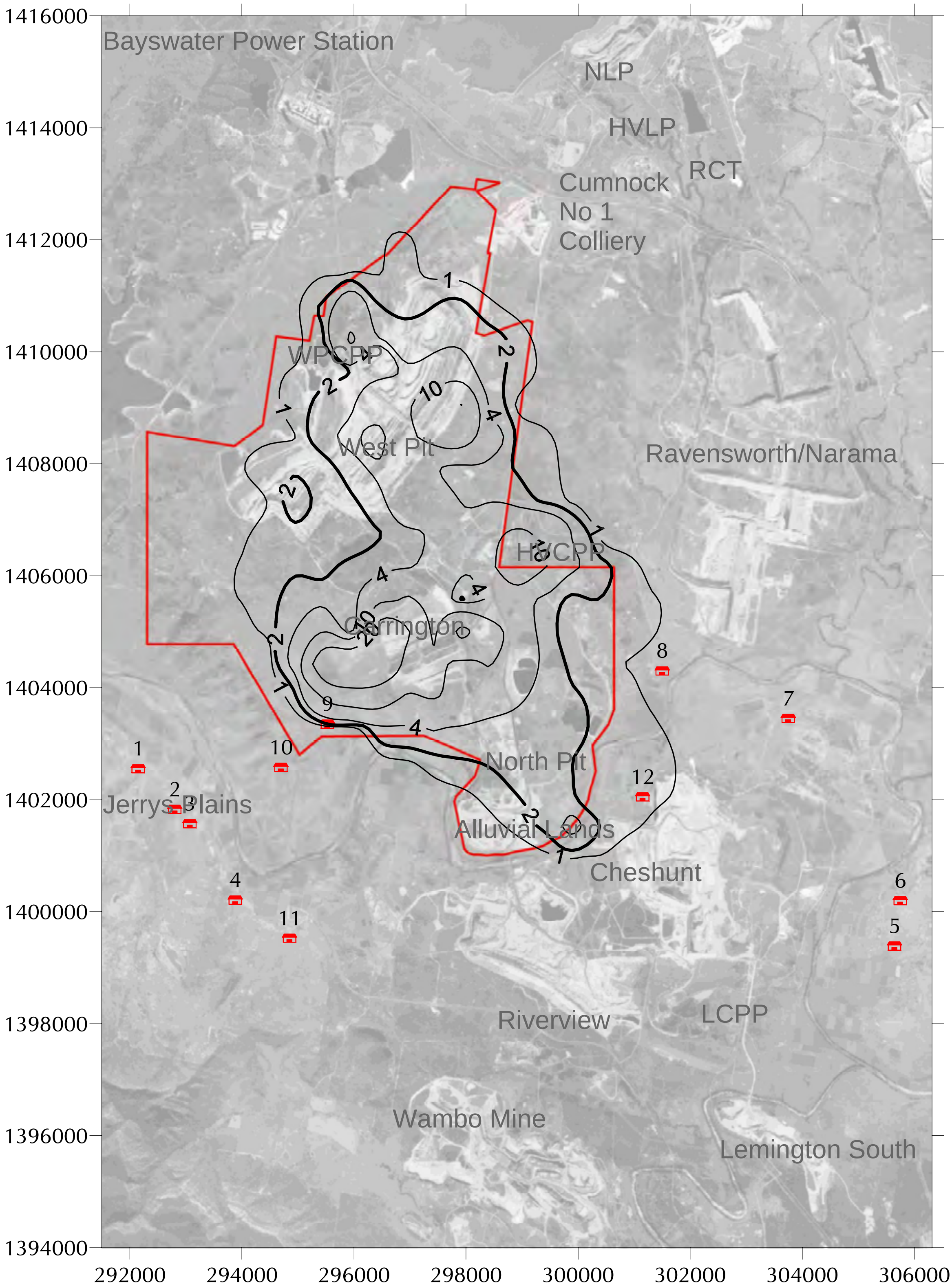
Predicted annual average TSP concentrations due to emissions from the Proposal in Year 3 ($\mu g/m^3$)

Figure 18



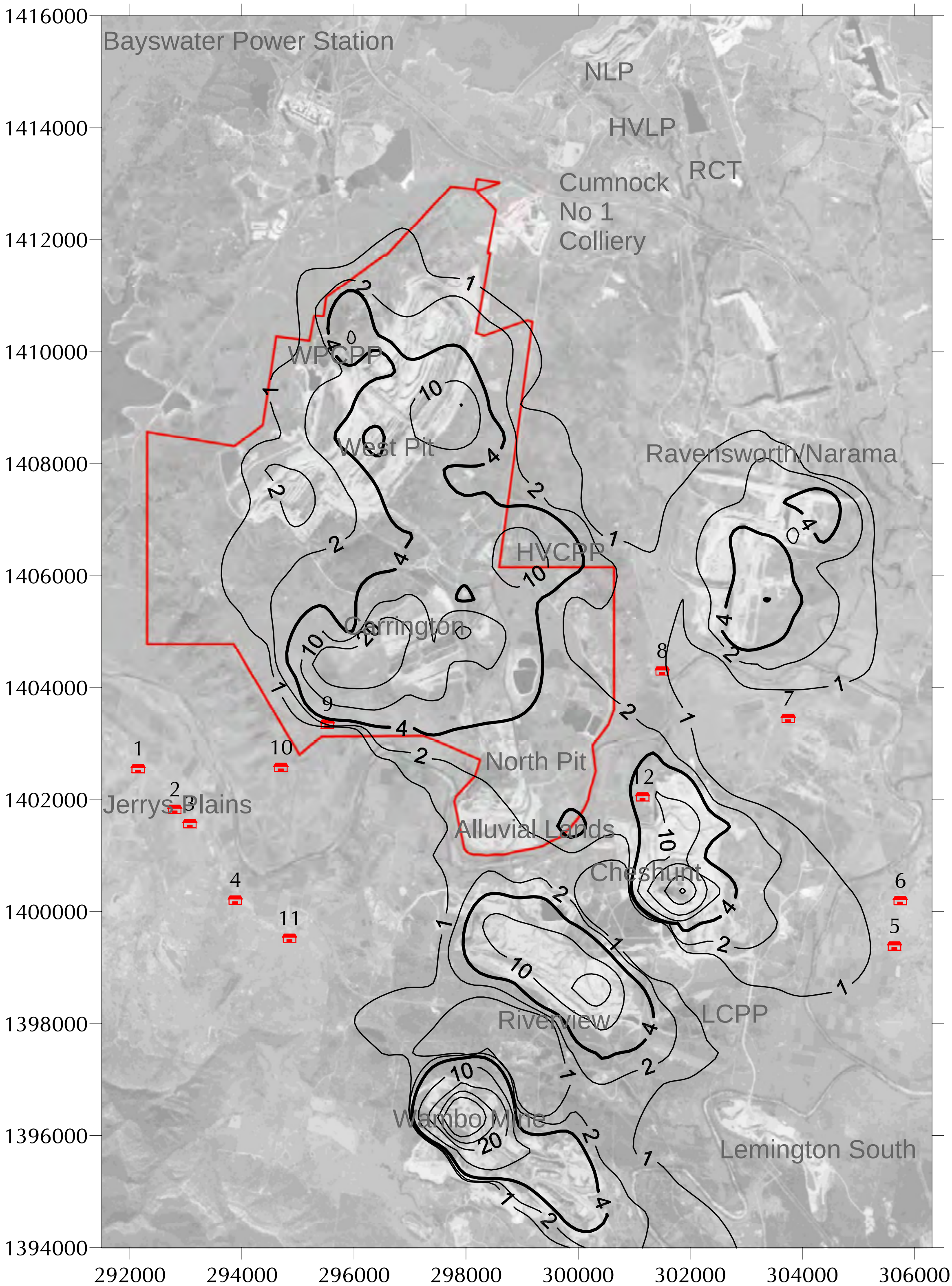
Predicted annual average TSP concentrations due to emissions from the Proposal and other sources in Year 3 (μg/m^3)

Figure 19



Predicted annual average dust deposition due to emissions from the Proposal in Year 3 (g/m²/month)

Figure 20



Predicted annual average dust deposition due to emissions from the Proposal and other sources in Year 3 (g/m²/month)

Figure 21

8.6 *Year 8 (without Carrington)*

Figures 22 to **29** show the predicted model results for Year 8 without Carrington operations.

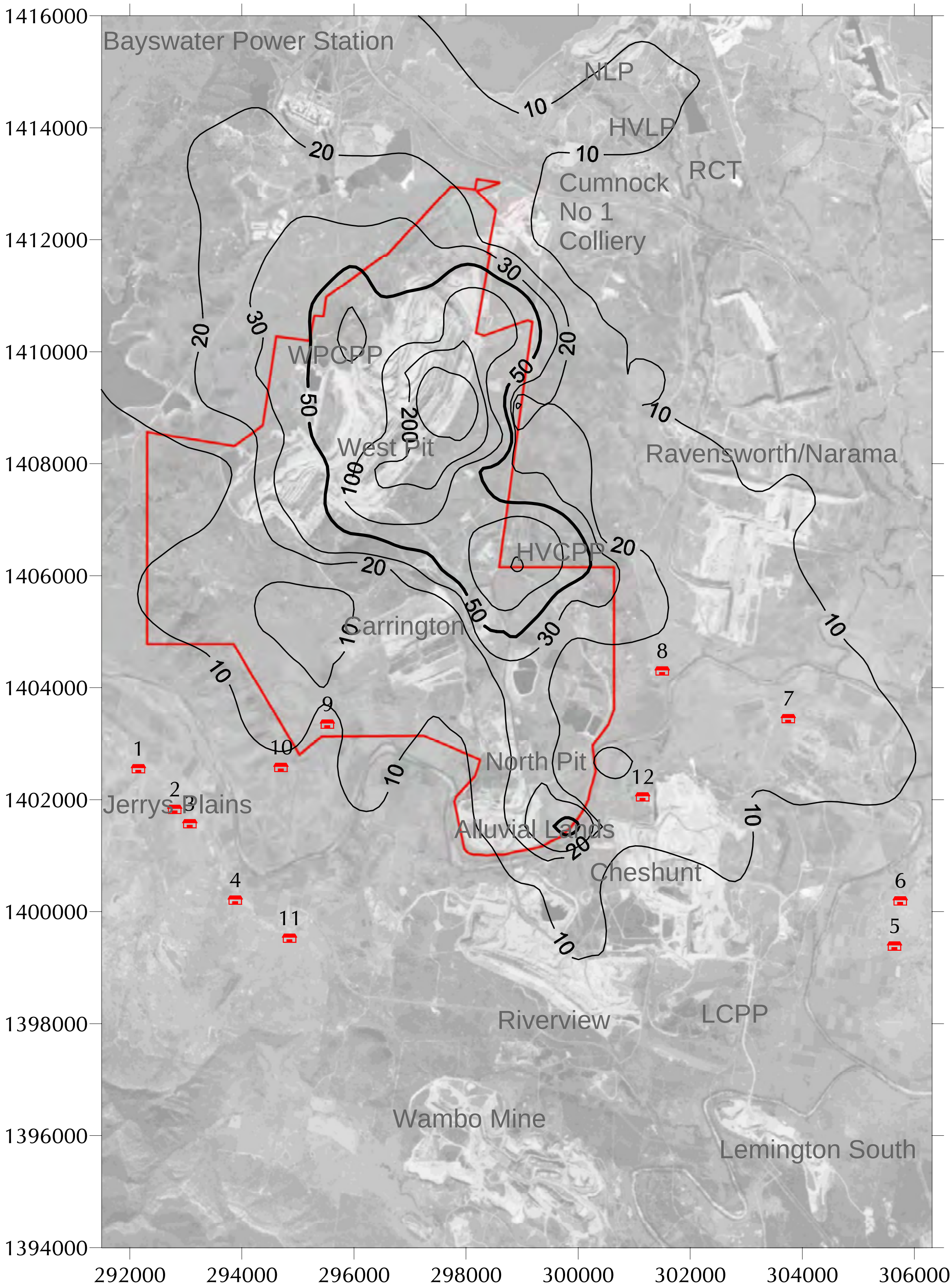
Table 17 summarises the results. No residences are predicted to experience exceedances of any of the EPA's assessment criterion due to emissions from HVO north of the Hunter River.

With the Proposal and other sources, Residence 12 is predicted to exceed the US EPA's 150 $\mu g/m^3$ 24-hour PM_{10} criterion and it is also predicted to experience annual average PM_{10} concentrations above the EPA's assessment criterion of 30 $\mu g/m^3$. In addition, Residence 12 is predicted to experience exceedances of EPA's assessment criteria for annual average TSP and dust deposition. The contribution the HVO north of the Hunter River makes to these exceedances is small and Residence 12 is already within an existing zone of affectation and has an agreement with the mining companies.

Table 17: Summary of affected residences for Year 8 (without Carrington)

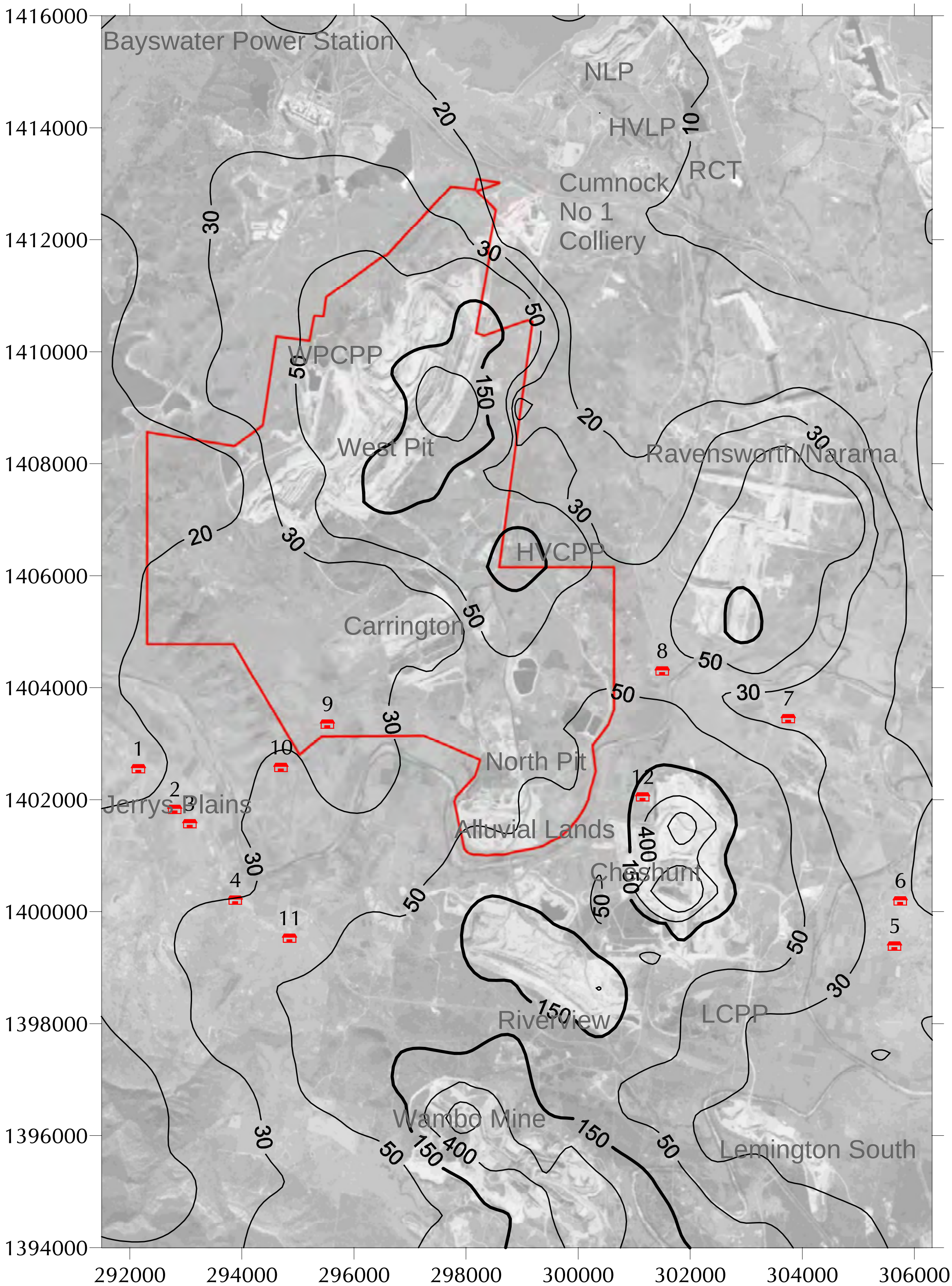
	Proposal in isolation in Year-8				Proposal with other sources in Year-8			
	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year
ID	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	g/m^2/month	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	g/m^2/month
Goal	*50*	*30*	*90*	*2*	*150*[(a)]	*30*	*90*	*4*
1	2.9	0.5	0.6	0.01	18.3	8.0	9.1	0.18
2	4.3	0.6	0.7	0.01	22.1	9.2	10.4	0.22
3	4.4	0.6	0.7	0.01	23.3	9.6	10.8	0.23
4	3.9	0.7	0.7	0.01	30.5	12.3	14.0	0.31
5	6.1	1.7	2.1	0.08	25.2	12.5	14.9	0.59
6	6.3	2.0	2.5	0.10	22.3	11.1	13.0	0.44
7	13.6	5.0	6.1	0.30	28.3	10.6	12.2	0.39
8	16.1	6.0	7.9	0.50	45.0	16.7	19.3	0.66
9	9.1	1.6	1.8	0.02	25.8	16.8	18.3	0.32
10	8.1	1.5	1.6	0.01	31.1	16.3	17.8	0.32
11	6.5	0.8	0.8	0.01	41.7	16.4	18.7	0.45
12	10.8	3.4	4.2	0.17	**225.5**	**97.7**	**133.9**	**5.91**

(a) US EPA 24-hr ambient air quality standard (99th percentile over 3 years)



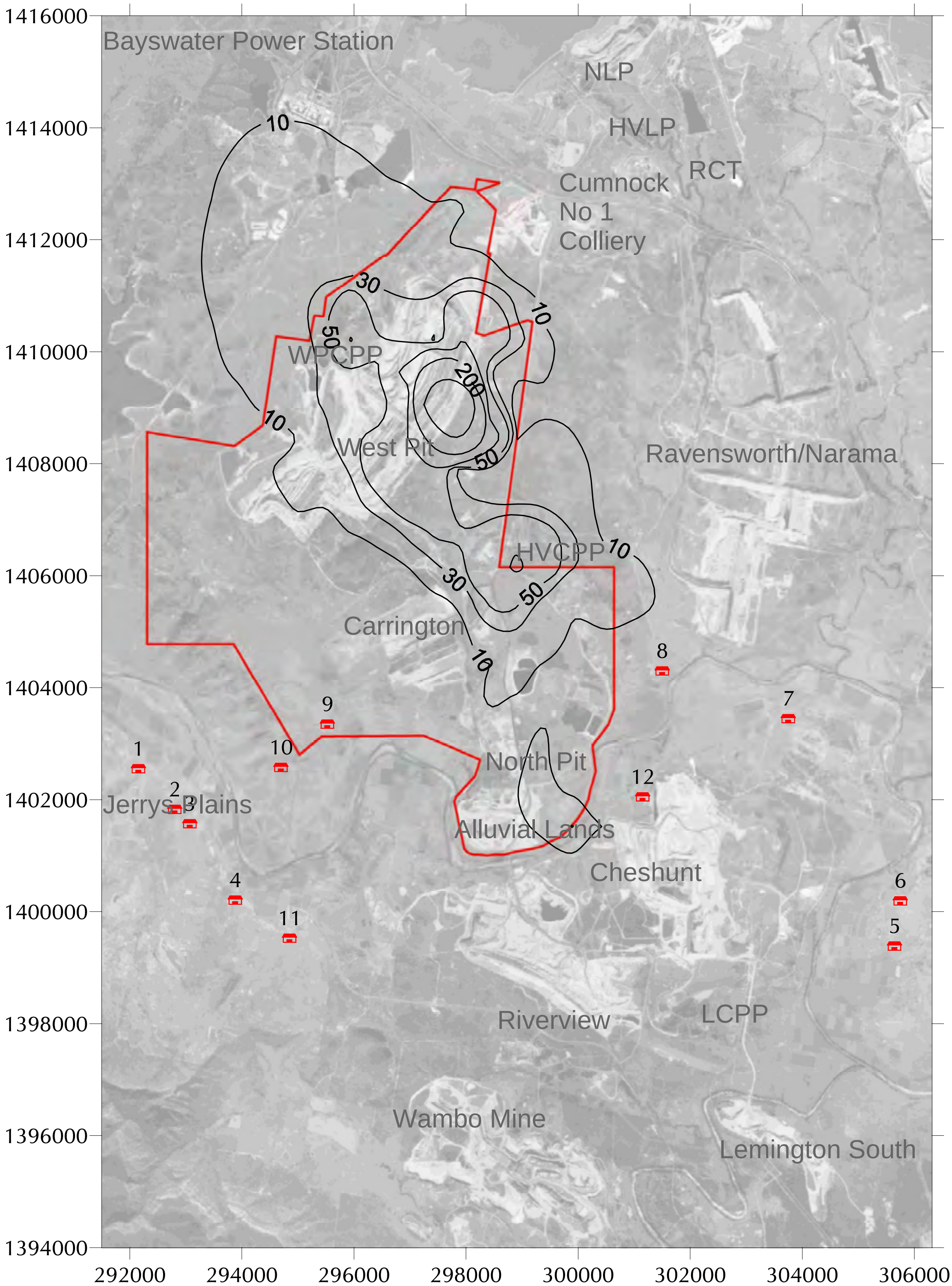
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal in Year 8 ($\mu g/m^3$)

Figure 22



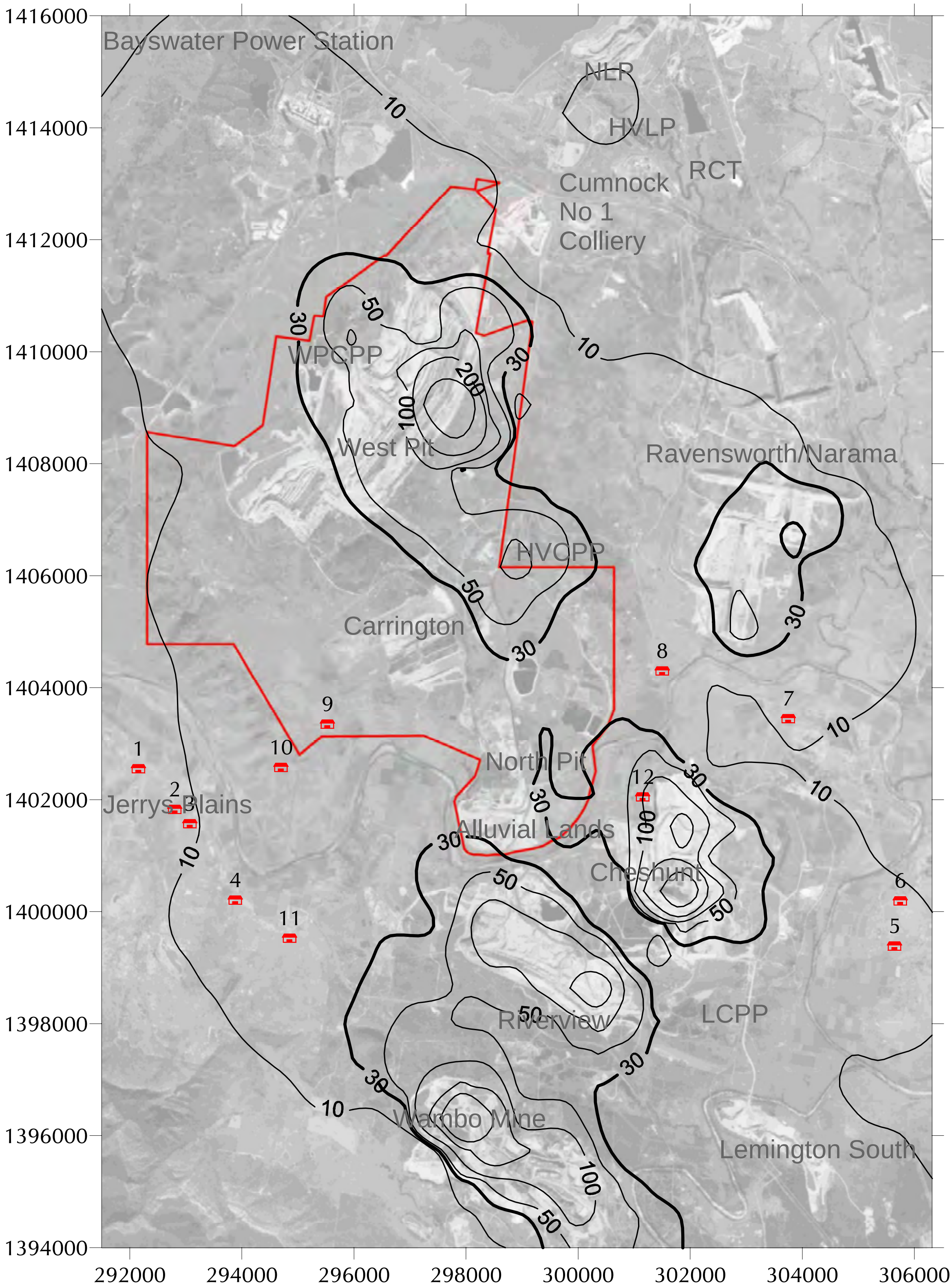
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal and other sources in Year 8 ($\mu g/m^3$)

Figure 23



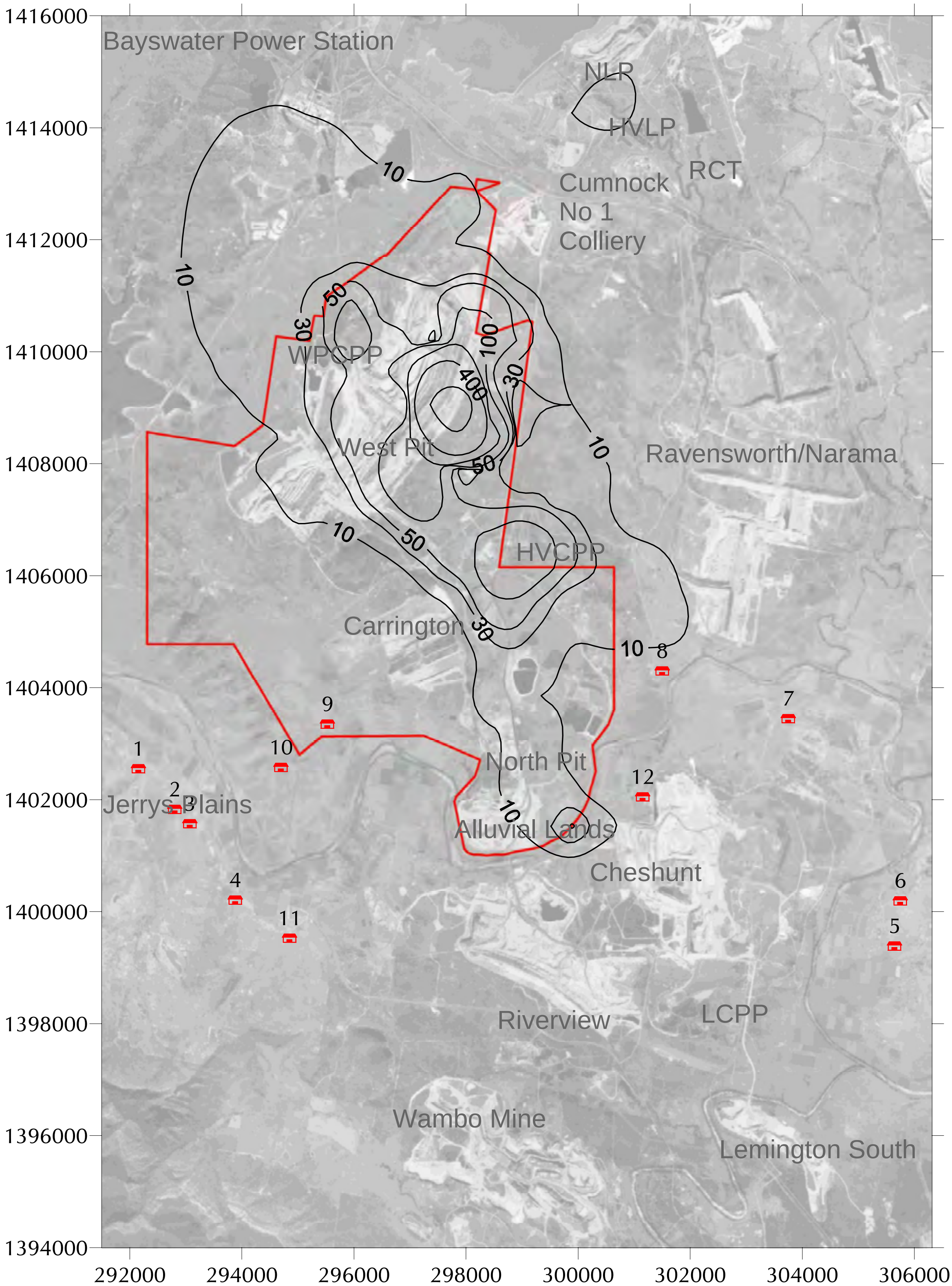
Predicted annual average PM_{10} concentrations due to emissions from the Proposal in Year 8 ($\mu g/m^3$)

Figure 24



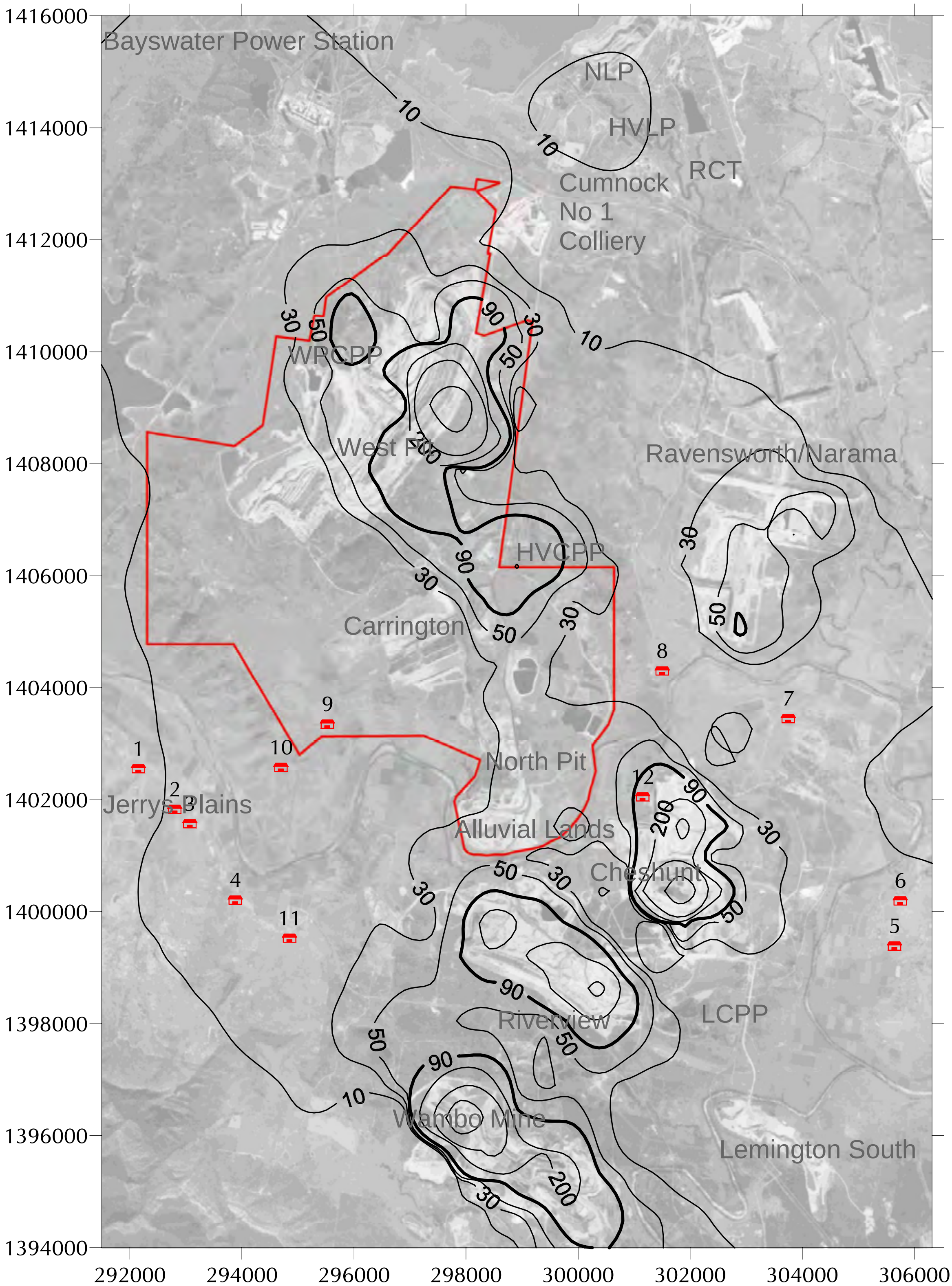
Predicted annual average PM_{10} concentrations due to emissions from the Proposal and other sources in Year 8 ($\mu g/m^3$)

Figure 25



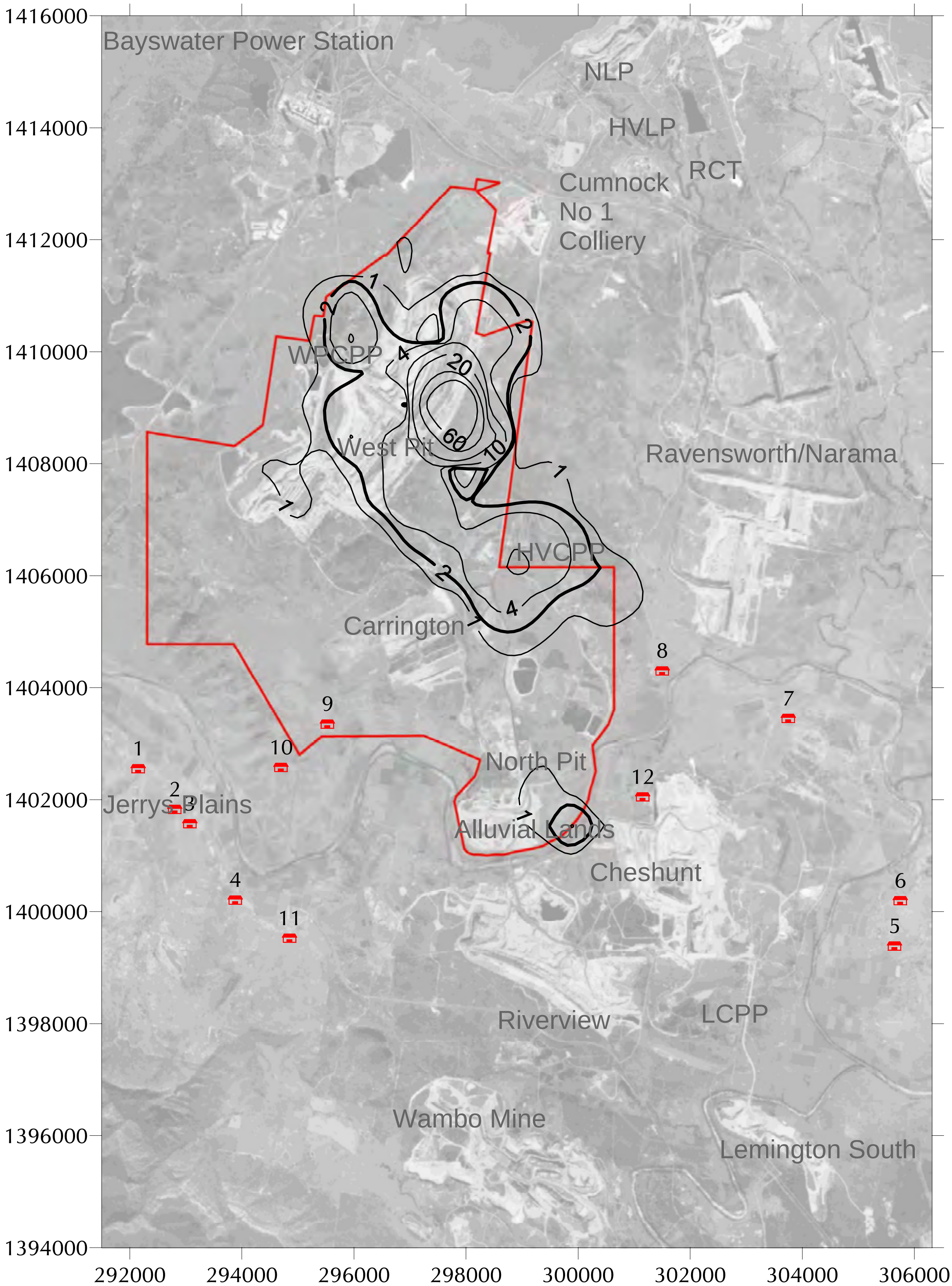
Predicted annual average TSP concentrations due to emissions from the Proposal in Year 8 ($\mu g/m^3$)

Figure 26



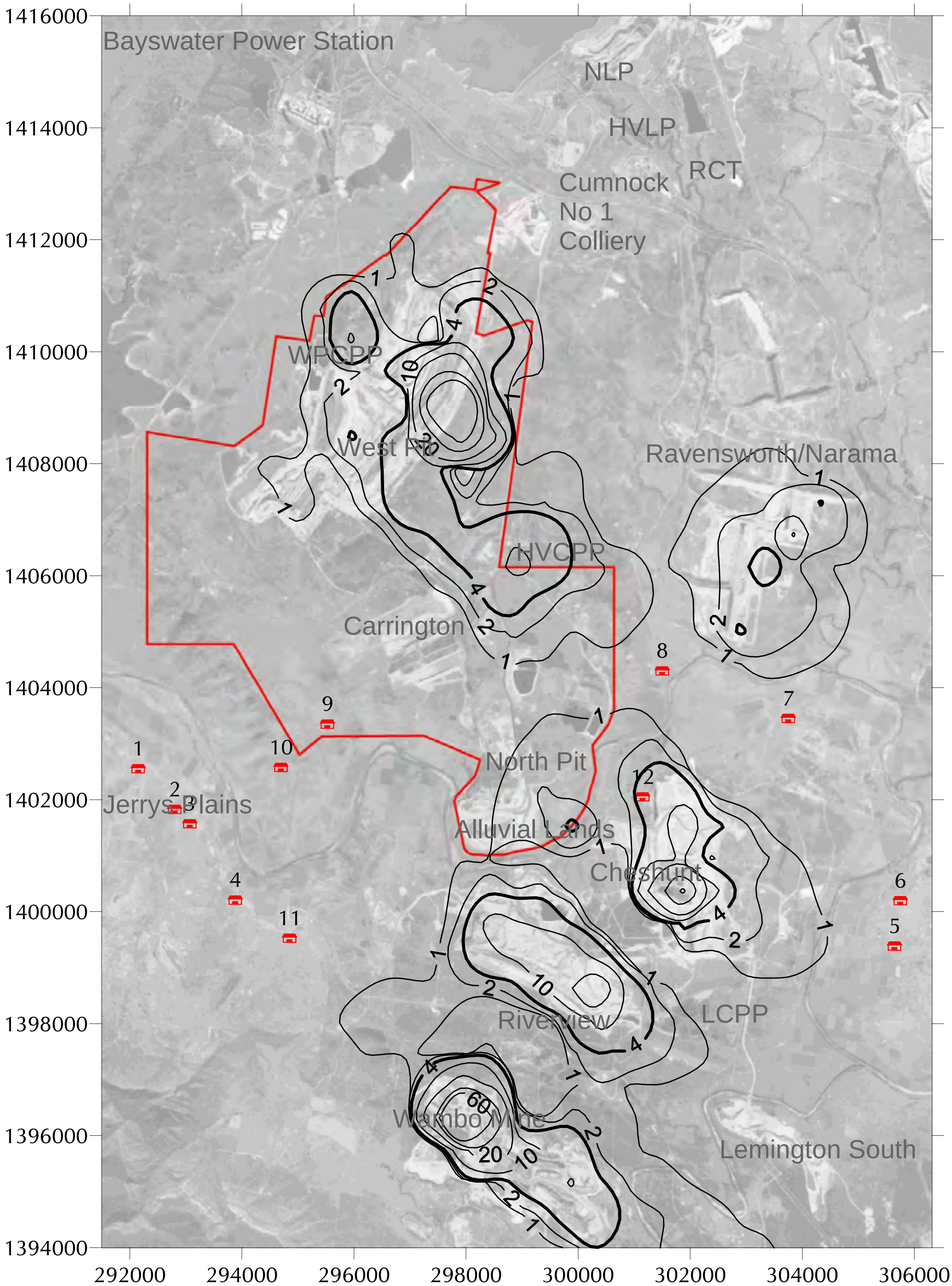
Predicted annual average TSP concentrations
due to emissions from the Proposal and other sources in Year 8 (μg/m^3)

Figure 27



Predicted annual average dust deposition due to emissions from the Proposal in Year 8 (g/m^2/month)

Figure 28



Predicted annual average dust deposition
due to emissions from the Proposal and other sources in Year 8 (g/m^2/month)

Figure 29

8.7 Year 8 (with Carrington)

Figures 30 to **37** show the predicted model results for the alternative option for Year 8 with Carrington mine still operating.

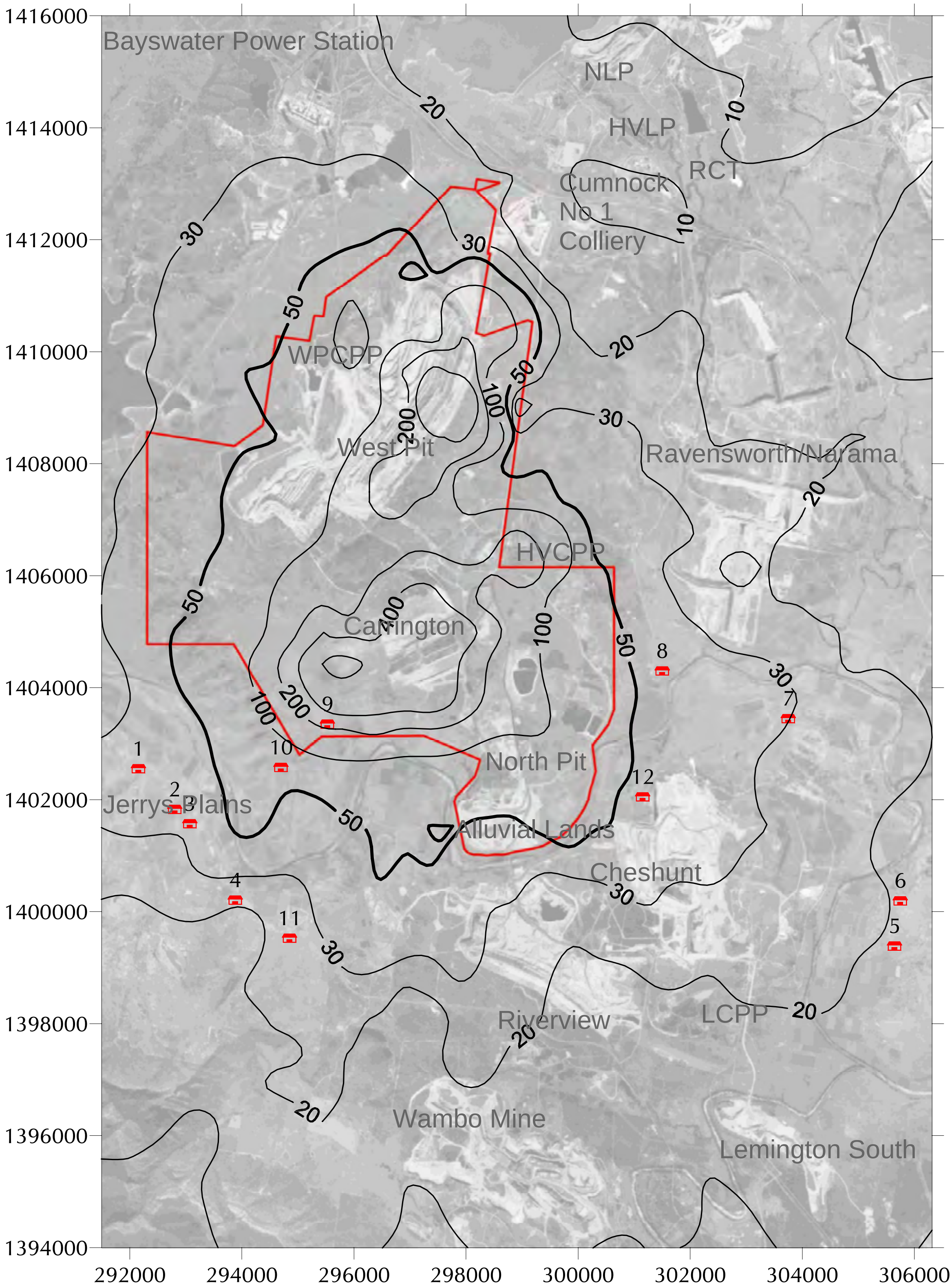
Table 18 summarises the results. Residences 9 and 10 are predicted to experience exceedances of the EPA's 50 μg/m^3 24-hour PM_{10} assessment criterion due to emissions from HVO north of the Hunter River. Residence 9 is also predicted to experience annual average concentrations of PM_{10} above the EPA's assessment criterion of 30 μg/m^3. As discussed before, these residences are already within an existing zone of affectation or have agreements with mining companies.

With the Proposal and other sources, Residences 9, 10, and 12 are predicted to experience 24-hour average PM_{10} concentrations above the US EPA's assessment criterion of 150 μg/m^3 and Residences 9 and 12 are predicted to experience annual average PM_{10} concentrations above the EPA's assessment criterion of 30 μg/m^3. In addition, Residence 12 is predicted to experience exceedances of EPA's assessment criteria for annual average TSP and dust deposition. The contribution the HVO north of the Hunter River makes to these exceedances is small.

Table 18: Summary of affected residences for Year 8 alternative option

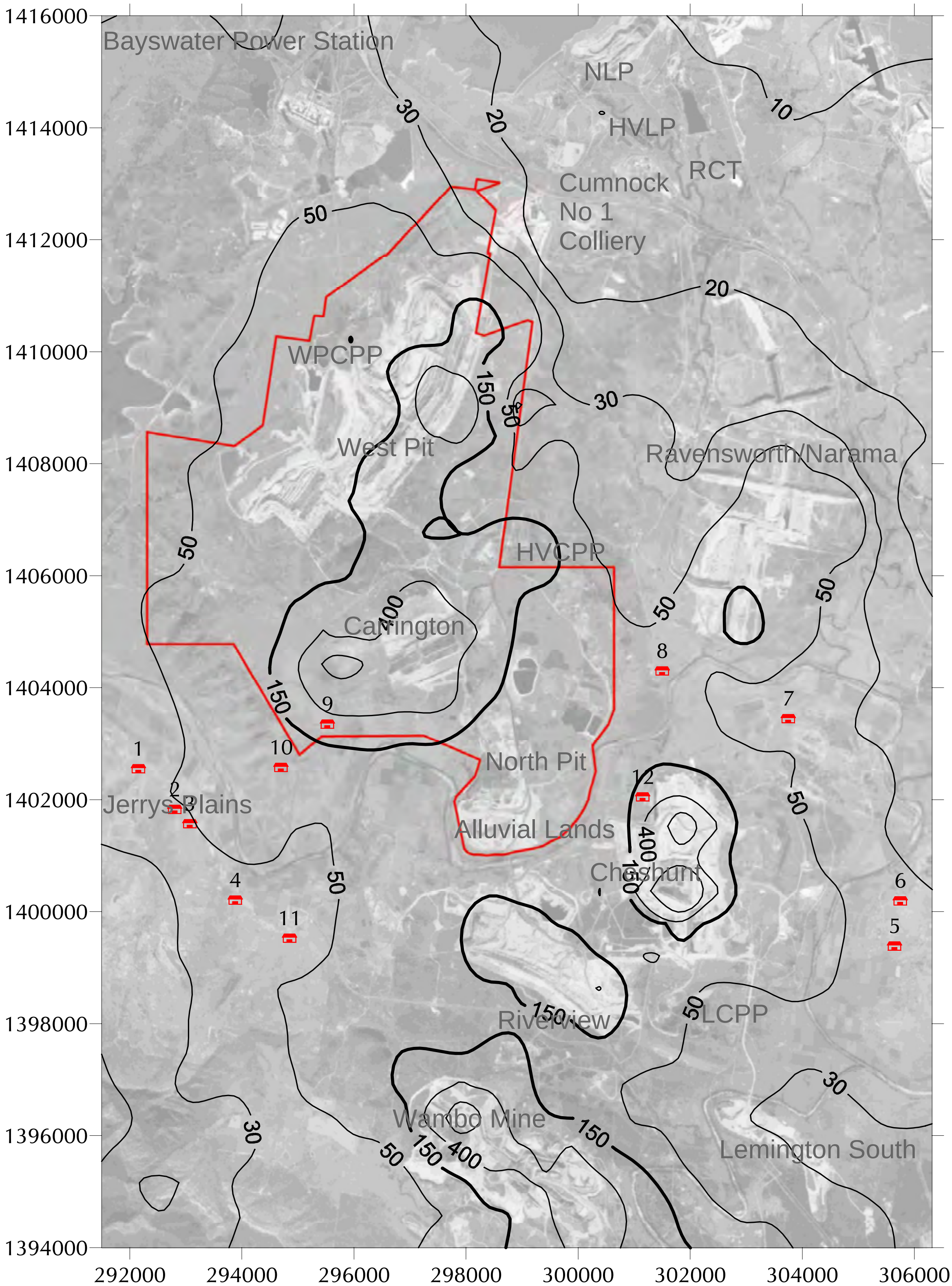
	Proposal in isolation in Year-8				Proposal with other sources in Year-8			
	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year
ID	μg/m^3	μg/m^3	μg/m^3	g/m^2/month	μg/m^3	μg/m^3	μg/m^3	g/m^2/month
Goal	*50*	*30*	*90*	*2*	*150*[(a)]	*30*	*90*	*4*
1	36.6	3.5	3.6	0.03	44.0	11.0	12.2	0.21
2	33.8	3.7	3.9	0.03	47.0	12.4	13.7	0.24
3	33.3	3.4	3.6	0.03	47.8	12.5	13.8	0.25
4	21.5	3.1	3.2	0.03	35.7	14.8	16.6	0.33
5	19.2	7.9	9.2	0.34	41.8	18.9	22.2	0.86
6	19.1	8.5	9.9	0.36	35.9	17.8	20.7	0.71
7	30.2	12.2	14.2	0.51	41.5	18.3	20.8	0.62
8	42.5	17.6	21.0	0.87	56.7	29.1	33.4	1.07
9	**245.0**	**48.8**	62.8	0.00	**253.6**	**64.2**	79.4	2.60
10	**65.7**	0.0	7.6	0.00	**76.8**	22.4	23.5	0.00
11	23.6	3.5	3.6	0.03	42.3	19.2	21.6	0.47
12	45.8	21.4	25.9	1.20	**227.0**	**115.9**	**155.8**	**6.94**

(a) US EPA 24-hr ambient air quality standard (99th percentile over 3 years)



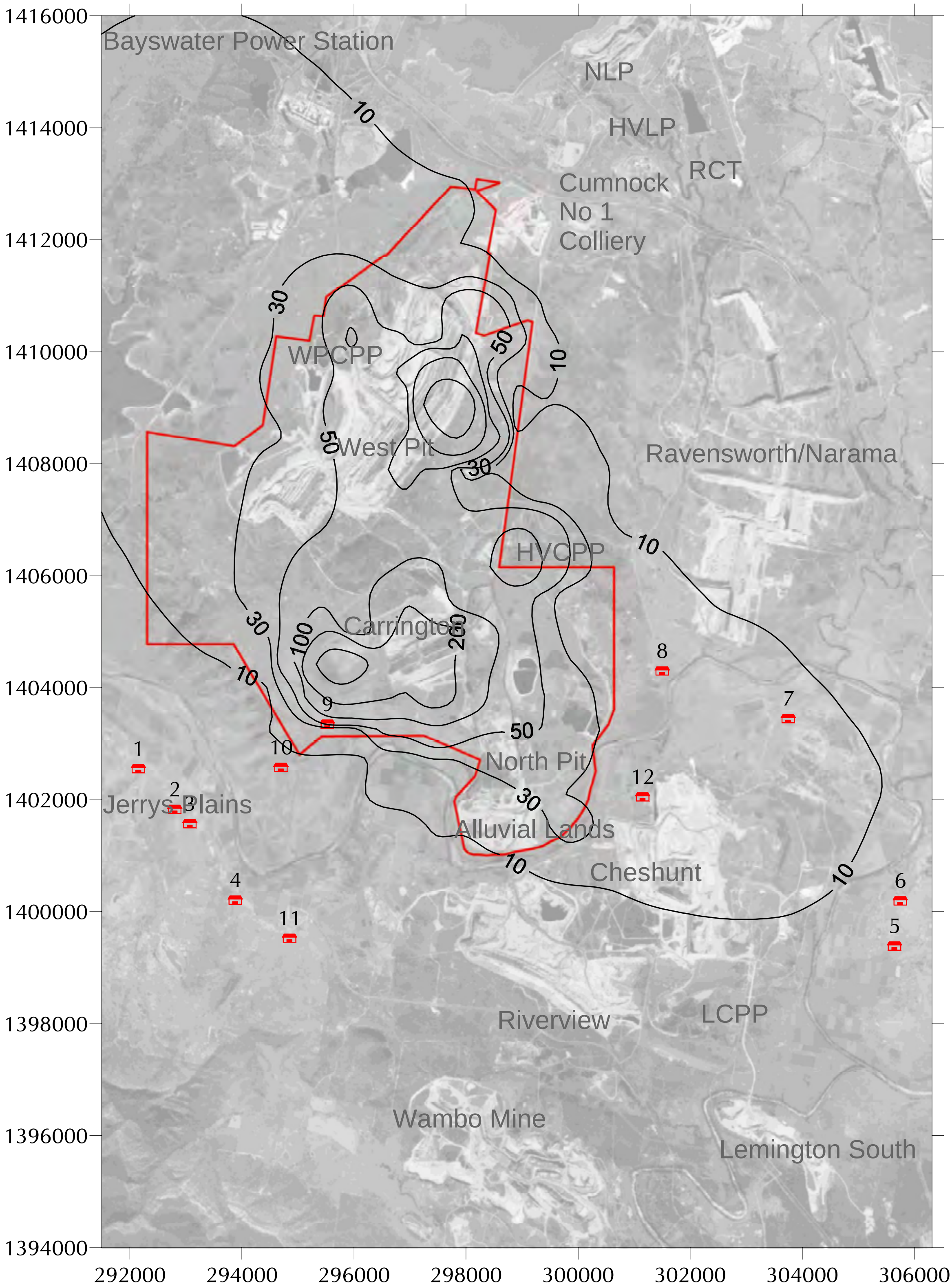
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal in Year 8 (alternative option) ($\mu g/m^3$)

Figure 30



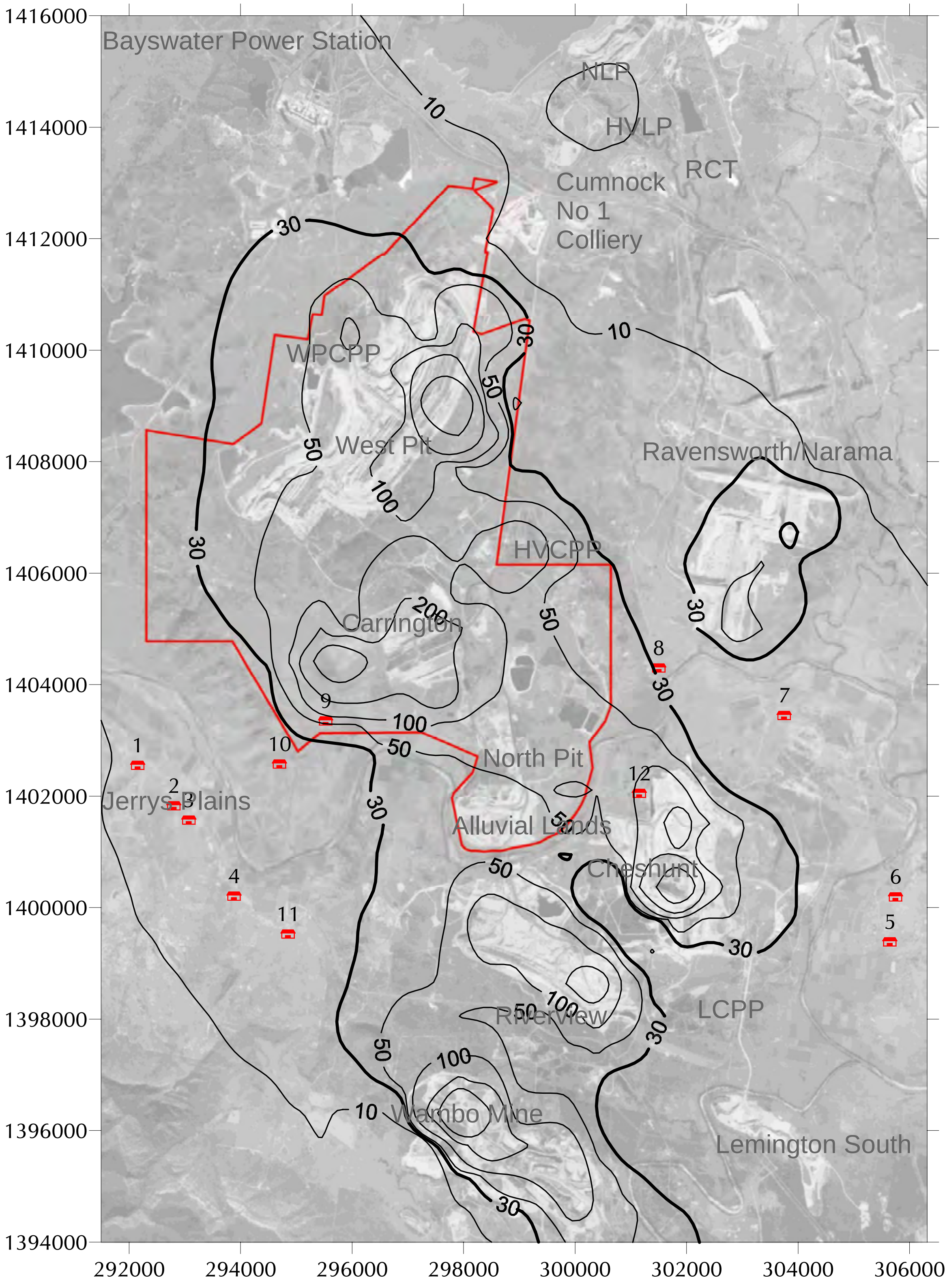
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal and other sources in Year 8 (alternative option) ($\mu g/m^3$)

Figure 31



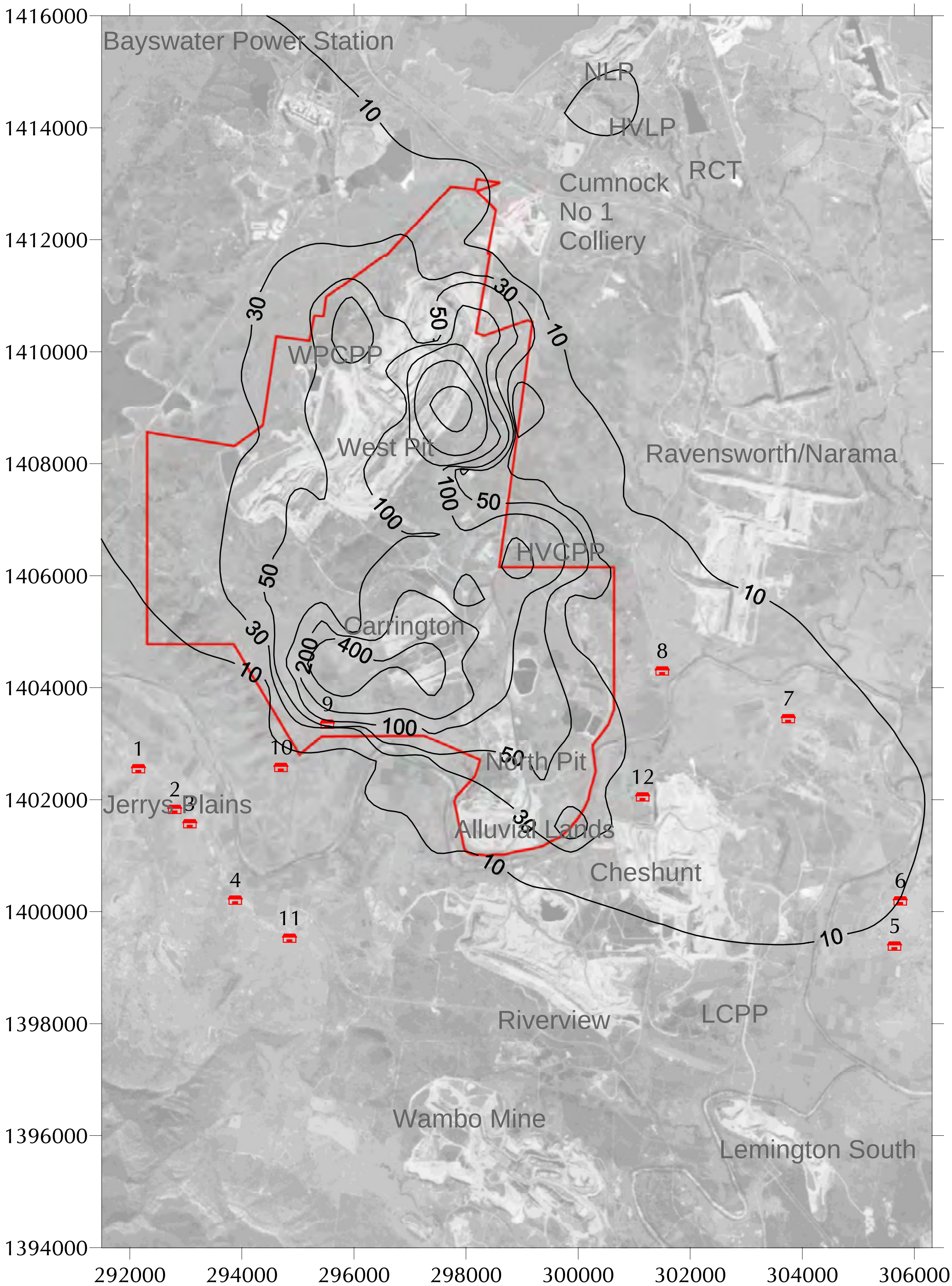
Predicted annual average PM_{10} concentrations
due to emissions from the Proposal in Year 8 (alternative option) ($\mu g/m^3$)

Figure 32



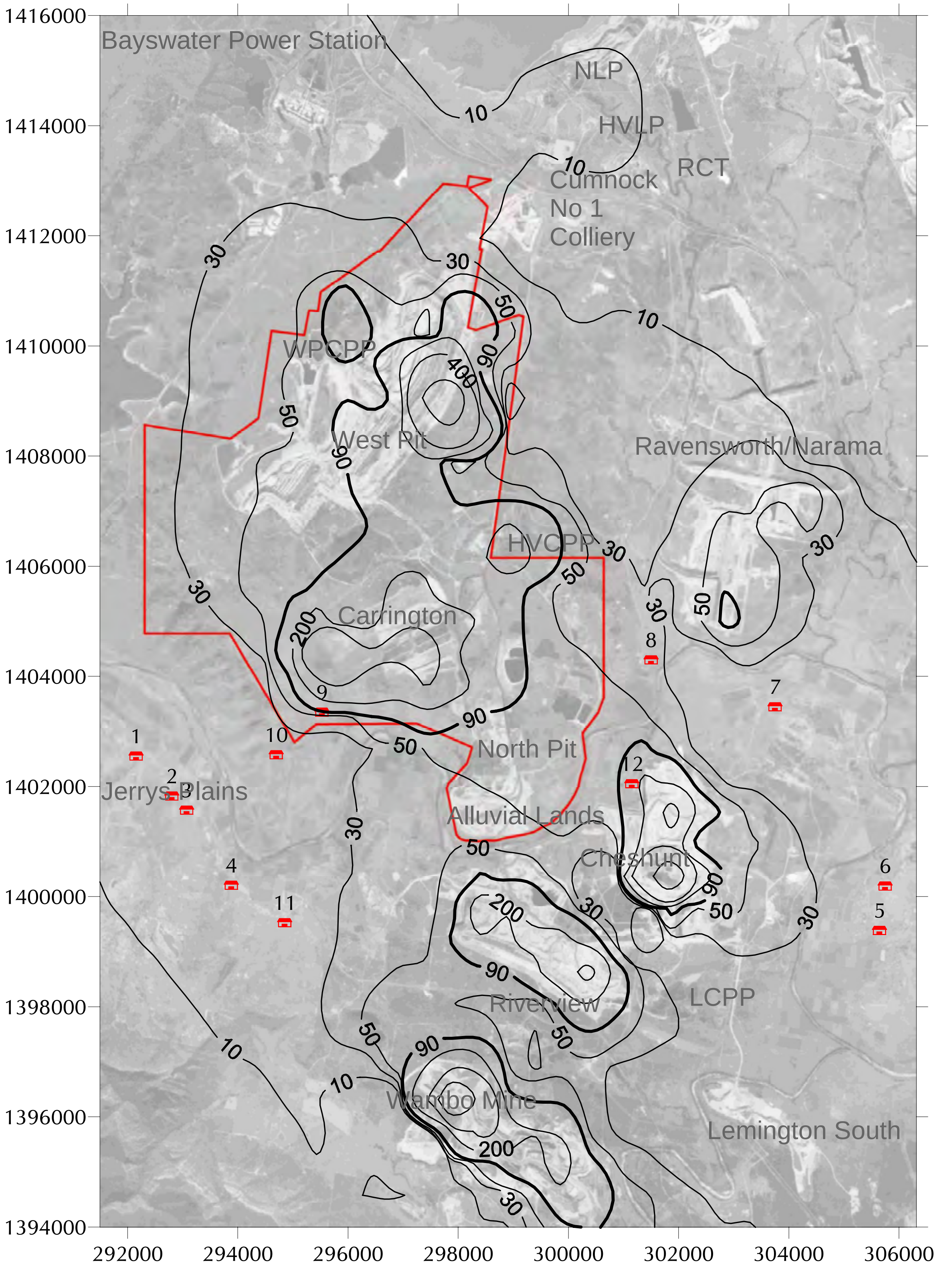
Predicted annual average PM_{10} concentrations
due to emissions from the Proposal and other sources in Year 8 (alternative option) ($\mu g/m^3$)

Figure 33



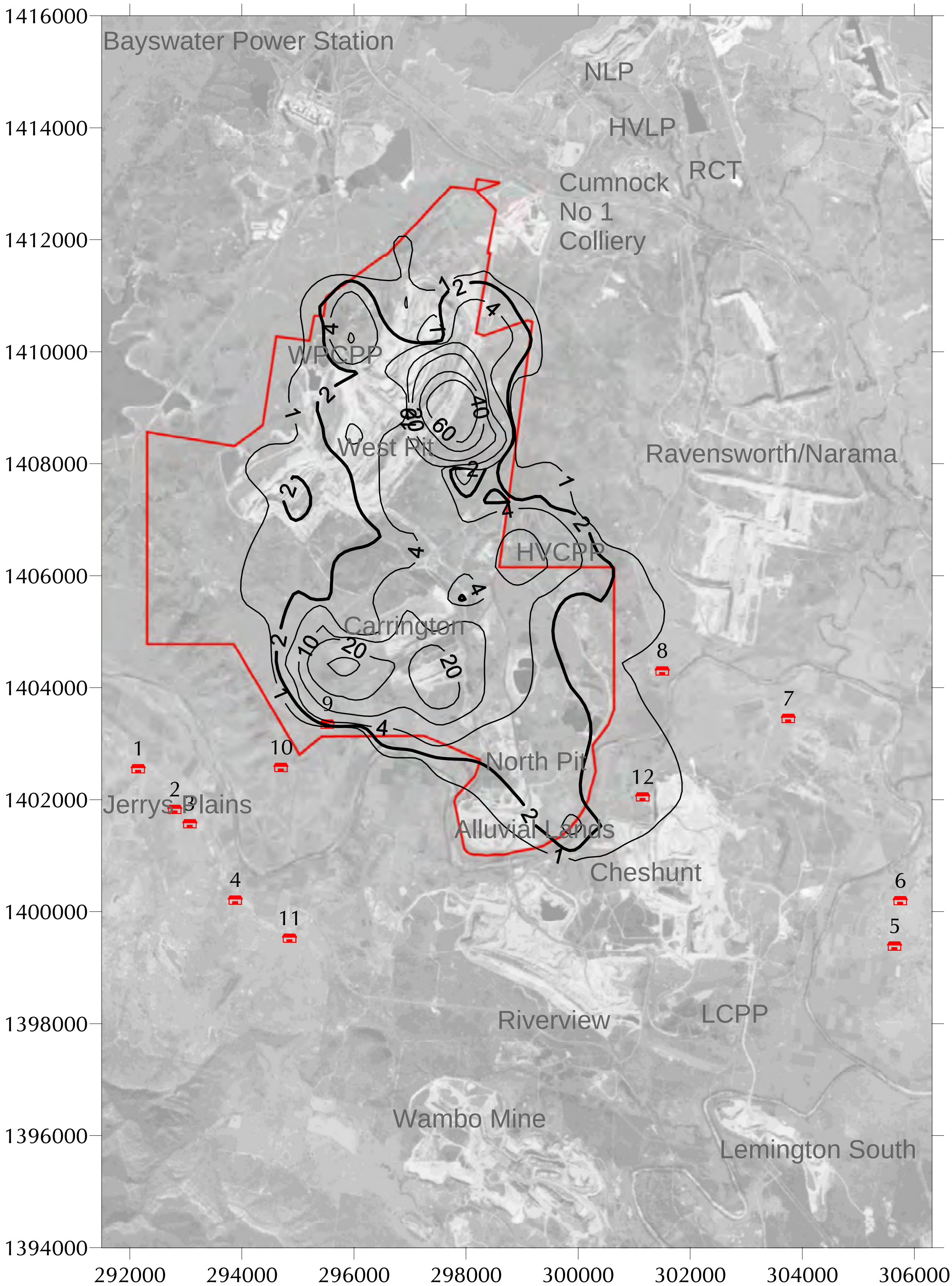
Predicted annual average TSP concentrations due to emissions from the Proposal in Year 8 (alternative option) ($\mu g/m^3$)

Figure 34



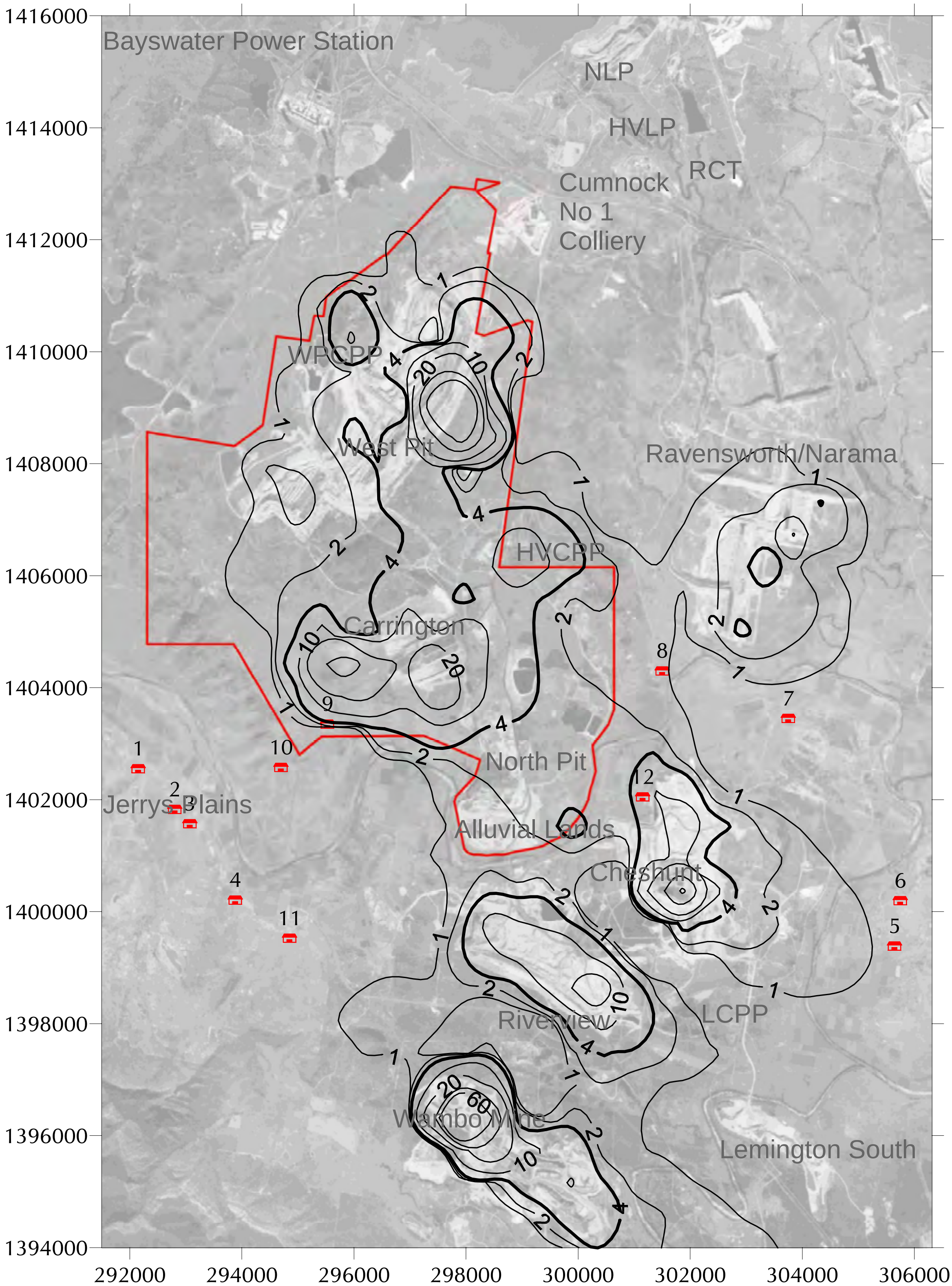
Predicted annual average TSP concentrations
due to emissions from the Proposal and other sources in Year 8 (alternative option) ($\mu g/m^3$)

Figure 35



Predicted annual average dust deposition due to emissions from the Proposal in Year 8 (alternative option) (g/m²/month)

Figure 36



Predicted annual average dust deposition due to emissions from the Proposal and other sources in Year 8 (alternative option) (g/m²/month)

Figure 37

8.8 Year 14

Figures 38 to **45** show the predicted model results for Year 14.

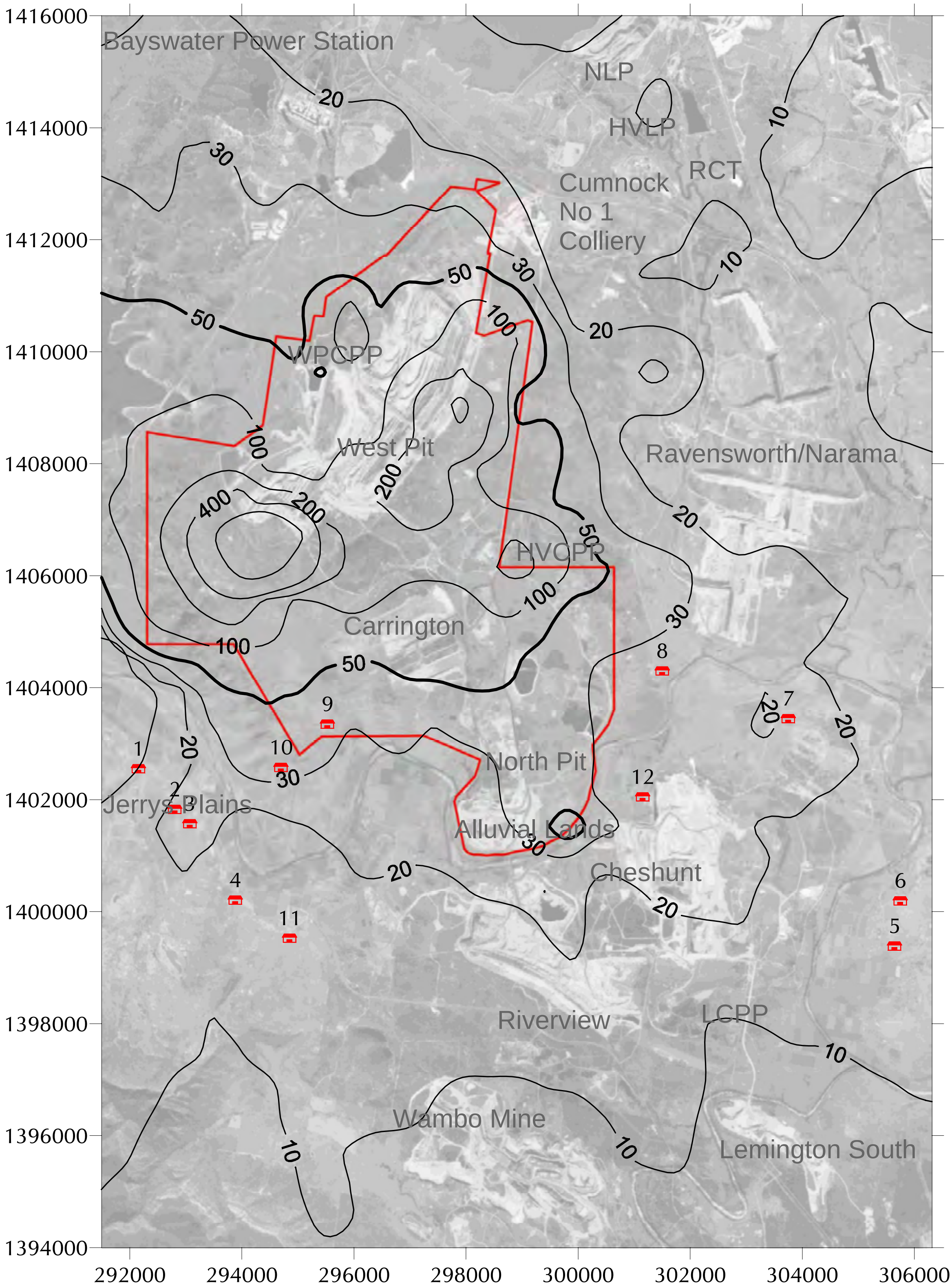
Table 19 summarises the results. No residences are predicted to experience exceedances of any of the EPA's assessment criterion due to emissions from HVO north of the Hunter River.

With the Proposal and other sources, Residence 12 is predicted to exceed the US EPA's 150 µg/m^3 24-hour PM_{10} criterion and is also predicted to experience annual average PM_{10} concentrations above the EPA's assessment criterion of 30 µg/m^3. In addition, Residence 12 is predicted to experience exceedances of EPA's assessment criteria for annual average TSP and dust deposition. The contribution the HVO north of the Hunter River makes to these exceedances is small. As noted previously, this residence is already within an existing zone of affectation and has an agreement with the mining companies.

Table 19: Summary of affected residences for Year 14

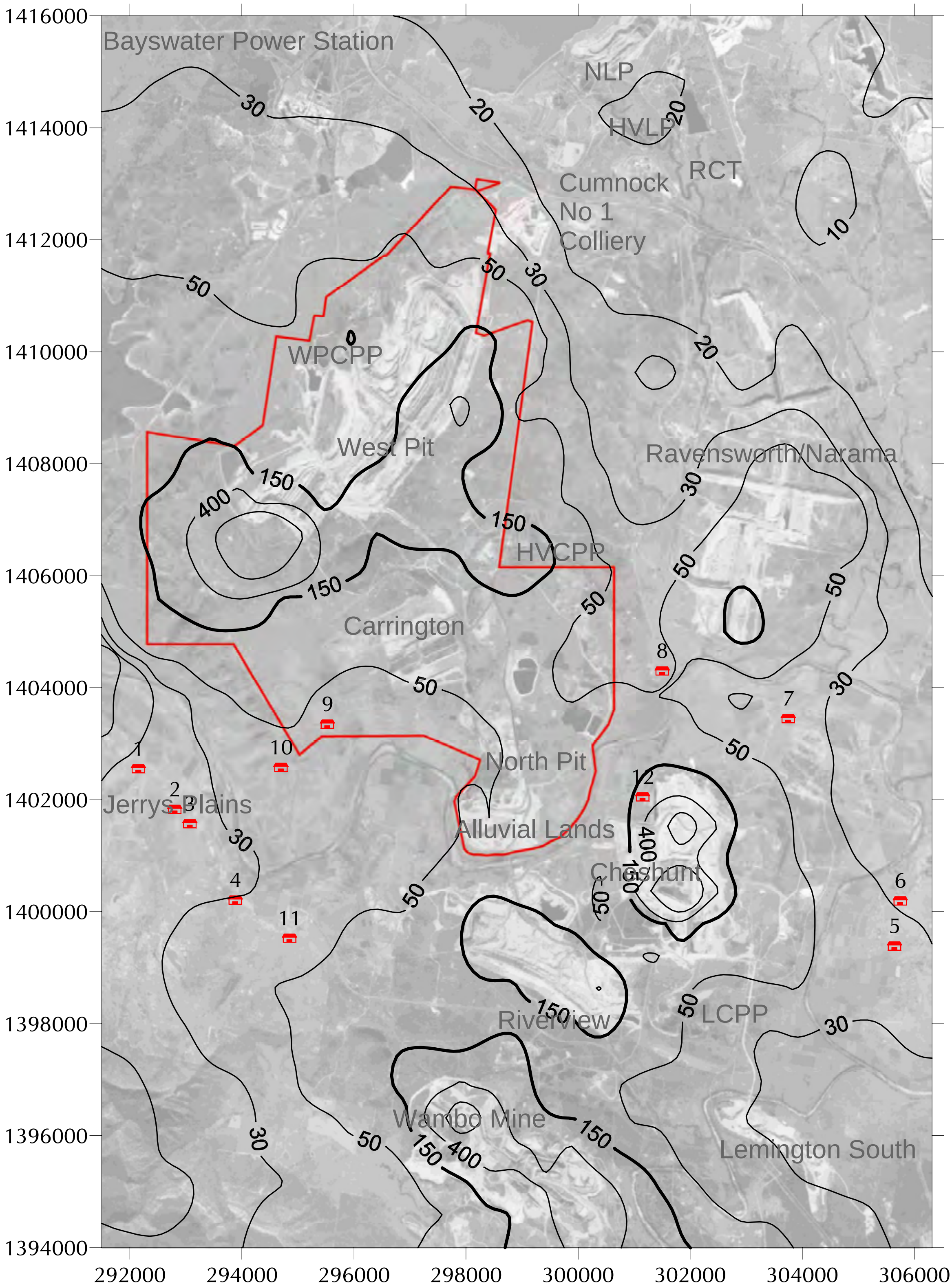
	Proposal in isolation in Year-14				Proposal with other sources in Year-14			
	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year
ID	µg/m^3	µg/m^3	µg/m^3	g/m^2/month	µg/m^3	µg/m^3	µg/m^3	g/m^2/month
Goal	*50*	*30*	*90*	*2*	*150*[(a)]	*30*	*90*	*4*
1	10.3	2.1	2.3	0.02	22.1	9.6	10.7	0.20
2	22.2	2.6	2.7	0.02	25.7	11.1	12.4	0.23
3	25.8	2.4	2.5	0.02	27.8	11.3	12.7	0.25
4	12.4	2.2	2.4	0.02	30.8	13.9	15.6	0.33
5	13.0	4.9	5.7	0.21	34.7	15.7	18.5	0.72
6	12.8	5.5	6.4	0.24	27.9	14.5	17.0	0.58
7	20.9	9.8	11.7	0.48	33.8	15.4	17.8	0.57
8	25.9	12.3	15.6	0.81	48.3	23.0	27.0	0.97
9	33.8	7.1	8.1	0.22	43.9	22.2	24.5	0.52
10	33.6	6.1	6.5	0.06	39.7	20.9	22.6	0.37
11	17.9	2.6	2.8	0.03	41.8	18.2	20.6	0.47
12	27.5	9.7	11.7	0.52	**226.2**	**104.1**	**141.5**	**6.25**

(a) US EPA 24-hr ambient air quality standard (99th percentile over 3 years)



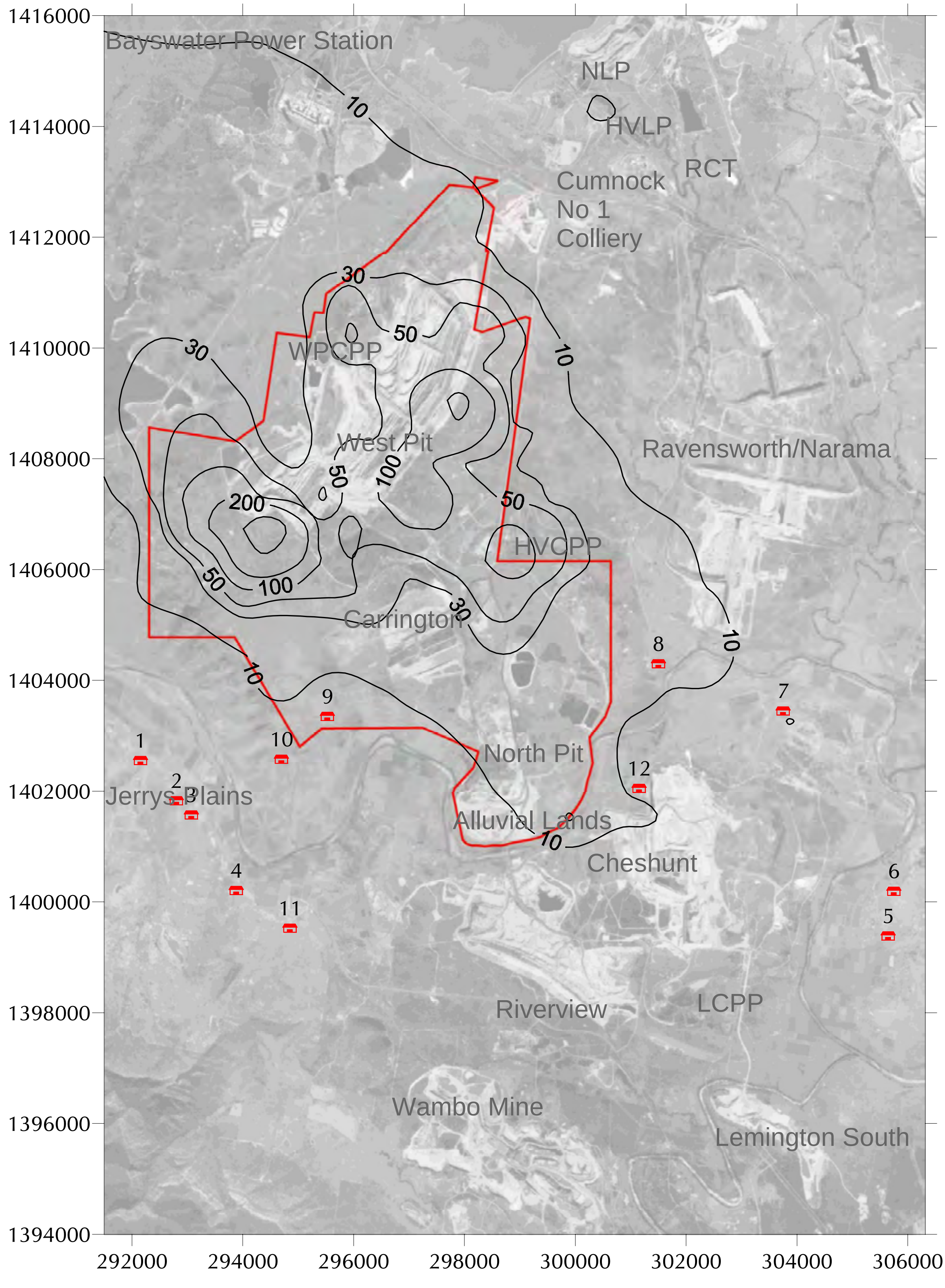
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal in Year 14 ($\mu g/m^3$)

Figure 38



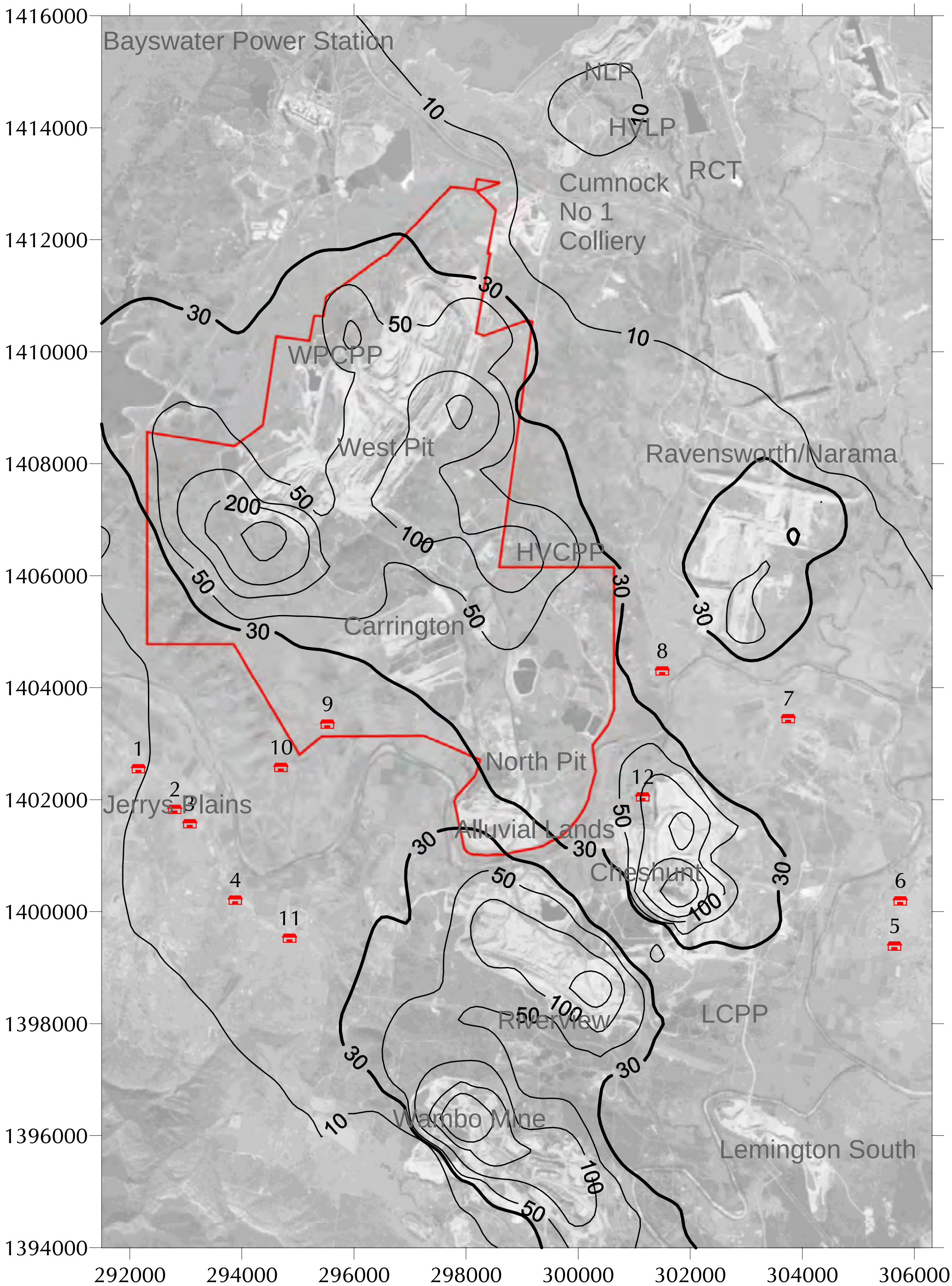
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal and other sources in Year 14 ($\mu g/m^3$)

Figure 39



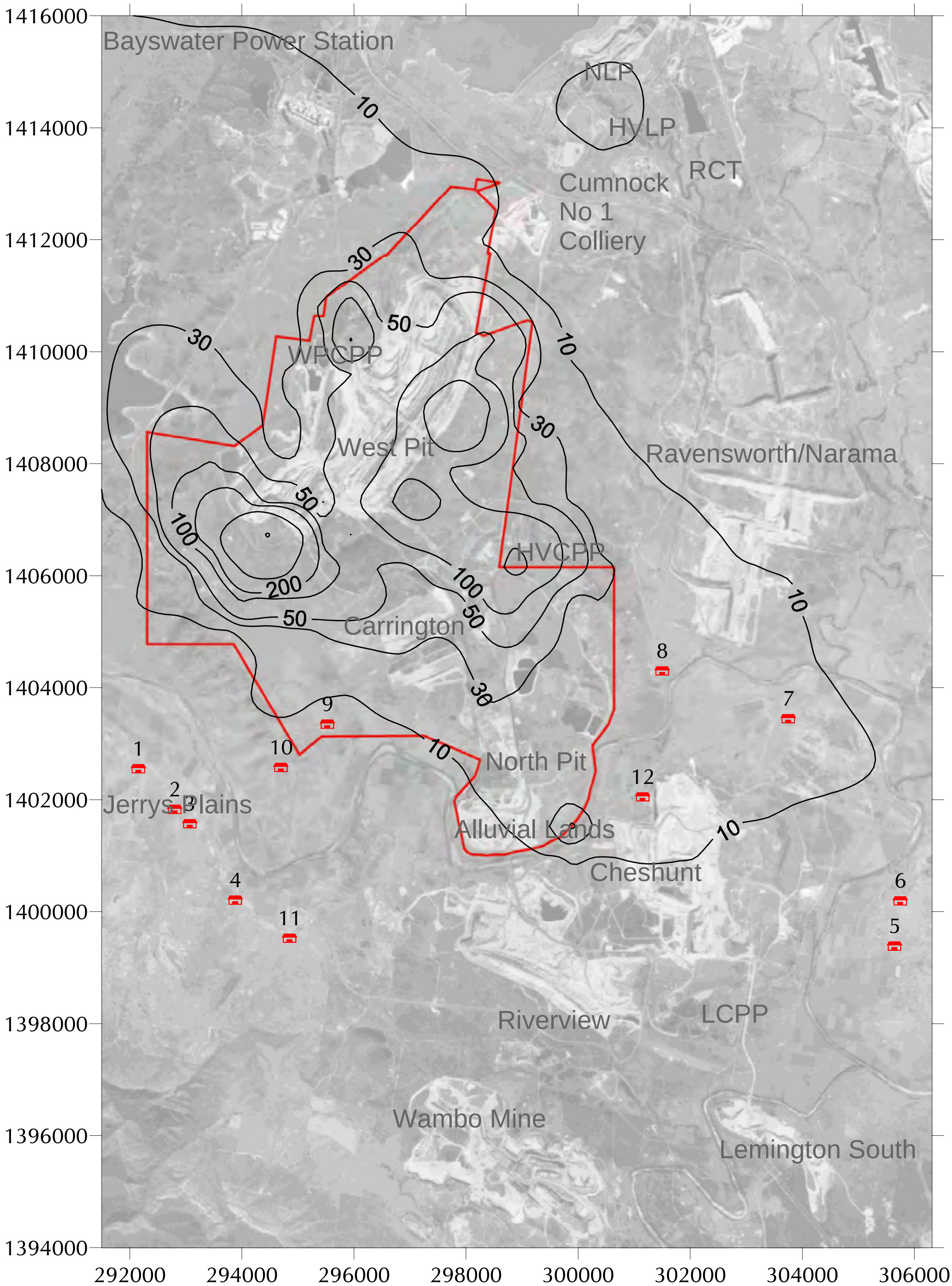
Predicted annual average PM_{10} concentrations due to emissions from the Proposal in Year 14 ($\mu g/m^3$)

Figure 40



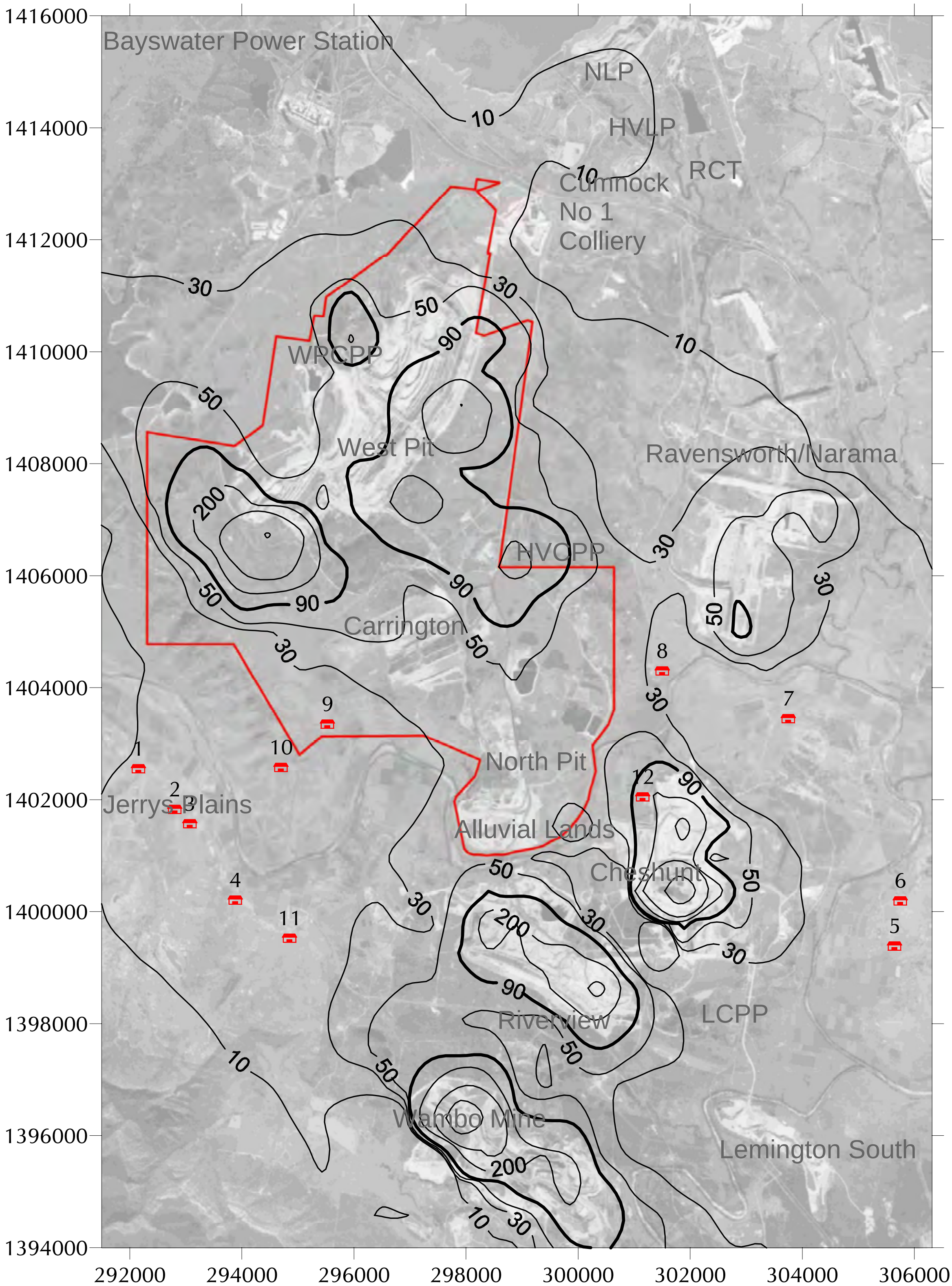
Predicted annual average PM_{10} concentrations
due to emissions from the Proposal and other sources in Year 14 ($\mu g/m^3$)

Figure 41



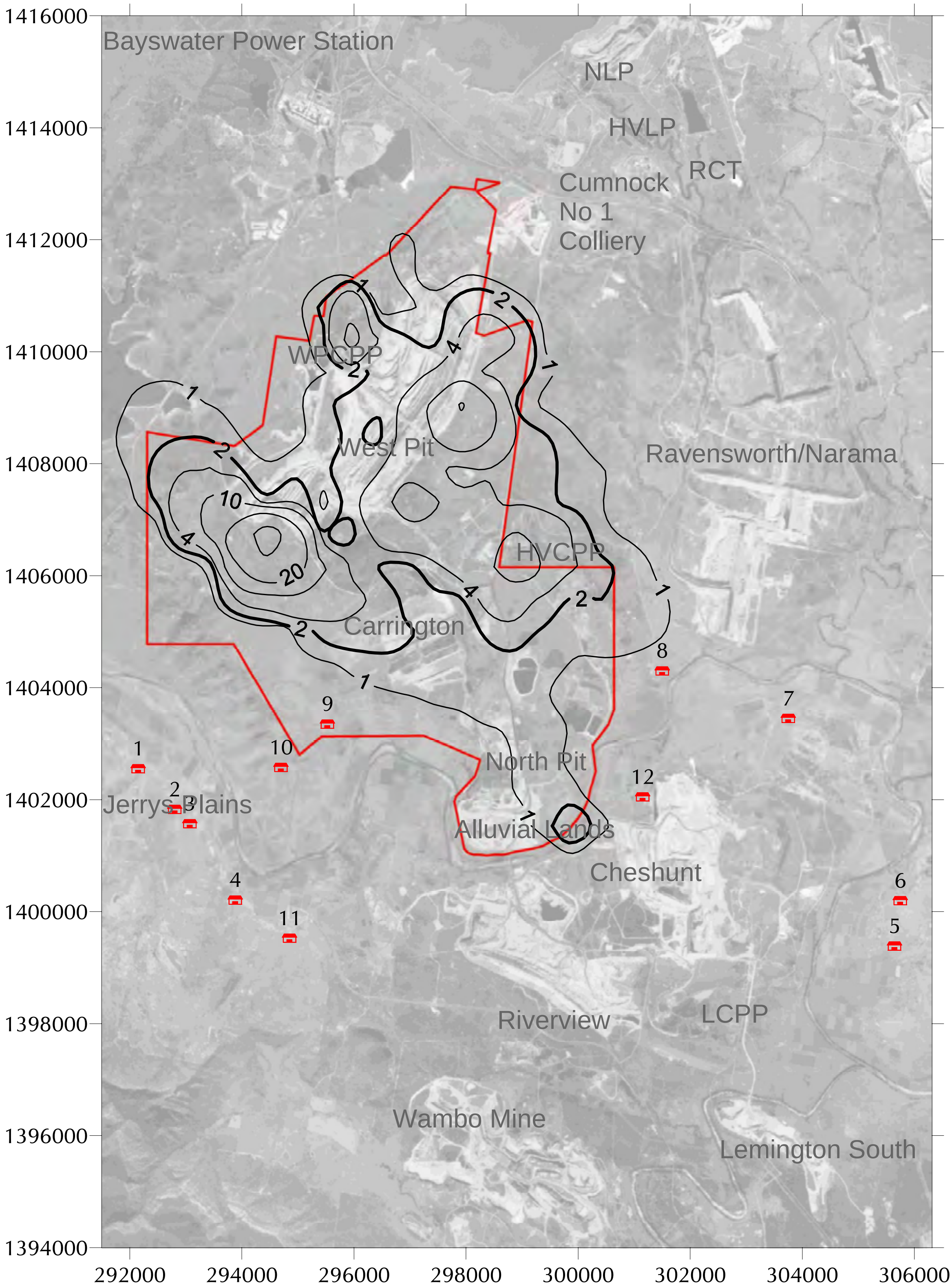
Predicted annual average TSP concentrations due to emissions from the Proposal in Year 14 ($\mu g/m^3$)

Figure 42



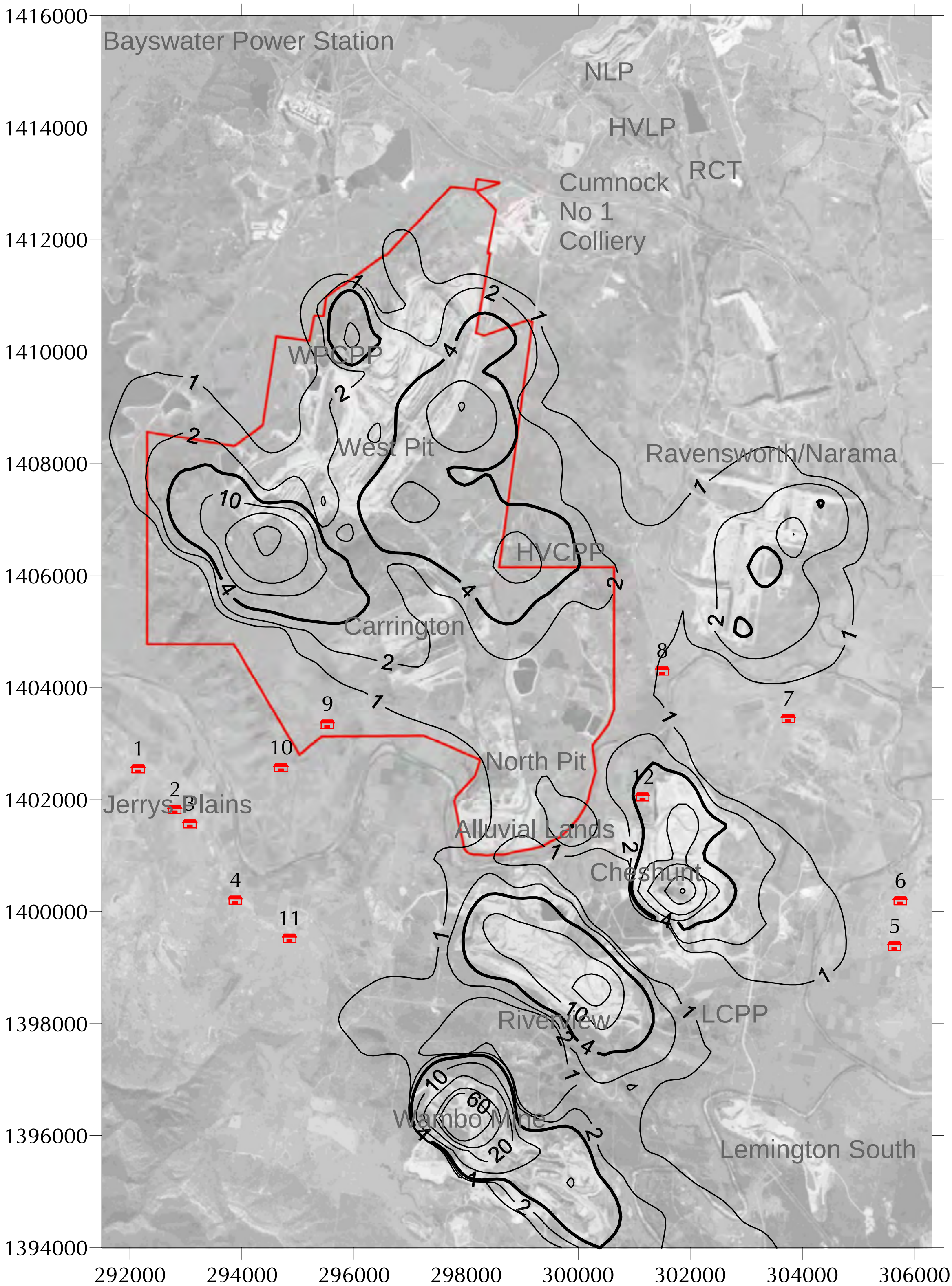
Predicted annual average TSP concentrations
due to emissions from the Proposal and other sources in Year 14 ($\mu g/m^3$)

Figure 43



Predicted annual average dust deposition due to emissions from the Proposal in Year 14 (g/m^2/month)

Figure 44



Predicted annual average dust deposition
due to emissions from the Proposal and other sources in Year 14 (g/m²/month)

Figure 45

8.9 Year 20

Figures 46 to **53** show the predicted model results for Year 20.

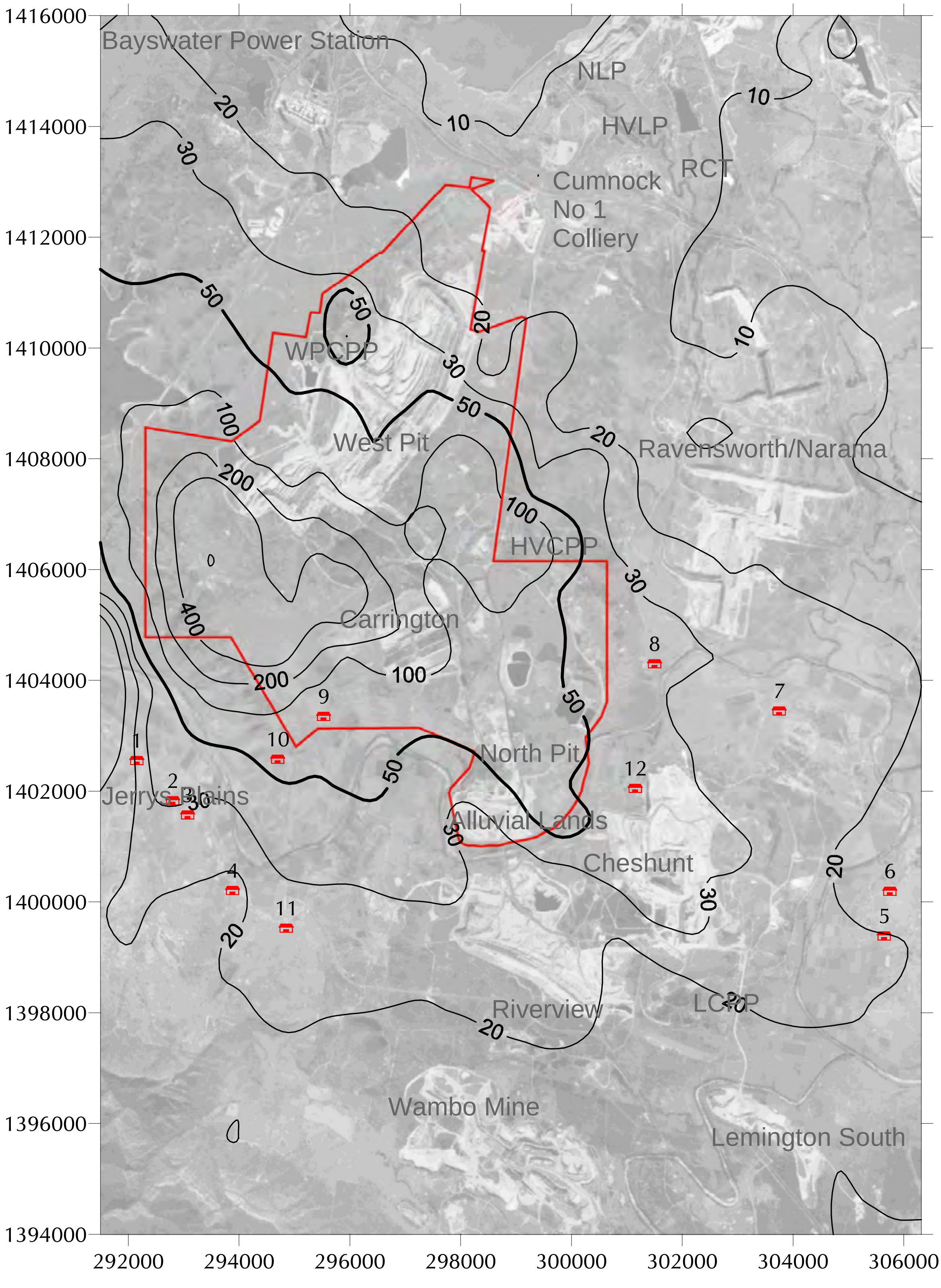
Table 20 summarises the results. No residences are predicted to experience exceedances of any of the EPA's assessment criterion due to emissions from HVO north of the Hunter River.

With the Proposal and other sources, Residence 12 is predicted to exceed the US EPA's 150 µg/m^3 24-hour PM_{10} criterion. Residences 9 and 12 are also predicted to experience annual average PM_{10} concentrations above the EPA's assessment criterion of 30 µg/m^3. In addition, Residence 12 is predicted to experience exceedances of EPA's assessment criteria for annual average TSP and dust deposition. The contribution the HVO north of the Hunter River makes to these exceedances is small. As noted previously, this residence is already within an existing zone of affectation and has an agreement with the mining companies.

Table 20: Summary of affected residences for Year 20

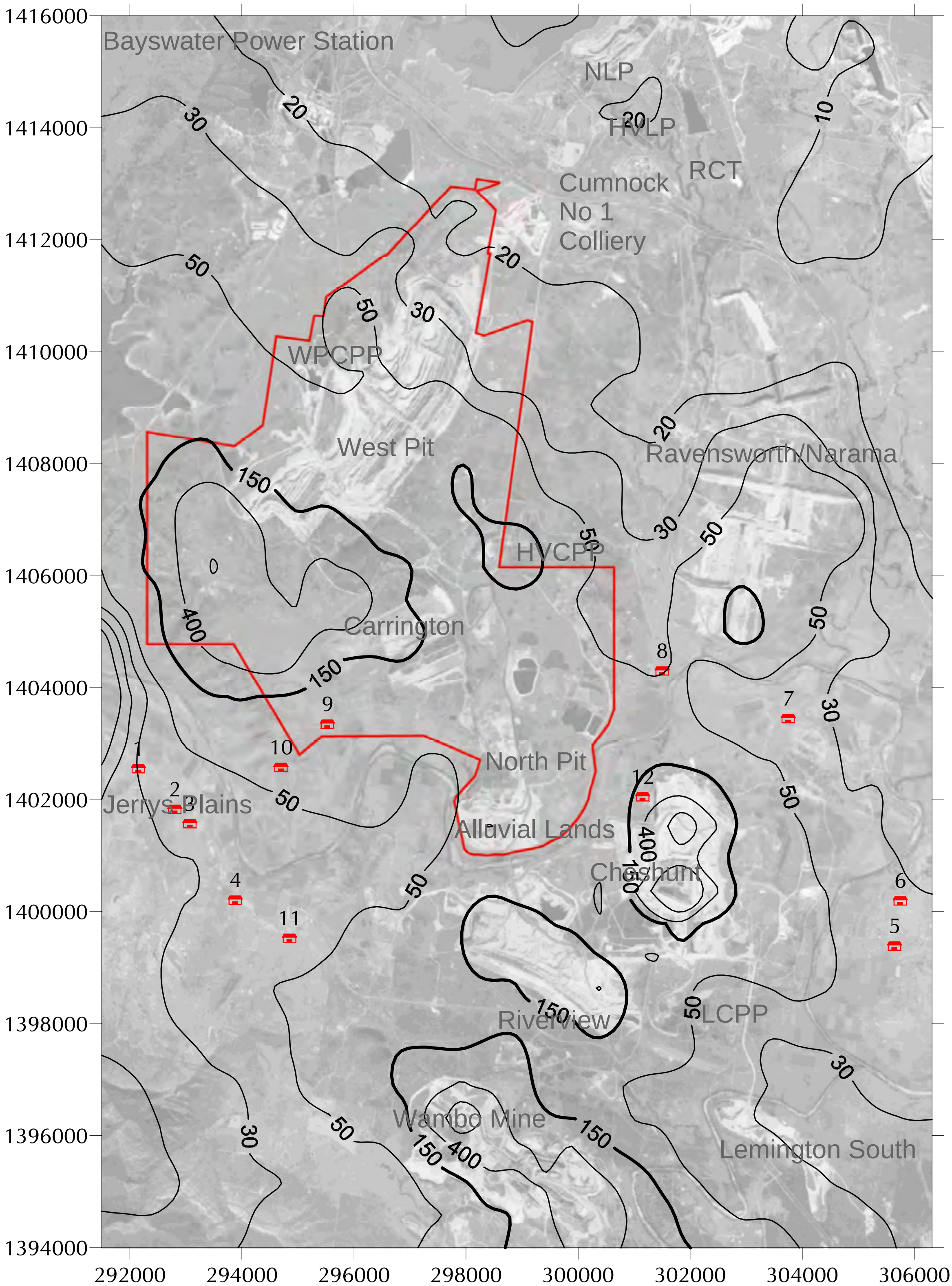
ID	Proposal in isolation in Year-14				Proposal with other sources in Year-14			
	PM_{10} 1-day µg/m^3	PM_{10} 1-year µg/m^3	TSP 1-year µg/m^3	Deposition 1-year g/m^2/month	PM_{10} 1-day µg/m^3	PM_{10} 1-year µg/m^3	TSP 1-year µg/m^3	Deposition 1-year g/m^2/month
Goal	50	30	90	2	150[(a)]	30	90	4
1	21.4	1.7	1.1	-0.13	30.2	9.2	9.6	0.05
2	30.7	3.7	4.0	0.03	36.6	12.2	13.6	0.24
3	25.8	3.7	3.9	0.02	36.3	12.7	14.1	0.25
4	18.0	3.4	3.7	0.04	34.0	15.1	16.9	0.34
5	20.1	6.9	8.0	0.29	42.5	17.7	20.8	0.80
6	17.8	7.2	8.4	0.29	34.3	16.2	18.9	0.64
7	24.5	9.5	11.0	0.38	37.2	15.1	17.1	0.47
8	35.0	12.6	15.3	0.64	49.8	23.3	26.7	0.80
9	76.9	16.9	21.2	0.99	80.9	**32.1**	37.6	1.29
10	58.7	11.2	12.0	0.13	64.9	26.0	28.1	0.43
11	25.3	3.6	3.9	0.04	42.1	19.3	21.8	0.49
12	43.1	15.2	18.3	0.81	**226.5**	**109.5**	**147.9**	**6.54**

(a) US EPA 24-hr ambient air quality standard (99th percentile over 3 years)



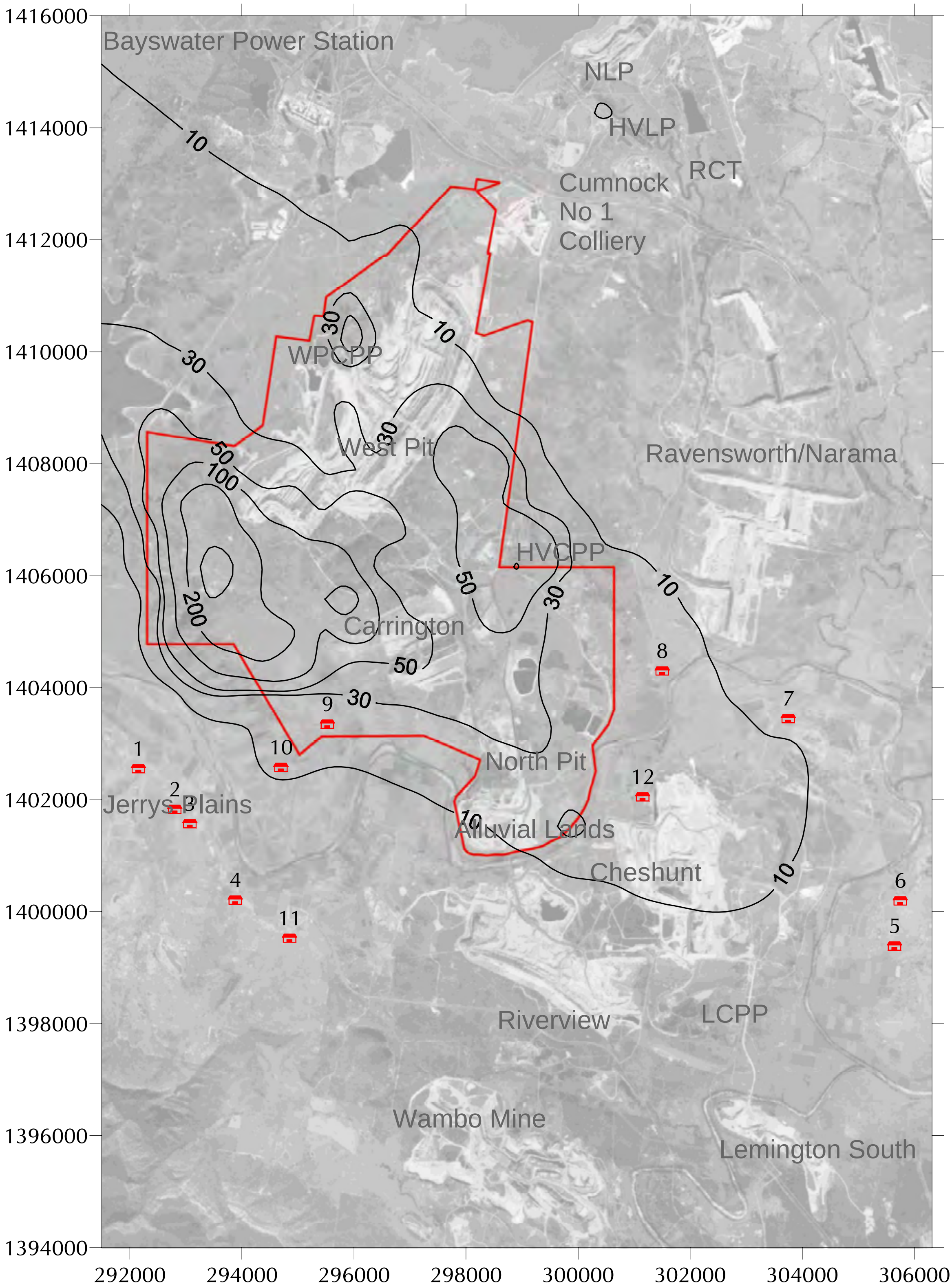
Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal in Year 20 ($\mu g/m^3$)

Figure 46



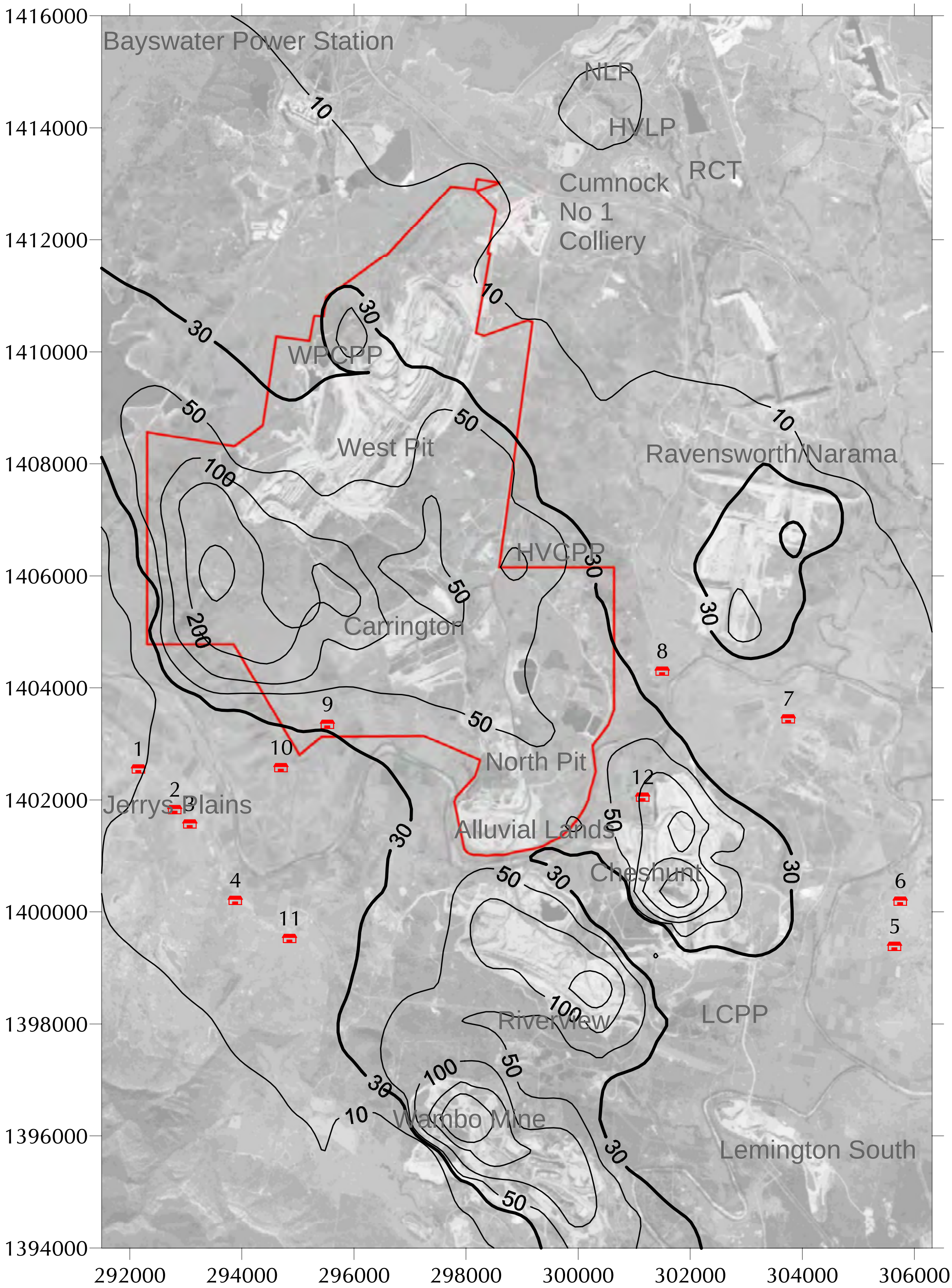
Predicted maximum 24-hour average PM_{10} concentrations
due to emissions from the Proposal and other sources in Year 20 ($\mu g/m^3$)

Figure 47



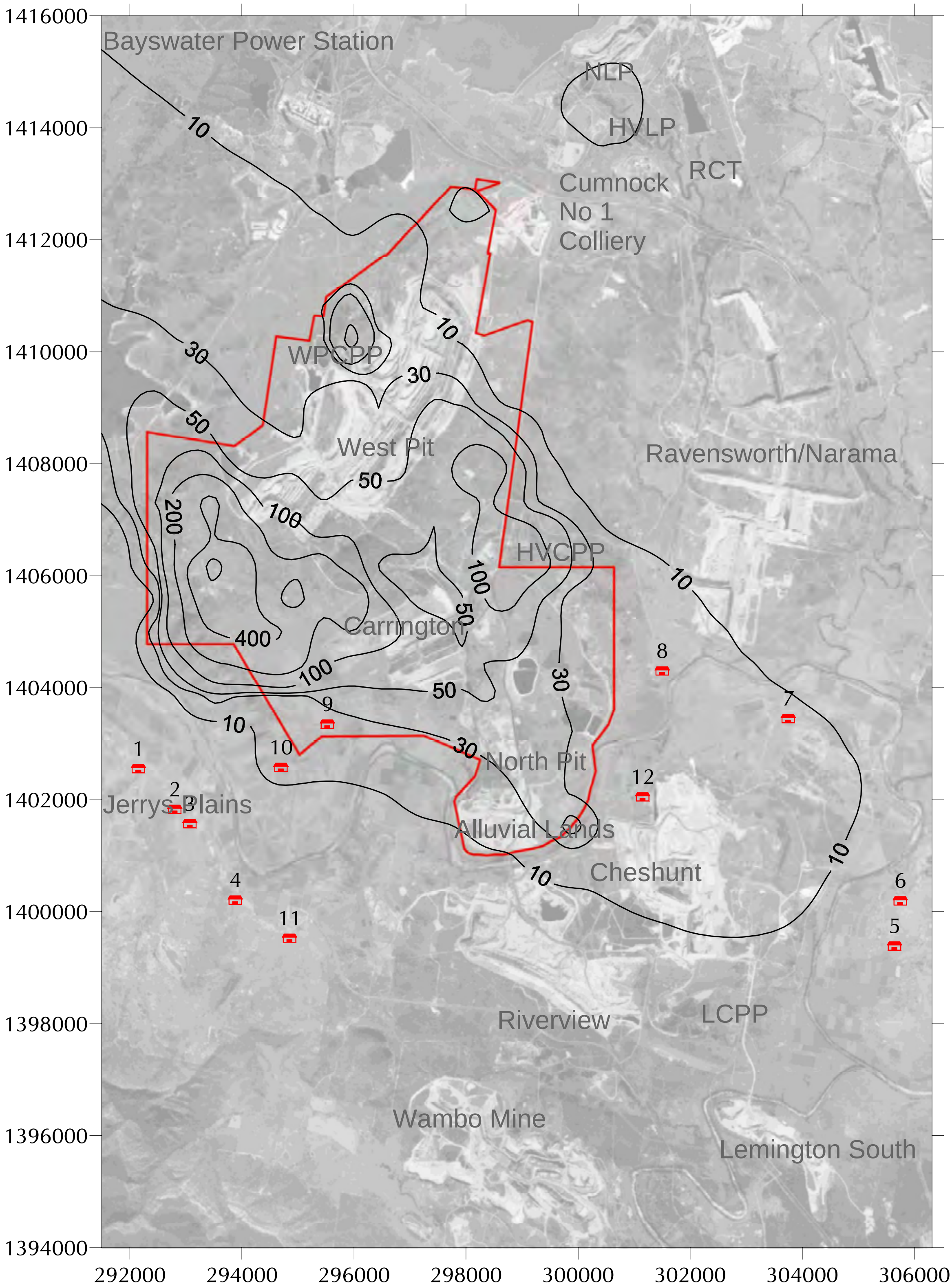
Predicted annual average PM_{10} concentrations due to emissions from the Proposal in Year 20 ($\mu g/m^3$)

Figure 48



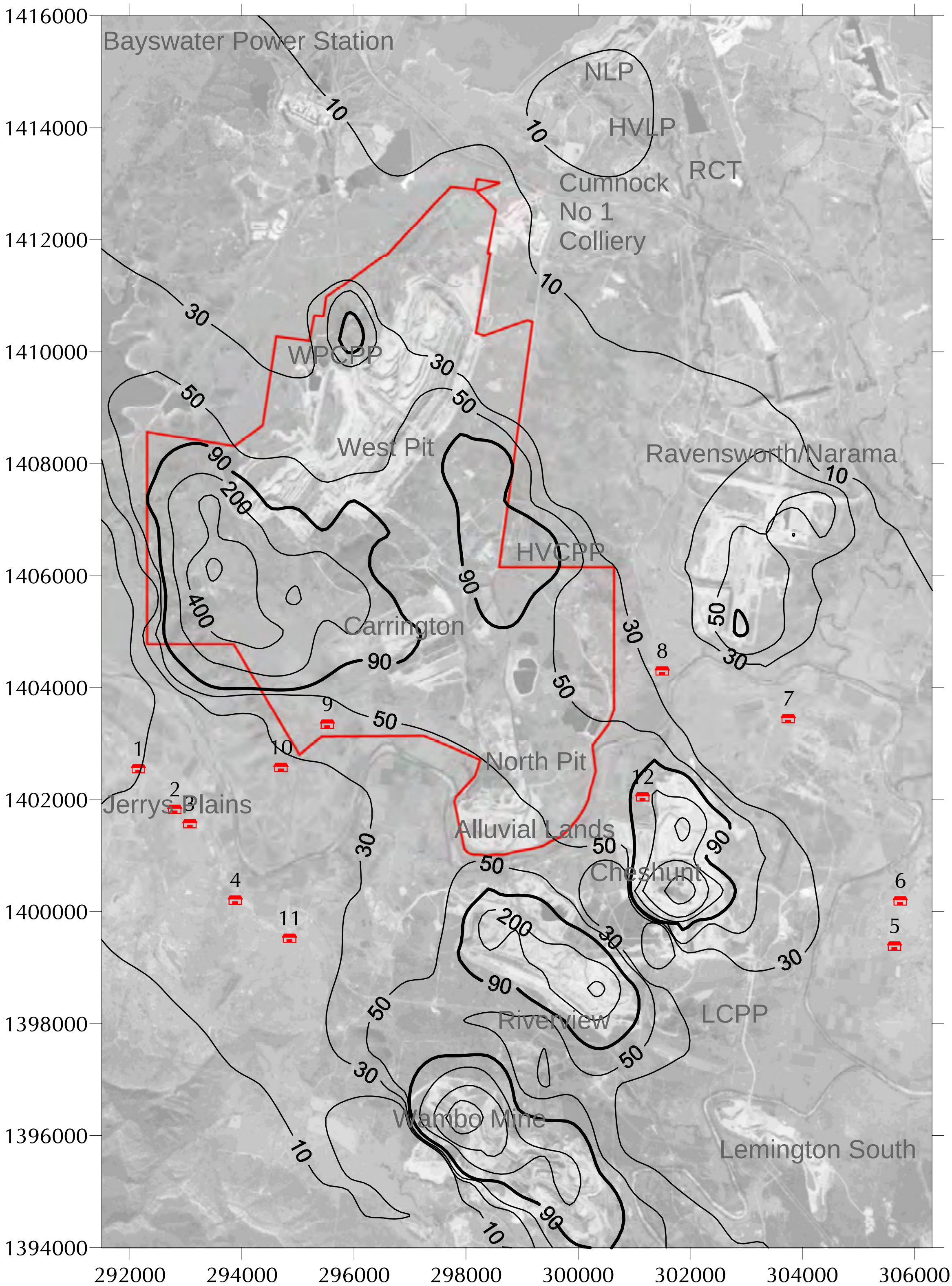
Predicted annual average PM_{10} concentrations
due to emissions from the Proposal and other sources in Year 20 ($\mu g/m^3$)

Figure 49



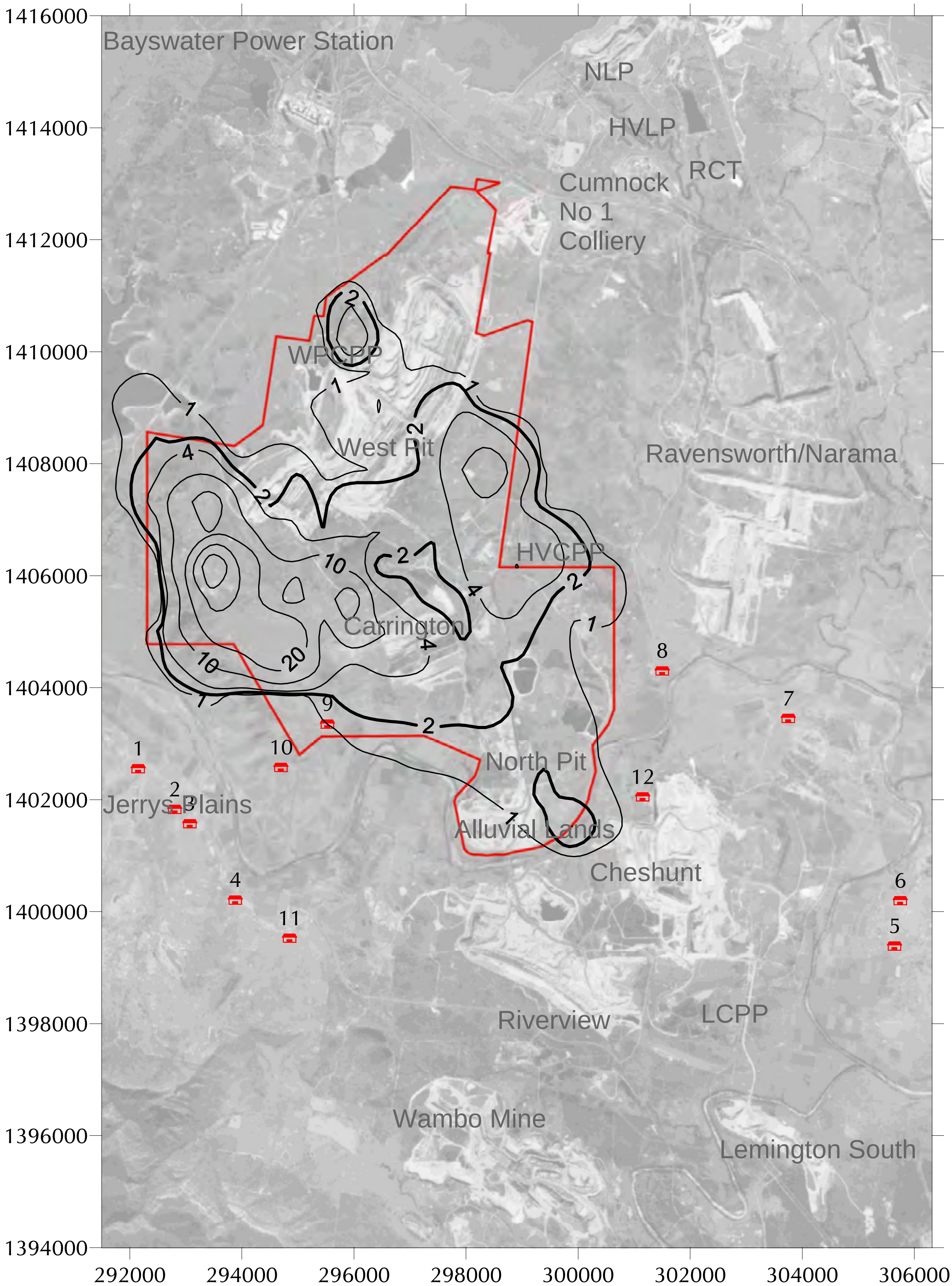
Predicted annual average TSP concentrations
due to emissions from the Proposal in Year 20 (μg/m^3)

Figure 50



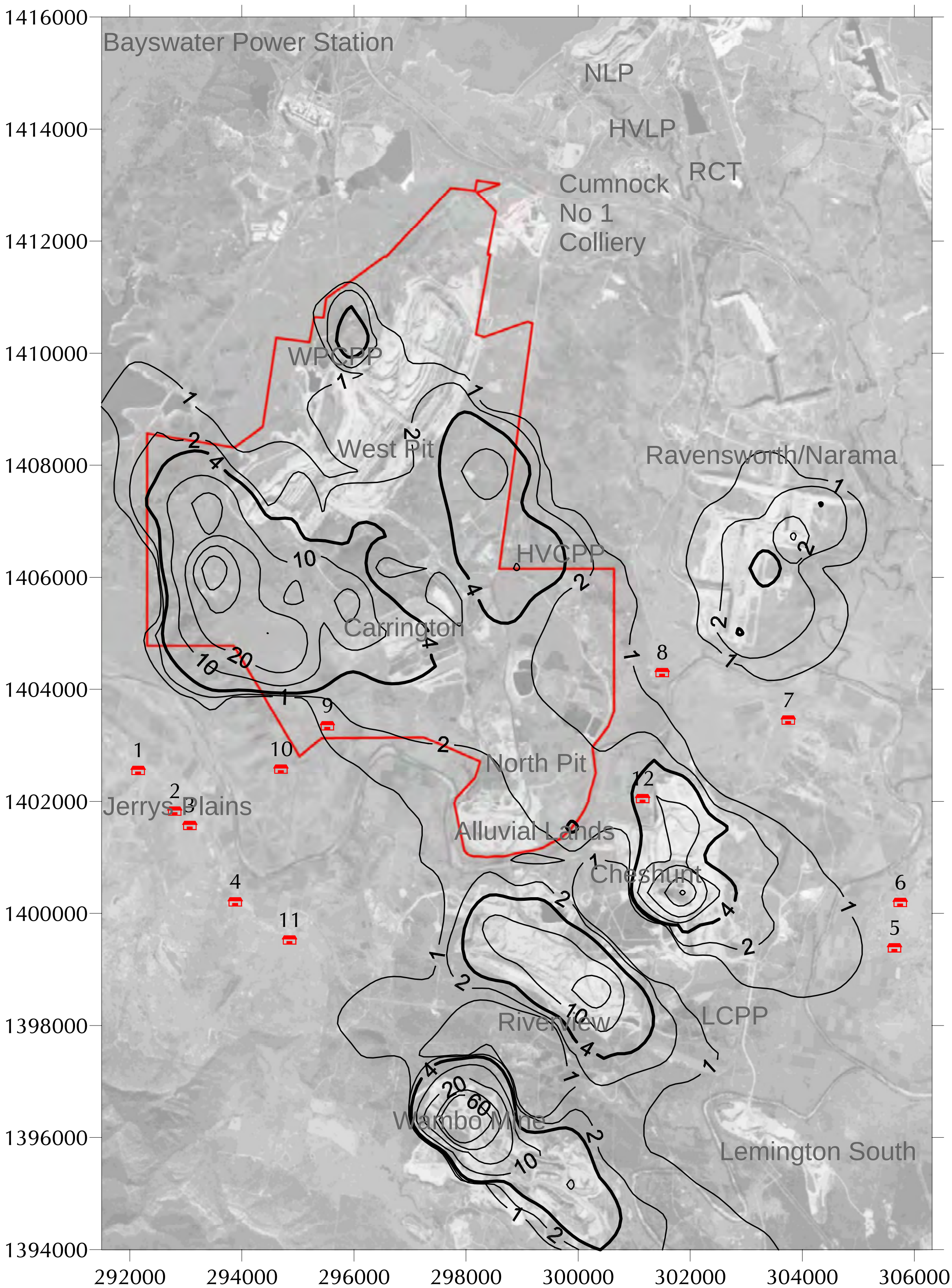
Predicted annual average TSP concentrations
due to emissions from the Proposal and other sources in Year 20 ($\mu g/m^3$)

Figure 51



Predicted annual average dust deposition
due to emissions from the Proposal in Year 20 (g/m²/month)

Figure 52



Predicted annual average dust deposition due to emissions from the Proposal and other sources in Year 20 (g/m²/month)

Figure 53

9 MITIGATION

The modelling results presented above are based on the assumption that the project applies control measures to minimise dust emissions. Because of the scale of mining operations in the Hunter Valley and the need to manage cumulative impacts, it will be necessary to ensure that dust emissions are kept to the minimum practicable level. This section outlines procedures proposed for the management and control of dust emissions.

Proposed dust management and control procedures

The following procedures are proposed for the management of dust emissions from the mine. The aim of these procedures is to minimise the emission of uncontrolled dust. Dust can be generated from two primary sources, these being:

i) wind blown dust from exposed areas, and

ii) dust generated by mining activities.

Table 21 and **Table 22** list the different sources of wind blown and mining generated dust respectively, and the proposed controls.

Table 21. Control procedures for wind blown dust

Source	Control Procedures
Areas Disturbed by Mining	Disturb only the minimum area necessary for mining. Reshape, topsoil and rehabilitate completed overburden emplacement areas as soon as practicable after the completion of overburden tipping.
Coal Handling Areas	Maintain coal-handling areas in a moist condition using water carts to minimise wind blown and traffic generated dust.
Coal Product Stockpiles	Maintain water sprays on product coal stockpiles and use sprays to reduce the risk of airborne dust.

Table 22. Mine generated dust and controls

Source	Control procedures
Haul Road Dust	All roads and trafficked areas will be watered using water carts to minimise the generation of dust. All haul roads will have edges clearly defined with marker posts or equivalent to control their locations, especially when crossing large overburden emplacement areas. Obsolete roads will be ripped and re-vegetated.
Minor Roads	Development of minor roads will be limited and the locations of these will be clearly defined. Minor roads used regularly for access etc will be watered. Obsolete roads will be, ripped and re-vegetated.
Topsoil Stripping	Access tracks used by topsoil stripping equipment during their loading and unloading cycle will be watered.
Topsoil Stockpiling	Long term topsoil stockpiles, not used for over 6 months will be re-vegetated.
Drilling	Dust aprons will be lowered during drilling. Drills will be equipped with dust extraction cyclones, or water injection systems. Water injection or dust suppression sprays will be used when high levels of dust are being generated.
Blasting	Adequate stemming will be used at all times.
Raw Coal Bins	Automatic sprays, or other dust control mechanisms will be used when tipping raw coal that generates excessive dust quantities.
Coal Preparation Plant	All spillage of material will be cleaned up to prevent dust. Water sprays are/will be fitted at all transfer points.
Conveyors	Conveyors will be covered on the top and wherever practicable on the upwind side. All spillages from conveyors will be cleaned up as soon as practicable.

It is envisaged that the monitoring program necessary to verify environmental performance will incorporate the following.

- One meteorological station at the existing location.
- Three high volume PM_{10} monitors at locations to be selected in consultation with the EPA but likely to include the current locations.
- The current network of deposition gauges would be used to monitor dust fallout.
- A real-time dust monitor will be installed to measure PM_{10} concentrations at a location agreed with the EPA
- Real time monitoring of wind speed and wind direction will also be undertaken to allow real-time dust monitoring data to be interpreted and assist in the implementation of best practice management to minimise the effects of dust emissions.

10 ECOLOGICALLY SUSTAINABLE DEVELOPMENT

Planning NSW has developed guidelines for assessing projects with respect to the principles of ESD. The principles include:

- The precautionary principle
- Intergenerational equity
- Conservation of biodiversity and ecological integrity
- Valuation and pricing of resources.

This report deals with air quality and consequently not all of these principles are relevant, although they are relevant when other aspects of the Proposal are considered.

Air quality impacts will be confined to health and nuisance impacts and there is a reasonable degree of certainty as to the extent and nature of these impacts.

It can be safely assumed that there is little prospect that air quality impacts due to the Proposal will cause "serious or irreversible environmental damage" and consequently the precautionary principle, applied to air quality, would not preclude the development of the Proposal.

On the second point concerning intergenerational equity, the coal resource will of course be unavailable for future use by future generations once mining is completed. However, this is not an issue that relates directly to air quality and will be dealt with elsewhere in the EIS. Similarly, the Proposal does require a detailed assessment under the third principle, namely the "conservation of biodiversity and ecological integrity". However, provided the ambient air quality criteria, which are designed to protect human health, are complied with, air quality impacts are not expected to impact either flora or fauna. Notwithstanding this, there will be temporary (over the life of the mine) loss of habitat as the area disturbed by mining passes through the lease area.

Finally, the principle titled "valuation and pricing of resources" includes requirements that the polluter pays, that users of goods and services should pay prices based on the full life cycle of the product including the costs for the disposal of wastes. The mine will of course be rehabilitated to standards set by the conditions of consent. Emissions of dust will be controlled so that ambient air quality criteria in the area are complied with on all land not owned by the proponent, or not subject to agreement with the affected landowner.

11 GREENHOUSE ISSUES

Coal mining results in the emission of carbon dioxide (CO_2) during the combustion of diesel fuel (used in diesel-powered equipment and in blasting) and indirectly in the use of electricity to power mining equipment and operate the coal preparation plants. In addition, methane is released as coal is mined.

To estimate emissions from these sources, the electrical and fuel requirement for existing mining operations have been used to determine the energy required to mine each tonne of coal on the existing mine. These estimates have then been used to estimate CO_2 emissions rates for future years.

The starting point for the estimates was data provided by CNA for HVO operations in 2002. These data showed that HVO used 51,196,989 litres of diesel and 132,920,819 kWh of electrical energy to produce 16,974,760 tonne of ROM coal.

In converting the information to estimates of CO_2-e (CO_2 equivalent) emissions it has been assumed that each kWh of electrical energy used results in the release of 0.904 kg of CO_2 (**Australian Greenhouse Office, 2003)** and that each litre of diesel fuel burnt (either in mobile plant or explosives) results in the release of 2.7 kg of CO_2 (**Australian Greenhouse Office, 2003**). In addition, it has been assumed that each tonne of ROM coal mined results in the release of 2.17 kg of methane and that methane has a greenhouse warming potential of 21. (This means that each kilogram of methane, because of its lifetime in the atmosphere and its spectral absorption characteristics, is equivalent to 21 kg of CO_2).

Table 23 summarises the estimated CO_2 emissions from the West Pit mine only for each year using the above emissions factors for the CHPP and open cut. Emissions from Carrington, Mitchell Pit and mines south of the river are not included in this estimate. This approach is in contrast to the assessment for dust impacts where all HVO mines north of the Hunter River have been included.

Table 23: Summary of estimated CO_2 emissions for West Pit

	WPCPP t of ROM coal	HVCPP t of ROM coal	Electricity used by WPCPP kWh	Electricity used by HVCPP kWh	Diesel used in transport and blasting at West Pit litres	kg CH4	Total CO2-e from mining at West Pit kg
2003	3,400,000	4,507,469	26,623,692	35,295,724	23,849,444	17,159,207	480,712,003
2004	3,500,000	6,649,923	27,406,742	52,072,208	30,612,834	22,025,333	617,035,619
2005	3,500,000	5,382,647	27,406,742	42,148,808	26,790,647	19,275,345	539,995,205
2006	3,500,000	6,591,658	27,406,742	51,615,964	30,437,103	21,898,898	613,493,564
2007	3,500,000	4,448,907	27,406,742	34,837,160	23,974,426	17,249,129	483,231,152
2008	3,500,000	6,927,011	27,406,742	54,241,945	31,448,549	22,626,614	633,880,393
2009	3,500,000	6,892,116	27,406,742	53,968,702	31,343,304	22,550,893	631,759,067
2010	3,500,000	5,491,605	27,406,742	43,001,997	27,119,269	19,511,782	546,618,944
2011	3,500,000	6,113,140	27,406,742	47,868,930	28,993,861	20,860,514	584,403,432
2012	3,500,000	6,312,728	27,406,742	49,431,803	29,595,831	21,293,620	596,536,811
2013	3,500,000	6,590,419	27,406,742	51,606,264	30,433,366	21,896,210	613,418,258
2014	4,600,000	8,274,157	36,020,289	64,790,767	38,829,302	27,936,921	782,647,645
2015	4,800,000	7,451,560	37,586,389	58,349,423	36,951,508	26,585,885	744,798,636
2016	5,500,000	8,530,884	43,067,737	66,801,069	42,318,067	30,447,019	852,967,576
2017	5,950,000	8,129,681	46,591,461	63,659,452	42,465,242	30,552,909	855,934,062
2018	6,300,000	5,304,981	49,332,135	41,540,638	35,001,382	25,182,808	705,491,686
2019	9,150,000	4,425,308	71,649,054	34,652,367	40,944,020	29,458,419	825,272,140
2020	10,050,000	3,086,736	78,696,502	24,170,679	39,621,257	28,506,717	798,610,385
2021	9,851,806	1,441,806	77,144,547	11,290,061	34,062,276	24,507,139	686,562,957
2022	11,373,143	1,323,143	89,057,374	10,360,872	38,292,834	27,550,943	771,834,541
2023	14,047,018	1,577,018	109,995,139	12,348,833	47,123,115	33,904,157	949,818,651
Total	**120,021,967**	**115,452,900**	**939,831,739**	**904,053,665**	**710,207,637**	**510,980,462**	**14,315,022,725**

The mine will also produce CO_2 when the coal is used by the ultimate customers. This is not included in the above estimates. Over the lifetime of the mine, a total of 235,474,867 t of ROM coal will be mined. This will yield approximately 164,832,407 t of product coal (70% recovery). On combustion, this will produce approximately 2.65 t of CO_2-e per tonne of coal burnt, that is the total CO_2-e emission from the West Pit mine over the 21-year life is 436,805,879 t of CO_2 equivalent or 20,800,280 t of CO_2-e per year on average. This can be compared with an average of 681,668 t of CO_2-e emission per year for mining and processing of the coal.

12 CONCLUSIONS

This report has developed emissions inventories for integrated operations at HVO north of the Hunter River for five representative periods in the next 21 Years. An additional scenario has been included for Year 8 based on the assumption that Carrington Pit is still operating. These have been used with local meteorological data and the US EPA's ISCST3 model to predict the maximum 24-hour PM_{10}, annual average PM_{10}, annual average TSP and annual average dust deposition (insoluble solids) over an area extending approximately 14 km (east-west) and 21 km (north-south). The modelling has been undertaken to show both the effects of mining HVO north of the Hunter River and the cumulative effects of these operations with neighbouring mines and other sources of dust.

It is concluded that a maximum of four residences (Residences 8, 9, 10 and 12) will be impacted by dust levels exceeding the EPA assessment criteria. These residences are already within an existing zone of affectation or have already made agreements either with CNA or with other mining companies.

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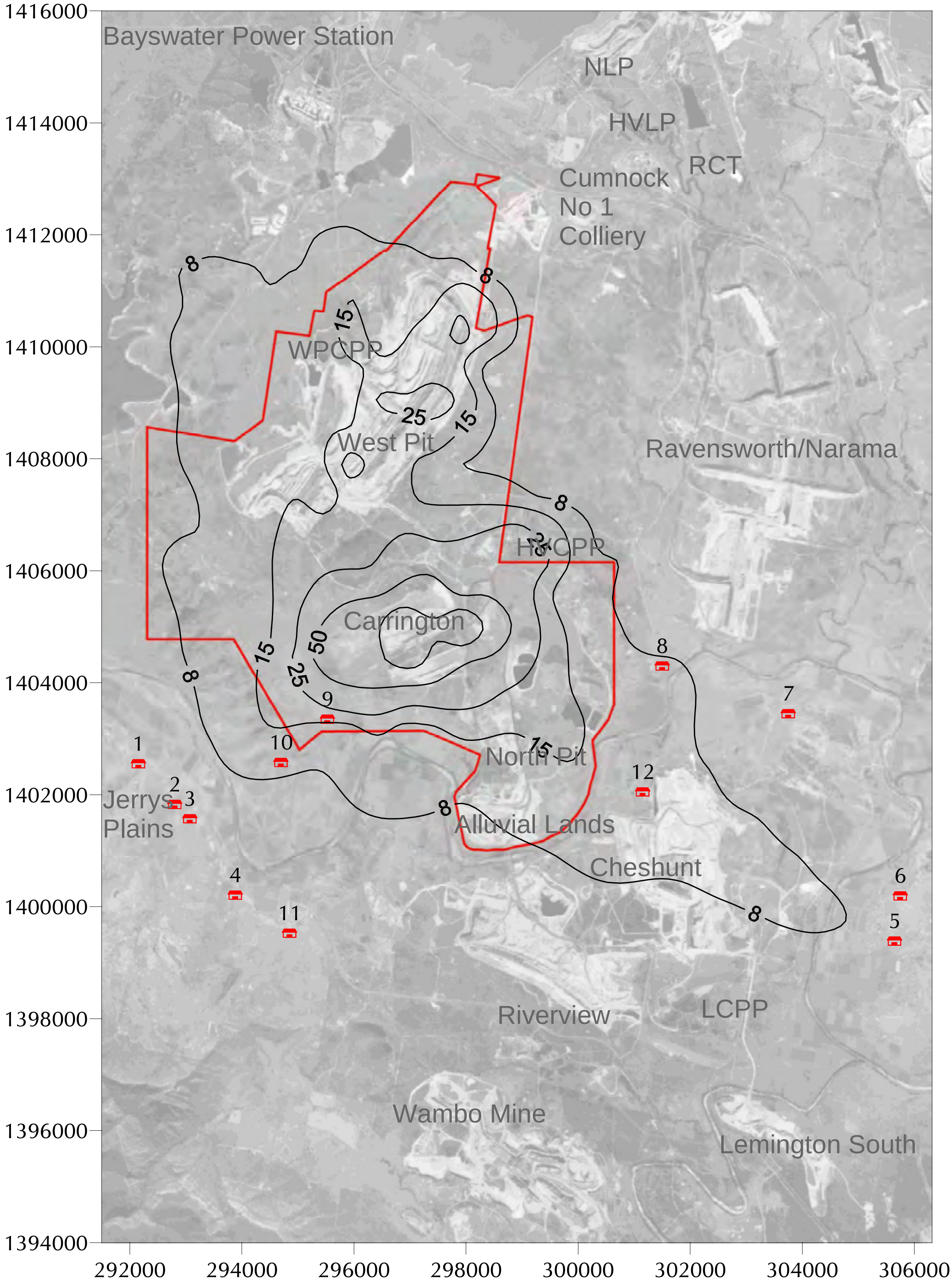
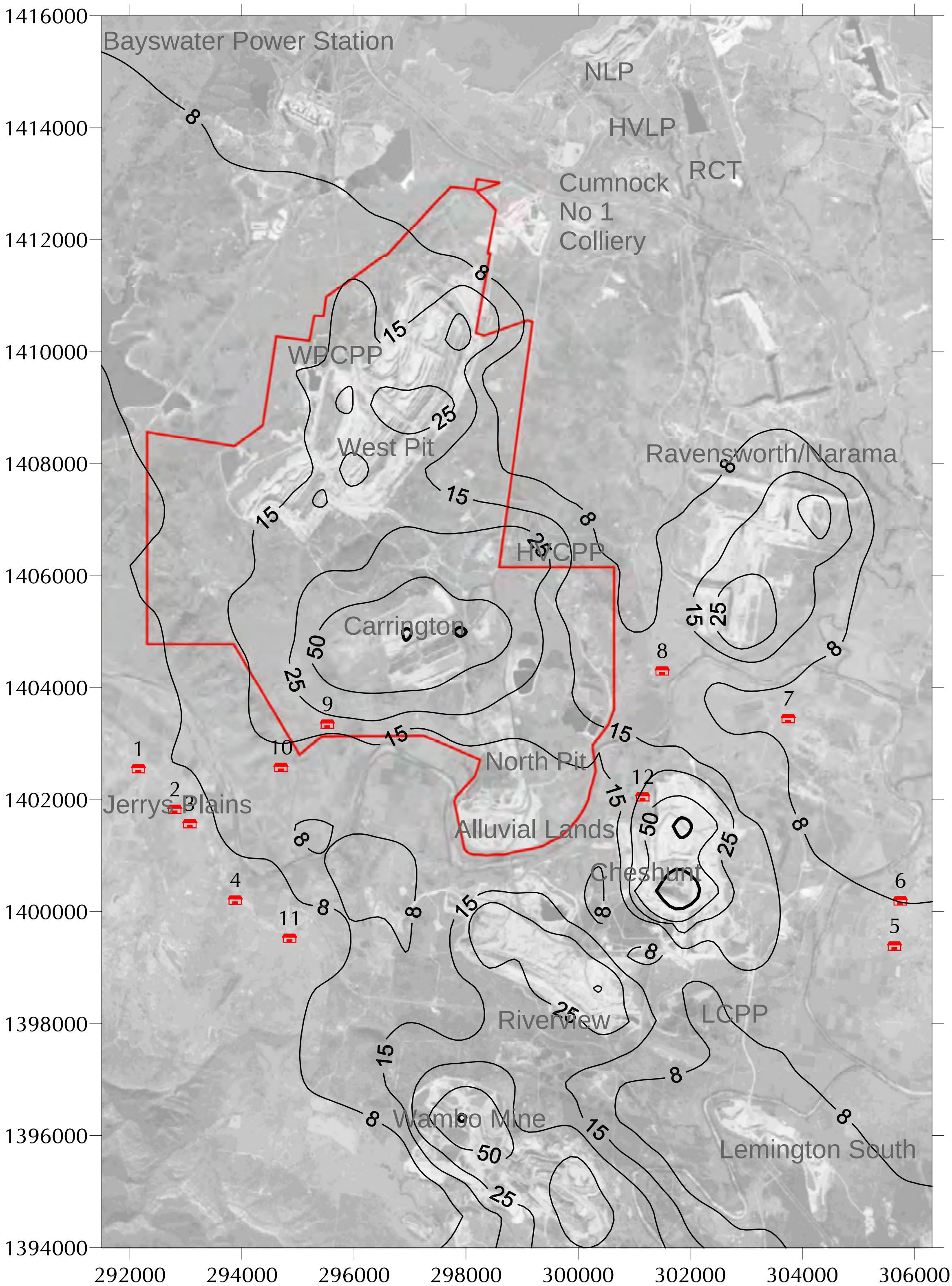
APPENDIX A
PREDICTED $PM_{2.5}$ CONCENTRATIONS FROM MINING SOURCES



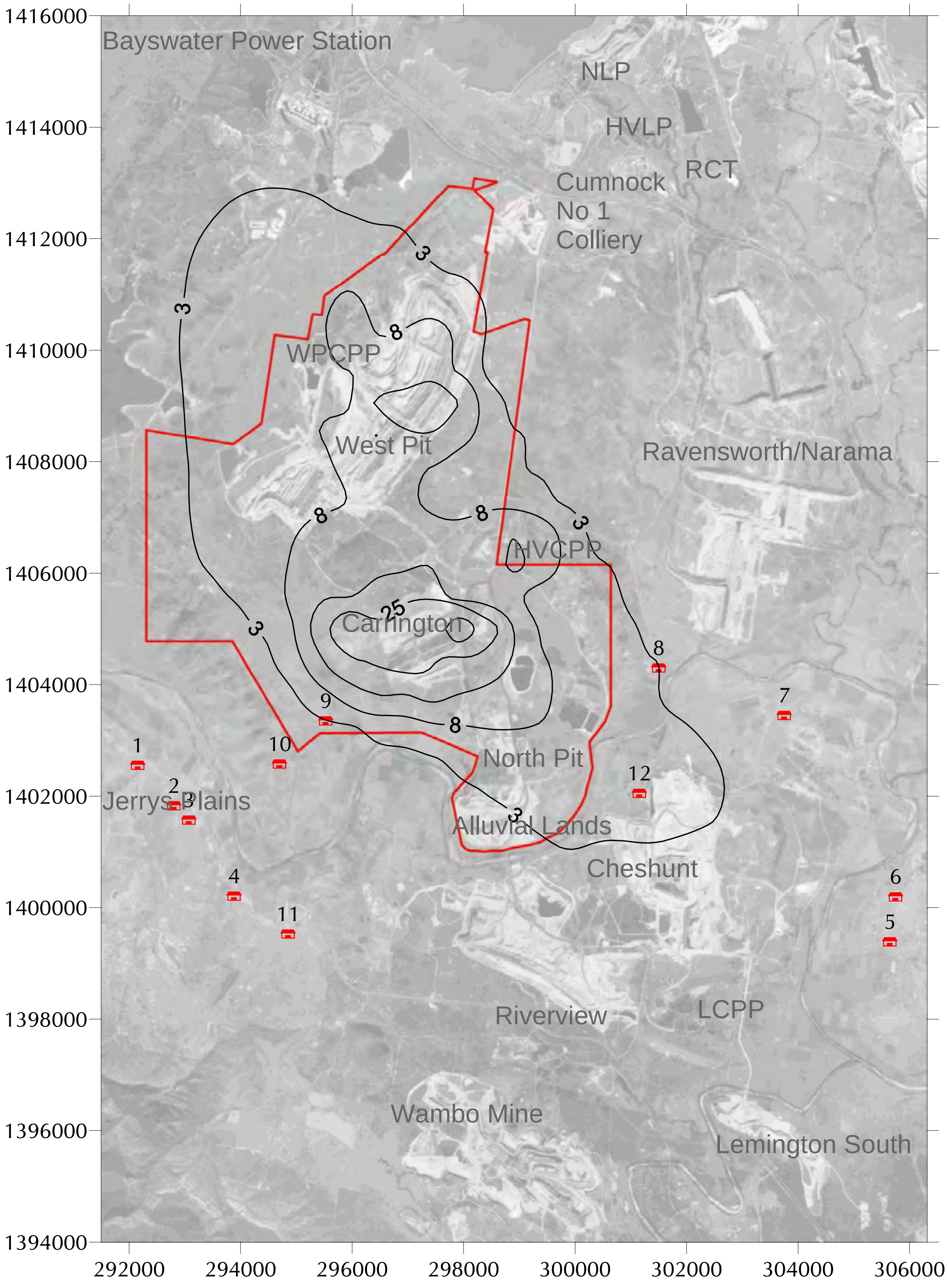
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 1 ($\mu g/m^3$)

Figure A1



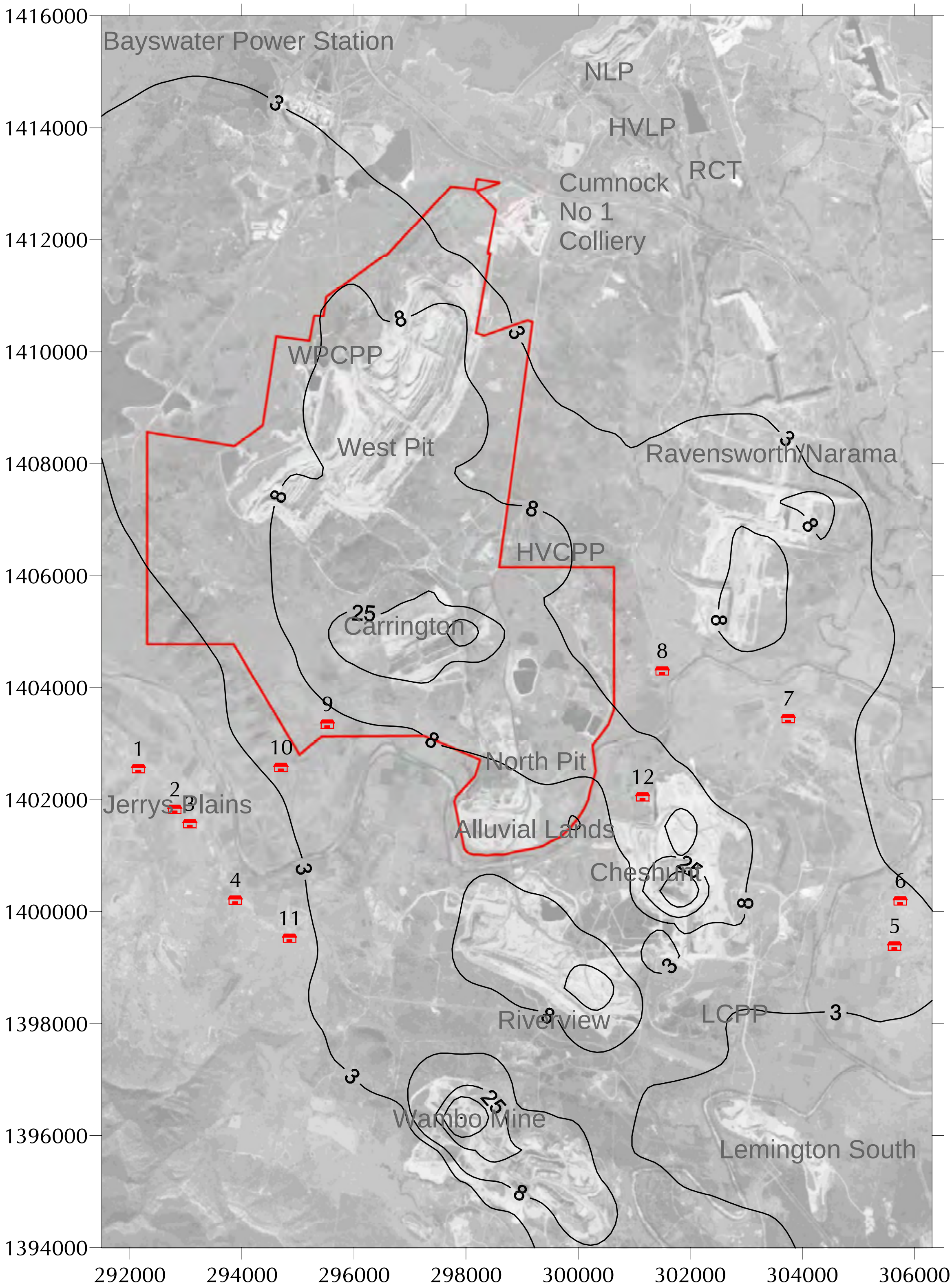
Predicted maximum 24-hour average $PM_{2.5}$ concentrations
due to emissions from the Proposal and other sources in Year 1 ($\mu g/m^3$)

Figure A2



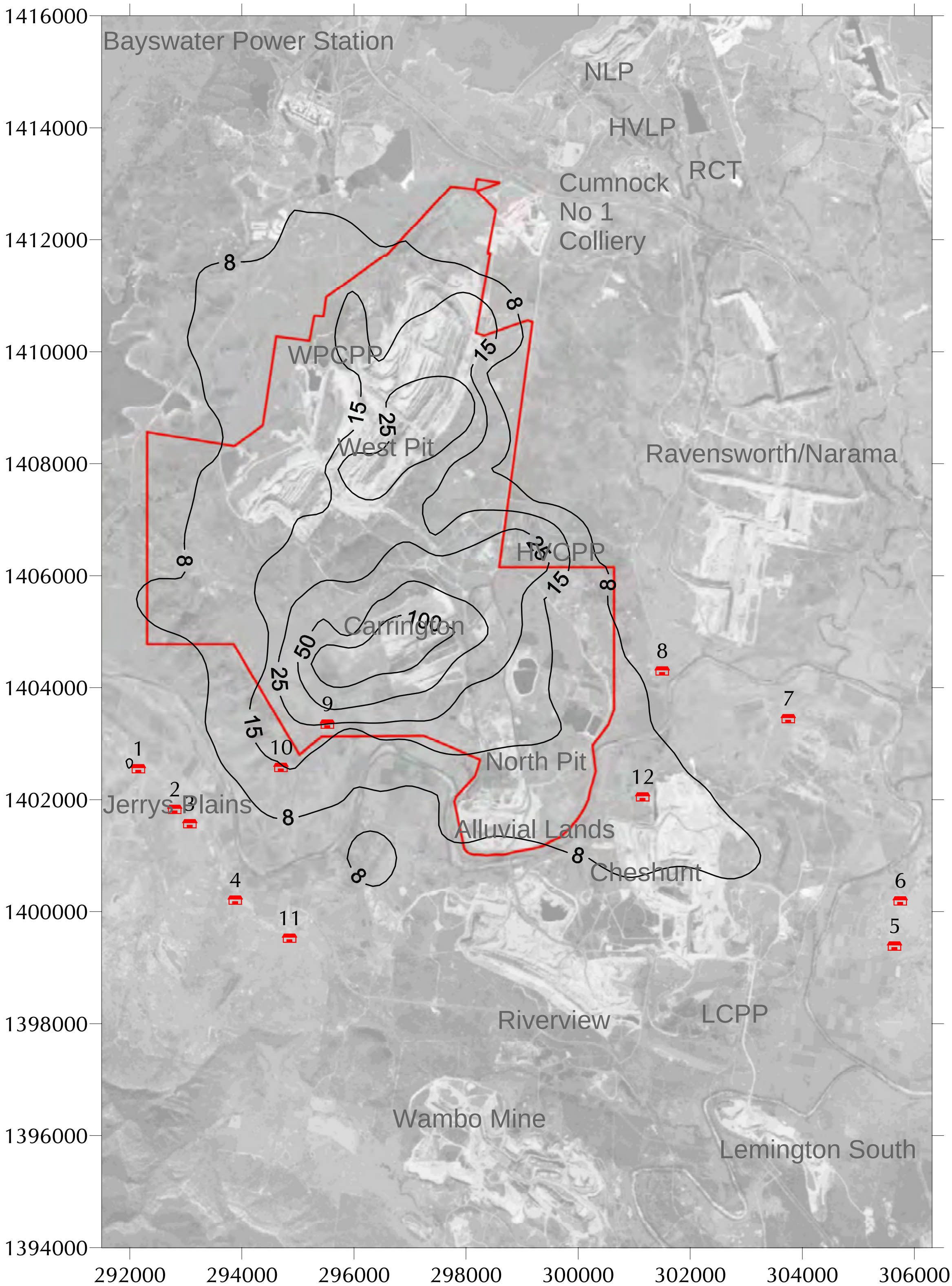
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 1 ($\mu g/m^3$)

Figure A3



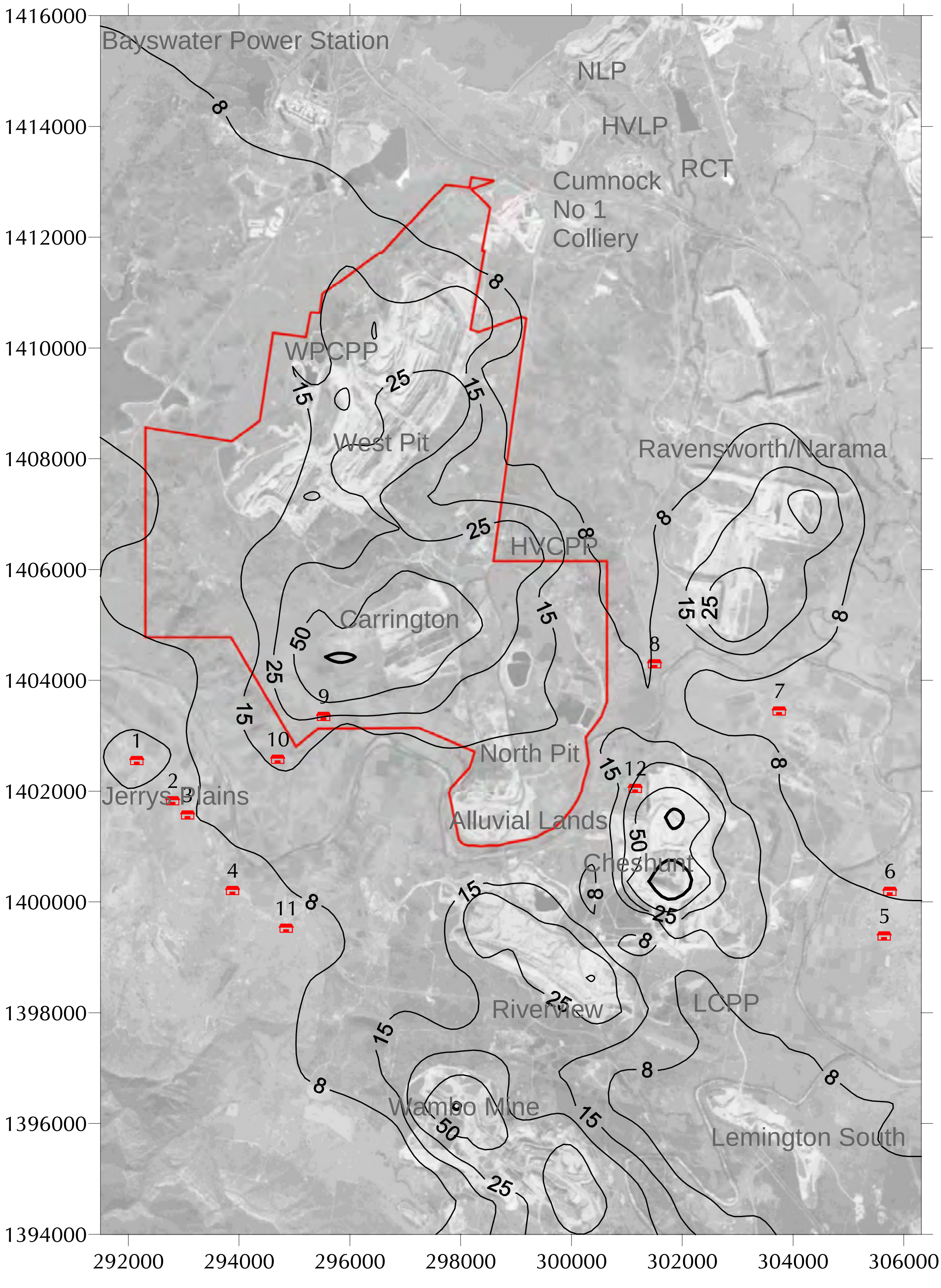
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 1 ($\mu g/m^3$)

Figure A4



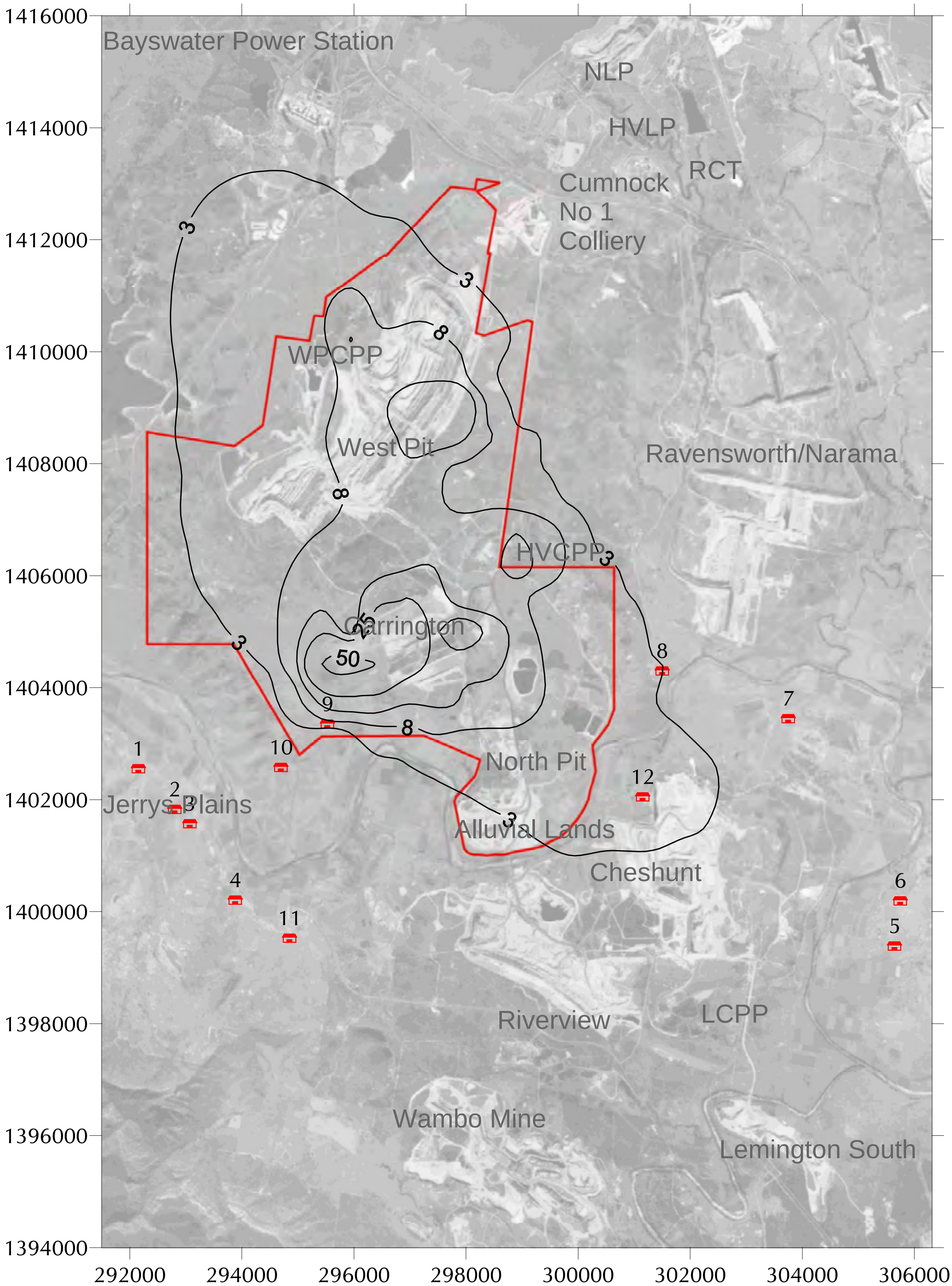
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 3 ($\mu g/m^3$)

Figure A5



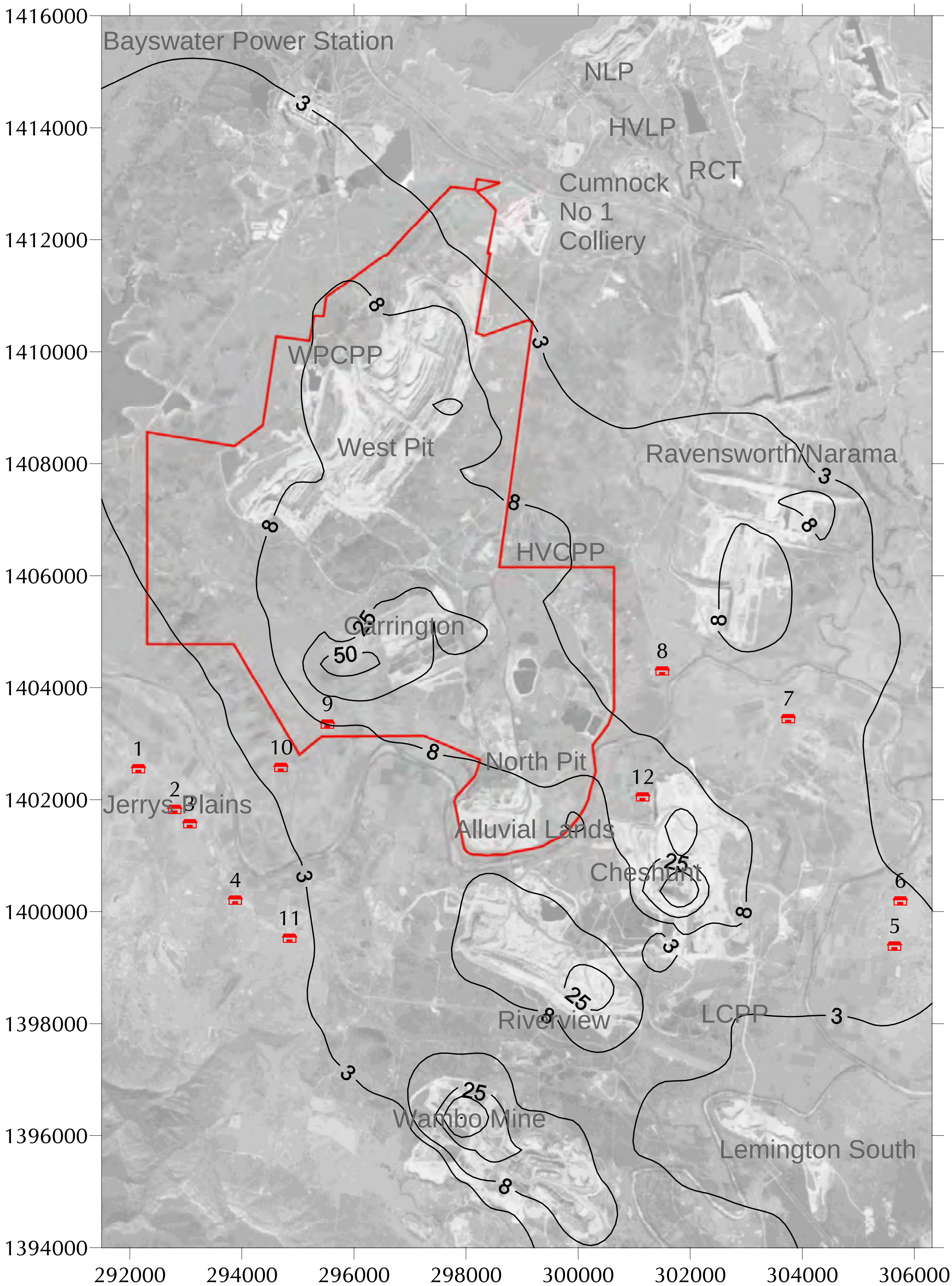
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 3 ($\mu g/m^3$)

Figure A6



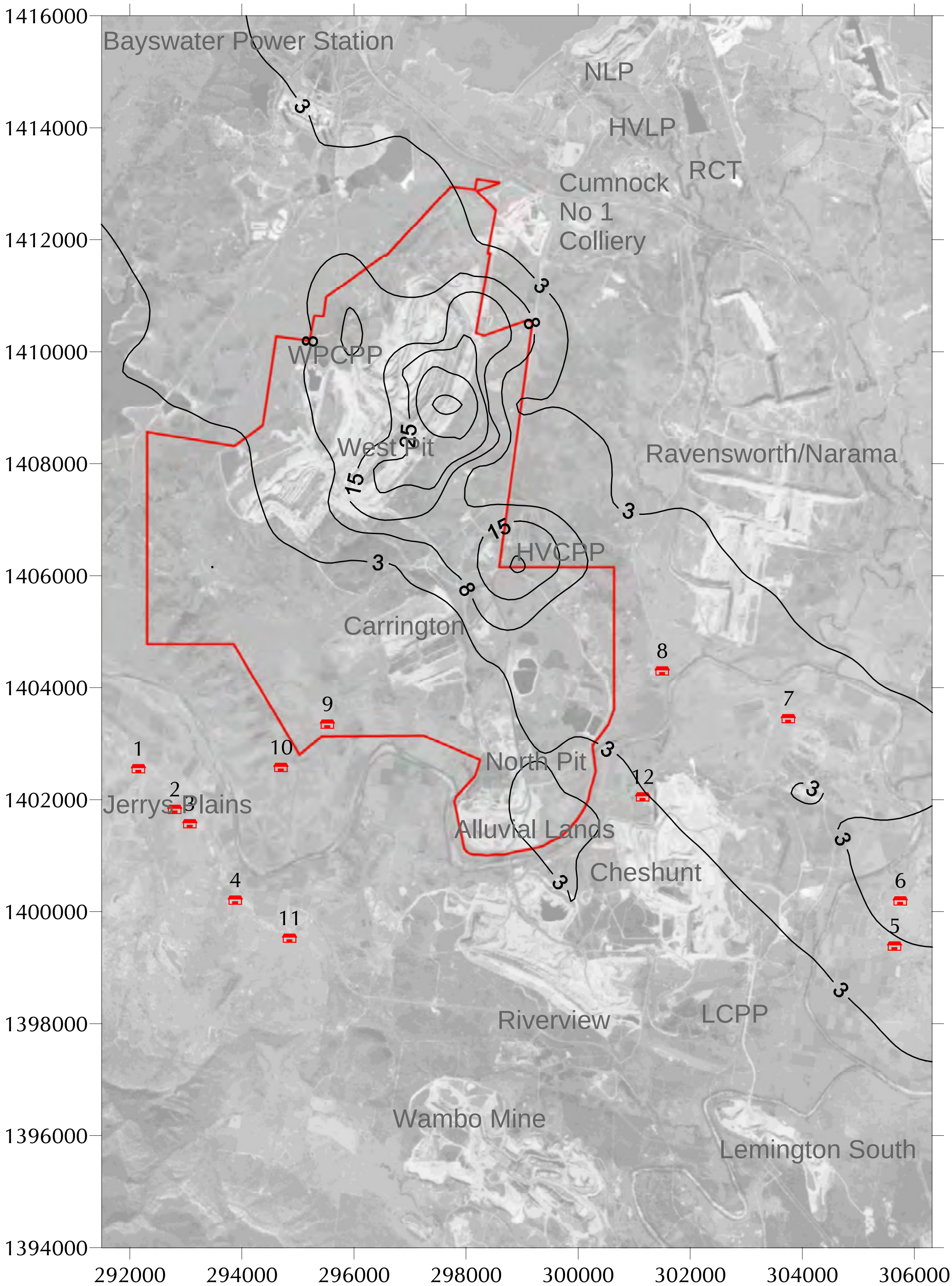
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 3 ($\mu g/m^3$)

Figure A7



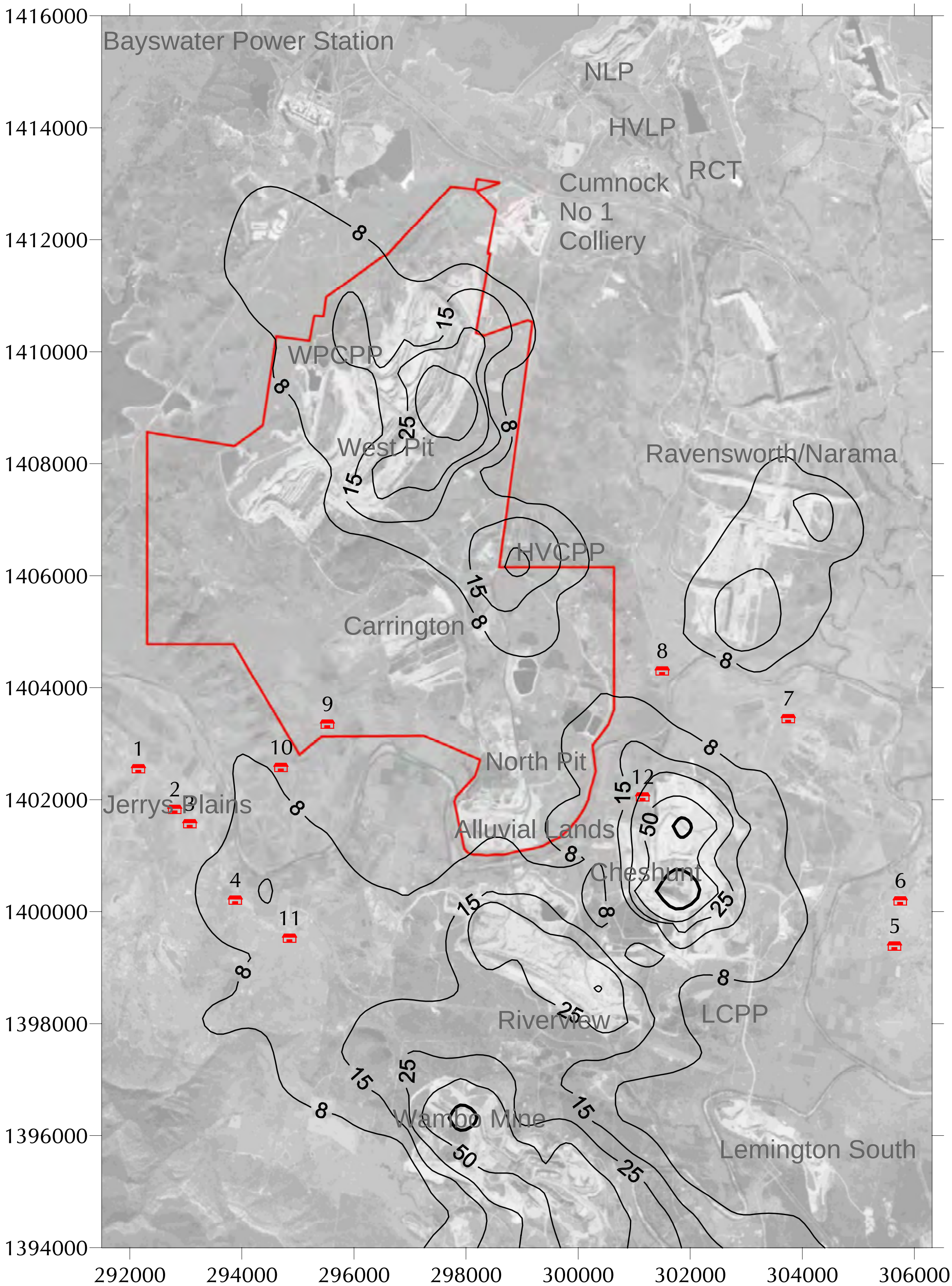
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 3 ($\mu g/m^3$)

Figure A8



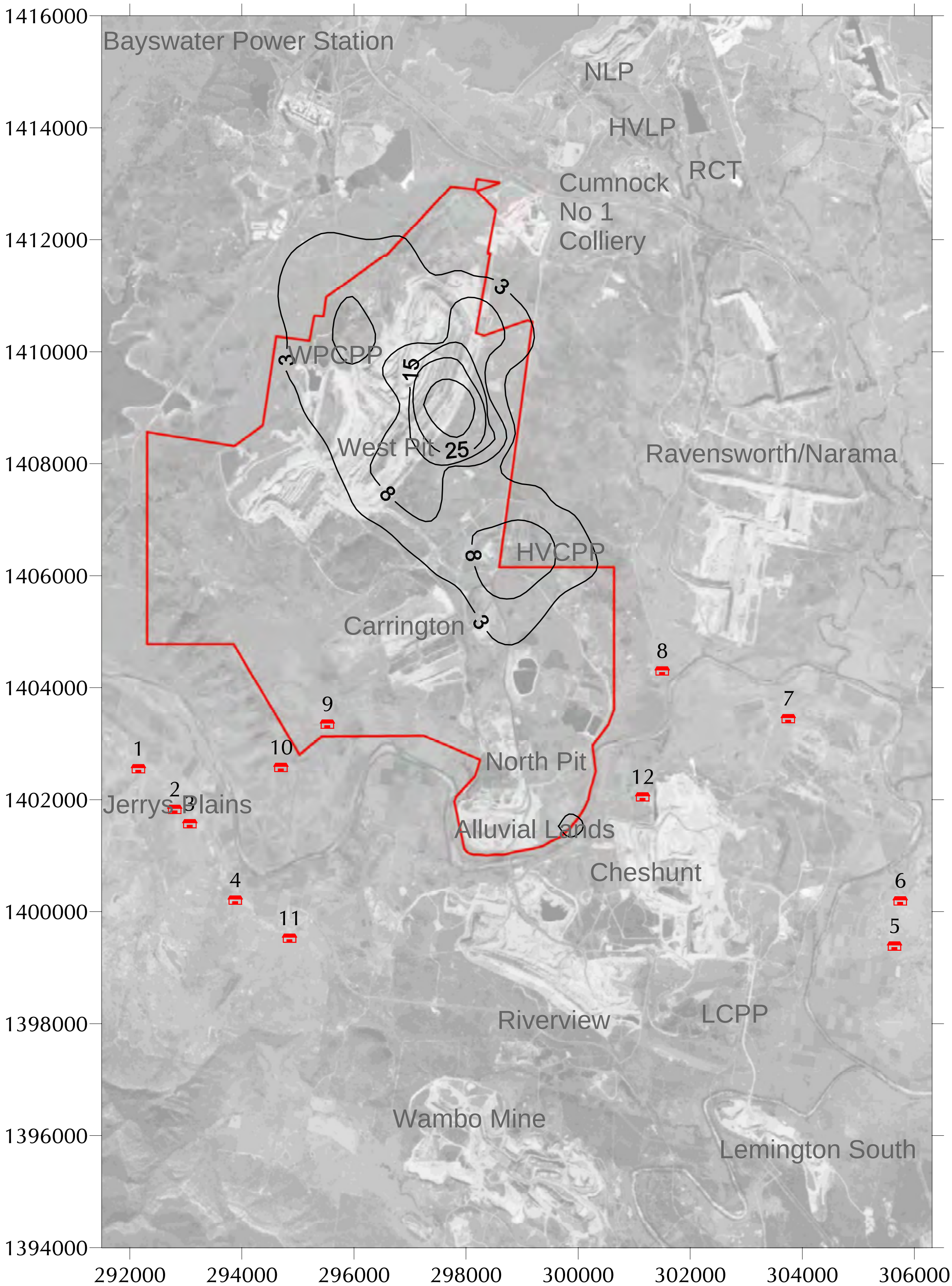
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 8 ($\mu g/m^3$)

Figure A9



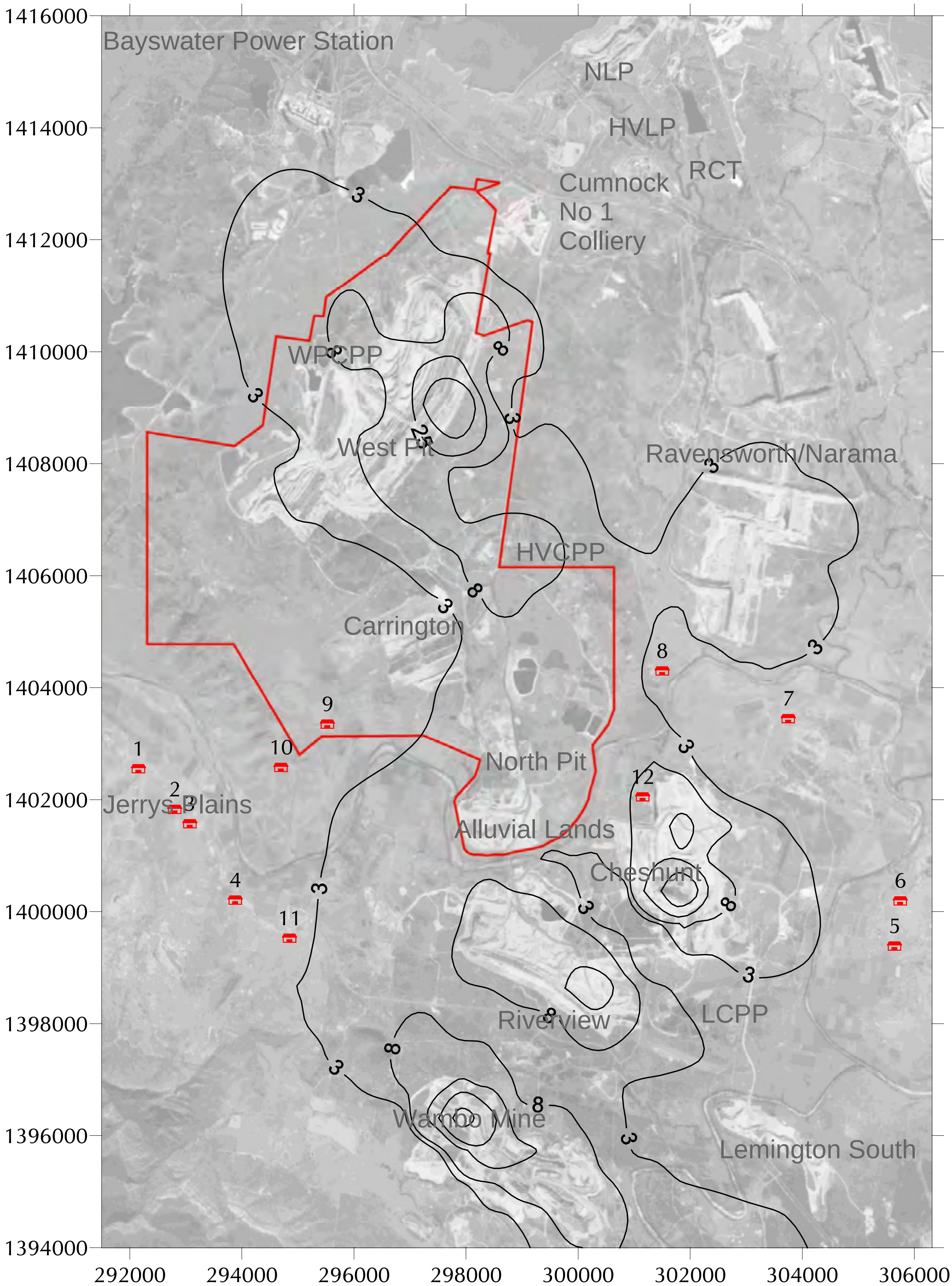
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 8 ($\mu g/m^3$)

Figure A10



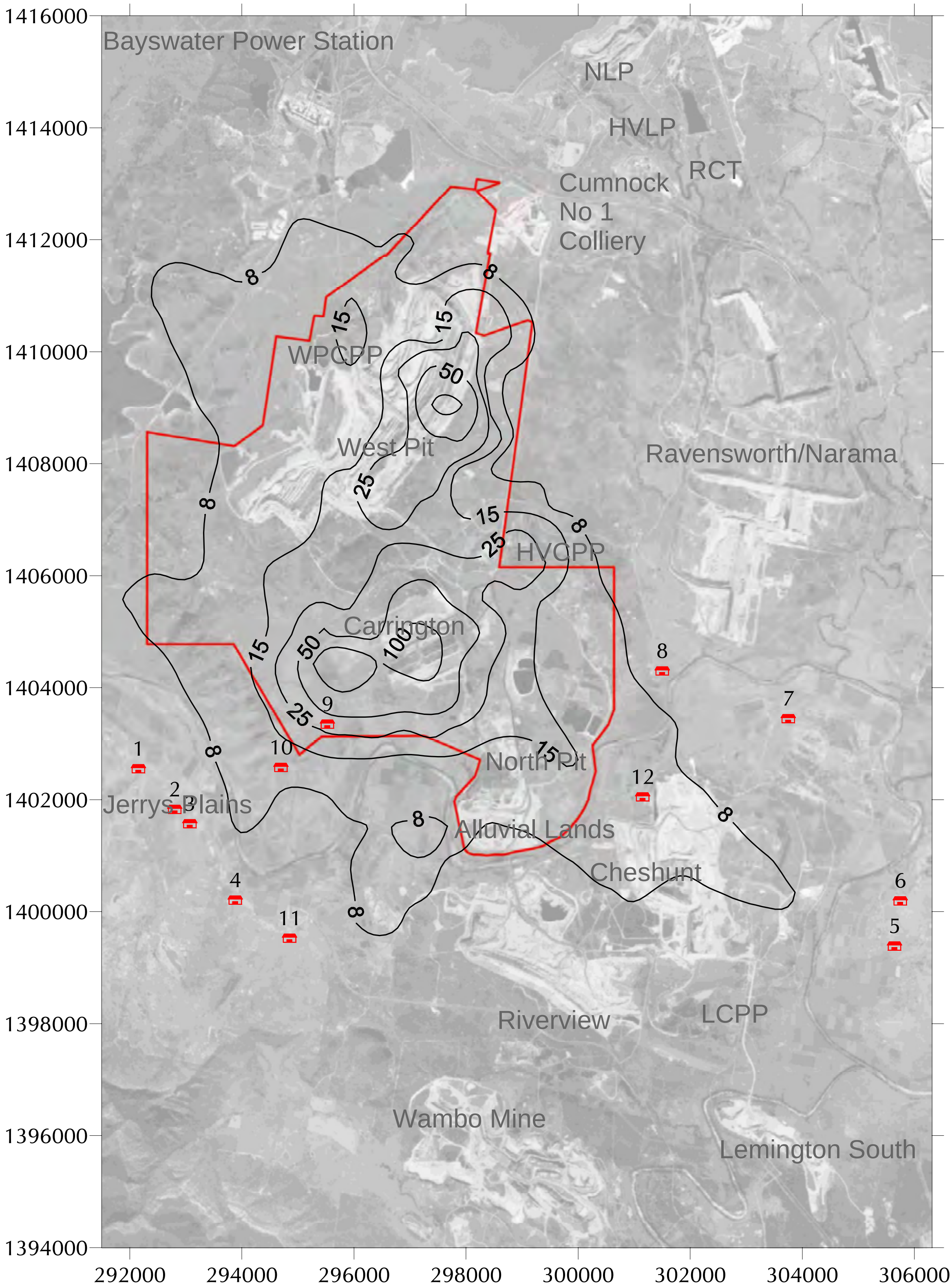
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 8 ($\mu g/m^3$)

Figure A11



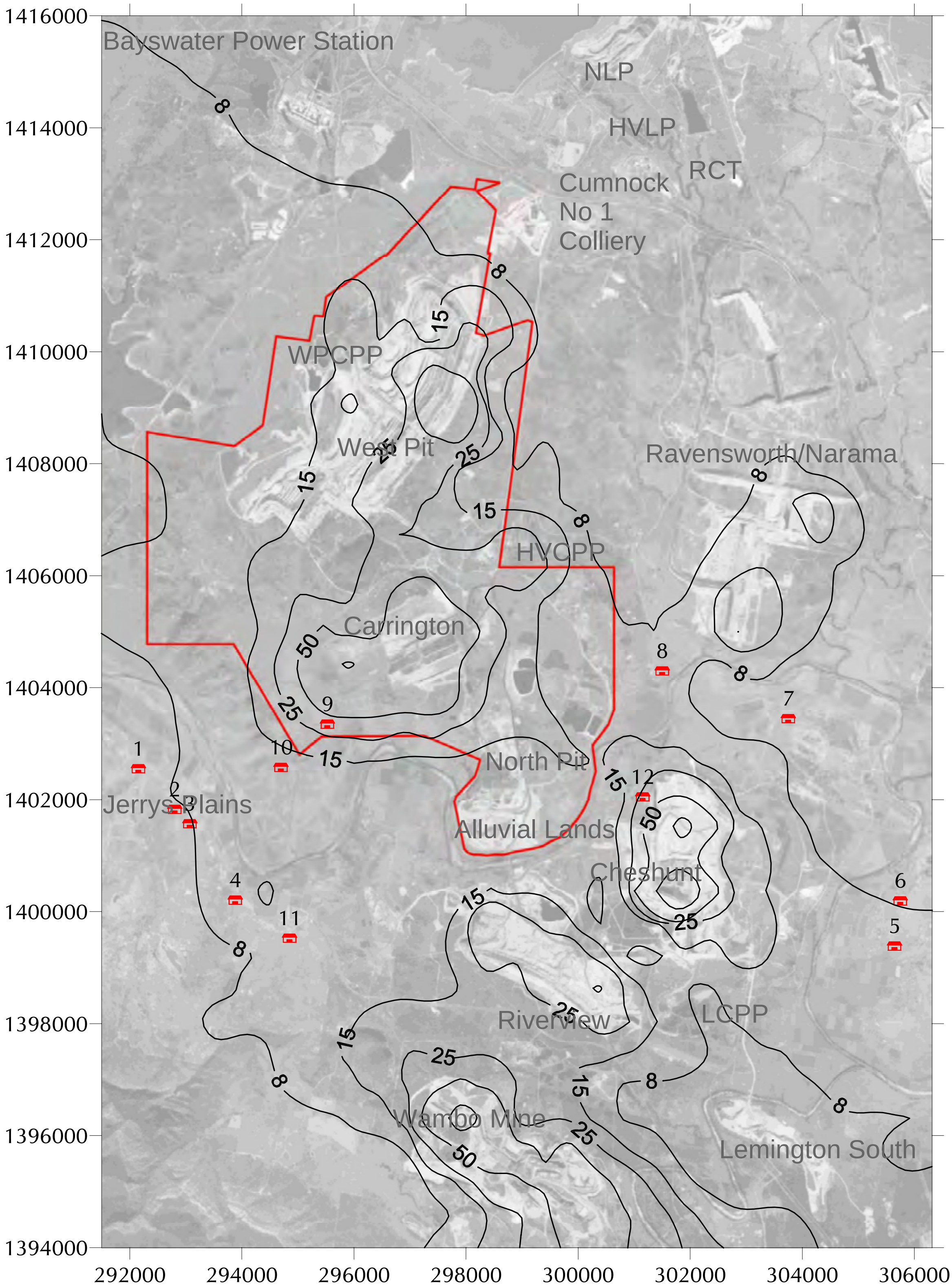
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 8 ($\mu g/m^3$)

Figure A12



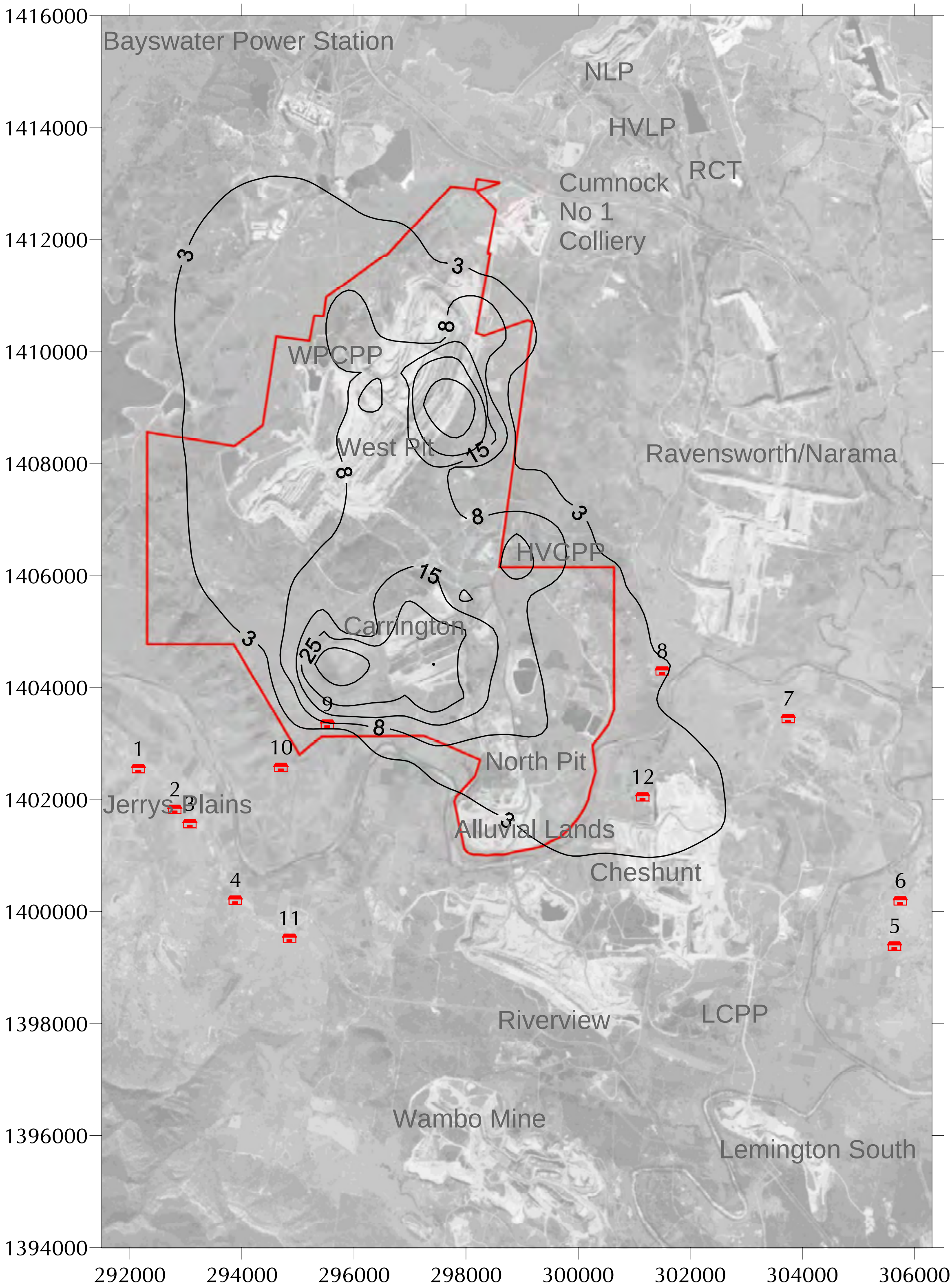
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 8 (alternative option) ($\mu g/m^3$)

Figure A13



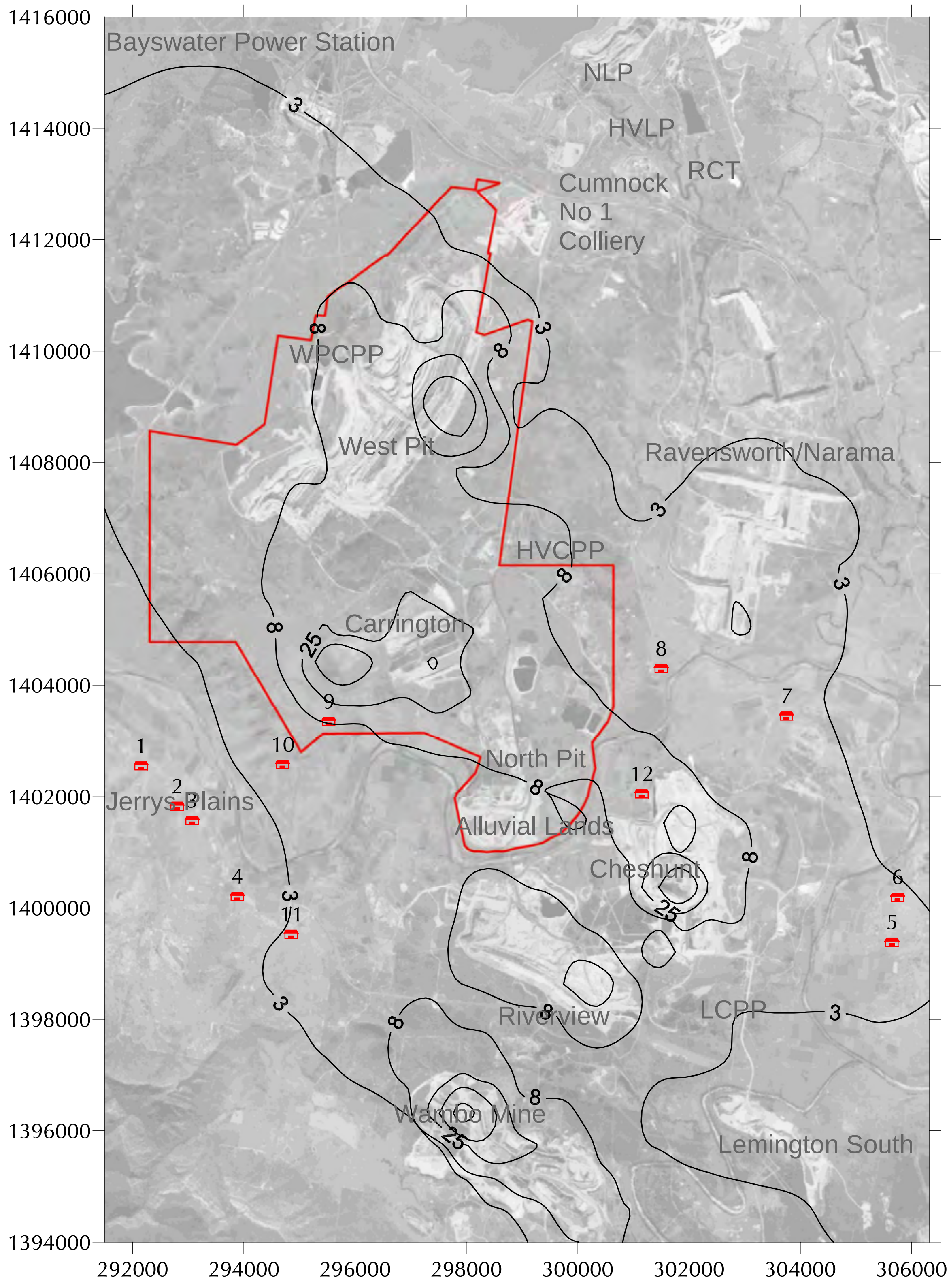
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 8 (alternative option) ($\mu g/m^3$)

Figure A14



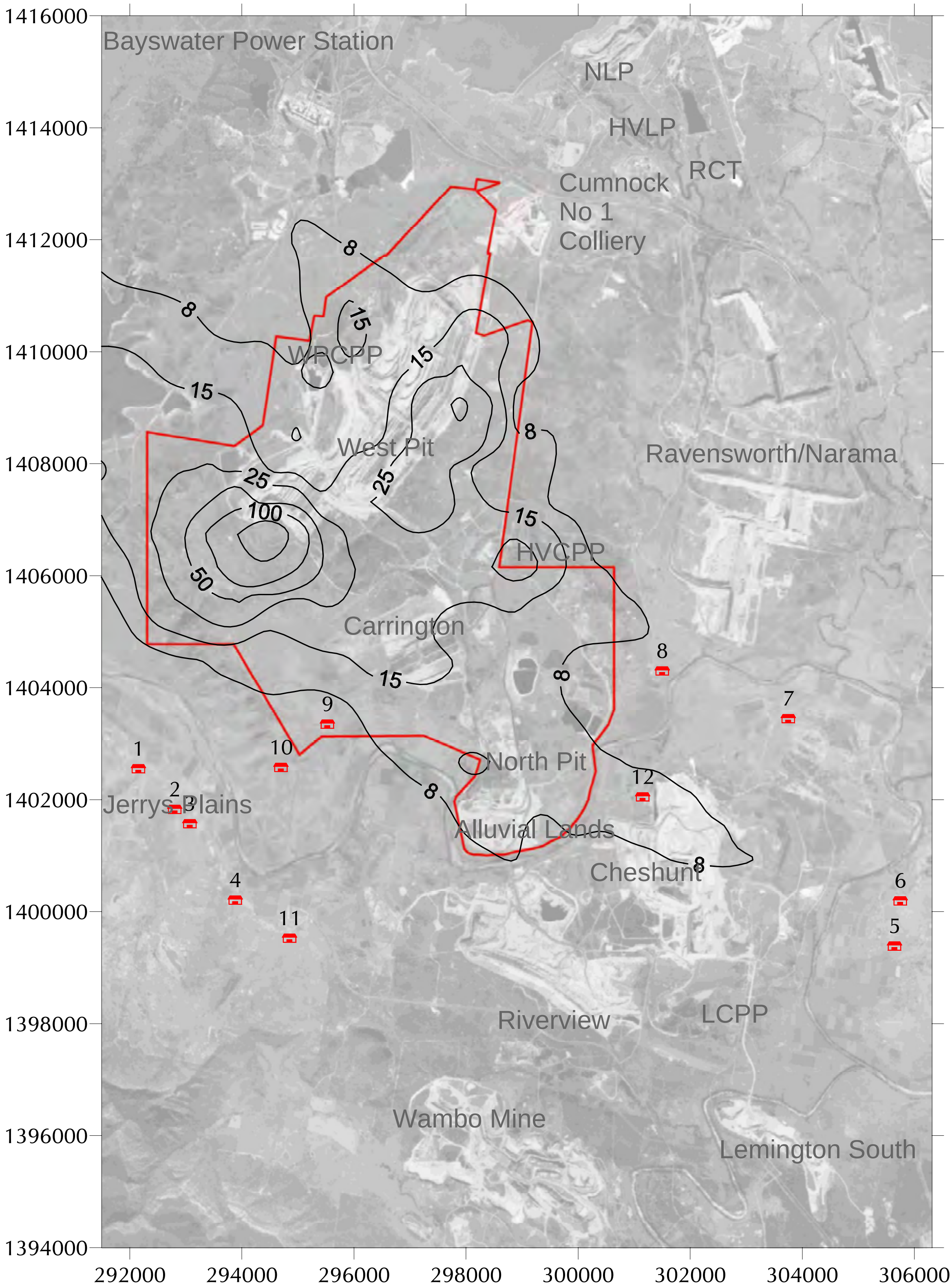
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 8 (alternative option) ($\mu g/m^3$)

Figure A15



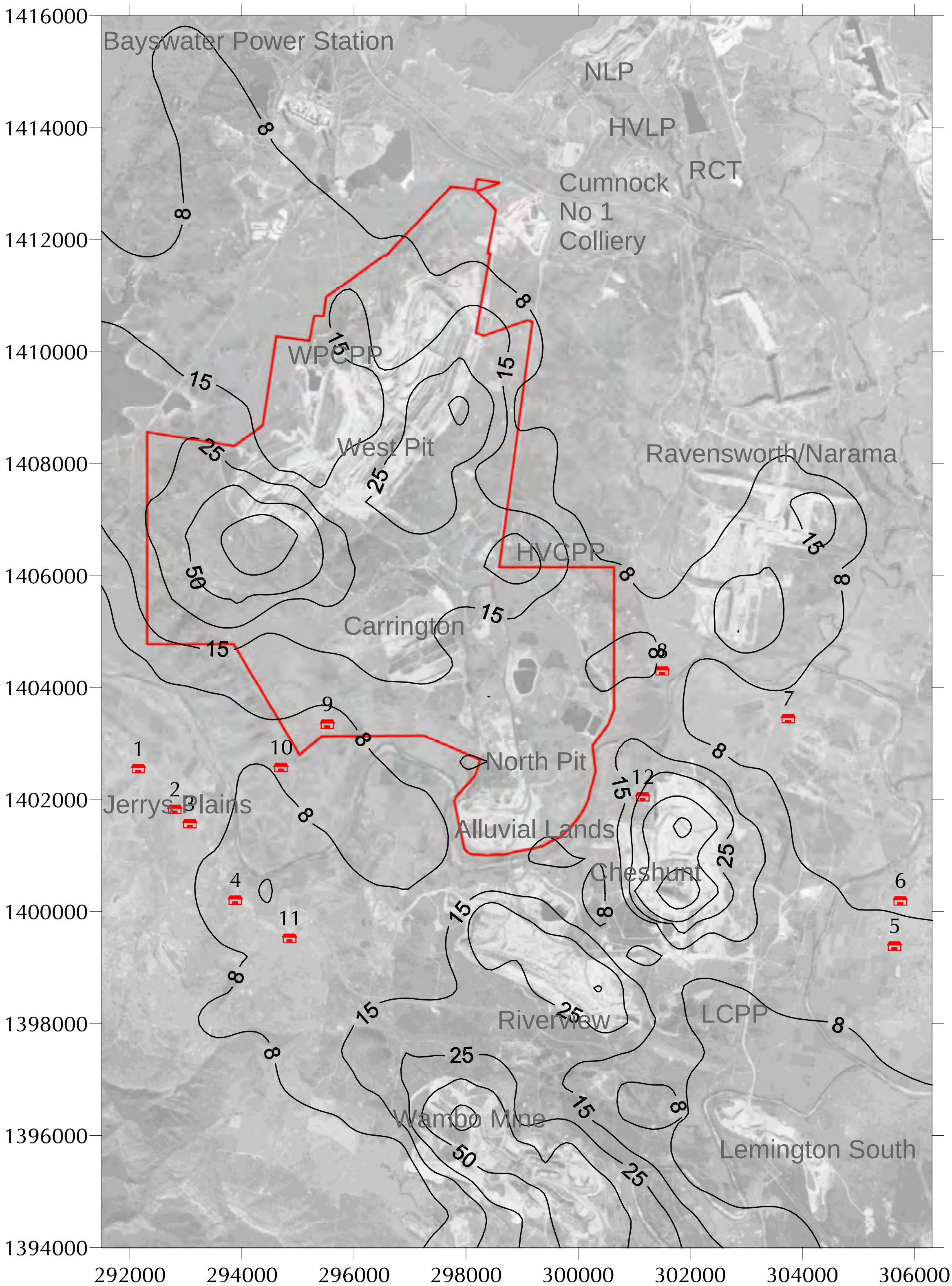
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 8 (alternative option) ($\mu g/m^3$)

Figure A16



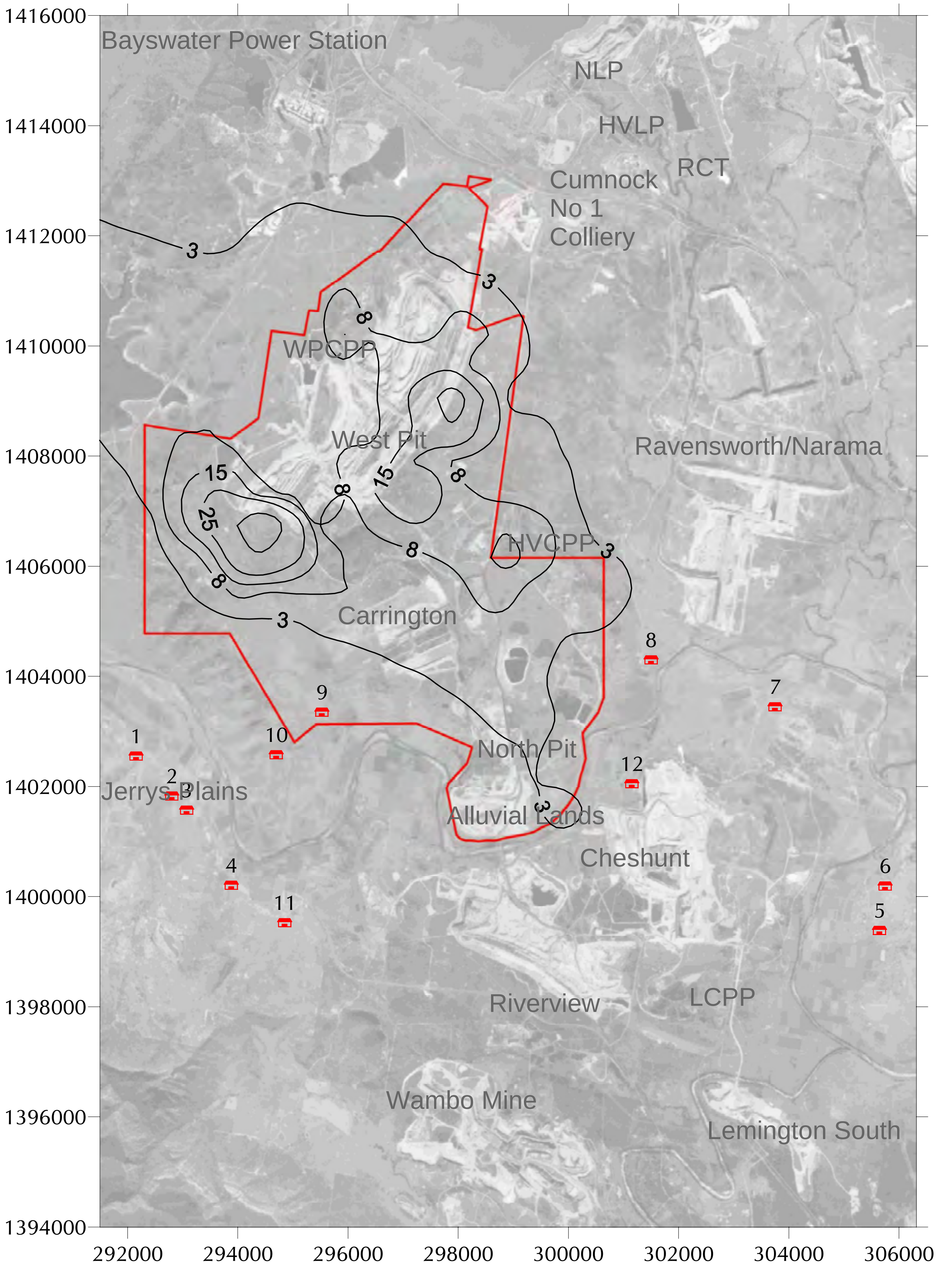
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 14 ($\mu g/m^3$)

Figure A17



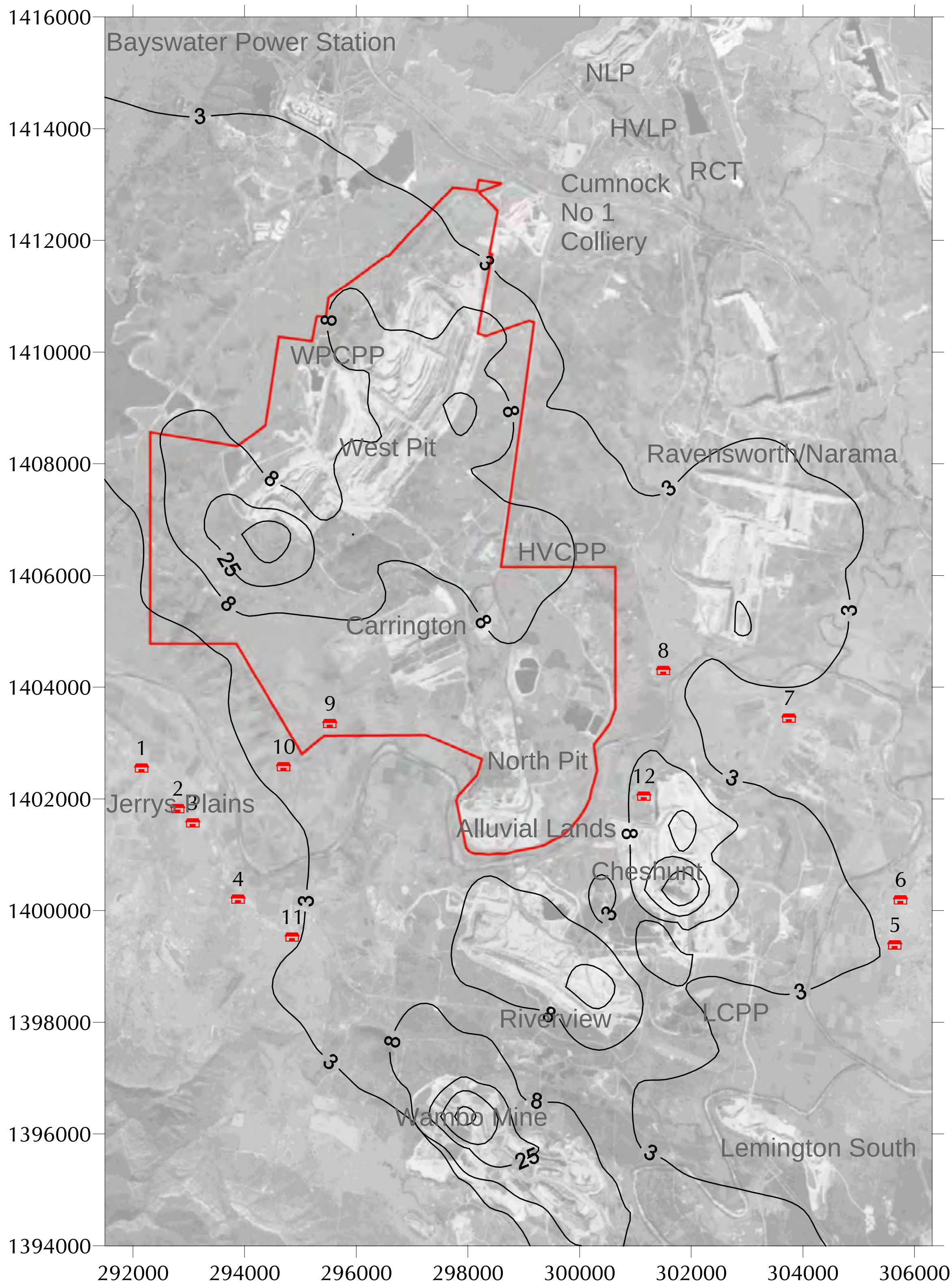
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 14 ($\mu g/m^3$)

Figure A18



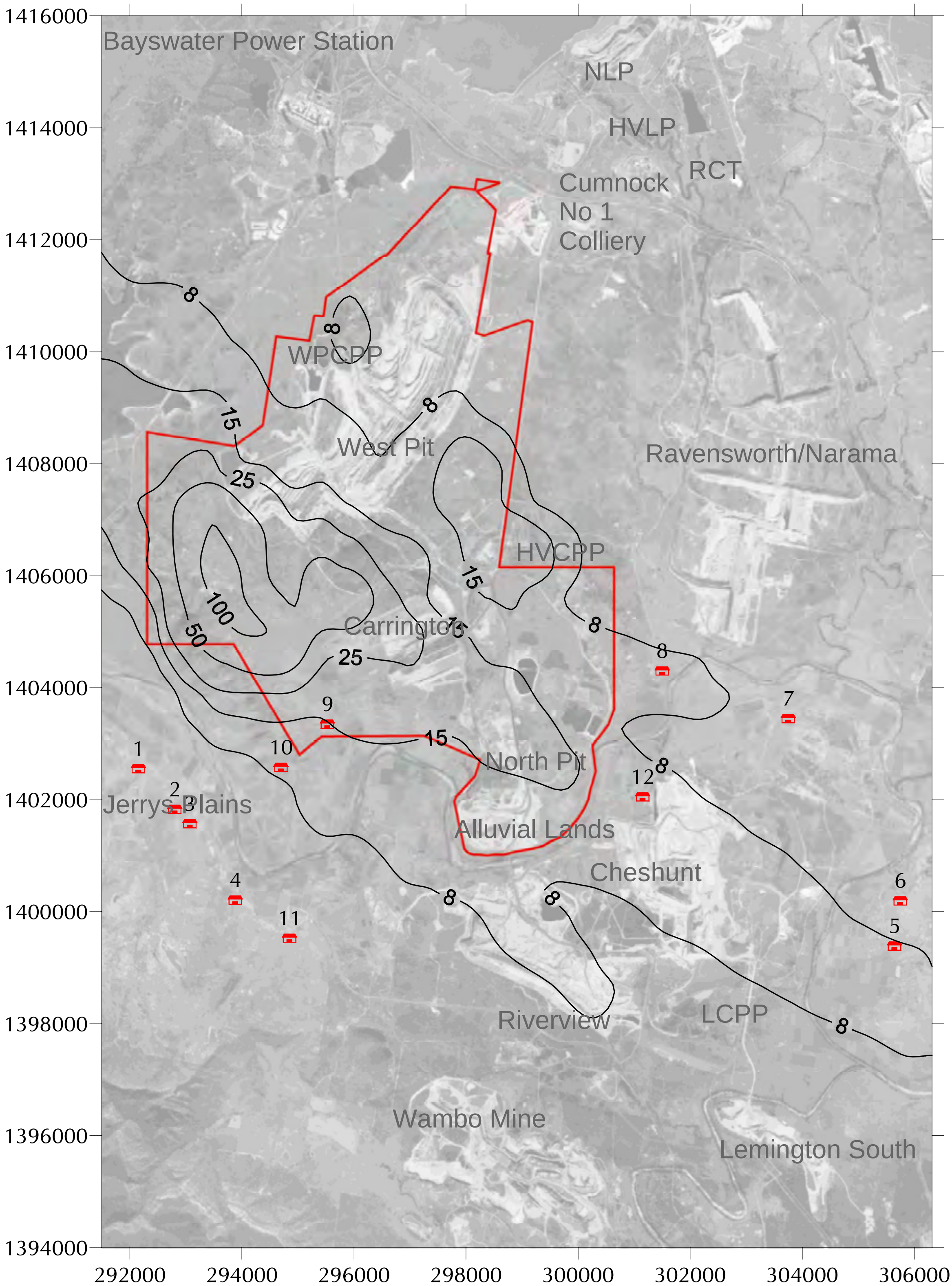
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 14 ($\mu g/m^3$)

Figure A19



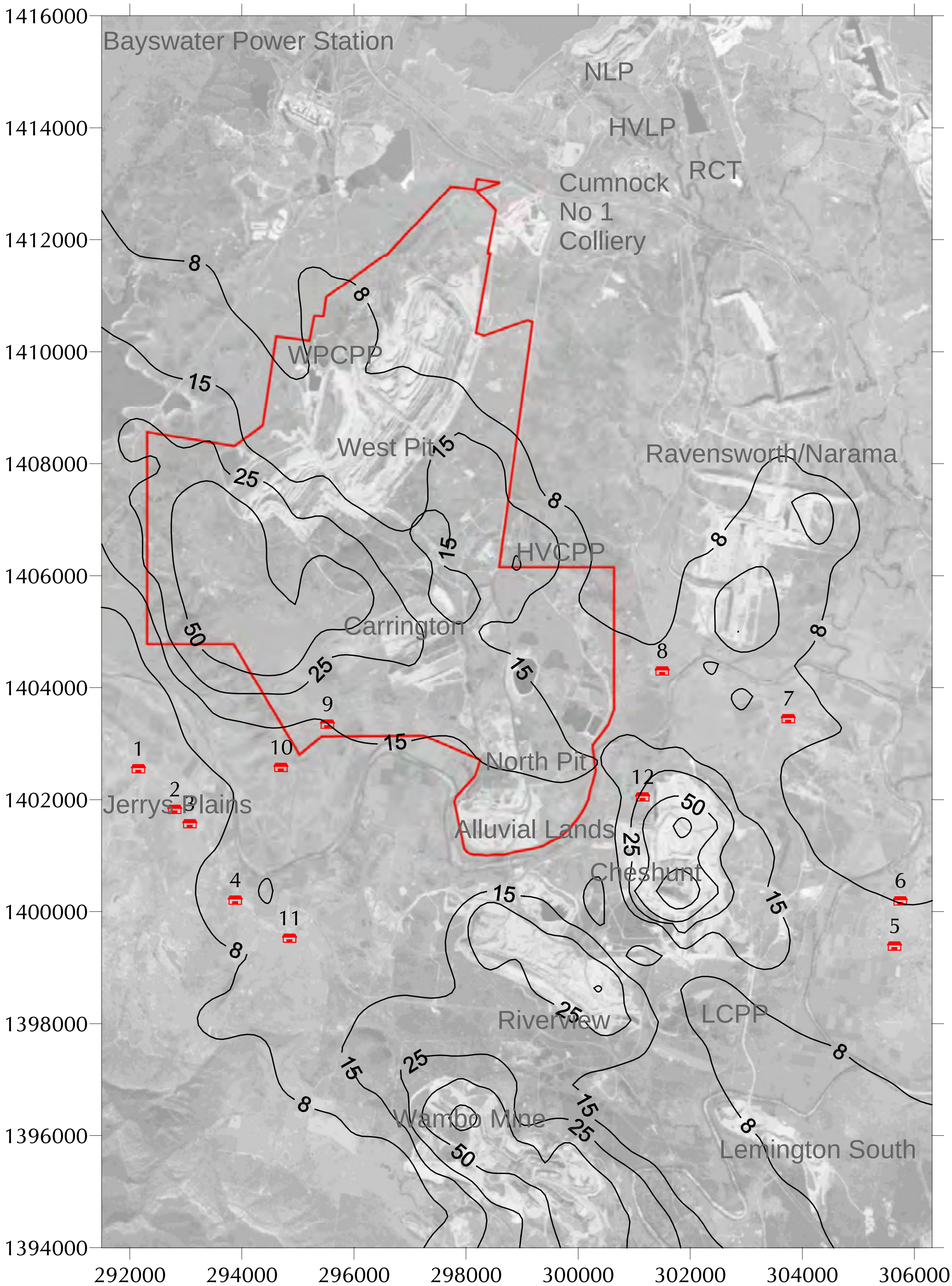
Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 14 ($\mu g/m^3$)

Figure A20



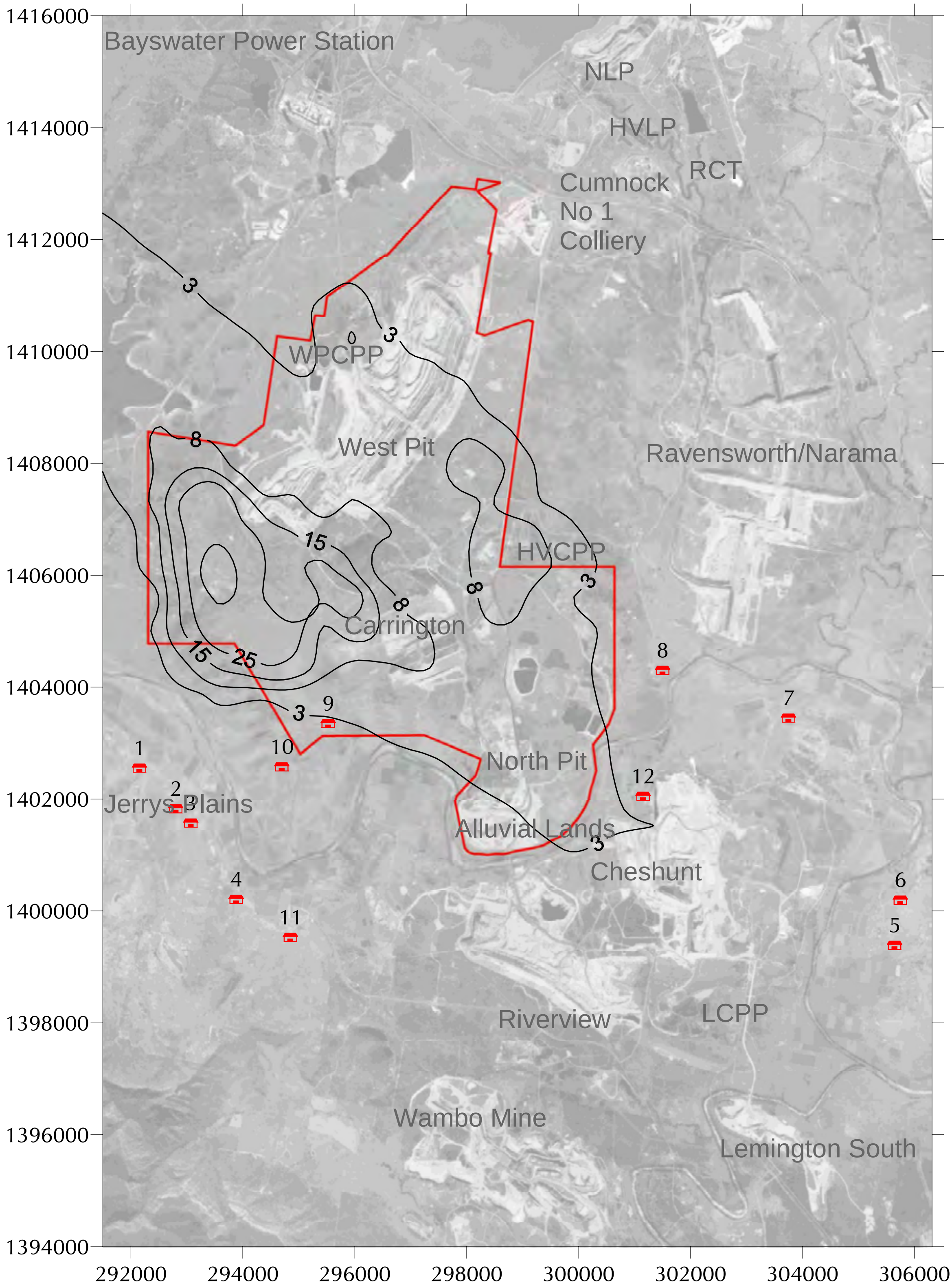
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 20 ($\mu g/m^3$)

Figure A21



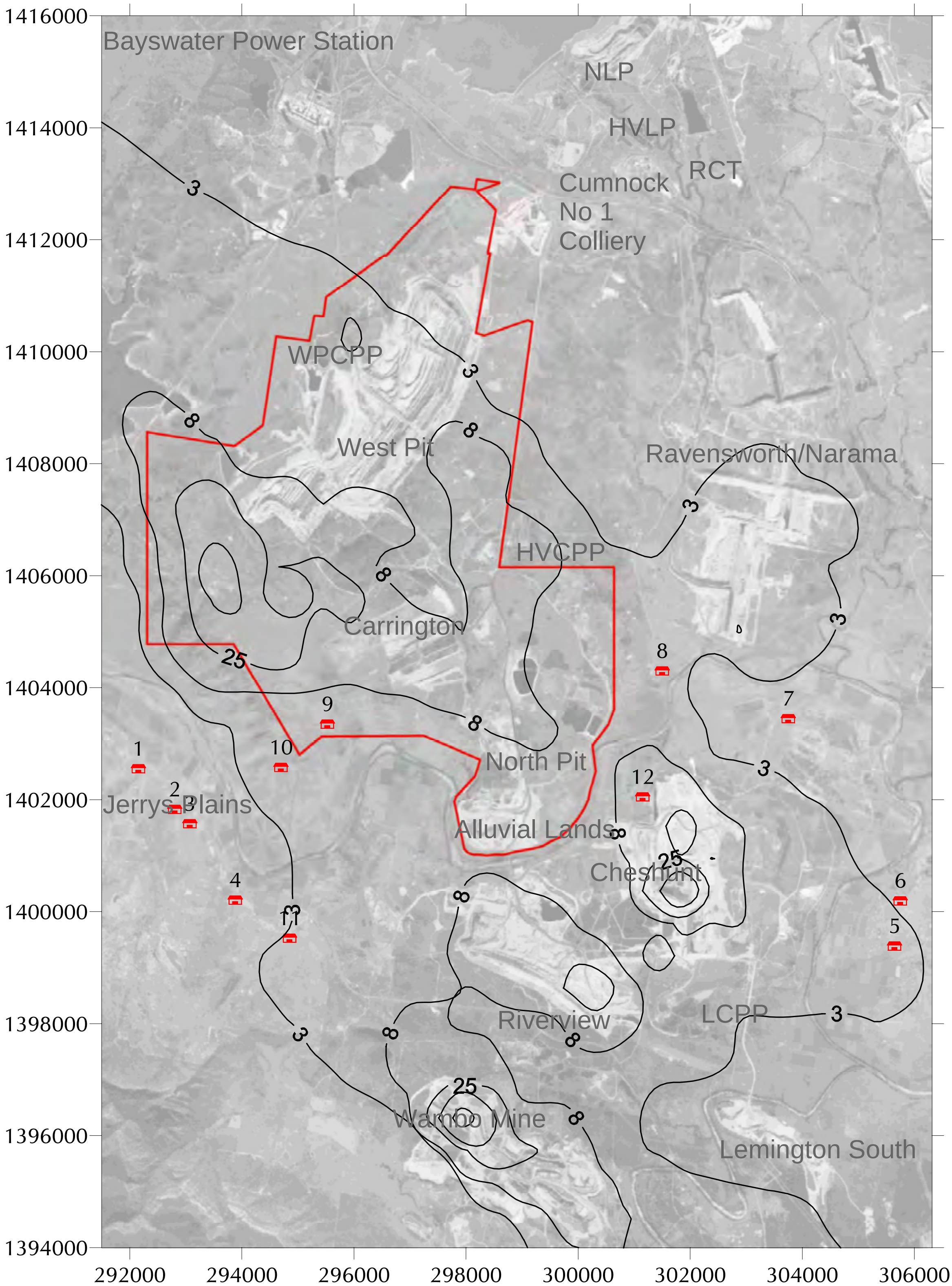
Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the Proposal and other sources in Year 20 ($\mu g/m^3$)

Figure A22



Predicted annual average $PM_{2.5}$ concentrations due to emissions from the Proposal in Year 20 ($\mu g/m^3$)

Figure A23



Predicted annual average $PM_{2.5}$ concentrations
due to emissions from the Proposal and other sources in Year 20 ($\mu g/m^3$)

Figure A24

APPENDIX B
JOINT WIND SPEED WIND DIRECTION AND STABILITY CLASS TABLES FOR WEST PIT 2002

STATISTICS FOR FILE: C:\WestPit\Met\2002 on-site met.isc
MONTHS: All
HOURS : All
OPTION: Frequency

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.005495	0.002060	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.007784
NE	0.004464	0.002060	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.006754
ENE	0.006868	0.001717	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.008700
E	0.008356	0.006639	0.001374	0.000000	0.000000	0.000000	0.000000	0.000000	0.016369
ESE	0.016712	0.031136	0.019689	0.010875	0.002976	0.000801	0.000000	0.000000	0.082189
SE	0.025984	0.065362	0.056548	0.031822	0.005838	0.000458	0.000000	0.000000	0.186012
SSE	0.026442	0.066850	0.036401	0.006181	0.000229	0.000000	0.000000	0.000000	0.136103
S	0.010875	0.013965	0.005266	0.000572	0.000114	0.000000	0.000000	0.000000	0.030792
SSW	0.005037	0.002175	0.000916	0.000000	0.000000	0.000000	0.000000	0.000000	0.008127
SW	0.004464	0.002633	0.000229	0.000229	0.000000	0.000000	0.000000	0.000000	0.007555
WSW	0.005151	0.002404	0.001030	0.000114	0.000000	0.000000	0.000000	0.000000	0.008700
W	0.013965	0.015911	0.006983	0.004350	0.002175	0.001145	0.000458	0.000000	0.044986
WNW	0.024954	0.050595	0.067651	0.030792	0.018887	0.008585	0.003549	0.001259	0.206273
NW	0.016026	0.030678	0.044872	0.028846	0.015682	0.007555	0.001946	0.000687	0.146291
NNW	0.008013	0.006868	0.005952	0.005151	0.003205	0.001145	0.000343	0.000000	0.030678
N	0.006754	0.003777	0.001832	0.000458	0.000000	0.000000	0.000000	0.000000	0.012821
CALM									0.059867
TOTAL	0.189560	0.304831	0.249199	0.119505	0.049107	0.019689	0.006296	0.001946	1.000000

MEAN WIND SPEED (m/s) = 3.01
NUMBER OF OBSERVATIONS = 8736

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

A : 12.6%
B : 8.1%
C : 12.7%
D : 40.9%
E : 13.3%
F : 12.3%

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001717	0.001488	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003205
NE	0.001946	0.000916	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002976
ENE	0.001946	0.001030	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002976
E	0.003549	0.004121	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.008127
ESE	0.003777	0.014538	0.003777	0.000229	0.000000	0.000000	0.000000	0.000000	0.022321
SE	0.003549	0.013164	0.004579	0.000343	0.000000	0.000000	0.000000	0.000000	0.021635
SSE	0.002976	0.004693	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.008356
S	0.001832	0.001374	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.003663
SSW	0.001259	0.000458	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.001946
SW	0.001030	0.000572	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.001717
WSW	0.001488	0.000572	0.000343	0.000114	0.000000	0.000000	0.000000	0.000000	0.002518
W	0.002175	0.002175	0.000229	0.000343	0.000000	0.000000	0.000000	0.000000	0.004922
WNW	0.002289	0.006639	0.002060	0.001145	0.000000	0.000000	0.000000	0.000000	0.012134
NW	0.004464	0.007212	0.002976	0.001030	0.000000	0.000000	0.000000	0.000000	0.015682
NNW	0.001832	0.002747	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.005266
N	0.002289	0.001488	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.004006
CALM									0.005037
TOTAL	0.038118	0.063187	0.016827	0.003320	0.000000	0.000000	0.000000	0.000000	0.126488

MEAN WIND SPEED (m/s) = 2.03
NUMBER OF OBSERVATIONS = 1105

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000114	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000229
NE	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000229
ENE	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
E	0.000229	0.000572	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
ESE	0.001030	0.004693	0.006525	0.001603	0.000000	0.000000	0.000000	0.000000	0.013851
SE	0.000687	0.010760	0.011561	0.003434	0.000000	0.000000	0.000000	0.000000	0.026442
SSE	0.000458	0.001946	0.002289	0.000114	0.000000	0.000000	0.000000	0.000000	0.004808
S	0.000343	0.000343	0.001145	0.000000	0.000000	0.000000	0.000000	0.000000	0.001832
SSW	0.000000	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
SW	0.000114	0.000229	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000458
WSW	0.000000	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
W	0.000343	0.000916	0.000458	0.000572	0.000000	0.000000	0.000000	0.000000	0.002289
WNW	0.001030	0.005037	0.003663	0.003892	0.000000	0.000000	0.000000	0.000000	0.013622
NW	0.000801	0.004350	0.003549	0.002976	0.000000	0.000000	0.000000	0.000000	0.011676
NNW	0.000229	0.000572	0.000916	0.001030	0.000000	0.000000	0.000000	0.000000	0.002747
N	0.000000	0.000343	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000687
CALM									0.000916
TOTAL	0.005609	0.029876	0.031250	0.013736	0.000000	0.000000	0.000000	0.000000	0.081387

MEAN WIND SPEED (m/s) = 3.25
NUMBER OF OBSERVATIONS = 711

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
NE	0.000114	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000458
ENE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	0.000114	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
ESE	0.000801	0.000916	0.002404	0.005609	0.000000	0.000000	0.000000	0.000000	0.009730
SE	0.001030	0.006983	0.010989	0.012706	0.000000	0.000000	0.000000	0.000000	0.031708
SSE	0.000229	0.005609	0.011447	0.003434	0.000000	0.000000	0.000000	0.000000	0.020719
S	0.000114	0.001717	0.001603	0.000114	0.000000	0.000000	0.000000	0.000000	0.003549
SSW	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
SW	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
WSW	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000229
W	0.000114	0.001259	0.000687	0.000229	0.000000	0.000000	0.000000	0.000000	0.002289
WNW	0.001603	0.007212	0.014194	0.011561	0.000000	0.000000	0.000000	0.000000	0.034570
NW	0.000916	0.004464	0.005952	0.007555	0.000000	0.000000	0.000000	0.000000	0.018887
NNW	0.000114	0.000458	0.000572	0.000572	0.000000	0.000000	0.000000	0.000000	0.001717
N	0.000114	0.000229	0.000687	0.000343	0.000000	0.000000	0.000000	0.000000	0.001374
CALM									0.001259
TOTAL	0.005838	0.029533	0.048649	0.042125	0.000000	0.000000	0.000000	0.000000	0.127404

MEAN WIND SPEED (m/s) = 3.76
NUMBER OF OBSERVATIONS = 1113

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000801
NE	0.000114	0.000229	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000458
ENE	0.000801	0.000229	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.001145
E	0.000343	0.000114	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000687
ESE	0.001488	0.003091	0.006754	0.003434	0.002976	0.000801	0.000000	0.000000	0.018544
SE	0.004808	0.019231	0.029418	0.015339	0.005838	0.000458	0.000000	0.000000	0.075092
SSE	0.006754	0.029533	0.021864	0.002633	0.000229	0.000000	0.000000	0.000000	0.061012
S	0.001259	0.002747	0.001832	0.000458	0.000114	0.000000	0.000000	0.000000	0.006410
SSW	0.000572	0.000572	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.001717
SW	0.000343	0.000343	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000916
WSW	0.000343	0.000458	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
W	0.001488	0.003892	0.005266	0.003205	0.002175	0.001145	0.000458	0.000000	0.017628
WNW	0.006410	0.017056	0.041667	0.013507	0.018887	0.008585	0.003549	0.001259	0.110920
NW	0.002404	0.008929	0.028846	0.017285	0.015682	0.007555	0.001946	0.000687	0.083333
NNW	0.001717	0.001832	0.003777	0.003549	0.003205	0.001145	0.000343	0.000000	0.015568
N	0.001259	0.000916	0.000572	0.000114	0.000000	0.000000	0.000000	0.000000	0.002862
CALM									0.010188
TOTAL	0.030907	0.089171	0.141598	0.059638	0.049107	0.019689	0.006296	0.001946	0.408539

MEAN WIND SPEED (m/s) = 4.06
NUMBER OF OBSERVATIONS = 3569

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000801	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.001030
NE	0.000343	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000458
ENE	0.001145	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
E	0.001259	0.001145	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
ESE	0.003777	0.006181	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.010188
SE	0.008242	0.012821	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.021062
SSE	0.009272	0.021864	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.031250
S	0.002633	0.005495	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.008356
SSW	0.001145	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001717
SW	0.000687	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
WSW	0.000801	0.000458	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.001374
W	0.002976	0.003320	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.006639
WNW	0.006868	0.009615	0.006067	0.000687	0.000000	0.000000	0.000000	0.000000	0.023237
NW	0.002175	0.003091	0.003549	0.000000	0.000000	0.000000	0.000000	0.000000	0.008814
NNW	0.001259	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001717
N	0.001030	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001145
CALM									0.010760
TOTAL	0.044414	0.066049	0.010875	0.000687	0.000000	0.000000	0.000000	0.000000	0.132784

MEAN WIND SPEED (m/s) = 1.71
NUMBER OF OBSERVATIONS = 1160

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.002060	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002404
NE	0.001832	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002175
ENE	0.002862	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003205
E	0.002862	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003434
ESE	0.005838	0.001717	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007555
SE	0.007669	0.002404	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.010073
SSE	0.006754	0.003205	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009959
S	0.004693	0.002289	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006983
SSW	0.001717	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002289
SW	0.002175	0.000916	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003091
WSW	0.002404	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003205
W	0.006868	0.004350	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011218
WNW	0.006754	0.005037	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011790
NW	0.005266	0.002633	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007898
NNW	0.002862	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003663
N	0.002060	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002747
CALM									0.031708
TOTAL	0.064675	0.027015	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.123397

MEAN WIND SPEED (m/s) = 1.05
NUMBER OF OBSERVATIONS = 1078

APPENDIX C
DETAILS OF METHODOLOGY USED TO ESTIMATE DUST EMISSIONS

WEST PIT OPEN CUT MINE OPERATIONS ESTIMATED DUST EMISSIONS IN YEAR 1

Introduction

This appendix provides information on the way in which estimates of TSP emissions for Year 1 have been made.

Calculations are presented to an apparent accuracy of ±1 kg. There may appear to be minor discrepancies in the calculations – less than a fraction of 1%. These are due to rounding errors that arise because the emission factors displayed in the text of this appendix are not shown to the same precision as the emission factors actually used in the spreadsheets when the calculations are done.

For example, in the estimate of TSP emissions from loading overburden to trucks in West Pit (see below) it is stated that the activity will produce 85,267 kg/y of TSP [43,911,992 t/y x 0.00194 kg/t]. Checking this formula using the printed figures gives an estimate of 85,189.3 kg/y. However if the emission factor is written to greater precision eg (0.001941760 kg/t) the estimate becomes 85,266.5 kg/y, which then is written as 85,267 kg/y.

It is not intended to suggest the actual emissions can be estimated to the level of precision used in the calculations. The accuracy of individual estimates is not known precisely but validation tests performed in 1984 (**Dames & Moore, 1984**) indicate that model predictions of annual average dust deposition rates can be estimated with sufficient accuracy so that 80% of predicted annual average deposition rates lie within ±40% of the measured deposition value. This provides an indication as to the overall accuracy of the modelling system. It includes the effects of errors in the estimated emissions, the potential errors introduced by uncertainties in meteorological conditions and the dispersion modelling process.

In addition to the impacts of mining at West Pit, the modelling also takes account of mining activities at Carrington, Ravensworth-Narama, Wambo, United Colliery and HVO south of the Hunter River (Cheshunt and Riverview).

The emissions from Carrington are described below. Emissions from Ravensworth-Narama, Cheshunt and Riverview have been calculated based on the annual ROM coal output of each mine and an emission rate of 0.52 kg/ton ROM coal. In Year 1 of the operation at West Pit, Ravensworth-Narama is expected to have a ROM coal output of 3,900,000 t/y (**Peabody Resources Limited, 1997)** and corresponding TSP emissions of 2,028,000 kg/y. Cheshunt has a ROM output of 5,000,000 t/y and emissions of 2,600,000 kg/y; and Riverview has a ROM output of 3,000,000 t/y and TSP emissions of 1,560,000 kg/y. Emissions from United Colliery and Wambo are based on a recent EIS (**Holmes Air Sciences, 2003**) with emissions being 1,026,264 t/y and 3,969,329 t/y respectively.

OPERATIONS AT CARRINGTON

It is proposed to increase the rate of mining at Carrington from 6 Mtpa to 10 Mtpa. The effects of this increased production on air quality has been estimated by assuming identical emission sources as were identified in the 1999 EIS **(ERM Mitchell McCotter, 1999)** except that emission rates have been increased by a factor of 10/6. The estimate of emissions has been taken directly from the modelling files used in the 1999 EIS for Carrington's Year 5. These files identify the locations of dust sources used in the Carrington modelling, but do not identify the activities that generate the dust in sufficient detail to allow the estimates to be applied in the current modelling. To overcome this the estimated emission due to hauling ROM coal from Carrington Mine to the HVCPP and emissions due to wind erosion have been calculated separately and, after scaling up by the "10/6" factor, these have been subtracted from the original Carrington Year 5 estimates of emissions. The remainder plus the estimated emissions due to wind erosion has been assumed to emanate from the three sources placed to represent mining at Carrington as it is now (2003). The estimated emission from haulage has been assumed to emanate from points along the Carrington to HVCPP ROM coal haulage route.

Hauling coal to HVCPP

It is proposed that 10,000,000 t of coal will be hauled from Carrington to the HVCPP. This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg per vehicle kilometre travelled (kg/VKT) (after application of water to the haul roads) and an average haul distance of 6 km (return), the total estimated TSP emissions for are 250,000 kg/y [10,000,000 t/y / 240 t/trip x 6 km/trip x 1.0 kg/VKT]

Wind Erosion

The **US EPA (1985)** emission factor for wind erosion is shown as **Equation 1**:

Equation 1

$$E_{TSP} = 1.9 \times \left(\frac{s}{15}\right) \times \left(\frac{365-p}{235}\right) \times \left(\frac{f}{15}\right) \quad \text{kg/ha/day}$$

where,

E_{TSP} = *TSP emissions*

s = silt content (%)

p = number of raindays per year, and

f = percentage of the time wind speed is above 5.4 m/s (%)

For the Carrington Pit area, the typical number of rain-days per year is 86 (taken from Bureau of Meteorology records for Jerry's Plains Station Number 061086, Latitude 32.4983 degrees South, Longitude 150.9083 degrees West and elevation 73.1 m). From the HVCPP Meteorological data for 2002 (the closest site to Carrington), the percentage of wind speeds above 5.4 m/s has been taken to be 10.1% and the percentage of silt in the surface material has been taken to be 10%. This gives an emission factor of 1.01 kg/ha/day. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

Location	Area (ha)	Silt content (%)	Annual TSP emission (kg)
- Carrington pit	185	10	68,374
- Carrington pit O/B	185	10	68,374

OPERATIONS AT WEST PIT

From data provided by Coal & Allied (CNA), in Year 1, mining taking place in West Pit will produce approximately 4,927,469 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

Open cut ROM coal will be hauled by 240 t trucks directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling processes that are likely to generate dust and provides estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Stripping topsoil

Stripping topsoil will generate dust at the rate of approximately 14.0 kg/h (**SPCC, 1983**). Assuming that stripping topsoil takes approximately 1,280 hr/y then the annual TSP emission rate will be 17,920 kg/y [1,280 hr/y x 14.0 kg/h].

Drilling overburden

Based on data provided by CNA, it is estimated in Year 1 that 40,982 holes will be required for overburden blasting in the West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 24,179 kg/y [40,982 holes x 0.59 kg/hole].

Blasting overburden

TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2**.

Equation 2

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad kg/blast$$

where :

E_{TSP} = *TSP emission factor*

A = *area to be blasted in* m^2

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 1 there will be 106 shots, the emissions from West Pit will be 75,993 kg/y.

Loading overburden to trucks

Based on information provided by CNA, in Year 1 approximately 18,296,663 bank cubic metres (bcm) will be handled by the truck and shovel in the West Pit. Assuming a density of 2.4 t/bcm it is estimated that 43,911,992 t will be loaded to trucks in West Pit.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 3** shows the relationship between these variables.

Equation 3

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad kg/t$$

where,

E_{TSP} = *TSP emissions*

$k = 0.74$

U = *wind speed (m/s)*

M = *moisture content (%)*

[where $0.25 \le M \le 4.8$*]*

For the West Pit meteorological data set used in the modelling the annual average value of $(u/2.2)^{1.3}$ is 1.64.

Assuming moisture content of 2% for overburden, the equation can be written as:

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where,

$E_{TSP} = TSP$ *emissions*

$U =$ *the wind speed in m/s.*

The annual average emission factor for loading overburden to trucks will therefore be 0.00194 kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 85,267 kg/y [43,911,992 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in Year 1 approximately 18,296,663 bcm of overburden will be hauled from West Pit to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 1 for West Pit will be 548,900 kg/y [18,296,663 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

In addition to this, approximately 833,333 bcm of overburden will be hauled from south of the River to the Alluvial Lands and the same amount will be hauled from North Pit to the Alluvial Lands. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 1 will be:

- South of the River to Alluvial Lands - 25,000 kg/y [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].
- North Pit to the Alluvial Lands - 25,000 [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in Year 1 approximately 43,911,992 t of overburden will be dumped in the West Pit waste emplacement areas. The total TSP emissions for Year 1 for West Pit will be 85,267 kg/y [43,911,992 t/y x 0.00194 kg/t].

In addition, approximately 4,000,000 t of overburden will be dumped in the Alluvial Lands. The total TSP emissions for Year 1 will be kg/y 7,767 [4,000,000 t/y x 0.00194 kg/t].

Dozers on overburden
The US EPA emission factor equation is given in **Equation 4**.

Equation 4

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad kg/hour$$

where,

$E_{TSP} = TSP$ *emissions*

$s =$ *silt content (%), and*

$M =$ *moisture content (%)*

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. Information provided by CNA shows that in Year 1 dozers will spend 12,833 hours in West Pit. The total TSP emission from the dozers working on overburden is therefore 214,770 kg/y [12,833 h/y x 16.7 kg/h].

Dragline handling of prime overburden
The US EPA emission factor equation is given by **Equation 5**.

Equation 5

$$E_{TSP} = 0.0046 \times \frac{d^{1.1}}{M^{0.3}} \qquad kg/m^3$$

where,

$E_{TSP} = TSP$ *emissions*

$d =$ *drop distance (m), and*

$M =$ *moisture content (%)*

Using **Equation 5** and assuming a drop distance of 10 m and moisture of 2% the emission factor becomes 0.04704 kg/bcm.

Based on information provided by CNA, in Year 1 15,064,957 bcm of overburden will be handled by dragline at West Pit.

The total TSP emission from dragline operations in each pit is therefore 708,625 kg/y [15,064,957 bcm x 0.04704 kg/bcm]

OPERATIONS ON COAL
Drilling coal
It is estimated that in Year 1, that 4,666 holes will be required for drilling coal in West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting coal is estimated to be 2,753 kg/y [4,666 holes x 0.59 kg/hole].

Blasting coal
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2** (see above).

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 1 there will be

25 shots, the emissions from West Pit will be 18,272 kg/y.

Dozers working on coal
The US EPA emission factor equation is given in **Equation 6**.

Equation 6

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \quad kg/hour$$

where,
s = silt content (%), and
M = moisture content (%)

Taking M to be 6 % and s to be 5 %, the emission factor is estimated to be approximately 20.0 kg/hour.

In Year 1, it is estimated that dozers will work on coal for 12,833 hours. The total TSP emission from dozers working on coal is therefore 256,532 kg/y [12,833 h/year x 20.0 kg/hour].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7**:

Equation 7

$$E_{TSP} = \frac{0.580}{M^{1.2}} \quad kg/t$$

where,
E_{TSP} = *TSP emissions*
M = moisture content (%)

Taking M to be 6 %, the emission factor is estimated to be 0.06755 kg/t. In Year 1 approximately 4,927,469 t of ROM will be recovered from West Pit. Therefore the TSP emission from loading coal to trucks is 332,867 kg/y [4,927,469 t/y x 0.06755 kg/t].

Hauling coal to HVCPP and WPCPP
In Year 1, based on information provided by CNA, 4,507,469 t of coal will be hauled from West Pit to the HVCPP and 3,400,000 t will be hauled from West Pit to the WPCPP. In addition, it is proposed that a maximum of 16,000,000 t of ROM coal will be hauled from south of the river to the HVCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from West Pit and 10 km (return) from south of the river, the total estimated TSP emissions for Year 1 are:

- West Pit to HVCPP– 150,249 kg/y [4,507,469 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- West Pit to WPCPP – 113,333 kg/y [3,400,000 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- S. of river to HVCPP – 666,667 kg/y [16,000,000 t/y / 240 t/trip x 10 km/trip x 1.0 kg/VKT].
-

Unloading coal to hoppers
Open cut ROM coal will be unloaded at the WPCPP and HVCPP dump hoppers.

Based on information provided by CNA, in Year 1 it is estimated that 3,400,000 t of coal will be unloaded at the WPCPP and 30,507,469 t will be unloaded at the HVCPP respectively. It is recognised that the HVCPP has a maximum capacity of 20 Mtpa. However, to account for the flexibility in movement that is required it is necessary to assume a greater throughout.

Assuming an emission factor of 0.01 kg/t, the total estimated TSP emissions are:

- WPCPP– 34,000 kg/y [3,400,000 t/y x 0.01 kg/t]
- HVCPP– 305,075 kg/y [30,507,469 t/y x 0.01 kg/t]

Rehandle of coal at WPCPP and HVCPP
From information provided by CNA, it is estimated that 170,000 t and 450,747 t of open cut ROM coal will need to be re-handled at the WPCPP and HVCPP respectively. Assuming the same emission factor as above, namely 0.01 kg/t, the total TSP emission from this operation will be:

- WPCPP– 1,700 kg/y [170,000 t/y x 0.01 kg/t]
- HVCPP– 4,507 kg/y [450,747 t/y x 0.01 kg/t].

Transport product coal to user/loadout point
Based on information provided by CNA, approximately 2,257,558 t of product coal will be transported from the WPCPP to the NLP. Based on a maximum of 25,000 t/d, one day a month, a maximum of 300,000 t/y will be transported from the HVCPP to HVLP. Based on a maximum of 15,000 t/d, five days a month, a maximum of 900,000 t/y will be transported from the HVLP to the RCT.

The transfer of product coal will be done using haul trucks with a capacity of 100 t. Assuming an emission factor of 0.2 kg/VKT (these trucks travel on sealed roads) and an average haul distance of 12 km to the NLP and HVLP and 14 km from the HVLP to the RCT, the total estimated TSP emissions for Year 1 are:

- WPCPP to NLP– 54,181 kg/y [2,257,558 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT]

- HVCPP to HVLP – 7,200 kg/y [300,000 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT].
- HVLP to RCT – 25,200 kg/y [900,000 /year / 100 t/trip x 14 km/trip x 0.2 kg/VKT].

In addition to this a maximum of 2,000,000 t/y will be transported from the HVLP to the NLP. An analysis of this operation estimated total emissions to be 0.00870 kg/t (**Holmes Air Sciences, 2003**). Therefore, the total estimated TSP emissions are 17,400 kg/y [2,000,000 t/y x 0.00870 kg/t].

Unloading coal
Based on information provided by CNA, an average of 2,500,000 t/y of coal will be unloaded at Bayswater Power Station from the WPCPP, 14,000,000 t/y will be unloaded at the HVLP and 4,257,558 t/y will be unloaded at the NLP. Assuming an emission factor of 0.01 kg/t the total estimated TSP emissions are:

- Bayswater Power Station – 25,000 kg/y [2,500,000 t/y x 0.01 kg/t]
- HVLP– 140,000 kg/y [14,000,000 t/y x 0.01 kg/t]
- NLP – 42,576 kg/y [4,257,558 t/y x 0.01 kg/t]

Loading open cut coal to trains
The emission factor for loading trains from the rail-loading bin is calculated using **Equation 2** (see above) with moisture assumed to be 8 %. The emission factor is 0.00028 kg/t and the annual quantity is 14,000,000 t at the HVLP and 4,257,558 t at the NLP. The annual TSP emissions are therefore:

- HVLP– 3,903 kg/y [14,000,000 t/y x 0.00028 kg/t]
- NLP – 1,187 kg/y [4,257,558 t/y x 0.00028 kg/t]

Handling open cut coal within CHPP
Coal handling in the CHPP takes place at the WPCPP and HVCPP in enclosed areas and under conditions where moisture levels are high. To account for the emissions from this area it has been assumed that the emission is equivalent to five transfers each of which generates the same quantity of TSP as estimated by **Equation 2**. The estimated annual TSP emission is therefore:

- WPCPP – 51,379 kg/y [24,637,344 t/y x 0.00209 kg/t]
- HVCPP– 318,106 kg/y [152,537,344 t/y x 0.00209 kg/t]

Note: the quantities of coal assumed to be handled by these CPPs is higher than will occur in practice. This is necessary in order to preserve the flexibility of operations required for the whole operation. Also note that the emission assumes that all coal is handled five times in the CPPs.

Graders on roads
Estimates of TSP emissions from grading roads have been made using the **US EPA (1985)** emission factor equation (**Equation 8**).

Equation 8

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad kg/vkt$$

where,
$E_{TSP} = TSP$ *emissions*
S = *speed of the grader in km/h*

Assuming an average speed of 8 km/h, the emission factor is 0.61547 kg/VKT. The distance travelled annually by the grader is estimated to be 100,000 km, which will result in an annual TSP emission of 61,547 kg [100,000 km/y x 0.61547kg/VKT].

WIND EROSION
The **US EPA (1985)** emission factor for wind erosion is shown as **Equation 9**:

Equation 9

$$E_{TSP} = 1.9 \times \left(\frac{s}{15}\right) \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right) \qquad kg/ha/day$$

where,
$E_{TSP} = TSP$ *emissions*
s = *silt content (%)*
p = *number of raindays per year, and*
f = *percentage of the time wind speed is above 5.4 m/s (%)*

For the West Pit area, the typical number of rain-days per year is 86 (taken from Bureau of Meteorology records for Jerry's Plains Station Number 061086, Latitude 32.4983 degrees South, Longitude 150.9083 degrees West and elevation 73.1 m). From the HVCPP Meteorological data for 2002 (the closest site to Carrington), the percentage of wind speeds above 5.4 m/s has been taken to be 10.1% and the percentage of silt in the surface material has been taken to be 10%. This gives an emission factor of 1.01 kg/ha/day. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

Location	Area (ha)	Silt content (%)	Annual TSP emission (kg)
- West Pit pit	500	10	184,796
- Alluvial Lands Pit	50	10	18,480
- West Pit pit O/B	500	10	184,796
- Alluvial Lands O/B	50	10	18,480

WEST PIT OPEN CUT MINE OPERATIONS ESTIMATED DUST EMISSIONS IN YEAR 3

Introduction
This appendix provides information on the way in which estimates of TSP emissions for Year 3 have been made.

Calculations are presented to an apparent accuracy of ±1 kg. There may appear to be minor discrepancies in the calculations – less than a fraction of 1%. These are due to rounding errors that arise because the emission factors displayed in the text of this appendix are not shown to the same precision as the emission factors actually used in the spreadsheets when the calculations are done.

For example, in the estimate of TSP emissions from loading overburden to trucks in West Pit (see below) it is stated that the activity will produce 108,623 kg/y of TSP [55,940,548 t/y x 0.00194 kg/t]. Checking this formula using the printed figures gives an estimate of 108,524.7 kg/y. However if the emission factor is written to greater precision eg (0.001941760 kg/t) the estimate becomes 108,623.1 kg/y, which then is written as 108,623 kg/y.

It is not intended to suggest the actual emissions can be estimated to the level of precision used in the calculations. The accuracy of individual estimates is not known precisely but validation tests performed in 1984 (**Dames & Moore, 1984**) indicate that model predictions of annual average dust deposition rates can be estimated with sufficient accuracy so that 80% of predicted annual average deposition rates lie within ±40% of the measured deposition value. This provides an indication as to the overall accuracy of the modelling system. It includes the effects of errors in the estimated emissions, the potential errors introduced by uncertainties in meteorological conditions and the dispersion modelling process.

In addition to the impacts of mining at West Pit, the modelling also takes account of mining activities at Carrington, Ravensworth-Narama, Wambo, United Colliery and HVO south of the Hunter River (Cheshunt and Riverview).

The emissions from Carrington are described below. Emissions from Ravensworth-Narama, Cheshunt and Riverview have been calculated based on the annual ROM coal output of each mine and an emission rate of 0.52 kg/ton ROM coal. In Year 3 of the operation at West Pit, Ravensworth-Narama is expected to have a ROM coal output of 3,900,000 t/y (**Peabody Resources Limited, 1997)** and corresponding TSP emissions of 2,028,000 kg/y. Cheshunt has a ROM output of 5,000,000 t/y and emissions of 2,600,000 kg/y; and Riverview has a ROM output of 3,000,000 t/y and TSP emissions of 1,560,000 kg/y. Emissions from United Colliery and Wambo are based on a recent EIS (**Holmes Air Sciences, 2003**) with emissions being 1,026,264 t/y and 3,969,329 t/y respectively.

OPERATIONS AT CARRINGTON
It is proposed to increase the rate of mining at Carrington from 6 Mtpa to 10 Mtpa. The effects of this increased production on air quality has been estimated by assuming identical emission sources as were identified in the 1999 EIS **(ERM Mitchell McCotter, 1999)** except that emission rates have been increased by a factor of 10/6. The estimate of emissions has been taken directly from the modelling files used in the 1999 EIS for Carrington's Year 5. These files identify the locations of dust sources used in the Carrington modelling, but do not identify the activities that generate the dust in sufficient detail to allow the estimates to be applied in the current modelling. To overcome this the estimated emission due to hauling ROM coal from Carrington Mine to the HVCPP and emissions due to wind erosion have been calculated separately and, after scaling up by the "10/6" factor, these have been subtracted from the original Carrington Year 5 estimates of emissions. The remainder plus the estimated emissions due to wind erosion has been assumed to emanate from the three sources placed to represent mining at Carrington as it is now (2003). The estimated emission from haulage has been assumed to emanate from points along the Carrington to HVCPP ROM coal haulage route.

Hauling coal to HVCPP
It is proposed that 10,000,000 t of coal will be hauled from Carrington to the HVCPP. This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg per vehicle kilometre travelled (kg/VKT) (after application of water to the haul roads) and an average haul distance of 6 km (return), the total estimated TSP emissions for are 250,000 kg/y [10,000,000 t/y / 240 t/trip x 6 km/trip x 1.0 kg/VKT]

Wind Erosion
The **US EPA (1985)** emission factor for wind erosion is shown as **Equation 1**:

Equation 1

$$E_{TSP} = 1.9 \times \left(\frac{s}{15}\right) \times \left(\frac{365-p}{235}\right) \times \left(\frac{f}{15}\right) \quad \text{kg/ha/day}$$

where,

$E_{TSP} = TSP$ *emissions*

s = silt content (%)

p = number of raindays per year, and

f = percentage of the time wind speed is above 5.4 m/s (%)

For the Carrington Pit area, the typical number of rain-days per year is 86 (taken from Bureau of Meteorology records for Jerry's Plains Station Number 061086, Latitude 32.4983 degrees South, Longitude 150.9083 degrees West and elevation 73.1 m). From the HVCPP Meteorological data for 2002 (the closest site to Carrington), the percentage of wind speeds above 5.4 m/s has been taken to be 10.1% and the percentage of silt in the surface material has been taken to be 10%. This gives an emission factor of 1.01 kg/ha/day. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

Location	Area (ha)	Silt content (%)	Annual TSP emission (kg)
- Carrington pit	185	10	68,374
- Carrington pit O/B	185	10	68,374

OPERATIONS AT WEST PIT

From data provided CNA, in Year 3, mining taking place in West Pit will produce approximately 6,382,647 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

Open cut ROM coal will be hauled by 240 t trucks directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling processes that are likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Stripping topsoil

Stripping topsoil will generate dust at the rate of approximately 14.0 kg/h (**SPCC, 1983**). Assuming that stripping topsoil takes approximately 1,280 hr/y then the annual TSP emission rate will be 17,920 kg/y [1,280 hr/y x 14.0 kg/h].

Drilling overburden

Based on data provided by CNA, it is estimated in Year 3 that 50,090 holes will be required for overburden blasting in the West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 29,553 kg/y [50,090 holes x 0.59 kg/hole].

Blasting overburden

TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2**.

Equation 2

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad kg/blast$$

where :

E_{TSP} = *TSP emission factor*

A = *area to be blasted in* m^2

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 3 there will be 133 shots, the emissions from West Pit will be 95,588 kg/y.

Loading overburden to trucks

Based on information provided by CNA, in Year 3 approximately 23,308,561 bank cubic metres (bcm) will be handled by the truck and shovel in the West Pit. Assuming a density of 2.4 t/bcm it is estimated that 55,940,548 t will be loaded to trucks in West Pit.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 3** shows the relationship between these variables.

Equation 3

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad kg/t$$

where,

E_{TSP} = *TSP emissions*

$k = 0.74$

U = *wind speed (m/s)*

M = *moisture content (%)*

[where $0.25 \le M \le 4.8$*]*

For the West Pit meteorological data set used in the modelling the annual average value of $(u/2.2)^{1.3}$ is 1.64.

Assuming moisture content of 2% for overburden, the equation can be written as:

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2} \right)^{1.3}$$

where,

E_{TSP} = *TSP emissions*

U = the wind speed in m/s.

The annual average emission factor for loading overburden to trucks will therefore be 0.00194 kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 108,623 kg/y [55,940,548 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in Year 3 approximately 23,308,561 bcm of overburden will be hauled from West Pit to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 3 for West Pit will be 699,257 kg/y [23,308,561 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

In addition to this, approximately 833,333 bcm of overburden will be hauled from south of the River to the Alluvial Lands and the same amount will be hauled from North Pit to the Alluvial Lands. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 3 will be:

- South of the River to Alluvial Lands - 25,000 kg/y [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].
- North Pit to the Alluvial Lands - 25,000 [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in Year 3 approximately 55,940,548 t of overburden will be dumped in the West Pit waste emplacement areas. The total TSP emissions for Year 3 for West Pit will be 108,623 kg/y [55,940,548 t/y x 0.00194 kg/t].

In addition, approximately 4,000,000 t of overburden will be dumped in the Alluvial Lands. The total TSP emissions for Year 3 will be kg/y 7,767 [4,000,000 t/y x 0.00194 kg/t].

Dozers on overburden
The US EPA emission factor equation is given in **Equation 4**.

Equation 4

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad kg/hour$$

where,

E_{TSP} = *TSP emissions*

s = silt content (%), and

M = moisture content (%)

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. Information provided by CNA shows that in Year 3 dozers would spend 16,316 hours in West Pit. The total TSP emission from the dozers working on overburden is therefore 273,058 kg/y [16,316 h/y x 16.7 kg/h].

Dragline handling of prime overburden
The US EPA emission factor equation is given by **Equation 5**.

Equation 5

$$E_{TSP} = 0.0046 \times \frac{d^{1.1}}{M^{0.3}} \qquad kg/m^3$$

where,

E_{TSP} = *TSP emissions*

d = drop distance (m), and

M = moisture content (%)

Using **Equation 5** and assuming a drop distance of 10 m and moisture of 2% the emission factor becomes 0.04704 kg/bcm.

Based on information provided by CNA, in Year 3 18,465,907 bcm of overburden will be handled by dragline at West Pit.

The total TSP emission from dragline operations in each pit is therefore 868,599 kg/y [18,465,907 bcm x 0.04704 kg/bcm]

OPERATIONS ON COAL
Drilling coal
It is estimated that in Year 3, that 5,873 holes will be required for drilling coal in West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting coal is estimated to be 3,465 kg/y [5,873 holes x 0.59 kg/hole].

Blasting coal
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2** (see above).

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 3 there will be

25 shots, the emissions from West Pit will be 18,111 kg/y.

Dozers working on coal
The US EPA emission factor equation is given in **Equation 6**.

Equation 6

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \qquad kg/hour$$

where,

$s = silt\ content\ (\%)$, and

$M = moisture\ \ content\ (\%)$

Taking M to be 6 % and s to be 5 %, the emission factor is estimated to be approximately 20.0 kg/hour.

In Year 3, it is estimated that dozers will work on coal for 16,316 hours. The total TSP emission from dozers working on coal is therefore 326,154 kg/y [16,316 h/year x 20.0 kg/hour].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7**:

Equation 7

$$E_{TSP} = \frac{0.580}{M^{1.2}} \qquad kg/t$$

where,

$E_{TSP} = TSP\ \ emissions$

$M = moisture\ \ content\ (\%)$

Taking M to be 6 %, the emission factor is estimated to be 0.06755 kg/t. In Year 3 approximately 6,382,647 t of ROM will be recovered from West Pit. Therefore the TSP emission from loading coal to trucks is 431,169 kg/y [6,382,647 t/y x 0.06755 kg/t].

Hauling coal to HVCPP and WPCPP
In Year 3, based on information provided by CNA, 5,382,647 t of coal will be hauled from West Pit to the HVCPP and 3,500,000 t will be hauled from West Pit to the WPCPP. In addition, it is proposed that a maximum of 16,000,000 t of ROM coal will be hauled from south of the river to the HVCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from West Pit and 10 km (return) from south of the river, the total estimated TSP emissions for Year 3 are:

- West Pit to HVCPP– 179,422 kg/y [5,382,647 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- West Pit to WPCPP – 116,667 kg/y [3,500,000 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- S. of river to HVCPP – 666,667 kg/y [16,000,000 t/y / 240 t/trip x 10 km/trip x 1.0 kg/VKT].
-

Unloading coal to hoppers
Open cut ROM coal will be unloaded at the WPCPP and HVCPP dump hoppers.

Based on information provided by CNA, in Year 3 it is estimated that 3,500,000 t of coal will be unloaded at the WPCPP and 31,382,647 t will be unloaded at the HVCPP respectively. It is recognised that the HVCPP has a maximum capacity of 20 Mtpa. However, to account for the flexibility in movement that is required it is necessary to assume a greater throughout.

Assuming an emission factor of 0.01 kg/t, the total estimated TSP emissions are:

- WPCPP– 35,000 kg/y [3,500,000 t/y x 0.01 kg/t]
- HVCPP– 313,826 kg/y [31,382,647 t/y x 0.01 kg/t]

Rehandle of coal at WPCPP and HVCPP
From information provided by CNA, it is estimated that 175,000 t and 538,265 t of open cut ROM coal will need to be re-handled at the WPCPP and HVCPP respectively. Assuming the same emission factor as above, namely 0.01 kg/t, the total TSP emission from this operation will be:

- WPCPP– 1,750 kg/y [175,000 t/y x 0.01 kg/t]
- HVCPP– 5,383 kg/y [538,265 t/y x 0.01 kg/t].

Transport product coal to user/loadout point
Based on information provided by CNA, approximately 2,486,399 t of product coal will be transported from the WPCPP to the NLP. Based on a maximum of 25,000 t/d, one day a month, a maximum of 300,000 t/y will be transported from the HVCPP to HVLP. Based on a maximum of 15,000 t/d, five days a month, a maximum of 900,000 t/y will be transported from the HVLP to the RCT.

The transfer of product coal will be done using haul trucks with a capacity of 100 t. Assuming an emission factor of 0.2 kg/VKT (these trucks travel on sealed roads) and an average haul distance of 12 km to the NLP and HVLP and 14 km from the HVLP to the RCT, the total estimated TSP emissions for Year 3 are:

- WPCPP to NLP– 59,674 kg/y [2,486,399 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT]

- HVCPP to HVLP – 7,200 kg/y [300,000 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT].
- HVLP to RCT – 1,800 kg/y [900,000 /year / 100 t/trip x 14 km/trip x 0.2 kg/VKT].

In addition to this a maximum of 2,000,000 t/y will be transported from the HVLP to the NLP. An analysis of this operation estimated total emissions to be 0.00870 kg/t (**Holmes Air Sciences, 2003**). Therefore, the total estimated TSP emissions are 17,400 kg/y [2,000,000 t/y x 0.00870 kg/t].

Unloading coal
Based on information provided by CNA, an average of 2,500,000 t/y of coal will be unloaded at Bayswater Power Station from the WPCPP, 14,000,000 t/y will be unloaded at the HVLP and 4,486,399 t/y will be unloaded at the NLP. Assuming an emission factor of 0.01 kg/t the total estimated TSP emissions are:

- Bayswater Power Station – 25,000 kg/y [2,500,000 t/y x 0.01 kg/t]
- HVLP– 140,000 kg/y [14,000,000 t/y x 0.01 kg/t]
- NLP – 44,864 kg/y [4,486,399 t/y x 0.01 kg/t]

Loading open cut coal to trains
The emission factor for loading trains from the rail-loading bin is calculated using **Equation 2** (see above) with moisture assumed to be 8 %. The emission factor is 0.00028 kg/t and the annual quantity is 14,000,000 t at the HVLP and 4,486,399 t at the NLP. The annual TSP emissions are therefore:

- HVLP– 3,903 kg/y [14,000,000 t/y x 0.00028 kg/t]
- NLP – 1,251 kg/y [4,486,399 t/y x 0.00028 kg/t]

Handling open cut coal within CHPP
Coal handling in the CHPP takes place at the WPCPP and HVCPP in enclosed areas and under conditions where moisture levels are high. To account for the emissions from this area it has been assumed that the emission is equivalent to five transfers each of which generates the same quantity of TSP as estimated by **Equation 2**. The estimated annual TSP emission is therefore:

- WPCPP – 66,553 kg/y [31,913,237 t/y x 0.00209 kg/t]
- HVCPP– 327,232 kg/y [156,913,237 t/y x 0.00209 kg/t]

Note: the quantities of coal assumed to be handled by these CPPs is higher than will occur in practice. This is necessary in order to preserve the flexibility of operations required for the whole operation. Also note that the emission assumes that all coal is handled five times in the CPPs.

Graders on roads
Estimates of TSP emissions from grading roads have been made using the **US EPA (1985)** emission factor equation (**Equation 6**).

Equation 6

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad kg/vkt$$

where,
$E_{TSP} = TSP\ \ emissions$
S *= speed of the grader in km/h*

Assuming an average speed of 8 km/h, the emission factor is 0.61547 kg/VKT. The distance travelled annually by the grader is estimated to be 100,000 km, which will result in an annual TSP emission of 61,547 kg [100,000 km/y x 0.61547kg/VKT].

WIND EROSION
The **US EPA (1985)** emission factor for wind erosion is shown as **Equation 1**:

Equation 1

$$E_{TSP} = 1.9 \times \left(\frac{s}{15}\right) \times \left(\frac{365-p}{235}\right) \times \left(\frac{f}{15}\right) \qquad kg/ha/day$$

where,
$E_{TSP} = TSP\ \ emissions$
s = silt content (%)
p = number of raindays per year, and
f = percentage of the time wind speed is above 5.4 m/s (%)

For the West Pit area, the typical number of rain-days per year is 86 (taken from Bureau of Meteorology records for Jerry's Plains Station Number 061086, Latitude 32.4983 degrees South, Longitude 150.9083 degrees West and elevation 73.1 m). From the HVCPP Meteorological data for 2002 (the closest site to Carrington), the percentage of wind speeds above 5.4 m/s has been taken to be 10.1% and the percentage of silt in the surface material has been taken to be 10%. This gives an emission factor of 1.01 kg/ha/day. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

Location	Area (ha)	Silt content (%)	Annual TSP emission (kg)
- West Pit pit	500	10	165,587
- Alluvial Lands Pit	50	10	16,559
- West Pit pit O/B	500	10	165,587
- Alluvial Lands O/B	50	10	16,559

WEST PIT OPEN CUT MINE OPERATIONS ESTIMATED DUST EMISSIONS IN YEAR 8

Introduction
This appendix provides information on the way in which estimates of TSP emissions for Year 8 have been made.

Calculations are presented to an apparent accuracy of ±1 kg. There may appear to be minor discrepancies in the calculations – less than a fraction of 1%. These are due to rounding errors that arise because the emission factors displayed in the text of this appendix are not shown to the same precision as the emission factors actually used in the spreadsheets when the calculations are done.

For example, in the estimate of TSP emissions from loading overburden to trucks in West Pit (see below) it is stated that the activity will produce 110,318 kg/y of TSP [56,813,541 t/y x 0.00194 kg/t]. Checking this formula using the printed figures gives an estimate of 110,218.3 kg/y. However if the emission factor is written to greater precision eg (0.001941760 kg/t) the estimate becomes 110,318.3 kg/y, which then is written as 110,318 kg/y.

It is not intended to suggest the actual emissions can be estimated to the level of precision used in the calculations. The accuracy of individual estimates is not known precisely but validation tests performed in 1984 (**Dames & Moore, 1984**) indicate that model predictions of annual average dust deposition rates can be estimated with sufficient accuracy so that 80% of predicted annual average deposition rates lie within ±40% of the measured deposition value. This provides an indication as to the overall accuracy of the modelling system. It includes the effects of errors in the estimated emissions, the potential errors introduced by uncertainties in meteorological conditions and the dispersion modelling process.

In addition to the impacts of mining at West Pit, the modelling also takes account of mining activities at Ravensworth-Narama, Wambo, United Colliery and HVO south of the Hunter River (Cheshunt and Riverview).

It is assumed that operations at Carrington have ceased by Year 8. An alternative for Year 8 has also been modelled with Carrington still operating. The emission calculations for this scenario are described in a separate section.

In Year 8 of the operation at West Pit, Ravensworth-Narama is expected to have a ROM coal output of 2,400,000 t/y (**Peabody Resources Limited, 1997)** and corresponding TSP emissions of 1,248,000 kg/y. Cheshunt has a ROM output of 5,000,000 t/y and emissions of 2,600,000 kg/y; and Riverview has a ROM output of 3,000,000 t/y and TSP emissions of 1,560,000 kg/y. Emissions from United Colliery and Wambo are based on a recent EIS (**Holmes Air Sciences, 2003**) with emissions being 1,026,264 t/y and 5,122,771 t/y respectively.

OPERATIONS AT WEST PIT
From data provided by CNA, in Year 8, mining taking place in West Pit will produce approximately 6,491,605 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

Open cut ROM coal will be hauled by 240 t trucks directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling processes that are likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Stripping topsoil
Stripping topsoil will generate dust at the rate of approximately 14.0 kg/h (**SPCC, 1983**). Assuming that stripping topsoil takes approximately 1,280 hr/y then the annual TSP emission rate will be 17,920 kg/y [1,280 hr/y x 14.0 kg/h].

Drilling overburden
Based on data provided by CNA, it is estimated in Year 8 that 31,091 holes will be required for overburden blasting in the West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 18,344 kg/y [31,091 holes x 0.59 kg/hole].

Blasting overburden
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2**.

Equation 2

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad kg/blast$$

where :

$E_{TSP} = TSP$ emission factor

A = area to be blasted in m^2

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 8 there will be 135 shots, the emissions from West Pit will be 96,994 kg/y.

Loading overburden to trucks
Based on information provided by CNA, in Year 8 approximately 23,672,309 bank cubic metres (bcm) will be handled by the truck and shovel in the West Pit. Assuming a density of 2.4 t/bcm it is estimated that 56,813,541 t will be loaded to trucks in West Pit.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 3** shows the relationship between these variables.

Equation 3

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad kg/t$$

where,

$E_{TSP} = TSP \ \ emissions$

$k = 0.74$

$U = wind\ speed\ (m/s)$

$M = moisture\ \ content\ (\%)$

$[where\ 0.25 \le M \le 4.8]$

For the West Pit meteorological data set used in the modelling the annual average value of $(u/2.2)^{1.3}$ is 1.64.

Assuming moisture content of 2% for overburden, the equation can be written as:

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where,

$E_{TSP} = TSP \ \ emissions$

$U = the\ wind\ \ speed\ \ in\ \ m/s.$

The annual average emission factor for loading overburden to trucks will therefore be 0.00194 kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 110,318 kg/y [56,813,541 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in Year 8 approximately 23,672,309 bcm of overburden will be hauled from West Pit to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 8 for West Pit will be 710,169 kg/y [23,672,309 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

In addition to this, approximately 833,333 bcm of overburden will be hauled from south of the River to the Alluvial Lands and the same amount will be hauled from North Pit to the Alluvial Lands. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 8 will be:

- South of the River to Alluvial Lands - 25,000 kg/y [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].
- North Pit to the Alluvial Lands - 25,000 [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in Year 8 approximately 56,813,541 t of overburden will be dumped in the West Pit waste emplacement areas. The total TSP emissions for Year 8 for West Pit will be 110,318 kg/y [56,813,541 t/y x 0.00194 kg/t].

In addition, approximately 4,000,000 t of overburden will be dumped in the Alluvial Lands. The total TSP emissions for Year 8 will be kg/y 7,767 [4,000,000 t/y x 0.00194 kg/t].

Dozers on overburden
The US EPA emission factor equation is given in **Equation 4**.

Equation 4

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad kg/hour$$

where,

$E_{TSP} = TSP \ \ emissions$

$s = silt\ content\ (\%), and$

$M = moisture\ content\ (\%)$

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. Information provided by CNA shows that in Year 8 dozers would spend 16,448 hours in West Pit. The total TSP emission from the dozers working on overburden is therefore 275,268 kg/y [16,448 h/y x 16.7 kg/h].

Dragline handling of prime overburden
The US EPA emission factor equation is given by **Equation 5**.

Equation 5

$$E_{TSP} = 0.0046 \times \frac{d^{1.1}}{M^{0.3}} \qquad kg/m^3$$

where,

$E_{TSP} = TSP \ \ emissions$

$d = drop\ distance\ (m), and$

$M = moisture\ content\ (\%)$

Using **Equation 5** and assuming a drop distance of 10 m and moisture of 2% the emission factor becomes 0.04704 kg/bcm.

Based on information provided by CNA, in Year 8 18,974,729 bcm of overburden will be handled by dragline at West Pit.

The total TSP emission from dragline operations in each pit is therefore 892,533 kg/y [18,974,729 bcm x 0.04704 kg/bcm]

OPERATIONS ON COAL
Drilling coal
It is estimated that in Year 8, that 3,654 holes will be required for drilling coal in West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting coal is estimated to be 2,156 kg/y [3,654 holes x 0.59 kg/hole].

Blasting coal
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2** (see above).

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 8 there will be 16 shots, the emissions from West Pit will be 11,268 kg/y.

Dozers working on coal
The US EPA emission factor equation is given in **Equation 6**.

Equation 6

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \qquad kg/hour$$

where,
s = silt content (%), and
M = moisture content (%)

Taking M to be 6 % and s to be 5 %, the emission factor is estimated to be approximately 20.0 kg/hour.

In Year 8, it is estimated that dozers will work on coal for 16,448 hours. The total TSP emission from dozers working on coal is therefore 328,794 kg/y [16,448 h/year x 20.0 kg/hour].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7**:

Equation 7

$$E_{TSP} = \frac{0.580}{M^{1.2}} \qquad kg/t$$

where,
E_{TSP} *= TSP emissions*
M = moisture content (%)

Taking M to be 6 %, the emission factor is estimated to be 0.06755 kg/t. In Year 8 approximately 6,491,605 t of ROM will be recovered from West Pit. Therefore the TSP emission from loading coal to trucks is 438,529 kg/y [6,491,605 t/y x 0.06755 kg/t].

Hauling coal to HVCPP and WPCPP
In Year 8, based on information provided by CNA, 5,491,605 t of coal will be hauled from West Pit to the HVCPP and 3,400,000 t will be hauled from West Pit to the WPCPP. In addition, it is proposed that a maximum of 16,000,000 t of ROM coal will be hauled from south of the river to the HVCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from West Pit and 10 km (return) from south of the river, the total estimated TSP emissions for Year 8 are:

- West Pit to HVCPP– 183,053 kg/y [5,491,605 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- West Pit to WPCPP – 113,333 kg/y [3,400,000 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- S. of river to HVCPP – 666,667 kg/y [16,000,000 t/y / 240 t/trip x 10 km/trip x 1.0 kg/VKT].
-

Unloading coal to hoppers
Open cut ROM coal will be unloaded at the WPCPP and HVCPP dump hoppers.

Based on information provided by CNA, in Year 8 it is estimated that 3,400,000 t of coal will be unloaded at the WPCPP and 21,491,605 t will be unloaded at the HVCPP respectively. It is recognised that the HVCPP has a maximum capacity of 20 Mtpa. However, to account for the flexibility in movement that is required it is necessary to assume a greater throughout.

Assuming an emission factor of 0.01 kg/t, the total estimated TSP emissions are:

- WPCPP– 34,000 kg/y [3,400,000 t/y x 0.01 kg/t]

- HVCPP– 214,916 kg/y [21,491,605 t/y x 0.01 kg/t]

Rehandle of coal at WPCPP and HVCPP
From information provided by CNA, it is estimated that 175,000 t and 549,160 t of open cut ROM coal will need to be re-handled at the WPCPP and HVCPP respectively. Assuming the same emission factor as above, namely 0.01 kg/t, the total TSP emission from this operation will be:

- WPCPP– 1,750 kg/y [175,000 t/y x 0.01 kg/t]
- HVCPP– 5,492 kg/y [549,160 t/y x 0.01 kg/t].

Transport product coal to user/loadout point
Based on information provided by CNA, approximately 2,257,558 t of product coal will be transported from the WPCPP to the NLP. Based on a maximum of 25,000 t/d, one day a month, a maximum of 300,000 t/y will be transported from the HVCPP to HVLP. Based on a maximum of 15,000 t/d, five days a month, a maximum of 900,000 t/y will be transported from the HVLP to the RCT.

The transfer of product coal will be done using haul trucks with a capacity of 100 t. Assuming an emission factor of 0.2 kg/VKT (these trucks travel on sealed roads) and an average haul distance of 12 km to the NLP and HVLP and 14 km from the HVLP to the RCT, the total estimated TSP emissions for Year 8 are:

- WPCPP to NLP– 54,181 kg/y [2,257,558 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT]
- HVCPP to HVLP – 7,200 kg/y [300,000 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT].
- HVLP to RCT – 1,800 kg/y [900,000 /year / 100 t/trip x 14 km/trip x 0.2 kg/VKT].

In addition to this a maximum of 2,000,000 t/y will be transported from the HVLP to the NLP. An analysis of this operation estimated total emissions to be 0.00870 kg/t (**Holmes Air Sciences, 2003**). Therefore, the total estimated TSP emissions are 17,400 kg/y [2,000,000 t/y x 0.00870 kg/t].

Unloading coal
Based on information provided by CNA, an average of 2,500,000 t/y of coal will be unloaded at Bayswater Power Station from the WPCPP, 14,000,000 t/y will be unloaded at the HVLP and 4,257,558 t/y will be unloaded at the NLP. Assuming an emission factor of 0.01 kg/t the total estimated TSP emissions are:

- Bayswater Power Station – 25,000 kg/y [2,500,000 t/y x 0.01 kg/t]
- HVLP– 140,000 kg/y [14,000,000 t/y x 0.01 kg/t]
- NLP – 42,576 kg/y [4,257,558 t/y x 0.01 kg/t]

Loading open cut coal to trains
The emission factor for loading trains from the rail-loading bin is calculated using **Equation 2** (see above) with moisture assumed to be 8 %. The emission factor is 0.00028 kg/t and the annual quantity is 14,000,000 t at the HVLP and 4,257,558 t at the NLP. The annual TSP emissions are therefore:

- HVLP– 3,903 kg/y [14,000,000 t/y x 0.00028 kg/t]
- NLP – 1,187 kg/y [4,257,558 t/y x 0.00028 kg/t]

Handling open cut coal within CHPP
Coal handling in the CHPP takes place at the WPCPP and HVCPP in enclosed areas and under conditions where moisture levels are high. To account for the emissions from this area it has been assumed that the emission is equivalent to five transfers each of which generates the same quantity of TSP as estimated by **Equation 2**. The estimated annual TSP emission is therefore:

- WPCPP – 67,689 kg/y [32,458,023 t/y x 0.00209 kg/t]
- HVCPP– 224,096 kg/y [107,458,023 t/y x 0.00209 kg/t]

Note: the quantities of coal assumed to be handled by these CPPs is higher than will occur in practice. This is necessary in order to preserve the flexibility of operations required for the whole operation. Also note that the emission assumes that all coal is handled five times in the CPPs.

Graders on roads
Estimates of TSP emissions from grading roads have been made using the **US EPA (1985)** emission factor equation (**Equation 8**).

Equation 8

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad kg/vkt$$

where,
$E_{TSP} = TSP \ emissions$
$S = speed\ of\ the\ grader\ in\ km/h$

Assuming an average speed of 8 km/h, the emission factor is 0.61547 kg/VKT. The distance travelled annually by the grader is estimated to be 100,000 km, which will result in an annual TSP emission of 61,547 kg [100,000 km/y x 0.61547kg/VKT].

WIND EROSION
The **US EPA (1985)** emission factor for wind erosion is shown as **Equation 9**:

Equation 9

$$E_{TSP} = 1.9 \times \left(\frac{s}{15}\right) \times \left(\frac{365-p}{235}\right) \times \left(\frac{f}{15}\right) \text{ kg/ha/day}$$

where,

E_{TSP} = *TSP emissions*

s = silt content (%)

p = number of raindays per year, and

f = percentage of the time wind speed is above 5.4 m/s (%)

For the West Pit area, the typical number of rain-days per year is 86 (taken from Bureau of Meteorology records for Jerry's Plains Station Number 061086, Latitude 32.4983 degrees South, Longitude 150.9083 degrees West and elevation 73.1 m). From the HVCPP Meteorological data for 2002 (the closest site to Carrington), the percentage of wind speeds above 5.4 m/s has been taken to be 10.1% and the percentage of silt in the surface material has been taken to be 10%. This gives an emission factor of 1.01 kg/ha/day. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

Location	Area (ha)	Silt content (%)	Annual TSP emission (kg)
- West Pit pit	500	10	165,587
- Alluvial Lands Pit	50	10	16,559
- West Pit pit O/B	500	10	165,587
- Alluvial Lands O/B	50	10	16,559

WEST PIT OPEN CUT MINE OPERATIONS ESTIMATED DUST EMISSIONS IN YEAR 8 (ALTERNATIVE OPTION)

Introduction

This appendix provides information on the way in which estimates of TSP emissions for Year 8 (alternative option) have been made.

Calculations are presented to an apparent accuracy of ± 1 kg. There may appear to be minor discrepancies in the calculations – less than a fraction of 1%. These are due to rounding errors that arise because the emission factors displayed in the text of this appendix are not shown to the same precision as the emission factors actually used in the spreadsheets when the calculations are done.

For example, in the estimate of TSP emissions from loading overburden to trucks in West Pit (see below) it is stated that the activity will produce 110,318 kg/y of TSP [56,813,541 t/y x 0.00194 kg/t]. Checking this formula using the printed figures gives an estimate of 110,218.3 kg/y. However if the emission factor is written to greater precision eg (0.001941760 kg/t) the estimate becomes 110,318.3 kg/y, which then is written as 110,318 kg/y.

It is not intended to suggest the actual emissions can be estimated to the level of precision used in the calculations. The accuracy of individual estimates is not known precisely but validation tests performed in 1984 (**Dames & Moore, 1984**) indicate that model predictions of annual average dust deposition rates can be estimated with sufficient accuracy so that 80% of predicted annual average deposition rates lie within $\pm 40\%$ of the measured deposition value. This provides an indication as to the overall accuracy of the modelling system. It includes the effects of errors in the estimated emissions, the potential errors introduced by uncertainties in meteorological conditions and the dispersion modelling process.

In addition to the impacts of mining at West Pit, the modelling also takes account of mining activities at Carrington, Ravensworth-Narama, Wambo, United Colliery and HVO south of the Hunter River (Cheshunt and Riverview).

The emissions from Carrington are described below. Emissions from Ravensworth-Narama, Cheshunt and Riverview have been calculated based on the annual ROM coal output of each mine and an emission rate of 0.52 kg/ton ROM coal. In Year 8 (alternative option) of the operation at West Pit, Ravensworth-Narama is expected to have a ROM coal output of 2,400,000 t/y (**Peabody Resources Limited, 1997**) and corresponding TSP emissions of 1,248,000 kg/y. Cheshunt has a ROM output of 5,000,000 t/y and emissions of 2,600,000 kg/y; and Riverview has a ROM output of 3,000,000 t/y and TSP emissions of 1,560,000 kg/y. Emissions from United Colliery and Wambo are based on a recent EIS (**Holmes Air Sciences, 2003**) with emissions being 1,026,264 t/y and 5,122,771 t/y respectively.

OPERATIONS AT CARRINGTON

It is proposed to increase the rate of mining at Carrington from 6 Mtpa to 10 Mtpa. The effects of this increased production on air quality has been estimated by assuming identical emission sources as were identified in the 1999 EIS **(ERM Mitchell McCotter, 1999)** except that emission rates have been increased by a factor of 10/6. The estimate of emissions has been taken directly from the modelling files used in the 1999 EIS for Carrington's Year 5. These files identify the locations of dust sources used in the Carrington modelling, but do not identify the activities that generate the dust in sufficient detail to allow the estimates to be applied in the current modelling. To overcome this the estimated emission due to hauling ROM coal from Carrington Mine to the HVCPP and emissions due to wind erosion have been calculated separately and, after scaling up by the "10/6" factor, these have been subtracted from the original Carrington Year 5 estimates of emissions. The remainder plus the estimated emissions due to wind erosion has been assumed to emanate from the three sources placed to represent mining at Carrington as it is now (2003). The estimated emission from haulage has been assumed to emanate from points along the Carrington to HVCPP ROM coal haulage route.

Hauling coal to HVCPP

It is proposed that 10,000,000 t of coal will be hauled from Carrington to the HVCPP. This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg per vehicle kilometre travelled (kg/VKT) (after application of water to the haul roads) and an average haul distance of 6 km (return), the total estimated TSP emissions for are 250,000 kg/y [10,000,000 t/y / 240 t/trip x 6 km/trip x 1.0 kg/VKT]

Wind Erosion

The **US EPA (1985)** emission factor for wind erosion is shown as **Equation 1**:

Equation 1

$$E_{TSP} = 1.9 \times \left(\frac{s}{15}\right) \times \left(\frac{365-p}{235}\right) \times \left(\frac{f}{15}\right) \text{ kg/ha/day}$$

where,

E_{TSP} = *TSP emissions*

s = silt content (%)

p = number of raindays per year, and

f = percentage of the time wind speed is above 5.4 m/s (%)

For the Carrington Pit area, the typical number of rain-days per year is 86 (taken from Bureau of Meteorology records for Jerry's Plains Station Number 061086, Latitude 32.4983 degrees South, Longitude 150.9083 degrees West and elevation 73.1 m). From the HVCPP Meteorological data for 2002 (the closest site to Carrington), the percentage of wind speeds above 5.4 m/s has been taken to be 10.1% and the percentage of silt in the surface material has been taken to be 10%. This gives an emission factor of 1.01 kg/ha/day. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

Location	Area (ha)	Silt content (%)	Annual TSP emission (kg)
- Carrington pit	185	10	68,374
- Carrington pit O/B	185	10	68,374

OPERATIONS AT WEST PIT

From data provided by CNA, in Year 8 (alternative option), mining taking place in West Pit will produce approximately 6,491,605 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

Open cut ROM coal will be hauled by 240 t trucks directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling processes that are likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Stripping topsoil

Stripping topsoil will generate dust at the rate of approximately 14.0 kg/h (**SPCC, 1983**). Assuming that stripping topsoil takes approximately 1,280 hr/y then the annual TSP emission rate will be 17,920 kg/y [1,280 hr/y x 14.0 kg/h].

Drilling overburden

Based on data provided by CNA, it is estimated in Year 8 (alternative option) that 31,091 holes will be required for overburden blasting in the West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 18,344 kg/y [31,091 holes x 0.59 kg/hole].

Blasting overburden

TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2**.

Equation 2

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad kg/blast$$

where :

E_{TSP} = TSP emission factor

A = area to be blasted in m^2

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 8 (alternative option) there will be 135 shots, the emissions from West Pit will be 96,994 kg/y.

Loading overburden to trucks

Based on information provided by CNA, in Year 8 (alternative option) approximately 23,672,309 bank cubic metres (bcm) will be handled by the truck and shovel in the West Pit. Assuming a density of 2.4 t/bcm it is estimated that 56,813,541 t will be loaded to trucks in West Pit.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 3** shows the relationship between these variables.

Equation 3

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad kg/t$$

where,

E_{TSP} = TSP emissions

k = 0.74

U = wind speed (m/s)

M = moisture content (%)

[where $0.25 \le M \le 4.8$]

For the West Pit meteorological data set used in the modelling the annual average value of $(u/2.2)^{1.3}$ is 1.64.

Assuming moisture content of 2% for overburden, the equation can be written as:

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where,

$E_{TSP} = TSP$ *emissions*

$U =$ *the wind speed in m/s.*

The annual average emission factor for loading overburden to trucks will therefore be 0.00194 kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 110,318 kg/y [56,813,541 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in Year 8 (alternative option) approximately 23,672,309 bcm of overburden will be hauled from West Pit to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 8 (alternative option) for West Pit will be 710,169 kg/y [23,672,309 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

In addition to this, approximately 833,333 bcm of overburden will be hauled from south of the River to the Alluvial Lands and the same amount will be hauled from North Pit to the Alluvial Lands. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 8 (alternative option) will be:

- South of the River to Alluvial Lands - 25,000 kg/y [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].
- North Pit to the Alluvial Lands - 25,000 [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in Year 8 (alternative option) approximately 56,813,541 t of overburden will be dumped in the West Pit waste emplacement areas. The total TSP emissions for Year 8 (alternative option) for West Pit will be 110,318 kg/y [56,813,541 t/y x 0.00194 kg/t].

In addition, approximately 4,000,000 t of overburden will be dumped in the Alluvial Lands. The total TSP emissions for Year 8 (alternative option) will be kg/y 7,767 [4,000,000 t/y x 0.00194 kg/t].

Dozers on overburden
The US EPA emission factor equation is given in **Equation 4**.

Equation 4

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad \textit{kg/hour}$$

where,

$E_{TSP} = TSP$ *emissions*

$s =$ *silt content (%), and*

$M =$ *moisture content (%)*

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. Information provided by CNA shows that in Year 8 (alternative option) dozers would spend 16,448 hours in West Pit. The total TSP emission from the dozers working on overburden is therefore 275,268 kg/y [16,448 h/y x 16.7 kg/h].

Dragline handling of prime overburden
The US EPA emission factor equation is given by **Equation 5**.

Equation 5

$$E_{TSP} = 0.0046 \times \frac{d^{1.1}}{M^{0.3}} \qquad \textit{kg/m}^3$$

where,

$E_{TSP} = TSP$ *emissions*

$d =$ *drop distance (m), and*

$M =$ *moisture content (%)*

Using **Equation 5** and assuming a drop distance of 10 m and moisture of 2% the emission factor becomes 0.04704 kg/bcm.

Based on information provided by CNA, in Year 8 (alternative option) 18,974,729 bcm of overburden will be handled by dragline at West Pit.

The total TSP emission from dragline operations in each pit is therefore 892,533 kg/y [18,974,729 bcm x 0.04704 kg/bcm]

OPERATIONS ON COAL
Drilling coal
It is estimated that in Year 8 (alternative option), that 3,654 holes will be required for drilling coal in West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting coal is estimated to be 2,156 kg/y [3,654 holes x 0.59 kg/hole].

Blasting coal

TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2** (see above).

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 8 (alternative option) there will be 16 shots, the emissions from West Pit will be 11,268 kg/y.

Dozers working on coal
The US EPA emission factor equation is given in **Equation 6**.

Equation 6

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \qquad kg/hour$$

where,
s = *silt content (%), and*
M = *moisture content (%)*

Taking M to be 6 % and s to be 5 %, the emission factor is estimated to be approximately 20.0 kg/hour.

In Year 8 (alternative option), it is estimated that dozers will work on coal for 16,448 hours. The total TSP emission from dozers working on coal is therefore 328,794 kg/y [16,448 h/year x 20.0 kg/hour].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7**:

Equation 7

$$E_{TSP} = \frac{0.580}{M^{1.2}} \qquad kg/t$$

where,
E_{TSP} = *TSP emissions*
M = *moisture content (%)*

Taking M to be 6 %, the emission factor is estimated to be 0.06755 kg/t. In Year 8 (alternative option) approximately 6,491,605 t of ROM will be recovered from West Pit. Therefore the TSP emission from loading coal to trucks is 438,529 kg/y [6,491,605 t/y x 0.06755 kg/t].

Hauling coal to HVCPP and WPCPP
In Year 8 (alternative option), based on information provided by CNA, 5,491,605 t of coal will be hauled from West Pit to the HVCPP and 3,400,000 t will be hauled from West Pit to the WPCPP. In addition, it is proposed that a maximum of 16,000,000 t of ROM coal will be hauled from south of the river to the HVCPP. This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from West Pit and 10 km (return) from south of the river, the total estimated TSP emissions for Year 8 (alternative option) are:

- West Pit to HVCPP– 183,053 kg/y [5,491,605 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- West Pit to WPCPP – 113,333 kg/y [3,400,000 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- S. of river to HVCPP – 666,667 kg/y [16,000,000 t/y / 240 t/trip x 10 km/trip x 1.0 kg/VKT].
-

Unloading coal to hoppers
Open cut ROM coal will be unloaded at the WPCPP and HVCPP dump hoppers.

Based on information provided by CNA, in Year 8 (alternative option) it is estimated that 3,400,000 t of coal will be unloaded at the WPCPP and 31,491,605 t will be unloaded at the HVCPP respectively. It is recognised that the HVCPP has a maximum capacity of 20 Mtpa. However, to account for the flexibility in movement that is required it is necessary to assume a greater throughout.

Assuming an emission factor of 0.01 kg/t, the total estimated TSP emissions are:

- WPCPP– 34,000 kg/y [3,400,000 t/y x 0.01 kg/t]
- HVCPP– 314,916 kg/y [31,491,605 t/y x 0.01 kg/t]

Rehandle of coal at WPCPP and HVCPP
From information provided by CNA, it is estimated that 175,000 t and 549,160 t of open cut ROM coal will need to be re-handled at the WPCPP and HVCPP respectively. Assuming the same emission factor as above, namely 0.01 kg/t, the total TSP emission from this operation will be:

- WPCPP– 1,750 kg/y [175,000 t/y x 0.01 kg/t]
- HVCPP– 5,492 kg/y [549,160 t/y x 0.01 kg/t].

Transport product coal to user/loadout point
Based on information provided by CNA, approximately 2,257,558 t of product coal will be transported from the WPCPP to the NLP. Based on a maximum of 25,000 t/d, one day a month, a maximum of 300,000 t/y will be transported from the HVCPP to HVLP. Based on a maximum of 15,000 t/d, five days a month, a maximum of 900,000 t/y will be transported from the HVLP to the RCT.

The transfer of product coal will be done using haul trucks with a capacity of 100 t. Assuming an emission factor of 0.2 kg/VKT (these trucks travel on sealed roads) and an average haul distance of 12 km to the NLP and HVLP and 14 km from the HVLP to the RCT, the total estimated TSP emissions for Year 8 (alternative option) are:

- WPCPP to NLP– 54,181 kg/y [2,257,558 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT]
- HVCPP to HVLP – 7,200 kg/y [300,000 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT].
- HVLP to RCT – 1,800 kg/y [900,000 /year / 100 t/trip x 14 km/trip x 0.2 kg/VKT].

In addition to this a maximum of 2,000,000 t/y will be transported from the HVLP to the NLP. An analysis of this operation estimated total emissions to be 0.00870 kg/t (**Holmes Air Sciences, 2003**). Therefore, the total estimated TSP emissions are 17,400 kg/y [2,000,000 t/y x 0.00870 kg/t].

Unloading coal
Based on information provided by CNA, an average of 2,500,000 t/y of coal will be unloaded at Bayswater Power Station from the WPCPP, 14,000,000 t/y will be unloaded at the HVLP and 4,257,558 t/y will be unloaded at the NLP. Assuming an emission factor of 0.01 kg/t the total estimated TSP emissions are:

- Bayswater Power Station – 25,000 kg/y [2,500,000 t/y x 0.01 kg/t]
- HVLP– 140,000 kg/y [14,000,000 t/y x 0.01 kg/t]
- NLP – 42,576 kg/y [4,257,558 t/y x 0.01 kg/t]

Loading open cut coal to trains
The emission factor for loading trains from the rail-loading bin is calculated using **Equation 2** (see above) with moisture assumed to be 8 %. The emission factor is 0.00028 kg/t and the annual quantity is 14,000,000 t at the HVLP and 4,257,558 t at the NLP. The annual TSP emissions are therefore:

- HVLP– 3,903 kg/y [14,000,000 t/y x 0.00028 kg/t]
- NLP – 1,187 kg/y [4,257,558 t/y x 0.00028 kg/t]

Handling open cut coal within CHPP
Coal handling in the CHPP takes place at the WPCPP and HVCPP in enclosed areas and under conditions where moisture levels are high. To account for the emissions from this area it has been assumed that the emission is equivalent to five transfers each of which generates the same quantity of TSP as estimated by **Equation 2**. The estimated annual TSP emission is therefore:

- WPCPP – 67,689 kg/y [32,458,023 t/y x 0.00209 kg/t]
- HVCPP– 328,368 kg/y [157,458,023 t/y x 0.00209 kg/t]

Note: the quantities of coal assumed to be handled by these CPPs is higher than will occur in practice. This is necessary in order to preserve the flexibility of operations required for the whole operation. Also note that the emission assumes that all coal is handled five times in the CPPs.

Graders on roads
Estimates of TSP emissions from grading roads have been made using the **US EPA (1985)** emission factor equation (**Equation 8**).

Equation 8

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad kg/vkt$$

where,
E_{TSP} = *TSP emissions*
S = *speed of the grader in km/h*

Assuming an average speed of 8 km/h, the emission factor is 0.61547 kg/VKT. The distance travelled annually by the grader is estimated to be 100,000 km, which will result in an annual TSP emission of 61,547 kg [100,000 km/y x 0.61547kg/VKT].

WIND EROSION
The **US EPA (1985)** emission factor for wind erosion is shown as **Equation 9**:

Equation 9

$$E_{TSP} = 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{365-p}{235}\right) \times \left(\frac{f}{15}\right) \qquad kg/ha/day$$

where,
E_{TSP} = *TSP emissions*
s = *silt content (%)*
p = *number of raindays per year, and*
f = *percentage of the time wind speed is above 5.4 m/s (%)*

For the West Pit area, the typical number of rain-days per year is 86 (taken from Bureau of Meteorology records for Jerry's Plains Station Number 061086, Latitude 32.4983 degrees South, Longitude 150.9083 degrees West and elevation 73.1 m). From the HVCPP Meteorological data for 2002 (the closest site to Carrington), the percentage of wind speeds above 5.4 m/s has been taken to be 10.1% and the percentage of silt in the surface material has been taken to be 10%. This gives an emission factor of 1.01 kg/ha/day. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

Location	Area (ha)	Silt content (%)	Annual TSP emission (kg)
- West Pit pit	500	10	165,587
- Alluvial Lands Pit	50	10	16,559
- West Pit pit O/B	500	10	165,587
- Alluvial Lands O/B	50	10	16,559

WEST PIT OPEN CUT MINE OPERATIONS ESTIMATED DUST EMISSIONS IN YEAR 14

Introduction
This appendix provides information on the way in which estimates of TSP emissions for Year 14 have been made.

Calculations are presented to an apparent accuracy of ±1 kg. There may appear to be minor discrepancies in the calculations – less than a fraction of 1%. These are due to rounding errors that arise because the emission factors displayed in the text of this appendix are not shown to the same precision as the emission factors actually used in the spreadsheets when the calculations are done.

For example, in the estimate of TSP emissions from loading overburden to trucks in West Pit (see below) it is stated that the activity will produce 151,277 kg/y of TSP [77,907,411 t/y x 0.00194 kg/t]. Checking this formula using the printed figures gives an estimate of 151,140.4 kg/y. However if the emission factor is written to greater precision eg (0.001941760 kg/t) the estimate becomes 151,277.5 kg/y, which then is written as 151,277 kg/y.

It is not intended to suggest the actual emissions can be estimated to the level of precision used in the calculations. The accuracy of individual estimates is not known precisely but validation tests performed in 1984 (**Dames & Moore, 1984**) indicate that model predictions of annual average dust deposition rates can be estimated with sufficient accuracy so that 80% of predicted annual average deposition rates lie within ±40% of the measured deposition value. This provides an indication as to the overall accuracy of the modelling system. It includes the effects of errors in the estimated emissions, the potential errors introduced by uncertainties in meteorological conditions and the dispersion modelling process.

In addition to the impacts of mining at West Pit, the modelling also takes account of mining activities at Ravensworth-Narama, Wambo, United Colliery and HVO south of the Hunter River (Cheshunt and Riverview).

It is assumed that operations at Carrington have ceased by Year 14. An alternative for Year 14 has also been modelled with Carrington still operating. The emission calculations for this scenario are described in a separate section.

In Year 14 of the operation at West Pit, Ravensworth-Narama is expected to have a ROM coal output of 2,400,000 t/y (**Peabody Resources Limited, 1997)** and corresponding TSP emissions of 1,248,000 kg/y. Cheshunt has a ROM output of 5,000,000 t/y and emissions of 2,600,000 kg/y; and Riverview has a ROM output of 3,000,000 t/y and TSP emissions of 1,560,000 kg/y. Emissions from United Colliery and Wambo are based on a recent EIS (**Holmes Air Sciences, 2003**) with emissions being 1,026,264 t/y and 5,139,243 t/y respectively.

OPERATIONS AT WEST PIT
From data provided by CNA, in Year 14, mining taking place in West Pit will produce approximately 9,530,884 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

Open cut ROM coal will be hauled by 240 t trucks directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling processes that are likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Stripping topsoil
Stripping topsoil will generate dust at the rate of approximately 14.0 kg/h (**SPCC, 1983**). Assuming that stripping topsoil takes approximately 1,280 hr/y then the annual TSP emission rate will be 17,920 kg/y [1,280 hr/y x 14.0 kg/h].

Drilling overburden
Based on data provided by CNA, it is estimated in Year 14 that 50,182 holes will be required for overburden blasting in the West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 29,607 kg/y [50,182 holes x 0.59 kg/hole].

Blasting overburden
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2**.

Equation 2

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad kg/blast$$

where :

$E_{TSP} = TSP$ emission factor

$A =$ area to be blasted in m^2

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 14 there will be 169 shots, the emissions from West Pit will be 121,604 kg/y.

Loading overburden to trucks
Based on information provided by CNA, in Year 14 approximately 32,461,421 bank cubic metres (bcm) will be handled by the truck and shovel in the West Pit. Assuming a density of 2.4 t/bcm it is estimated that 77,907,411 t will be loaded to trucks in West Pit.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 3** shows the relationship between these variables.

Equation 3

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad kg/t$$

where,

$E_{TSP} = TSP \ \ emissions$

$k = 0.74$

$U = wind\ speed\ (m/s)$

$M = moisture\ \ content\ (\%)$

$[where\ 0.25 \leq M \leq 4.8]$

For the West Pit meteorological data set used in the modelling the annual average value of $(u/2.2)^{1.3}$ is 1.64.

Assuming moisture content of 2% for overburden, the equation can be written as:

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where,

$E_{TSP} = TSP \ \ emissions$

$U = the\ wind\ \ speed\ \ in\ \ m/s.$

The annual average emission factor for loading overburden to trucks will therefore be 0.00194 kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 151,277 kg/y [77,907,411 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in Year 14 approximately 32,461,421 bcm of overburden will be hauled from West Pit to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 14 for West Pit will be 973,843 kg/y [32,461,421 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in Year 14 approximately 77,907,411 t of overburden will be dumped in the West Pit waste emplacement areas. The total TSP emissions for Year 14 for West Pit will be 151,277 kg/y [77,907,411 t/y x 0.00194 kg/t].

Dozers on overburden
The US EPA emission factor equation is given in **Equation 4**.

Equation 4

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad kg/hour$$

where,

$E_{TSP} = TSP \ \ emissions$

$s = silt\ content\ (\%),\ and$

$M = moisture\ content\ (\%)$

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. Information provided by CNA shows that in Year 14 dozers would spend 21,398 hours in West Pit. The total TSP emission from the dozers working on overburden is therefore 358,098 kg/y [21,398 h/y x 16.7 kg/h].

Dragline handling of prime overburden
The US EPA emission factor equation is given by **Equation 5**.

Equation 5

$$E_{TSP} = 0.0046 \times \frac{d^{1.1}}{M^{0.3}} \qquad kg/m^3$$

where,

$E_{TSP} = TSP \ \ emissions$

$d = drop\ distance\ (m),\ and$

$M = moisture\ content\ (\%)$

Using **Equation 5** and assuming a drop distance of 10 m and moisture of 2% the emission factor becomes 0.04704 kg/bcm.

Based on information provided by CNA, in Year 14 19,385,703 bcm of overburden will be handled by dragline at West Pit.

The total TSP emission from dragline operations in each pit is therefore 911,865 kg/y [19,385,703 bcm x 0.04704 kg/bcm]

OPERATIONS ON COAL
Drilling coal
It is estimated that in Year 14, that 6,906 holes will be required for drilling coal in West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from

drilling holes for blasting coal is estimated to be 4,075 kg/y [6,906 holes x 0.59 kg/hole].

Blasting coal
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2** (see above).

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 14 there will be 38 shots, the emissions from West Pit will be 27,044 kg/y.

Dozers working on coal
The US EPA emission factor equation is given in **Equation 6**.

Equation 6

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \qquad kg/hour$$

where,
$s = silt\ content\ (\%),\ and$
$M = moisture\ \ content\ (\%)$

Taking M to be 6 % and s to be 5 %, the emission factor is estimated to be approximately 20.0 kg/hour.

In Year 14, it is estimated that dozers will work on coal for 21,398 hours. The total TSP emission from dozers working on coal is therefore 427,730 kg/y [21,398 h/year x 20.0 kg/hour].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7**:

Equation 7

$$E_{TSP} = \frac{0.580}{M^{1.2}} \qquad kg/t$$

where,
$E_{TSP} = TSP\ \ emissions$
$M = moisture\ \ content\ (\%)$

Taking M to be 6 %, the emission factor is estimated to be 0.06755 kg/t. In Year 14 approximately 9,530,884 t of ROM will be recovered from West Pit. Therefore the TSP emission from loading coal to trucks is 643,843 kg/y [9,530,884 t/y x 0.06755 kg/t].

Hauling coal to HVCPP and WPCPP
In Year 14, based on information provided by CNA, 8,530,884 t of coal will be hauled from West Pit to the HVCPP and 3,400,000 t will be hauled from West Pit to the WPCPP. In addition, it is proposed that a maximum of 16,000,000 t of ROM coal will be hauled from south of the river to the HVCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from West Pit and 10 km (return) from south of the river, the total estimated TSP emissions for Year 14 are:

- West Pit to HVCPP– 284,363 kg/y [8,530,884 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- West Pit to WPCPP – 113,333 kg/y [3,400,000 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- S. of river to HVCPP – 666,667 kg/y [16,000,000 t/y / 240 t/trip x 10 km/trip x 1.0 kg/VKT].
-

Unloading coal to hoppers
Open cut ROM coal will be unloaded at the WPCPP and HVCPP dump hoppers.

Based on information provided by CNA, in Year 14 it is estimated that 3,400,000 t of coal will be unloaded at the WPCPP and 24,530,884 t will be unloaded at the HVCPP respectively. It is recognised that the HVCPP has a maximum capacity of 20 Mtpa. However, to account for the flexibility in movement that is required it is necessary to assume a greater throughout.

Assuming an emission factor of 0.01 kg/t, the total estimated TSP emissions are:

- WPCPP– 34,000 kg/y [3,400,000 t/y x 0.01 kg/t]
- HVCPP– 245,309 kg/y [24,530,884 t/y x 0.01 kg/t]

Rehandle of coal at WPCPP and HVCPP
From information provided by CNA, it is estimated that 175,000 t and 853,088 t of open cut ROM coal will need to be re-handled at the WPCPP and HVCPP respectively. Assuming the same emission factor as above, namely 0.01 kg/t, the total TSP emission from this operation will be:

- WPCPP– 1,750 kg/y [175,000 t/y x 0.01 kg/t]
- HVCPP– 8,531 kg/y [853,088 t/y x 0.01 kg/t].

Transport product coal to user/loadout point
Based on information provided by CNA, approximately 2,257,558 t of product coal will be transported from the WPCPP to the NLP. Based on a maximum of 25,000 t/d, one day a month, a maximum of 300,000 t/y will be transported from the HVCPP to HVLP. Based on a maximum of 15,000

t/d, five days a month, a maximum of 900,000 t/y will be transported from the HVLP to the RCT.

The transfer of product coal will be done using haul trucks with a capacity of 100 t. Assuming an emission factor of 0.2 kg/VKT (these trucks travel on sealed roads) and an average haul distance of 12 km to the NLP and HVLP and 14 km from the HVLP to the RCT, the total estimated TSP emissions for Year 14 are:

- WPCPP to NLP– 54,181 kg/y [2,257,558 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT]
- HVCPP to HVLP – 7,200 kg/y [300,000 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT].
- HVLP to RCT – 1,800 kg/y [900,000 /year / 100 t/trip x 14 km/trip x 0.2 kg/VKT].

In addition to this a maximum of 2,000,000 t/y will be transported from the HVLP to the NLP. An analysis of this operation estimated total emissions to be 0.00870 kg/t (**Holmes Air Sciences, 2003**). Therefore, the total estimated TSP emissions are 17,400 kg/y [2,000,000 t/y x 0.00870 kg/t].

Unloading coal
Based on information provided by CNA, an average of 2,500,000 t/y of coal will be unloaded at Bayswater Power Station from the WPCPP, 14,000,000 t/y will be unloaded at the HVLP and 4,257,558 t/y will be unloaded at the NLP. Assuming an emission factor of 0.01 kg/t the total estimated TSP emissions are:

- Bayswater Power Station – 25,000 kg/y [2,500,000 t/y x 0.01 kg/t]
- HVLP– 140,000 kg/y [14,000,000 t/y x 0.01 kg/t]
- NLP – 42,576 kg/y [4,257,558 t/y x 0.01 kg/t]

Loading open cut coal to trains
The emission factor for loading trains from the rail-loading bin is calculated using **Equation 2** (see above) with moisture assumed to be 8 %. The emission factor is 0.00028 kg/t and the annual quantity is 14,000,000 t at the HVLP and 4,257,558 t at the NLP. The annual TSP emissions are therefore:

- HVLP– 3,903 kg/y [14,000,000 t/y x 0.00028 kg/t]
- NLP – 1,187 kg/y [4,257,558 t/y x 0.00028 kg/t]

Handling open cut coal within CHPP
Coal handling in the CHPP takes place at the WPCPP and HVCPP in enclosed areas and under conditions where moisture levels are high. To account for the emissions from this area it has been assumed that the emission is equivalent to five transfers each of which generates the same quantity of TSP as estimated by **Equation 2**. The estimated annual TSP emission is therefore:

- WPCPP – 99,380 kg/y [47,654,421 t/y x 0.00209 kg/t]
- HVCPP– 255,787 kg/y [122,654,421 t/y x 0.00209 kg/t]

Note: the quantities of coal assumed to be handled by these CPPs is higher than will occur in practice. This is necessary in order to preserve the flexibility of operations required for the whole operation. Also note that the emission assumes that all coal is handled five times in the CPPs.

Graders on roads
Estimates of TSP emissions from grading roads have been made using the **US EPA (1985)** emission factor equation (**Equation 8**).

Equation 8

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad kg/vkt$$

where,
$E_{TSP} = TSP$ *emissions*
S = *speed of the grader in km/h*

Assuming an average speed of 8 km/h, the emission factor is 0.61547 kg/VKT. The distance travelled annually by the grader is estimated to be 100,000 km, which will result in an annual TSP emission of 61,547 kg [100,000 km/y x 0.61547kg/VKT].

WIND EROSION
The **US EPA (1985)** emission factor for wind erosion is shown as **Equation 9**:

Equation 9

$$E_{TSP} = 1.9 \times \left(\frac{s}{15}\right) \times \left(\frac{365-p}{235}\right) \times \left(\frac{f}{15}\right) \qquad kg/ha/day$$

where,
$E_{TSP} = TSP$ *emissions*
s = *silt content (%)*
p = *number of raindays per year, and*
f = *percentage of the time wind speed is above 5.4 m/s (%)*

For the West Pit area, the typical number of rain-days per year is 86 (taken from Bureau of Meteorology records for Jerry's Plains Station Number 061086, Latitude 32.4983 degrees South, Longitude 150.9083 degrees West and elevation 73.1 m). From the HVCPP Meteorological data for 2002 (the closest site to Carrington), the percentage of wind speeds above 5.4 m/s has been taken to be 10.1% and the percentage of silt in the surface material has been taken to be 10%. This gives an emission factor of 1.01 kg/ha/day. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

Location	Area (ha)	Silt content (%)	Annual TSP emission (kg)
- West Pit pit	500	10	165,587
- West Pit pit O/B	500	10	165,587

WEST PIT OPEN CUT MINE OPERATIONS ESTIMATED DUST EMISSIONS IN YEAR 20

Introduction

This appendix provides information on the way in which estimates of TSP emissions for Year 20 have been made.

Calculations are presented to an apparent accuracy of $\pm$1 kg. There may appear to be minor discrepancies in the calculations – less than a fraction of 1%. These are due to rounding errors that arise because the emission factors displayed in the text of this appendix are not shown to the same precision as the emission factors actually used in the spreadsheets when the calculations are done.

For example, in the estimate of TSP emissions from loading overburden to trucks in West Pit (see below) it is stated that the activity will produce 70,588 kg/y of TSP [36,352,655 t/y x 0.00194 kg/t]. Checking this formula using the printed figures gives an estimate of 70,524.1 kg/y. However if the emission factor is written to greater precision eg (0.001941760 kg/t) the estimate becomes 70,588.1 kg/y, which then is written as 70,588 kg/y.

It is not intended to suggest the actual emissions can be estimated to the level of precision used in the calculations. The accuracy of individual estimates is not known precisely but validation tests performed in 1984 (**Dames & Moore, 1984**) indicate that model predictions of annual average dust deposition rates can be estimated with sufficient accuracy so that 80% of predicted annual average deposition rates lie within $\pm$40% of the measured deposition value. This provides an indication as to the overall accuracy of the modelling system. It includes the effects of errors in the estimated emissions, the potential errors introduced by uncertainties in meteorological conditions and the dispersion modelling process.

In addition to the impacts of mining at West Pit, the modelling also takes account of mining activities at Ravensworth-Narama, Wambo, United Colliery and HVO south of the Hunter River (Cheshunt and Riverview).

It is assumed that operations at Carrington have ceased by Year 20. An alternative for Year 20 has also been modelled with Carrington still operating. The emission calculations for this scenario are described in a separate section.

In Year 20 of the operation at West Pit, Ravensworth-Narama is expected to have a ROM coal output of 2,400,000 t/y (**Peabody Resources Limited, 1997)** and corresponding TSP emissions of 1,248,000 kg/y. Cheshunt has a ROM output of 5,000,000 t/y and emissions of 2,600,000 kg/y; and Riverview has a ROM output of 3,000,000 t/y and TSP emissions of 1,560,000 kg/y. Emissions from United Colliery and Wambo are based on a recent EIS (**Holmes Air Sciences, 2003**) with emissions being 1,026,264 t/y and 5,139,243 t/y respectively.

OPERATIONS AT WEST PIT

From data provided by CNA, in Year 20, mining taking place in West Pit will produce approximately 2,323,143 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

Open cut ROM coal will be hauled by 240 t trucks directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling processes that are likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Stripping topsoil

Stripping topsoil will generate dust at the rate of approximately 14.0 kg/h (**SPCC, 1983**). Assuming that stripping topsoil takes approximately 1,280 hr/y then the annual TSP emission rate will be 17,920 kg/y [1,280 hr/y x 14.0 kg/h].

Drilling overburden

Based on data provided by CNA, it is estimated in Year 20 that 10,093 holes will be required for overburden blasting in the West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 5,955 kg/y [10,093 holes x 0.59 kg/hole].

Blasting overburden

TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2**.

Equation 2

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad kg/blast$$

where :

$E_{TSP} = TSP\ \ emission\ \ factor$

$A = area\ to\ be\ blasted\ \ in\ m^2$

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 20 there will be 55 shots, the emissions from West Pit will be 39,693 kg/y.

Loading overburden to trucks
Based on information provided by CNA, in Year 20 approximately 15,146,940 bank cubic metres (bcm) will be handled by the truck and shovel in the West Pit. Assuming a density of 2.4 t/bcm it is estimated that 36,352,655 t will be loaded to trucks in West Pit.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 3** shows the relationship between these variables.

Equation 3

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad kg/t$$

where,

$E_{TSP} = TSP \ \ emissions$

$k = 0.74$

$U = wind\ speed\ (m/s)$

$M = moisture\ \ content\ (\%)$

$[where\ 0.25 \le M \le 4.8]$

For the West Pit meteorological data set used in the modelling the annual average value of $(u/2.2)^{1.3}$ is 1.64.

Assuming moisture content of 2% for overburden, the equation can be written as:

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where,

$E_{TSP} = TSP \ \ emissions$

$U = the\ wind\ \ speed\ \ in\ \ m/s.$

The annual average emission factor for loading overburden to trucks will therefore be 0.00194 kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 70,588 kg/y [36,352,655 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in Year 20 approximately 15,146,940 bcm of overburden will be hauled from West Pit to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/bcm (after the application of water) and an average haul distance of 3 km the total TSP emissions for Year 20 for West Pit will be 454,408 kg/y [15,146,940 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in Year 20 approximately 36,352,655 t of overburden will be dumped in the West Pit waste emplacement areas. The total TSP emissions for Year 20 for West Pit will be 70,588 kg/y [36,352,655 t/y x 0.00194 kg/t].

Dozers on overburden
The US EPA emission factor equation is given in **Equation 4**.

Equation 4

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad kg/hour$$

where,

$E_{TSP} = TSP \ \ emissions$

$s = silt\ content\ (\%), and$

$M = moisture\ content\ (\%)$

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. Information provided by CNA shows that in Year 20 dozers would spend 7,653 hours in West Pit. The total TSP emission from the dozers working on overburden is therefore 128,074 kg/y [7,653 h/y x 16.7 kg/h].

OPERATIONS ON COAL
Drilling coal
It is estimated that in Year 20, that 1,037 holes will be required for drilling coal in West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting coal is estimated to be 612 kg/y [1,037 holes x 0.59 kg/hole].

Blasting coal
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2** (see above).

The area of a typical blast has been estimated to be 22000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in Year 20 there will be 4 shots, the emissions from West Pit will be 3,199 kg/y.

Dozers working on coal
The US EPA emission factor equation is given in **Equation 5**.

Equation 5

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \qquad kg/hour$$

where,

$s = silt\ content\ (\%), and$

$M = moisture\ \ content\ (\%)$

Taking M to be 6 % and s to be 5 %, the emission factor is estimated to be approximately 20.0 kg/hour.

In Year 20, it is estimated that dozers will work on coal for 7,653 hours. The total TSP emission from dozers working on coal is therefore 152,978 kg/y [7,653 h/year x 20.0 kg/hour].

Loading coal to trucks
The emission factor used for this process is given by **Equation 6**:

Equation 6

$$E_{TSP} = \frac{0.580}{M^{1.2}} \qquad kg/t$$

where,

$E_{TSP} = TSP\ emissions$

$M = moisture\ content\ (\%)$

Taking M to be 6 %, the emission factor is estimated to be 0.06755 kg/t. In Year 20 approximately 2,323,143 t of ROM will be recovered from West Pit. Therefore the TSP emission from loading coal to trucks is 156,936 kg/y [2,323,143 t/y x 0.06755 kg/t].

Hauling coal to HVCPP and WPCPP
In Year 20, based on information provided by CNA, 1,323,143 t of coal will be hauled from West Pit to the HVCPP and 3,400,000 t will be hauled from West Pit to the WPCPP. In addition, it is proposed that a maximum of 16,000,000 t of ROM coal will be hauled from south of the river to the HVCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from West Pit and 10 km (return) from south of the river, the total estimated TSP emissions for Year 20 are:

- West Pit to HVCPP– 44,105 kg/y [1,323,143 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- West Pit to WPCPP – 113,333 kg/y [3,400,000 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- S. of river to HVCPP – 666,667 kg/y [16,000,000 t/y / 240 t/trip x 10 km/trip x 1.0 kg/VKT].
-

Unloading coal to hoppers
Open cut ROM coal will be unloaded at the WPCPP and HVCPP dump hoppers.

Based on information provided by CNA, in Year 20 it is estimated that 3,400,000 t of coal will be unloaded at the WPCPP and 17,323,143 t will be unloaded at the HVCPP respectively. It is recognised that the HVCPP has a maximum capacity of 20 Mtpa. However, to account for the flexibility in movement that is required it is necessary to assume a greater throughout.

Assuming an emission factor of 0.01 kg/t, the total estimated TSP emissions are:

- WPCPP– 34,000 kg/y [3,400,000 t/y x 0.01 kg/t]
- HVCPP– 173,231 kg/y [17,323,143 t/y x 0.01 kg/t]

Rehandle of coal at WPCPP and HVCPP
From information provided by CNA, it is estimated that 91,157 t and 132,314 t of open cut ROM coal will need to be re-handled at the WPCPP and HVCPP respectively. Assuming the same emission factor as above, namely 0.01 kg/t, the total TSP emission from this operation will be:

- WPCPP– 912 kg/y [91,157 t/y x 0.01 kg/t]
- HVCPP– 1,323 kg/y [132,314 t/y x 0.01 kg/t].

Transport product coal to user/loadout point
Based on information provided by CNA, approximately 2,257,558 t of product coal will be transported from the WPCPP to the NLP. Based on a maximum of 25,000 t/d, one day a month, a maximum of 300,000 t/y will be transported from the HVCPP to HVLP. Based on a maximum of 15,000 t/d, five days a month, a maximum of 900,000 t/y will be transported from the HVLP to the RCT.

The transfer of product coal will be done using haul trucks with a capacity of 100 t. Assuming an emission factor of 0.2 kg/VKT (these trucks travel on sealed roads) and an average haul distance of 12 km to the NLP and HVLP and 14 km from the HVLP to the RCT, the total estimated TSP emissions for Year 20 are:

- WPCPP to NLP– 54,181 kg/y [2,257,558 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT]
- HVCPP to HVLP – 7,200 kg/y [300,000 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT].
- HVLP to RCT – 1,800 kg/y [900,000 /year / 100 t/trip x 14 km/trip x 0.2 kg/VKT].

In addition to this a maximum of 2,000,000 t/y will be transported from the HVLP to the NLP. An analysis of this operation estimated total emissions to be 0.00870 kg/t (**Holmes Air Sciences, 2003**). Therefore, the total estimated TSP emissions are 17,400 kg/y [2,000,000 t/y x 0.00870 kg/t].

Unloading coal
Based on information provided by CNA, an average of 2,500,000 t/y of coal will be unloaded at Bayswater Power Station from the WPCPP, 14,000,000 t/y will be unloaded at the HVLP and 4,257,558 t/y will be unloaded at the NLP. Assuming

an emission factor of 0.01 kg/t the total estimated TSP emissions are:

- Bayswater Power Station – 25,000 kg/y [2,500,000 t/y x 0.01 kg/t]
- HVLP– 140,000 kg/y [14,000,000 t/y x 0.01 kg/t]
- NLP – 42,576 kg/y [4,257,558 t/y x 0.01 kg/t]

Loading open cut coal to trains
The emission factor for loading trains from the rail-loading bin is calculated using **Equation 2** (see above) with moisture assumed to be 8 %. The emission factor is 0.00028 kg/t and the annual quantity is 14,000,000 t at the HVLP and 4,257,558 t at the NLP. The annual TSP emissions are therefore:

- HVLP– 3,903 kg/y [14,000,000 t/y x 0.00028 kg/t]
- NLP – 1,187 kg/y [4,257,558 t/y x 0.00028 kg/t]

Handling open cut coal within CHPP
Coal handling in the CHPP takes place at the WPCPP and HVCPP in enclosed areas and under conditions where moisture levels are high. To account for the emissions from this area it has been assumed that the emission is equivalent to five transfers each of which generates the same quantity of TSP as estimated by **Equation 2**. The estimated annual TSP emission is therefore:

- WPCPP – 24,224 kg/y [11,615,717 t/y x 0.00209 kg/t]
- HVCPP– 180,631 kg/y [86,615,717 t/y x 0.00209 kg/t]

Note: the quantities of coal assumed to be handled by these CPPs is higher than will occur in practice. This is necessary in order to preserve the flexibility of operations required for the whole operation. Also note that the emission assumes that all coal is handled five times in the CPPs.

Graders on roads
Estimates of TSP emissions from grading roads have been made using the **US EPA (1985)** emission factor equation (**Equation 7**).

Equation 7

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad kg/vkt$$

where,
$E_{TSP} = TSP$ *emissions*
S = *speed of the grader in km/h*

Assuming an average speed of 8 km/h, the emission factor is 0.61547 kg/VKT. The distance travelled annually by the grader is estimated to be 100,000 km, which will result in an annual TSP emission of 61,547 kg [100,000 km/y x 0.61547kg/VKT].

WIND EROSION
The **US EPA (1985)** emission factor for wind erosion is shown as **Equation 8**:

Equation 8

$$E_{TSP} = 1.9 \times \left(\frac{s}{15}\right) \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right) \qquad kg/ha/day$$

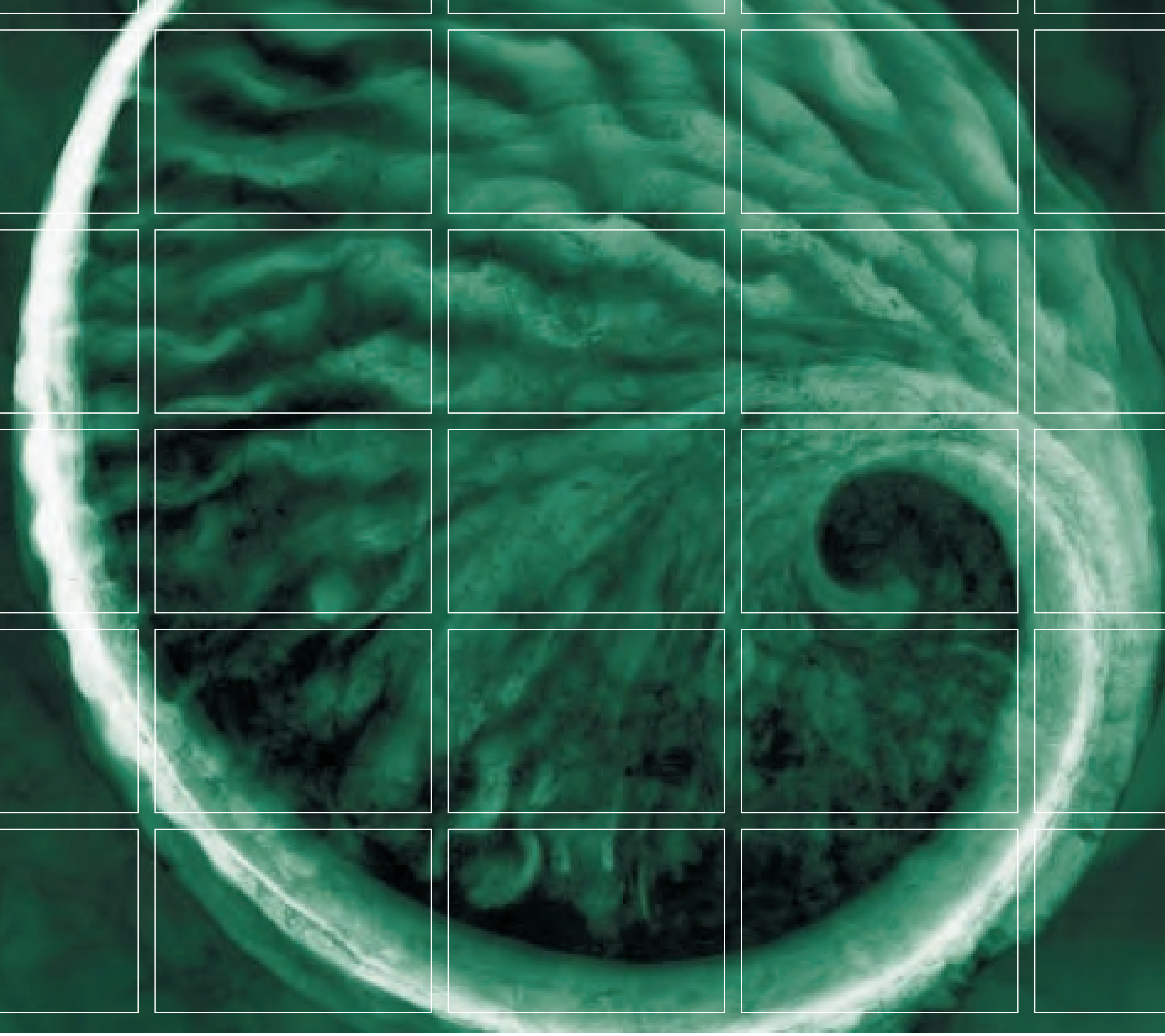
where,
$E_{TSP} = TSP$ *emissions*
s = *silt content (%)*
p = *number of raindays per year, and*
f = *percentage of the time wind speed is above 5.4 m/s (%)*

For the West Pit area, the typical number of rain-days per year is 86 (taken from Bureau of Meteorology records for Jerry's Plains Station Number 061086, Latitude 32.4983 degrees South, Longitude 150.9083 degrees West and elevation 73.1 m). From the HVCPP Meteorological data for 2002 (the closest site to Carrington), the percentage of wind speeds above 5.4 m/s has been taken to be 10.1% and the percentage of silt in the surface material has been taken to be 10%. This gives an emission factor of 1.01 kg/ha/day. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

Location	Area (ha)	Silt content (%)	Annual TSP emission (kg)
- West Pit pit	500	10	165,587
- West Pit pit O/B	500	10	165,587

PART J

noise and vibration study



Hunter Valley Operations West Pit Extension and Minor Modifications

Noise Assessment

Coal & Allied

October 2003

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Position:	Project Manager
Signed:	
Date:	*24 October, 2003*
Approved by:	*David Snashall*
Position:	Project Director
Signed:	
Date:	*24 October, 2003*

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FINAL REPORT

Coal & Allied

Hunter Valley Operations West Pit Extension and Minor Modifications

Noise Assessment

October 2003

Environmental Resources Management Australia
Building C, 33 Saunders Street
Pyrmont, NSW 2009
Telephone +61 2 8584 8888
Facsimile +61 2 8584 8800
www.erm.com

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EXECUTIVE SUMMARY

Coal & Allied (CNA) wish to continue mining operations at West Pit at Hunter Valley Operations (HVO) beyond current consent boundaries. Additionally, CNA wish to simplify the planning approvals platform for all of HVO north of the Hunter River's mining activities.

This study assesses the noise implications as a result of the proposed extension to West Pit, and includes an assessment of the noise effects from all of CNA's operations at HVO north of the Hunter River, including operations at North Pit/the Alluvial Lands, Carrington and the existing West Pit (including Mitchell & Wilton Pits)

This study draws on earlier detailed acoustic analyses, including site-specific equipment measurements. It concludes that while there will be some exceedance of Environment Protection Authority (EPA) goals, there will be no significant increase in noise impacts at most nearby private residential properties.

The modelling has shown that under still isothermal (SI) or calm weather conditions, all private residences not currently in a zone of affectation will experience noise levels below the EPA's noise goals, which are as low as 36 dB(A).

The model has also shown that under INP derived weather conditions, noise at all private residences not currently in a zone of affectation will be below or only marginally above EPA noise goals. Notwithstanding this, the mining noise levels at these properties are predicted to remain generally unchanged compared to existing levels.

A comparison against acquisition limits imposed on other mining operations demonstrates no exceedances at private residences not currently in a zone of affectation, even under assessable INP weather.

The conclusions drawn from this extensive detailed analysis demonstrates that the existing noise amenity of all adjacent private residences will not be significantly affected.

1 INTRODUCTION

This report was prepared for CNA to assess environmental noise associated with proposed and existing operations within HVO north of the Hunter River.

Existing operations within HVO north of the Hunter River contain four mining areas, two coal preparation plants (CPPs), two rail loading points, internal haul roads, conveyors and administration buildings. The mining areas include West Pit (including Wilton & Mitchell Pits), Carrington, North Pit and the Alluvial Lands, the CPPs are West Pit CPP (WPCPP) and Hunter Valley CPP (HVCPP), and the loading points are Hunter Valley Load Point (HVLP) and Newdell Loading Point (NLP)

As part of the proposal, these existing operations will either continue to operate as they do now or will be modified as follows:

- increase in capacity of the HVCPP from 13 to 20 Mtpa ROM;
- increase in haulage of coal from mining areas south of the Hunter River to HVCPP from 8 to 16 Mtpa ROM coal;
- allowing the HVCPP and WPCPP to process coal from any of the mining areas in HVO (including south of the Hunter River) and the ability to dispose of reject from any CPP in any approved disposal area within HVO;
- upgrading the Belt Line Conveyor which transfers coal from the HVCPP to the HVLP along the Belt Line Road; and
- increasing production rates at Carrington from 6 Mtpa to 10 Mtpa.

New activities which form part of the proposal include:

- the extension of West Pit to the east and south east;
- intermittent transport of product coal between the HVLP, NLP and Ravensworth Coal Terminal (RCT); and
- intermittent haulage of coal from the HVCPP to the HVLP along the privately owned Belt Line Road;
- transfer of heavy equipment across the Hunter River via temporary crossings; and
- the possible construction of a conveyor between the HVLP and NLP if economically feasible.

In addition to these activities, it is also proposed to consolidate the existing 18 approvals for HVO north of the Hunter River into a single consent which covers all existing activities and the new activities described above.

The location of West Pit and HVO north of the Hunter River can be seen in *Figure 1.1*. The proposal area can be seen in *Figure 1.2*.

The noise modelling includes five mining stages representative of 20 years of future operations. The modelled noise sources include all those operations described above.

The above constitutes the proposal and all major noise producing activities north of the Hunter River. Noise modelling conservatively assumed concurrent occurrence of all or most of such operations as described in the noise modelling results section of this report. This assessment has been prepared in accordance with the EPA's *Industrial Noise Policy* (*INP*), which was published in January 2000.

1.1 GLOSSARY

A number of technical terms used in this report describe various noise levels from the mine. These are explained in *Table 1.1*.

Table 1.1 Glossary of Terms

Term	Description
ABL	Assessment Background Level (ABL) is defined in the *INP* as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L_{90} statistical noise levels.
dB(A)	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
dB(LinPeak)	The peak sound pressure level (not RMS) expressed as decibels with no frequency weighting.
L1	The noise level exceeded for 1 % of a measurement period.
L10	A noise level which is exceeded 10 % of the time. It is approximately equivalent to the average of maximum noise levels.
L90	Commonly referred to as the background noise, this is the level exceeded 90 % of the time.
Leq	The summation of noise over a selected period of time. It is the energy average noise from a source, and is the equivalent continuous sound pressure level over a given period.
Lmax	The maximum root mean squared (rms) sound pressure level received at the microphone during a measuring interval.
MIC_{8MS}	Maximum Instantaneous Charge (with a minimum 8 milli-sec delay).
Peak Particle Velocity	The maximum velocity of a particle of the transmission medium, used in assessment of vibration.
RBL	The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the ABL's.
RMS	Root Mean Square which is a measure of the mean displacement (velocity or acceleration) of a vibrating particle.
SI	Still isothermal (SI) refers to calm weather conditions (defined as no wind and standard temperature gradients).
sigma-theta (σ_θ)	The standard deviation of horizontal wind fluctuation.

Term	Description
Sound power level	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental location of the source and is independent of the surrounding environment.
Temperature inversion	A positive temperature gradient. A meteorological condition where atmospheric temperature increases with altitude to some height.

The following indicates what an average person perceives about noise levels in practice:

- noise differences of less than approximately 2 dB are generally imperceptible; and
- a difference of around 10 dB seems to be a doubling or halving of loudness.

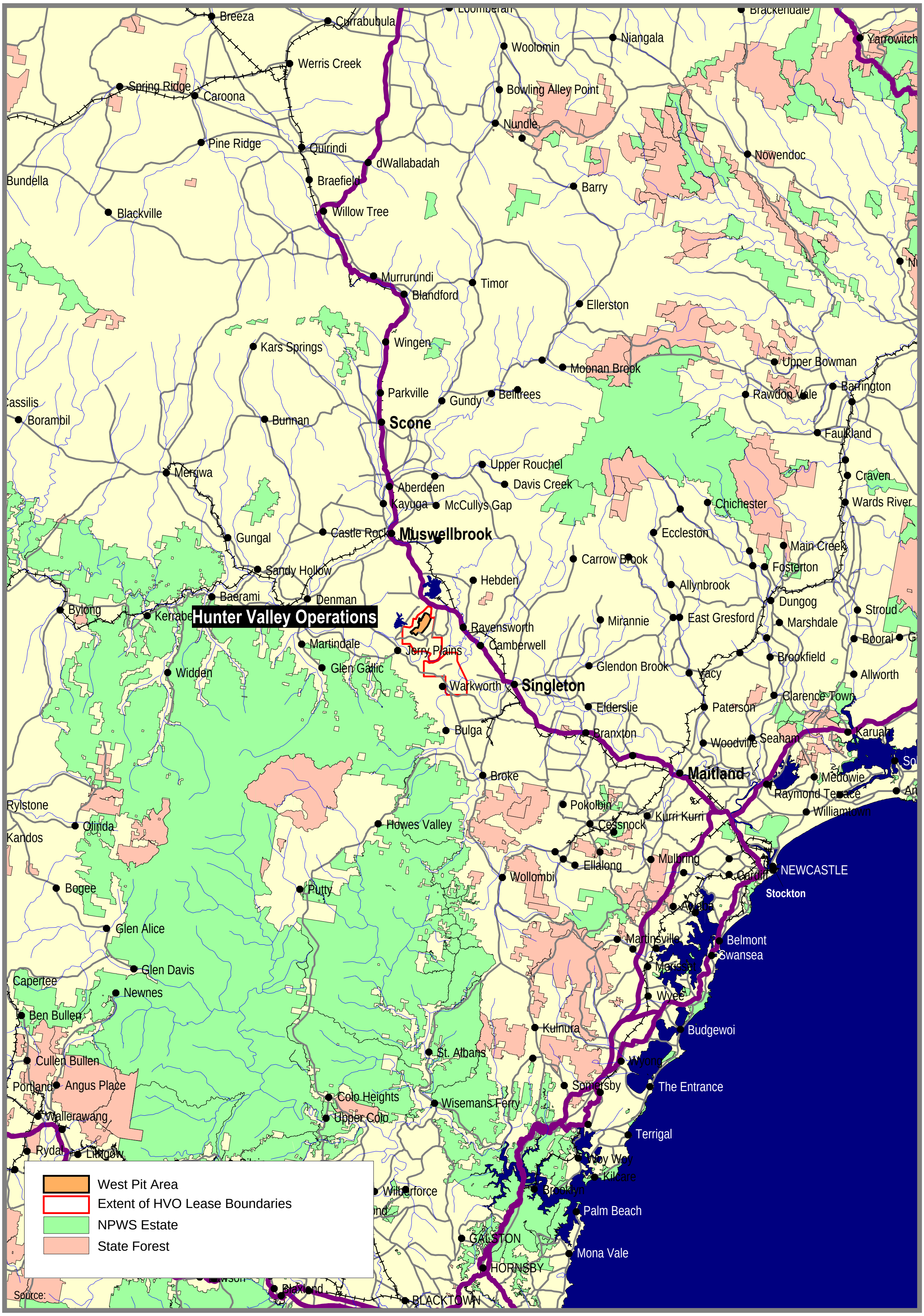

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FIGURE 1.1

Location of HVO and West Pit in their Regional Setting

FIGURE 1.2

The Proposal Area

2 THE EXISTING NOISE ENVIRONMENT

2.1 REPRESENTATIVE PROPERTIES

The following noise assessment provides a graphical representation of the proposal's noise emissions in the form of noise contours. In addition, to provide a higher level of accuracy for specific off-site locations, noise levels at a number of surrounding properties were modelled individually.

A total of 12 properties were considered representative of assessable locations surrounding the mine. Of these 12 representative properties, six are private residential properties (Location Nos. 1 to 6) while the others have agreements with CNA or are currently covered under existing mine noise affectation zones. These are shown in *Table 2.1* and illustrated in *Figure 2.1*. Other properties are located as shown in *Figure 2.2*. Location Nos. 1 to 6 are private residential properties.

Table 2.1 ***Surrounding Representative Properties Used for Modelling Purposes***

Property No.	ISG Coordinates		Location from West Pit Mine
	Easting	Northing	Compass Point
1	292153	1402554	SW
2	292801	1401825	SW
3	293074	1401571	SW
4	293884	1400207	S
5	305645	1399385	SE
6	305748	1400194	SE
7[2]	303750	1403450	SE
8[2]	301500	1404300	SE
9[1]	295525	1403350	SW
10[1]	294700	1402575	SW
11[1]	294850	1399525	S
12[1]	301150	1402050	SE

Notes:
1. These private residences are currently inside an HVO zone of affectation or subject to a private land holders agreement
2. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.

2.2 BACKGROUND AND AMBIENT NOISE

A background ambient noise survey was developed and implemented for this study. Five representative sites were chosen for long term monitoring, conducted in accordance with the EPA's INP (Refer to *Figure 2.1* N1 to N5).

Additionally, data from unattended monitoring measured at four locations for compliance purposes by WTS Environmental Laboratories Pty Limited was re-analysed in accordance with the INP and is also presented below. The results are listed in *Table 2.2* and the ERM data shown in *Annex A*.

Table 2.2 Summary of Measured Background Noise Levels

Location		Rating Background Level, dB(A)			Ambient Noise Level, dB(A)$L_{eq,period}$		
ERM Monitoring Site	Property No.	Day	Evening	Night	Day	Evening	Night
N1	1(1)	33	34	31	53	53	50
N2	7(1)	32	33	33	46	47	42
N3	8(2)	35	33	35	49	43	41
N4	2(1)	31	32	31	49	49	52
N5	10(3)	33	37	35	55	50	46
	9(1 and 4)	31	32	33	50	43	43
	Jerrys Plains Police Station(4)	32	32	32	44	45	46
	11(4)	34	33	33	51	50	47
	12(2 and 4)	39	32	40	49	49	50

1. Wind speed limit for daytime levels at these locations was 6 m/s.
2. Wind speed limit for daytime levels at these locations was 7 m/s.
3. Data for this location is a combination of ERM and WTS Environmental Laboratories measurements.
4. Data sourced from WTS Environmental Laboratories, HVO compliance reports.

In addition to the data presented above, on-going monitoring as part of CNA's noise management procedure includes attended noise levels measured at representative locations. These reports were reviewed and the total measured noise level, as well as the contribution from HVO's current operations north of the Hunter River is identified by authors of the report (prepared by WTS Environmental Laboratories Pty Limited).

This information is summarised in *Table 2.3* for quarterly monitoring undertaken in 2002. The quoted "Howick/HVO1 Contribution" in the table is representative of the area surrounding the site. It should be noted that ERM are not able to validate or confirm the accuracy of the data presented. It is noted that noise measurements were conducted during various prevailing weather conditions that influenced the results. These weather conditions may or may not be assessable under the INP and therefore cannot necessarily be directly compared to the modelled results (eg for Year 1) provided later in this assessment.

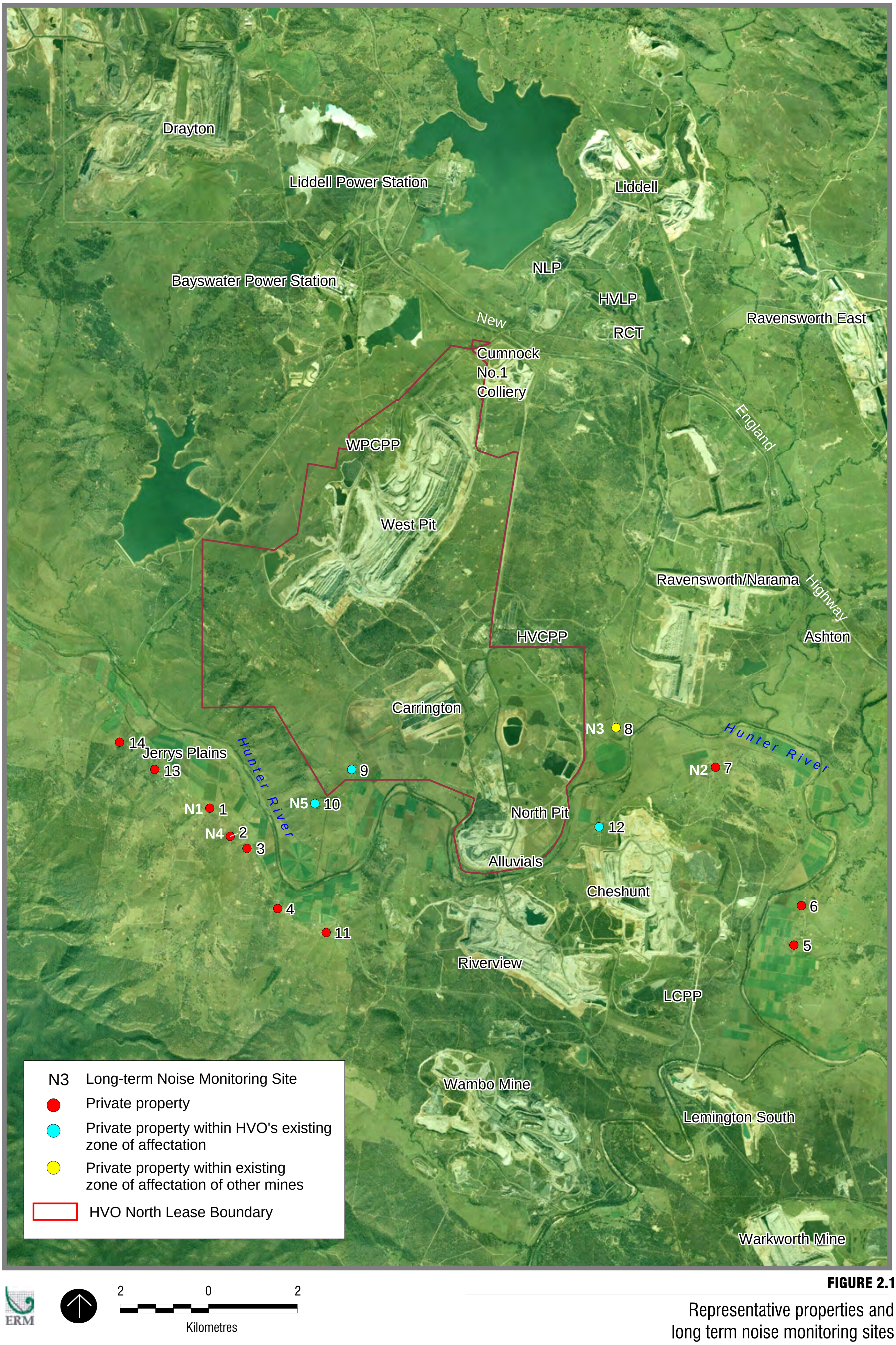


FIGURE 2.1

Representative properties and long term noise monitoring sites

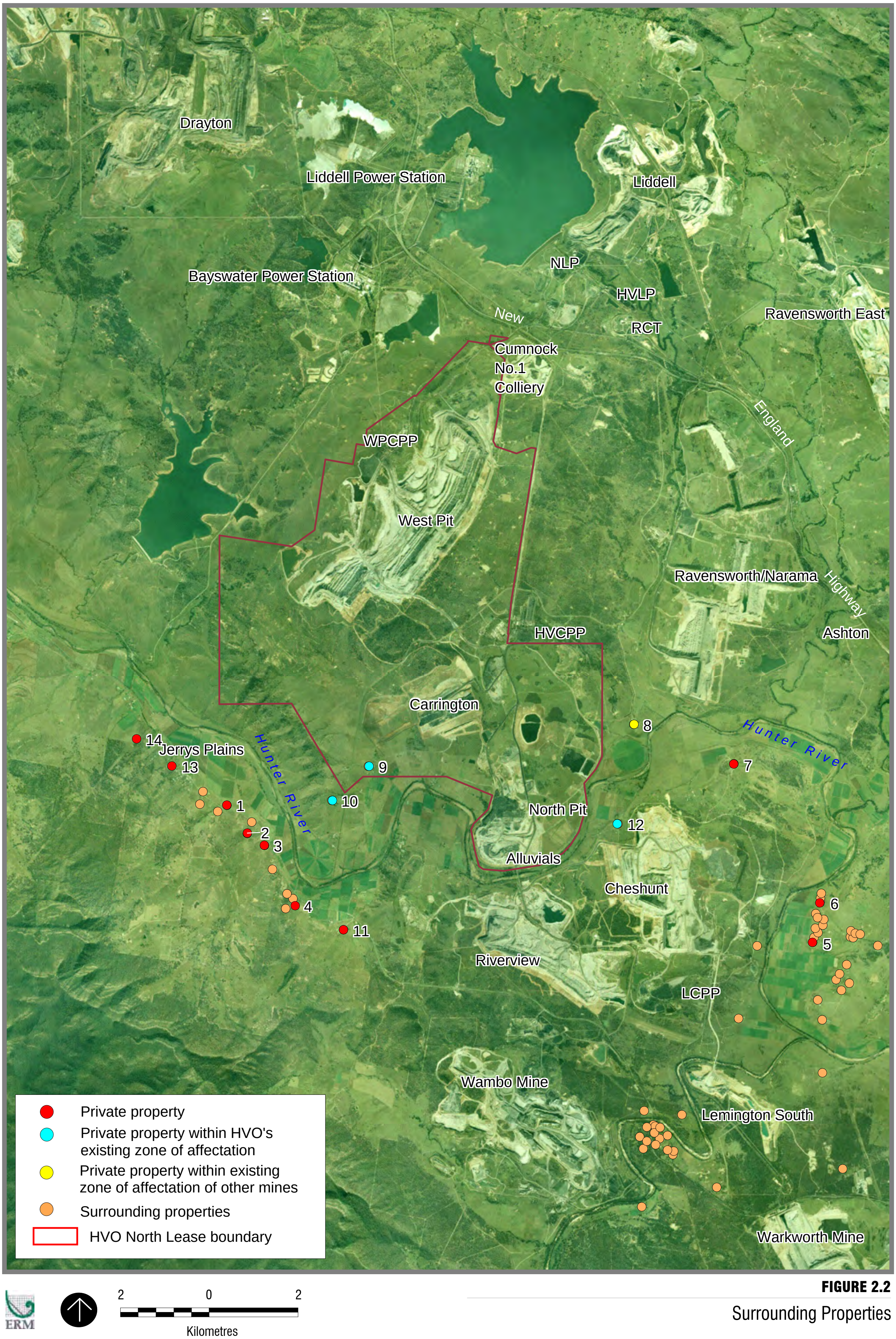


FIGURE 2.2

Surrounding Properties

Table 2.3 2002 Quarterly Noise monitoring – WTS Environmental Laboratories

Property No.		Measured Noise Level, dB(A)	
		Total	Howick/HVO1 Contribution
~1[3]	Jerrys Plains Police Station	31 – 47	26 – 28
6		34 - 43	31 – 36
7[2]		39	39
8[2]		41 – 46	41 – 44
9[1]		37 - 50	40 – 45
10[1]		34 - 44	35 – 44
11[1]		35 – 37	26 – 37
12[1]		47 - 52	47 - 51
13		33	32

1. These private residences are currently inside an HVO zone of affectation or subject to a private land holders agreement.
2. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
3. Monitoring Location ~1 is the Jerrys Plains Police Station, and is representative of assessment location 1.

2.3 PREVAILING WEATHER CONDITIONS

The efficiency of noise propagation over long distances can be significantly affected by the weather conditions. Of most interest are source to receiver winds and the presence of temperature inversions as both these conditions can enhance received noise levels. To account for these phenomena the EPA in their INP specify weather analysis procedures to determine the prevalent weather conditions that enhance noise propagation with a view to determining whether they can be described as a feature of the project area.

In this study, a comprehensive set of hourly weather data consisting of approximately four years data obtained from the weather station at HVO, was analysed. This was done in accordance with the procedures defined in the INP, and as otherwise advised by the EPA. For the purposes of this report, weather conditions modelled as a result of this analysis are referred to as INP weather conditions.

2.3.1 Temperature Inversions

Records of the Pasquill Stability Class, a parameter representing the degree of mixing in the atmosphere, can gauge the prevalence and magnitude of temperature inversions. Stability classes are categorised as A to G. Stability Class A applies under sunny conditions with light winds when dispersion is most rapid. Stability Class D applies under windy and/or overcast conditions when dispersion is moderately rapid and Stability Class F and G can occur at night when winds are light and the sky is clear. Stability Classes B, C and E are intermediate conditions between those described above. Temperature inversions may occur during stability classes E, F and G. In particular, stability class F generally represents a range of temperature gradients from 1.5 ^{o}C/100 m to less than 4 ^{o}C/100 m.

Records of wind speed, wind direction and sigma-theta (σ_θ - used to calculate Pasquill Stability Classes) were available from HVO's weather station. Almost four years of hourly data were used, including, the periods 1 July 1996 to 1 July 1997, 9 January 1999 to 6 October 2000 and 1 January 2002 to 28 February 2003. This was the data available at the time of the noise assessment.

The frequency of each stability class occurrence is shown in *Table 2.4*, based on the aforementioned hourly data. Combining the atmospheric Stability Class F and G data indicates that temperature inversions having potential to enhance noise propagation are marginal above the EPA's 30 % occurrence threshold for autumn nights only. Hence, temperature inversions are considered to be a feature of the area in autumn according to the INP. This analysis is consistent with the EPA's INP (Appendix F) which shows that the percentage of atmospheric stability Class F is 25 to 30 % for the area encompassing the proposal and surrounds. A calculation for noise impact under the INP's suggested 3 ^{o}C/100 m temperature inversion parameter is provided in noise modelling results below.

Table 2.4 ***Stability Class Frequency***

Stability Class	Percentage of Occurrence			
	Summer	**Autumn**	**Winter**	**Spring**
A	1.10	0.00	0.43	1.19
B	0.59	0.00	0.05	0.47
C	2.08	0.00	0.19	4.53
D	41.58	29.48	29.38	43.26
E	35.62	39.24	45.14	29.85
F	11.48	13.66	16.14	11.36
G	7.56	17.61	8.69	9.35
TOTAL	**100**	**100**	**100**	**100**

Source: Holmes Air Sciences

2.3.2 *Prevailing Winds*

The prevailing wind directions to be used in the noise model were determined in accordance with the INP which requires that winds with an occurrence greater than 30 % be assessed. A thorough review of the vector components of the hourly wind data described above was undertaken. The EPA assessable wind direction is graphically demonstrated in *Annex B*, where the windrose arm exceeds the 30 % threshold as indicated by the rose. The assessable wind speed was also determined in accordance with the intent of the INP and is the upper tenth percentile speed for each of the assessable directions. The wind directions and wind speed determined to be a feature of the area in accordance with the INP are summarised in *Table* 2.5.

It is demonstrated that the assessable winds occur during evening and night time, and that daytime winds are not considered a feature of the area according to the INP. Since the evening and night mine operations are the same, and the night time wind data set provides a more statistically valid analysis, the feature winds occurring during the night are used for noise assessment. The wind roses in *Annex B* also demonstrate that a combined wind and temperature inversion occur significantly less than the EPA's 30 % threshold. Hence, a combined wind and temperature inversion calculation was not produced.

The results are consistent with the well documented north west to south east dominant wind axis found in the Hunter Valley, however, north westerly winds are excluded as a large proportion exceed 3 m/s, which the INP excludes for noise assessment purposes.

Table 2.5 Assessable INP Wind Conditions

Wind (Origin) Direction	Upper 10% Night Wind Speed, m/s
E	1.8
ESE	2.3
SE	2.6
SSE	2.7
S	2.5
SSW	2.1
SW	1.5

3 *OPERATIONAL NOISE CRITERIA*

3.1 *GENERAL CRITERIA*

The EPA, in its INP, gives guidelines for assessing industrial facilities. Assessment criteria depend on the existing amenity of areas potentially affected by a proposed development as outlined below.

Assessment criteria for sensitive receivers near industry are based on the following objectives:

- protection of the community from excessive intrusive noise; and
- preservation of amenity for specific land uses.

To ensure that these objectives are met two separate criteria exist, the intrusiveness criteria and the amenity criteria, which are described in detail below. A fundamental difference between the intrusiveness and the amenity criteria is that the former is applicable over 15 minutes in any period, while the latter covers the entire assessment period (day, evening and night).

3.1.1 *Intrusiveness*

The intrusiveness criterion requires that $L_{Aeq,15min}$ noise levels from a newly introduced source during the day, evening and night do not exceed the existing Rating Background Levels (RBL) by more than 5dB. This is expressed as:

$$L_{Aeq,15min} \leq RBL + 5 - K$$

where $L_{Aeq,15min}$ is the L_{eq} noise level from the source, measured over a 15 minute period and K is a series of adjustments for various noise characteristics. Where the RBL is less than 30 dB(A), a value of 30 dB(A) is used. For typical noise from an open-cut mine, no adjustment factors are considered applicable.

Using the monitoring data obtained from the long term survey described in *Section 2.2*, the intrusiveness criteria derived for the proposal are shown in *Table 3.1*. The locations are residential dwellings taken to be representative of each particular area. Where the measured night time background noise level is higher than that for other periods, the lower of the day or evening intrusiveness goal has been adopted for the night period. This is consistent with the EPA's advice.

Table 3.1 Project Specific Intrusiveness Criteria for Representative Receiver Locations

Property No.	$L_{eq,15min}$ Intrusiveness Noise Goals, dB(A)		
	Day	Evening	Night
1	38	39	36
2	36	37	36
3[1]	36	37	36
4[1]	36	37	36
5[2]	36	36	36
6[2]	36	36	36
7[3]	37	38	37
8[3]	40	38	38
9[4]	36	37	36
10[4]	38	42	38
11[4]	39	38	38
12[4]	44	37	37

1. Background noise at these locations is considered represented by that measured at location 2
2. Background noise at these locations is based on monitoring undertaken as part of previous studies and is consistent with existing consent limits for these receptors from other mines in the area.
3. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
4. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.

The proposal is unique in that it combines various operations that currently have separate consents, inclusive of noise limits. This implies surrendering such limits and adopting one set of intrusiveness noise goals approximately equivalent to that contained in the consent for each one of the previous individual operations. Hence, the application of the intrusiveness criteria to the whole of these combined activities imposes an added restriction to operational flexibility than would otherwise exist. This is because existing noise limits for individual operations are approximately each equivalent to that adopted for the proposal. Therefore, a more relevant target is that derived through the EPA's amenity criteria, described in *Section 3.1.2.*

3.1.2 Amenity

The EPA's amenity criterion requires industrial noise to be within an acceptable level for the particular locality and land use. Where ambient noise is already high, the acoustic environment should not be deteriorated significantly. The strategy behind the amenity criterion is a holistic approach to noise, where all industrial noise (existing and future) received at a given receptor does not exceed the recommended goals.

This is particularly appropriate for this proposal as it is an amalgamation of all or most of the industrial operations that contribute to total industrial noise at private residences.

Private residences potentially affected by the proposal are covered by the EPA's rural or suburban amenity categories. The EPA's definition for a rural area is:

"*an acoustical environment that is dominated by natural sounds, having little or no road traffic*".

The definition of a suburban area is:

"*an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry*".

Base amenity criteria for these two categories are given in *Table 3.2*. Adjustments to these target levels may apply where the environment has existing industrial noise (excluding the proposal) or high levels of road traffic noise. Such adjustments were made on the basis of our short term observations and the ongoing quarterly monitoring summarised earlier in *Table 2.3*.

Table 3.2 EPA Base Amenity Criteria

Location	**Indicative Area**	**Time**	**Recommended L_{eq} period Noise Level dB(A)**	
			Acceptable	**Maximum**
Residential	Rural	Day	50	55
		Evening	45	50
		Night	40	45
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45

Table 3.3 presents the project specific amenity limits based on the EPA's INP. The amenity targets have been presented for the proposal as a whole, where all current HVO activities north of the Hunter River are integrated. It should be noted that where the proposal contributes all the industrial noise at some locations, the amenity target (under an integrated consent) remains unaltered from the INP target for those locations. Similarly, where the existing industrial noise (excluding the proposal) is less than the INP's "acceptable noise level minus 6 dB", the acceptable target is adopted as per the requirements of the INP. It should be noted that the amenity targets differ from those of the intrusiveness targets as they are the noise level from the proposal averaged over the duration of the period (for example, the nine hour night time period).

Table 3.3 Derived Project Specific Noise Amenity Targets

Property No.	Amenity, dB(A) $L_{eq,period}$		
	Day	Evening	Night
1	50	45	40
2	50	45	40
3	50	45	40
4	50	45	40
5	50	45	40
6	50	45	40
7[2]	55	45	38
8[2]	55	45	38
9[1]	55	45	40
10[1]	55	45	40
11[1]	50	45	37
12[1]	55	45	40

1. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
2. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.

No attended measurements were performed by ERM at Location 11 and as such the industrial noise level at this location is not known. Some guidance has been taken from the WTS Environmental Laboratories compliance monitoring

3.2 *PROJECT SPECIFIC NOISE GOALS*

To simplify the assessment procedure it is often appropriate to define a single noise goal for each of the assessment periods. This is particularly so where noise from a project can be considered consistent such that it is reasonable to assume that (in terms of emissions from the project) the $L_{eq,15min}$ is approximately equal to the $L_{eq,period}$. With mines, this is generally the case. However, consideration should be given to typical equipment downtime for normal staff breaks and maintenance. This is likely to result in the average noise level for a given day (11 hr) or night (9 hr) period being 3 dB lower than the predicted worst case $L_{eq,15minute}$ noise level. This is based on discussions with mine operators and their input into typical mobile plant operations. For example, trucks will be idle waiting to be loaded or unloaded, loaders or dozers are idle waiting for trucks to arrive (to load or unload), plus the normal sustenance breaks. Nonetheless, the project specific noise goals are taken to be the lesser of the amenity and intrusiveness criteria.

Project specific noise goals, determined on this basis, are presented in *Table 3.4.* The outcome is that the intrusiveness goal is the more limiting in all instances. However, as described earlier, the amenity goal is more appropriate in this assessment for most privately owned residences as they are only exposed to industrial noise from the proposal and hence if the amenity goal is achieved the EPA's holistic strategy to noise management would be satisfied. The exception would be Property Nos. 5, 6, 7, 8, 11 and 12 where industrial noise contributions from other mines are likely.

Also shown in *Table 3.4* are potential acquisition limits based on an "existing background plus 10 dB" concept for night time. These acquisition limits are based on previous limits imposed on similar operations.

Table 3.4 *Project Specific Noise Limits*

Location	$L_{eq,15minute}$ Noise Level Criteria, dB(A)			Likely Night Time Mine L_{eq} Noise Acquisition Goal, dB(A)
	Day	Evening	Night	
1	38	39	36	41
2	36	37	36	41
3	36	37	36	41
4	36	37	36	41
5	36	36	36	41
6	36	36	36	41
7[2]	37	38	37	42
8[2]	40	38	38	43
9[1]	36	37	36	41
10[1]	38	42	38 (37[3])	43
11[1]	39	38	38	43
12[1]	44	37	37	42

1. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
2. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
3. This level is an $L_{eq,9hour}$ amenity target.

3.3 CUMULATIVE NOISE

The cumulative impact of more than one development can be compared against the base amenity criteria listed above (refer *Table 3.2*). This is consistent with the INP's holistic approach to industrial noise.

3.4 SLEEP DISTURBANCE

The above criteria are appropriate for assessing noise from continuous and intermittent sources, such as engine noise from mobile plant, fixed plant and pit equipment. However, given the transient nature of some operations, noise sources such as bulldozer track plates, reversing alarms and the banging of shovel gates, the L_{eq} noise level alone would not adequately describe all the potential impacts of the noise in question, hence an additional approach is required, as described below.

The most important impact of transient noises would be to disturb the sleep of nearby residents. While the INP does not specify a criterion for assessing sleep disturbance, its *Environmental Criteria for Road Traffic Noise* (EPA 1999) indicates that levels below 50 to 55 dB(A) inside residences are unlikely to wake sleeping occupants.

If bedroom windows are open, this corresponds to an external maximum noise level of approximately 60 to 65 dB(A) at a residence. The likely number of noise events per night should also be considered.

However, in this case, this is considerably less stringent than the EPA's previous position on sleep disturbance as presented in its *Environmental Noise Control Manual* (ENCM), dated 1994. The ENCM recommended that $L_{1,1minute}$ noise from a source should not exceed the existing background noise by more than 15 dB. Depending on the measured background noise, the sleep disturbance criteria for the quietest location could be as low as 45 dB(A)L_1 for SI weather conditions.

The latter more conservative sleep disturbance criterion was adopted for this study.

3.5 BLASTING

3.5.1 Recommended Criteria

Recommended criteria for the assessment of noise and vibration from blasting are provided by the Australian and New Zealand Environment and Conservation Council (ANZECC) in its publication entitled *Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration*. These criteria apply to minimise human annoyance and discomfort and were not developed to control possible structural damage. However, if ground vibration peak particle velocities comply with criteria for minimising human annoyance and discomfort, they would also be below levels that may cause structural damage to buildings.

3.5.2 Noise Overpressure

The ANZECC guidelines specify that air-blast overpressure should not exceed 115 dB(L_{peak}) for more than 5 % of the total number of blasts over a period of 12 months. However, the maximum level should not exceed 120 dB(L_{peak}) at any time. The dB(L_{peak}) unit of sound measurement considers the low frequency sounds which are not audible to the human ear but can be 'felt'.

3.5.3 Ground Vibration

The ANZECC guidelines specify that the peak particle velocity (ppv) from ground vibration should not exceed 5 mm/s for more than 5 % of the total number of blasts over a period of 12 months. However, the maximum level should not exceed 10 mm/s at any time. The ANZECC guidelines also recommend that a level of 2 mm/s be considered as the long-term regulatory goal for the control of ground vibration.

3.5.4 Time and Frequency of Blasting

The ANZECC guidelines state that blasting should generally be limited to the hours not take place from 9.00 am to 5.00 pm Monday to Saturday and should not take place on Sundays or public holidays. The ANZECC guidelines recognise that under some circumstances or at certain mines, blasting cannot always be restricted to general working hours and achieve compliance with blast level limits. This may be due to prevailing winds being less favourable during these periods.

CNA have consulted with the rural communities surrounding their operations and have found that generally the community support more flexibility in blast times. These communities are more reactive to dust from blasting and would prefer blasting to be undertaken earlier or later in the day where wind conditions are more suitable and less likely to carry dust.

The guidelines recommend that except for minor blasts such as for clearing of crushers and feed chutes, blasting should generally be limited to once per day. Blasting at the West Pit mine will occur more often, as it has previously with no limiting consequences as it is well removed from private residences. Other mining operations' blast schedules covered within the proposal (eg Carrington) will remain unchanged.

The guidelines recommend that when a temperature inversion is known to exist, blasting should be avoided if practical. These restrictions do not apply where the effects of blasting are not perceived at noise sensitive locations.

Under this proposal blasting operations at HVO will continue to be undertaken between the hours of 7:00 am to 6:00 pm. Monday to Saturday inclusive with no blasting undertaken on Sundays and public holidays. Across the operation several blasts may take place on any one day.

In addition to the above criteria, general best practice procedures can be used to effectively minimise noise impacts.

4 NOISE MODELLING

4.1 MODELLING SCENARIOS

To enable potential noise impacts to be assessed, the expected life and progression of each pit was examined to produce a timetable that indicated when each will be operating. Based on this timetable it was found that North Pit and the Alluvial Lands would cease operation as a mine in 2003, however, overburden dumping would continue in the Alluvial Lands up until Year 8 of the proposal. The Carrington operation will continue over a similar period and West Pit will operate for the full 21 years of the proposal. A total of six mine scenarios, which can be seen in *Annex C*, were then developed and modelled to cover all of these operations. The first five scenarios cover different years in the life of the proposal and the sixth provides an alternative scenario for Year 8 which includes both Carrington and the Alluvial Lands dumps still in operation. This is a highly unlikely and therefore conservative scenario as CNA anticipate that these activities are likely to cease by this time.

The mine plans present worst-case scenarios for the West Pit extension. This allows a conservative assessment to be made of potential impacts the proposal will have on the area surrounding the mine. The years modelled are Year 1, Year 3, Year 8, Year 14 and Year 20, calculated from an approval date in the first quarter of 2004. *Table 4.1* details the operations modelled in each scenario.

Table 4.1 Operations Modelled in Each Scenario

Proposal Year	West Pit	Carrington	Alluvial Lands dumps
Year 1	✓	✓	✓
Year 3	✓	✓	✓
Year 8	✓		
Year 8 (alternate)	✓	✓	✓
Year 14	✓		
Year 20	✓		

4.2 PLANT NOISE LEVELS

A comprehensive noise measurement procedure was used to obtain noise emission data for both fixed and mobile equipment specific to the proposal. All or most mobile plant modelled as part of this assessment were measured in operation at West Pit early in 2003. The representative noise emission levels used in modelling are summarised in *Table 4.2*. *Annex D* describes the measurement procedures used.

Typical equipment used during earth-moving and associated operations in the pit and overburden emplacement areas are listed in *Table 4.2*. Sound power levels shown in *Table 4.2* are indicative and are based on measurements at the existing West Pit and neighbouring activities as described earlier.

Table 4.2 Equipment Sound Power Levels

Typical Item	Representative $L_{eq,15minute}$ Sound Power Level, dB(A)
Haul truck (Komatsu 830E, 240t Leibherr, 190 CAT)	114
Large drill[1]	118
Medium drill[1]	118
Shovels (2800, 4100 and 5700)	118
Fuel truck	103
Lube truck	103
Water truck	116
Front end loader (L1400)	113
Dragline	114
Excavator	113
Dozer (Komatsu)	116
Dozer (CATD11)	110
Rubber tyred dozer (CAT 690D in low gear)	116
Grader	113
Scraper	110
Pump	113
Light plant	104
Cable reeler	115
CPPs and loading points	112
Conveyor	83 per linear meter

Notes 1. Drills will be required to achieve a sound power level of 114dB(A) beyond Year 14 mining operations in Mitchell Pit. This was adopted for Year 20 modelling purposes.
Refer to *Annex D* for spectral data used for noise modelling

4.3 MINING EQUIPMENT SCHEDULE

4.3.1 West Pit

The typical West Pit equipment schedules for the five modelled mining scenarios are described in *Table 4.3*. The specific type of plant used may vary, however, the associated sound emissions will be unchanged. It is relevant to note that the modelled Year 1 mine plan approximates current mining activities.

It should be noted that daytime and night time (including evening) operations vary and thus were modelled separately. More specifically, the main difference between day and night (plus evening) operations is the use of lighting plant at night and the cable operations during the day.

Table 4.3 West Pit - Typical Mining Equipment Schedule

Description	Proposal Year				
	Year 1	Year 3	Year 8	Year 14	Year 20
Loader	3	3	1	2	2
Excavator	0	0	0	3	3
Coal shovel	1	1	2	2	3
CAT cable reeler	1	1	1	1	1

Description	Proposal Year				
	Year 1	Year 3	Year 8	Year 14	Year 20
Coal haul to HVCPP	6	6	6	8	6
Coal haul to WPCPP	6	6	7	19	37
Diesel pump	4	4	4	4	0
Dragline	1	1	1	1	0
Drill	2	2	3	4	5
Dozer	5	6	6	10	10
Electric pump	9	9	8	8	0
Grader	2	2	2	4	5
Coal from WPCPP to NLP	6	6	6	6	6
Lighting plant	8	7	8	13	13
West Pit reject	1	1	1	1	1
Rubber tyred dozer	1	1	1	1	1
Scraper	1	1	1	0	1
Water truck	2	2	2	4	5
Waste truck	14	14	19	19	14
TOTAL	**73**	**73**	**79**	**110**	**113**

4.3.2 *Other Equipment – Carrington and Alluvial Lands*

As described earlier, the proposal comprises all operations at HVO north of the Hunter River. In addition to the equipment operating at West Pit described above, mining within Carrington and dumping within the Alluvial Lands area may occur concurrently. For modelling purposes, the overlap between these operations are during the Year 1 and 3, and possibly Year 8 of West Pit mining activities. *Table 4.4* summarises the equipment that are typically associated with Carrington and the Alluvial Lands areas. It should be noted that it is likely that these operations will cease from Year 8 onwards.

Table 4.4 Typical Mining Equipment Schedule – Carrington and Alluvial Lands

Item	Description	Proposal Year		
		Year 1	Year 3	Year 8
Alluvial Lands				
	Haul truck	5	5	5
	Haul truck	5	5	5
	Dozer	2	2	2
	Lighting plant	2	2	2
Total		**14**	**14**	**14**
Carrington				
	Dump trucks	19	21	21
	Water truck	2	2	2
	Scraper	2	2	2
	Grader	2	2	2
	Dozer	5	5	5
	Lube truck	1	1	1
	Large drill	1	1	1
	Fuel truck	1	1	1
	Front end loader	2	2	2
	Rubber tyred dozer	1	1	1
	Excavator/Shovel	3	3	3
	Medium drill	2	2	2
TOTAL		**41**	**43**	**43**

4.3.3 *Other Equipment – Additional Coal Transportation and Fixed Plant*

In addition to the mining and dumping operations described earlier, other coal transportation and processing activities exist that form part of the proposal. These were included in the noise model as on-going activities and are:

- coal truck haulage from south of the Hunter River to the HVCPP (17 haul trucks were dedicated to these activities);
- auxiliary coal haulage can occur intermittently using road trucks to transport coal between the HVCPP and HVLP and between the HVLP, to NLP and RCT (conservatively 8 trucks were dedicated to this activity);
- Belt Line Conveyor – this conveyor system spans several kilometres between the HVCPP and HVLP;
- conveyor from WPCPP to Bayswater Power Station;
- HVCPP and WPCPP; and
- HVLP, NLP and RCT.

5 PREDICTED NOISE LEVELS

5.1 SI WEATHER CONDITIONS

5.1.1 *Calculation Procedures*

The Environmental Noise Model (ENM) noise prediction software was used for modelling purposes. ENM takes into account distance, ground effect, atmospheric absorption and topographic detail. ENM is an EPA accepted noise prediction model as it gives consistently reliable predictions of environmental noise. Initial calculations were performed with no wind or temperature gradients, which are termed SI or calm conditions. Assumed night time air temperature and relative humidity were 10 °C and 80 % respectively. Noise levels during other conditions are discussed in *Section 5.2*.

The model incorporates three-dimensional digitised ground contours for the surrounding land and mine plans. Contours of the mine and overburden emplacement areas for each project stage were superimposed on surrounding base topography. Equipment was placed at various locations and heights, representing realistic operating conditions throughout the life of the mine. These locations were chosen to represent operations for each period and represent worst case situations.

The noise model predicts L_{eq} noise levels, based on equipment sound power levels determined from measurements conducted at the existing operations as detailed in *Annex E.* The results assume all plant and equipment operate simultaneously. In practice, such an operating scenario would be unlikely to occur. The results are therefore considered conservative.

5.1.2 *Results*

Table 5.1 summarises noise modelling results for SI (calm weather) conditions. A selected set of calm weather noise contours are presented graphically in *Figure 5.1* to *Figure 5.3* . These are Year 1, Year 8 (including Carrington and Alluvial Lands) and All Years (1 to 20) respectively. The results demonstrated that there was no difference in noise between day and night (and evening) operations. This is not unexpected as the equipment fleet is similar in all these operating periods (generally only lighting plant are excluded from daytime operations).

For private residences not inside a zone of affectation or subject to a private land holders agreement (Property Nos. 1 to 6), the highest modelled noise level corresponds to Year 8 of the proposal, where equipment numbers are highest at West Pit and Carrington, with the main contributor being Carrington.

It is clear from *Table 5.1* that daytime and night time mine operations will satisfy EPA noise goals during calm weather conditions at all private residences not already within a zone of affectation.

Of the private residences currently inside a zone of affectation modelled noise levels at Property No's 9, 10 and 12 are predicted to exceed EPA goals.

As described earlier, Year 1 operations are similar to current activities. The results in *Table 5.1* demonstrate that only marginal (less than 3 dB) increases are likely for assessed locations and generally these increases are not perceptible (less than 2 dB). This is evident when comparing Year 1 results with those of subsequent years.

Table 5.1 ***$L_{eq,15minute}$ Noise Under SI Meteorology, dB (A)***

Location	Day, Evening and Night Time						Intrusiveness Noise Criteria	
Property No.	**Year 1**	**Year 3**	**Year 8**		**Year 14**	**Year 20**	**Day**	**Night**
			Carrington & Alluvial Lands	**Likely Scenario**				
1	18	17	19	17	18	18	38	36
2	21	21	22	18	19	19	36	36
3	22	22	22	18	19	19	36	36
4	26	26	27	21	21	21	36	36
5	19	19	20	19	18	18	36	36
6	17	17	19	18	16	16	36	36
7[2]	31	31	31	29	29	29	37	37
8[2]	36	36	37	34	34	34	40	38
9[1]	44	44	44	30	32	37	38	38
10[1]	39	39	39	30	30	36	38	38
11[1]	27	27	27	22	21	24	39	38
12[1]	42	42	42	40	40	40	44	37

1. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
2. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.

5.2 *PREDICTED NOISE LEVELS - PREVAILING WEATHER CONDITIONS*

Under various wind and temperature gradient conditions, noise levels may increase or decrease compared with SI conditions (ie zero wind and negligible temperature gradient). This is due to refraction of sound propagating through the atmosphere, brought about by a change in sound speed with height. Sound levels increase when the wind blows from source to receiver or under temperature inversion conditions, and decrease when the wind blows from receiver to source or under temperature lapse conditions.

The intrusiveness noise criterion has traditionally been applied under SI conditions, as described in *Section 3.1*. Experience indicates that if the criterion is met under SI conditions, higher noise under prevailing meteorology is generally acceptable. This is because the ambient noise at properties also increases during such weather conditions and mine noise is masked (for example, wind induced vegetation noise).

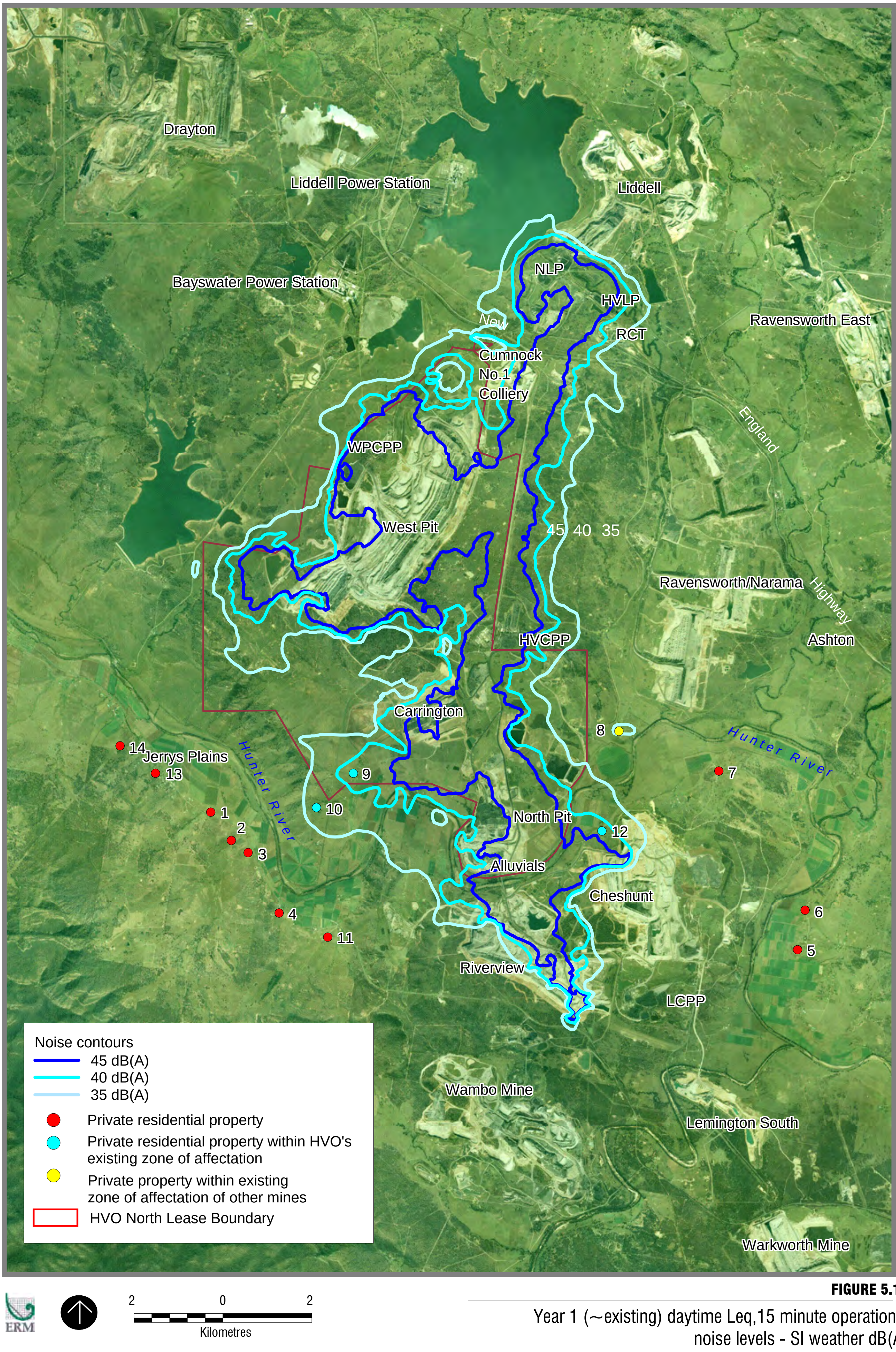


FIGURE 5.1

Year 1 (~existing) daytime Leq,15 minute operational noise levels - SI weather dB(A)

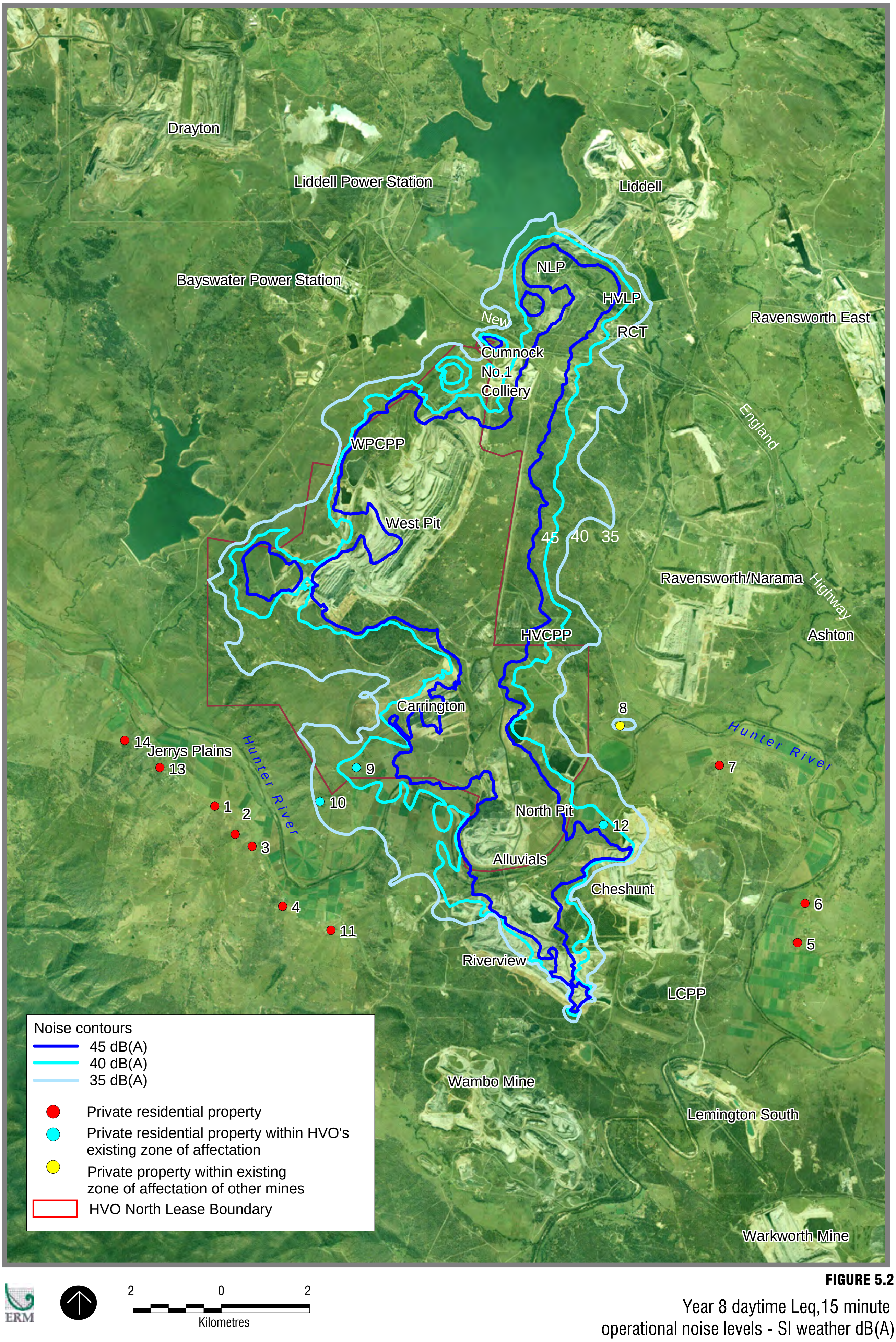
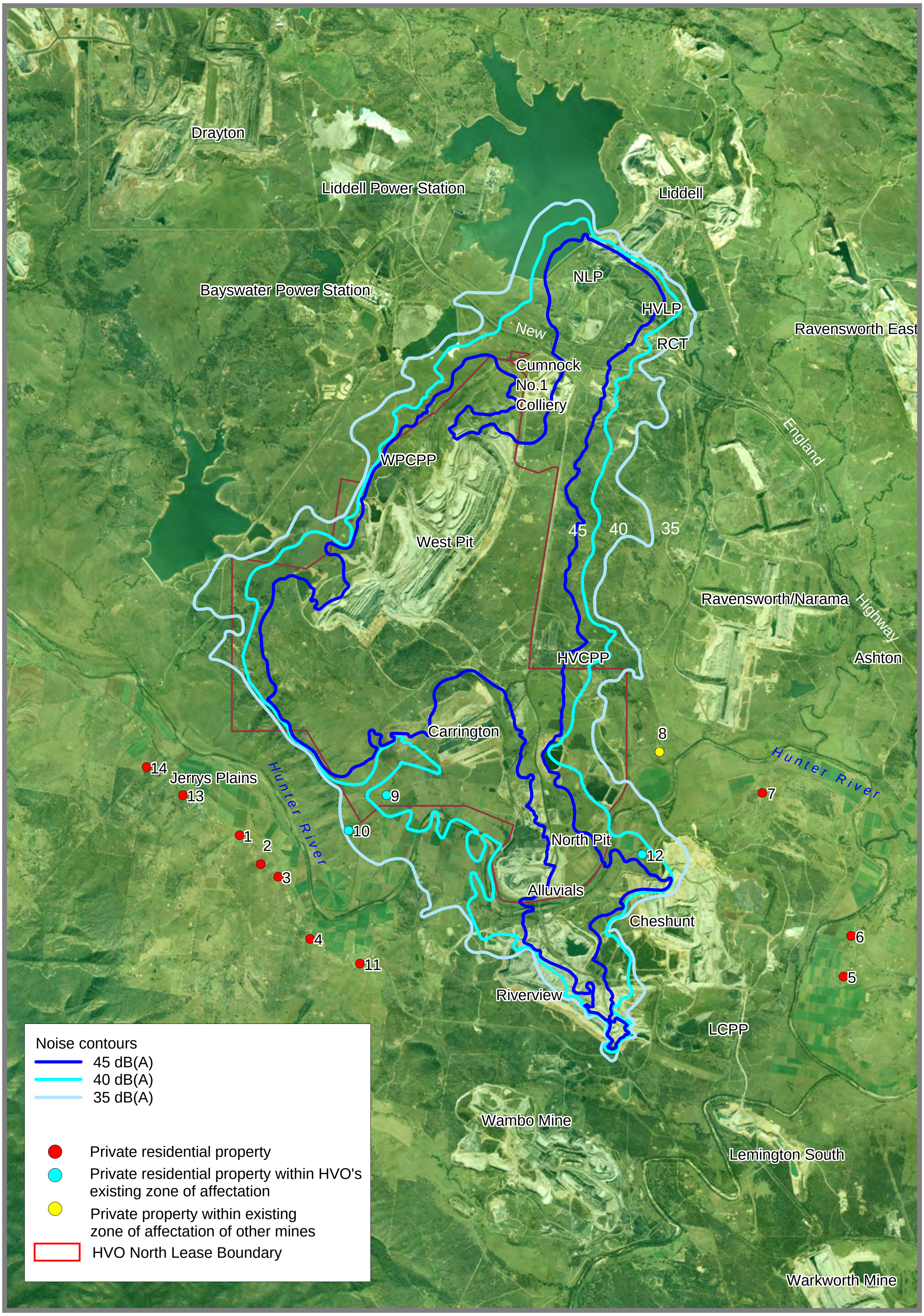


FIGURE 5.2

Year 8 daytime Leq,15 minute operational noise levels - SI weather dB(A)



ERM

2 0 2

Kilometres

FIGURE 5.3

All years daytime Leq,15 minute operational noise levels - SI weather dB(A)

Based on experience throughout the Hunter Valley, people become more noise sensitive if night time levels exceed approximately 40 dB(A) on a regular basis. This is 5 dB above the minimum level that would be traditionally set under SI conditions.

The INP sets out recommended procedures to assess noise under a range of meteorological conditions. Specific adverse meteorological conditions are applied which should be used in assessment (in lieu of monitored data) and the intrusiveness criteria are applied under these conditions.

5.2.1 Discussion Of Results

Intrusiveness

For private residences, *Table 5.2* and *Figures 5.4 to 5.9* indicates that noise levels for INP winds will generally be within or marginally (up to 3 dB) higher than the EPA's intrusiveness goal (which is as low as 36 dB(A) depending on the receiver location's background noise). The exceptions are residences in the vicinity of Property Nos. 1 and 4 where winds cause enhanced noise for these locations during either earlier (for Property No. 1) and later (for Property No. 4) mine operations. The combined worst case noise levels over the life of the project for the region are shown in *Figure 5.10.* A comparison between the modelled wind affected and the SI results (*Table 5.1)* demonstrates an increase of up to 23 dB for these properties under weather enhanced conditions.

The highest difference between calm and adverse weather is predicted for Jerrys Plains residences during latter mining operations. The major noise source to Jerrys Plains during this stage of the Proposal is operations at the Mitchell Pit. There exists a significant ridge (spanning several kilometres and up to 200m above sea level) between Mitchell Pit and these residences. This ridge is the reason the ENM software models such an enhancement between calm (SI) and adverse wind results. Previous field validation by ERM of the ENM software results, has demonstrated that ENM can over predict noise levels by at least 3 dB under wind enhanced conditions. Where significant topography exists such as the aforementioned ridge, the ENM over-predictions are likely to be more than 3dB. In practice, an increase of 23 dB for Jerrys Plains is considered unlikely. Additionally, the modelling assumes simultaneous operations of all equipment.

The background noise at properties is also expected to rise during such adverse wind conditions due to wind induced vegetation noise and other mining or industrial activities. These will assist in masking noise from the Proposal.

Table 5.2 Noise for INP Weather - Night

Location	Predicted $L_{eq,15\ minute}$ Noise Level, dB(A)									
Property No.	**Year 1**	**Year 3**	**Year 8**		**Year 14**	**Year 20**	**Noise Level Criteria, dB(A)**			**Likely Night Time Mine L_{eq} Noise Acquisition Goal, dB(A)**
							Intrusiveness $L_{eq,15minute}$		**Amenity Leq,9h**	
			Carrington & Alluvial Lands	**Likely Scenario**			**Day**	**Night**	**Night**	
1	38	37	38	35	38	41	38	36	40	41
2	38	38	39	34	36	38	36	36	40	41
3	38	38	39	34	36	37	36	36	40	41
4	40	40	41	34	34	35	36	36	40	41
5	29	29	30	28	27	27	36	36	40	41
6	29	29	30	27	26	27	36	36	40	41
7[2]	40	40	40	36	36	37	37	37	38	42
8[2]	**46**	**46**	**46**	42	42	42	40	38	38	43
9[1]	**54**	**54**	**54**	40	42	**46**	36	36	40	41
10[1]	**48**	**48**	**48**	39	40	42	38	38	40	43
11[1]	39	39	39	34	35	35	39	38	37	43
12[1]	**53**	**53**	**53**	**52**	**52**	**52**	44	37	40	42
13[3]	-	-	-	-	-	41	38	36	40	41
14[3]	-	-	-	-	-	41	38	36	40	41

1. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
2. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
3. Additional Jerrys Plains Assessment locations were added for Year 20 as noise contours extended further west than other years.

Bold numbers indicate exceedance of possible acquisition goals.

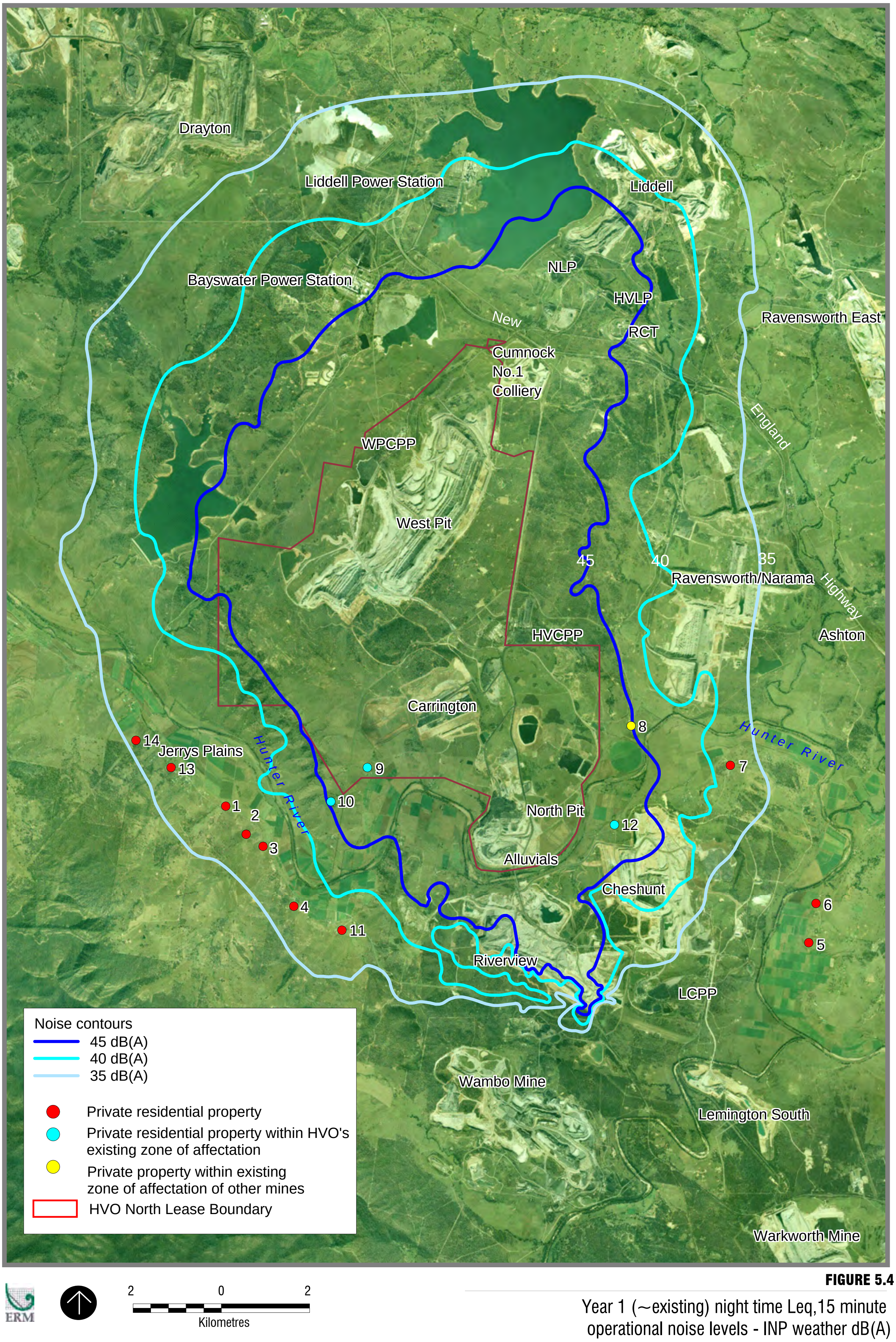
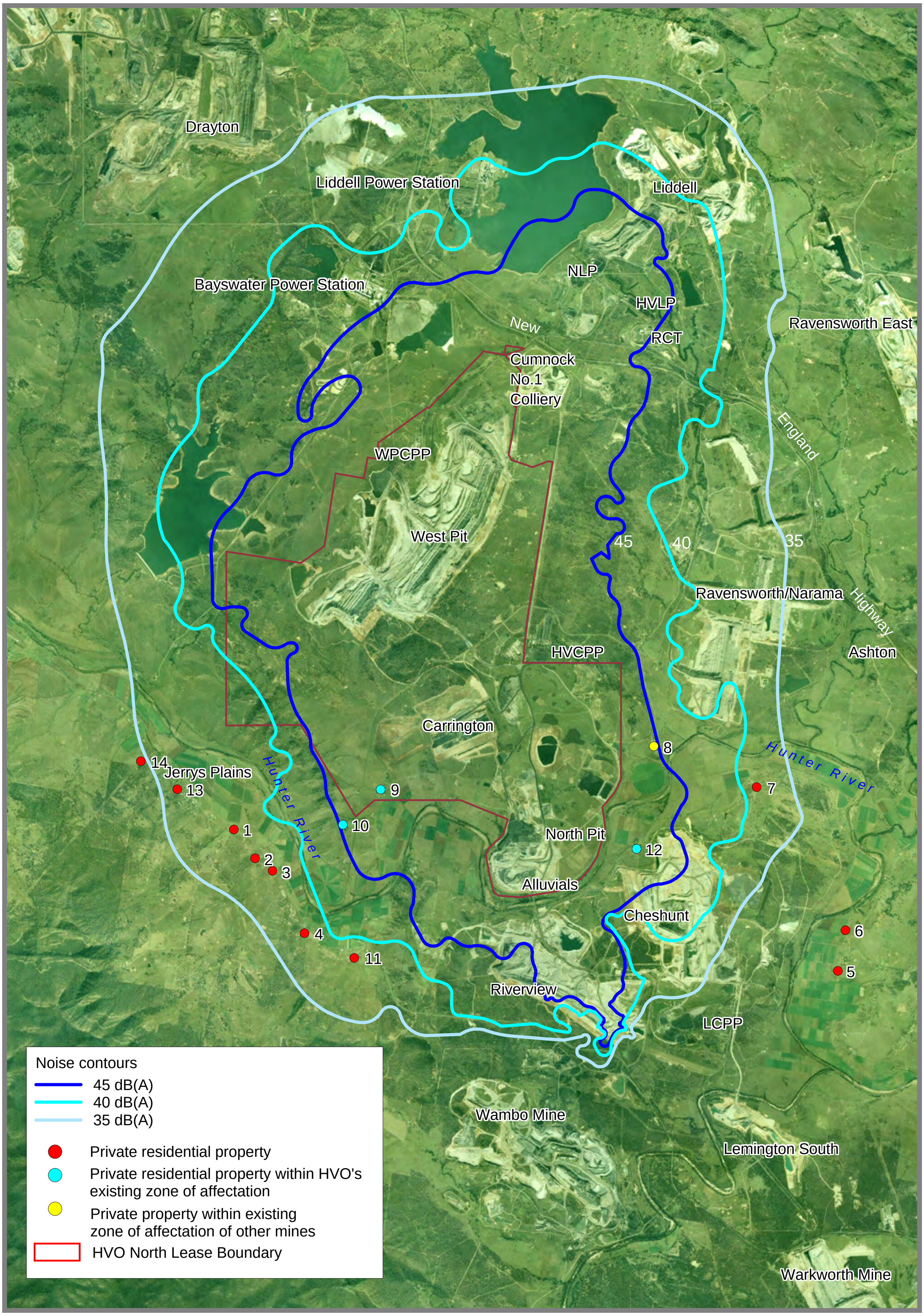


FIGURE 5.4

Year 1 (~existing) night time Leq,15 minute operational noise levels - INP weather dB(A)



ERM

2 0 2

Kilometres

FIGURE 5.5

Year 3 night time Leq,15 minute operational noise levels - INP weather dB(A)

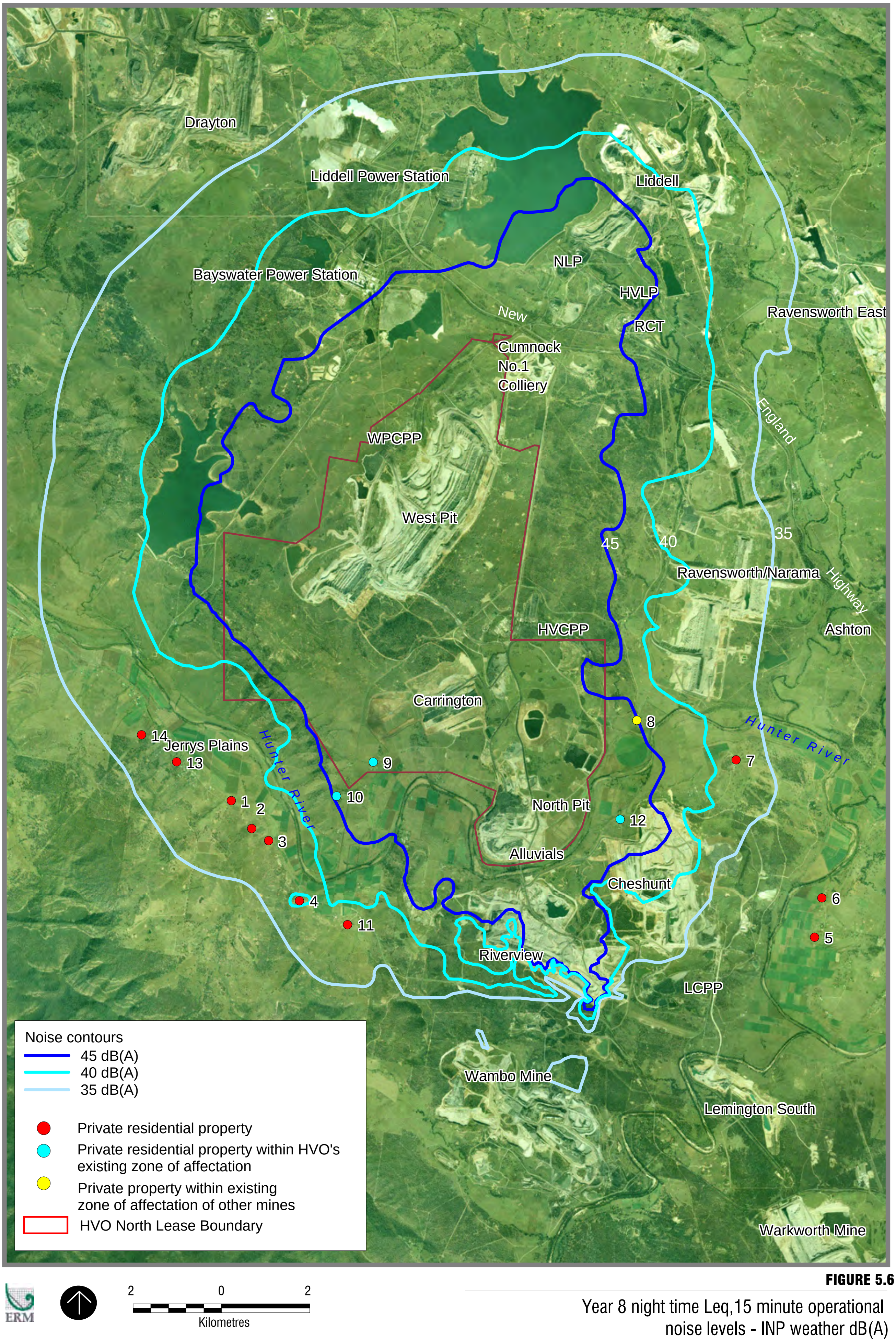


FIGURE 5.6

Year 8 night time Leq,15 minute operational noise levels - INP weather dB(A)

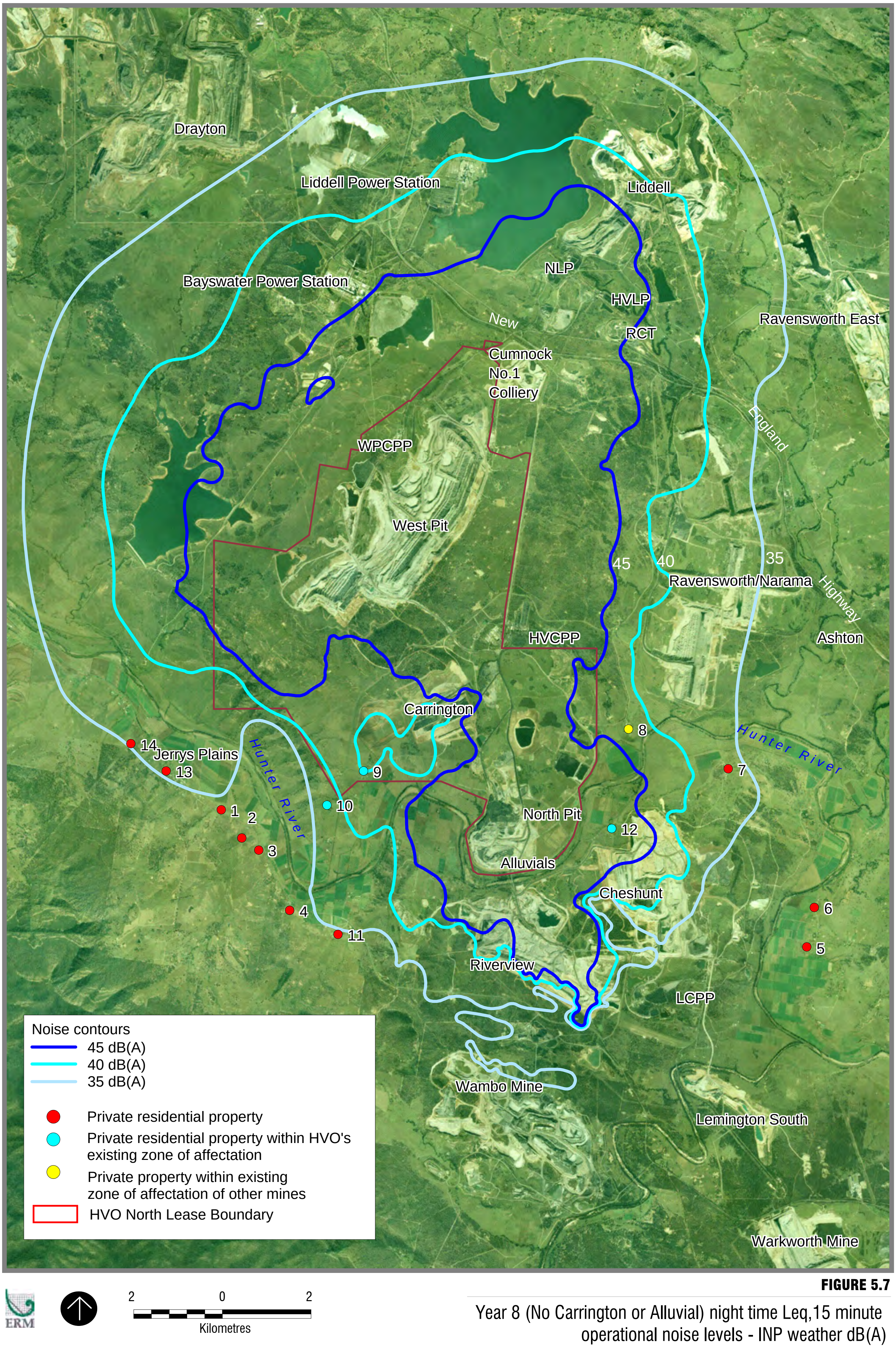
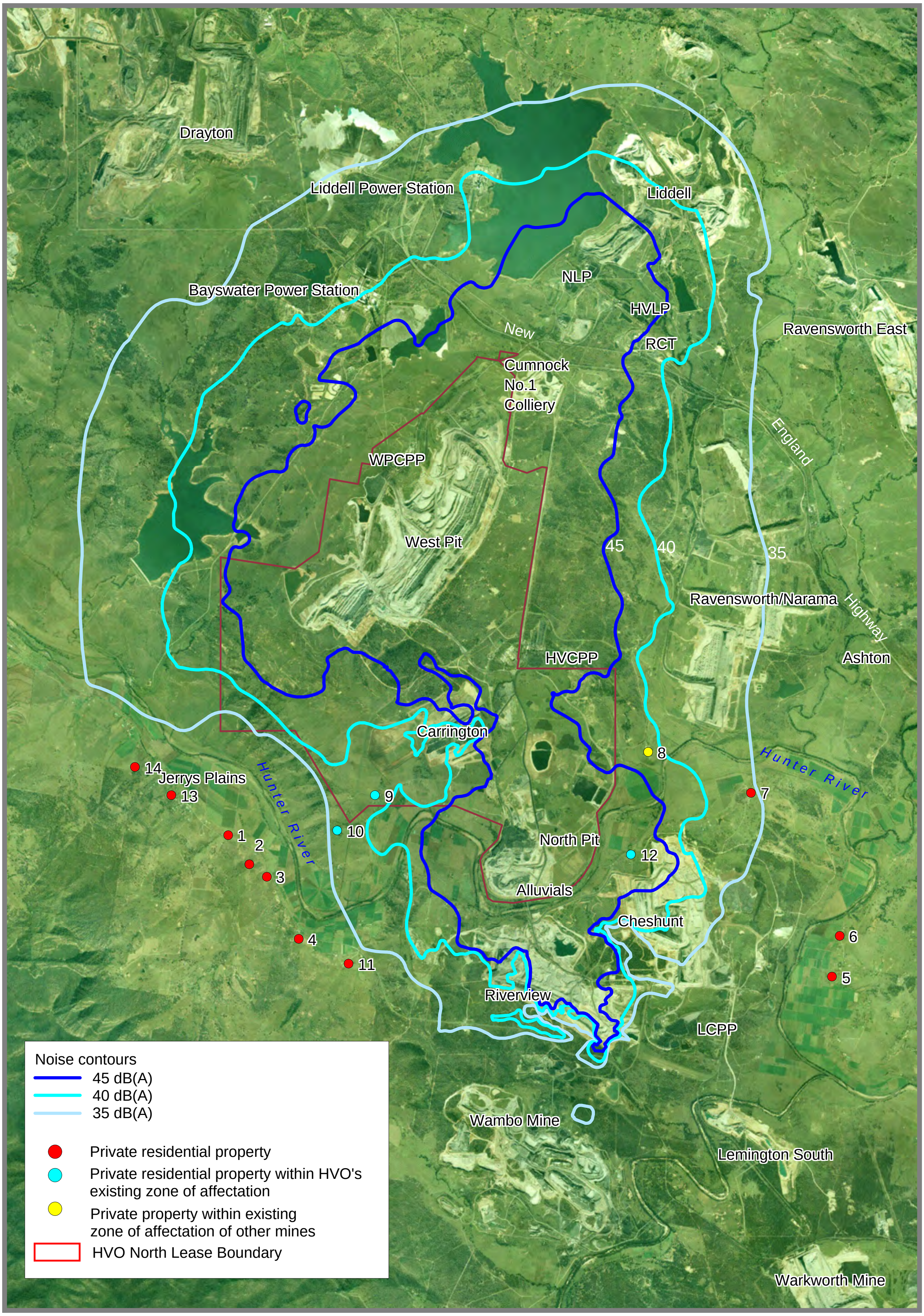


FIGURE 5.7

Year 8 (No Carrington or Alluvial) night time Leq,15 minute operational noise levels - INP weather dB(A)



ERM

2 0 2

Kilometres

FIGURE 5.8

Year 14 night time Leq,15 minute operational noise levels - INP weather dB(A)

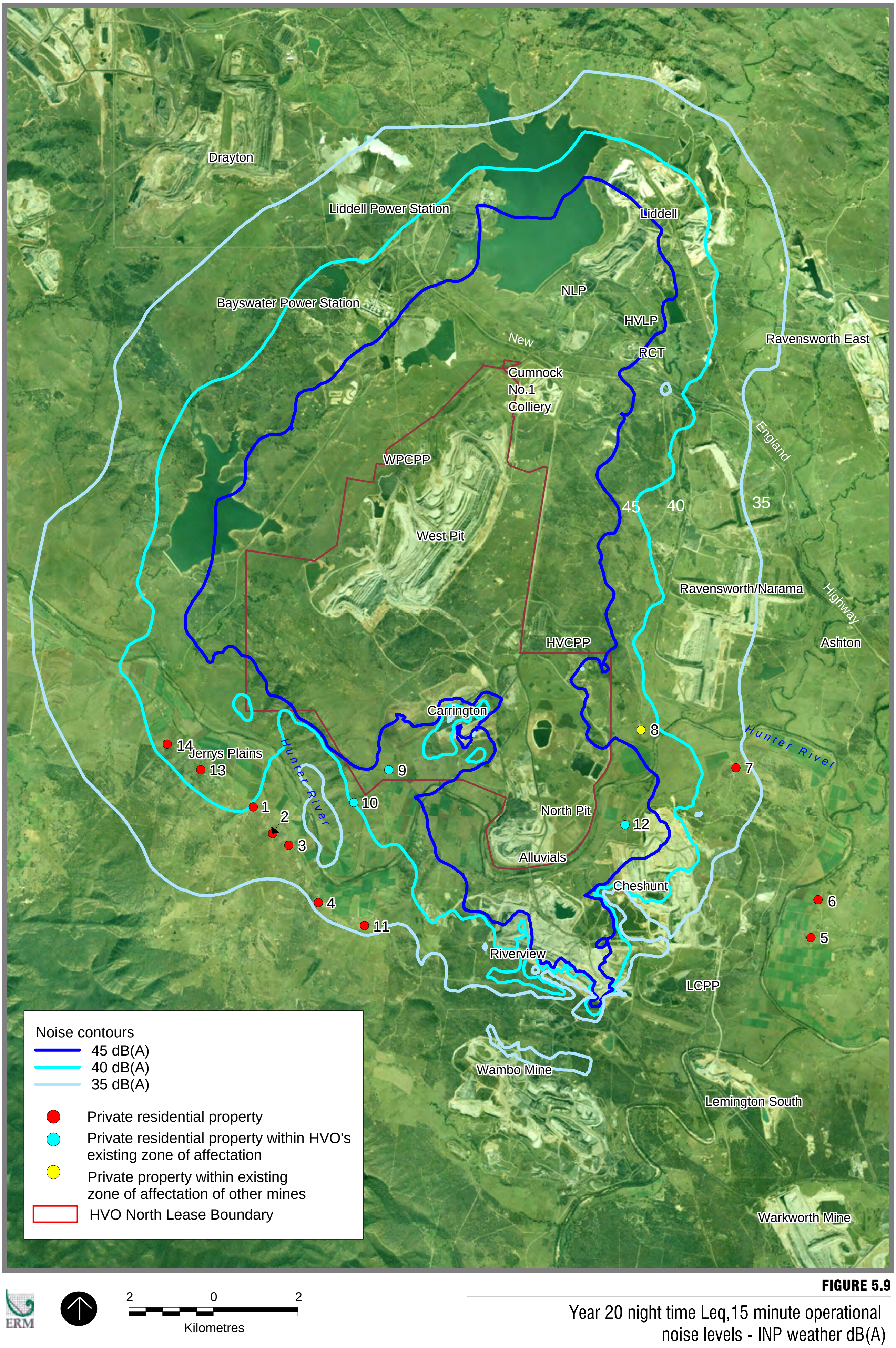


FIGURE 5.9

Year 20 night time Leq,15 minute operational noise levels - INP weather dB(A)

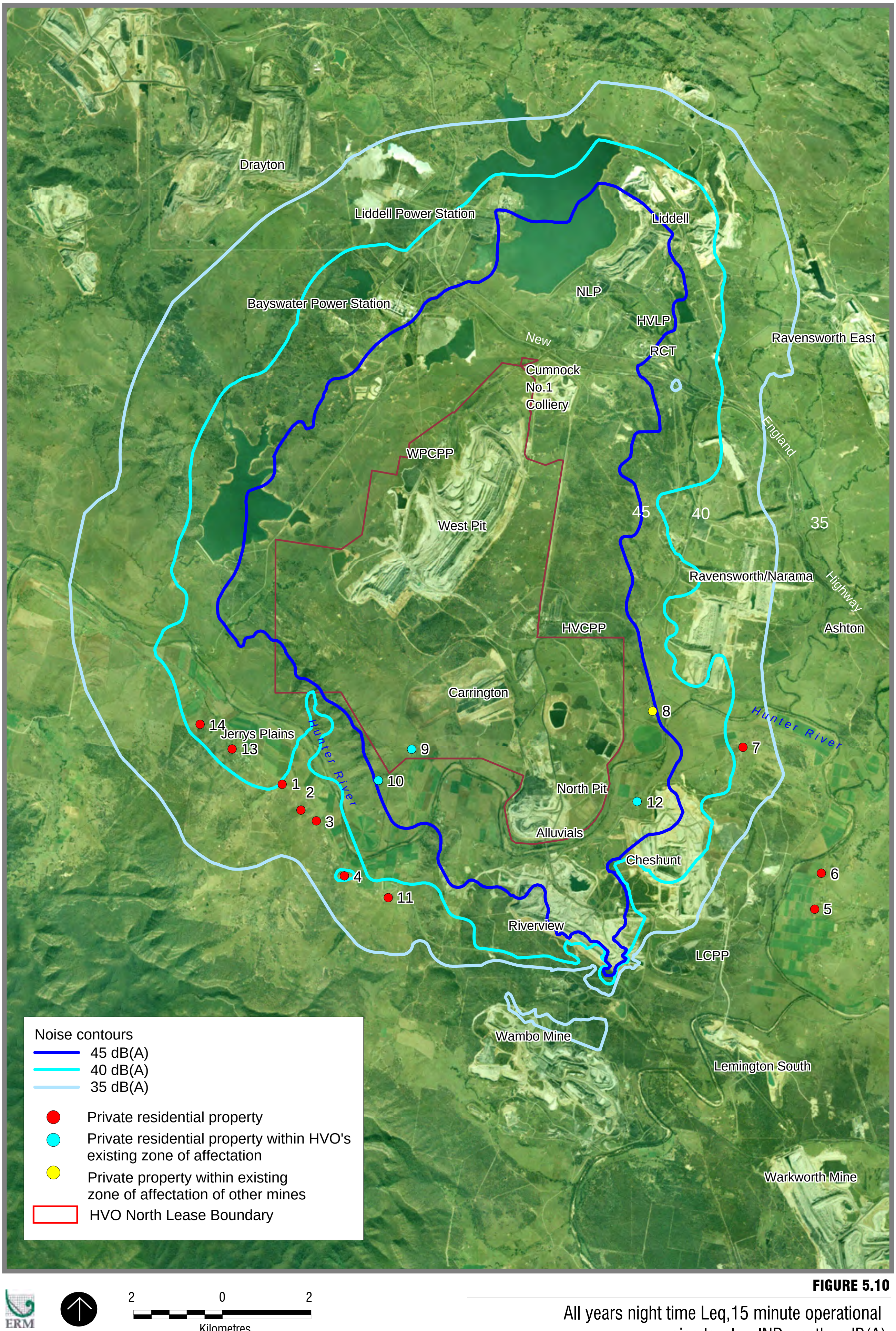


FIGURE 5.10

All years night time Leq,15 minute operational noise levels - INP weather dB(A)

Amenity

Table 5.2 shows that Property Nos. 7 through 12 are predicted to receive noise levels above the project specific amenity target under weather enhanced conditions, however for Property Nos. 7 and 11, the exceedances are marginal and generally not perceptible (that is they are 2 dB or less).

Taking into account the expected 3dB difference between $L_{eq,15minute}$ and $L_{eq,period}$ noise levels explained in *Section 3.2* these predicted noise levels are reduced to within the amenity target for all private residences. Private residences currently inside a zone of affectation or subject to a private land holders agreement are predicted to receive noise levels above the project specific amenity targets.

Assessing the noise predictions shown in *Table 5.2* against corresponding night time acquisition goals shown in *Section 3.2* shows that all private residences not currently within a zone of affectation are at or below this level.

Of the properties that are within a current zone of affectation or subject to a private land holders agreement, Property Nos. 8, 9, 10 and 12 are predicted to exceed likely noise acquisition targets.

It should be noted that noise assessment location No. 4 is representative of dwellings situated on localised elevated ground (eg Muller residence). The noise contours do not reflect the Year 8 tabulated result at this location for this reason.

The wind conditions in *Table 2.5* and a 3 °C/100 m temperature inversion were modelled separately and the highest resulting noise level for each location is presented in *Table 5.2*. These results are also presented graphically as noise contours that incorporate all assessable INP weather conditions (ie SI and INP weather for night time operations.

For Property Nos. 7 to 12, the Year 1 model results demonstrate good correlation with monitoring data for 2002 (refer *Table 2.3*), with the exception of Property No. 9. The model is typically 1 to 4 dB more conservative than monitoring data for these locations, however it is at least 9 dB too conservative for Property No. 9. For residences in the vicinity of Property Nos. 1 to 4, the model is highly conservative. For Maison Dieu locations (Property Nos. 5 and 6) the model is within 2 dB of monitoring data at times. It should be noted that whilst this does provide some degree of certainty, the model results are for specific worst case assessable INP weather conditions and the monitoring conditions are likely to have varied from these conditions.

5.3 *SLEEP DISTURBANCE*

There is a potential for sleep of residents to be disturbed by transient noise such as shovel gates banging, bulldozer track plates, truck engine at fast revving and vehicle reversing alarms. *Table 5.3* presents noise levels for the noisiest of these sources measured by ERM for previous projects.

Table 5.3 Maximum Transient Noise

Noise Source	Measured L_{max} Noise Level, dB(A)	Distance from Source (metres)
Shovel gate banging	60	400
Bulldozer with reversing alarm	69	80

A single truck movement may cause sleep disturbance, particularly if it is isolated from other mine-related noise. From the model results, it was determined that for most cases, truck movements would give higher noise levels at residences than the events listed in *Table 5.3*. The maximum sound power level (L_{Wmax}) of haul trucks was measured at up to 125 dB(A).

Maximum noise levels were calculated under INP wind conditions for each location and each operational scenario. *Table 5.4* shows calculated maximum noise levels from the highest ranked source for a given residence. This is based on the typical equipment locations used for mining operations and corresponds to the maximum sound power level for the particular item of plant (generally that for a truck or 125 dB(A)). Calculations were for a single event, rather than the simultaneous operation of a number of plant items because the values given are instantaneous maxima and such events are not expected simultaneously. The Year 8 predictions conservatively assume that Carrington and the Alluvial Lands dumps are operational. The criteria used to assess sleep disturbance are based on the EPA's background plus 15 dB for the $L_{1,1min}$ noise level (which in this case is conservatively approximated by the maximum noise level (L_{max})).

Table 5.4 demonstrates that calculated noise levels under prevailing weather conditions are within the EPA's conservative sleep disturbance criterion at all private residences not currently within a zone of affectation. Property Nos. 9, and 12 are likely to experience noise levels above the EPA's sleep disturbance goal. For Property No. 9, this is attributed to operations at Carrington, and for Property No. 12, this is associated with truck haulage operations. Both Property Nos. 9 and 12 are currently inside a zone of affectation.

Table 5.4 Sleep Disturbance Impact – INP Weather

Location	External L_{max} Noise Level From On-Site Plant, dB(A)					$L_{1,1min}$ Criteria, dB(A)
Property No.	Year 1	Year 3	Year 8	Year 14	Year 20	
1	34	35	35	33	39	46
2	36	36	36	33	37	46
3	37	36	36	32	34	46
4	35	35	35	34	34	46
5	28	28	28	28	28	46
6	28	28	28	27	27	46
7[2]	40	40	40	40	40	47
8[2]	46	46	46	46	46	48
9[1]	**51**	**49**	**49**	43	41	46
10[1]	46	47	43	37	37	48
11[1]	39	39	39	34	34	48
12[1]	**60**	**60**	**60**	**60**	**60**	47

1. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
2. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.

Bold numbers indicate exceedance of sleep disturbance goals.

5.4 *CUMULATIVE NOISE ASSESSMENT*

Adjoining industrial activity also influences the noise climate at residences potentially exposed to the proposal. However, for most residences this is limited as the proposal constitutes the main contributor of industrial noise. Other industrial operations of significance are Riverview and Cheshunt Pits, Wambo, Ravensworth-Narama and Ashton Coal Mine.

Noise from surrounding mines was sourced from the following documents:

- an EIS produced by Resource Strategies Pty Limited in June 2003 for the Wambo Development Project;
- an SEE produced by ERM Australia Pty Limited in November 2001 for a Section 96(2) modification of development consent at HVO;
- an EIS produced by ERM Mitchell McCotter in August 1997 for the extension of mining operations at Ravensworth-Narama; and
- an EIS produced by HLA-Envirosciences Pty Limited in November 2001 for the Ashton Coal Project.

The aforementioned documents provide predicted L_{10} or L_{eq} noise levels for calm and adverse weather. For the purposes of this cumulative assessment, the following was adopted:

- For the Wambo project, the L_{eq} predicted noise levels enhanced under south easterly winds were used as those present the worst case impact on the private residences being addressed. It is assumed that operations extend to 2017 or Year 14 of the subject Proposal.

- For HVO south of the Hunter River, the predicted noise levels were presented as L_{10}, and additionally weather effects were predicted through statistically determining the frequency of occurrence of particular noise levels. These levels presented in the SEE are the 90th percentile point in that occurrence frequency set. These have been used as L_{eq} weather enhanced results in this assessment.

- For Ravensworth-Narama the predictions under a 3 °C/100 m temperature inversion were adopted. This is considered more appropriate than say winds in a given direction, given the relative locations of residences potentially affected by the Proposal and Ravensworth-Narama. That is, winds that enhance noise from one mine will not enhance noise from the other at the same residential location.

- For the Ashton Coal Project, the predicted results for temperature inversions were used. These range from 31 dB(A) to 35 dB(A) Leq for potentially the most exposed Maison Dieu residence for various operating scenarios. However, a timeline breakdown is not provided hence the upper level of the range was adopted for the cumulative assessment.

The cumulative noise from these operations was added to the results for worst case INP weather from the proposal. This is a conservative approach as, for example, a south easterly wind that may enhance noise from Wambo will not equally enhance noise from the proposal. Nonetheless, this approach does provide a crude method of assessing cumulative noise during prevailing weather.

5.4.1 *Cumulative Noise Impact*

Table 5.5 summarises the cumulative noise effects of surrounding mines and related infrastructure. The percentage values in the parenthesis indicate the proposal's contribution (in noise terms) at that residence. The results are for prevailing weather conditions as described earlier and are therefore conservative. It should be noted that based on the information provided in corresponding EIS's, both Wambo and Ravensworth/Narama mines will cease operations in 2016 (year 14) and 2007 (year 4) respectively. However, the Ravensworth Narama mine was presumed to operate until 2012 (year 8) for assessment purposes. The predicted noise from these operations were therefore cumulative assessed accordingly. From beyond year 14, noise is attributed to the proposal, Ashton and HVO south of the Hunter River.

Table 5.5 Cumulative Night-time L_{eq} Noise Levels at Properties

Location	Proposal Year				
Property No.	Year 1	Year 3	Year 8	Year 14	Year 20
	Cumulative Noise Level (Proposal contribution), dB(A)				
1	39 (79%)	38 (79%)	39 (79%)	39 (79%)	41 (95%)
2	40 (63%)	40 (63%)	40 (79%)	39 (50%)	39 (79%)
3	40 (63%)	40 (63%)	41 (63%)	39 (50%)	39 (60%)
4	42 (63%)	43 (50%)	43 (63%)	39 (32%)	40 (28%)
5	40 (8%)	41 (6%)	40 (10%)	38 (8%)	38 (9%)
6	40 (8%)	41 (6%)	40 (10%)	37 (8%)	37 (9%)
7[2]	43 (50%)	43 (50%)	42 (63%)	37 (79%)	39 (56%)
8[2]	**48 (63%)**	**48 (63%)**	**48 (63%)**	43 (79%)	**46 (43%)**
9[1]	**54 (100%)**	**54 (100%)**	**54 (100%)**	43 (79%)	**47 (76%)**
10[1]	**48 (100%)**	**48 (100%)**	**48 (100%)**	42 (63%)	44 (62%)
11[1]	43 (40%)	**45 (25%)**	42 (50%)	40 (32%)	40 (30%)
12[1]	**57 (40%)**	**56 (50%)**	**54 (79%)**	**52 (100%)**	**52 (98%)**

1. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
2. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
3. Numbers in bold indicates levels above EPA night amenity goals (applying an expected minimum 3dB correction for $L_{eq,15minute}$ vs $L_{eq,9hour}$ noise levels)

   The Year 8 results assume Carrington and Alluvial Lands areas are operating
   Bold numbers indicate exceedance of possible acquisition goals

Applying a night time cumulative noise criterion equivalent to the EPA's night time amenity goal of 40 dB(A) $L_{eq,9hour}$, applicable for a rural residence according to the INP, shows that all private residences not currently within a zone of affectation will be within or marginally (not more than 3 dB) above the EPA's amenity goal. As discussed earlier, the predictions above are based on a worst case $L_{eq,15minute}$ noise level from each operation. Adopting a conservative 3 dB correction that is expected between the predicted worst case $L_{eq,15minute}$ and $L_{eq,9hour}$ noise level, implies that noise levels at these private residences are predicted to be below the EPA's amenity goal. This correction is due to the inherent downtime of plant over the 9 hour night-time period as compared with a worst case 15-minute noise emission level. It should be noted that this 3 dB intrusiveness to amenity correction has not been applied to any results.

Private residences predicted to experience cumulative noise above the EPA criterion are Property Nos. Nos. 8 to 12. These properties are currently inside a zone of affectation or subject to a private land holders agreement. The proposal's contribution to these exceedances is displayed in percentage terms in *Table 5.5*.

5.5 *OTHER NOISE EMISSIONS*

5.5.1 *Construction Activities*

Construction activities will be confined to:

- the upgrade of sections of the haul route between the HVLP, NLP and RCT;
- works associated with the intermittent transfer of heavy equipment across the Hunter River;
- upgrading of the Belt Line Conveyor;
- upgrading of the HVCPP to increase its washing capacity to 20 Mtpa;
- construction of a new conveyor between HVO south of the Hunter River and the HVCPP (only if feasible); and
- construction of a new conveyor linking the HVLP and NLP (only if feasible).

The works above are well removed from private residences and there will be no significant construction activities that are likely to add to received noise levels (from mining operations) at residences.

5.5.2 *Road Traffic Noise*

The existing staff numbers and shift times are not expected to change significantly as a result of the proposal. The traffic assessment presented in the EIS indicates an increase of between 0.9 and 11.9 % in daily staff traffic volumes. In noise terms this equates to an increase of up to 0.5 dB. Such an increase will not be perceptible in practice. Hence no road traffic noise impact is anticipated.

5.5.3 *Rail Traffic Noise*

The proposal will not result in any net increase in rail traffic, on the main northern railway line, over and above that which is currently approved. When coal production rates increase at one CPP, it will reduce equally at another. This will essentially result in a balance of coal related rail traffic operations, with no net change anticipated. The increase sought in throughput for the HVCPP will not exceed current coal loader consent conditions.

6 BLASTING NOISE AND VIBRATION

The proposal has two mining areas where blasting will occur. These are Carrington and West Pit. The Carrington Mine EIS prepared by ERM Mitchell McCotter Pty Limited in May 1999 provides a detailed noise and vibration assessment for blasts within Carrington. The assessment concludes that no blast overpressure and vibration exceedances are likely for any residence other than Dallas. This was demonstrated using formulae derived from site specific data obtained from various Hunter Valley mines, including a validation of data collected at Carrington. The blast operations within Carrington will not change due to the proposal, and hence the 1999 EIS assessment remains valid.

In respect of the West Pit extension, new blast areas are proposed. A schedule of blast locations for each mining stage was provided to ERM by CNA. The minimum separation distance between such blast locations and assessment locations are summarised in *Table 6.1*. The closest and therefore potentially most affected residence to such blast locations is Property No. 9, which is approximately 1.8 km away from potential blasts in the latter most stages of the Proposal (ie, Mitchell Pit blasts in Year 20).

Table 6.1 Blast Locations

Location Property No.	Minimum Blast Separation Distance, m
1	3,104
2	3,331
3	3,472
4	5,630
5	11,541
6	11,021
7[2]	7,353
8[2]	5,116
9[1]	3,298 prior Year 14 2,844 Year 14 1,810 in Year 20
10[1]	4,297 prior Year 14 3,400 Year 14 2,258 in Year 20
11[1]	6,445
12[1]	6,576

1. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
2. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.

The blast design, and hence corresponding air blast overpressure and ground vibration, is within the control of operators. The site's existing blast management procedures will be used to ensure appropriate charge masses are used for blasting. Such charge masses (or maximum instantaneous charge, MIC) are presented in *Table 6.2*. These were derived from 95 % formulae in

Blastronics Pty Limited publication for monitoring data collected at similar mines in the area.

Table 6.2 Blasting Assessment

Blast to Location Distance, m	MIC_{8ms} to Satisfy ANZECC 95 % Overpressure Limit of 115 dB(Lin), kg	MIC_{8ms} to Satisfy ANZECC 95% Ground Vibration Limit of 5 mm/s (ppv), kg
1,500	163	745
2,000	386	1,324
2,500	753	2,069
3,000	1,302	2,980
4,000	3,088	5,299
5,000	6,031	8,279
6,000	10,422	11,922

Notes: 1. These results are derived from equations contained in the Drill and Blast Study, Mount Pleasant prepared by Blastronics Pty Limited for CNA in September 1994

2. In general, blastover pressure considerations limit MIC

The highest MIC that could be used in the West Pit extension is unlikely to exceed approximately 3,000 kg. Given that most residences are more than 3 km from blast locations, blast ground vibration impacts from the West Pit extension are unlikely. The exceptions are Property Nos. 9 and 10 where blast activities proposed for the latter stages of mining in the south western most areas of West Pit (formerly Mitchell Pit) may be closer. This is demonstrated in mining footprints for Year 14 and Year 20. In terms of blast overpressure noise, if 3,000 kg MIC is used, the formulae suggest most residences are unlikely to experience impacts. The exceptions again are Properties Nos. 9 and 10, during the latter stages of operations in the Mitchell Pit. For blasts closest to Property Nos. 9 and 10 (for example, blasting in the Mitchell Pit in Year 14 and beyond), a lower MIC should be deployed and monitored at these locations.

Blasting will occur between the hours of 7.00 am to 6.00 pm. This will provide the mine with flexibility to blast during meteorological conditions that will result in the least impact on its neighbours. Typically, the proposal will be conducting blasting operations more than once a day. All blasts will be monitored for overpressure noise and ground vibration at several locations.

7 *NOISE MANAGEMENT*

As discussed earlier, the proposal includes the consolidation of consents for HVO north of the Hunter River. This consolidation provides the opportunity for improved operational management and therefore improved environmental control over a large source of industrial noise. It will be a significant and positive step toward noise management, which also provides operational flexibility. In addition, a detailed noise management procedure (including monitoring) exists for the proposal and will be used to reduce impacts further. Features of the noise monitoring program includes attended as well as unattended monitoring in specified locations and operating conditions.

Permanent real time noise monitors are to be established at locations surrounding HVO north of the Hunter River. These monitors will consist of either directional or non-directional real time noise monitors. All stations have frequency filtering capabilities to enable mine related noise to be identified from other background noise sources such as insects.

The establishment of real time noise monitors will provide accurate and reliable noise data to key personnel instantaneously. This will be a proactive management tool that will allow ameliorative measures to be undertaken to prevent the occurrence of potential noise impacts.

8 *CONCLUSION*

This study considers the potential noise impacts of the proposal, which incorporates all of HVO north of the Hunter River. The acoustic assessment includes modelling of all major mining equipment at representative operational locations. The study had the following features:

- long term ambient noise survey at five representative locations in accordance with the EPA's INP;
- noise criteria derived in accordance with the EPA's INP;
- almost 4 years of site-specific hourly meteorological data analysed in accordance with the EPA's INP;
- source sound power levels for all equipment measured under operational conditions at mines, rather than using catalogue values or estimations; and
- the modelling itself addressed the EPA's INP with regard to weather effects.

The noise modelling has shown that under SI or calm weather conditions all private residential properties not currently located within a zone of affectation experience noise levels below the EPA's noise goals. Of the residences currently inside a zone of affectation or subject to a private land holders agreement, Property Nos. 9, 10 and 12 are predicted to exceed EPA goals. The model has also shown that under worst case INP derived weather conditions, noise at most properties is below or marginally (less than 3 dB) above EPA noise goals that have been historically applied for calm weather. The exceptions are residences in the vicinity of Property Nos. 1 and 4 where winds cause enhanced noise for these locations.

However, the proposal's noise impacts at all these locations are predicted to remain similar to existing levels for the life of the proposal.

As discussed earlier, the Year 1 model results demonstrate good or conservative correlation with monitoring data for 2002. It should be noted that whilst this does provide some degree of certainty, the model results are for specific worst case assessable INP weather conditions and the monitoring conditions are likely to have varied from these conditions.

A comparison against possible acquisition limits imposed on similar mining operations indicates exceedances at four private residences, including Property Nos. 8, 9, 10 and 12. These properties are currently inside a zone of affectation or subject to a private land holders agreement. Also, mining noise at these locations is predicted to remain relatively unchanged compared to existing levels.

On going noise monitoring will be used to assess the performance of the mining operations against the predicted noise levels.

Blast design will incorporate control on the MIC (maximum instantaneous charge) as described in this study and ensure acceptable limits are maintained. This will also be addressed through monitoring.

9 *REFERENCES*

Australian and New Zealand Environment and Conservation Council (ANZECC) "Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration".

Blastronics Pty Ltd Drill & Blast Study, Mount Pleasant, prepared for CNA in September 1994.

Environment Protection Authority of NSW (January 2000) Industrial Noise Policy.

Environment Protection Authority (1994), Environmental Noise Control Manual (ENCM).

ERM Australia Pty Ltd SEE of November 2001 for Hunter Valley Operations Section 96(2) Modification of Development Consent.

ERM Mitchell McCotter EIS of August 1997 for the Extension of Mining Operations at Ravensworth Mine.

HLA Envirosciences Pty Limited EIS of November 2001 for the White Mining Limited Ashton Coal Project.

Resource Strategies Pty Ltd, EIS of June 2003 for the expansion of Wambo Development Project.

RTA Technology, Environmental Noise Model (ENM), Windows Version 3.06.

Annex A

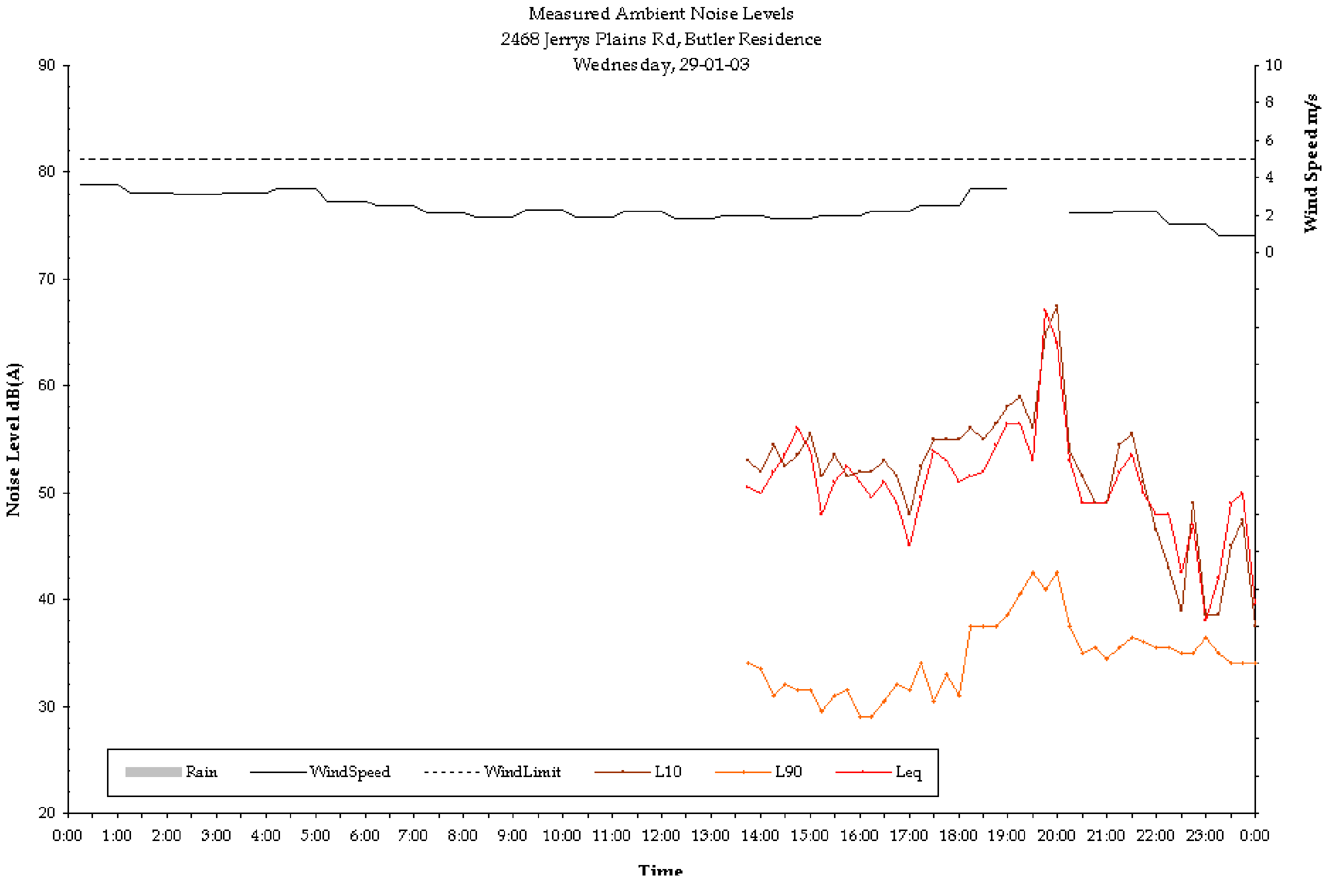
Noise Monitoring

A.1 MEASUREMENT LOCATION N1 – BUTLER, JERRYS PLAINS ROAD

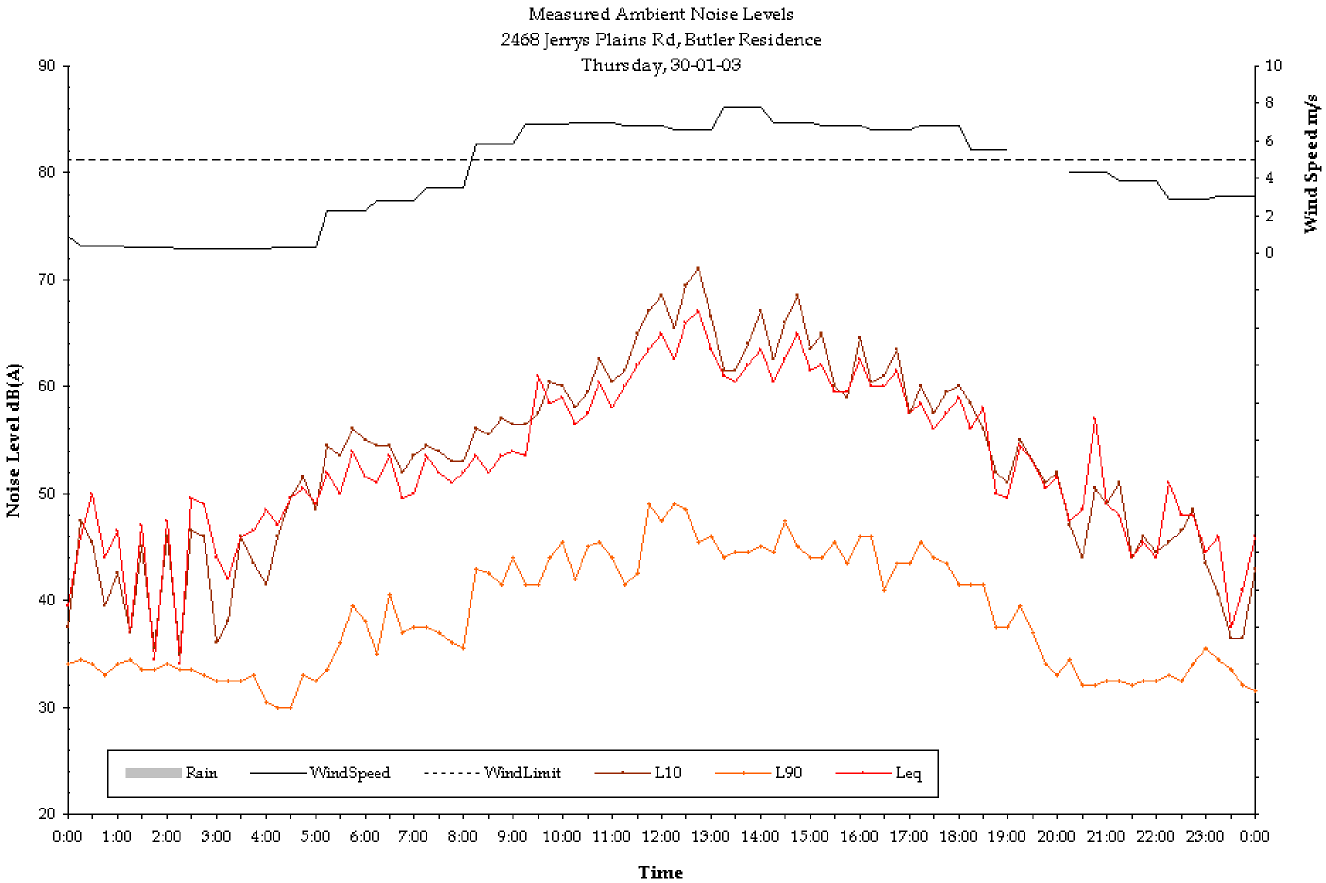
Table A.1 Summary of Daily Noise Levels Measured at Location N1 (Butler, Jerrys Plains Road)

Date	Assessment Background Level dB(A)L_{90}			Ambient Noise Levels dB(A)$L_{eq,period}$		
	Day	**Evening**	**Night**	**Day** $L_{eq,11hr}$	**Evening** $L_{eq,4hr}$	**Night** $L_{eq,9hr}$
Wednesday, 29-01-03	-	35	32.5	-	58	48.5
Thursday, 30-01-03	-	-	31	-	52.4	49.8
Friday, 31-01-03	-	-	-	-	-	52.1
Saturday, 01-02-03	-	-	35	-	-	50.2
Sunday, 02-02-03	-	-	35.5	-	-	50.4
Monday, 03-02-03	-	37	35.5	-	52.4	50.9
Tuesday, 04-02-03	-	-	35.5	-	54.5	51.8
Wednesday, 05-02-03	35	37	29.5	54	52.6	49.5
Thursday, 06-02-03	-	-	30.5	-	53.8	51.4
Friday, 07-02-03	29	33.5	30	52.9	51.7	46
Saturday, 08-02-03	-	-	29.5	-	51.5	46.2
Sunday, 09-02-03	32.5	34.5	29.5	52.7	52.7	48.6
Monday, 10-02-03	-	30	30.5	-	48	48.5
Tuesday, 11-02-03	32.5	-	30.5	54	52.7	50
Wednesday, 12-02-03	29	33	31.5	50.9	52.3	49.6
Thursday, 13-02-03	28.5	30	30.5	51.1	50.3	50.9
Friday, 14-02-03	37.5	-	30	55.4	53.2	48.3
Saturday, 15-02-03	-	-	-	-	-	-
(RBL)	33	34	31			
Average L_{eq}				53	53	50

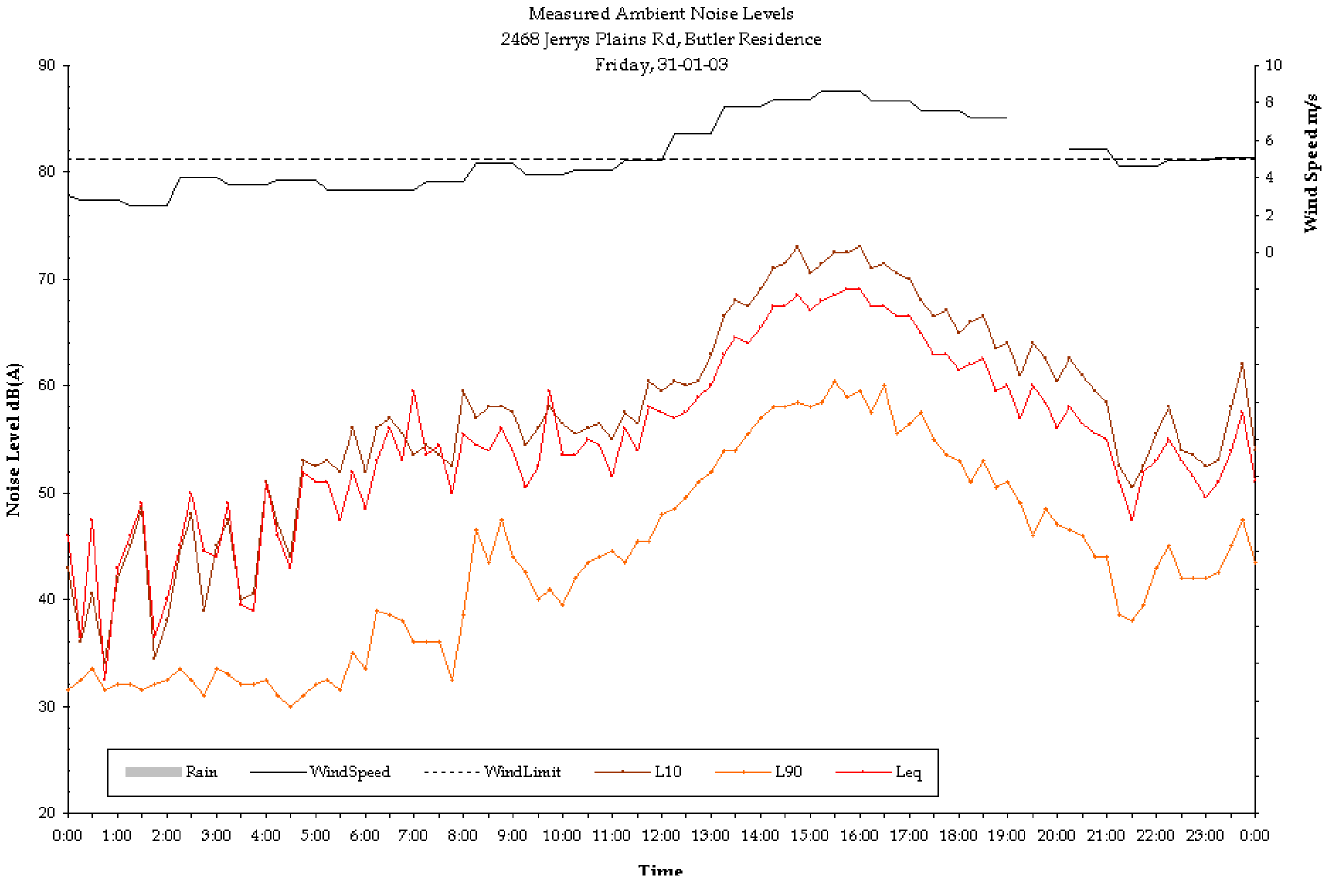
Notes: 1. "-" denotes periods excluded due to weather or insufficient data

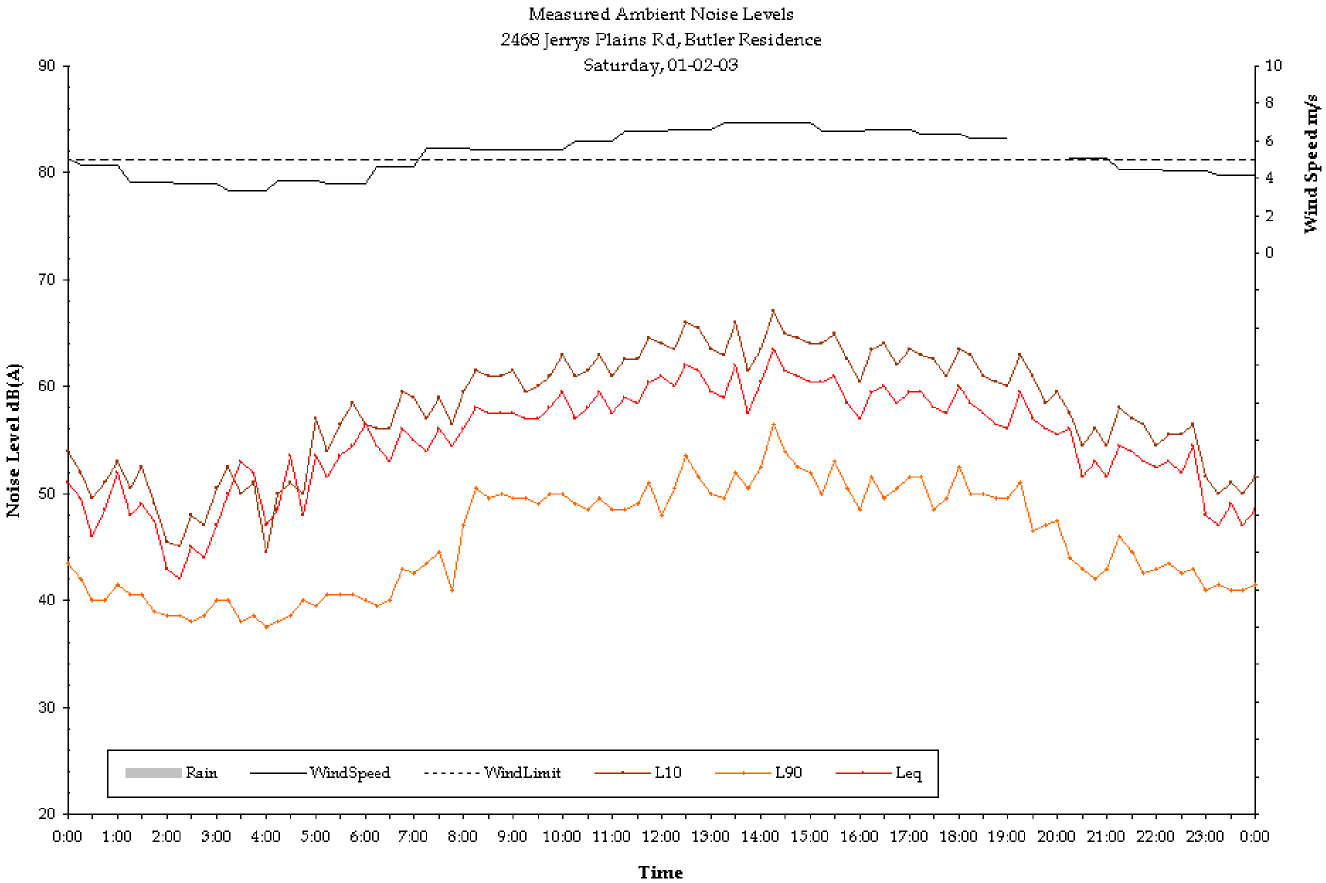


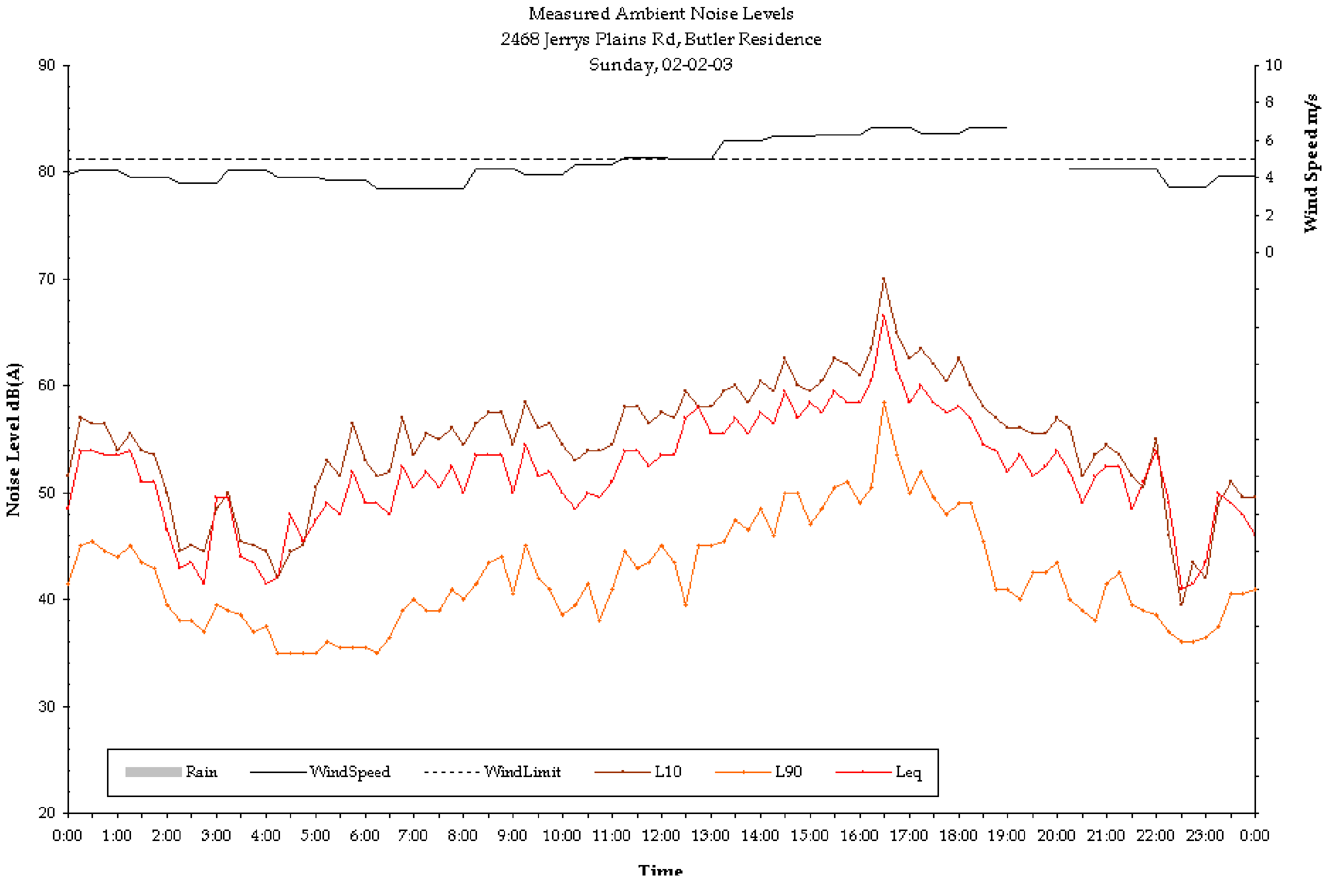
Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Wednesday, 29-01-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time



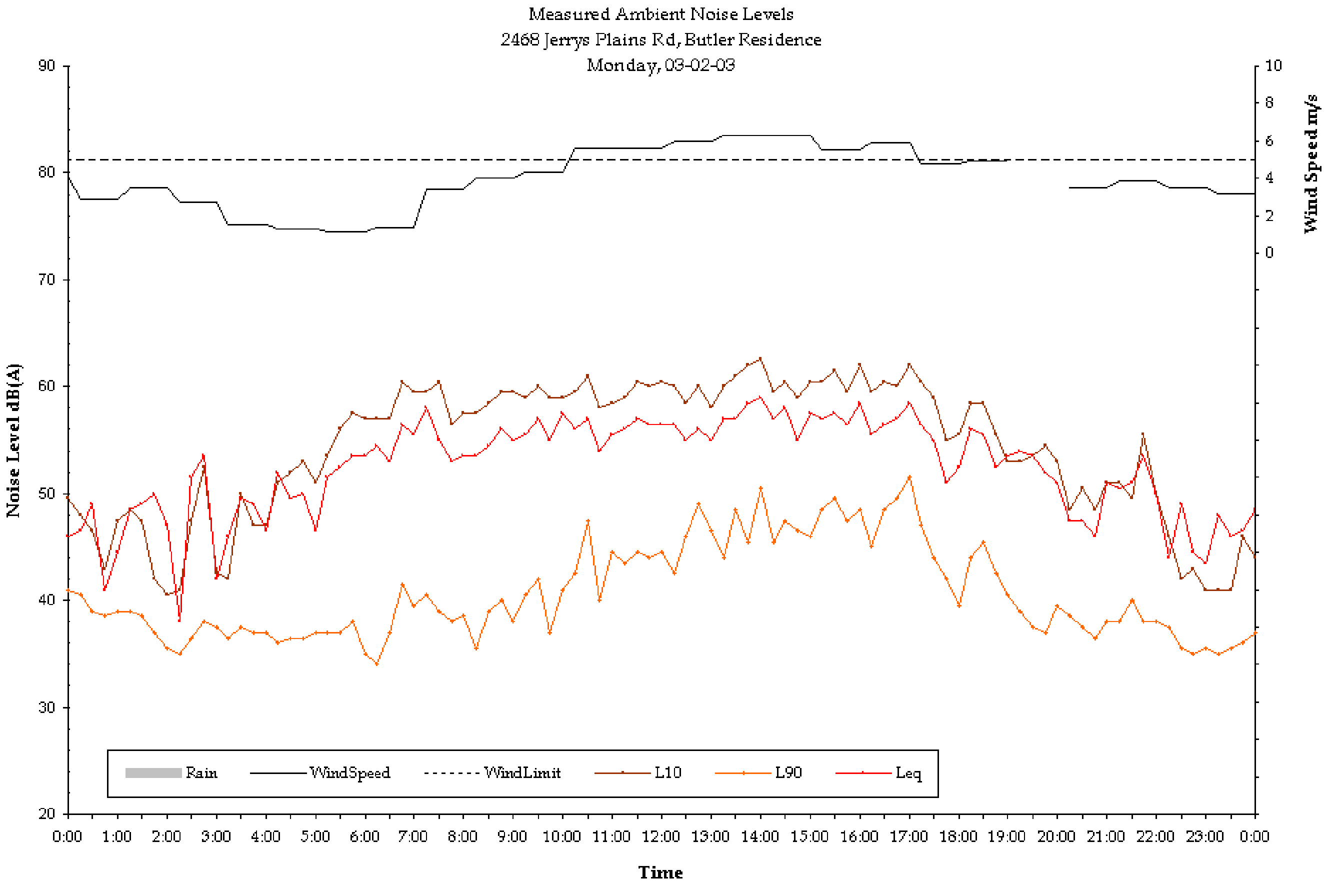
Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Thursday, 30-01-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time


Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Friday, 31-01-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq

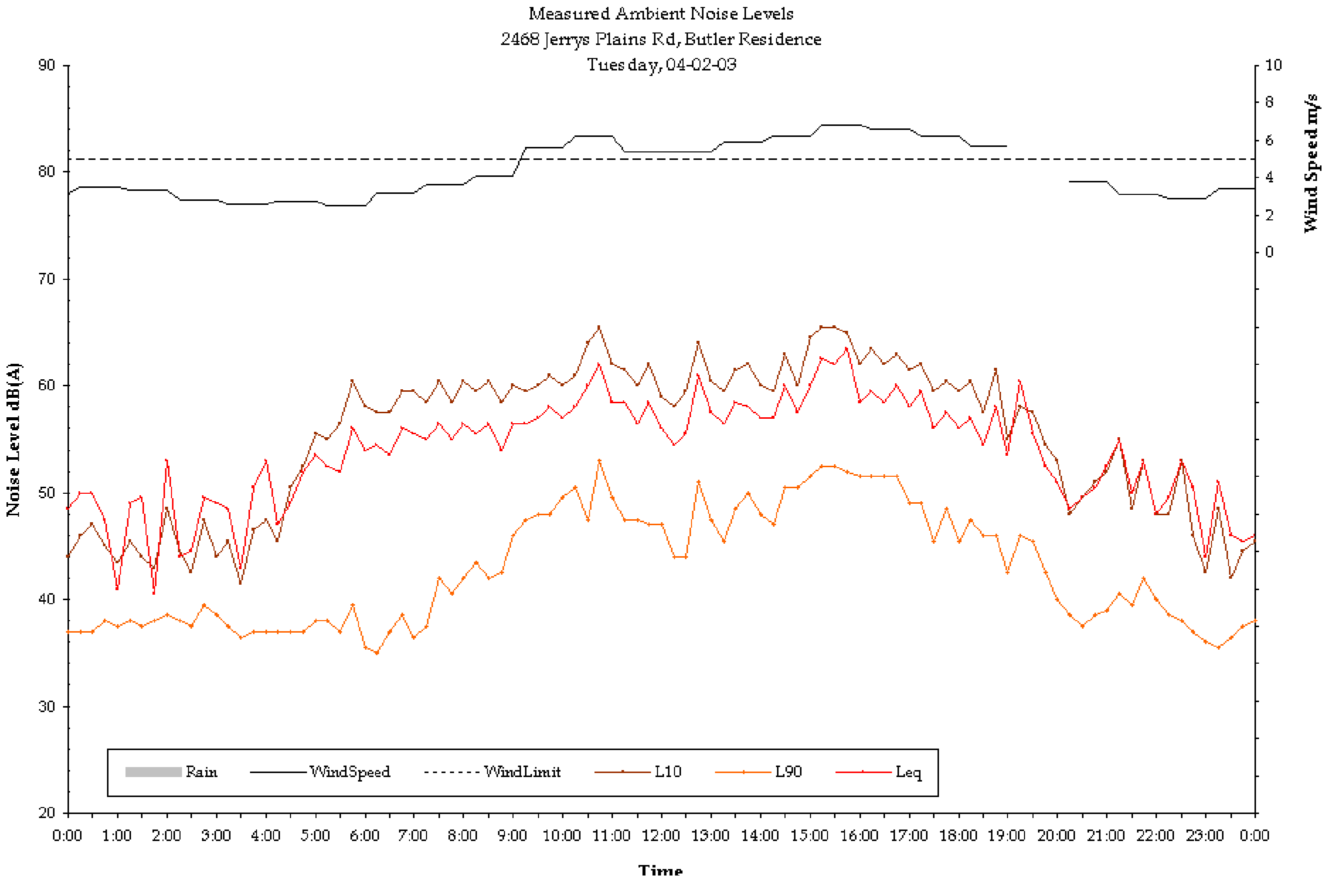

Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Saturday, 01-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq

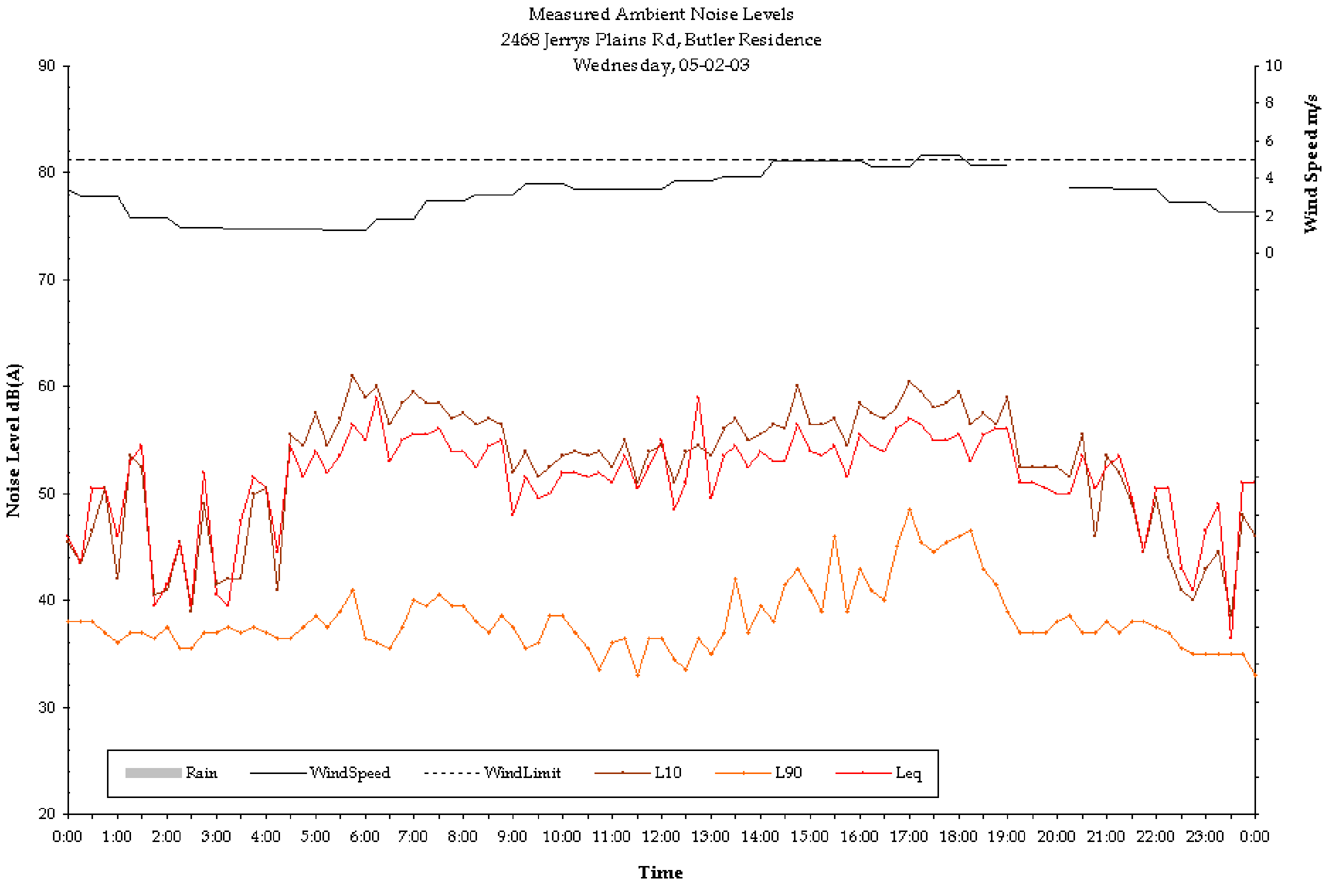


Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Sunday, 02-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time



Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Monday, 03-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time


Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Tuesday, 04-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
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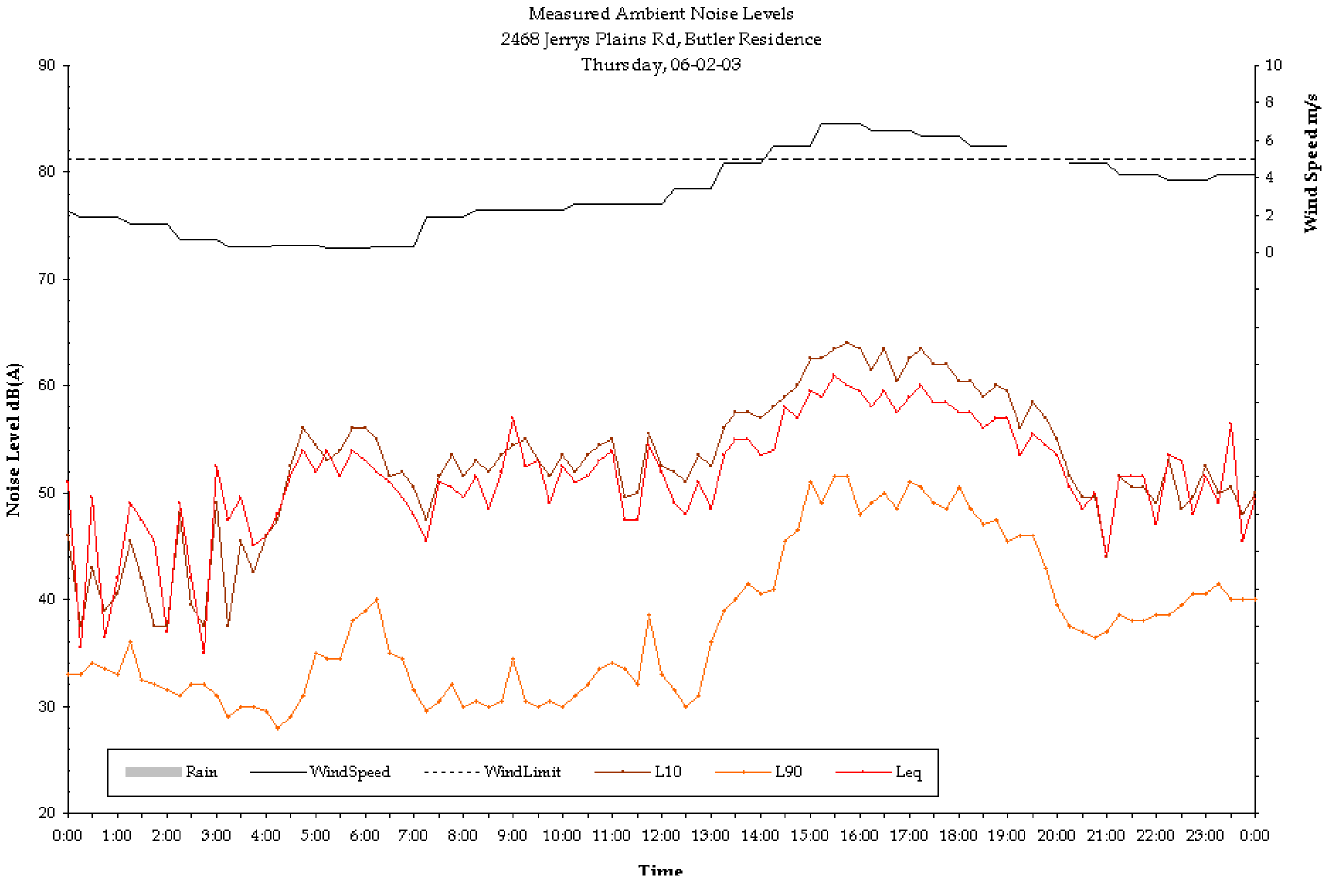
Wednesday, 05-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Thursday, 06-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
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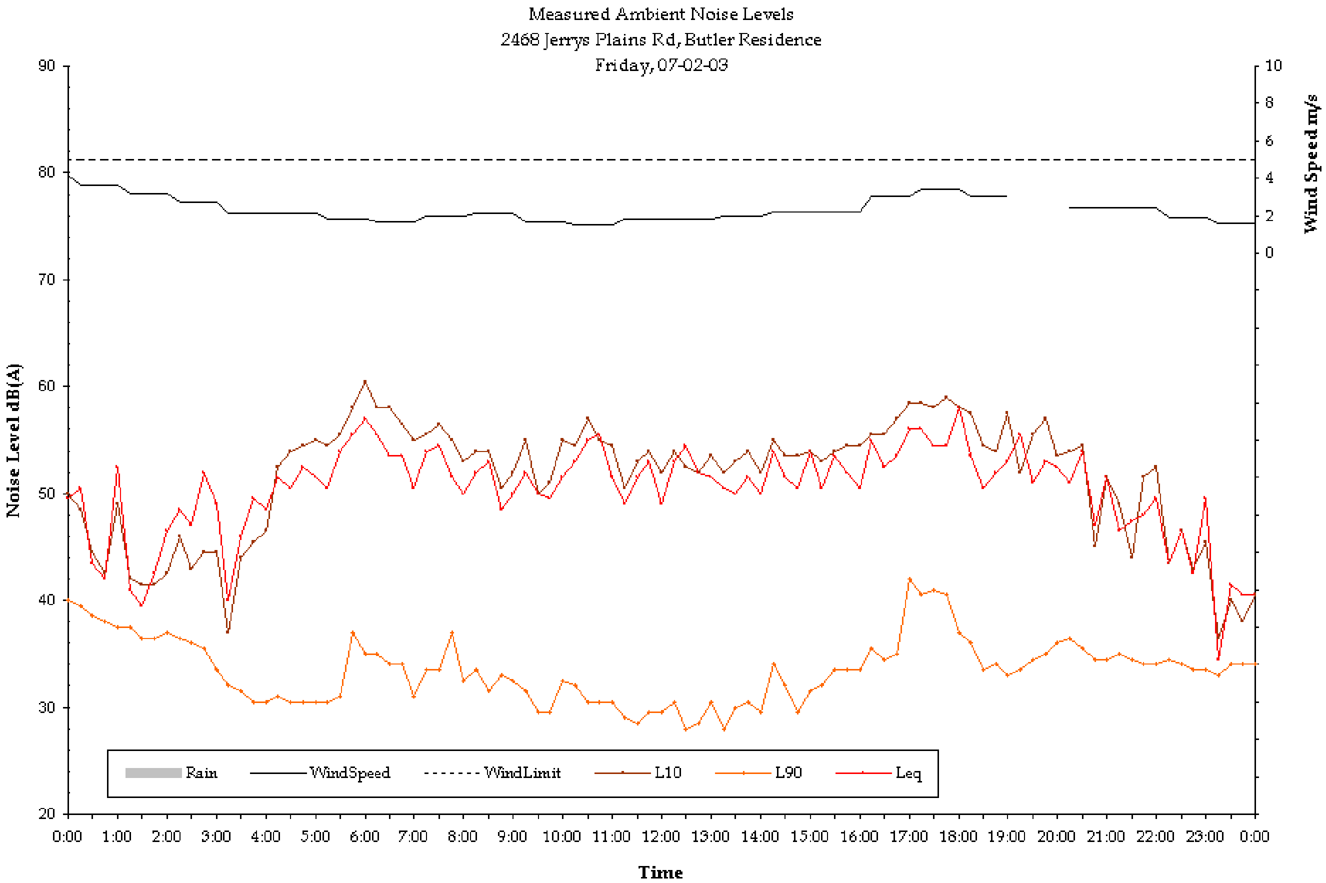
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00


Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Friday, 07-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
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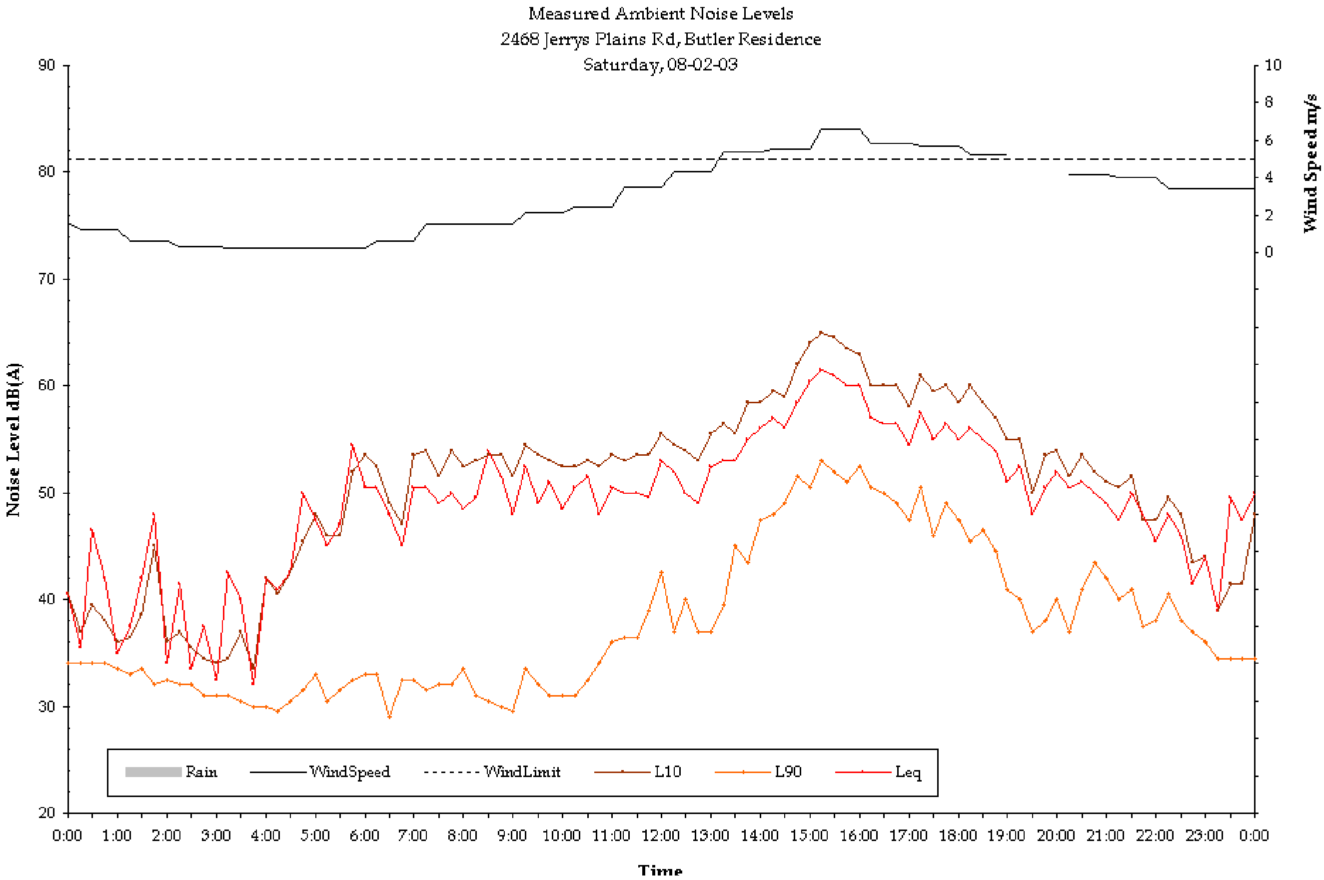
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00



Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Saturday, 08-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
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50
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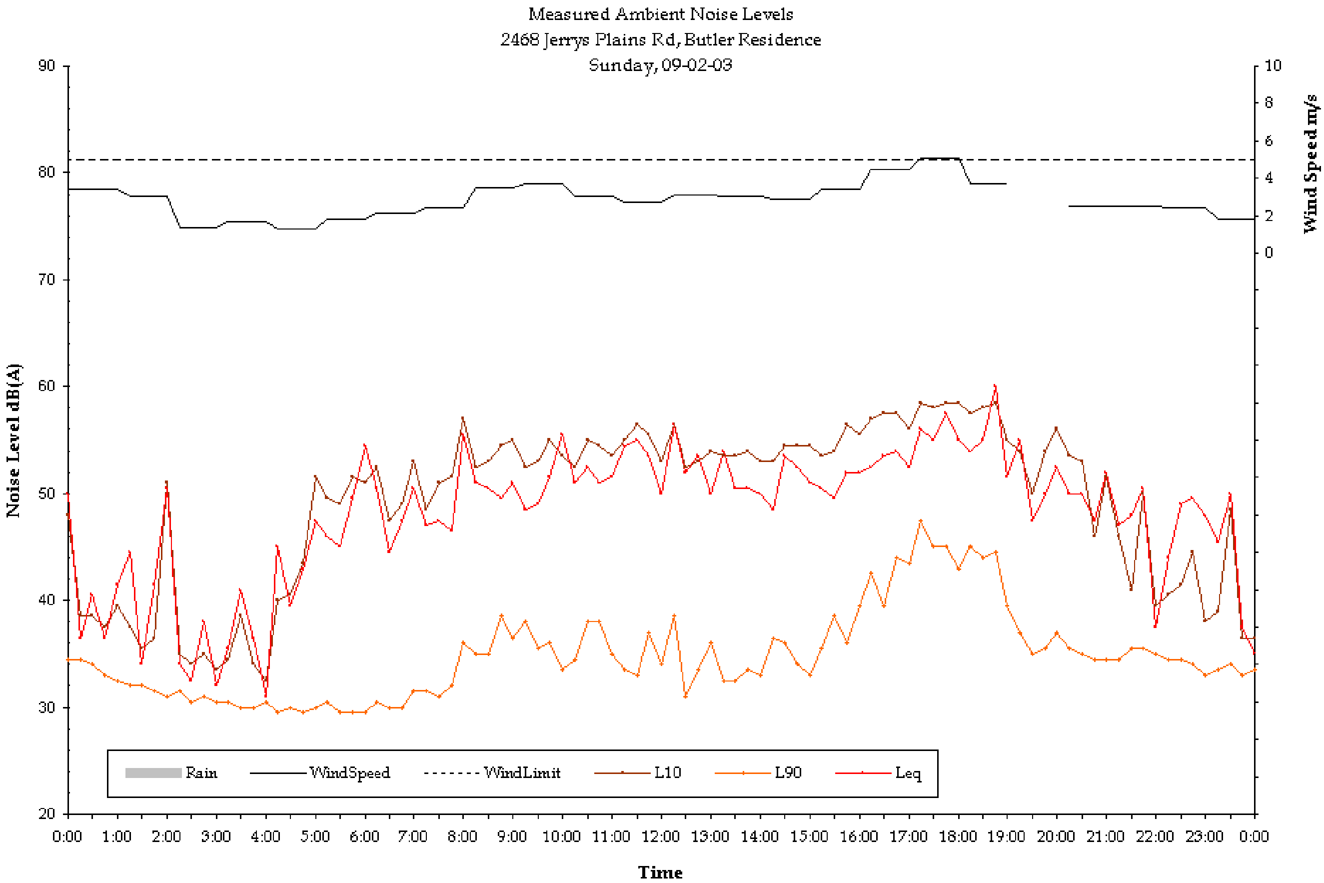

Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Sunday, 09-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
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Leq
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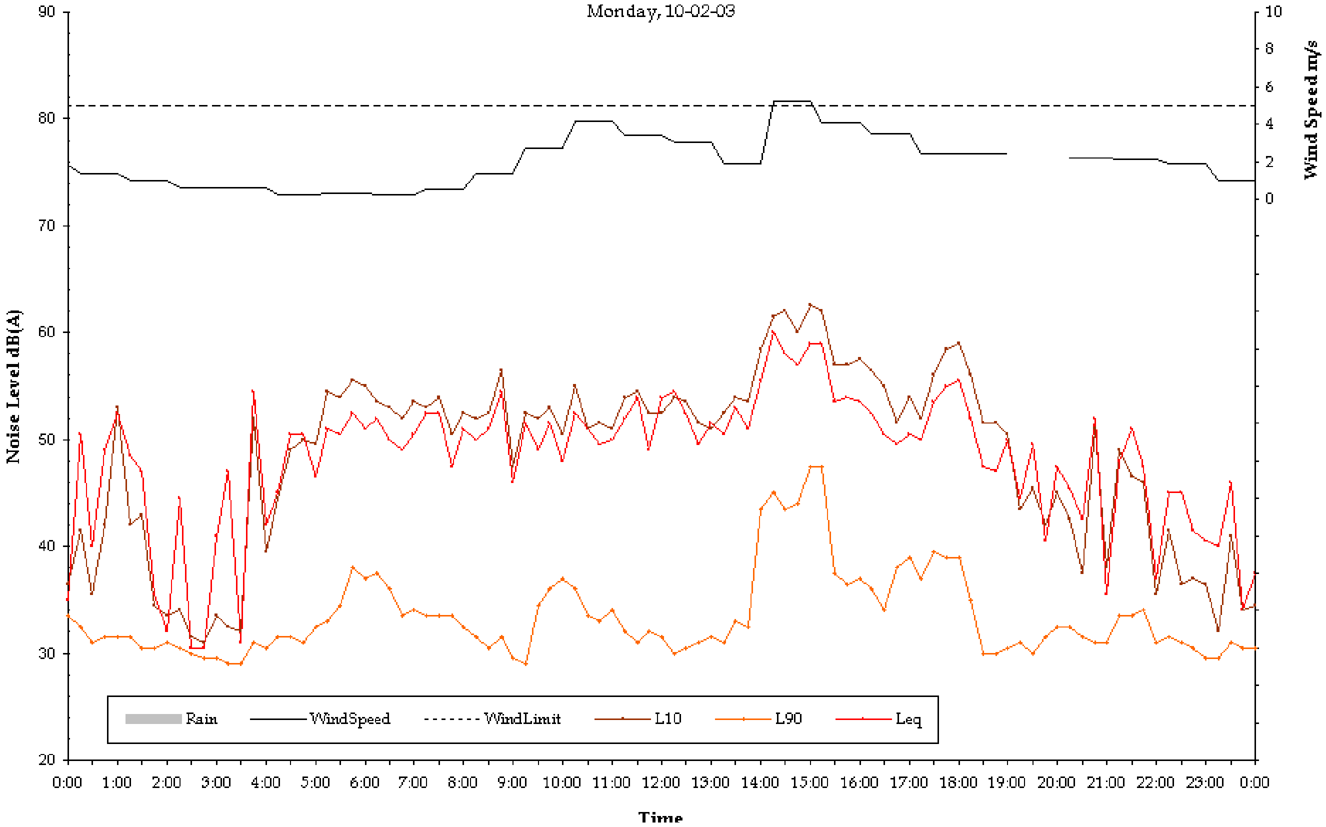
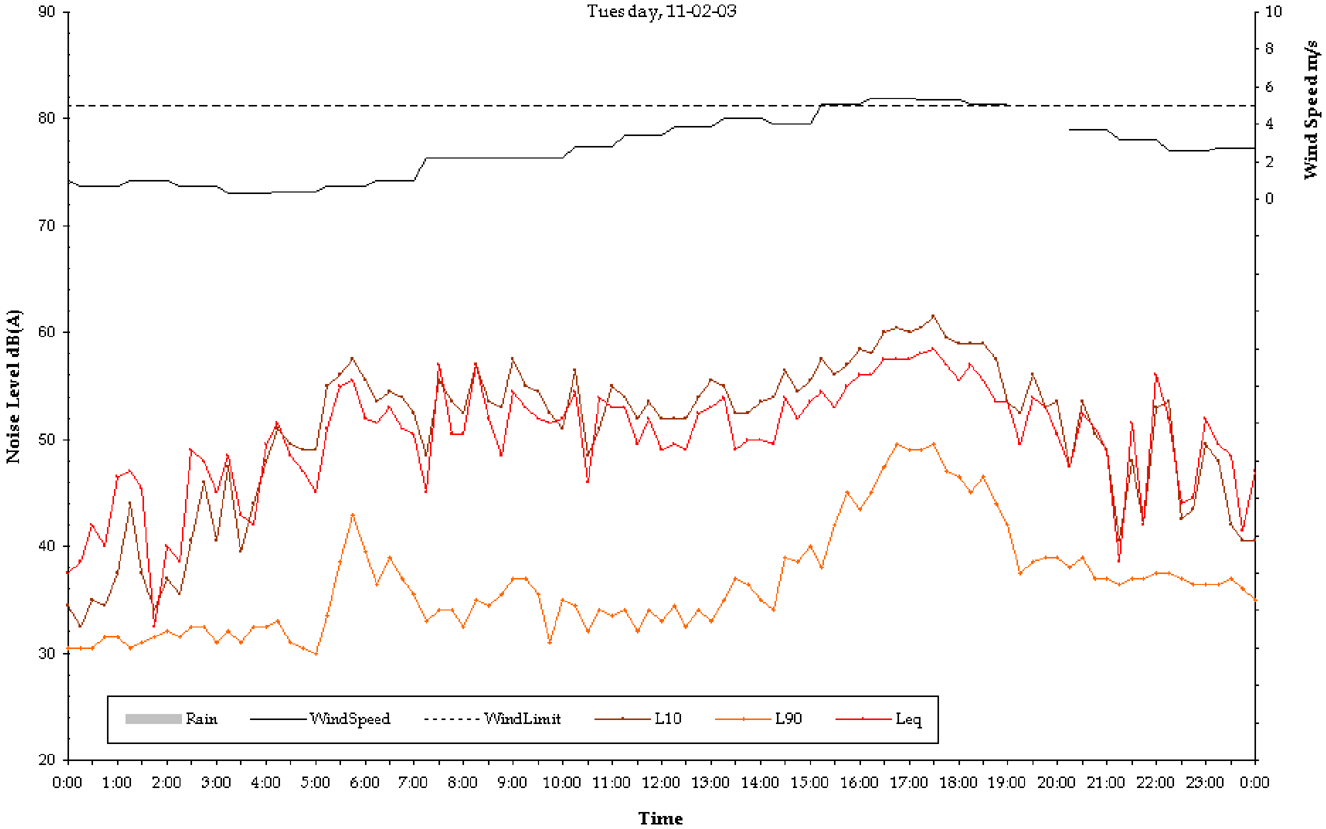
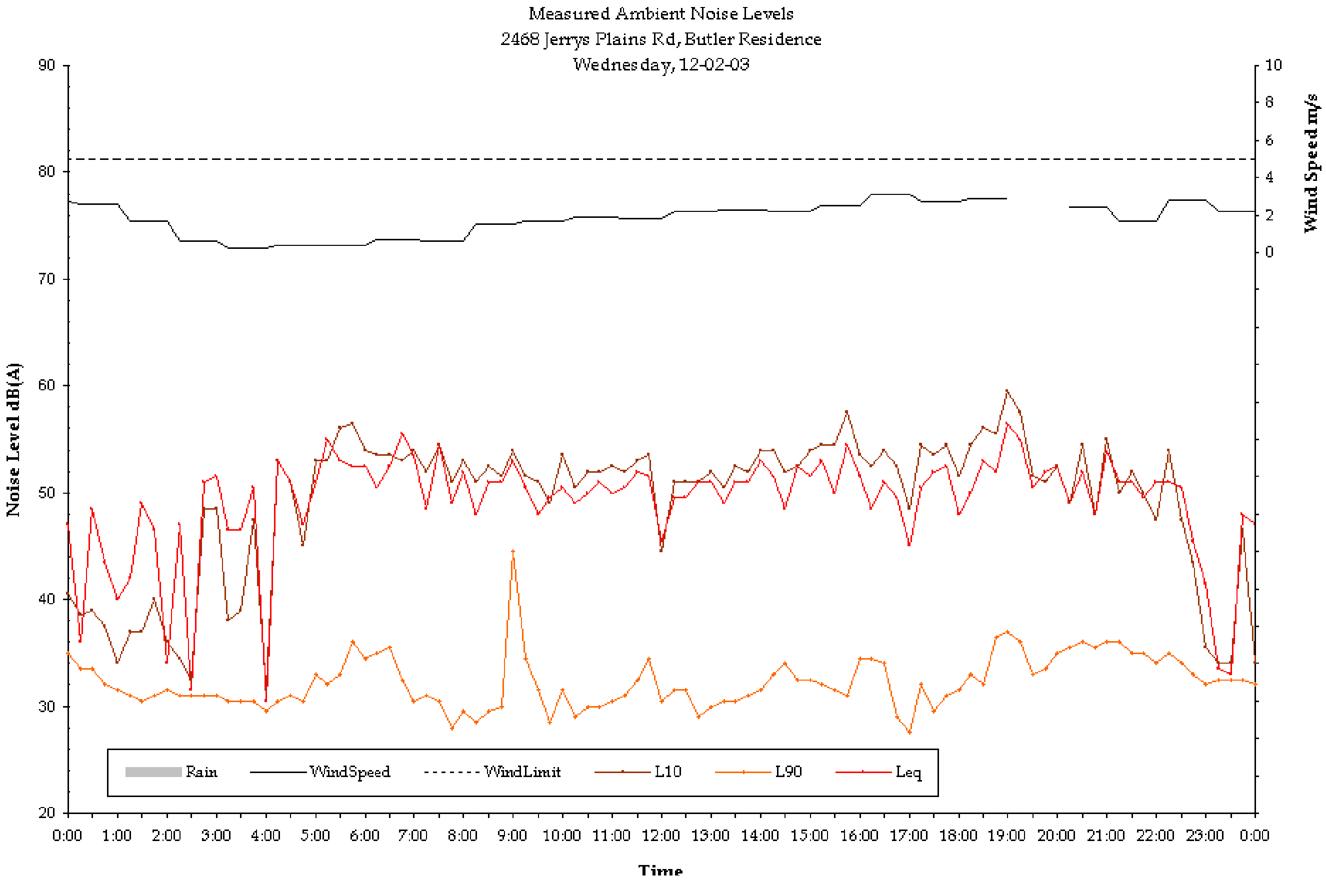
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00

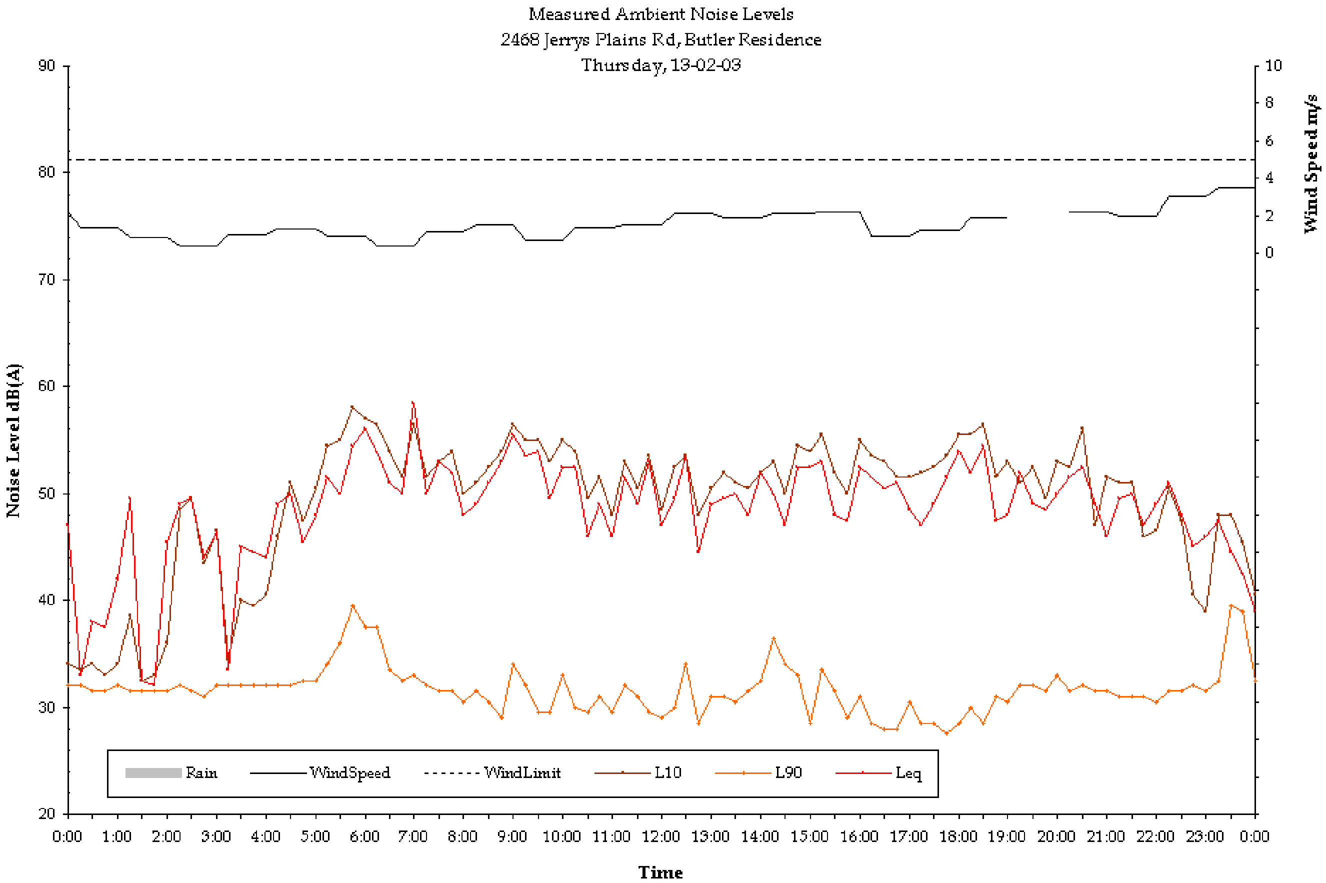
Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Monday, 10-02-03

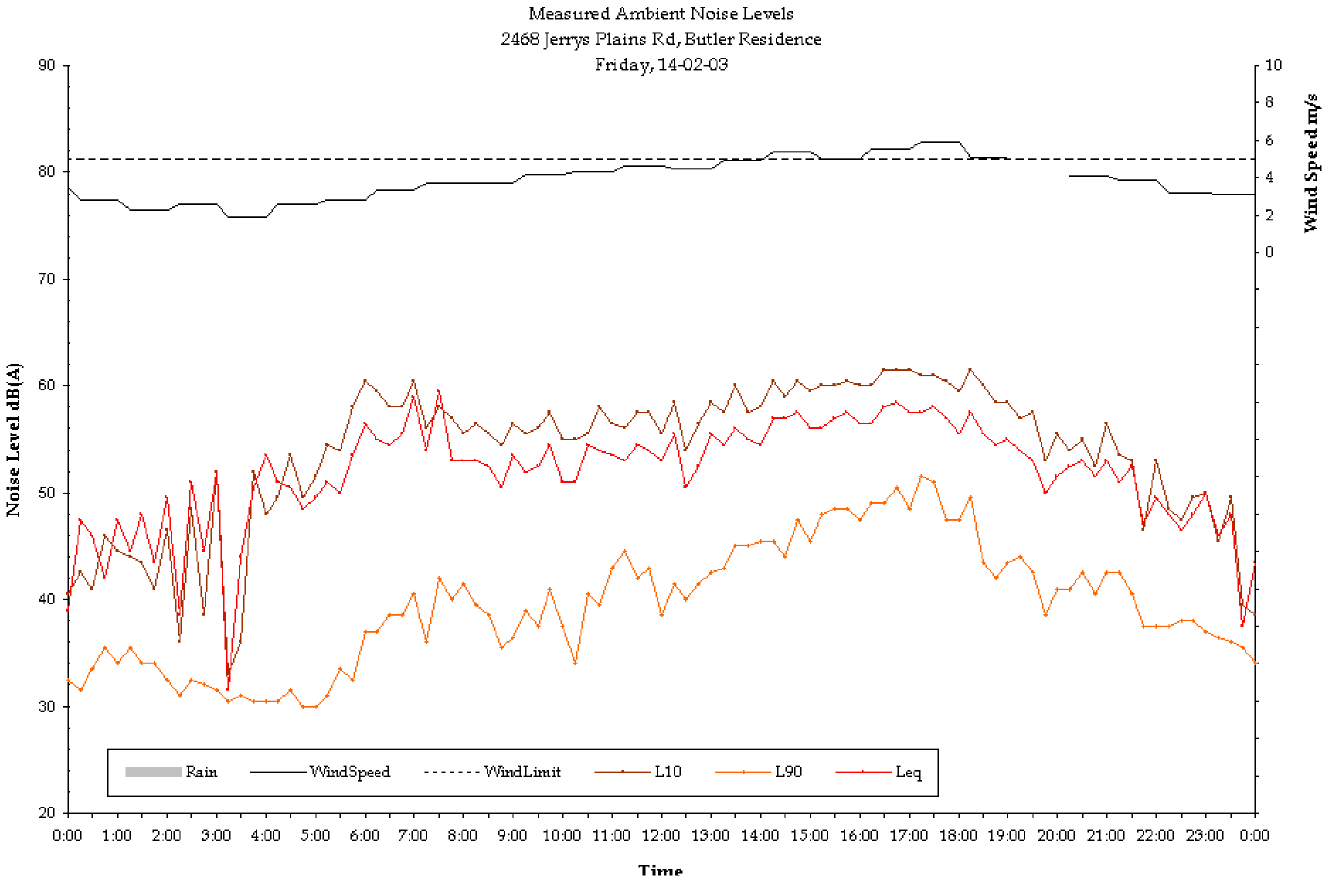


Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Tuesday, 11-02-03




Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Wednesday, 12-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time


Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Thursday, 13-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time


Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Friday, 14-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
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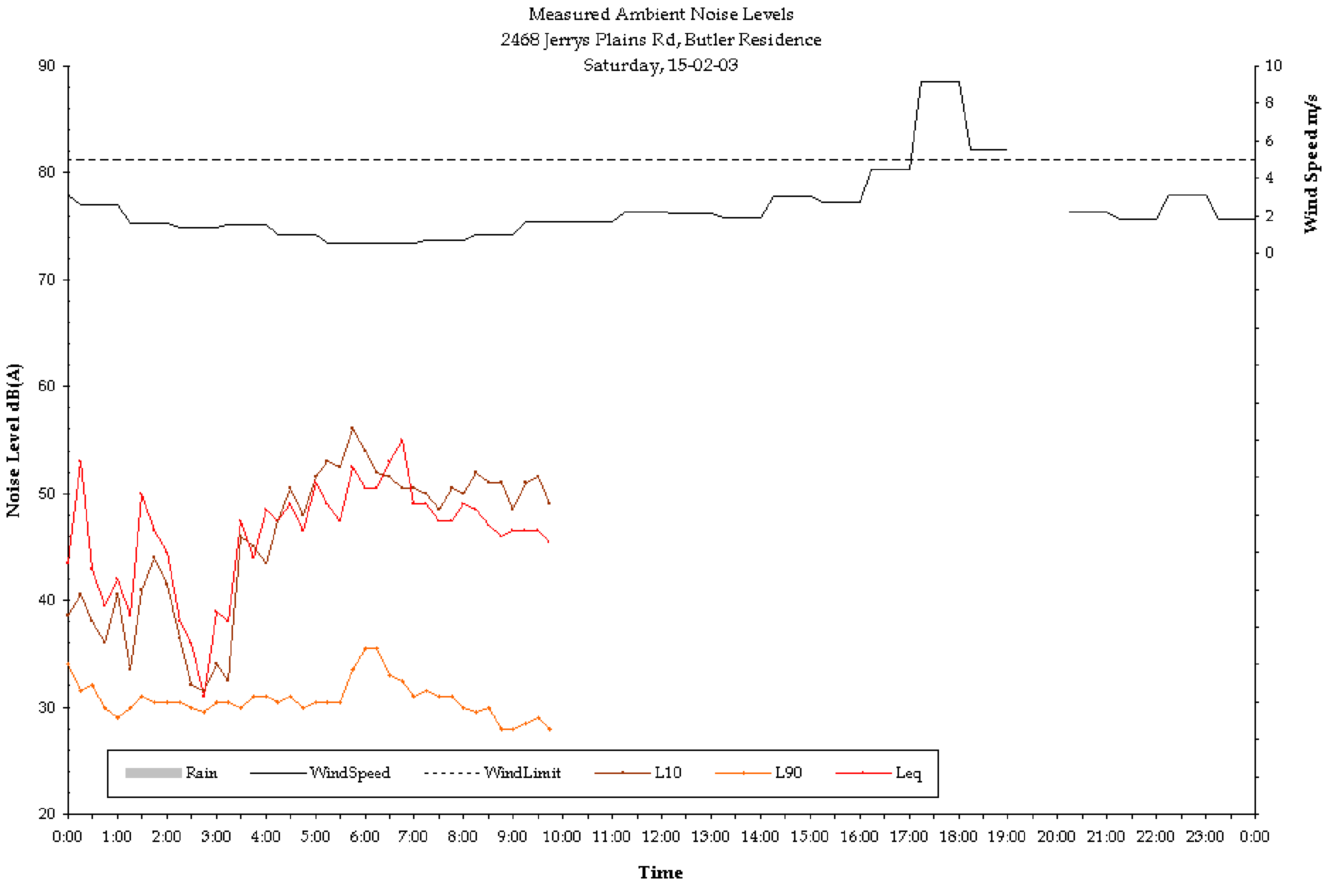
Measured Ambient Noise Levels
2468 Jerrys Plains Rd, Butler Residence
Saturday, 15-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
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Leq
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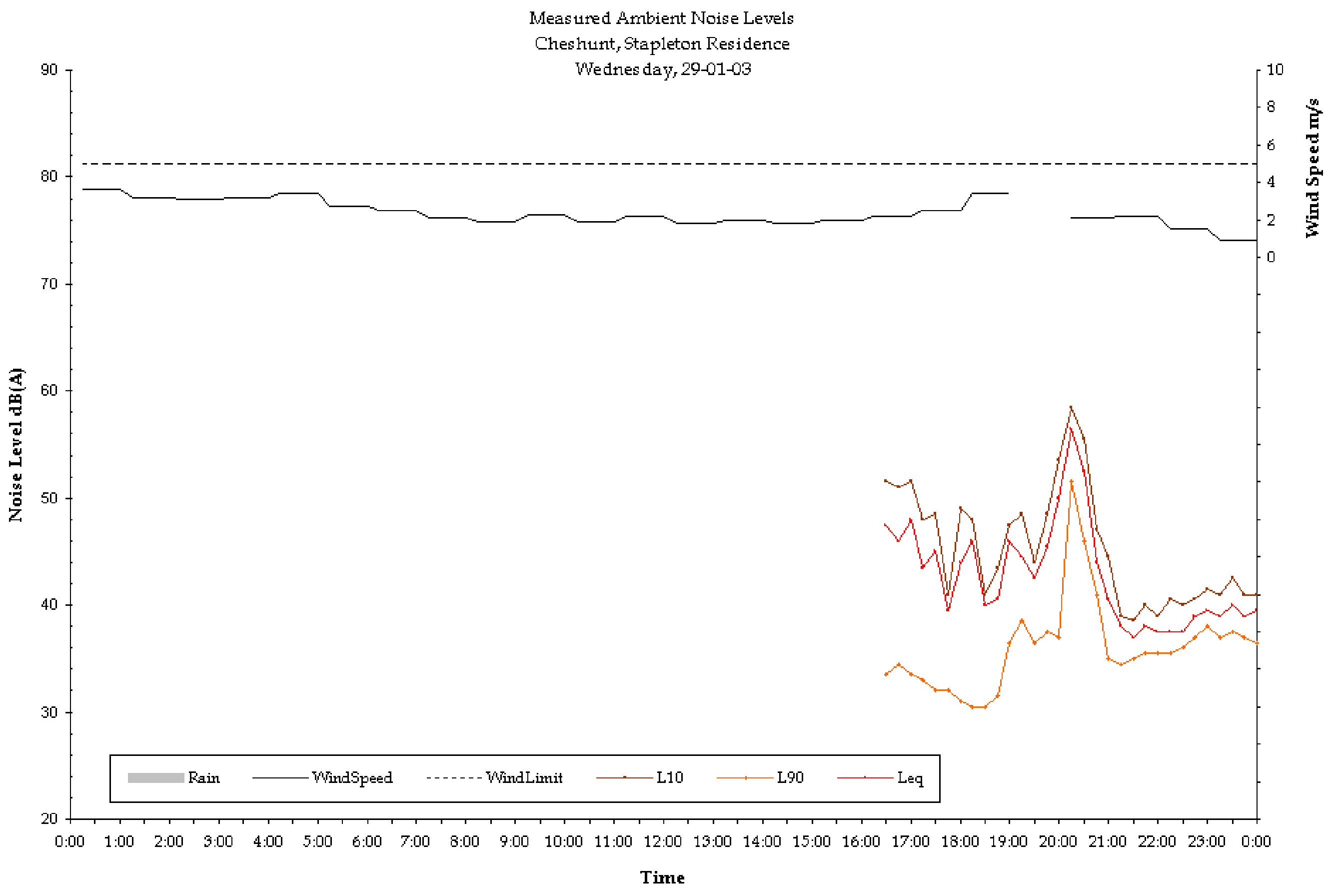
A.2 *MEASUREMENT LOCATION N2 - STAPLETON, CHESHUNT.*

Table A.2 Summary of Daily Noise Levels Measured at Location N2 (Stapleton, Cheshunt)

Date	**Assessment Background Level dB(A)L_{90}**			**Ambient Noise Levels dB(A)$L_{eq,period}$**		
	Day	**Evening**	**Night**	**Day $L_{eq,11hr}$**	**Evening $L_{eq,4hr}$**	**Night $L_{eq,9hr}$**
Wednesday, 29-01-03	-	30.5	36.5	-	47.8	40.9
Thursday, 30-01-03	-	-	33	-	-	41.3
Friday, 31-01-03	-	-	-	-	-	-
Saturday, 01-02-03	-	-	32	-	-	40
Sunday, 02-02-03	-	-	31.5	-	-	38.1
Monday, 03-02-03	-	32.5	32.5	-	48.5	41.1
Tuesday, 04-02-03	-	-	31	-	-	39.6
Wednesday, 05-02-03	-	35.5	32	-	46.9	42.7
Thursday, 06-02-03	-	-	32.5	-	-	41.3
Friday, 07-02-03	31.5	33	33	47	41.6	42.4
Saturday, 08-02-03	-	-	32	-	-	40.8
Sunday, 09-02-03	-	33	33.5	-	44.7	43.6
Monday, 10-02-03	-	33.5	33	-	47.2	42.2
Tuesday, 11-02-03	-	-	31	-	-	40.5
Wednesday, 12-02-03	31.5	28.5	35	46.2	48.8	44.6
Thursday, 13-02-03	29.5	28	32	45.2	45.4	44.1
Friday, 14-02-03	-	-	32.5	-	-	40
(RBL)	32	33	33			
Average L_{eq}				46	47	42

Notes: 1. "-" denotes periods excluded due to weather or insufficient data.


Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Wednesday, 29-01-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
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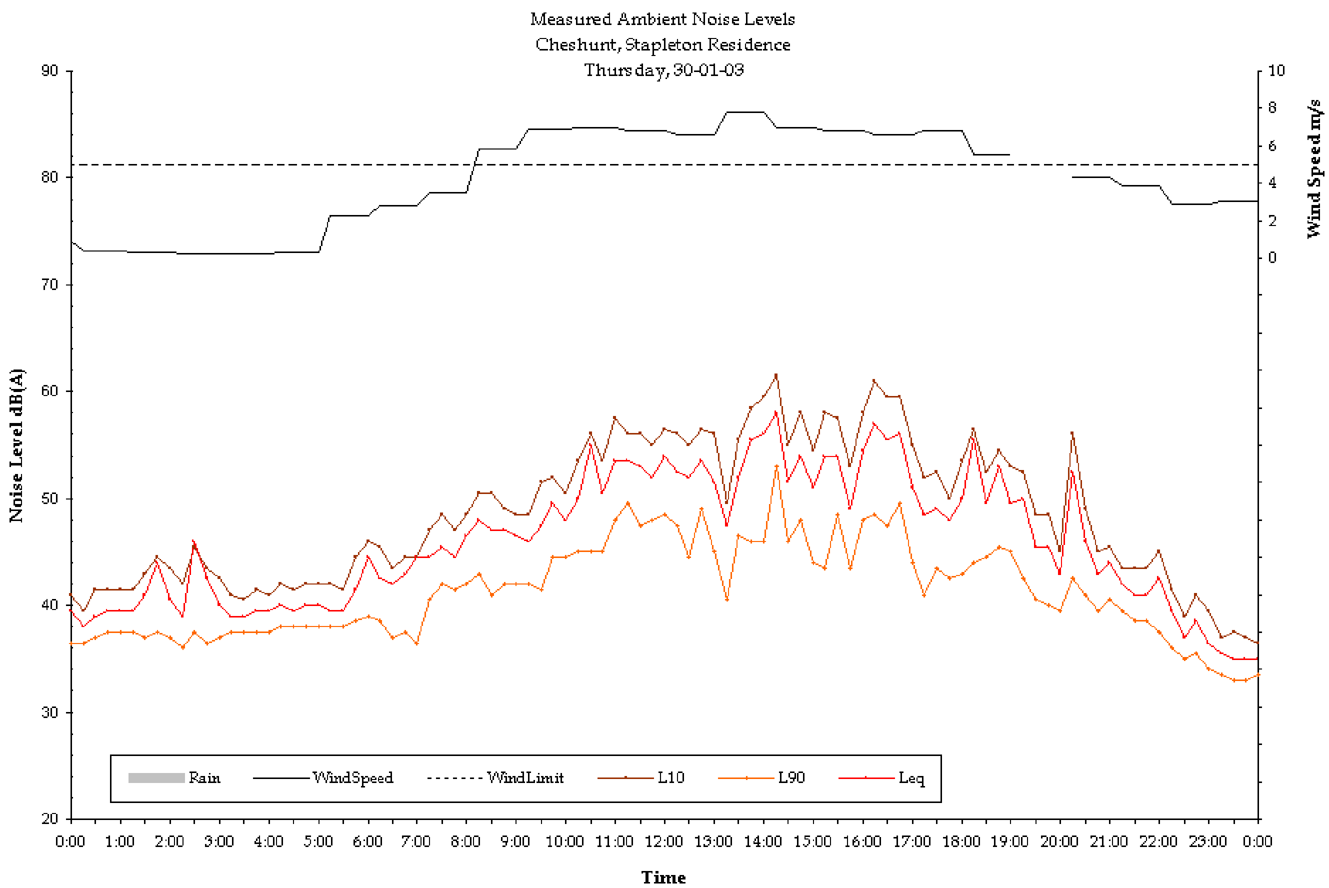
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00


Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Thursday, 30-01-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
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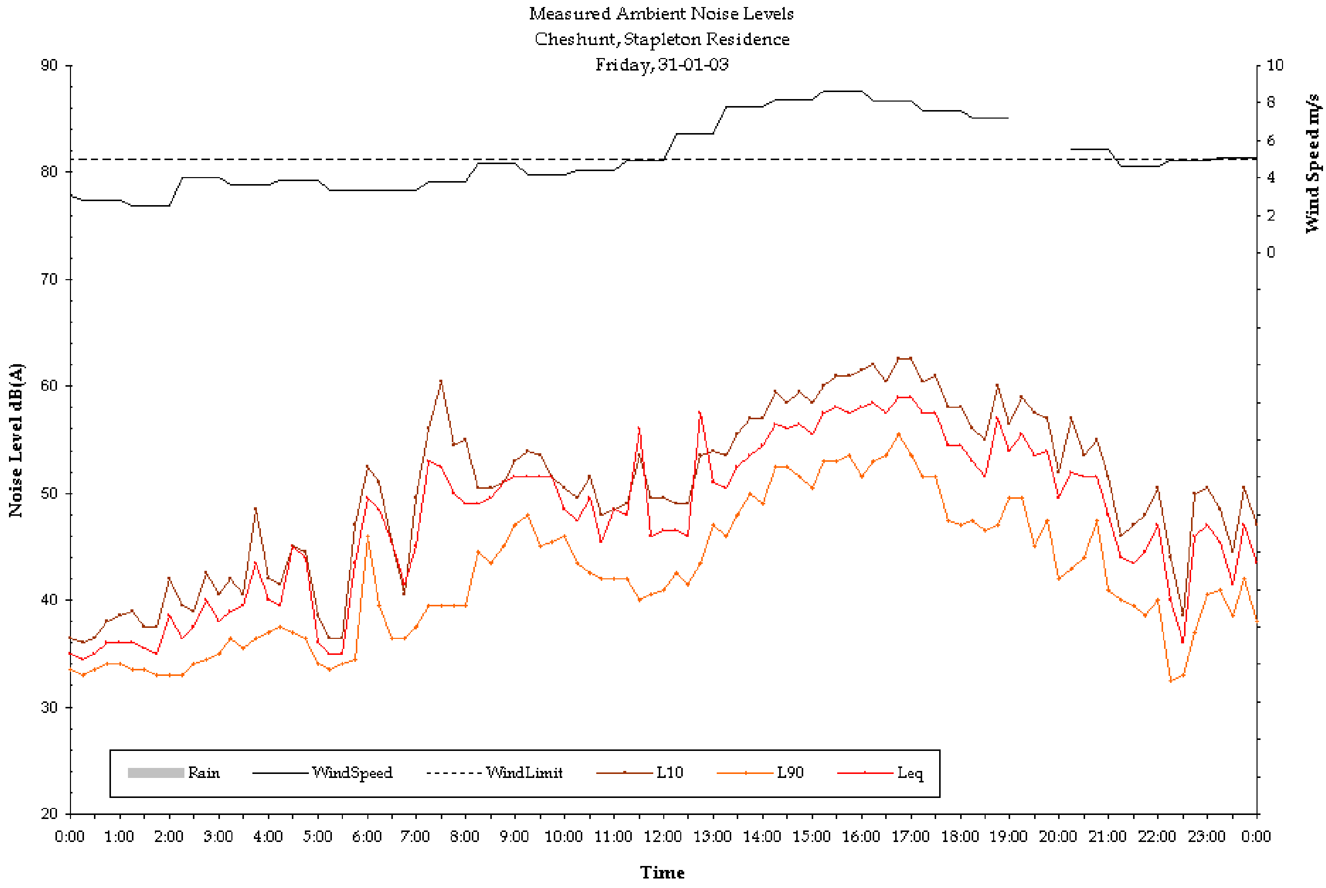
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00



Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Friday, 31-01-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
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20
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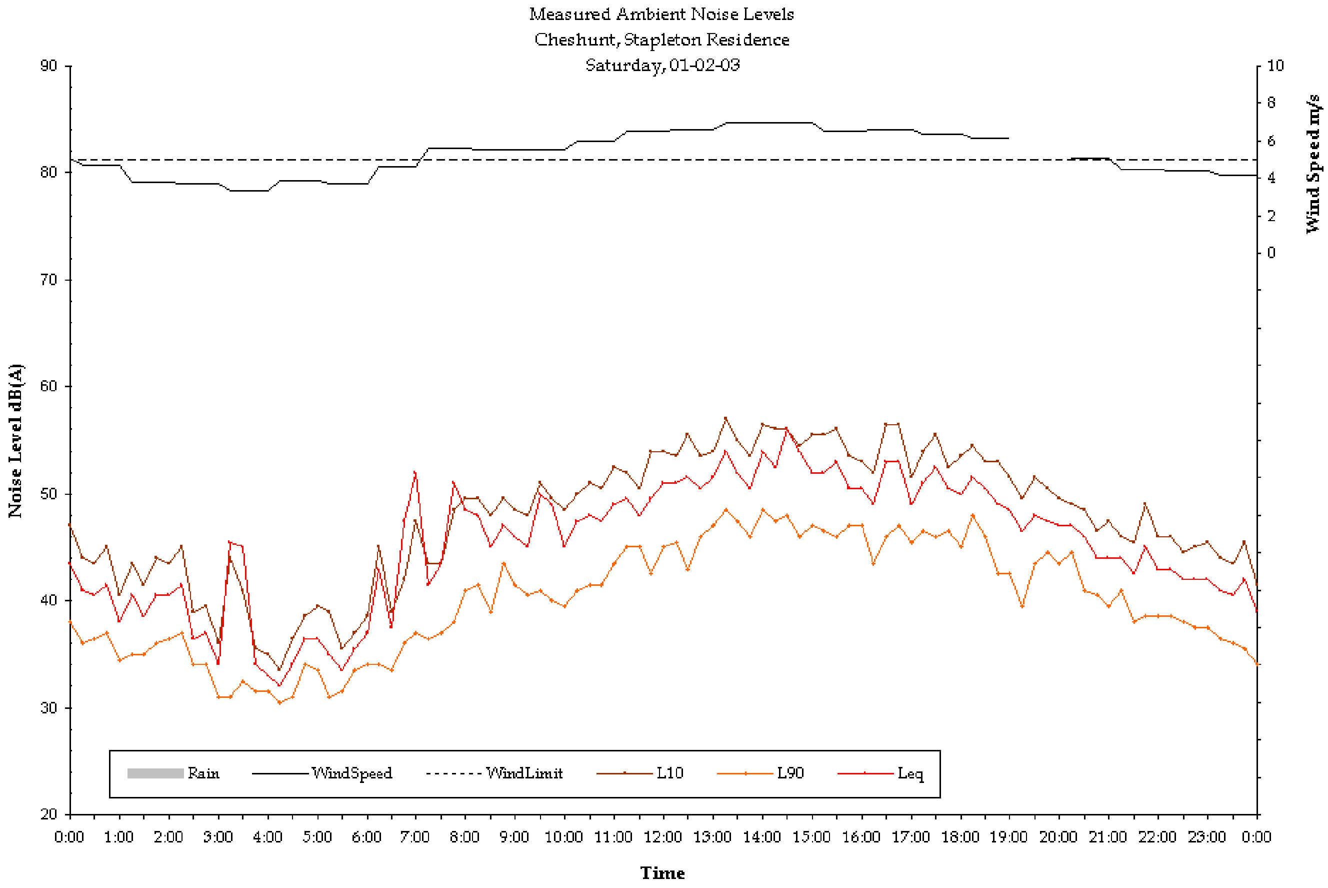

Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Saturday, 01-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
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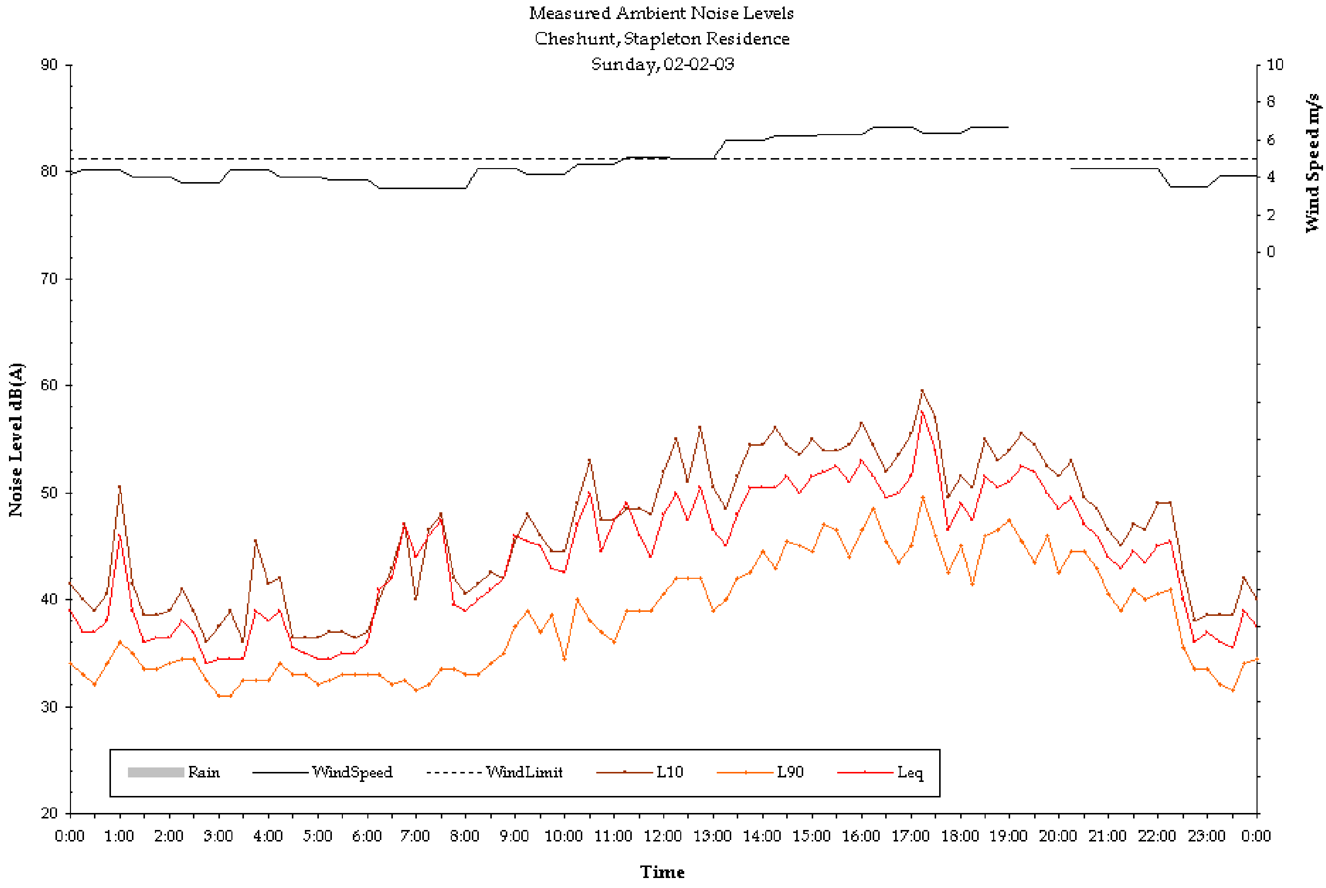
Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Sunday, 02-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
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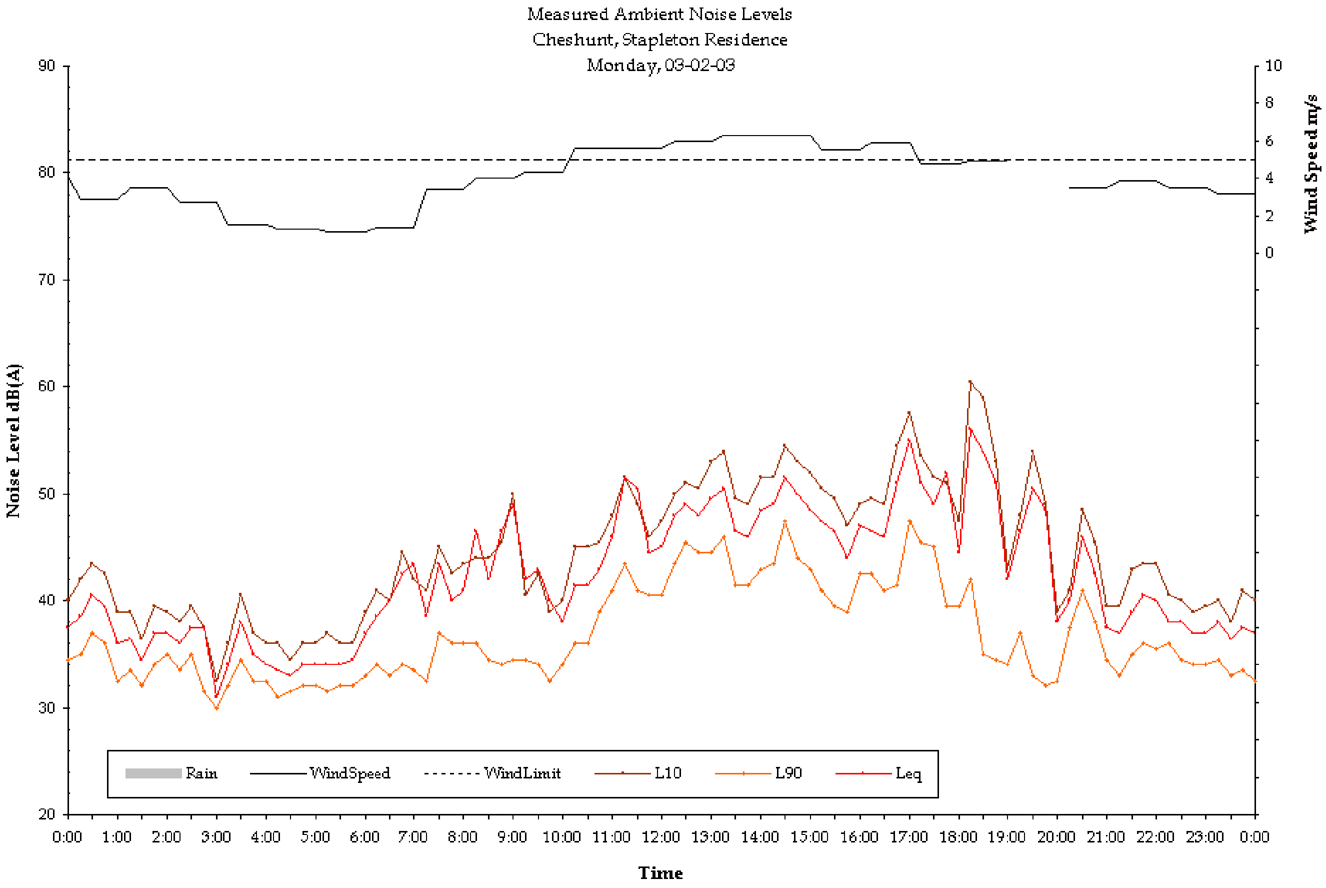
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00


Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Monday, 03-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
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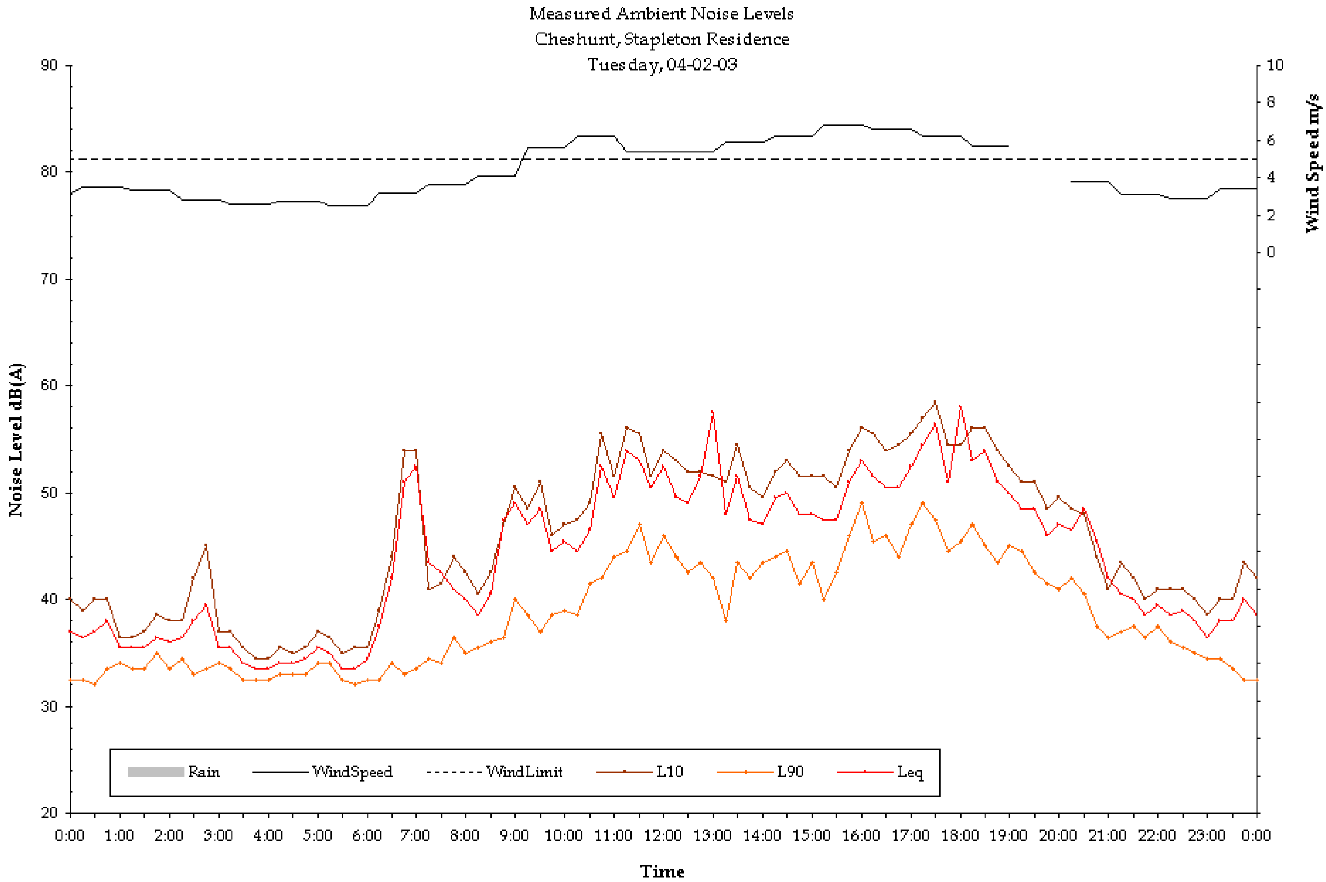
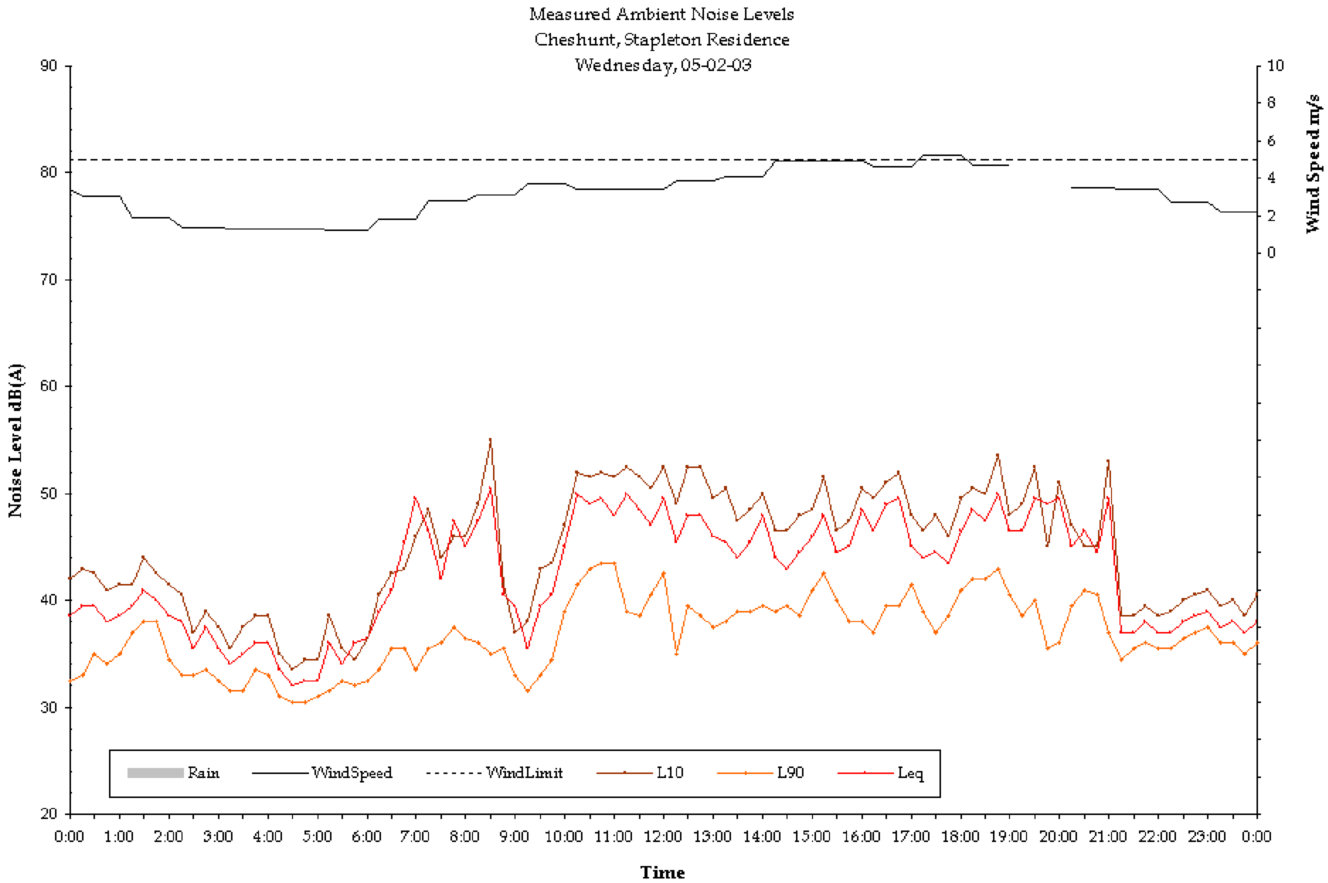
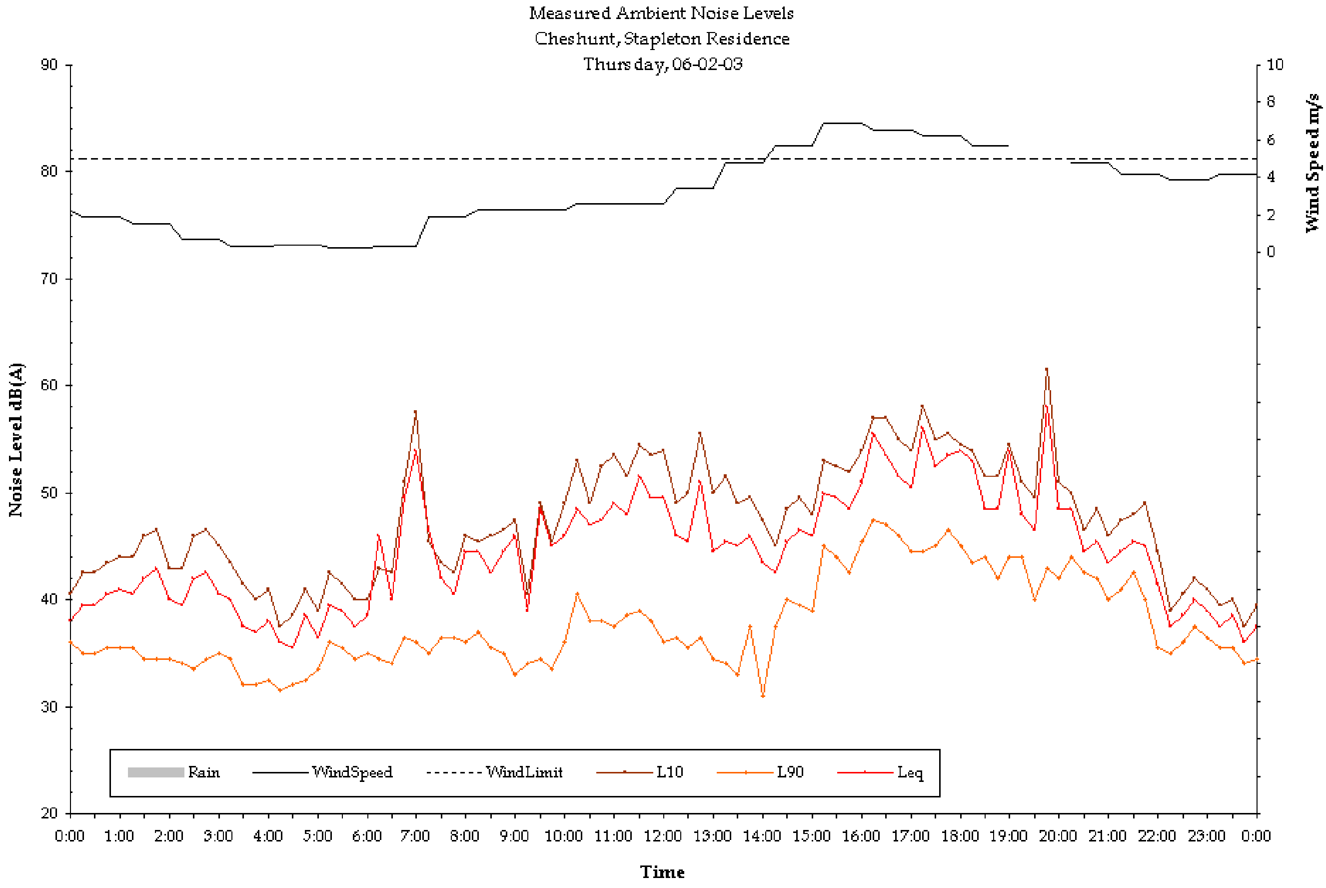

Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Tuesday, 04-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Wednesday, 05-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Thursday, 06-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
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Leq
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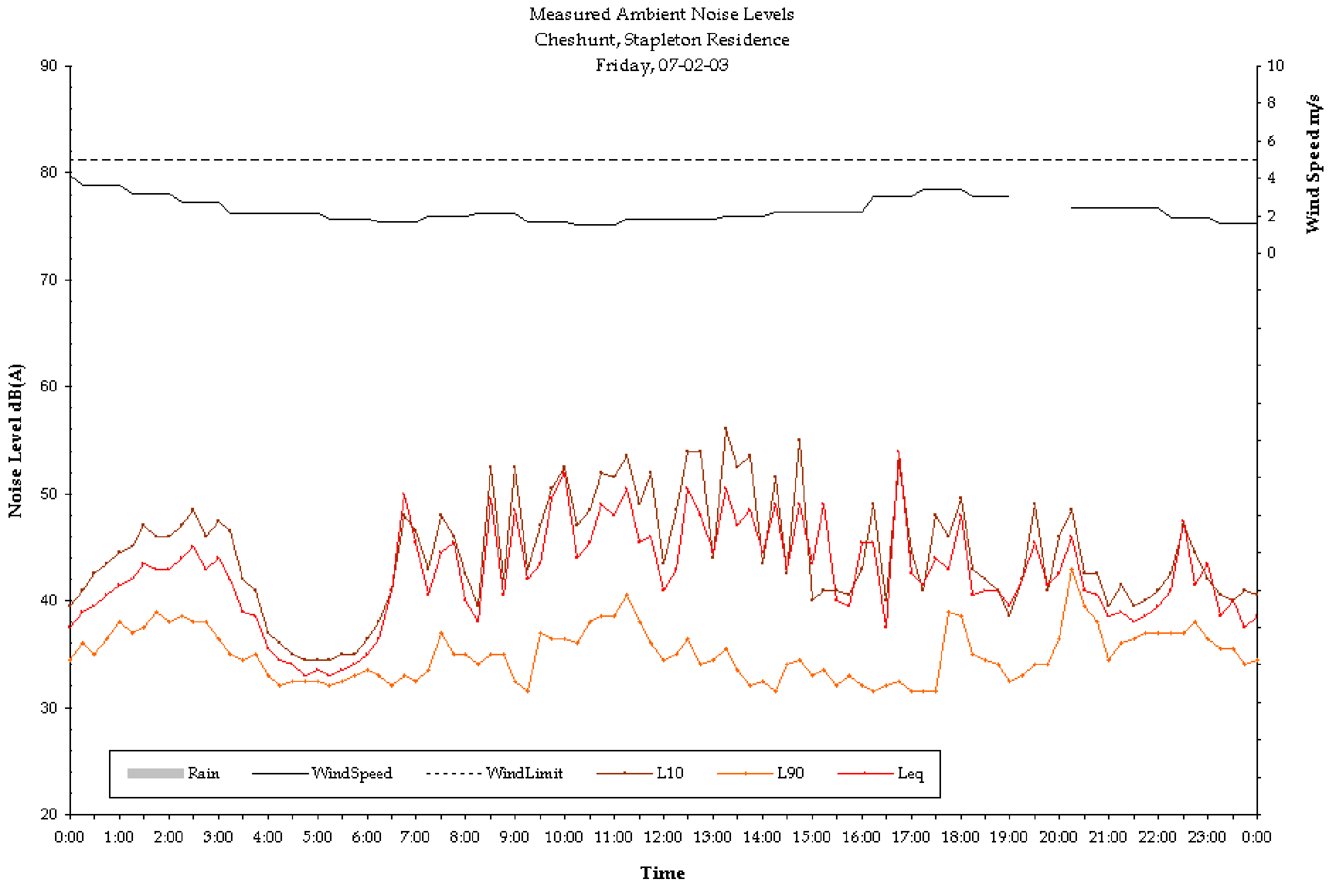
Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Friday, 07-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
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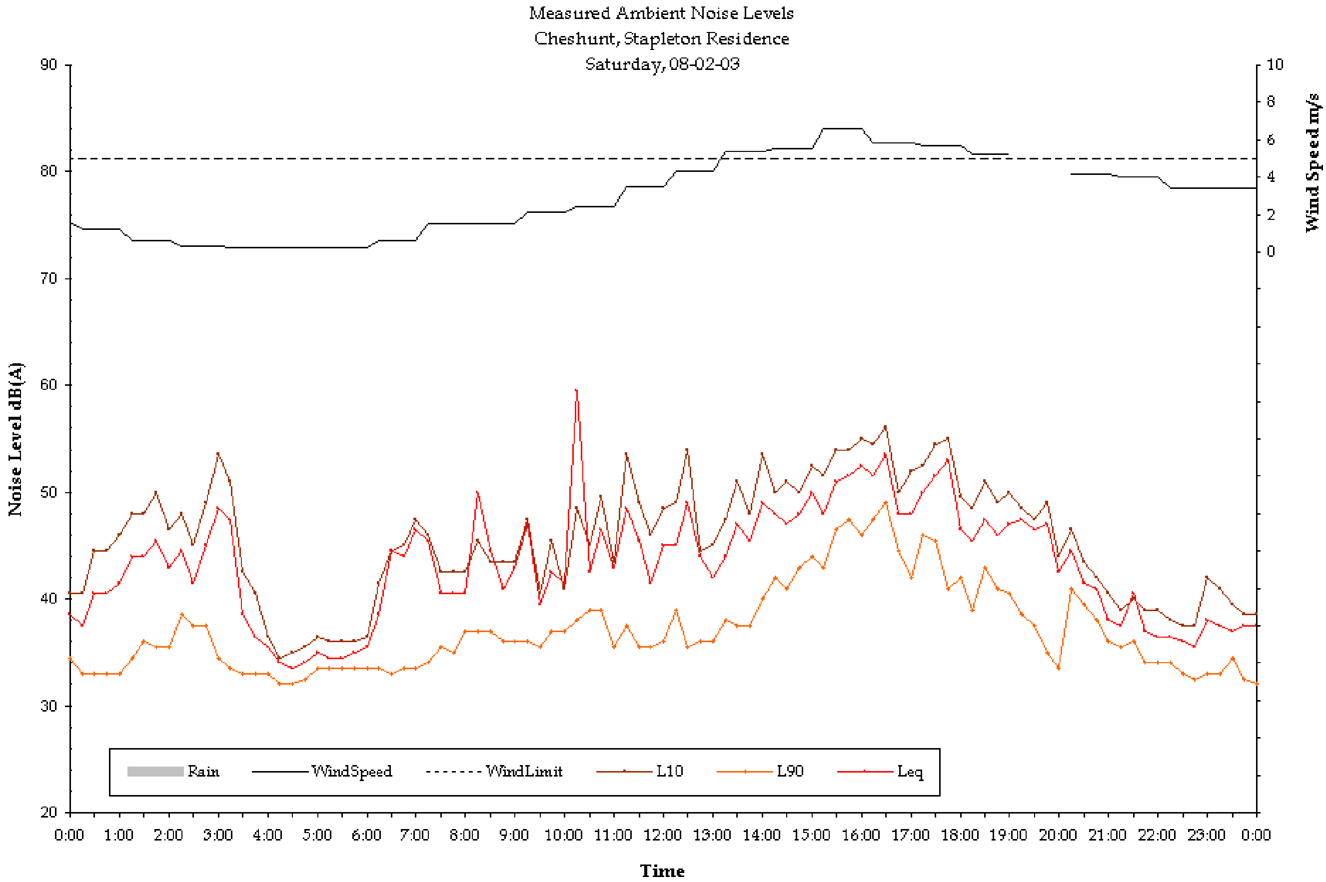
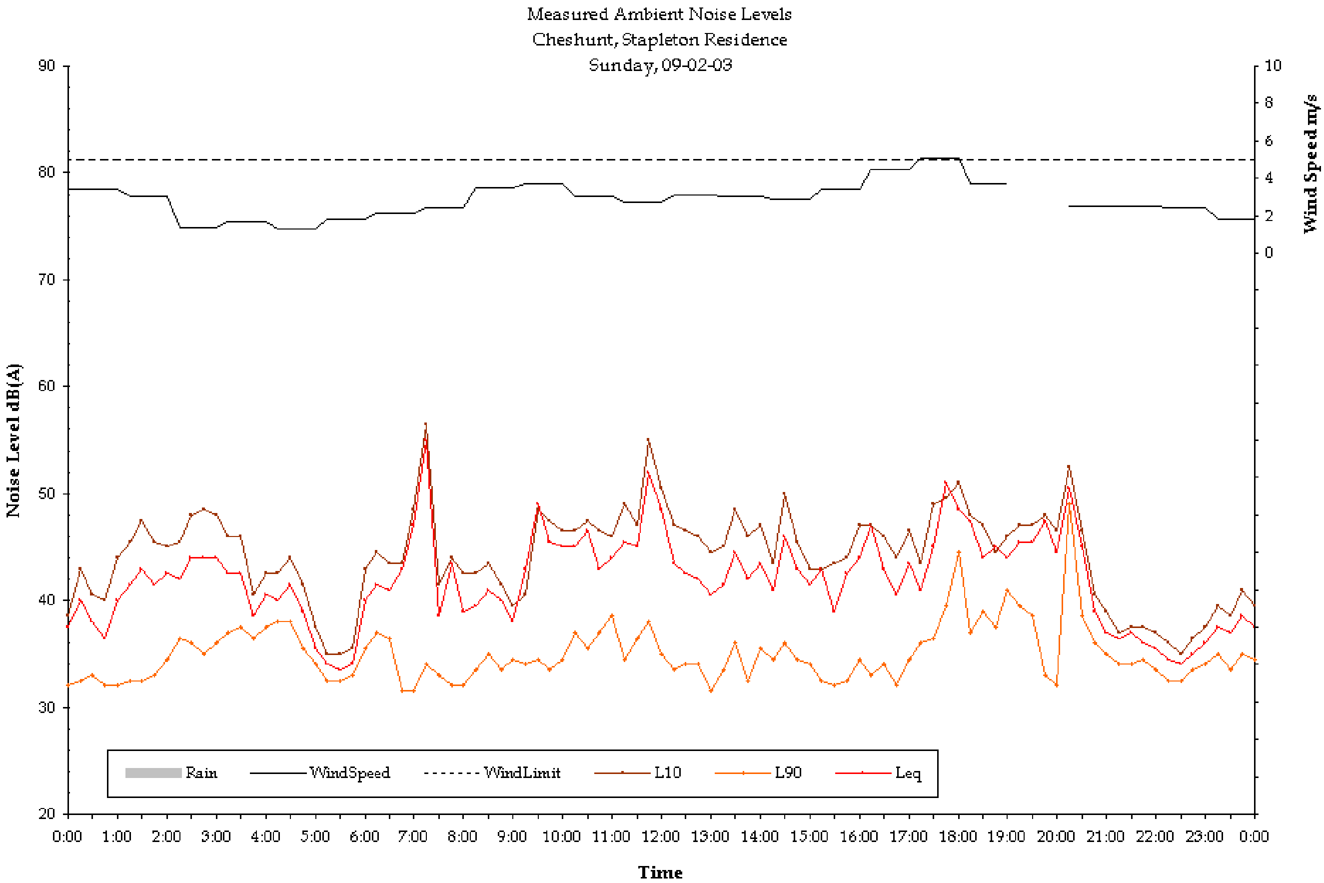
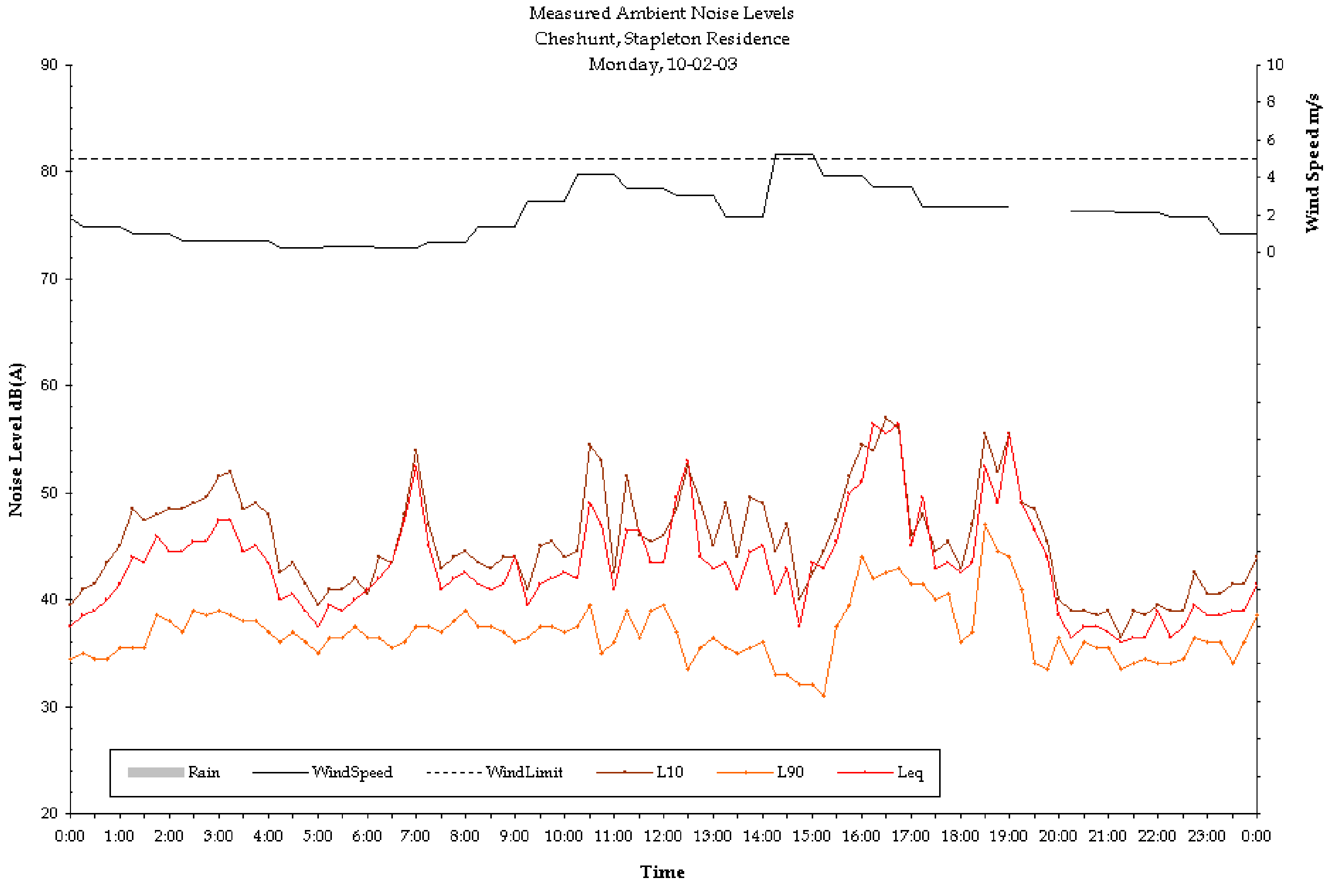

Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Saturday, 08-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Sunday, 09-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Monday, 10-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
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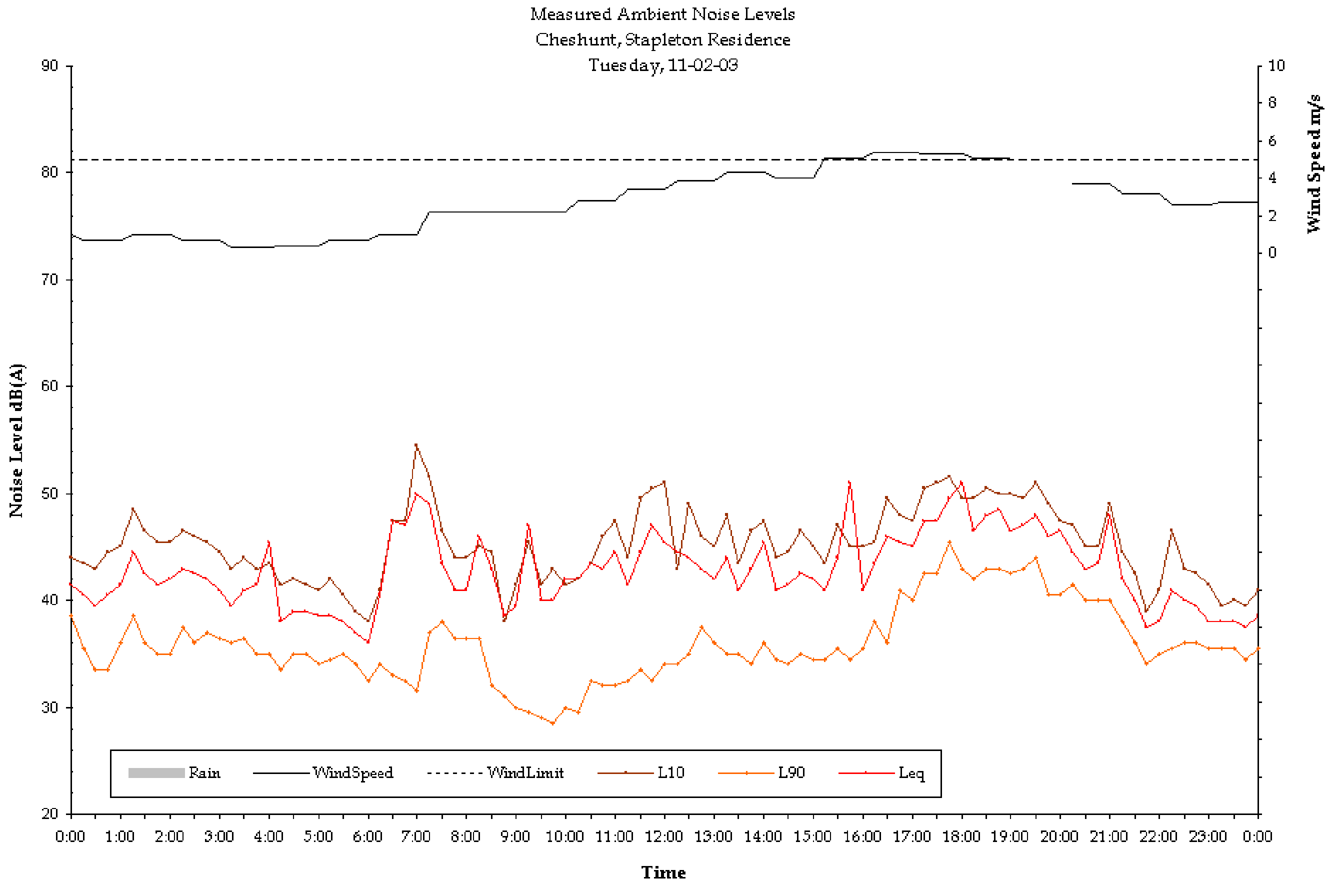
Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Tuesday, 11-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
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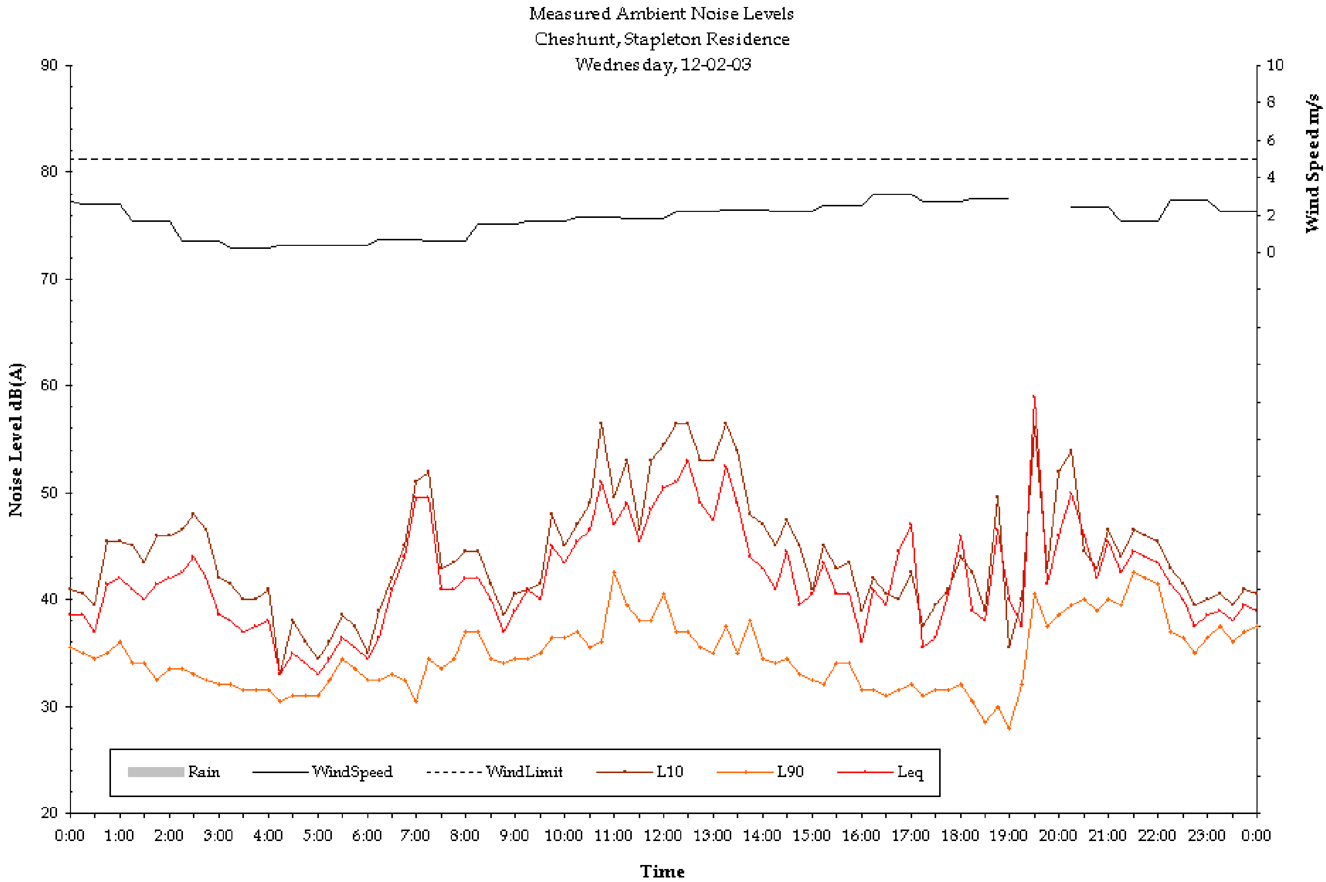
Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Wednesday, 12-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
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Leq
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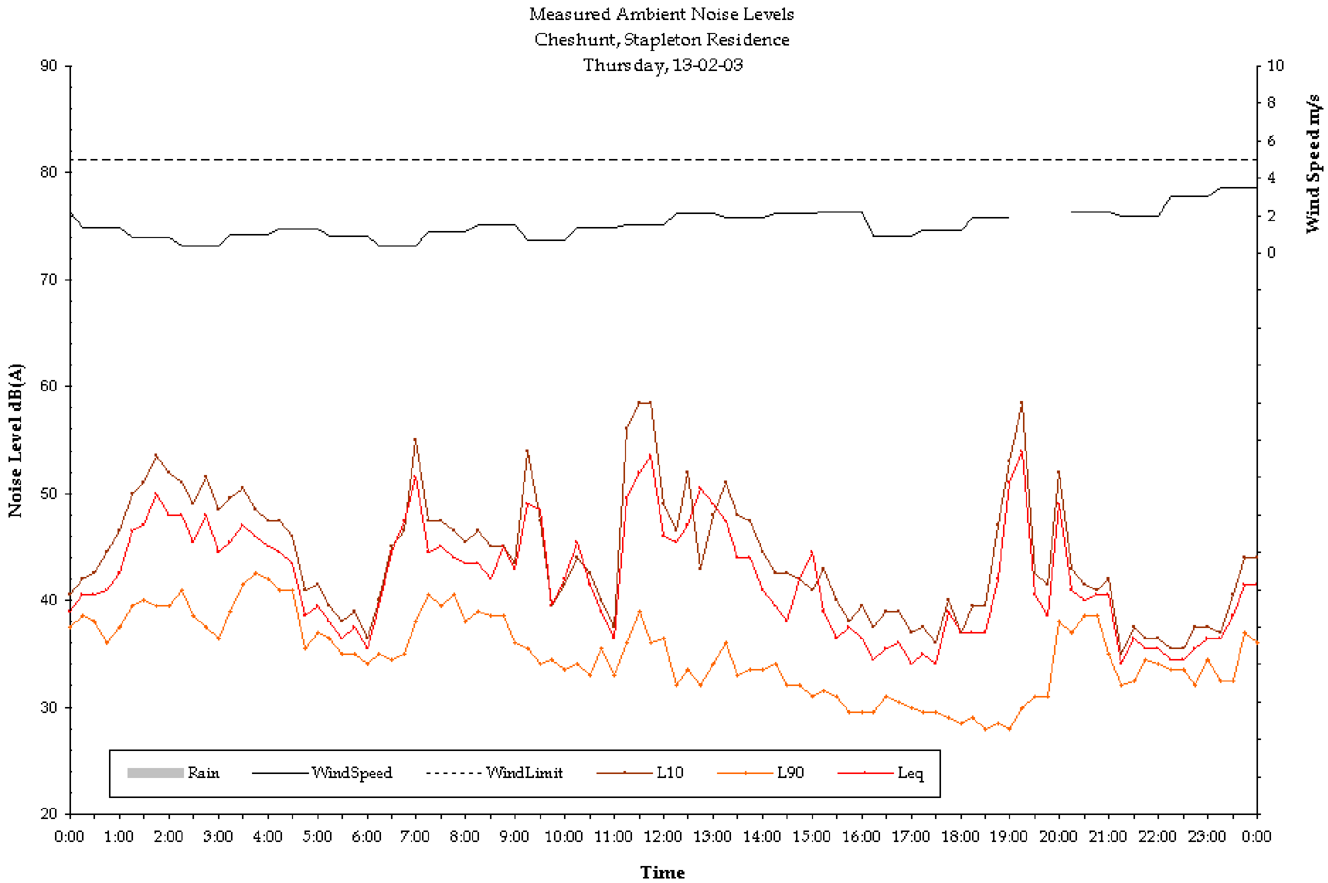
Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Thursday, 13-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
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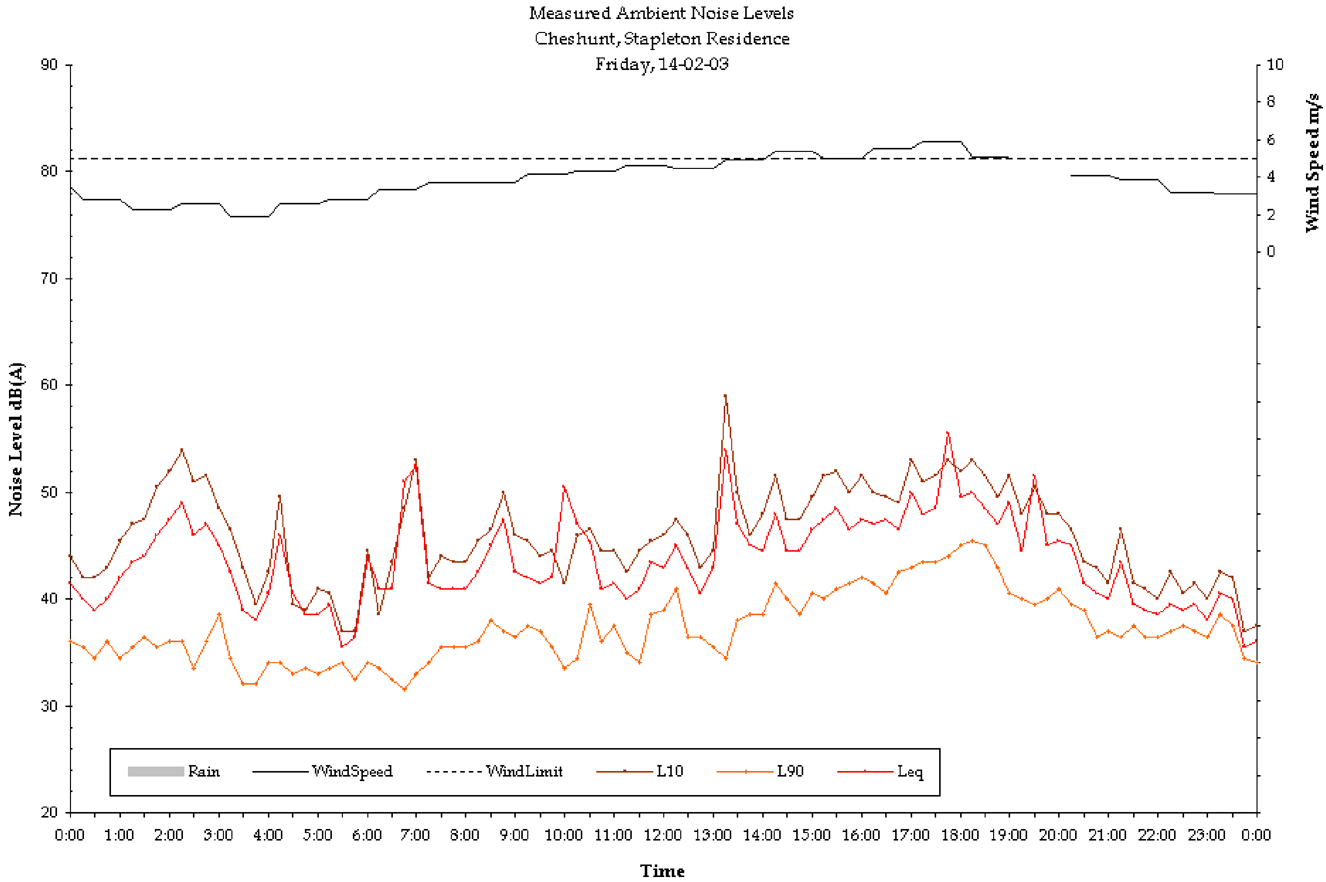
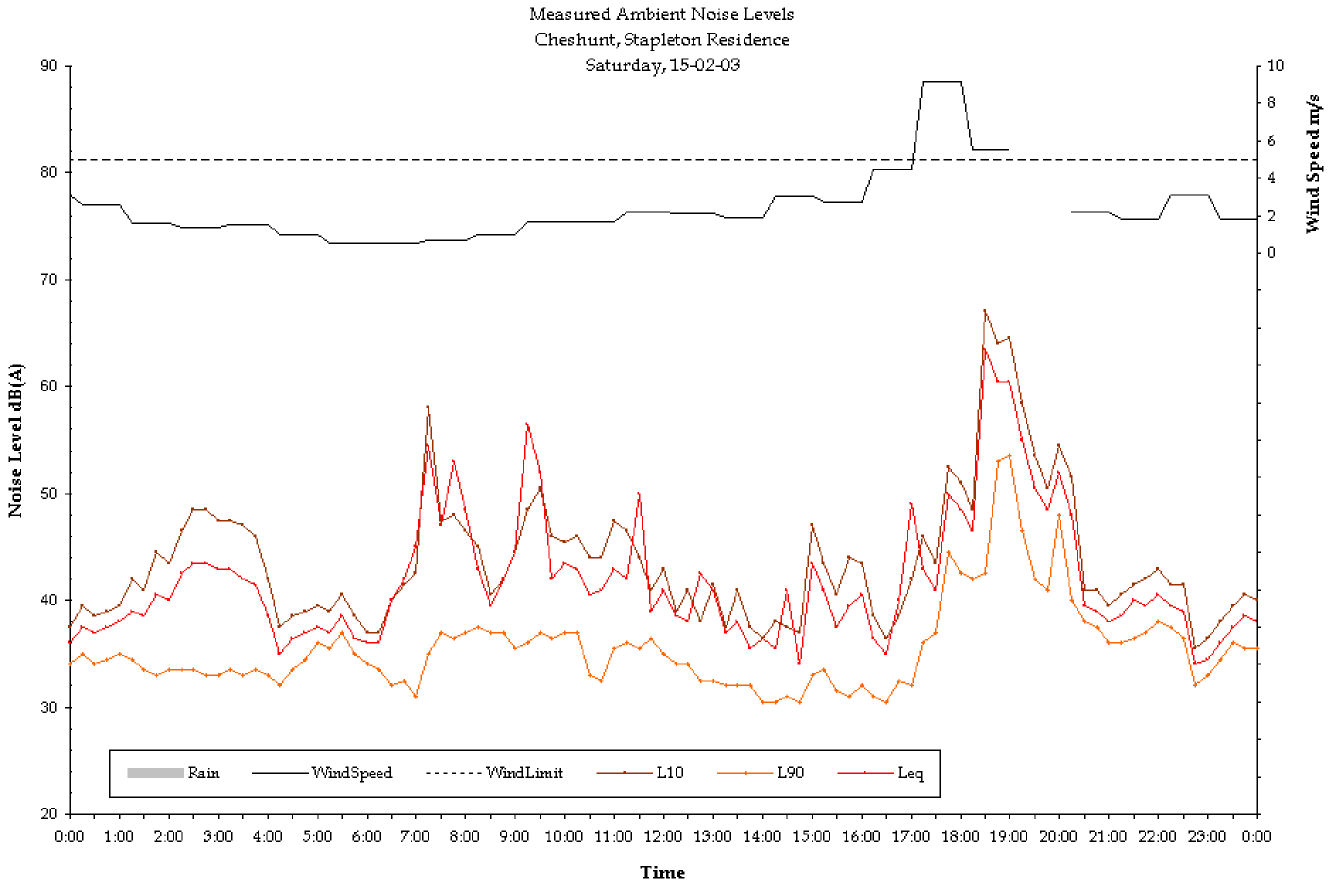
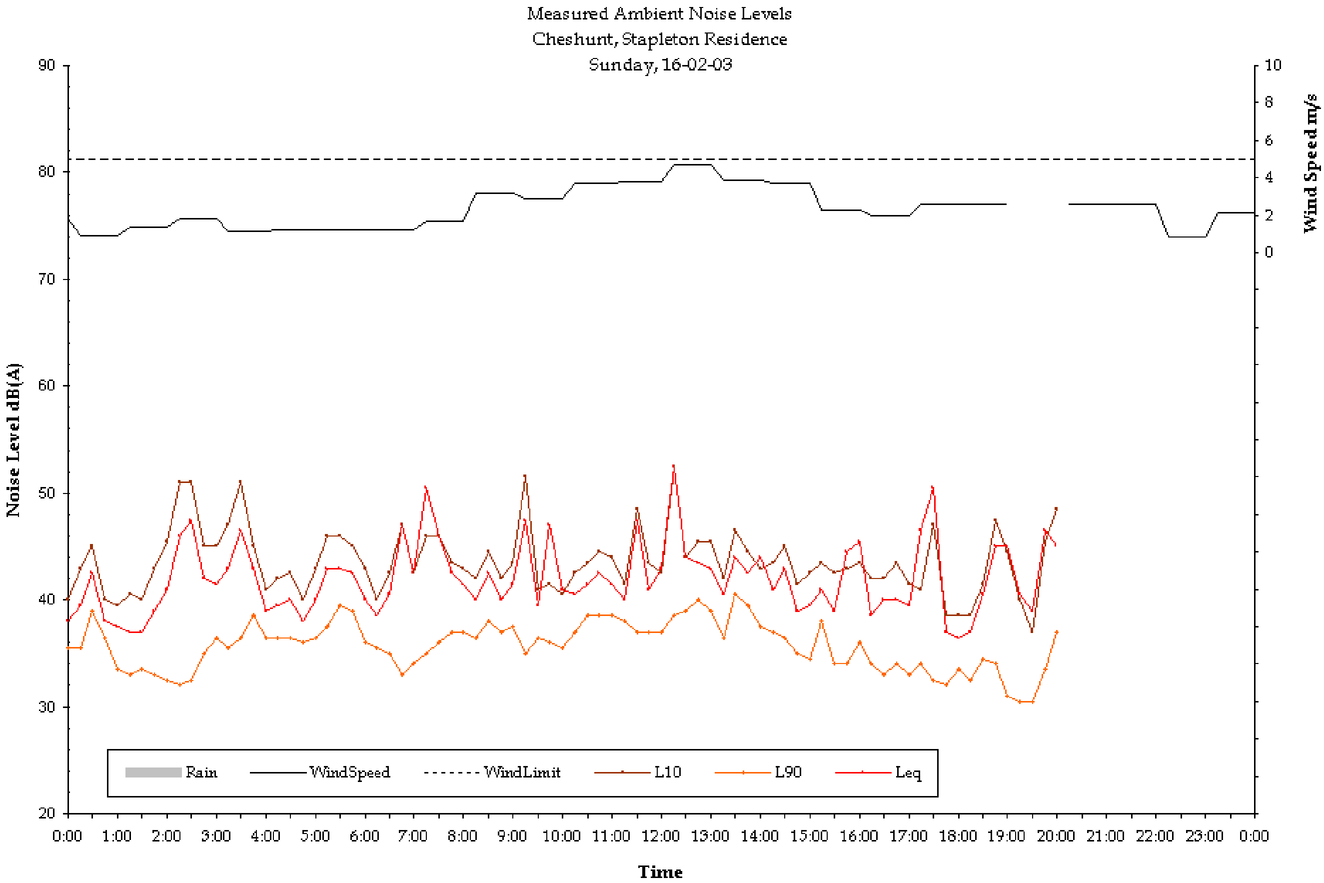


Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Friday, 14-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq



Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Saturday, 15-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
Cheshunt, Stapleton Residence
Sunday, 16-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
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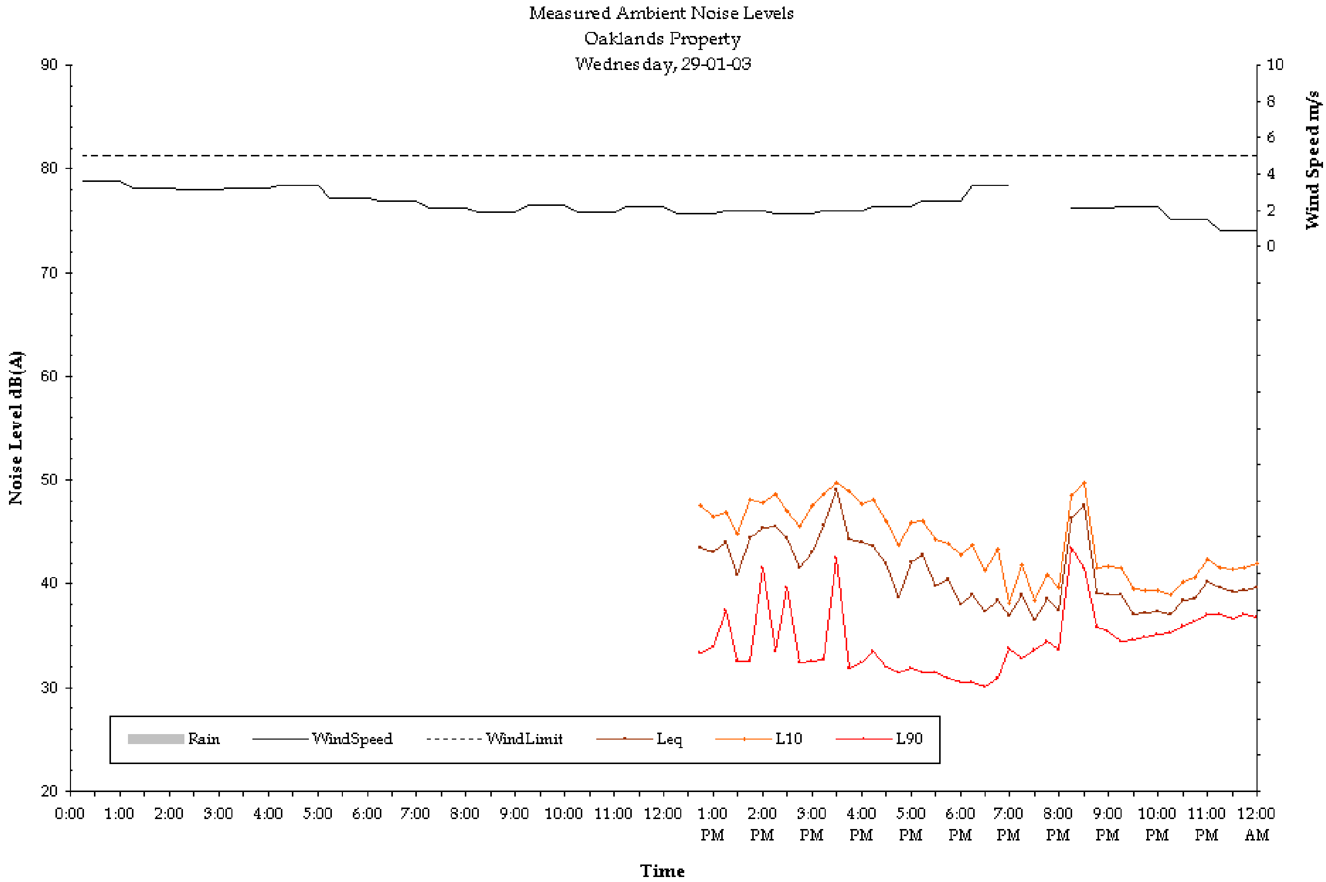
A.2 *MEASUREMENT AT LOCATION N3 - OAKLANDS, LEMINGTON*

Table A.1 Summary of Daily Noise Levels Measured at Location N3 (Oaklands, Lemington)

Date	**Assessment Background Level dB(A)L_{90}**			**Ambient Noise Levels dB(A)$L_{eq,period}$**		
	Day	**Evening**	**Night**	**Day $L_{eq,11hr}$**	**Evening $L_{eq,4hr}$**	**Night $L_{eq,9hr}$**
Wednesday, 29-01-03	-	30.5	36.7	-	40.8	42
Thursday, 30-01-03	-	-	33.7	-	-	41
Friday, 31-01-03	-	-	-	-	-	-
Saturday, 01-02-03	38.7	-	35.5	-	-	40.7
Sunday, 02-02-03	34.9		32.8	-	-	40.5
Monday, 03-02-03	35.7	33.3	34.6	-	44.1	38.5
Tuesday, 04-02-03	35.9	-	33.9	-	-	39.2
Wednesday, 05-02-03	34.8	34.1	36.7	46.7	45.1	42.9
Thursday, 06-02-03	33.6	-	35.8	-	-	39.9
Friday, 07-02-03	32.7	33.1	33.9	46.4	40.6	39.7
Saturday, 08-02-03	35	-	36	-	-	40.3
Sunday, 09-02-03	33.4	31.6	32.2	51.9	43.6	40.1
Monday, 10-02-03	-	-	-	-	-	-
(RBL)	35	33	35			
Average L_{eq}				49	43	41

Notes: 1. “-“ denotes periods excluded due to weather or insufficient data

.


Measured Ambient Noise Levels
Oaklands Property
Wednesday, 29-01-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
Leq
L10
L90
0:00
1:00
2:00
3:00
4:00
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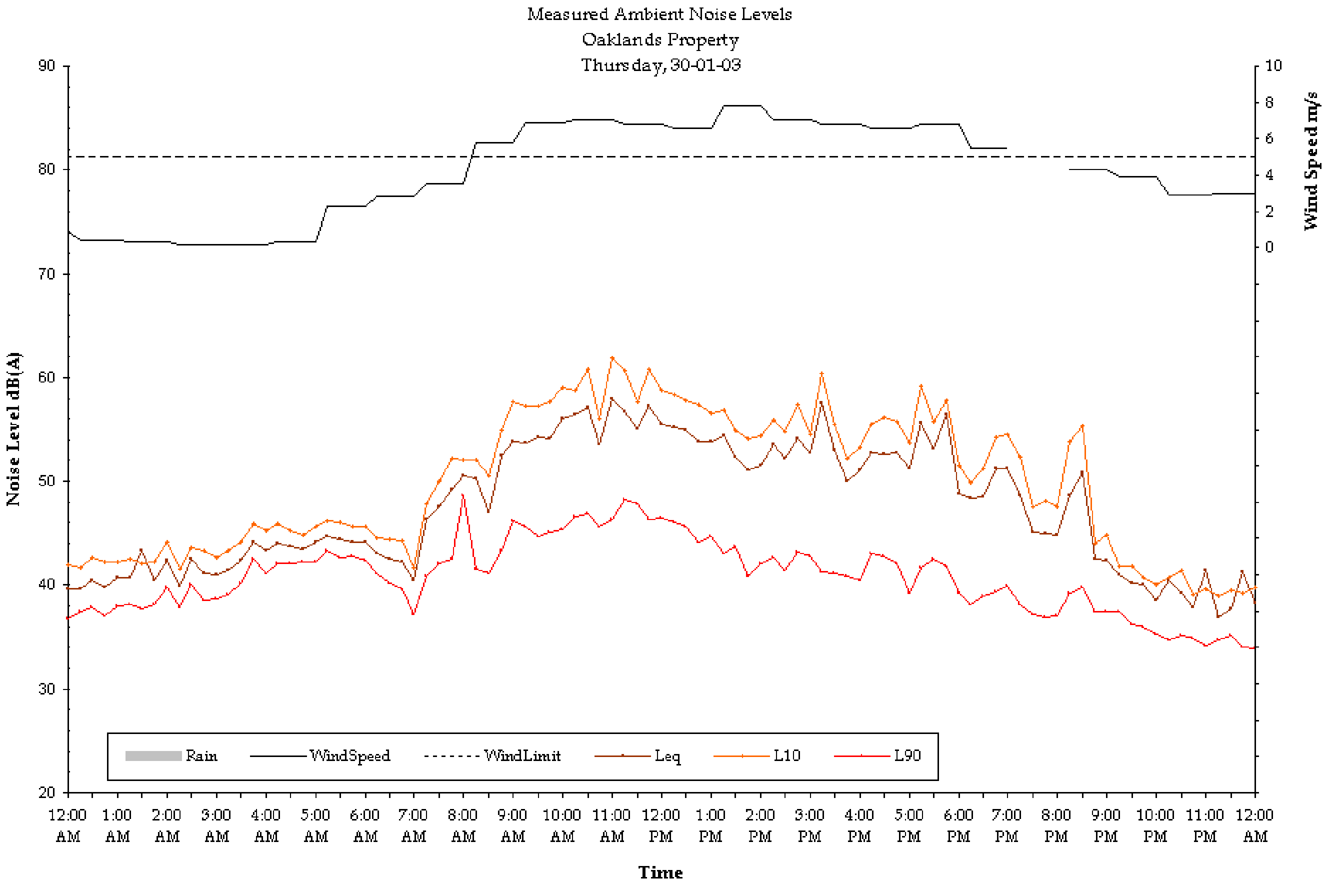
Measured Ambient Noise Levels
Oaklands Property
Thursday, 30-01-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
Leq
L10
L90
12:00 AM
1:00 AM
2:00 AM
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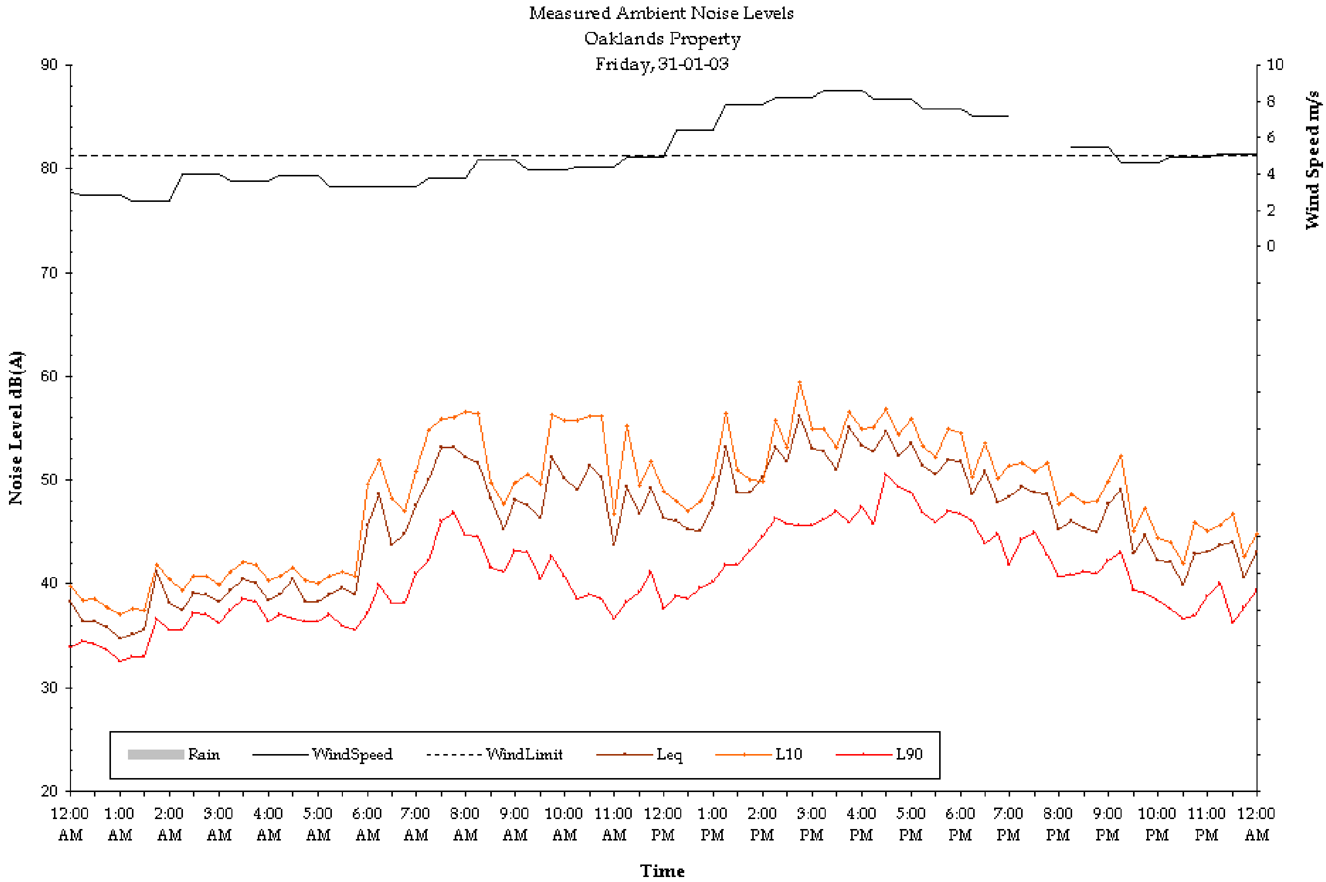
Measured Ambient Noise Levels
Oaklands Property
Friday, 31-01-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
Leq
L10
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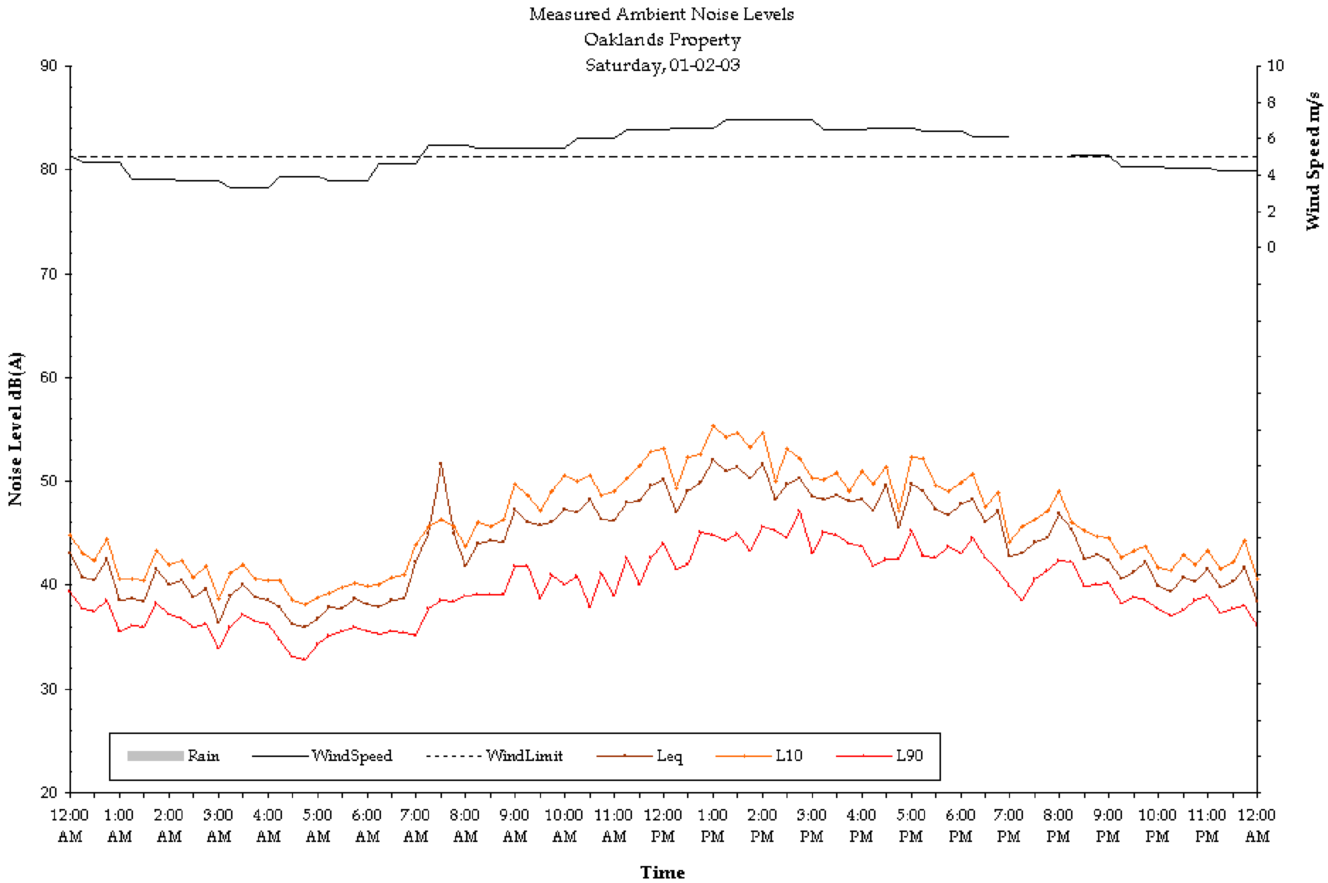
Measured Ambient Noise Levels
Oaklands Property
Saturday, 01-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
Leq
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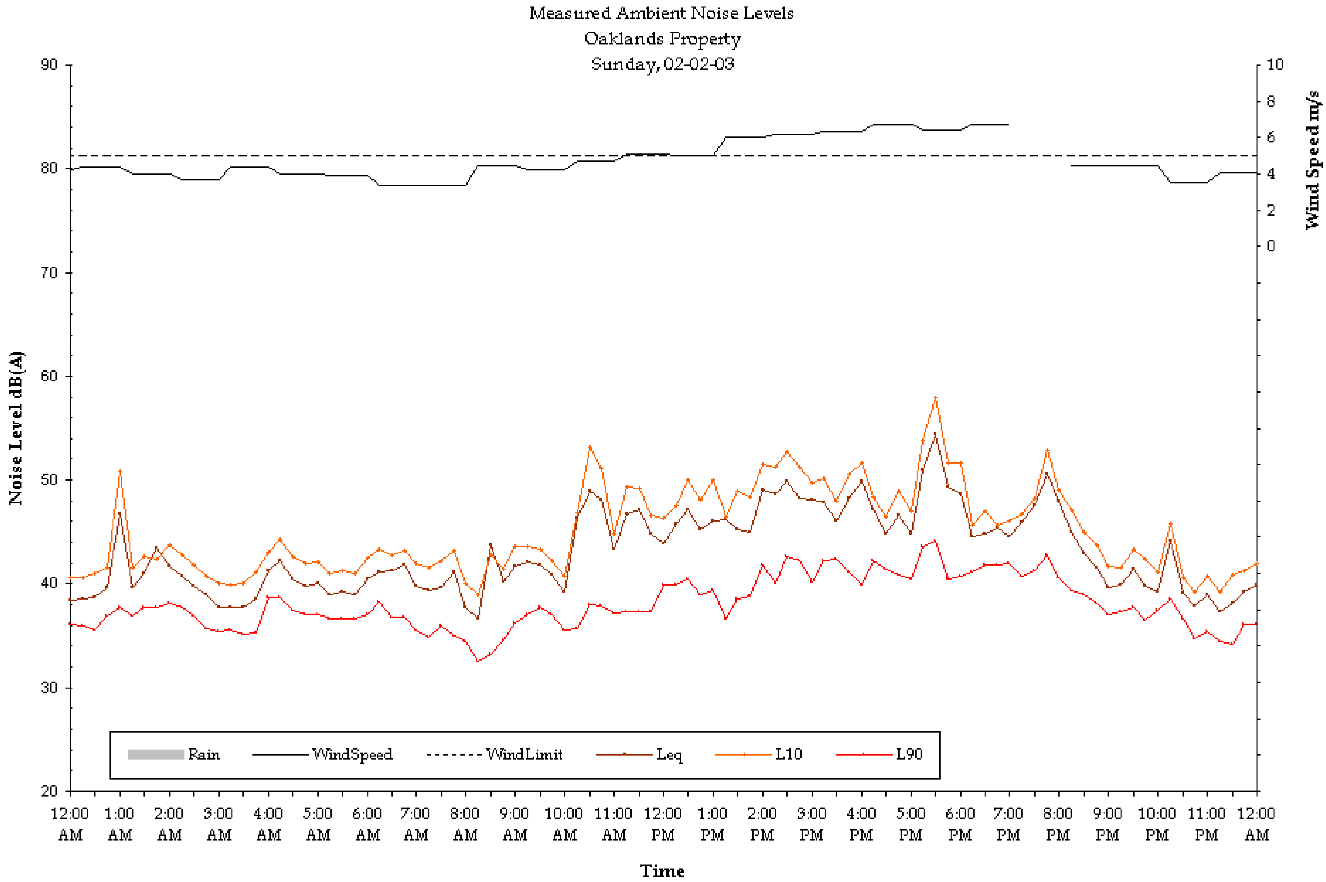

Measured Ambient Noise Levels
Oaklands Property
Sunday, 02-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
Leq
L10
L90
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
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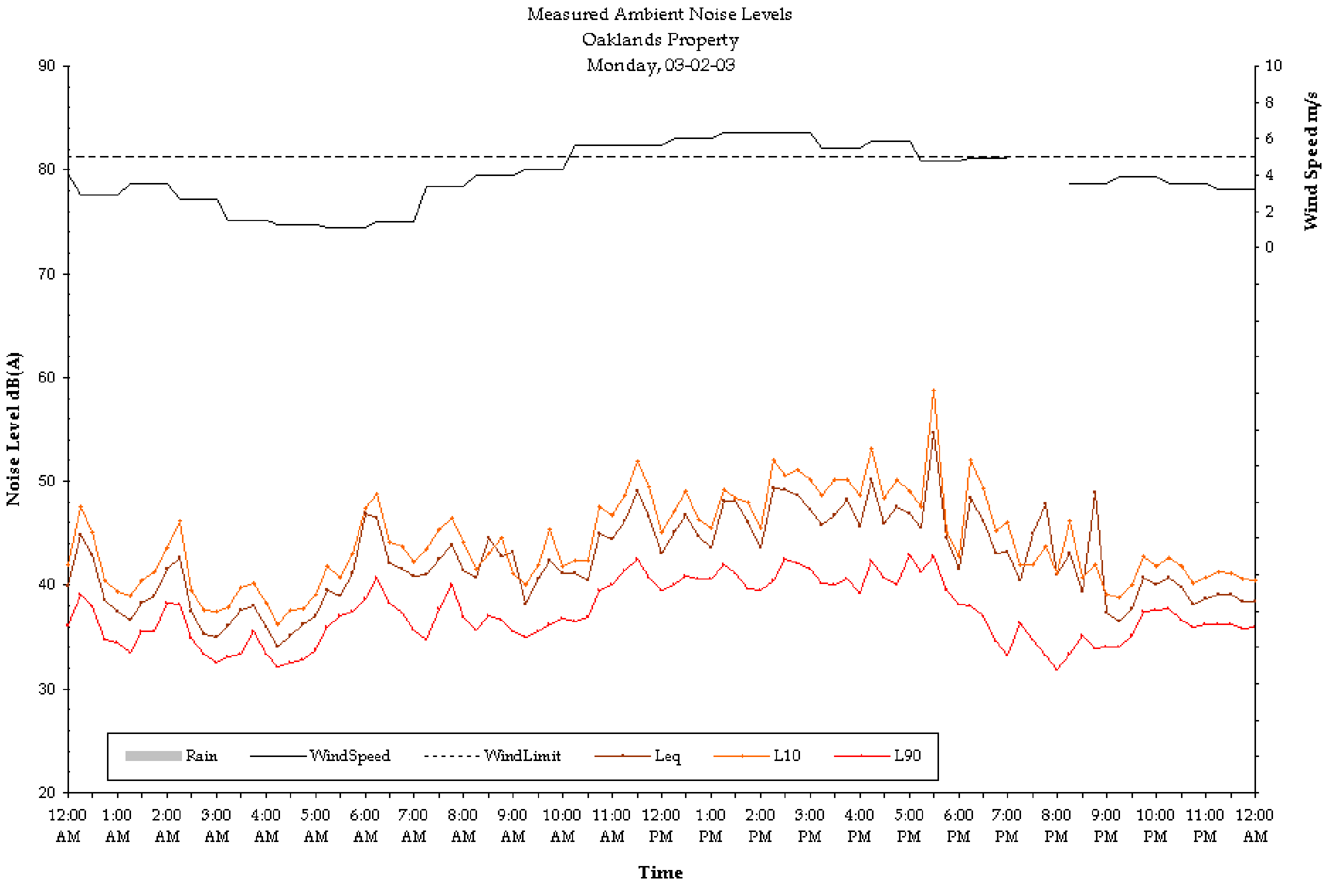

Measured Ambient Noise Levels
Oaklands Property
Monday, 03-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
Leq
L10
L90
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
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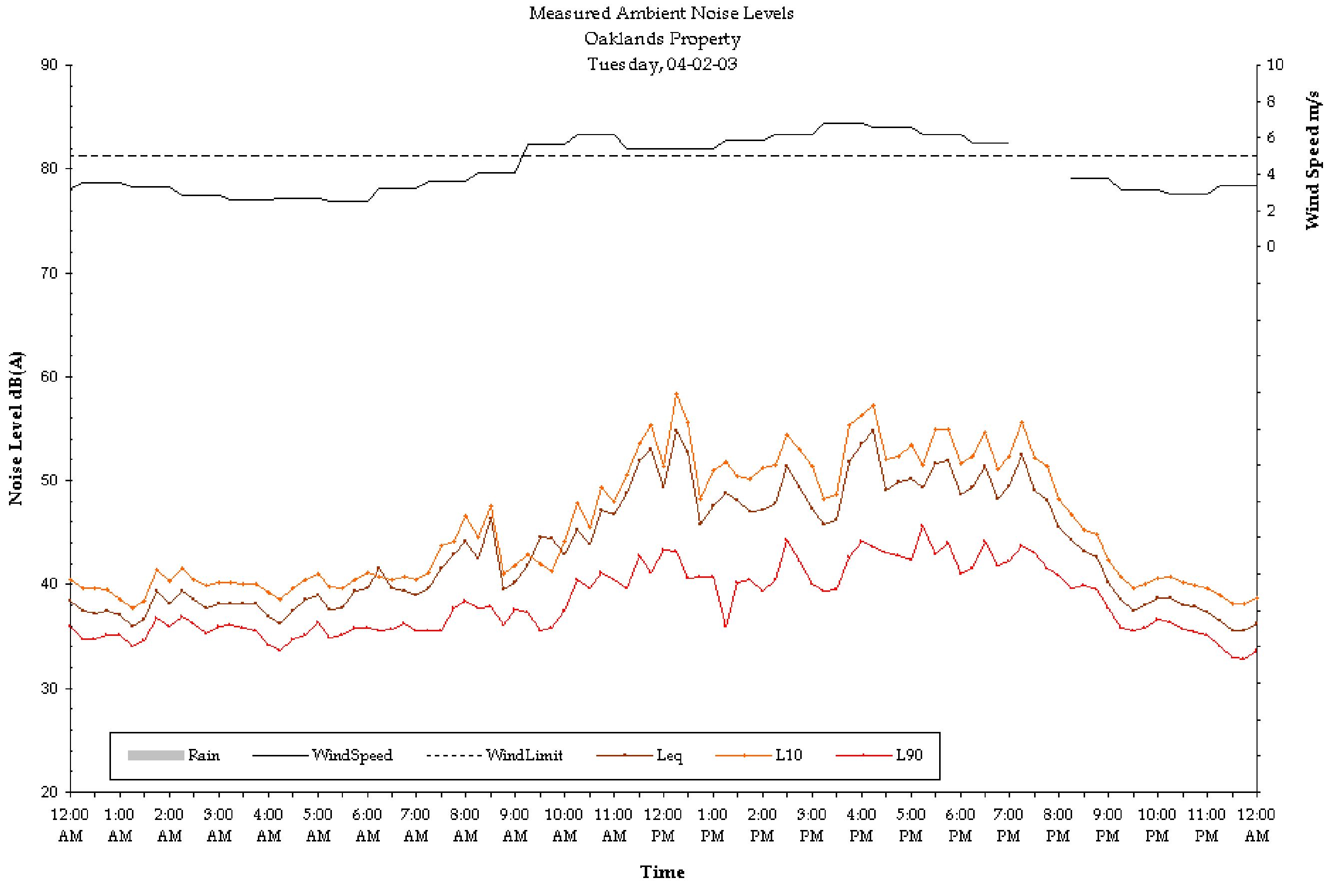
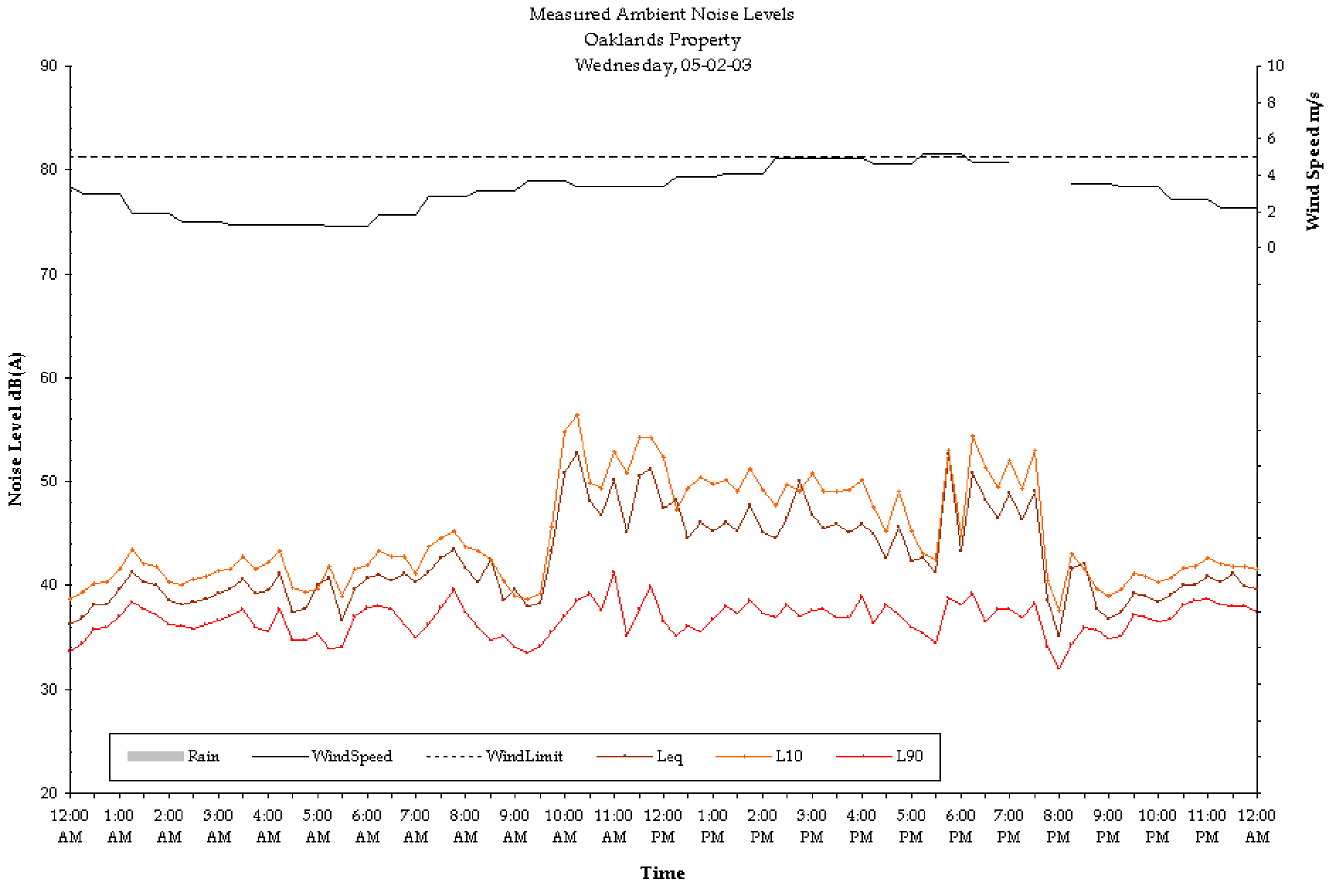
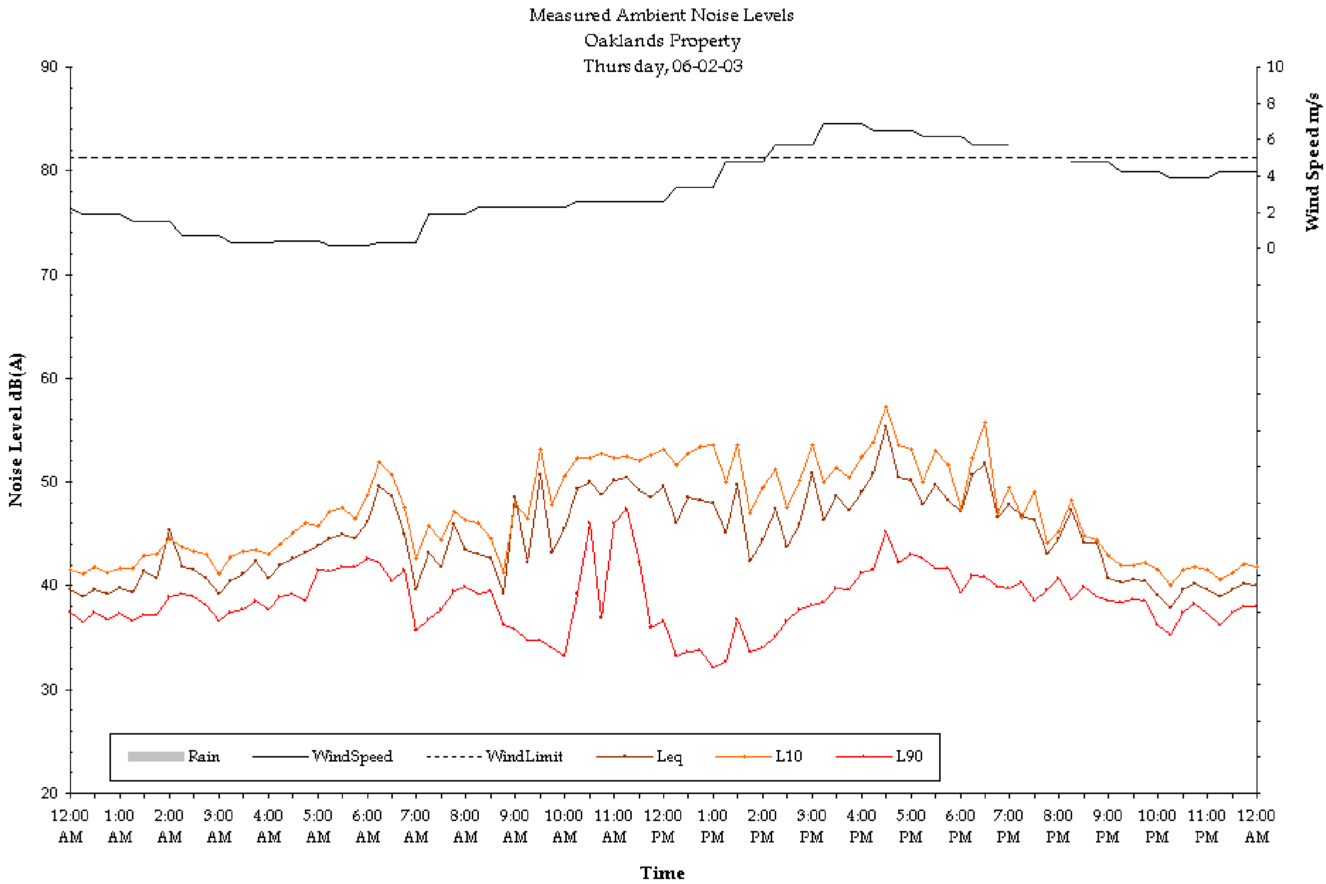


Measured Ambient Noise Levels
Oaklands Property
Tuesday, 04-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
Leq
L10
L90
Time



Measured Ambient Noise Levels
Oaklands Property
Wednesday, 05-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
Leq
L10
L90
Time


Measured Ambient Noise Levels
Oaklands Property
Thursday, 06-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
Leq
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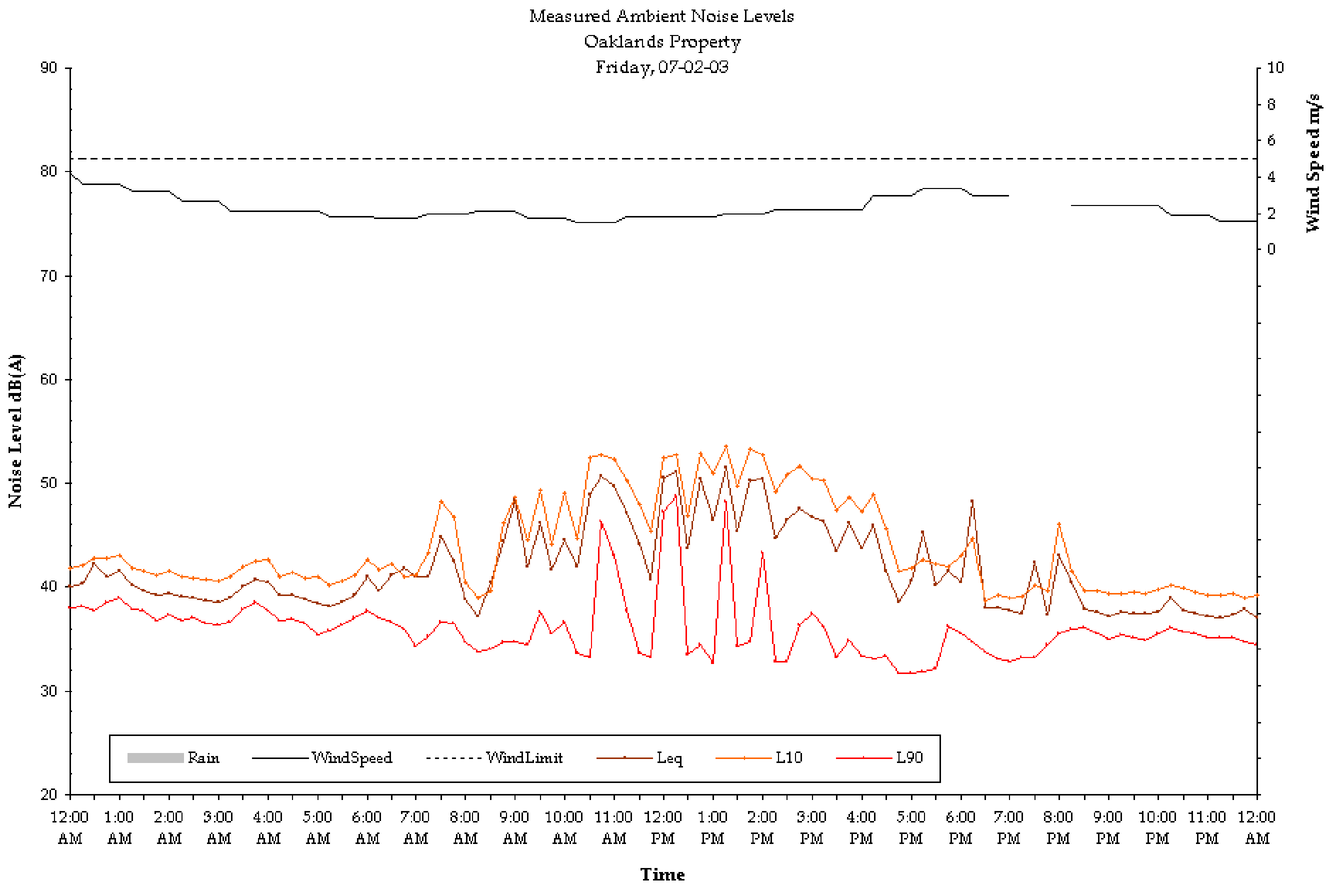
Measured Ambient Noise Levels
Oaklands Property
Friday, 07-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
Leq
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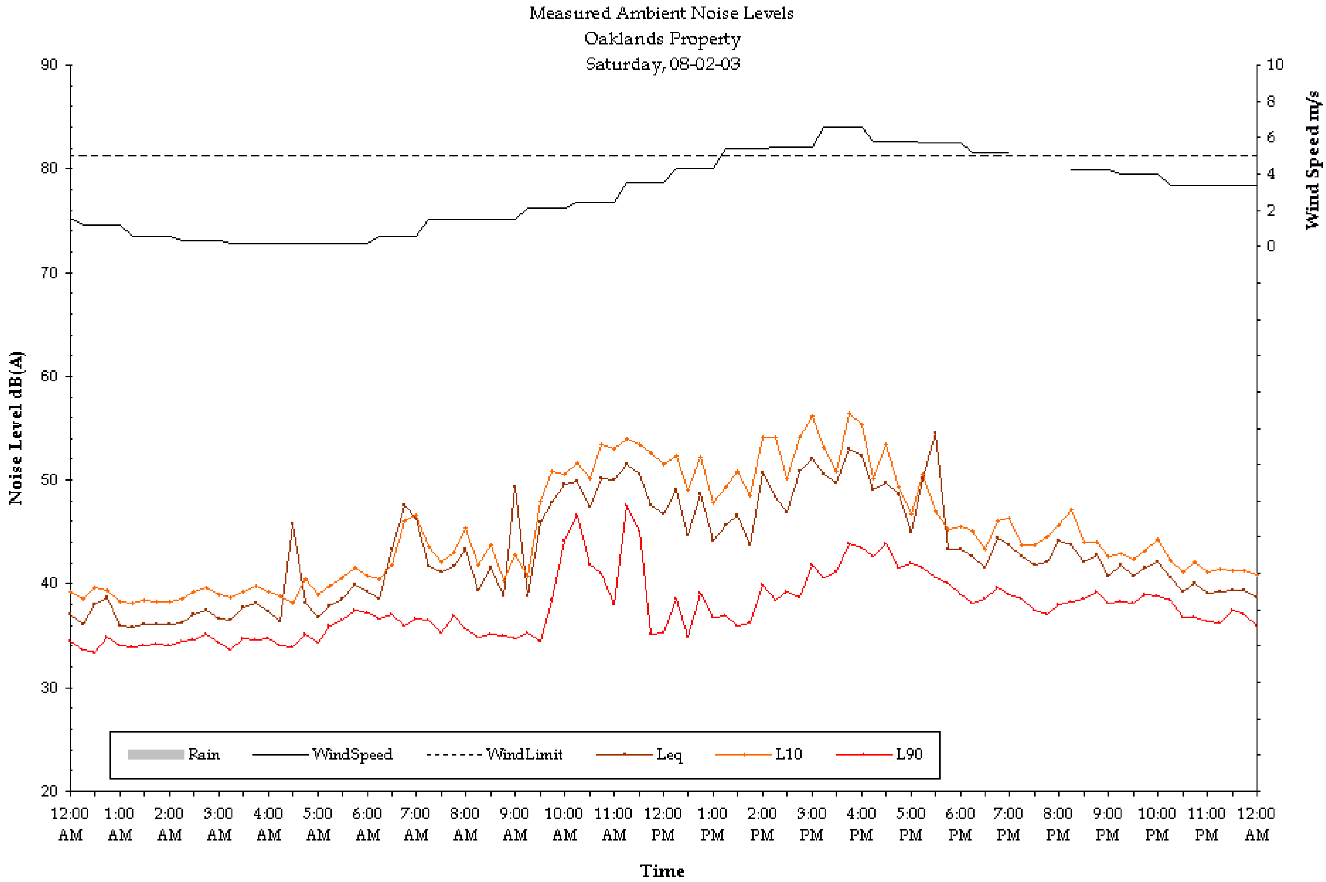

Measured Ambient Noise Levels
Oaklands Property
Saturday, 08-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
Leq
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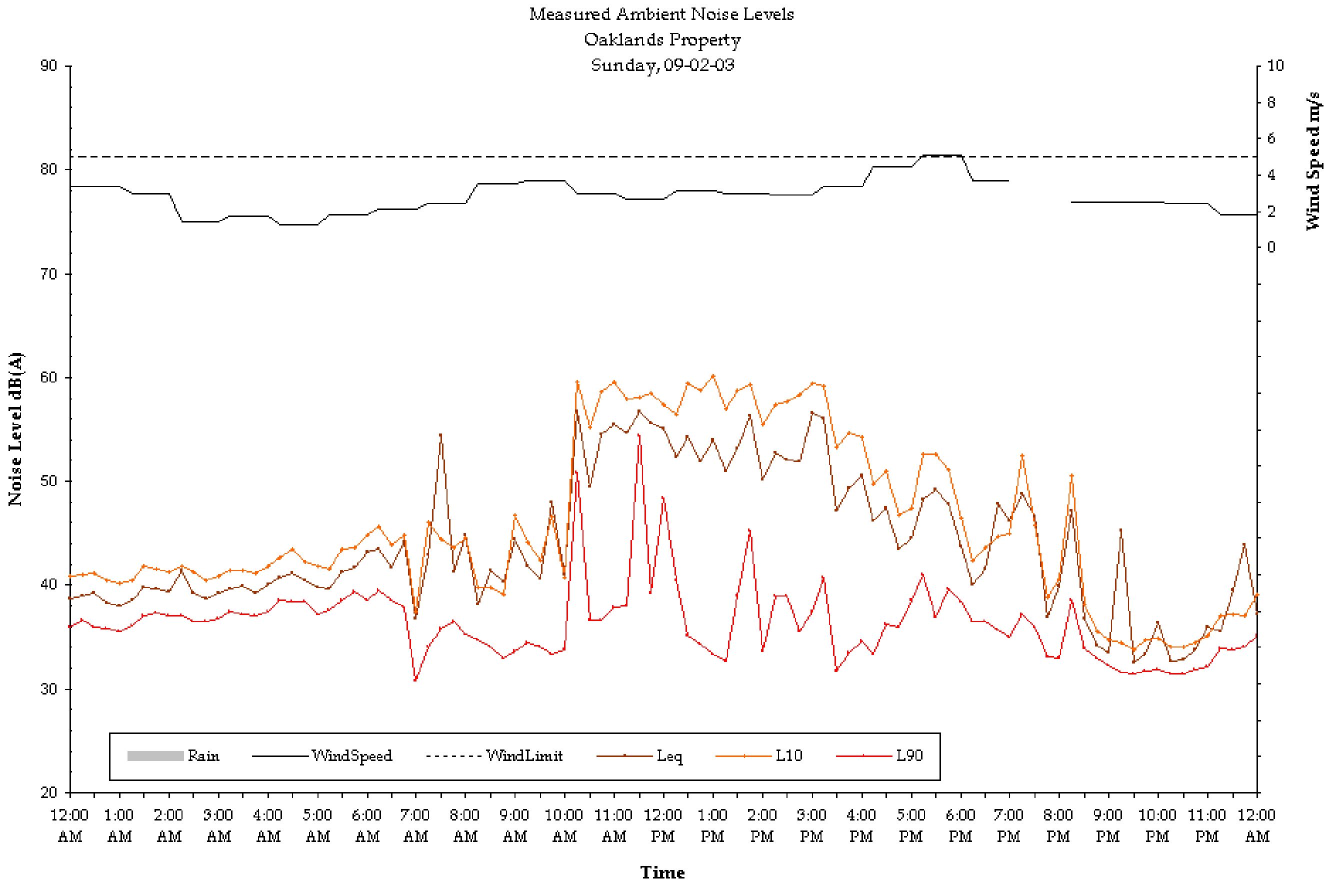
Time



Measured Ambient Noise Levels
Oaklands Property
Sunday, 09-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
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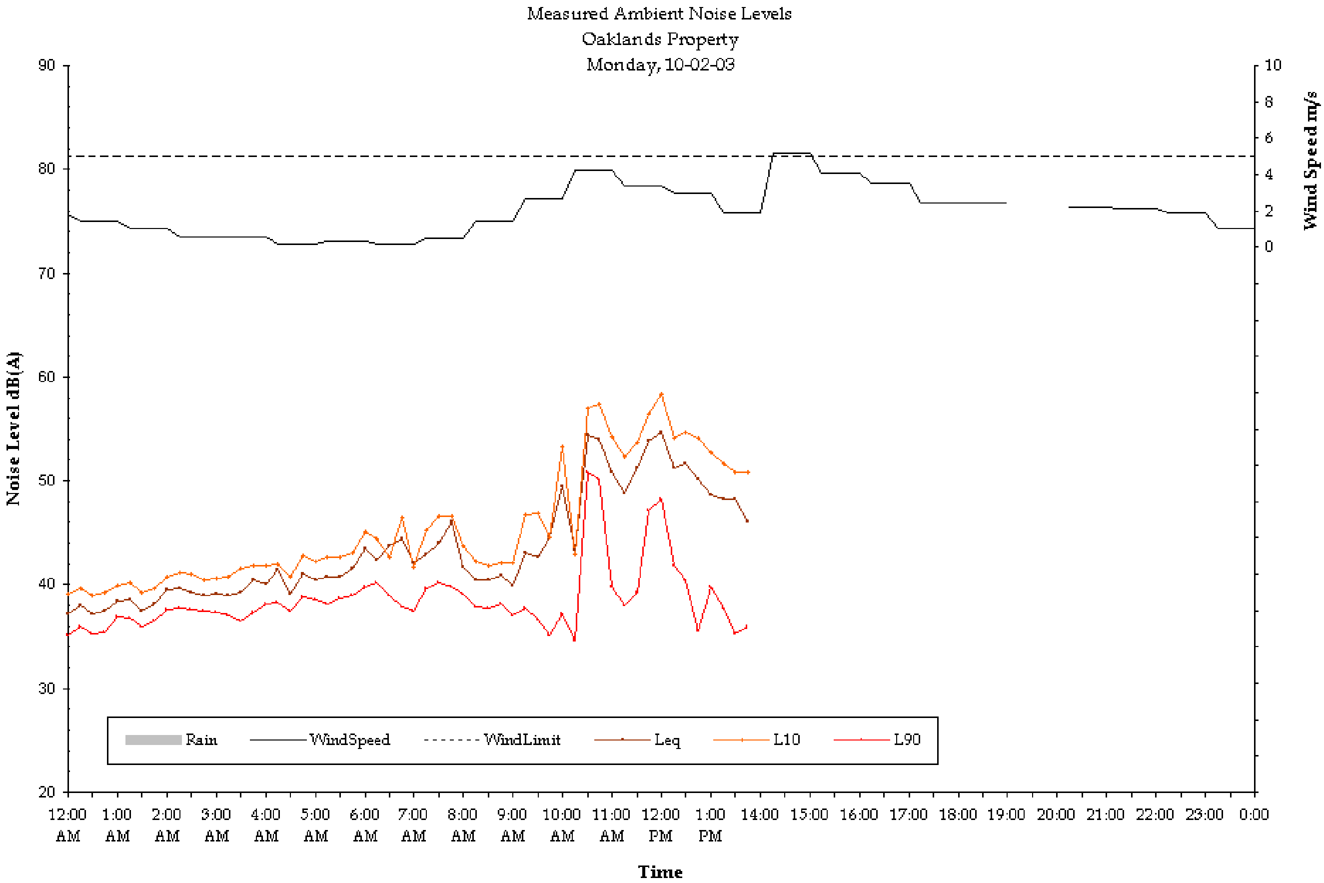
Time


Measured Ambient Noise Levels
Oaklands Property
Monday, 10-02-03
Noise Level dB(A)
Wind Speed m/s
90
80
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Time

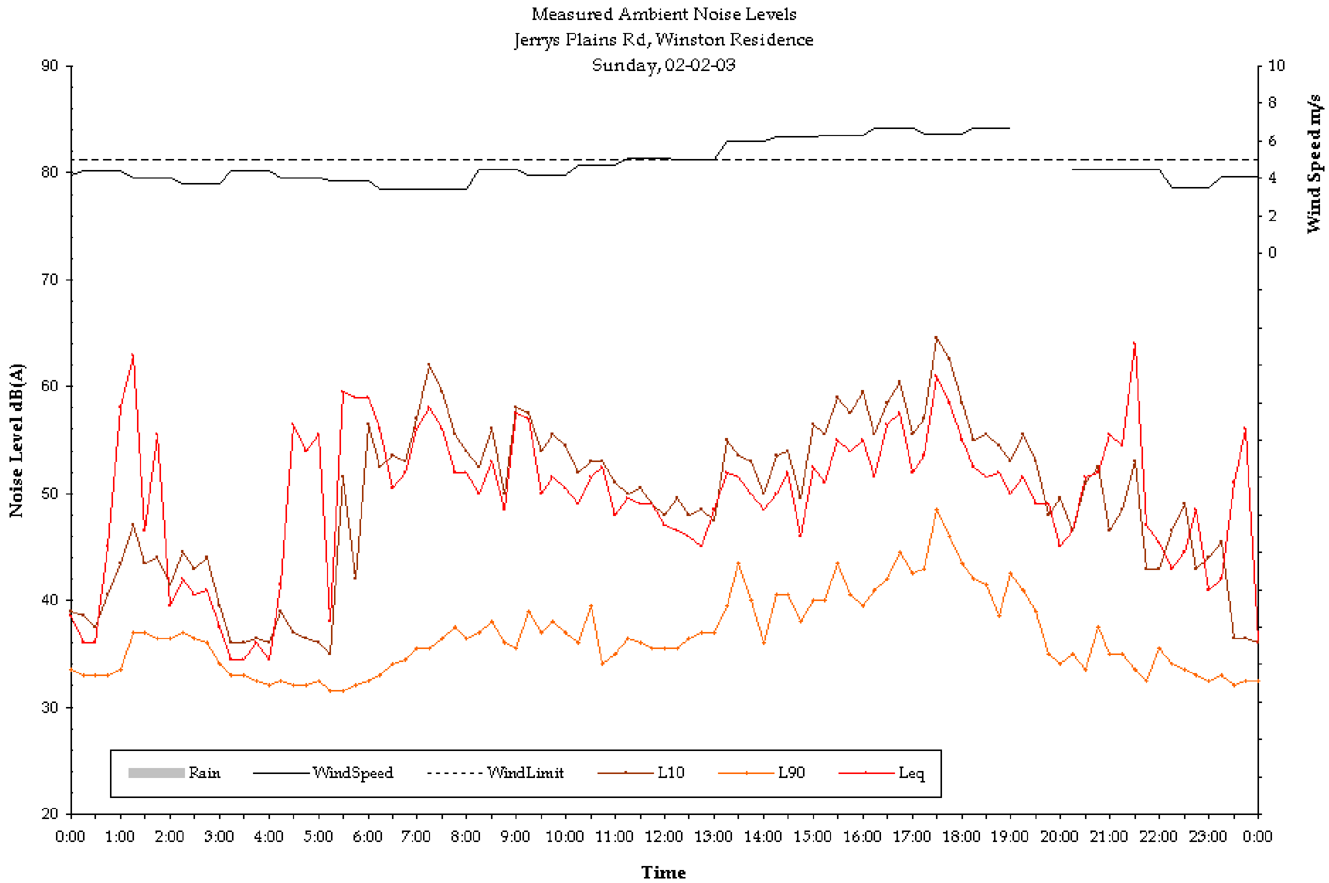
A.3 *MEASUREMENT LOCATION N4 - WINSTON, JERRYS PLAINS ROAD*

Table A.2 ***Summary of daily noise levels measured at Location N4 (Winston, Jerrys Plains Road)***

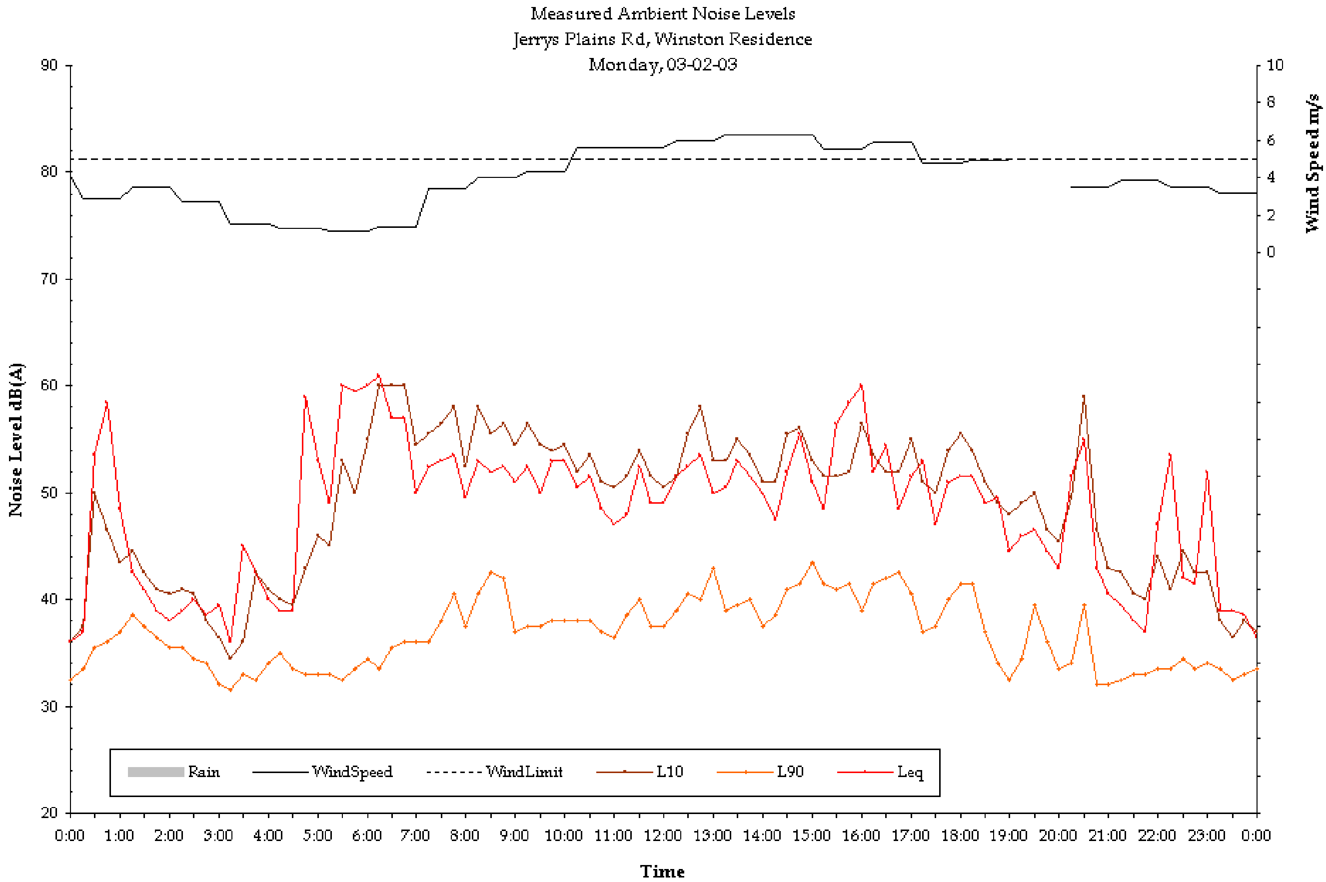
Date	Assessment Background Level dB(A)L_{90}			Ambient Noise Levels dB(A)$L_{eq,period}$		
	Day	**Evening**	**Night**	**Day** $L_{eq,11hr}$	**Evening** $L_{eq,4hr}$	**Night** $L_{eq,9hr}$
Friday, 31-01-03	-	-	18.5	-	-	18.5
Saturday, 01-02-03	-	-	32	-	-	53.4
Sunday, 02-02-03	-	-	32.5	-	-	53.6
Monday, 03-02-03		32	33.5	-	48.1	52.9
Tuesday, 04-02-03	-	-	33.5	-	-	53
Wednesday, 05-02-03	32.5	33	28.5	-	50.8	52.7
Thursday, 06-02-03	-	-	30	-	-	51.3
Friday, 07-02-03	30.5	32	29	52.1	49.9	51.7
Saturday, 08-02-03	-	-	29.5	-	-	51.6
Sunday, 09-02-03	31	31.5	30.5	-	46.8	51.6
Monday, 10-02-03	-	28.5	29	-	47.4	51.8
Tuesday, 11-02-03	32	-	30	-	-	50.9
Wednesday, 12-02-03	29	29	31	49.2	47.5	52.2
Thursday, 13-02-03	28	29.5	30	47.6	43.6	52.1
Friday, 14-02-03	35.5	-	31	-	-	53.8
Saturday, 15-02-03	-	-	-	-	-	-
Sunday, 16-02-03	-	-	31.5	-	-	51.2
Monday, 17-02-03	-	-	-	-	-	-
Tuesday, 18-02-03	-	32	31.5	-	52.6	52.1
Wednesday, 19-02-03	31	32.5	32.5	-	50.6	49.6
Thursday, 20-02-03	-	37.5	-	-	50.3	-
(RBL)	31	32	31			
Average L_{eq}				50	49	52

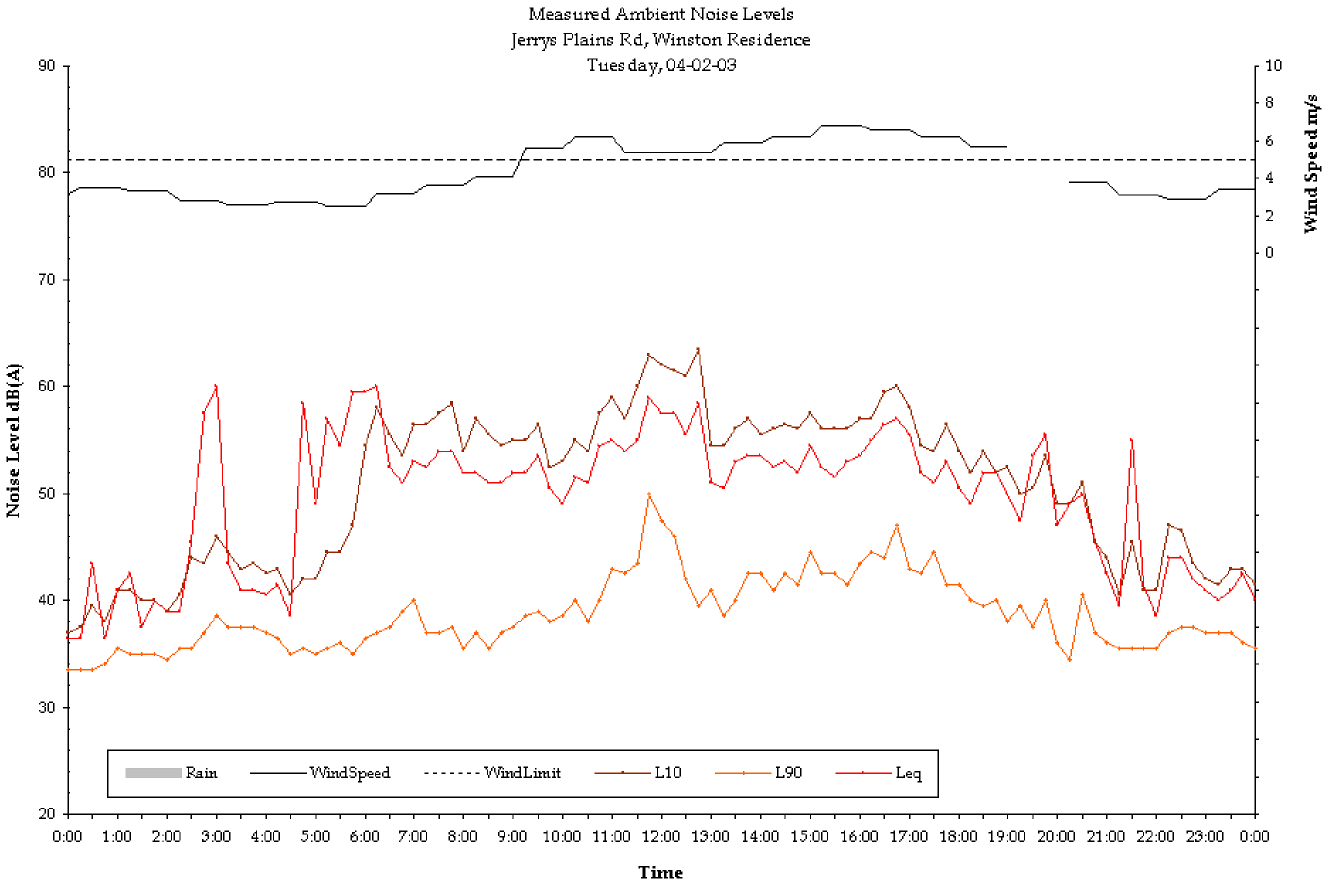
Notes: 1. “-“ denotes periods excluded due to weather or insufficient data.

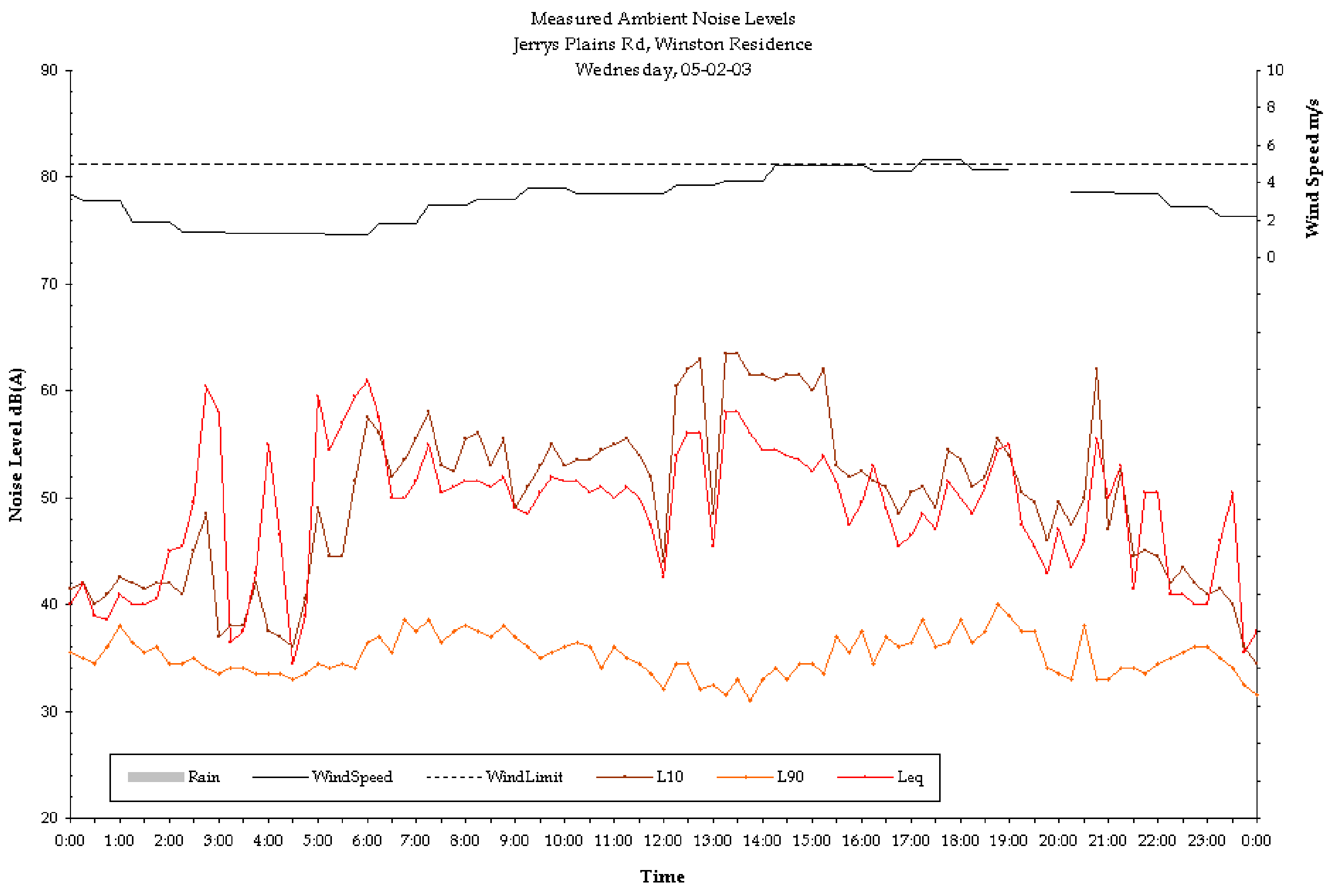
Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Saturday, 01-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq



Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Sunday, 02-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Monday, 03-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00
20 30 40 50 60 70 80 90
0 2 4 6 8 10


Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Tuesday, 04-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00
20 30 40 50 60 70 80 90
0 2 4 6 8 10


Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Wednesday, 05-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
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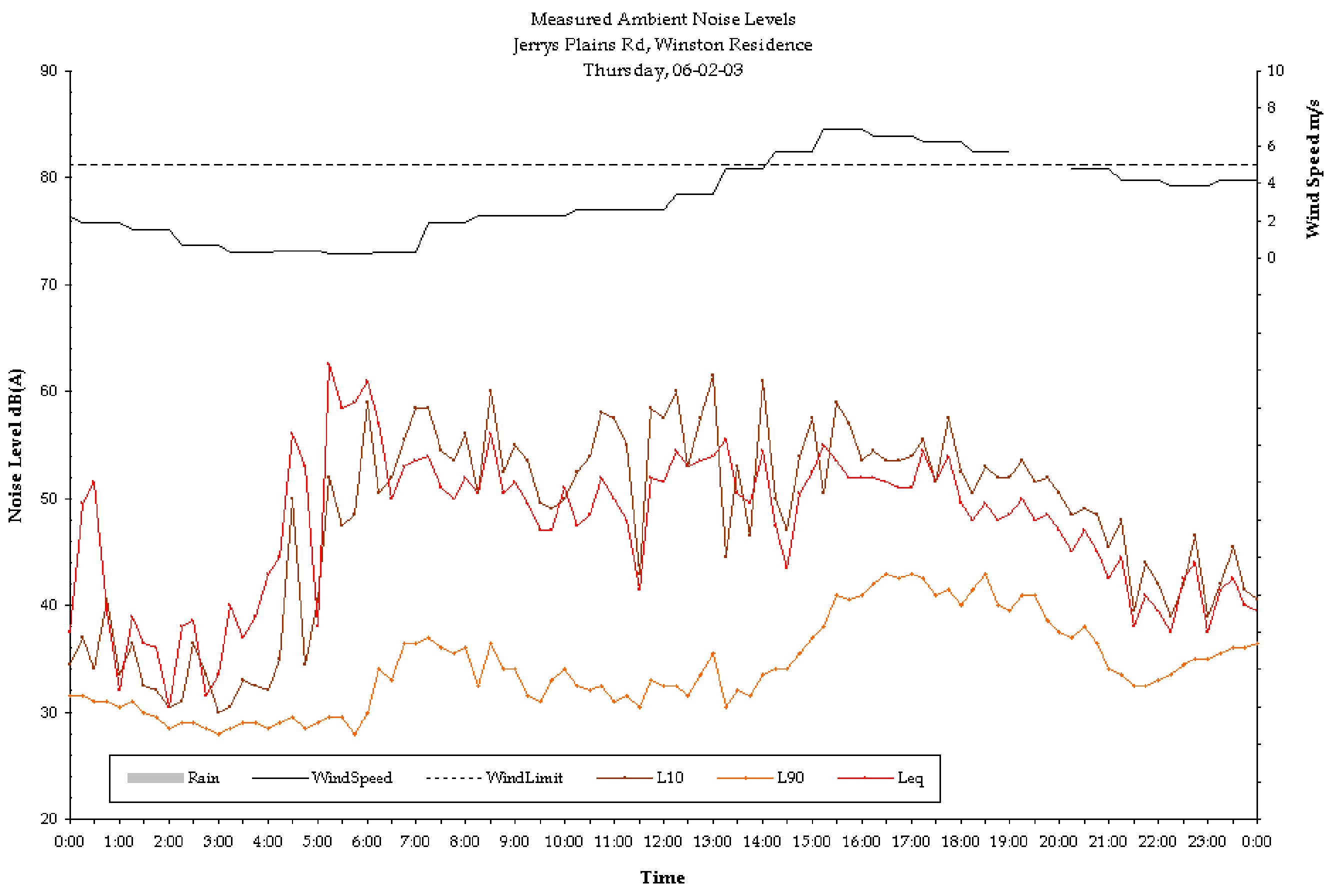
22:00
23:00
0:00


Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Thursday, 06-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
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11:00
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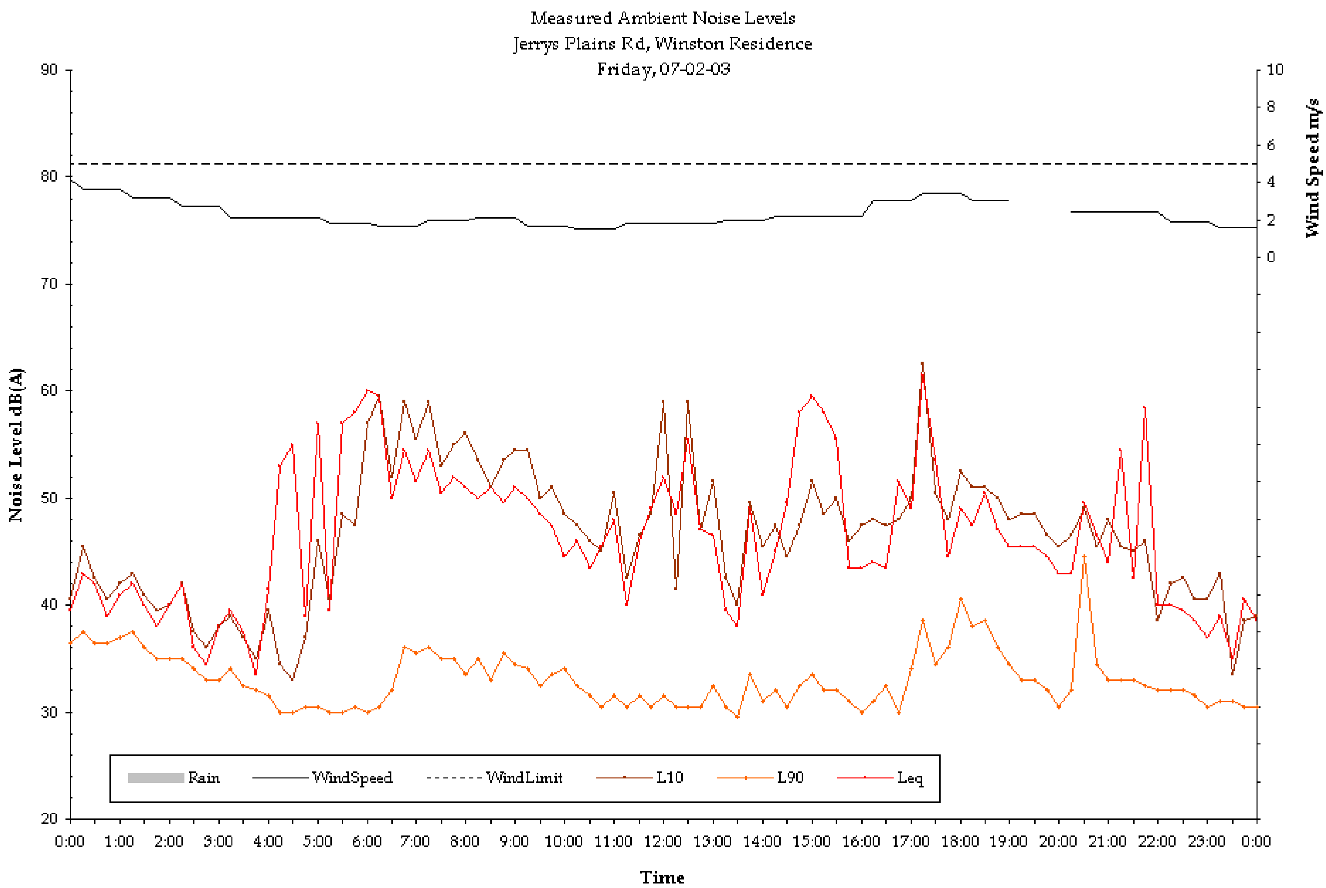
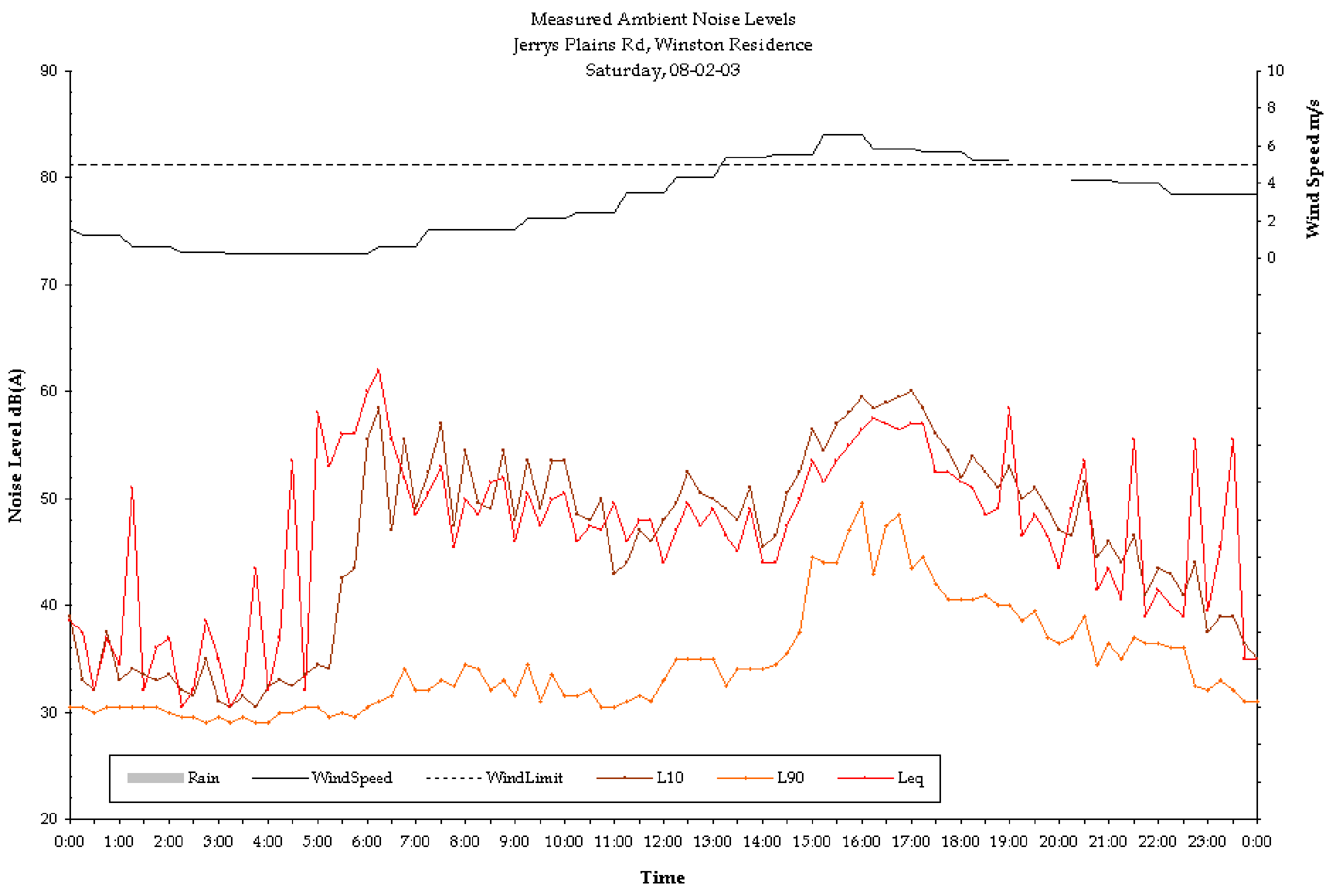
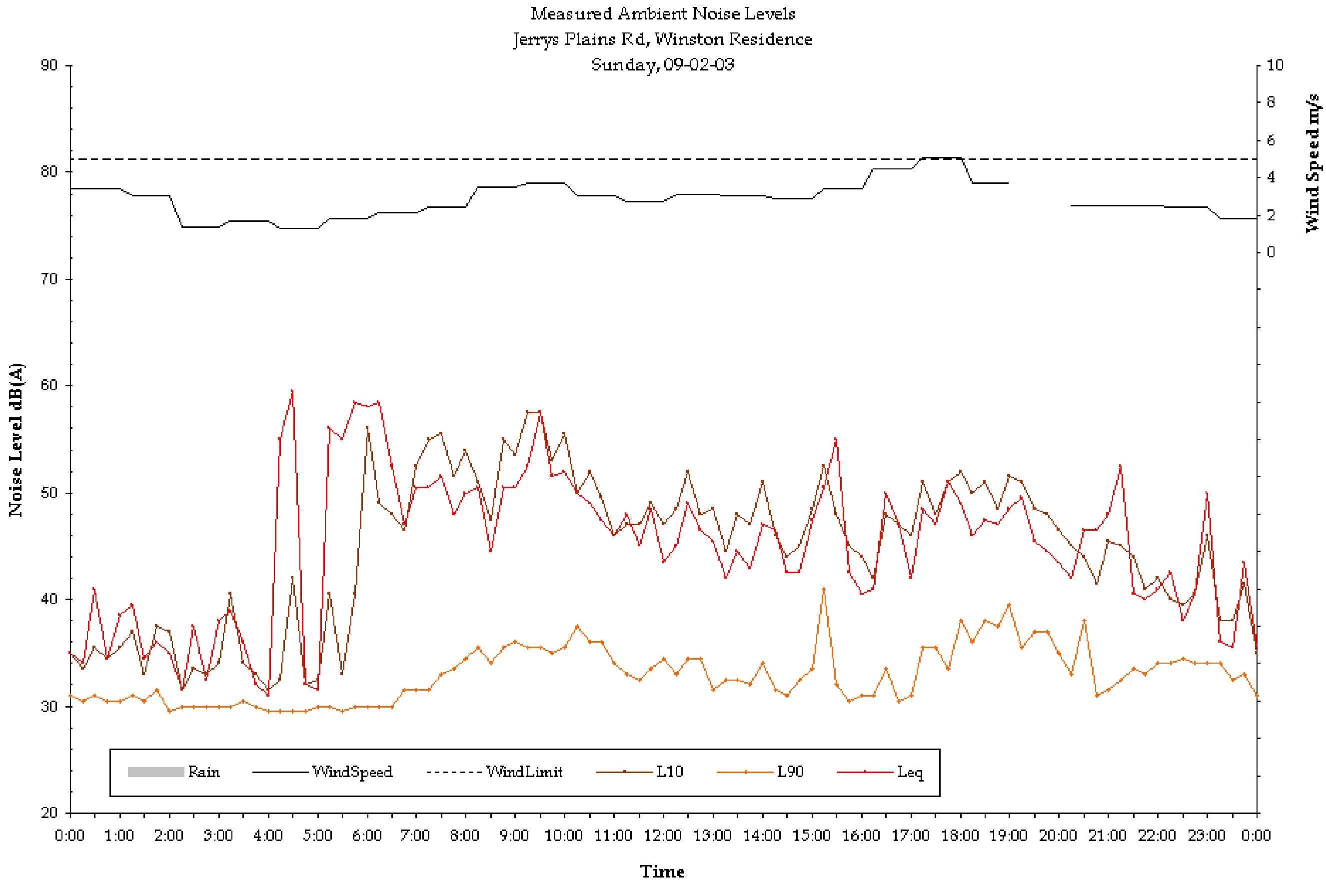
22:00
23:00
0:00

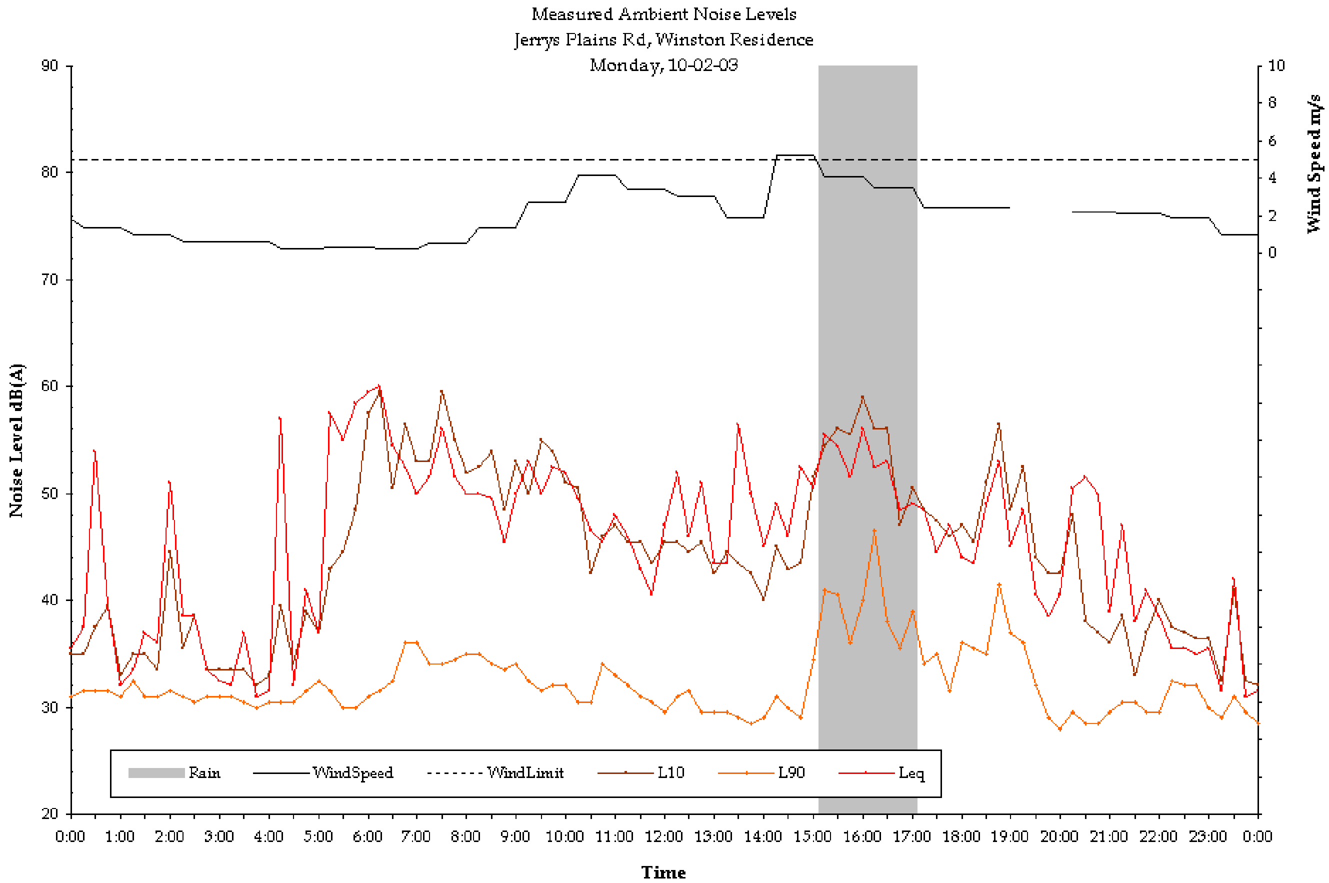


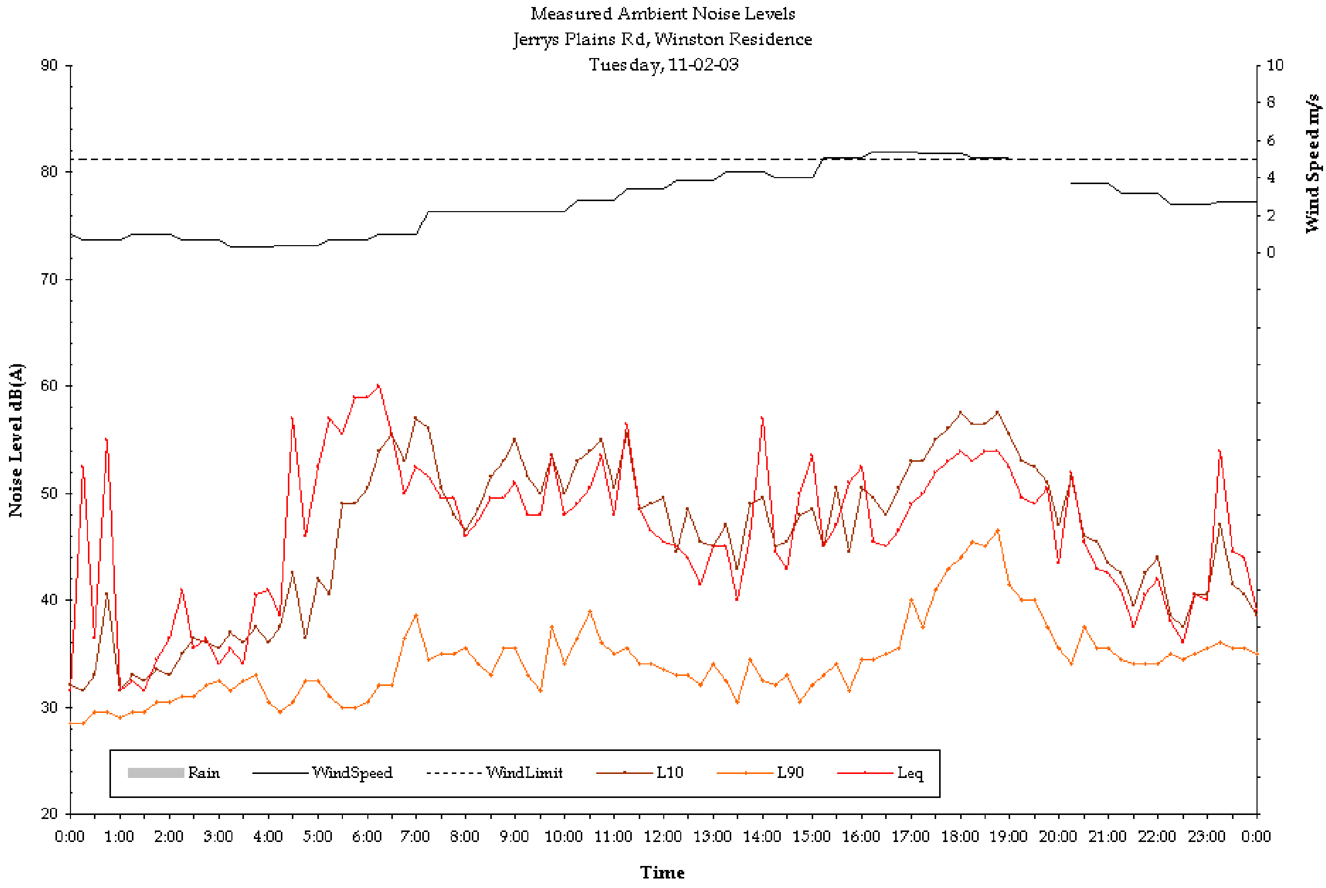
Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Friday, 07-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00



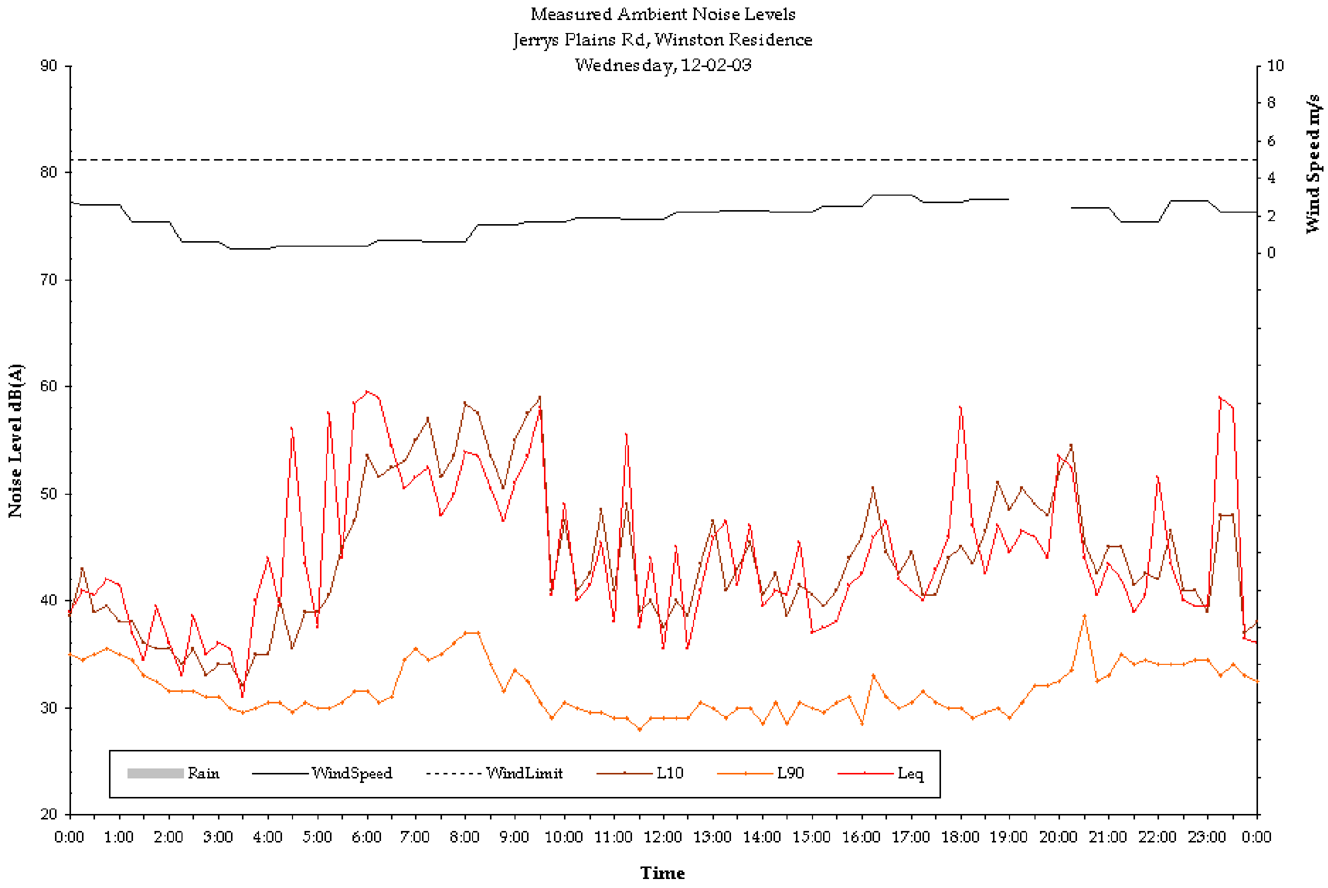
Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Saturday, 08-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00


Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Sunday, 09-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq

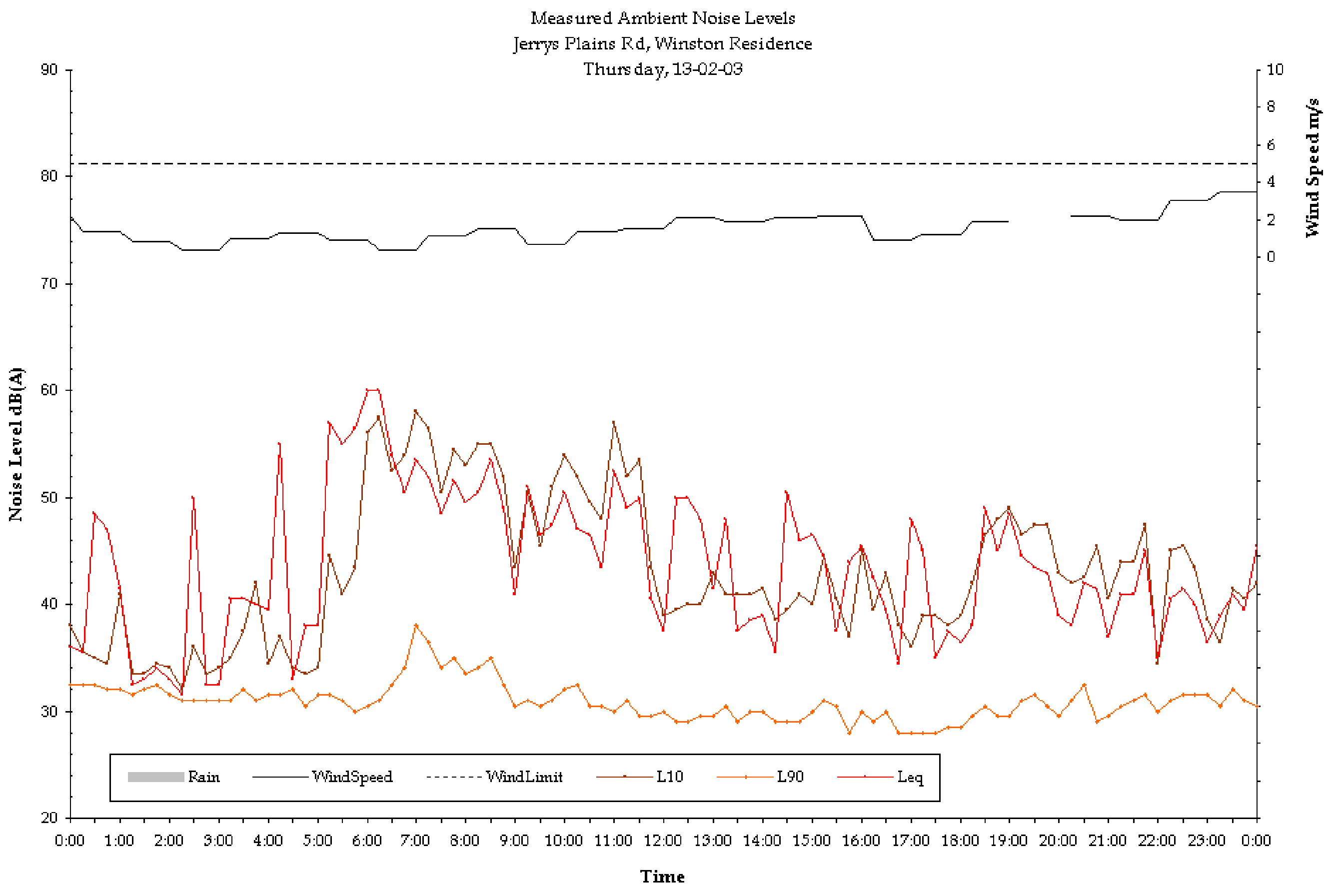

Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Monday, 10-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq



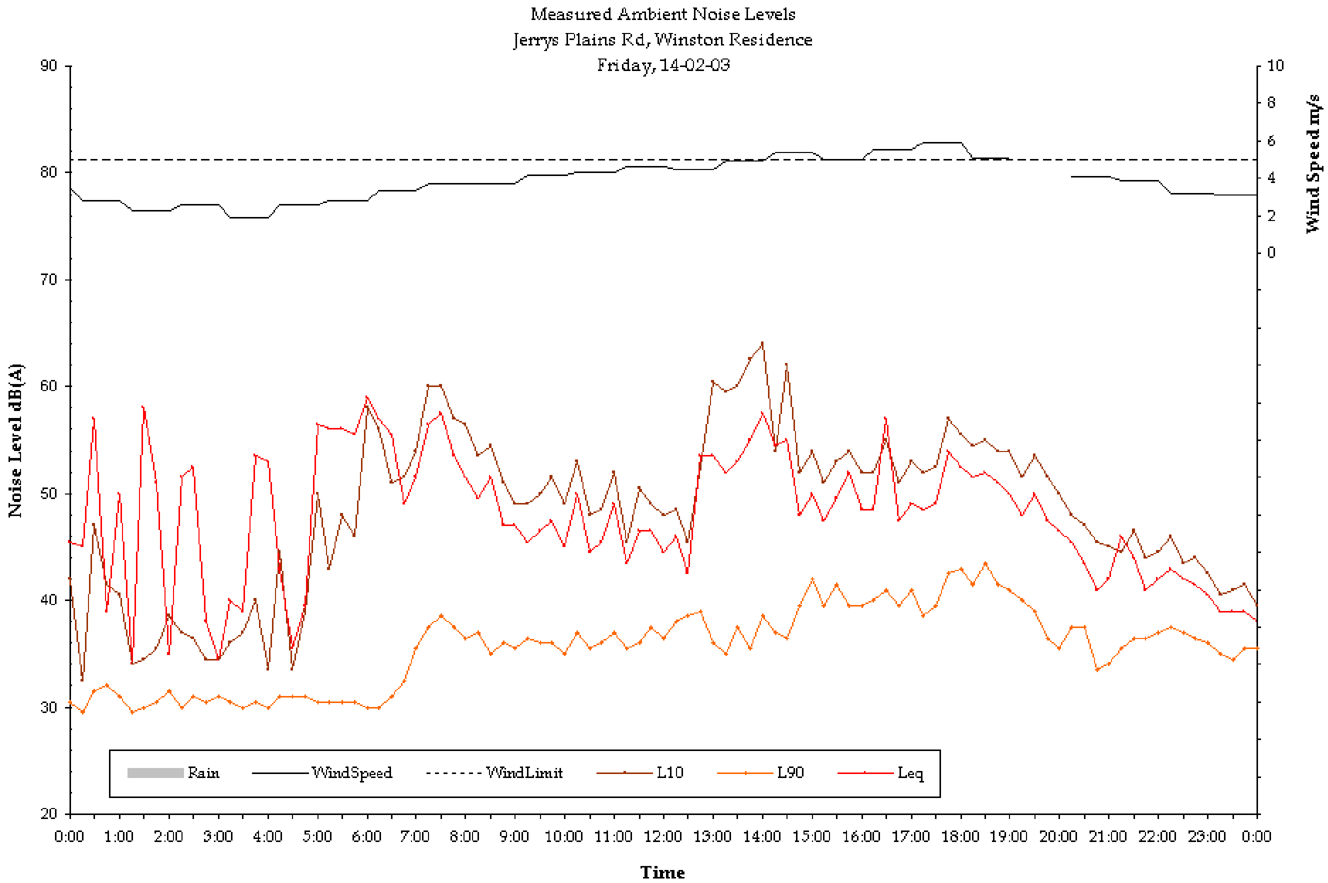
Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Tuesday, 11-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq



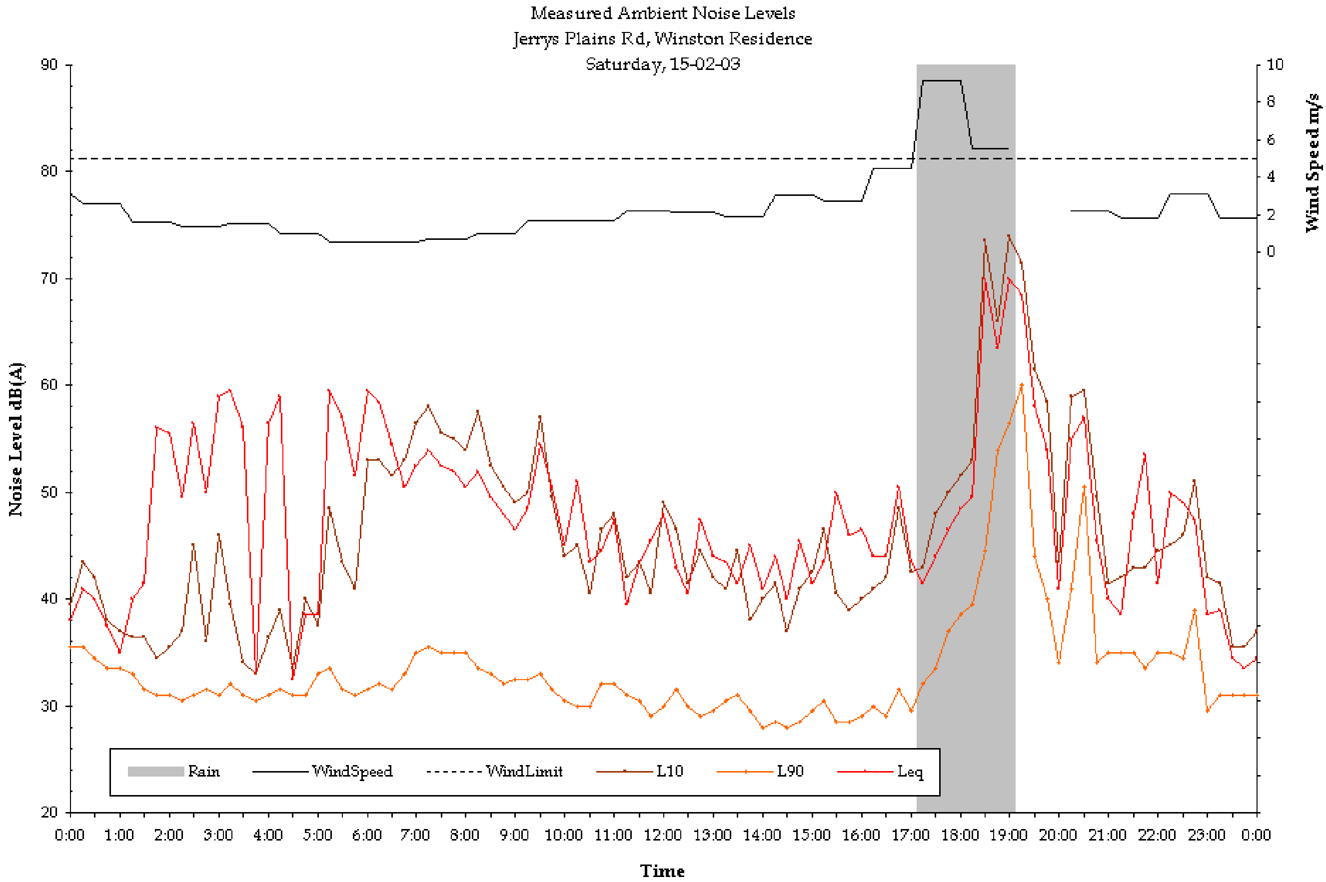
Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Wednesday, 12-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq



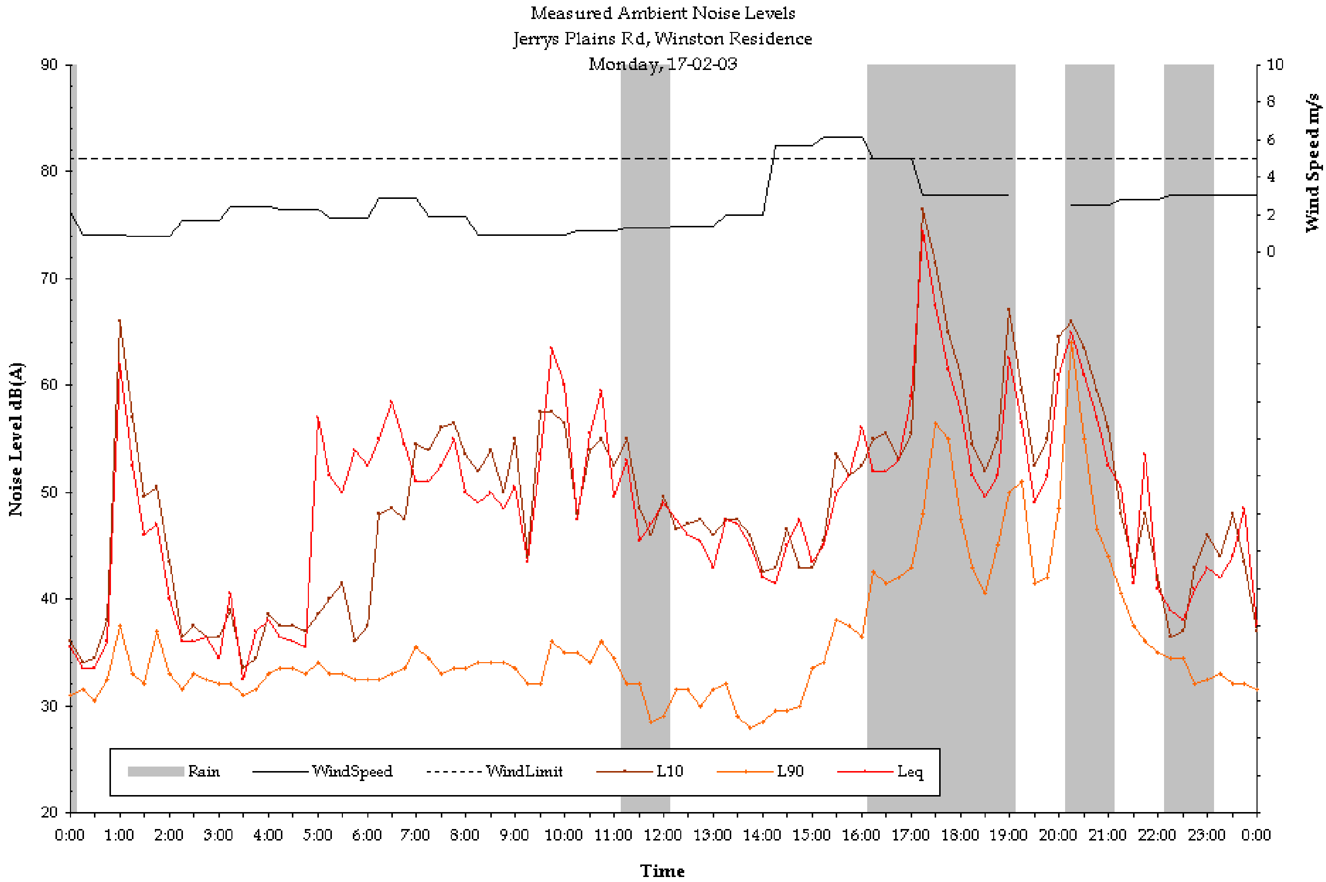
Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Thursday, 13-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq



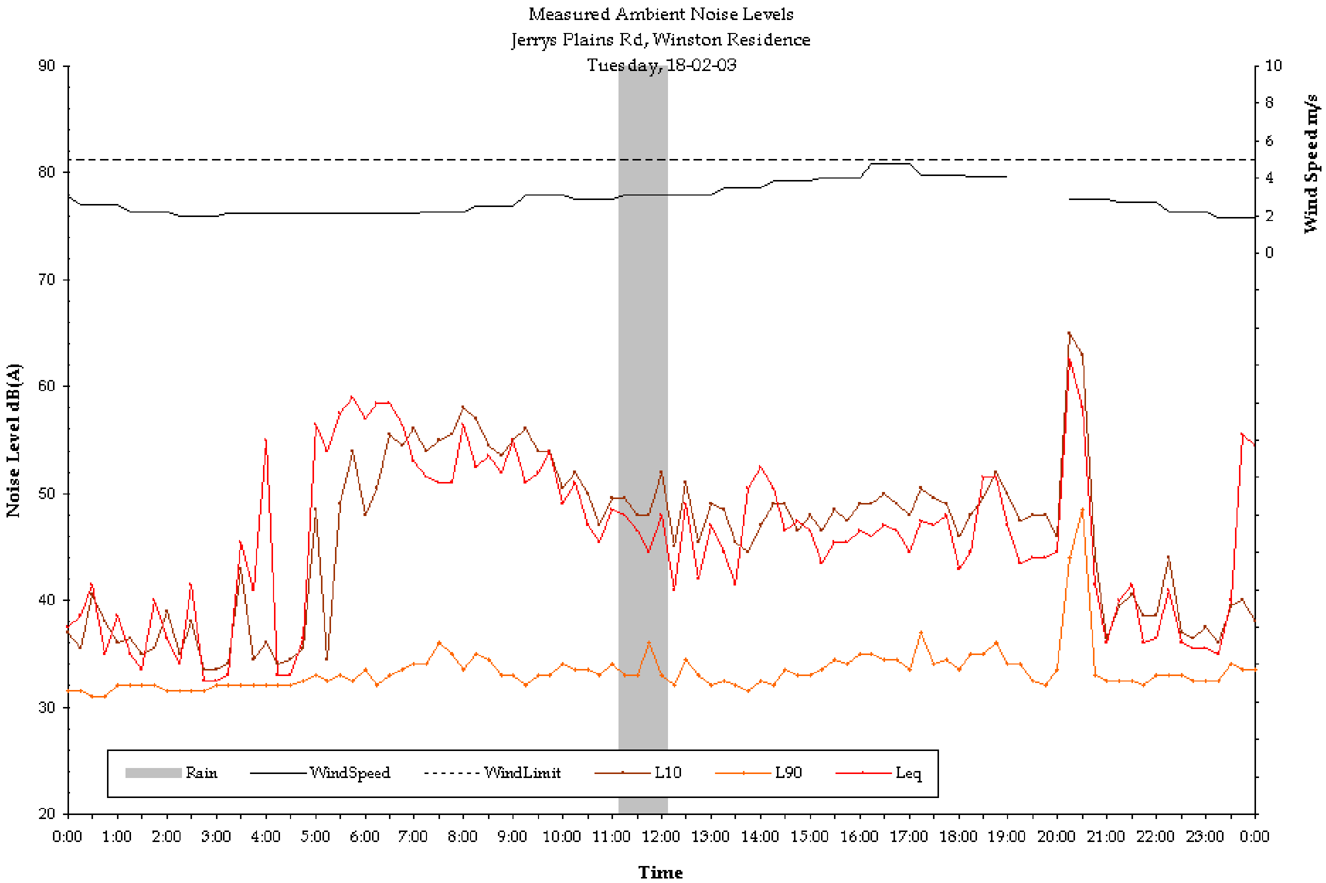
Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Friday, 14-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Saturday, 15-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq

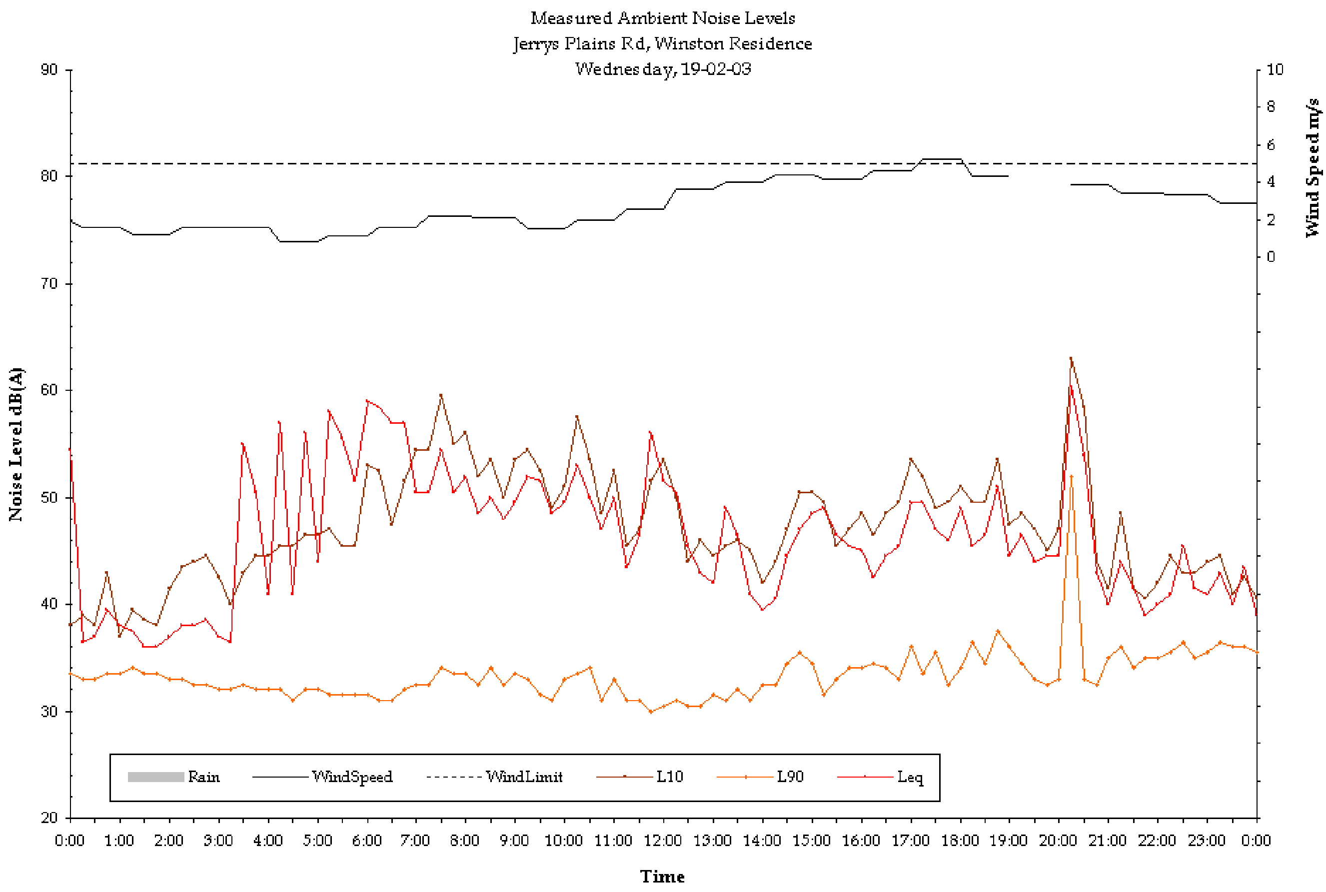

Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Sunday, 16-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq



Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Monday, 17-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time



Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Tuesday, 18-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time


Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Wednesday, 19-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
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3:00
4:00
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11:00
12:00
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18:00
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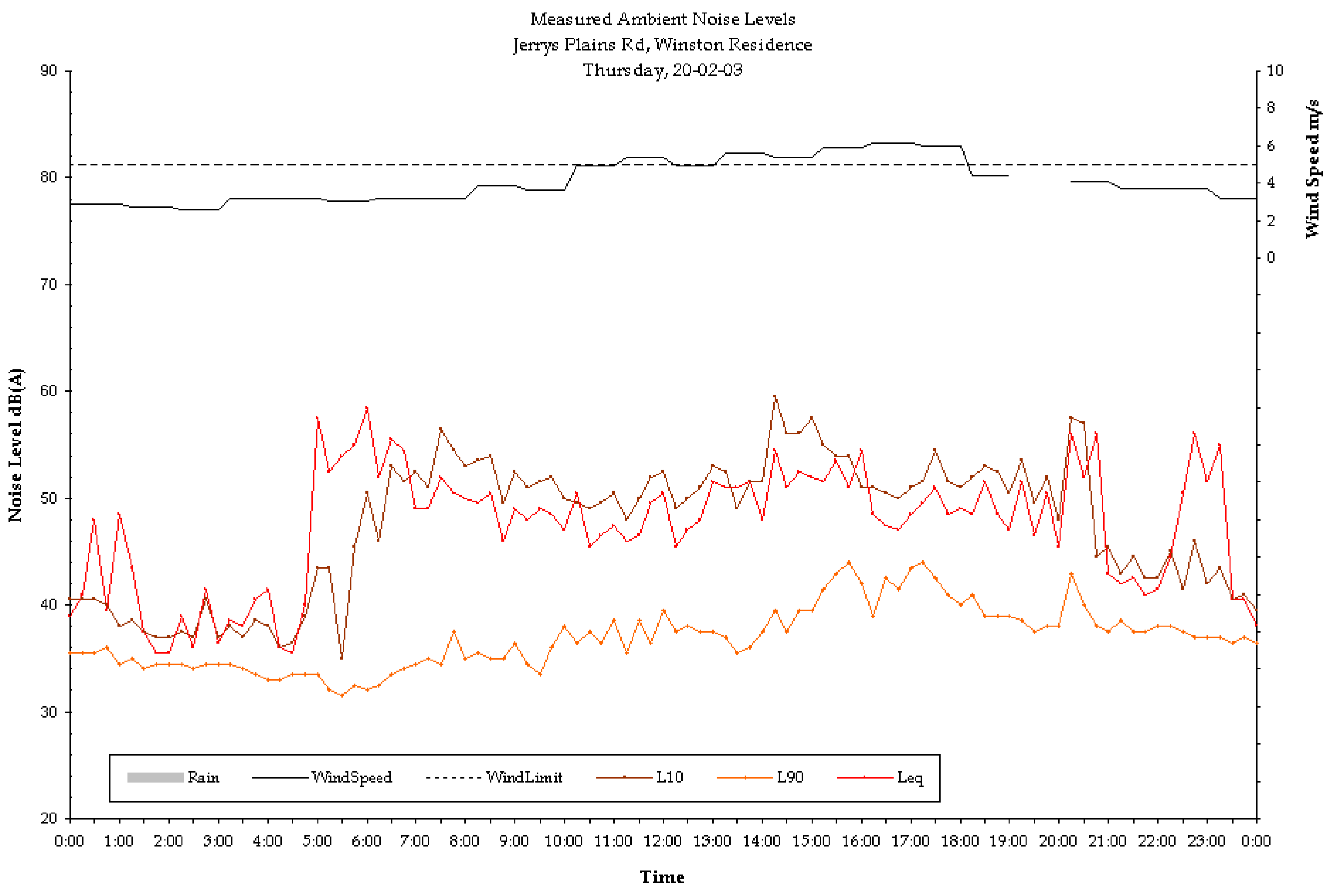
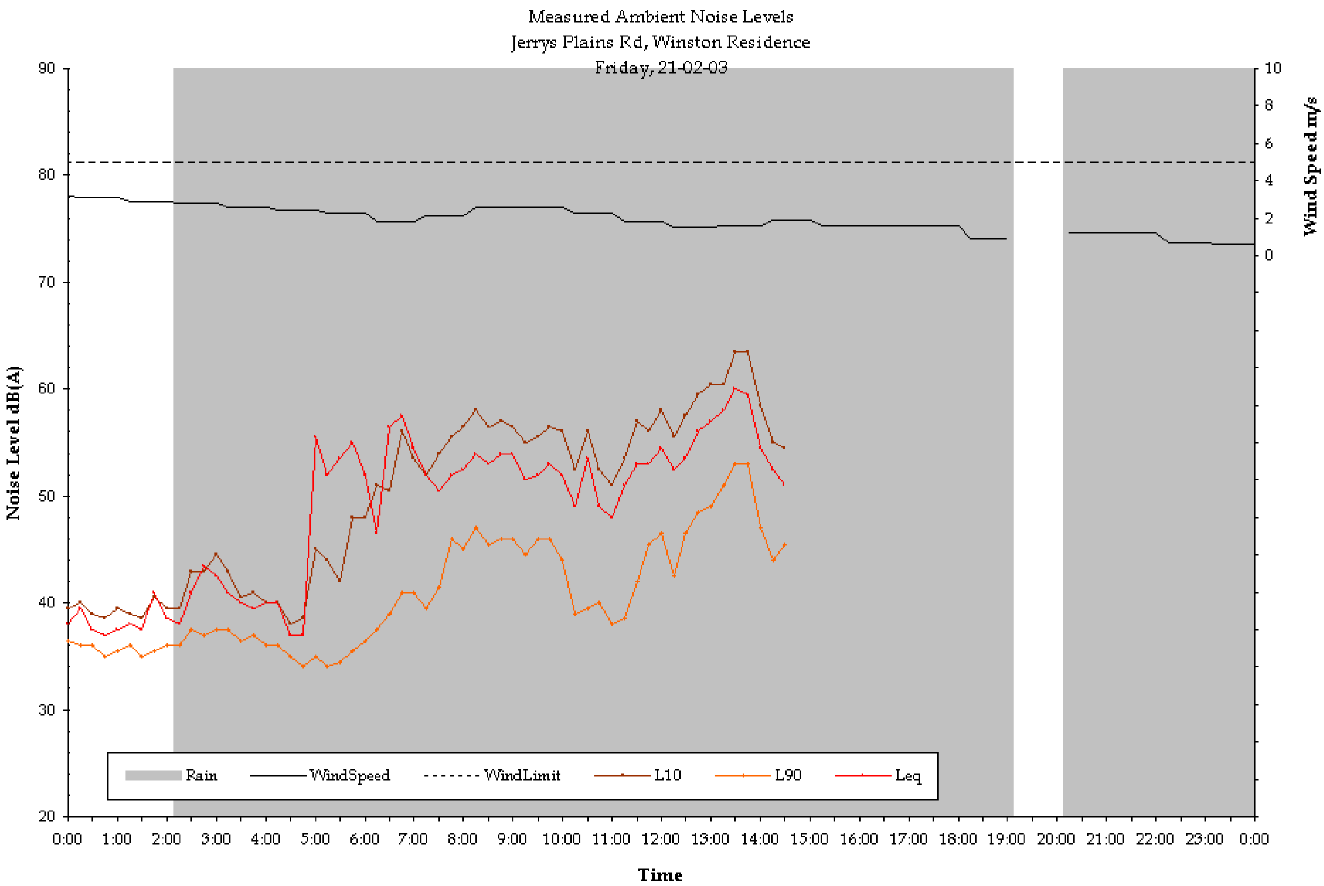
20:00
21:00
22:00
23:00
0:00


Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Thursday, 20-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00


Measured Ambient Noise Levels
Jerrys Plains Rd, Winston Residence
Friday, 21-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
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10:00
11:00
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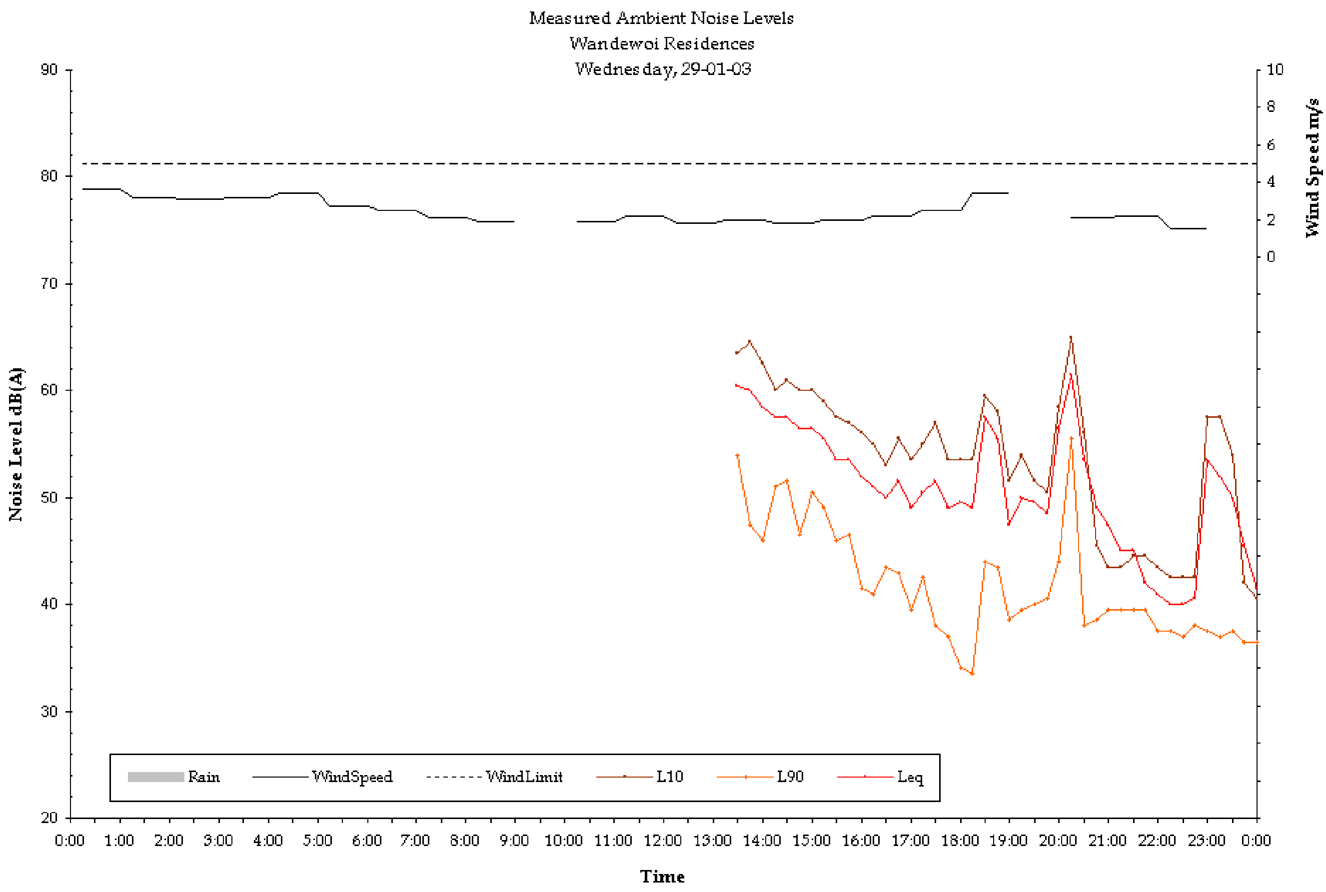
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00

A.4 *MEASUREMENT LOCATION N5 - WANDEWOI, LEMINGTON ROAD*

Table A.3 Summary of Daily Noise Levels Measured at Location N5 (Wandewoi, Lemington Road)

Date	**Assessment Background Level dB(A)L_{90}**			**Ambient Noise Levels dB(A)$L_{eq,period}$**		
	Day	**Evening**	**Night**	**Day** $L_{eq,11hr}$	**Evening** $L_{eq,4hr}$	**Night** $L_{eq,9hr}$
Wednesday, 29-01-03	-	37.5	34.5	-	53.5	47
Thursday, 30-01-03	-	37	30.5	-	-	51.3
Friday, 31-01-03	-	-	37	-	-	44.6
Saturday, 01-02-03	-	-	37	58.4	-	46.9
Sunday, 02-02-03	-	-	35	51.2	-	43.5
Monday, 03-02-03	-	38.5	37.5	49.7	50.1	42.9
Tuesday, 04-02-03	-	41	36.5	52.4	-	47.1
Wednesday, 05-02-03	35.5	36	30	47.9	48	43.9
Thursday, 06-02-03	-	41	33	52.9	-	42.8
Friday, 07-02-03	32.5	32.5	31	54.5	48.9	41
Saturday, 08-02-03	-	38	33.5	55.9	-	40.9
Sunday, 09-02-03	32	37	-	54.5	47.1	-
Monday, 10-02-03	-	-	-	-	-	-
(RBL)	33	37	35			
Average L_{eq}				54	50	46

Notes: 1. "-" denotes periods excluded due to weather or insufficient data.


Measured Ambient Noise Levels
Wandewoi Residences
Wednesday, 29-01-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
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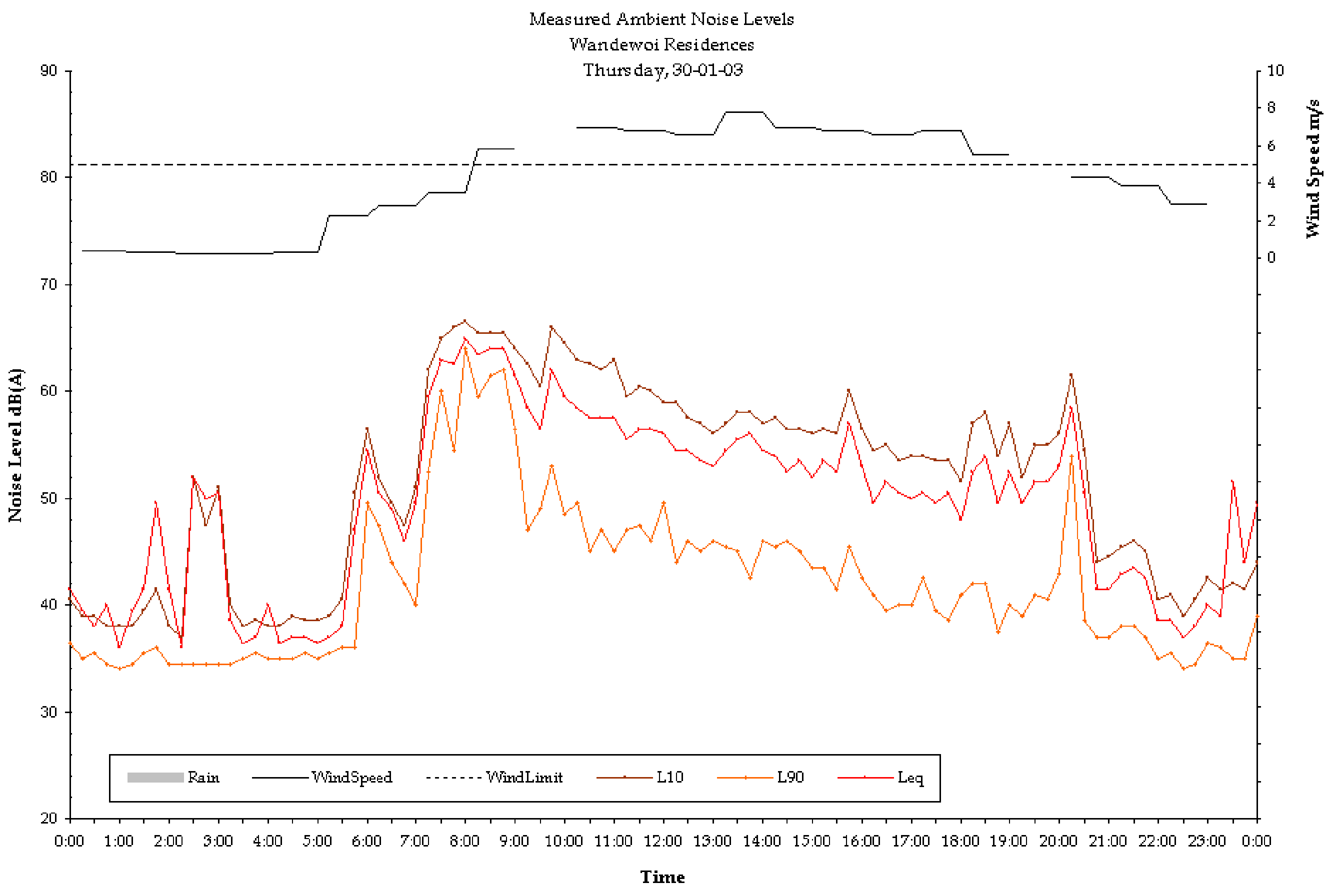
22:00
23:00
0:00


Measured Ambient Noise Levels
Wandewoi Residences
Thursday, 30-01-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
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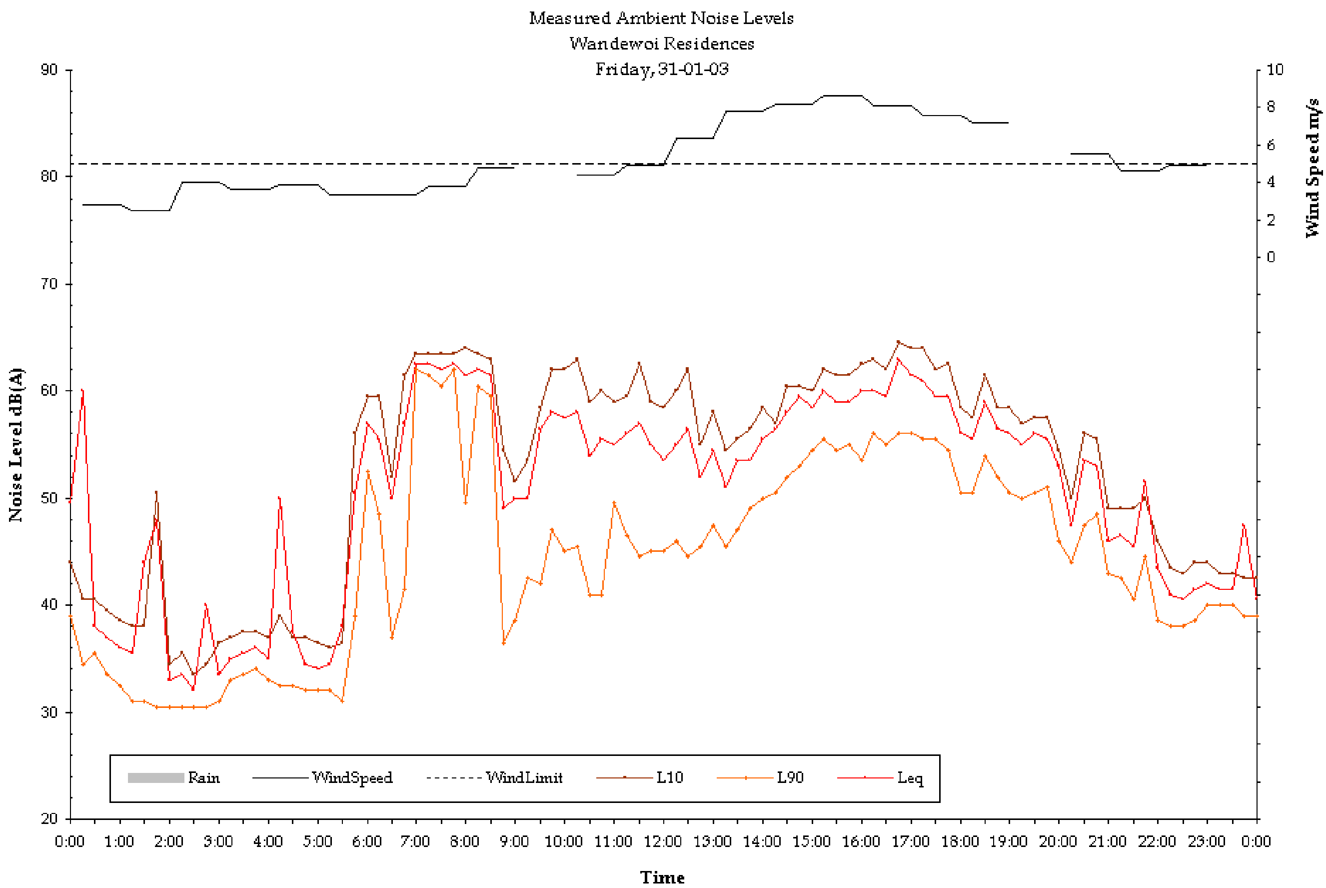
Measured Ambient Noise Levels
Wandewoi Residences
Friday, 31-01-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
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22:00
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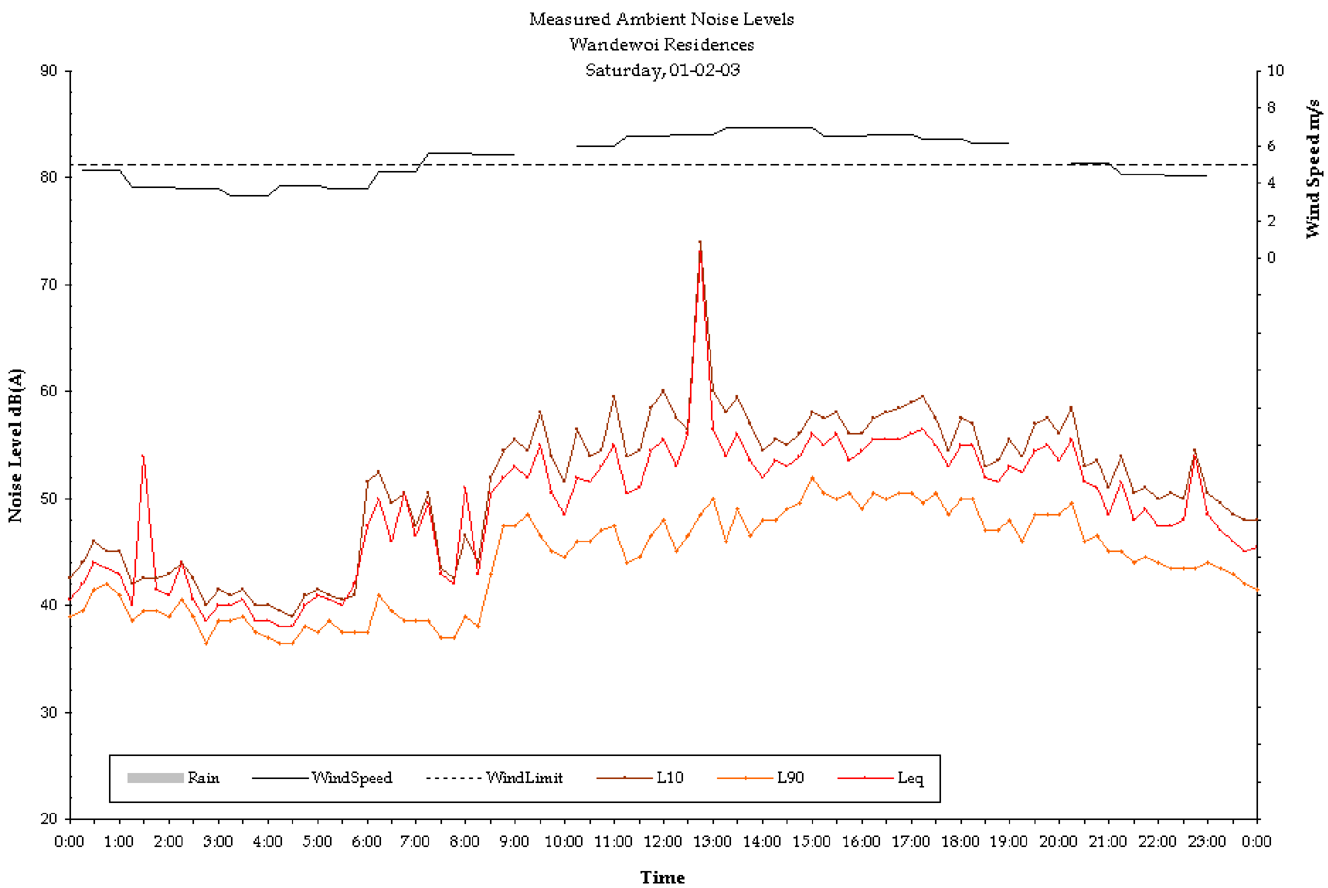
0:00


Measured Ambient Noise Levels
Wandewoi Residences
Saturday, 01-02-03
Noise Level dB(A)
Wind Speed m/s
Rain
WindSpeed
WindLimit
L10
L90
Leq
Time
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
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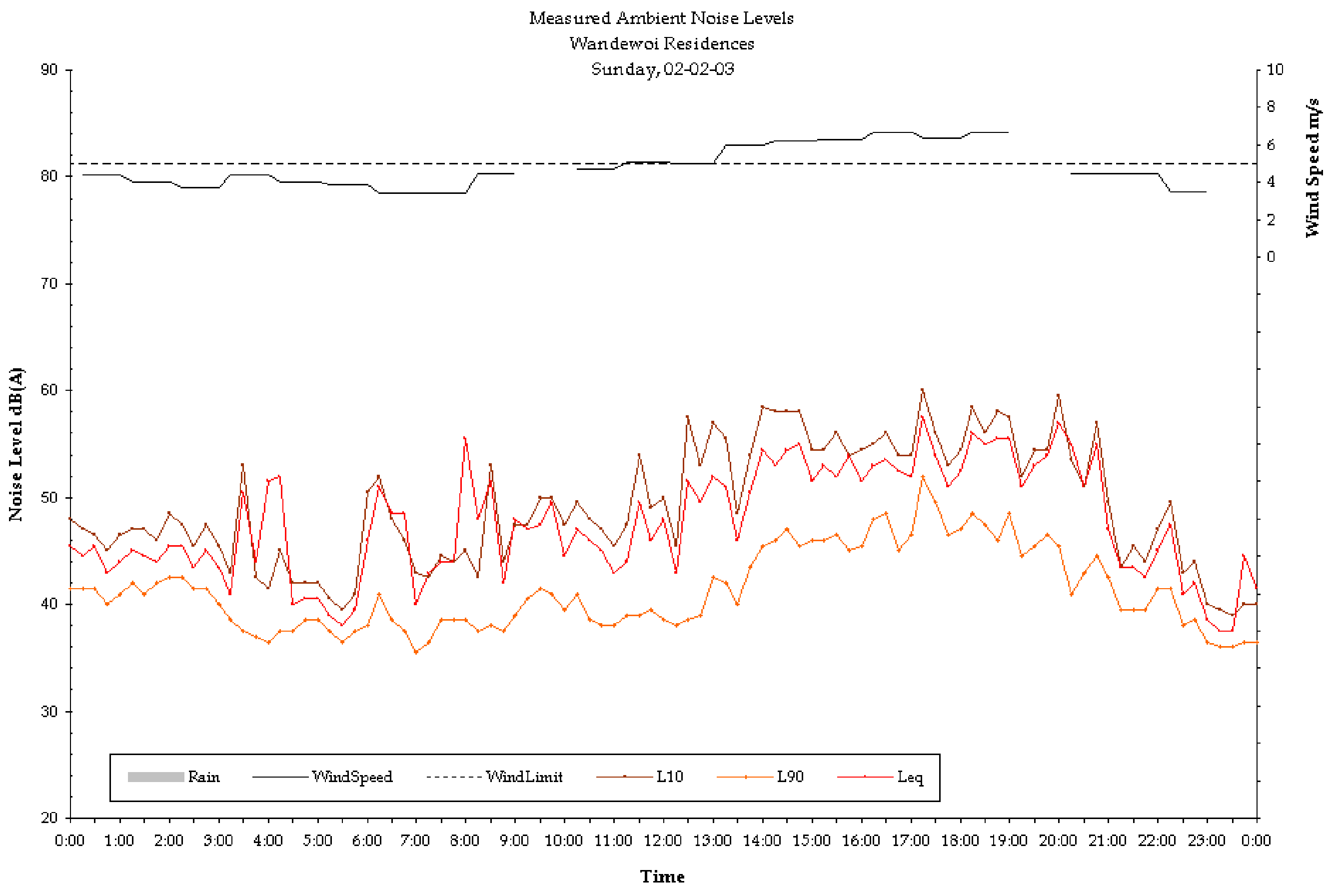
Measured Ambient Noise Levels
Wandewoi Residences
Sunday, 02-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
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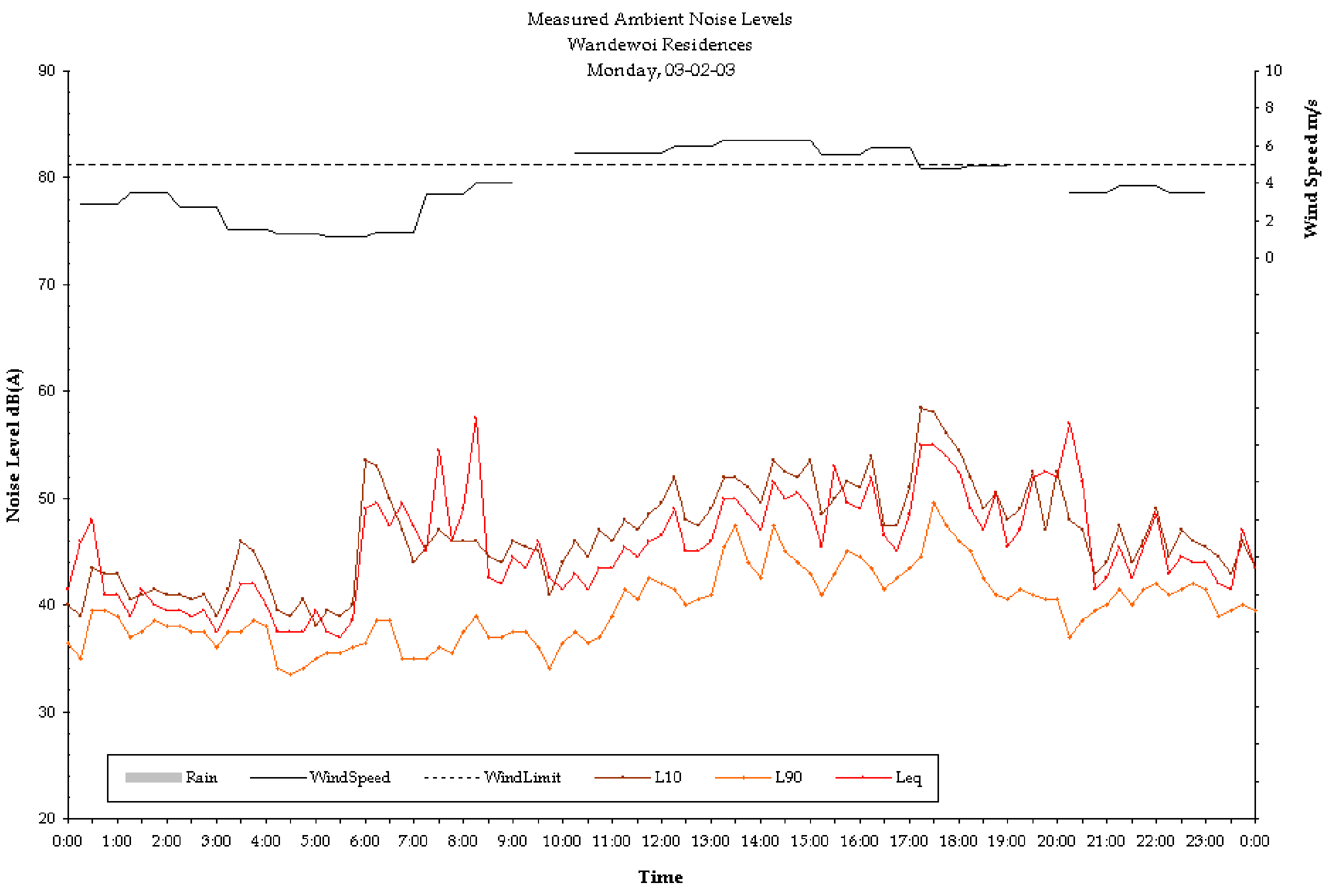
22:00
23:00
0:00


Measured Ambient Noise Levels
Wandewoi Residences
Monday, 03-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
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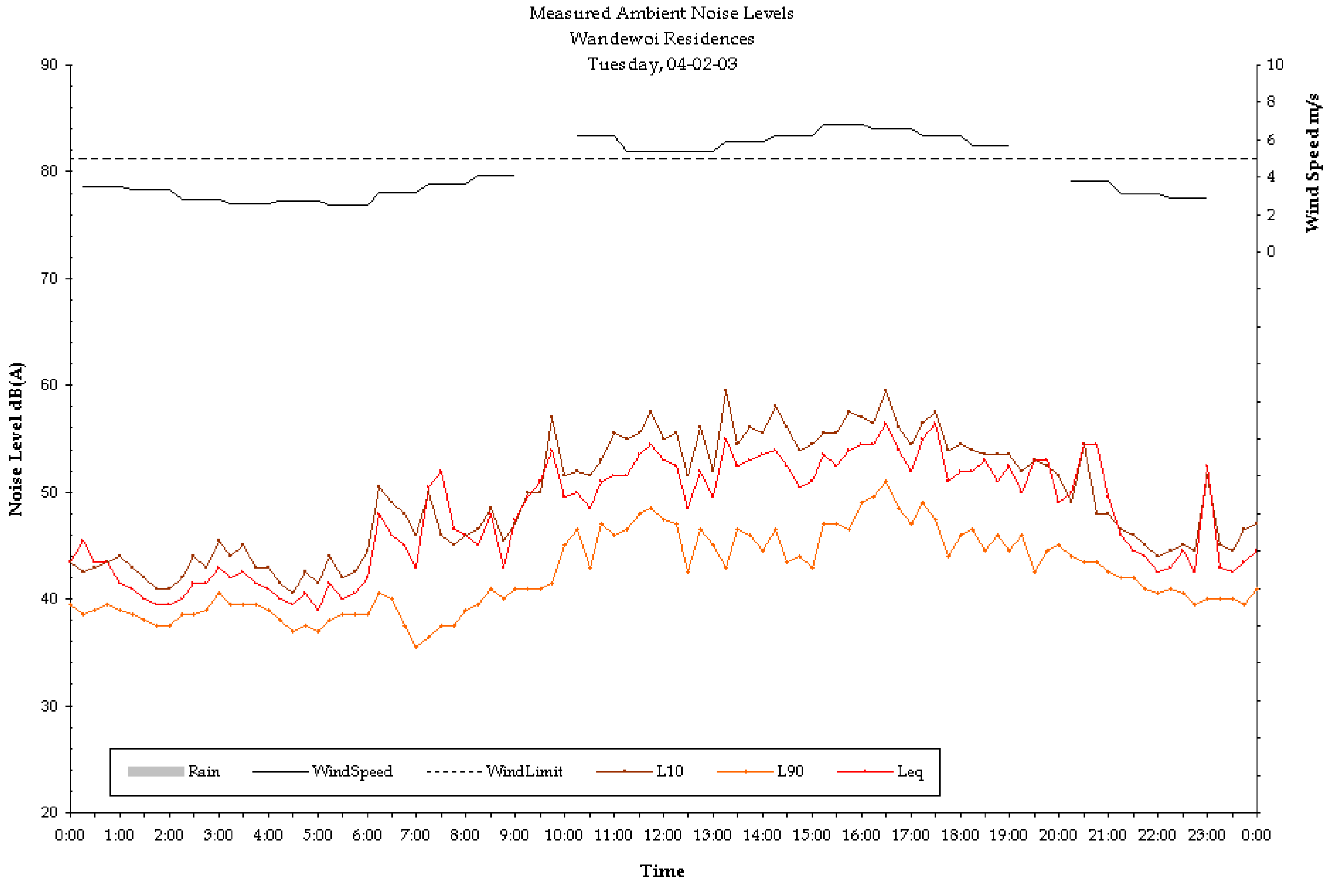
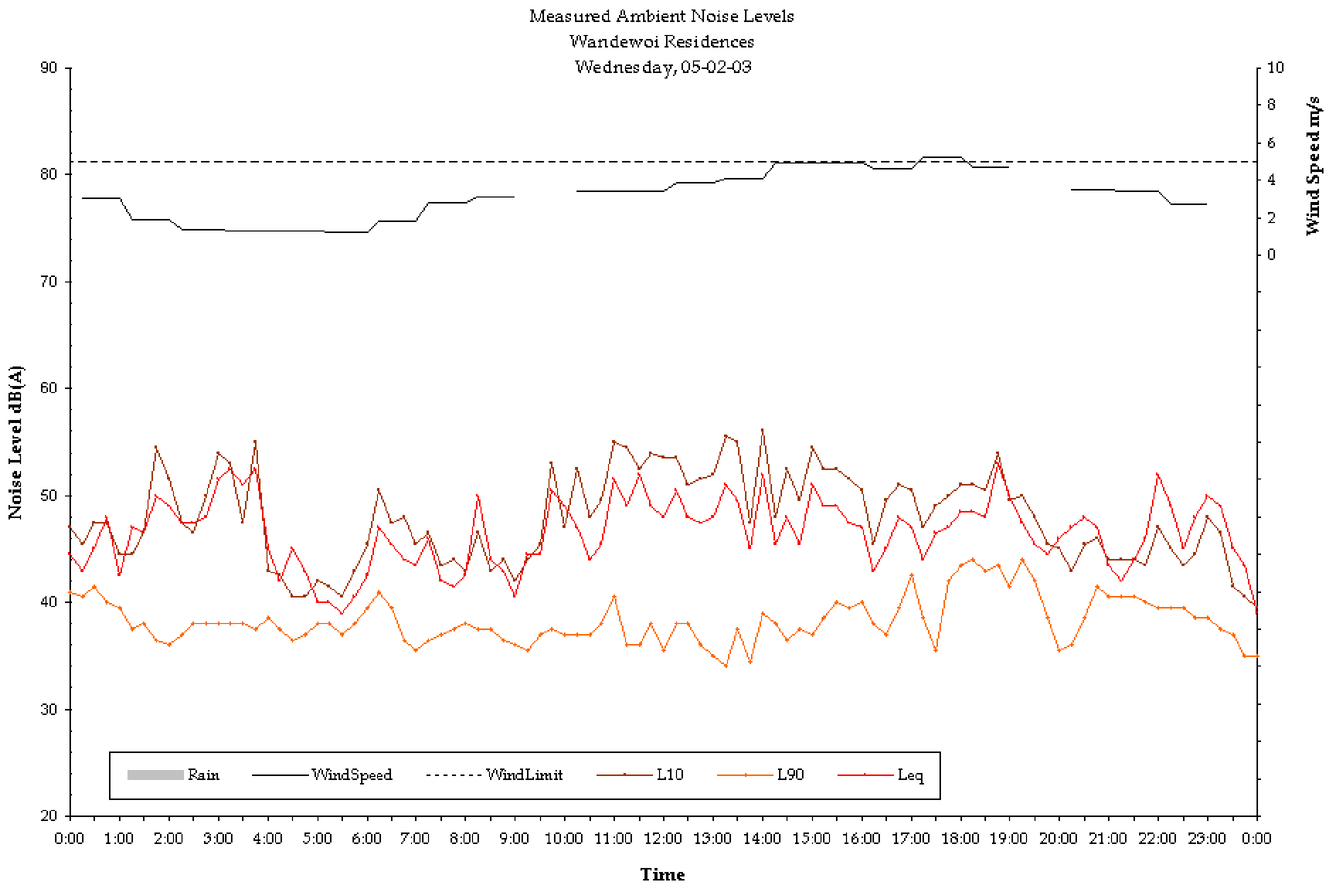
0:00



Measured Ambient Noise Levels
Wandewoi Residences
Tuesday, 04-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00



Measured Ambient Noise Levels
Wandewoi Residences
Wednesday, 05-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
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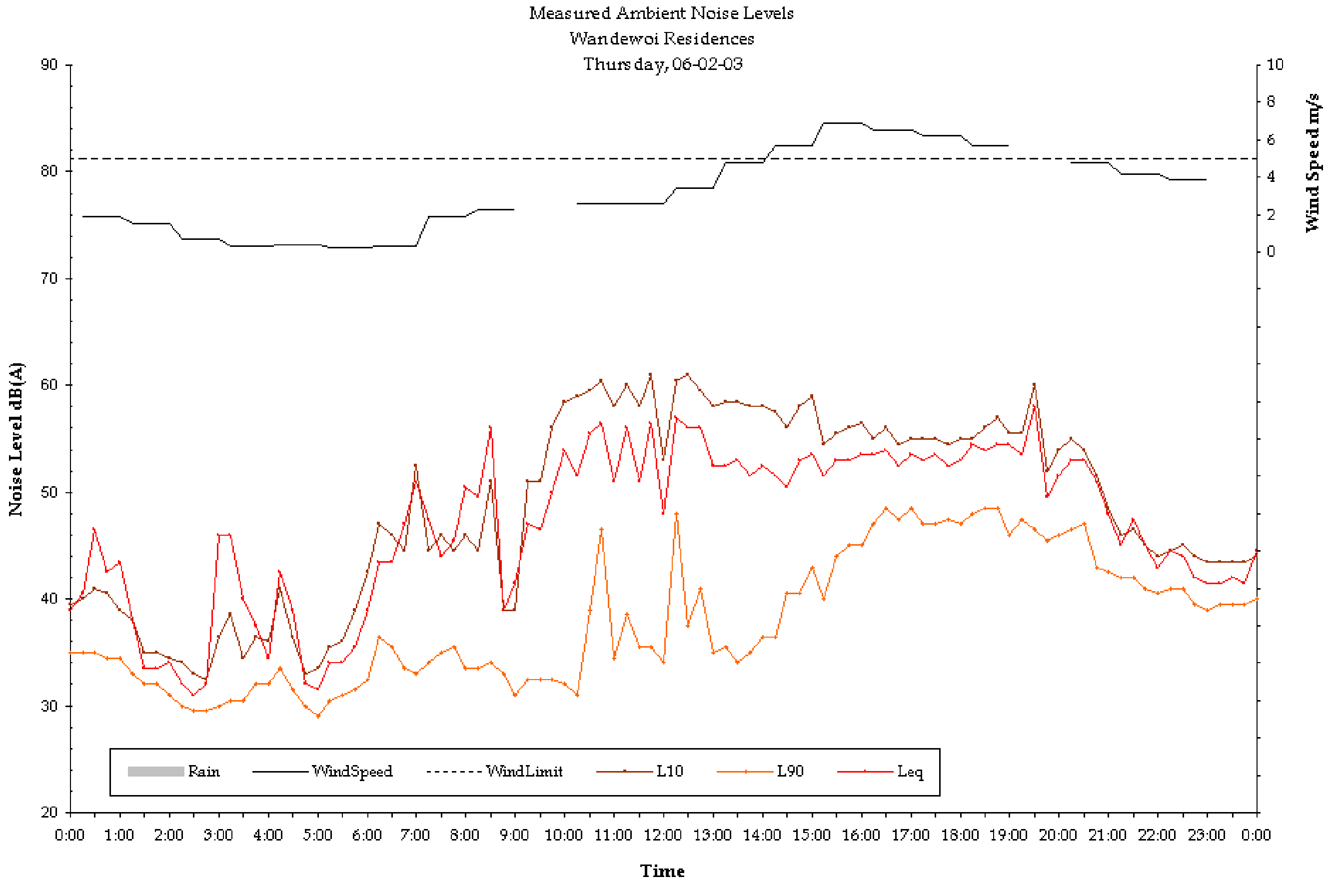
22:00
23:00
0:00


Measured Ambient Noise Levels
Wandewoi Residences
Thursday, 06-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
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Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
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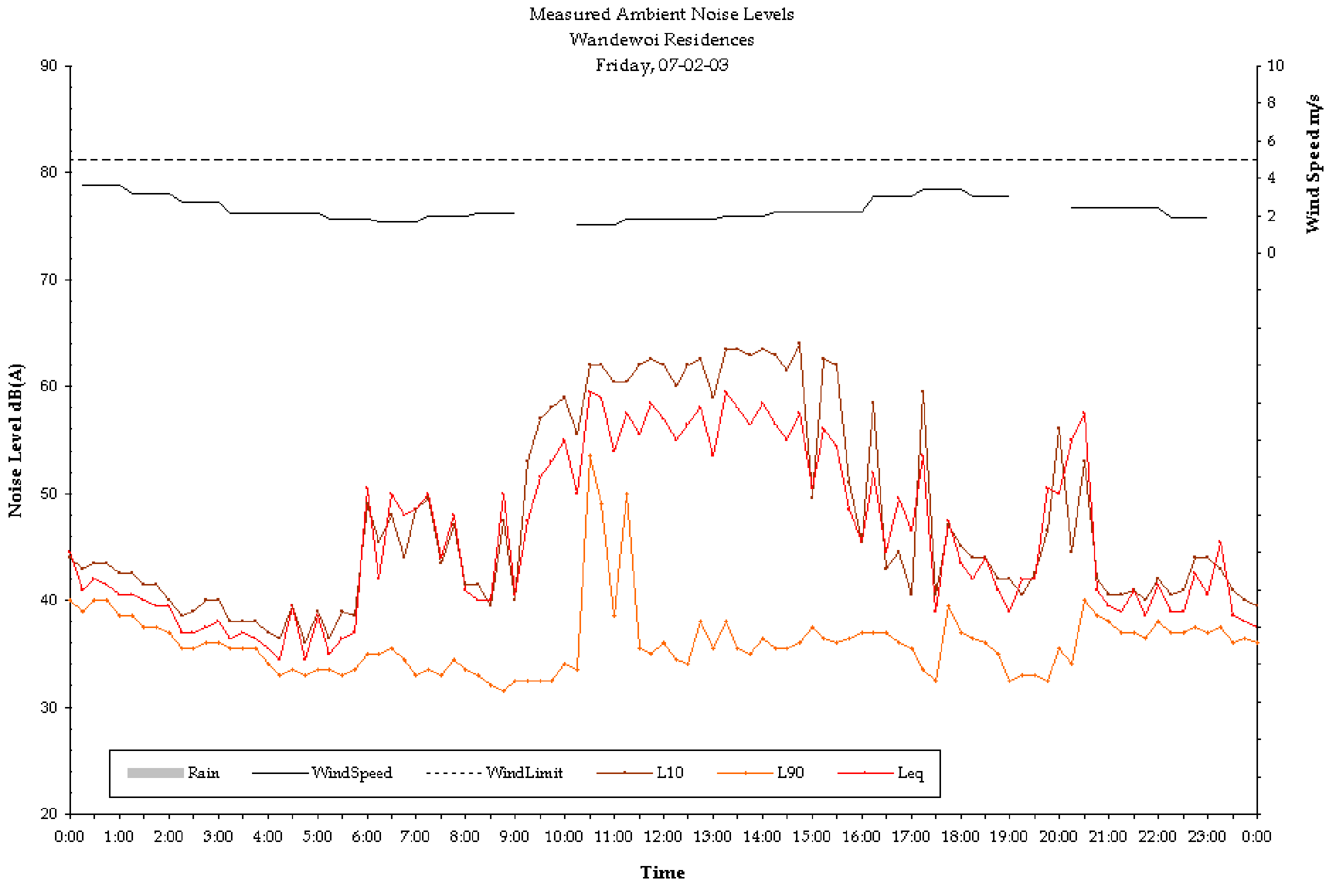
22:00
23:00
0:00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Wandewoi Residences
Friday, 07-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
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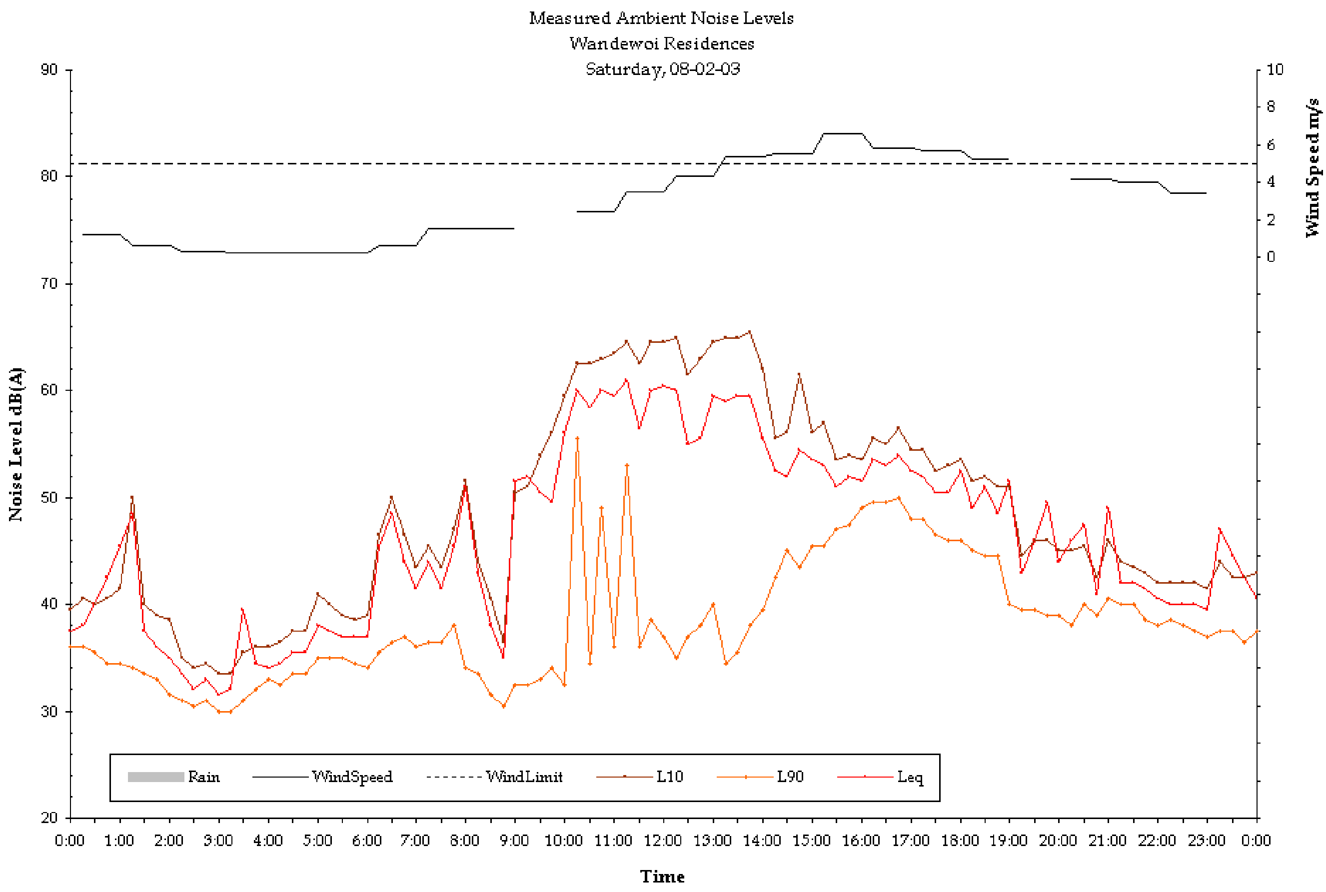
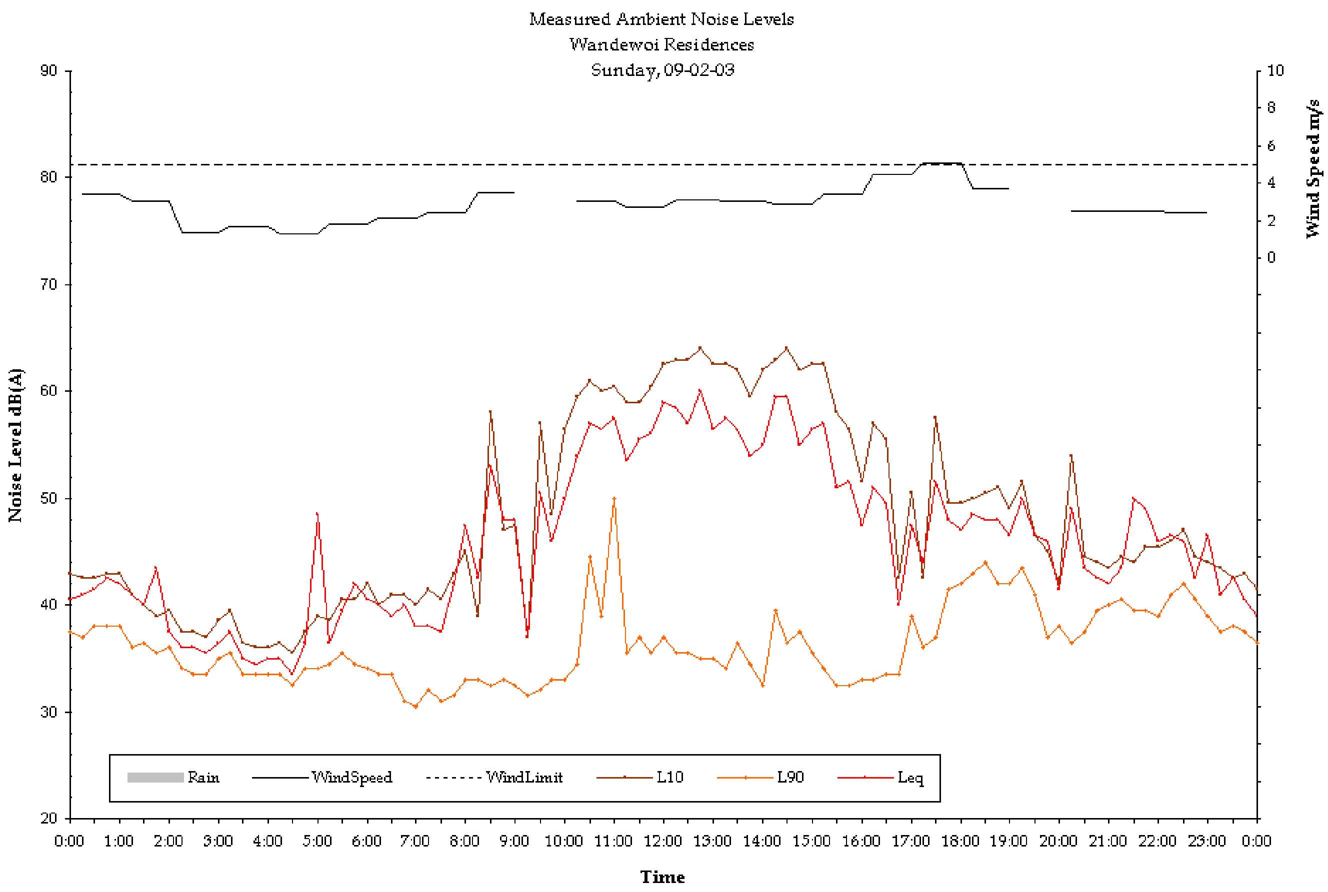
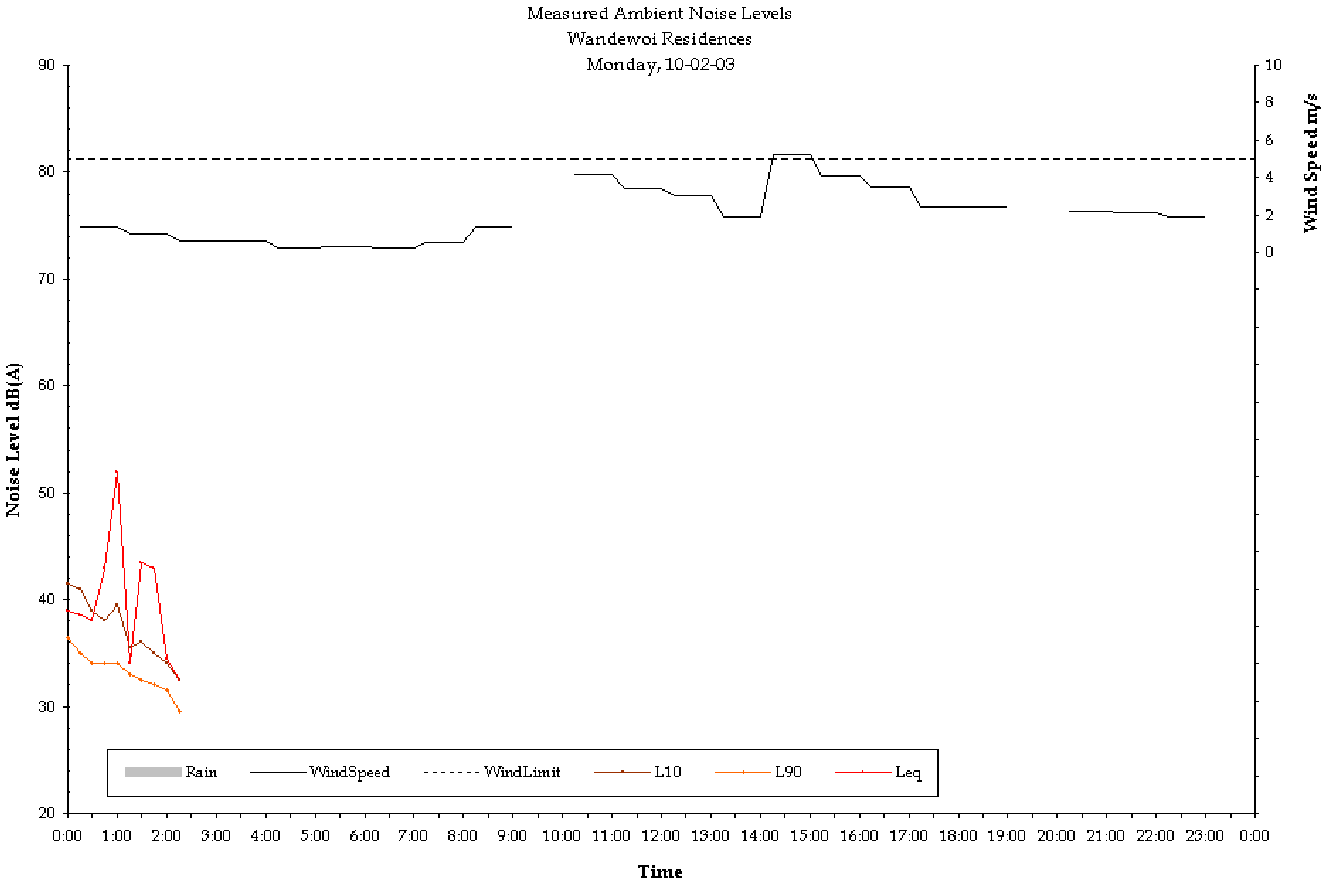
23:00
0:00


Measured Ambient Noise Levels
Wandewoi Residences
Saturday, 08-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq

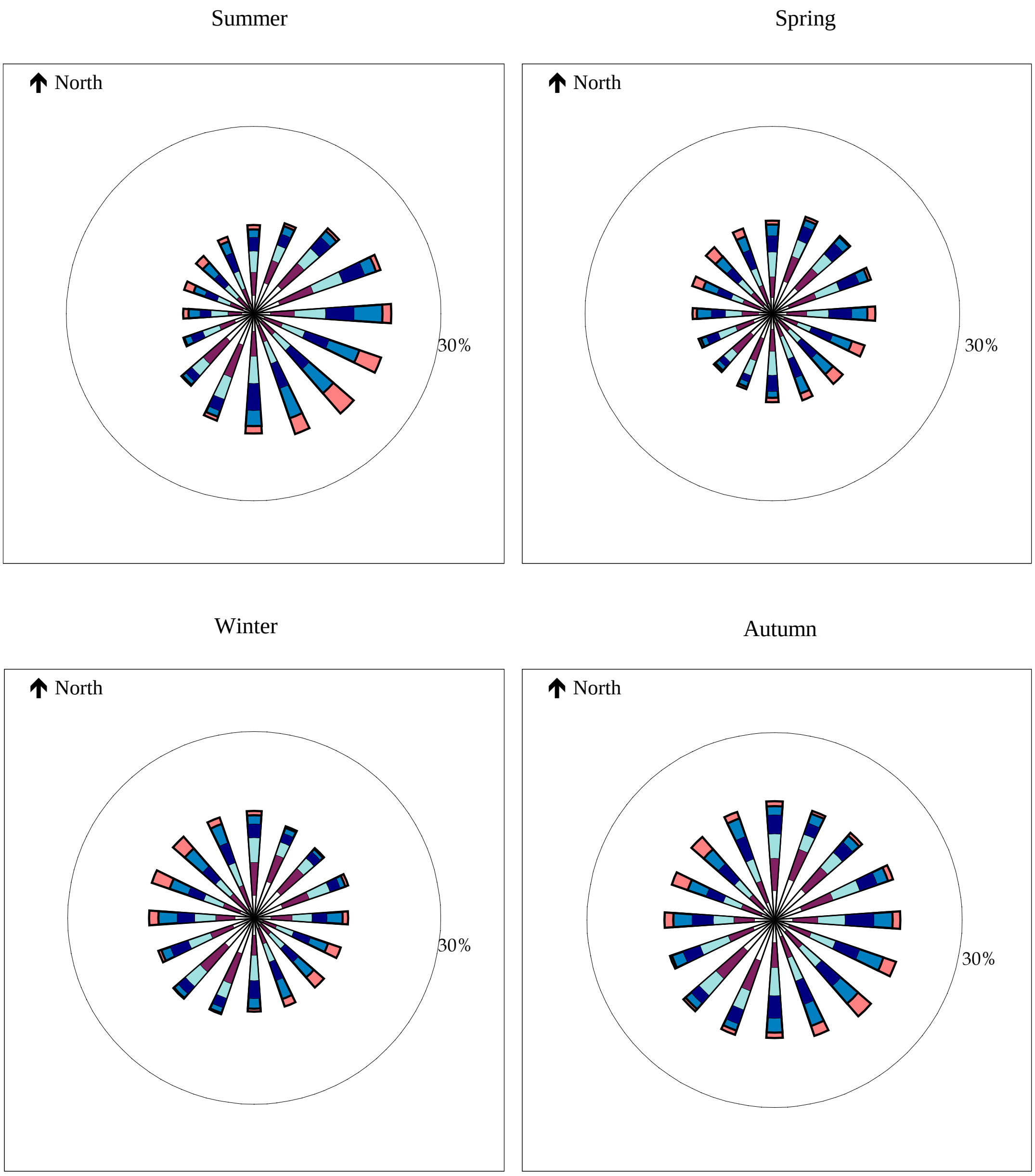

Measured Ambient Noise Levels
Wandewoi Residences
Sunday, 09-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq


Measured Ambient Noise Levels
Wandewoi Residences
Monday, 10-02-03
Noise Level dB(A)
Wind Speed m/s
Time
Rain
WindSpeed
WindLimit
L10
L90
Leq
90
80
70
60
50
40
30
20
10
8
6
4
2
0
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00

Annex B

Vector Wind Roses Annual Hourly Wind Analysis

Day

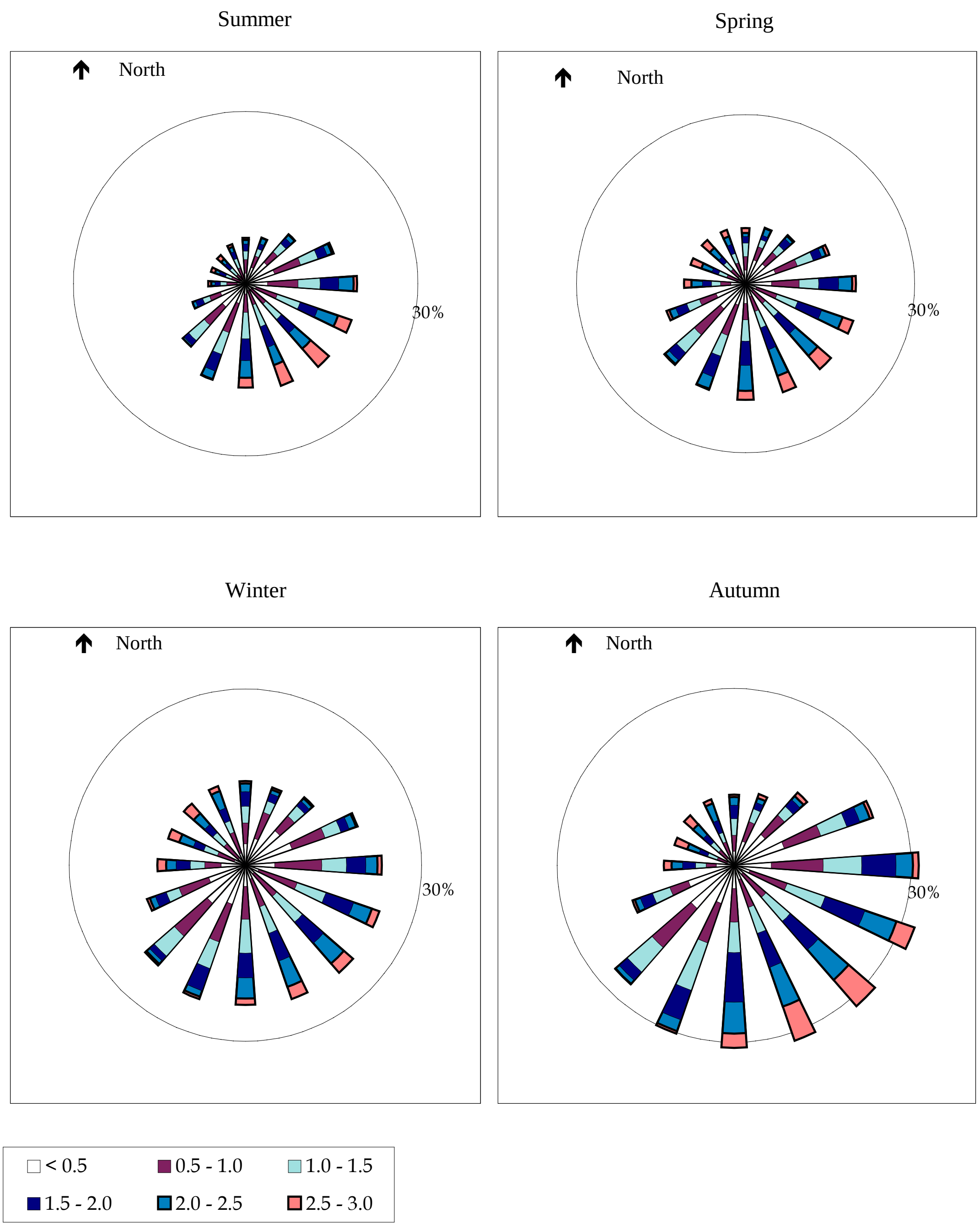


< 0.5	0.5 - 1.0	1.0 - 1.5
1.5 - 2.0	2.0 - 2.5	2.5 - 3.0

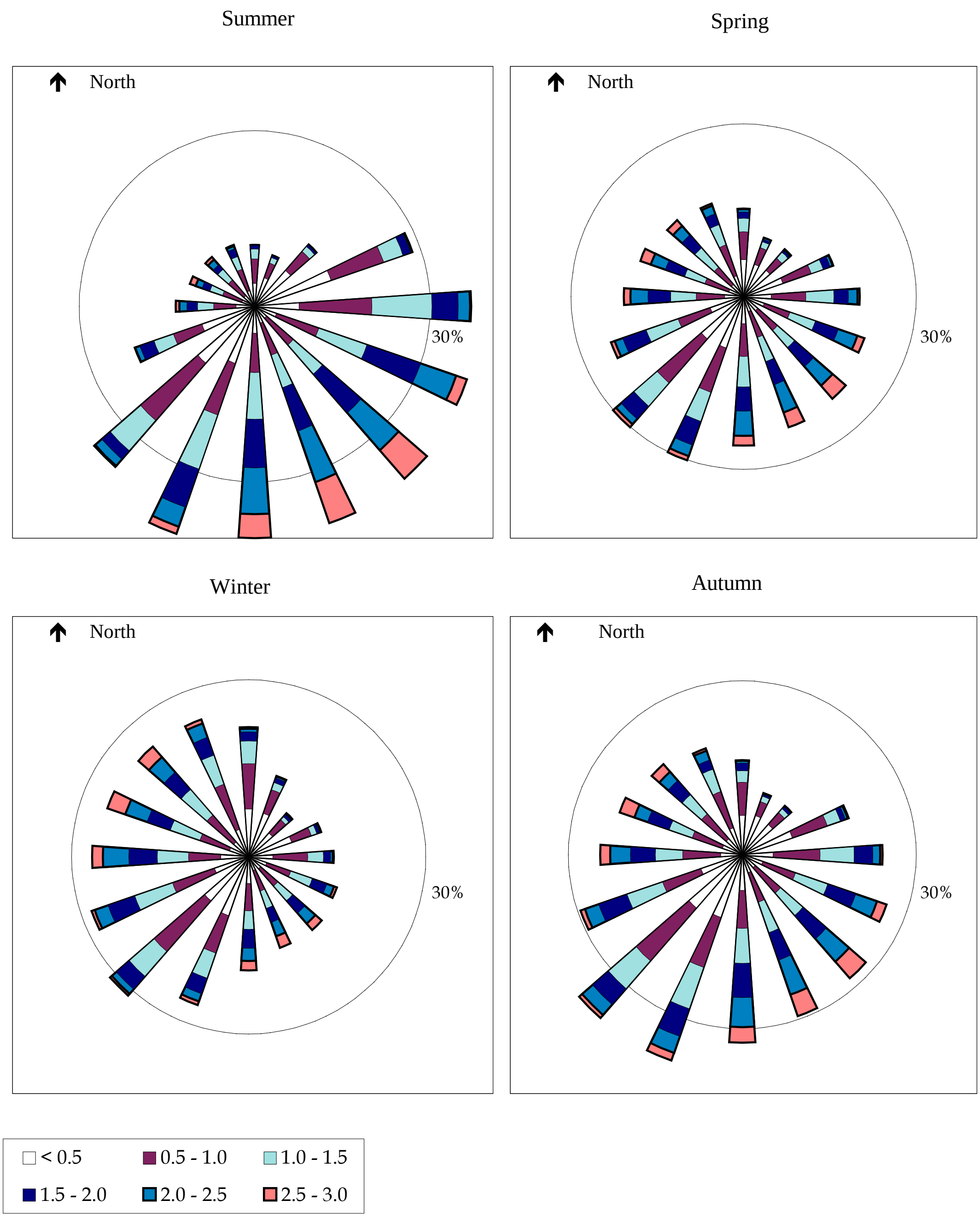
Data Source: Hunter Valley Operations
Data Range: hourly, ~4 years

The segments of each arm represent the six valid wind speed classes, with increasing windspeed from the centre outwards. The length of each arm represents the vector components (for each direction) of wind speeds 3m/s or below as a proportion of the total time for the period .
The circle represents the 30% occurrence threshold.

Evening

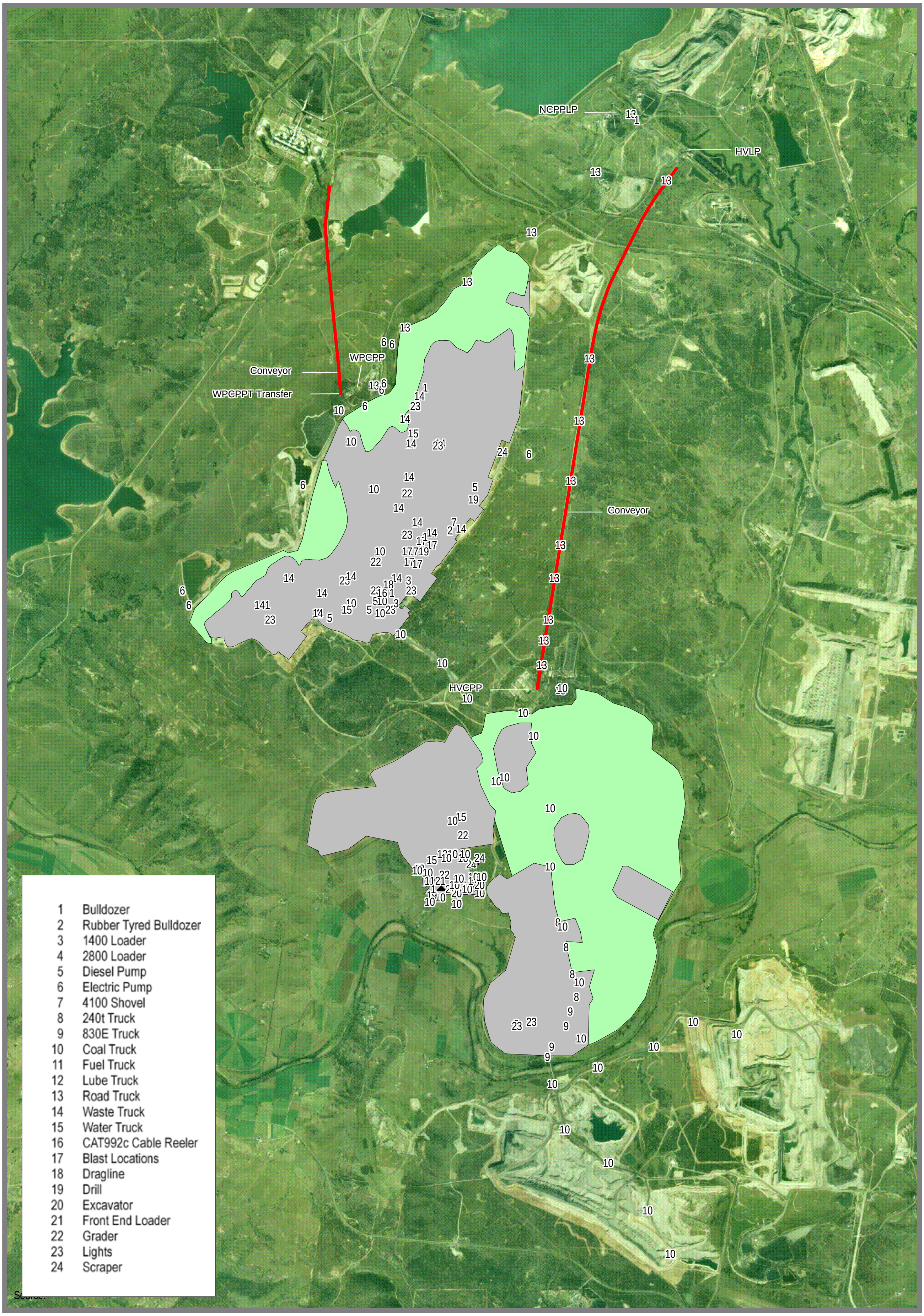

Summer
North
30%
Spring
North
30%
Winter
North
30%
Autumn
North
30%
< 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0

Night


Summer
Spring
North
30%
Winter
Autumn
< 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0

Annex C

Mine Plans and Equipment Locations

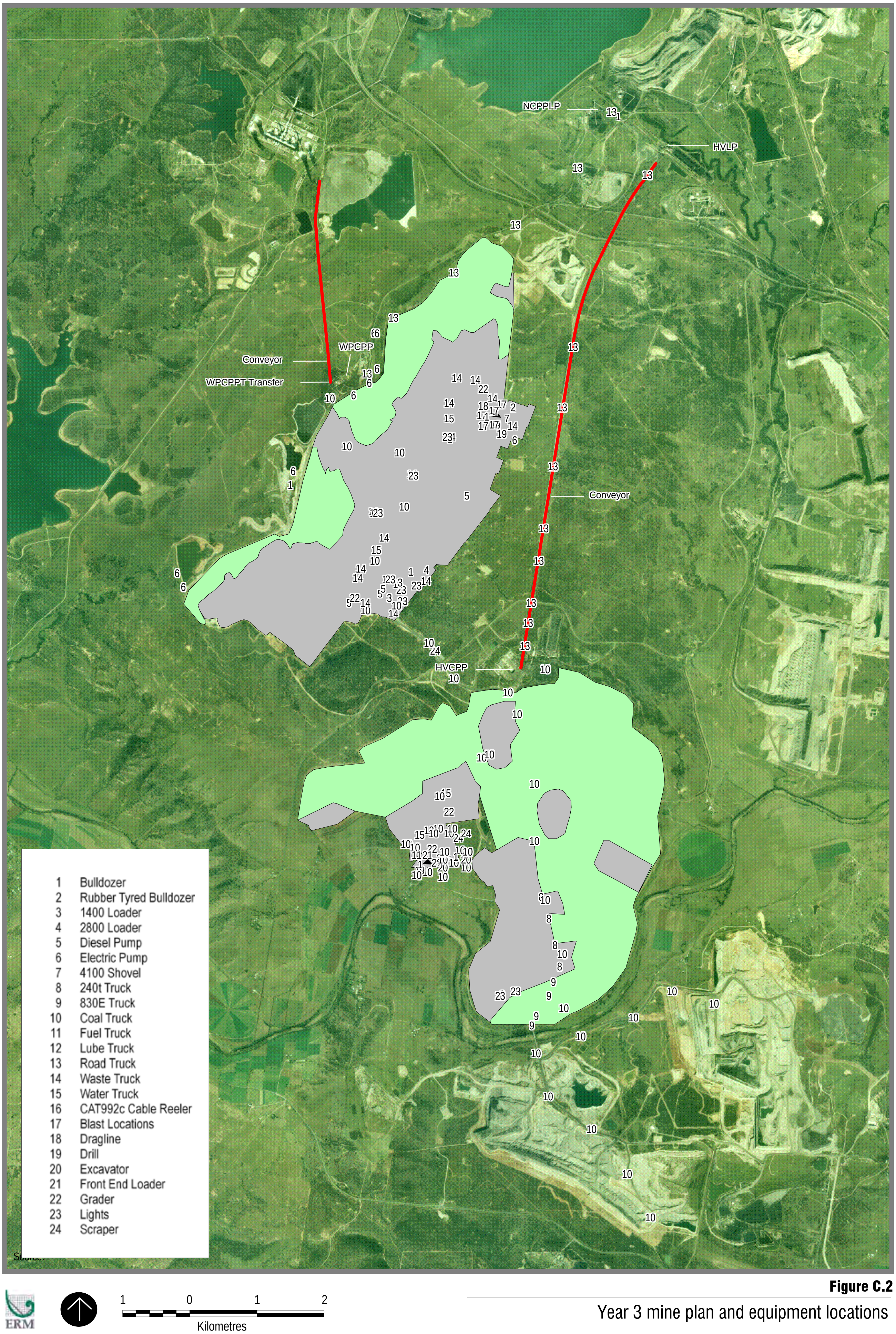


1 0 1 2

Kilometres

Figure C.1

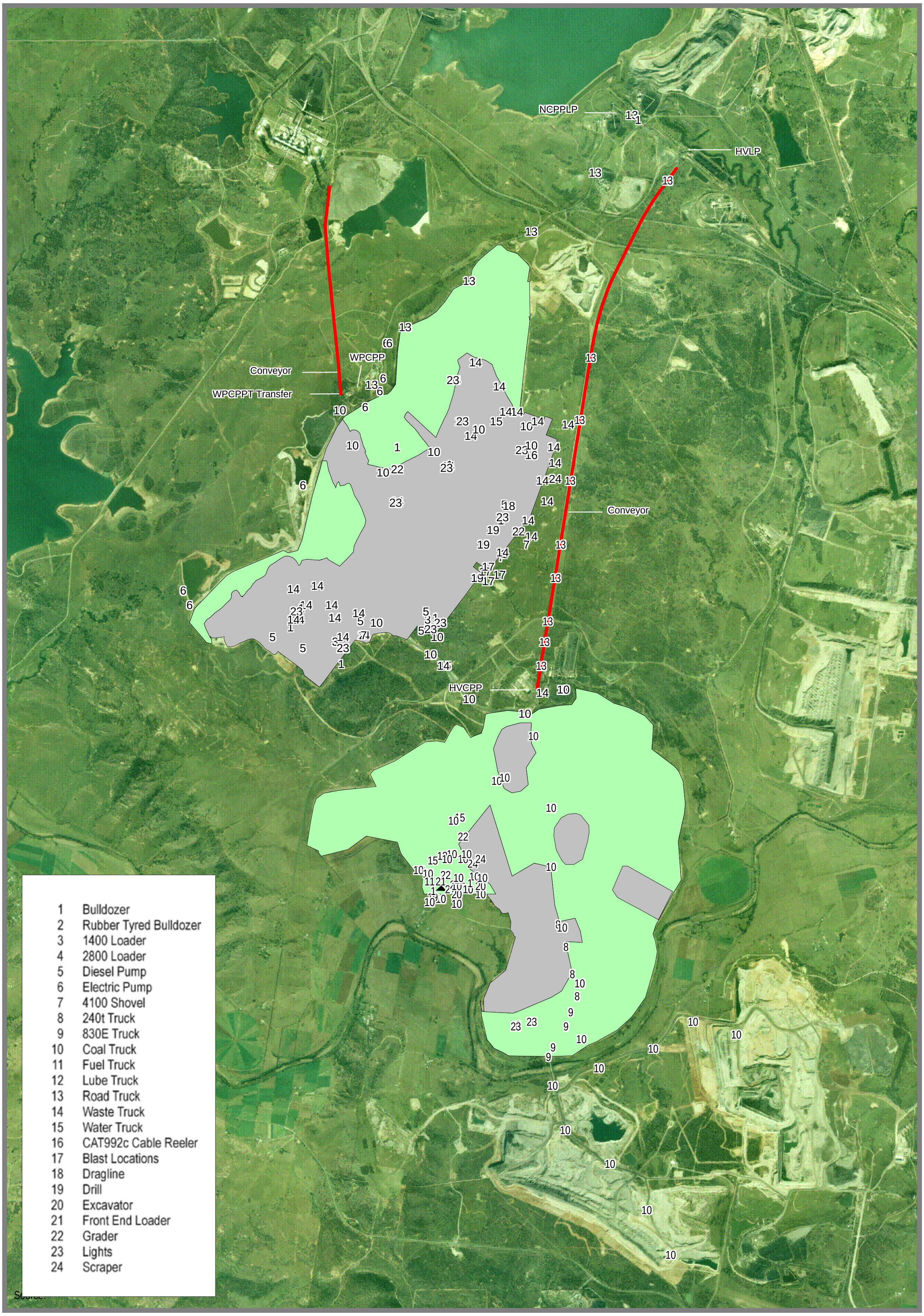
Year 1 mine plan and equipment locations



ERM

Figure C.2

Year 3 mine plan and equipment locations



X:\8030094\NoiseEquip.wor 22 08 2003 GV Environmental Resources Management Australia Pty Ltd

1 0 1 2
Kilometres

ERM

Figure C.3

Year 8 mine plan and equipment locations

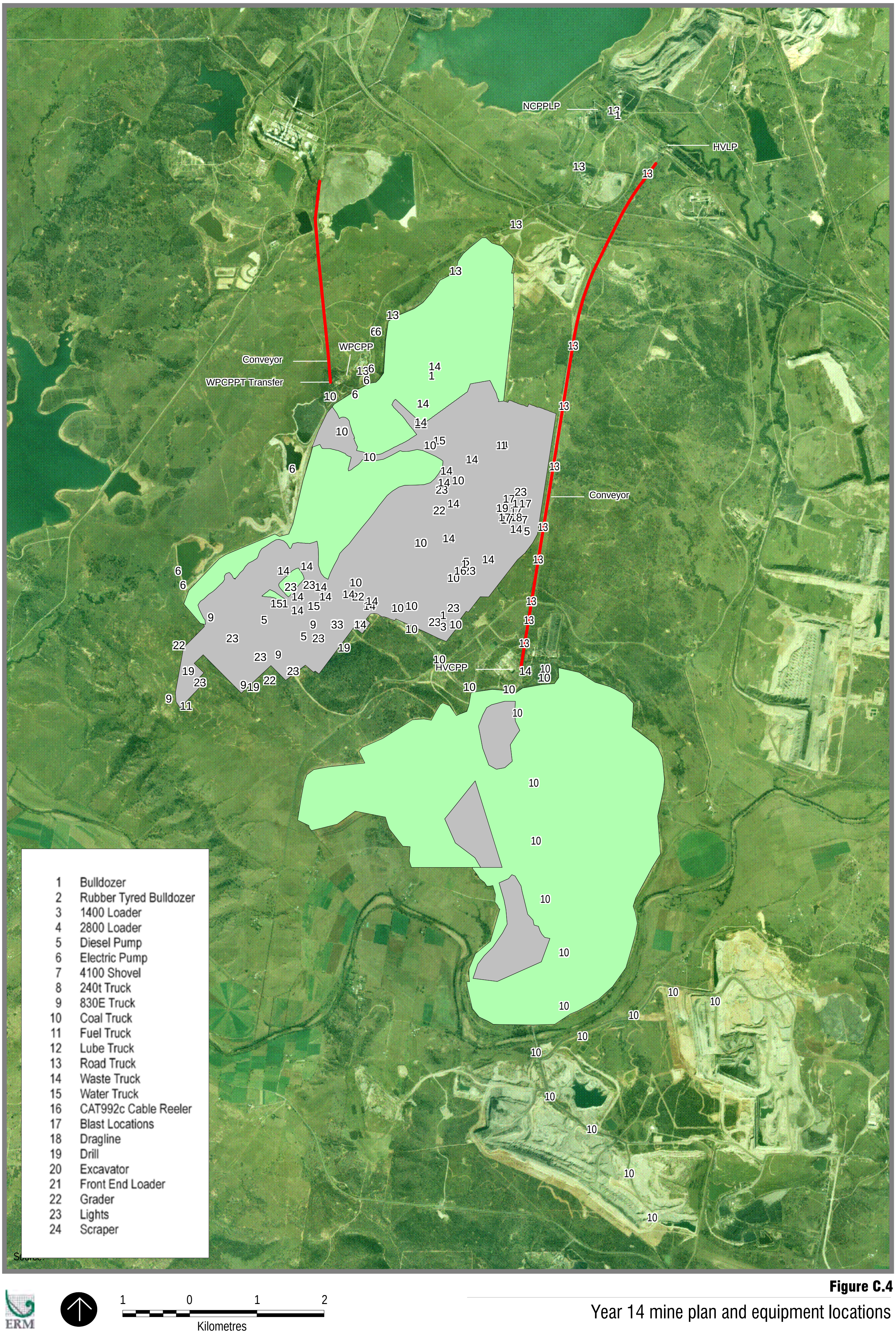
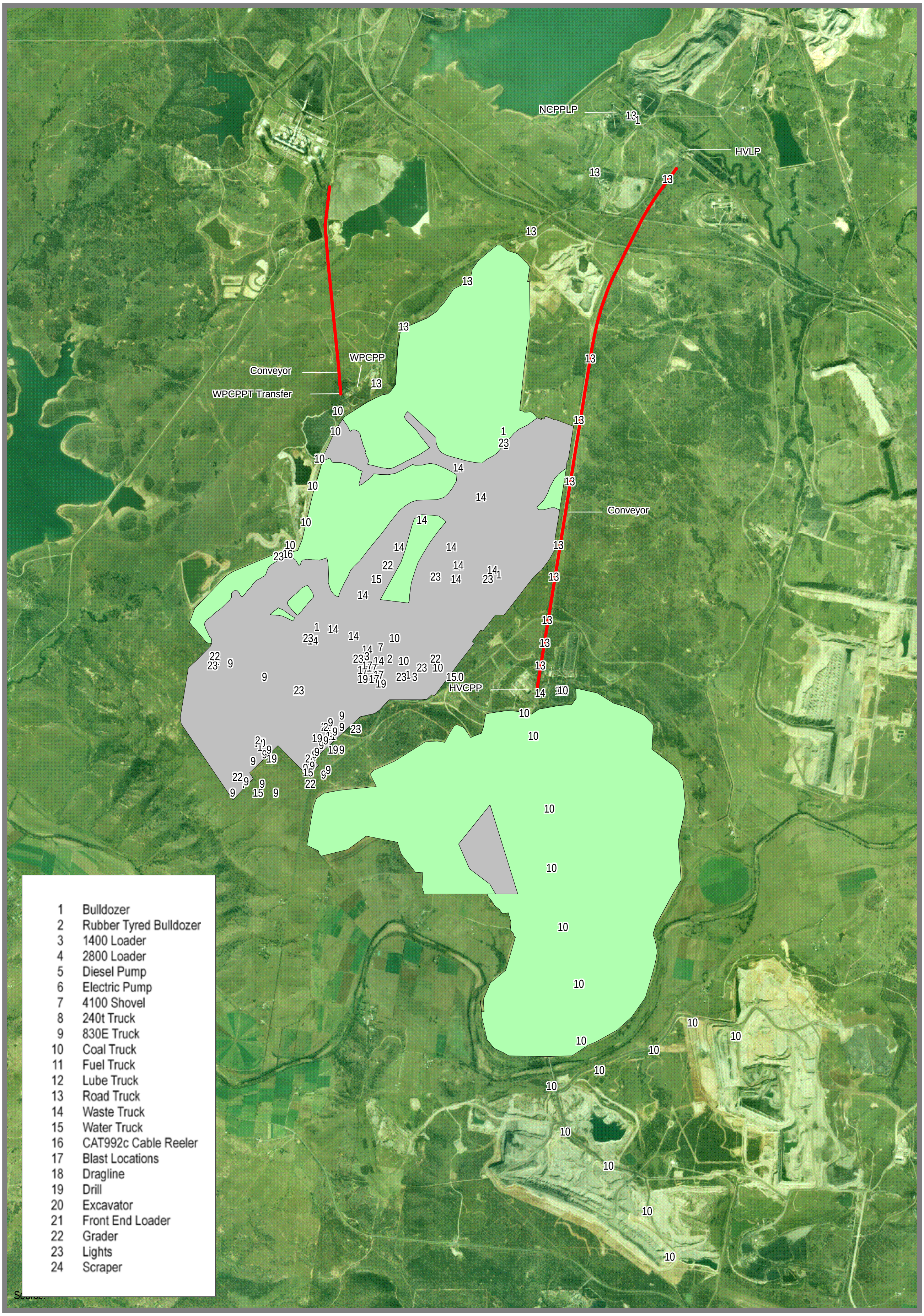


Figure C.4

Year 14 mine plan and equipment locations



ERM

Figure C.5

Year 20 mine plan and equipment locations

Annex D

Sound Power Spectral Data

Table D.1 Sound Power Spectral Data, dB

Item	31.5	63.0	125.0	250.0	500.0	1000.0	2000.0	4000.0	8000.0	16000.0	Linear	A-weight	
WATER PUMP - MULTIFLOW 360 (6CYL CAT ENGINE)	100	104	114	110	108	108	106	102	95	85	117	113	L_{eq}
CABLE REELER CAT992 #616	107	106	116	117	112	109	106	100	96	83	121	115	L_{eq}
VOLVO FL7 SERVICE TRUCK #987	99	109	103	98	96	99	97	92	85	5	111	103	L_{eq}
WEST PIT CPP	135	120	117	109	108	105	103	103	101	5	135	112	L_{eq}
LIGHTING PLANT #4318 (LARGE)	98	114	105	99	100	99	97	91	87	80	115	104	L_{eq}
LOADER LETOURNEAU #641	101	109	114	112	111	107	104	98	93	86	119	112	L_{eq}
REFUELING TANKER #1581 (4CLY)	111	104	89	87	88	84	84	83	76	5	112	91	L_{eq}
OVERLAND CONVEYOR 500m SWL (using 83dBA /linear metre & DJ Spectra)	112	112	121	114	106	103	98	97	94	84	123	111	L_{eq}
FE LOADER CAT 992D #608	98	99	108	109	106	107	102	96	92	80	114	111	L_{eq}
DOZER KOMATSU #515	105	108	122	115	114	111	109	99	91	5	124	116	L_{eq}
DOZER CAT D11R #524	115	111	110	112	106	106	102	97	88	5	119	110	L_{eq}
GRADER CAT 24H #817	107	108	115	111	109	108	106	99	99	92	119	113	L_{eq}
P&H SHOVEL 4100	110	111	112	114	118	112	108	103	96	86	122	118	L_{eq}
DRAGLINE B.E.	117	117	116	115	111	109	105	103	101	5	123	114	L_{eq}
DRILL SK50I REEDRILL	106	110	123	114	119	111	109	103	98	90	125	118	L_{eq}
RUBBER TIRED DOZER CAT 690D #537	108	107	115	115	112	112	107	101	97	5	120	116	L_{eq}
WATER CART CAT 777 #825	113	112	113	115	112	111	109	102	96	5	121	116	L_{eq}
DUMP TRUCK #445 830E	101	101	110	111	109	111	105	101	96	-5	117	114	L_{eq}
SCRAPER CAT 637E #809	114	113	114	106	107	105	104	96	87	5	119	110	L_{eq}
DUMP TRUCK WEISEDA (LIEBHERR) 240T #487	112	110	112	109	108	109	105	99	94	5	118	113	L_{eq}
WATER CART CAT 777 #825	113	112	113	115	112	111	109	102	96	5	121	116	L_{eq}
DUMP TRUCK WEISEDA (LIEBHERR) 240T #487	112	111	113	113	111	110	108	101	95	5	120	115	L_{eq}
VOLVO FL7 SERVICE TRUCK #987	99	109	103	98	96	99	97	92	85	5	111	103	

Annex E

Mine Equipment Measurement Procedure

E.1 *MINE EQUIPMENT MEASUREMENT PROCEDURE*

Following are comprehensive noise testing procedures that were used to determine representative sound power levels for all West Pit Operational Equipment.

E.2 *HAUL TRUCKS, WATER CARTS, FUEL AND LUBE TRUCKS*

- All trucks were required to be loaded within 10% of rated carrying capacity for the engine load (incline) and braking (decline) tests, with exception of haul trucks that can be empty for the braking test due to safety and/or logistical concerns;

- a straight test section of haul road (6 to 10% gradient) was marked with a 40 metre line corresponding to the centre of the road using orange cones;

- A measurement position, also marked with an orange cone, was placed at a distance of 16 metres (in accordance with risk assessment) perpendicular to one side of the centre line mid-point. The trucks were driven up and down the grade straddling the marked centre line;

- the microphone position was located at a constant distance equal to half the height of the machine or four metres, whichever was the smallest, above the ground;

- the trucks were required to approach the test section at the maximum speed limit allowable on site according to vehicle types (eg. haul trucks – 50 km/h);

- noise measurements commenced when the front of the truck passed the first orange cone and ceased when the rear tyres of the truck passed the last orange cone for a total travel distance of 40 metres plus the truck length; and

- testing requirements were a once only incline and decline drive-by with a single noise measurement occurring for each run.

E.3 DOZER TESTING

- The dozers were required to operate with the blade in the normal travelling position and reversing and/or warning beepers switched off or disconnected;

- A straight test section of level (< 1% incline) haul road or similar work location was be marked with a 40 metre line corresponding to the centre of the test section;

- A measurement position, marked with an orange cone, was placed at a distance of 16 metres perpendicular to the centre line mid-point. The dozer was be driven forward and then reversed, straddling the marked centre line;

- The microphone position was be located at a constant distance equal to half the height of the machine or four metres, whichever was the smallest, above the ground;

- The dozers were be required to approach the test section for individual tests of the gear range (eg. first gear, second gear etc) with the engine operating at the governed speed for rated power (high idle) and maintained for the duration of measurement. The matching gear ratio will be used for reverse, regardless of the travel speed;

- Noise measurement commenced when the front of the tracks passed the first centre line marker and ceased when the front of the tracks returned to the first centre line marker for a total travel distance of 80 metres. During each test the machine travelled forward in the nominated gear to the last marker, stopped, immediately selected reverse and travelled back to the start location;

- Testing requirements were a once only forward and reverse test for each selectable forward gear per dozer.

E.4 DRAGLINE AND SHOVEL TESTING

- The test site was the machine location on the day of measurement;

- Where possible, machine noise levels were measured in isolation from other nearby noise sources and any significant reflective surfaces if possible (eg. high wall);

- two measurement positions, marked with orange cones, will be placed around the circumference of the machines mid-point at a distance determined by the following equation:

  $r = l + h/2$

  r = radius to measurement location (m)

  l = maximum machine dimension (m)

  h = overall height of the top of the machine above the ground surface (m);

- Upon calculation of the required radius from the machine mid-point, a GPS was used to measure distance; and

- At the measurement location, the microphone position was located at a constant height of four metres above the ground.

E.4.1 Dragline Testing Operation

- The dragline was required to simulate excavation of a layer in a trench and dumping of the material adjacent to the trench. For the duration of the test cycle, the boom position was required to be at an angle of 40 degrees. The bucket hung vertically under the end of the boom and 0.5 meters above ground level with drag chains not touching the ground;

- First retract the bucket to bring it as close as possible to the machine while maintaining a distance of 0.5 metres above the test site. When the bucket was retracted, a 90 degree swing to the left of the dragline operator was executed. Simultaneously, the bucket was raised to 75 % of the maximum lift height and extended to maximum reach in the loaded bucket position. A return swing was then executed, finally simultaneously actuate the bucket dump and retract the bucket to the starting position; and

- The sequence of events was repeated two more consecutive times to complete a single dynamic test cycle.

E.4.2 Shovel Testing Operation

- The shovel was required to simulate excavation at the height of a high wall. At the beginning of the cycle, with the bucket cutting edge parallel to the ground, the bucket was required to be 0.5 metres above ground in the 75 % retracted position;

- The bucket was extended to 75 % of total travel while maintaining the original bucket orientation. Then the bucket was rolled back or curled and raised it to 75 % of maximum lift height and 75 % of dipper arm extension.

A 90-degree swing to the left of the shovel operator and at the end of the swing the bucket dump mechanism was actuated. A return swing was executed, then simultaneously retracted the bucket to 0.5 metres above ground level in the 75 % retracted starting position;

- The sequence of events was repeated two more consecutive times to complete a single dynamic test cycle;
- All machines were required to operate with reversing and/or warning beepers switched off or disconnected; and
- A straight test section of level (< 1% incline) haul road or similar work location was marked with a 14 metre line corresponding to the centre of the test section using painted markings and orange cones to ensure driver vision.
- Four measurement positions, also marked with paint, were located at a distance of 10 diagonally either side of the centre line mid-point. The tested machine was driven forward and then reversed straddling the marked centre line;
- The microphone positions were located at a constant height of 1.5 metres above the ground; and
- Noise measurements commenced when the machine mid-point passes the first centre line marker and ceased when the machine mid-point returns to the first centre line marker, for a total travel distance of 28 meters. During each test the machine had travelled forward in the nominated gear until the machine mid-point was over the last centre line marker, stopped, immediately selected reverse and travelled back to the start location.

E.5 GRADER AND SCRAPER TESTING OPERATION

- The machine tested was required to operate with the blade 300 mm above the ground for the duration of the test run; and
- The machine was operated at the maximum governed engine speed (high idle) in a constant forward and reverse travel speed. The forward travel speed was required to be close to but not exceeding 8 km/hr, if the lowest gear resulted in a higher speed, was used with the engine operating at maximum governed speed. The matching gear ratio was used for reverse, regardless of the travel speed.

E.6 LOADER TESTING OPERATION

- The machine tested was required to operate with an empty bucket in a lowered carry position 300 mm above the ground for the duration of the test run; and
- The machine was operated at the maximum governed engine speed (high idle) in a constant forward and reverse travel speed. The forward travel speed was required to be close to but not exceeding 8 km/hr, if the lowest gear resulted in a higher speed, it was used with the engine operating at maximum governed speed. The matching gear ratio was used for reverse, regardless of the travel speed.

E.7 BLAST HOLE DRILLS

- The test site was governed by the machine location on the day of measurement;
- Where possible, the machine noise levels were measured in isolation from other nearby noise sources and any significant reflective surfaces if possible;
- Four measurement positions, marked with paint and/or orange cones, was located at a distance of 16 metres diagonally in circumference of a centre-point. The tested machine will be driven forward straddling a marked centre line until the machine mid-point is located above the marked centre-point;-
- the microphone positions were located at a constant height of 1.5 metres above the ground;
- during testing, the engine was to be operated at the maximum governed speed (high idle) while conducting normal drilling with the maximum safe "pull down" pressure for the rock type; and
- Noise measurements were conducted for the duration of drilling one blast hole. However because only one measurement could be performed at a time, microphone positions were changed during a drill shaft extension.

PART K

aboriginal archaeological study

K

ABORIGINAL STAKEHOLDER STRATEGY AND SOCIAL VALUES ASSESSMENT OF THE PROPOSED EXTENSION OF WEST PIT

A REPORT TO ENVIRONMENTAL RESOURCES MANAGEMENT AUSTRALIA (ERM)

FOR COAL & ALLIED OPERATIONS

OCTOBER 2003

Prepared by

Australian Archaeological Survey Consultants Pty Limited
GPO Box 943
CANBERRA ACT 2601

Phone: 0412 211137
E-mail: davej@austarmetro.com.au

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- Ungooroo Aboriginal Corporation Representatives: Graham Ward, Rhonda Ward, Samantha Ward and Allan Paget.

- Upper Hunter Tribal Council Representatives: Victor Perry (also the Wonnarua Nations Aboriginal Corporation representative) and Rhoda Perry.

- Lower Wonnarua Tribal Consultancy Pty Limited Representative: Barry Anderson.

- Wanaruah Local Aboriginal Land Council Representatives: Noel Downs (Coordinator), Trevor Griffiths, Beverley van Vliet, Carl Hedgers and Roger Matthews.

- Combined Council Hunter Valley Aboriginal Corporation Representatives: Margaret Matthews, John Matthews, Darrell Matthews, Christine Matthews, Michael Matthews and Tony Matthews.

- Wonnarua Nations Aboriginal Corporation Representatives: Barbara Foot, David Foot, Luke Hicky and Robert Lester.

- Lower Hunter Wonnarua Council Incorporated Representative: Lea-Ann Miller.

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- Glenn Morris, Margaret Koettig and Shaun Hooper of NSW National Parks and Wildlife Service.

- Brett McLennan and Neville Baker of Environmental Resources Management Australia Pty Limited (ERM).

- Isabel McBryde, Peter Kuskie, Rob Paton, Meredith Wilson and Alison Stewart.

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APPENDICES

1. INTRODUCTION

1.1 Background

Coal & Allied Operations (Coal & Allied) plan to extend open cut operations at Hunter Valley Operations (HVO) West Pit (formerly known as Howick Mine) from the existing open cut pit east to the Belt Line Road. An Environmental Impact Statement (EIS) is being prepared to accompany the Development Application to the Minister for Infrastructure and Planning. As part of this EIS, an assessment of Aboriginal heritage is required. This requirement derives from the National Parks and Wildlife Service (NPWS) guidelines, *Aboriginal Cultural Heritage and the Integrated Development Approval Process* (1998), updated 2001. These guidelines set out the requirement for two types of information in an Integrated Development Assessment (IDA) application where Aboriginal sites are to be impacted; an "Aboriginal cultural heritage assessment" and an "archaeological assessment".

Coal & Allied recognise there is a need for the heritage values identified in the Aboriginal heritage report and the archaeological report to be considered in an overall assessment of cultural significance (as defined in the *ICOMOS Australia Burra Charter 1999*).

In taking a proactive and innovative approach, Coal & Allied, besides carrying out an archaeological assessment, have also undertaken an Aboriginal Stakeholder strategy and social values assessment of the proposed extension of West Pit. This innovative approach involves carrying out a detailed program of Aboriginal community consultation and assessment of social values in relation to Aboriginal heritage associated with the project area.

Environmental Resources Management Australia Pty Limited (ERM), who have been commissioned to carry out the EIS, contracted Dave Johnston, an Indigenous Archaeologist and Director of Australian Archaeological Survey Consultants Pty Limited (AASC) to carry out the Aboriginal Stakeholder strategy and social values assessment project.

The study area (*Figures 1 & 2*) considered in the Aboriginal social values assessment comprises the land within EL5243 north of Lemington Road and ML1406, a total area of approximately 240 hectares (AMBS 2003:1).

1.2 Project Objective

The objective of this project is to provide an Aboriginal Stakeholder strategy that identifies who the stakeholders are, and highlight the social values relating to heritage sites in the West Pit Extension study area.

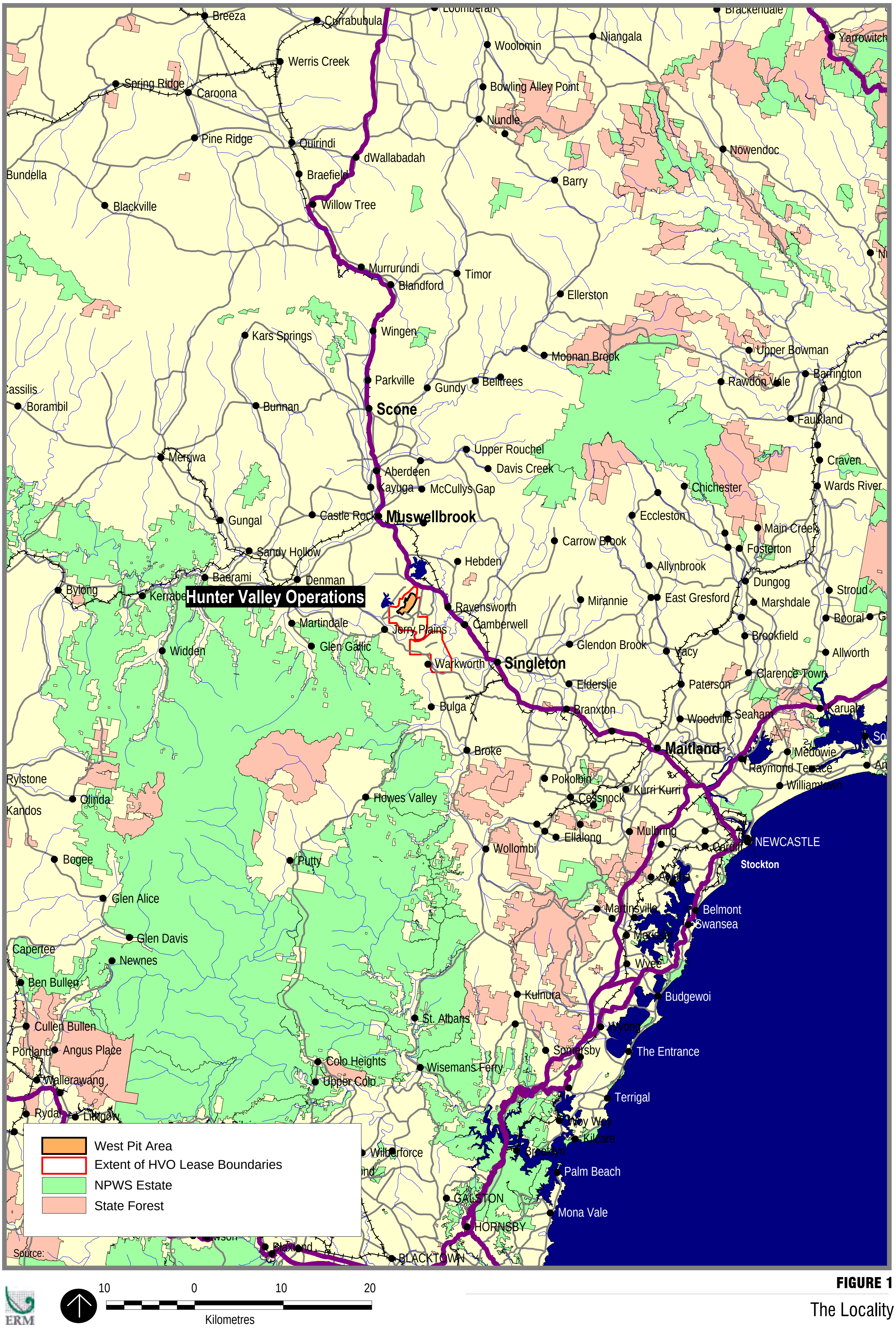

FIGURE 1

The Locality

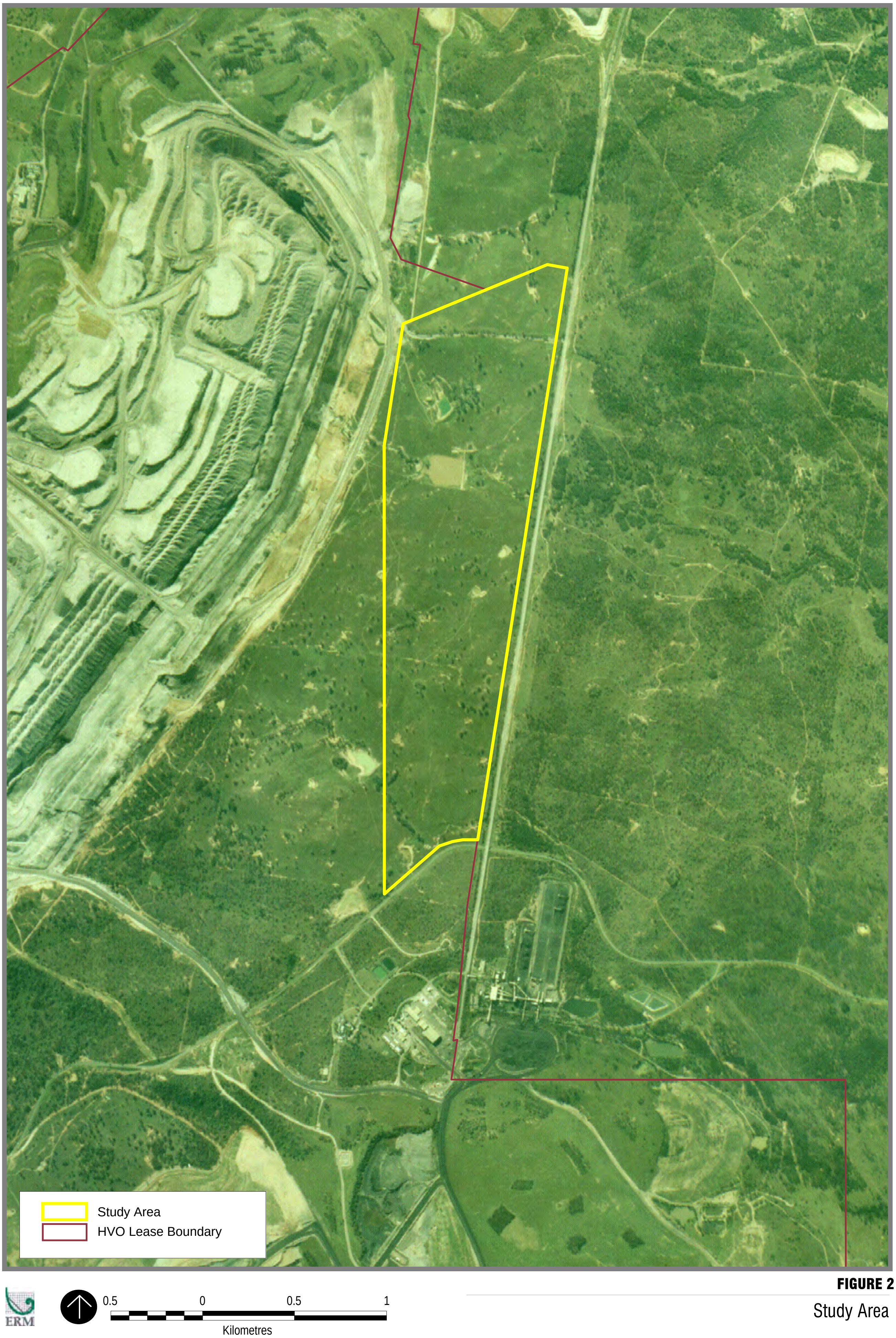

FIGURE 2

Study Area

The report will form a specialist study in the West Pit extension EIS.

1.3 Project Brief

The Consultants' brief states that the study should identify:

- the existing knowledge about Aboriginal sites in the West Pit study area;
- who to speak to - organisations, knowledge holders;
- the most appropriate mode of consultation and relevant protocols eg. informal conversation, formal meeting, site visit;
- differing rights to speak - negotiating traditional owners versus out of country Aboriginal peoples' rights to speak and associated concerns;
- the social values of the study area (and heritage places therein) to the various groups; and
- a negotiated agreement on documentation of those values in a report.

As can be seen in Section 3 of this report, a methodology to achieve the aims of this project has been developed by the Consultant.

1.4 Scope of Report

This report documents the results of the Aboriginal community consultations and other scopes of work as defined by the Project Brief.

Community consultations were carried out from late May through to September 2003.

2. DEFINING SOCIAL VALUE

The Burra Charter defines social value as embracing "the qualities for which a place has become a focus of spiritual, political, national or other cultural sentiment to a majority or minority group." Pearson and Sullivan (1995:153) state that, "those places with social value have often acquired it because of their historic, aesthetic, educational or scientific significance."

NSW NPWS have recently produced a discussion paper on social significance which focuses on, "the significance assessment process and the potential for expanded community involvement in this."(Byrne et al 2001:ix) The discussion paper argues that:

> The established four-part significance classification (aesthetic, historical, scientific, social), while it has been useful in distinguishing areas of professional practice in cultural heritage (i.e., architecture, history, archaeology), represents a poor fit for the reality of the way communities value and interact with their heritage places. We suggest the NPWS use a more fluid approach to significance assessment, one, that is responsive to the range of heritage values as they exist in communities in NSW today.
>
> (Byrne et al 2001:ix)

For this project, the Consultant utilised the widely accepted Burra Charter definition of 'social value', but focused specifically on consulting the identifiable Aboriginal custodial (or historically associated) representative groups/organisations/individuals regarding Aboriginal 'social values'.

This partly mirrors the approach advocated by Pearson and Sullivan (1995:18-19) in relation to their issue, *Value to Minority Groups*. The relevant points for this study are:

- Part of the value of cultural places is their special value to minority groups in the community;
- This may include people from ethnic minorities [in this case Aboriginal groups] who have a particular interest in their own history; and
- Value to minority groups is a very important part of the social value of sites.

Commensurate with this approach to the task, Pearson's and Sullivan's (1995:19) definitions are also significant for this study. In particular the Consultant notes the following:

> Aboriginal significance may be:
>
> *traditional:* the place may be a sacred, or important religious site; for example, a place that has an important association with a cultural hero, or a place where a ceremony is or was held
>
> *historic:* the place may be important in post-European Aboriginal history—it may tell the story of Aboriginal contact with Europeans, or their subsequent history—a massacre site like Myall Creek (NSW) or a cemetery or an Aboriginal mission may be such a place

contemporary: the place may be a site with no traditional associations—it may be an archaeological site unknown to present Aborigines; but it may, when discovered, acquire importance to Aborigines because of what it symbolizes, and because it tells them about their past; for instance, sites at Lake Mungo (NSW), among the earliest known human occupation sites in Australia, are obviously of importance to Aborigines, though discovered and interpreted by archaeologists.

3. METHODOLOGY

The methodology used for this project has evolved as a result of the need to consult with Aboriginal Stakeholder organisations in a manner sensitive to their requirements. The Consultant invited each representative Aboriginal organisation to comment on and participate in the development of the methodology and report structure to ensure that the Final Report addresses their concerns relating to the project. Specific requirements or protocols to be followed were identified by the Aboriginal organisations and adopted as part of this project's methodology. These are included below in Section 3.2.

The proposed methodology has been prepared based on the Consultant's understanding of the Brief and experience in liaising with his people on similar heritage related projects and issues. Relevant experience also includes the consultants active involvement in projects such as the preparation of the Australian Heritage Commission's report, *Ask First: A guide to respecting Indigenous heritage places and values* (2001) and preparation of an Aboriginal History Monograph, *Australia Our Sacred Place: Perspective's of Aboriginal Archaeologists* (in preparation), which addresses Aboriginal views on social significance.

The proposed methodology adopts and adheres to the procedures set out in the *Draft Guidelines for Aboriginal Heritage Impact Assessment* produced by NSW NPWS (2003), particularly in regards to assessing Aboriginal heritage values and the associated consultation process. NSW NPWS' reports, *Talking History Oral History Guidelines* (2003) and *Social Significance: A Discussion Paper* (2001) have also been reviewed and the current methodology has taken both these into account.

3.1 Scope of Works to Achieve Project Aims

3.1.1 Background Ethnohistorical Summary

The Consultant has collated and reviewed the ethnohistorical evidence for the region to produce a general summary. This information previously documented by a range of researchers, is important in providing an historic setting of Indigenous occupation and association with this region.

3.1.2 Background Archaeological Report Summary

The Consultant has collated and reviewed relevant archaeological reports for the region to gain an understanding of the level that Aboriginal social significance values have previously been documented and included in management recommendations. This review was undertaken to provide the consultant with an overview of archaeological site management and mitigation strategies developed and actioned in the region. Of most relevance to this report is a understanding of how, and in what capacity, Aboriginal groups have voiced their recommendations relating to archaeological assessments and how effective this has been. An understanding of this situation allowed the Consultant to gain a better awareness of the heritage management issues the Aboriginal Stakeholders currently hold and their reasons why.

3.1.3 NSW NPWS Consultation

The Consultant held telephone discussions with Shaun Hooper, Glen Morris and Margaret Koettig, of NSW NPWS regarding the project scope and proposed methodology. This liaison provided the Consultant with an additional understanding of Aboriginal heritage issues in the Hunter Valley. The project methodology was also submitted and discussed at a meeting between Coal & Allied, Teresa Gay and Jason Ardler of NSW NPWS in August 2003 to confirm their acceptance of the proposed methodology.

3.1.4 Meetings with the Aboriginal Stakeholder Organisations

Details of the Aboriginal Stakeholder groups consulted and the results of the meetings are documented in Section 5 of this report.

Initial Introduction Meetings and telephone consultations

Initial introduction meetings were organised by Coal & Allied on the 28th and 29th May 2003 to introduce the Consultant and the project to the Hunter Valley Aboriginal Representative organisations. Telephone contact was made with those organisations who where not able to be visited on those dates.

Initial Project Consultation Meetings

Initial consultation meetings were organised and held with each of the Hunter Valley Aboriginal Representative organisations relevant to the project area and who wanted to be involved in the project. These meetings were carried out in July 2003.

3.1.5 Structure of Initial Project Consultation Meetings

The structure and nature of the meetings was determined through a mutual consultative process between each of the organisations and the consultant and reflected any protocols and specifications the organisations had.

While the agenda for the meetings was flexible there where a number of core issues or components, which were addressed at each meeting. These were as follows:

- The Consultant explained the project, its background and discussed the general objectives.

- It was clearly stated up-front that this project was not attempting to identify or establish family genealogies or attempting to document sensitive or secret cultural information which is inappropriate to disclose. It was explained that this Aboriginal Stakeholder strategy and social values assessment for the West Pit Extension, was an opportunity to specifically identify, and document appropriate Aboriginal 'social values' for the project area.

- The Consultant explained that if there were specific Aboriginal 'social values' related to the project area, then this project allows the opportunity for the recognition and development of specific management recommendations if required.

- Consultation protocols with each group were established. This involved developing a 'check list' of how consultations with each group were to be carried out. It identified who was to be the contact point for the project, which Aboriginal Representatives need to be involved and consulted within each group, how the consultant was to record the meetings and any appropriate oral histories and how each group wanted to review and comment on their meeting's results and findings.

- The Consultant presented the draft methodology and associated strategies and invited feedback to develop them further.

- Information was sort regarding the association the organisations or individuals have with the site area.

- The Consultant documented the Representative Aboriginal organisations'/individuals' issues, concerns and aspirations regarding the management of their cultural heritage in general and at the study area.

- The consultant led discussions on Indigenous 'social values' and significance for sites or places in general and referred to examples, to illustrate to the representatives the nature of social value assessment.

- The consultant explained to the representatives the potential impact the pit extension works will have on the general landscape and therefore to any tangible or intangible cultural heritage, in the project area.

- Discussions were held regarding the archaeological survey carried out at the project area, the sites located and recommendations developed.

- The Consultant asked if individuals or the Aboriginal Representative organisations held 'social values' to either features, objects or places within the project area and whether people were willing to be forthcoming with any such information at this point.

- The Consultant documented any 'social values' identified for the project area and other associated significance statements and responses, in a manner acceptable to the informant/s. Where there was no 'social values' identified or communicated the Consultant recorded these results.

- Inquiries were made as to whether there were other Aboriginal Stakeholders that the consultant should speak to, who may not as yet be represented by one of the representative organisations.

- A date and time for the on-site visit was established.

- Protocols for the report production were confirmed.

- Future protocols for consulting the organisation/individual were established.

3.1.6 Project Area Inspections

On site inspections were held with each of the relevant Hunter Valley Aboriginal Representative organisations during July 2003. Sites identified during the archaeological survey were visited or identified in the landscape and discussions were held to see if there were any Aboriginal 'social values' associations. Sites highlighted during earlier meetings or identified by the representatives during the current field inspections were also inspected.

The field inspections allowed people to get out and onto the project area to familiarise themselves with the location and allowed them the opportunity to be informed and involved stakeholders. On the ground inspections are of use in Aboriginal heritage recording projects such as this as it gives people the opportunity to reflect, reminisce and become more comfortable in relaying oral history to the recorder.

Following the site inspections, meetings were held back at the Coal & Allied office with each organisation. Heritage management recommendations identified during the previous meetings or during the project area inspection were discussed, confirmed and recorded for inclusion in this report.

3.2 Aboriginal Stakeholder Protocols and Specifications Relating to the Methodology

Following the initial round of phone consultations and meetings with the Aboriginal Representative organisations, the following general protocols and specifications were identified and incorporated into the final project methodology. Discussions held with each of the organisations can be referred to in Section 5. Individual specifications identified by the groups regarding their involvement and the methodology have also been adopted for that particular group and can also be referred to in Section 5.

Protocols and Specifications:

- Unless specified, all the identified Aboriginal Stakeholder organisations wished to be consulted regarding the project and the majority expressed gratitude to Coal & Allied for initiating the consultation project.

- All but one of the organisations involved in the project agreed to hold a field inspection and recommended that this occur.

- Meetings and consultations were not to be tape recorded. Notes were to be hand written and later reviewed and endorsed by the organisation.

- Liaison between the Consultant, Dave Johnston and each group would be via the designated Representative.

- General conversations were not to be recorded.
- The report would be sent to each group for comment and endorsement.

4. ABORIGINAL OCCUPATION AND HISTORY OF THE HUNTER VALLEY

4.1 Social Organisation

According to Brayshaw (1986) and S.E. Archaeology (1999: 55), the organisation of Aboriginal groups within the Hunter Valley is difficult to define due to: a) a dearth of ethnohistoric sources, and b) the major disruptions to traditional culture during the post-contact period. The term 'tribe' was commonly used in the ethnographic literature to differentiate between groups within the Hunter region, but unfortunately failed to discriminate between a group of five and a group of five hundred (Brayshaw 1986: 36). James Miller, a member of the Gringai sub-group of the Wonnarua, states that four groups or tribes traditionally occupy both the middle and upper areas of the Hunter Valley: Geawagal, Wonnarua, Awabakal and the Worimi.

The Geawegal, Awabakal and also the Gringai (based on the Allyn and Peterson Rivers) are suggested as being possible sub-groups of the Wonnarua (Miller 1985), which finds some level of support from linguistics (Gunson 1974: 3, in Brayshaw 1986: 41). The Wonnarua, according to Tindale (1974), inhabited a 5,200 square kilometre area of land which extended from just to the west of Maitland across to the Great Dividing Range, south to the boundary of the Darkinjung (north of Wollombi) and north to Muswellbrook. Another group, described by Brayshaw (1986) as having been 'closely affiliated' with the Wonnarua, was the northwestern Kamilaroi. Both Threlkeld (1892) and Matthews (1903) (cited in Brayshaw 1986: 38) describe the Kamilaroi territory as extending southwards as far as Jerrys Plains. By the time of European contact, the Kamilaroi are considered to have been a dominant influence in the Hunter Region (Brayshaw 1986: 41).

The earliest ethnographic literature suggests that connections between each of these groups were probably maintained through inter-tribal communication involving trade, particularly between the inland and the coast (Berrallier 1802, cited in Brayshaw 1986: 41). Brayshaw (1986: 67) notes, for instance, that coastal people exchanged tomahawks, scrapers, glass and spears with inland people for their objects made of possum skin and fur.

4.2 Modification of the Landscape

According to Brayshaw (1986: 20) the main ethnographic evidence for deliberate modification of the landscape by Aboriginal people in the Hunter Region was through their use of fire. Commonly carrying firesticks with them, they are said to have burned the landscape mainly for the purposes of either attracting game or signalling. Accidental firing has also been reported (Dawson 1830: 209; in Brayshaw 1986: 22).

4.3 Campsites

Aspects of Aboriginal lifestyle can be gleaned from a combination of ethnographic pictorial and literary sources, particularly in relation to campsites, which form a major component of the contemporary archaeological landscape. Ethnographic information concerning the exact whereabouts of campsites is quite rare (but see Mathews 1830 and

Grant 1803). However Fawcett (1898; cited in Brayshaw 1986) suggests that campsite selection was made on the condition that they were located near to fresh water and a food supply, and that they were in some way strategically located to defend themselves in the case of an enemy attack. The components of a campsite apparently varied from site to site (particularly in terms of the numbers of people present), but some rare ethnographic art (e.g. Joseph Lycett) indicates that huts or 'gunyers' formed part of the campsite context (Brayshaw 1986: 42).

4.4 Population Figures

Ethnographic sources contain very little information about the actual numbers of Aboriginal people residing in the Hunter Region but there are strong indications that the effects of disease, especially the smallpox epidemic of 1789, decimated the population to such a degree that very few Europeans had an opportunity to document traditional Aboriginal life (Butlin 1983, cited in Brayshaw 1986). According to Miller (1985: 66), by the end of the nineteenth century the number of Wonnarua, Geawegal and Gringai people amounted to less than 80. Other figures provided by the sources cited by Brayshaw indicate that, by contact, there were probably no more than about 300 people in the Hunter Valley.

4.5 Material Culture

Brayshaw (1986: 59-68) provides a detailed digest of the types and functions of material culture found in the Hunter Valley that are described in the ethnohistoric literature. Some of this information is incongruous with the archaeological evidence which indicates a large proportion of stone artefacts. As Brayshaw (1986: 68) surmises, perhaps this is an indication that stone artefacts found in archaeological assemblages were no longer present in the landscape at the time of European contact, or rather that they failed to attract the attention of early ethnographers and therefore went unrecorded.

Among the raw materials used by Aboriginal people in the region Brayshaw (1986) lists bark as one of the most versatile and widely used, having been employed in the construction of huts, the production of string, nets, baskets, drinking vessels, and shields. The latter, which were also made of wood, were often painted.

Hardwoods such as iron bark (e.g. *Eucalyptus crebra*) were also used extensively in the manufacture of particular objects, such as clubs (e.g. 'waddies') which were used either to procure food (such as bandicoot) or as an aid in battle (generally in one-on-one combat). A more substantial, heavier type of club with a circular head, sometimes referred to as a 'nullanulla', tended to be employed in larger battles. Other hardwood objects include the 'wooden sword' (like a boomerang but with a handle at one end), yamsticks (used by women either for food foraging or in the case of an altercation) and boomerangs. Boomerangs are described in the ethnographic literature as having a range of functions, including as a means of dispersing a crowd, as a mode of entertainment, or 'for the purpose of destruction' (Brayshaw 1986: 65).

Aside from bark and wood there existed an array of objects made from composite materials, such as the fishing spear, which was composed of the grass tree (*Xanthorrhoea australis*), hard wood, bark thread, grass tree gum and bone; spearthrowers (or woomeras), which had several functions ranging from opening oysters to dislodging bark from trees (Gunson 1974 and Dawson 1830, cited in Brayshaw 1986: 66); and hatchets (small axes), commonly fitted with a basalt or diorite head, which were used to produce notches in trees for climbing and to remove bark and animals from trees (Brayshaw 1986: 66). Other tools include 'scrapers', which were formerly made of shell but replaced by glass at contact, and 'awls', manufactured from kangaroo bone.

Clothing, according to Brayshaw (1986: 67), was almost entirely manufactured from possum and kangaroo material, such as opossum skin cloaks and belts. Dawson (1830: 115-16, cited in Brayshaw 1986: 67) also describes a range of adornments such as 'possum yarn', which was used to bind the hair, and kangaroo bone, which functioned as a comb placed just above the ear.

4.6 Food

Reconstruction of the diet of the Aboriginal groups of the Hunter Valley relies heavily on evidence obtained from coastal regions (Brayshaw 1986: 74). Among the plant foods listed by Brayshaw (1986: 74-75) are fern roots, yams, the giant lily, seeds from *Zamia spiralis*, native cherry (*Exocarpus*), wild plum, water lily, honeysuckle blossums and grasstree blossums (for nectar). Of the available marine resources, the main shellfish consumed was the cockle, which was available all year round. Crayfish (a general favourite), oysters (the 'mud', 'rock' and 'drift'-oyster), and mussels also formed part of the diet. Fish included the sea mullet, freshwater eels, perch, flathead, bream, snapper, whiting and flounder (Sokolhoff 1973: 142, cited in Brayshaw 1986: 77).

Procurement strategies varied and were sometimes divided according to gender. Women in canoes were observed catching fish using the 'hook and line' method, the hook consisting of ground shell (e.g. oyster). Men were noted fishing along the coast and possibly also inland using spears. Other methods included the use of weirs made of grasses, and hand nets (Brayshaw 1986: 76-77). Terrestrial animals mentioned as food in the ethnographic literature included various macropod (with little differentiation between species, apart from 'kangaroos', 'small kangaroos' and 'wallabies': Brayshaw 1986: 79); echidnas, bandicoots, possums, flying foxes, and mutton bird and larvae. In the Lake Macquarie area, certain creatures, such as goannas, snakes and dogs, appear to have been reserved for consumption by restricted sectors of society, such as elders and the initiated.

Vinnicombe (1980; cited in Brayshaw 1986: 81) has suggested that food procurement was largely governed by the seasons. Much of the marine-related activity (shellfish gathering and fishing) was most likely practiced in summer while terrestrial animals were probably more commonly sought in the winter. If this was the case, as the ethnographic literature suggests (e.g. Threlkheld in Gunson 1974: 82, cited in Brayshaw 1986: 82), then Aboriginal people from inland regions are likely to have visited the coast for marine resources in the summer, and coastal people probably travelled inland in the winter to hunt for terrestrial animals.

4.7 Ritual Life

Ritual life in the Hunter Valley is inextricably linked with the land. Brayshaw (1986: 83-88) describes two of the main ritual activities for which ethnographic evidence is available: initiation and burial. Initiation ceremonies commonly involved the use of cleared circles surrounded by carved trees. In some instances raised earth mounds were also constructed.

Various types of burials have been recorded in the Hunter Region, including earth burials, which appear to have been the most common, and cremations, for which there is limited evidence. Observations of cave burials have been made but not documented. The ethnography of ritual surrounding burials indicates a high degree of variability across the region. For instance, in 1825, Threlkeld (in Gunson 1974, cited in Brayshaw 1986) observed the burial of a young girl whose sandy hilltop grave was excavated by four women. Her body was wrapped in the bark of tea tree, placed on a bed of branches and shrubs, and covered with sand. An old man, who had lain her body in the grave, then stamped the sand down firmly. The surface was smoothed over and the site was made less conspicuous with a covering of branches. The same ethnographer also witnessed the burial of a man in 1825. His grave was excavated with shovels, and his body was painted red and wrapped in bark. Accompanying him in the grave were his life possessions, including spears (broken and tied in a bundle) and hatchets. While the details of interring a body seemingly varied across the region, two of the more constant features of burial rituals included encasing the body in bark and burying the deceased person's material possessions (Brayshaw 1986: 87).

5. ABORIGINAL STAKEHOLDER CONSULTATIONS

5.1 Aboriginal Organisations and Representatives Consulted

One of the main objectives of this project was to identify who are the Aboriginal Stakeholders to be consulted regarding an Aboriginal 'social values' heritage assessment for the project. The task was made simpler by the fact that numerous archaeological projects have been carried out in the Upper Hunter Valley region and so the main Traditional Owner representatives and relevant Aboriginal Stakeholder organisations are known to Coal & Allied, ERM and NSW NPWS.

The Consultant was provided with the NSW NPWS Hunter Valley Aboriginal Consultation list by ERM. This list provides the names and contact details of the relevant Aboriginal Stakeholder organisations to be consulted (Table 1).

TABLE 1. Hunter Valley – Aboriginal Community Consultation (NPWS) As at February 2003

Wonnarua Nation Aboriginal Corporation (WNAC) Lot 2A Pioneer Road PO Box 3066 Singleton Delivery Centre SINGLETON NSW 2330	Attention: Robert Lester Phone: (02) 6572 1077
Upper Hunter Tribal Council (UHTC) ** 17/174 John St PO Box 184 SINGLETON NSW 2330	Attention: Victor Perry Phone: (02) 6571 4888 Fax:: (02) 6571 4889
Lower Wonnarua Tribal Consultancy Pty Limited *** 156 The Inlet Rd BULGA NSW 2330	Attention: Barry Anderson Phone : (02) 6574 5311 Fax: (02) 6574 5322 Mobile: 0417 403 153
Ungooroo Aboriginal Corporation (UAC) PO Box 3095 SINGLETON NSW 2330	Attention: Graham Ward Phone: (02) 6571 5111 Fax: (02) 6571 1660

Wanaruah Local Aboriginal Land Council (WLALC) 17 – 19 Maitland St MUSWELLBROOK NSW 2333	Attention: Noel Downs Phone (02) 6543 1288 Fax: (02) 6542 5377
Lower Hunter Wonnarua Council Incorporated (LHWC) 19 O'Donnell Cres METFORD NSW 2323	Attention : Lea-Ann Miller Phone : 02 4933 9810 Fax : 02 4933 9810
Combined Council Hunter Valley Aboriginal Corporation (CCHVAC) 31 Mitchell St MUSWELLBROOK NSW 2333	Attention: Margaret and John Matthews Phone: (02) 6541 1397 Fax: (02) 6542 5377
Mindaribba Local Aboriginal Land Council (MLALC) Lot 475 Chelmsford METFORD NSW 2323 PO Box 401 EAST MAITLAND NSW 2320	Attention: Rick Griffiths Phone: 02 4934 8511 Fax: 02 4934 8544

Source:

Central Aboriginal Heritage Unit (CAHU) – Central Directorate of NSW NPWS
Revised by Neville Baker of ERM 5 June 2003)

Note:

Land council areas are defined.

** UHTC area has been defined as the same WLALC.

*** Lower Wonnarua Tribal Consultancy Pty Limited have indicated that their area of Aboriginal cultural heritage concern is the whole of the Hunter Valley.

From the above list, the MLALC has its boundaries outside and south of the project area so consultation with this group was not required. The other Aboriginal organisations confirmed this position. The Representatives of the seven remaining Aboriginal organisations were contacted by the Consultant and the results of these consultations and the subsequent meetings are documented below in Section 5.2.

In consulting the various Aboriginal Stakeholder organisations, the Consultant sought to identify if there were any other Aboriginal individuals or organisations who may not be affiliated with any organisation and who should be consulted. Barbara Foot a senior Wonnarua Elder, with extensive cultural heritage knowledge was identified as previously, but no longer being a member of Ungooroo. The Consultant contacted and visited Mrs Foot, who explained that she was a member of the WNAC and as a senior Elder wanted to be consulted and involved in the project. Subsequently, the Consultant contacted Robert Lester, Chairperson of the WNAC, who confirmed that Barbara Foot, her son David Foot and Luke Hicky would be acting as the WNAC's Representatives on this project.

Information, that Barbara Foot had established a new Aboriginal organisation was checked with her. Mrs Foot indicated that she was setting up the 'Wonnarua Custodians', but that it was not registered as yet. She is involved in this project as a WNAC representative and in her own capacity as a Senior Wonnarua Elder associated with the 'Wonnarua Custodians'.

The LHWC, as discussed in the following Section, indicated that their organisation will not become involved in this project as they are at present, concentrating on working in the lower half of the Hunter Valley.

No other individuals (not affiliated with the above organisations) were identified by the Consultant through the various consultations as being Aboriginal Stakeholders who should be consulted on this project.

5.2 Results of Aboriginal Stakeholder Consultation Meetings

During the course of this project a number of the Aboriginal Stakeholder organisations linked up with other Aboriginal Stakeholder organisations to meet with the Consultant, an action that was to suit all parties involved.

The issues and recommendations documented at the meetings are identified as coming from all the Representatives of the particular organisation (indicated as – 'All') unless otherwise indicated (indicated by the individual's initials). While writing the notes, the Consultant would confirm that the main issues and recommendations were supported and endorsed by all the Representatives of the organisation.

The Consultant faxed or e-mailed the Draft Report to each of the participating organisations at the end of the project and followed this up with phone calls to each organisation to document any comments or amendments and confirm the consultations and recommendations recorded. All the participating Aboriginal Stakeholder organisations confirmed their agreement with the sections of the report relevant to them. At the time of finalising this report, four letters of endorsement have been received from the organisations with the last two reportedly on the way (See Appendix 1).

5.2.1 Consultation with the Ungooroo Aboriginal Corporation (UAC)

Background Liaison

An initial introduction meeting with Graham Ward, Coordinator of the UAC was organised by Sarah Fish of Coal & Allied and held on the 29 May 2003. A brief description of the project was provided and a tentative date was organised to carry out the initial project consultation meeting. A meeting date was subsequently confirmed following further phone discussions.

Initial Project Consultation Meeting

Date: 9 July 2003

Attendance: UAC Representatives**:** Graham Ward, Rhonda Ward and Allan Paget.
AASC Consultant: Dave Johnston.

Consultant's Introduction

The Consultant, Dave Johnston (AASC) explained the objectives of the project and the background as to how Coal & Allied had initiated the project.

Discussion / Issues and Recommendations Identified

(All) "There remains an ongoing issue regarding the care and control of artefacts from these types of projects." "This is an ongoing issue which needs to be further addressed."

(All) "There are two scarred trees that have been identified in the archaeological study that have been identified as European scars of origin that we would like inspected during the field inspection."

Regarding Protocols for this project:

> (All) "Ungooroo insists on having involvement in the process."
> (All) "Ungooroo wants all other Aboriginal Representative organisations consulted."
> (All) "The organisation is happy for and would like a project site field inspection to be carried out."
> (All) "Ungooroo will go through the report for ratification."
> (All) "The Consultant can send the report on a disc or directly to Ungooroo."
> (All) " The meetings are not to be taped but notes can be taken."

(All) "The West Pit location is in 'Wonnarua Country'."

(All) "Ungooroo is an Aboriginal community organisation which includes Wonnarua Representatives as well as Representatives of the wider Aboriginal community."

(GW) "Upon a State Unknown," by Faye Atwell, is a source of history for the Taggart clan." "Eric Taggart was also a source of information on Wanaruah culture (ie. newspapers) and was referred to by many researchers as a traditional source."

(All) "Oral history says that this area [in general] was a travelling route."

Site Inspection and Consultation Meeting

(Combined Inspection and Meeting between UAC and Lower Wonnarua Tribal Consultancy Pty Limited)

Date: 24 July 2003

Attendance: UAC Representatives: Allan Paget, Rhonda Ward and Samantha Ward.
Lower Wonnarua Tribal Consultancy Pty Limited Representative: Barry Anderson.
AASC Consultant: Dave Johnston.

Consultant's Introduction

The Consultant, Dave Johnston (AASC) explained the results of the archaeological study in further detail, specifically the landform categorisation used. A number of the key sites including the two European scarred trees were inspected and the representatives were invited to inspect any areas they wanted specifically to look at. Discussions on the likely impacts of the proposed mining works on the sites and general area were also held. An inspection of the possible scarred tree identified by the WNAC's Representatives was also carried out. A copy of the draft Archaeological survey report was provided.

Discussion / Issues and Recommendations Identified

(All) "The current site boundaries fenced at Emu Creek are to be extended to include the whole identified site area. The southern side of the Emu Creek site is not fenced fully."

(BA) "There is a known silcrete site in the area southeast of the Extension Pit." "Emu Creek extends to the east." "Vanessa Hardy with HLA has recorded sites and possible grinding groves as part of the Cumnock Colliery survey in 2001-2002."

(All) "We require an open excavation up to 100m squared be carried out at both the Emu Creek and Farrells Creek sites from a cultural heritage point of view to determine the nature and extent of these sites as they will be destroyed."

(All) "The methodology proposed for the excavations at both locations would include: a 40m by 2m excavated trench, a series of 1m squared test pits broken up into 50cm by 50cm squares by 5cm spit levels, plus the option of having up to 20m squared, extra excavation area if extensions are required."

(All) "As well, there is to be grader scraping monitoring at Emu Creek and Farrells Creek up to 50m on either side of both creeks."

(All) "There is to be grader scrapes and associated monitoring carried out within all landform units with associated sites."

(BA/All) "If any hearths are located during grader scrapping, work is to cease and a detailed excavation is to be carried out to document and record the site so that Carbon 14 dating can be carried out."

(BA/All) "in regards to any proposed heritage works, OHS policy requires two people on site at all times."

(All) "There are no other major socially significant sites in the project area. A silcrete quarry exists nearby to the east."

(All) "More and more, our sites are being destroyed by this type of development, hence the reason why we the Aboriginal community would like all our sites to be well documented and properly recorded, for our future generations and to educate the wider community about the history of the Aboriginal people of the Hunter Valley."

(All) "Our sites as they are situated in the landscape have aesthetic values…, visual values, for us."

(All) "We need to look outside the current mining extension area and look at the connection between sites and how they are interlinked." "We see our country as a cultural landscape, with a vast abundance of resources, flora, fauna and stone." "Our ancestors lived and we live today within this landscape and the many different types of sites that exist across the Hunter Valley reflect the connection we have with the land."

(All) The Representatives stated that they agreed that the original two scarred trees identified were of European origin.

(All) The Representatives expressed gratitude to Coal & Allied for carrying out the project and for the site inspection.

5.2.2 Consultation with the Wanaruah Local Aboriginal Land Council (WLALC) and the Combined Council Hunter Valley Aboriginal Corporation (CCHVAC)

Background Liaison
An initial introduction meeting with Noel Downs, Coordinator of the WLALC was planned by Sarah Fish of Coal & Allied on the 28 May 2003. Time constraints did not allow this meeting to occur on the day and subsequently, Sarah Fish and the Consultant rang the WLALC to inform them of the project and to organise an initial consultation meeting. Noel Downs informed the Consultant that Margaret Matthews, Chairperson of the CCHVAC was contactable via the WLALC and that he would organise a date for both organisations to meet the Consultant. This meeting was subsequently confirmed with both organisations.

Initial Project Consultation Meeting

Date: 10 July 2003

Attendance: WLALC Representatives: Noel Downs (in Coordinators role only), Trevor Griffiths, Beverley van Vliet, Carl Hedgers.
CCHVAC Representatives: Margaret Matthews, John Matthews, Darrell Matthews, Christine Matthews, Michael Matthews.
AASC Consultant: Dave Johnston.

Consultant's Introduction

The Consultant, Dave Johnston (AASC) explained the objectives of the project and the background as to how Coal & Allied had initiated the project.

Discussion / Issues and Recommendations Identified

Regarding protocols for this project:

(All) The Representatives expressed that they were happy to be involved in the project and were happy with the proposed methodology.
(All) The proposed reporting process was also acceptable to the Representatives.
(All) The Representatives requested that notes be taken by the Consultant and that tape recordings of meetings and individual's discussions were not to occur.

(All) "The WLALC represents both Wonnarua Traditional Owners as well as the wider Aboriginal community." "The WLALC represents the Land Council Representatives."

Margaret Matthews stated that her family was involved with the CCHVAC which was set up to represent Wonnarua Traditional Owners.

(All) The Representatives stated that in regards to the heritage of the area that, "all sites are linked".

(All) A number of the Representatives indicated that there are issues needing to be sorted out regarding the traditional boundaries of the area.

(BvV) "North of the Hunter River is Gumaroi,… Wonnarua is a clan of Kamilaroi". "Wiradjuri borders near here also."

[The consultant was provided with a copy of Mathews, (1917) report which states that, ".. the various triblets of the Kamilaroi community may be indicated as extending from Jerry's Plains on the Hunter River, northerly…" (Mathews 1917:423).]

(TG) "Archaeological reports refer to the area being occupied by the Wonnarua, some reports, like Mathews (1917) say different." "Boundary issues need to be addressed still."

(All) There is a Bora ground near the Warkworth Western Extension, which was recorded as being used in 1852, with 500-600 Aboriginal people attending.

(All) "The Consultant should bring Barbara Foot out on the field inspection. She is a Wonnarua Senior Elder and Margaret Matthews' aunty."

Site Inspection and Consultation Meeting

Date: 23 July 2003

Attendance: WLALC Representatives: Roger Matthews, Trevor Griffiths, Beverley van Vliet.
CCHVAC Representatives: Margaret Matthews, John Matthews, Tony Matthews.
AASC Consultant: Dave Johnston.

Consultant's Introduction

The Consultant, Dave Johnston (AASC) explained the results of the archaeological study in further detail, specifically the landform categorisation used. A number of the key sites including the two European scarred trees were inspected and the Representatives were invited to inspect any areas they wanted specifically to look at.

Discussions on the likely impacts of the proposed mining works on the sites and general area were also held. Each organisation was provided with a copy of the draft Archaeological survey report.

Discussion / Issues and Recommendations Identified

(All) "No known significant 'other' site types are identified for the study area."

(TG) "The current fencing boundaries may not represent the sub-surface archaeological extent at Emu and Farrells Creeks." "This needs to be explored further or at least salvage monitoring at the current fenced boundaries should extend until no more artefacts are located."

(BvV) "The current fenced site boundary [southwestern boundary of Emu Creek Site] is not in line with the extent of the surface artefact distribution." "The road way [access track] should be closed and the site fencing extended around the complete site."

(All) "The sites, places and artefacts representing our heritage are important to us as evidence of our culture and heritage and existence in this area."

(All) "The sites here are linked to other areas as part of our living landscape." "Songline, story line, camping areas, ceremonial areas, burial sites etc,… All our heritage sites are part of the landscape our ancestors used." "Our people lived in the area and utilised the landscape for various purposes." "These [the Bora ground site] are our traditional boundaries where other people came once a year for ceremonies."

(All) "The issue of site linkages, we feel is not being addressed."

(All) "There are many known sites which are important to us in the area." "The Bora ground at Warkworth, Biamie Shelter at Millbrodale Station, Lizard Rock at Wollombi, Big Yengo and Little Yengo, these are all part of the storyline."

(TG) "People camped and lived between these significant places."

(All) "Camp sites, artefact scatters and the associated artefacts are important to us [JM - especially axes]." "If we allow our artefact scatters to be destroyed we want the artefacts to be salvaged as they are important to us as part of our heritage,. of our old people,… our ancestors."

(All) The Representatives stated that they agreed that the original two scarred trees identified were of European origin.

(All) "If a NSW NPWS Consent to Destroy is given to the Mine, then we require all identified artefact locations to be salvaged."

(All) "If NSW NPWS issues a Consent to Destroy, then the Emu Creek and Farrells Creek sites are to have a salvage monitoring program undertaken for surface and sub-surface artefacts, as these areas have sub-surface potential." "For salvage, we require sub-surface artefact salvage using a theoretical and organised monitoring program."

(All) "Further consultations are required with Coal & Allied to discuss future works at Emu Creek and Farrells Creek."

(BvV) "The land is important to us, 'our mother earth', she looked after us, we need to look after her." "Our ancestors and future generations are part of her,…the land!" "The 'value' of the land is at the heart, not dollars!"

(BvV/All) "Access to sites is a big issue." "We take the kids to Biamie,… we need to get them out to other sites."

(All) The Representatives expressed gratitude to Coal & Allied for carrying out the project and for the site inspection.

[The possible scarred tree identified by the Wonnarua Nations Aboriginal Corporation's Representatives was not identified before this field inspection. Subsequent telephone consultations with Noel Downs and Margaret Matthews, the WLALC and CCHVAC have indicated that their Representatives support Barbara Foot's recommendation that the Aboriginal Stakeholder organisations meet with Coal & Allied and their archaeologist to discuss the possible scarred tree further. The WLALC and CCHVAC also support Barbara Foot's identification of a 'Mens' Area' near or possibly in the northwestern section of the project area and any recommendations she proposes for the well being of Aboriginal heritage workers working in the area.]

5.2.3 Consultation with the Wonnarua Nations Aboriginal Corporation (WNAC)

Background Liaison

An initial introductory meeting with Victor Perry acting Representative of the WNAC was organised by Sarah Fish of Coal & Allied and held on the 29 May 2003. Rhoda Perry, a Wonnarua Elder, was also present. This initial introductory meeting was in one sense a combined meeting with the UHTC as Victor also is the Coordinator of that organisation. A brief description of the project was provided.

The Consultant asked if it was appropriate to contact the WNAC Chairperson, Robert Lester to ensure the right protocols were being adhered to. Victor said that this would be was fine and subsequently, the Consultant contacted Robert Lester who confirmed that Victor was the WNAC's Representative. Robert stated, that as Barbara Foot a Senior Elder had expressed a desire to be consulted in this project, she and her son David Foot as well as Luke Hicky would be involved in this project as the WNAC's representatives.

Following initial phone conversations made by the consultant with Barbara Foot a meeting date was identified.

Initial Project Consultation Meeting

Date: 11 July 2003

Attendance: WNAC Representatives: Barbara Foot, David Foot, Luke Hicky.
AASC Consultant: Dave Johnston.

Consultant's Introduction

The Consultant, Dave Johnston (AASC) explained the objectives of the project and the background as to how Coal & Allied had initiated the project.

Discussion / Issues and Recommendations Identified

Regarding protocols for this project:

> (All) The WNAC Representatives stated that they wanted to be involved in the project.
> (All) The WNAC Representatives stated that they wanted to be involved in a Project Site inspection.
> (All) The WNAC Representatives indicated that they were happy with the proposed project methodology.
> (All) The WNAC Representatives stated Consultations were not to be taped, notes and recommendations were to be taken by the Consultant and ratified by the Representatives at the meetings.

(LH) "The community want employment, jobs at the mines."

(LH) "There is a big confusion with so many groups."

(LH) "There is a need for a Keeping Place for all the salvaged artefacts." "Artefacts need to be put into a Keeping Place."

(LH) "There are significant sites around the area, not exactly in that block." "Creeks and waterways are very significant to Aboriginal people – as a natural and cultural resource."

(LH) "Ever project should employ an Aboriginal Heritage Manager on a full time basis."

[The Consultant had various telephone discussions with Robert Lester, Chairperson of the WNAC during the course of the project. The WNAC is a large organisation representing the interests of Wonnarua Traditional Owners. A number of Wonnarua representatives of other Aboriginal Stakeholder organisations are members of the WNAC.]

Site Inspection and Consultation Meeting

Date: 24 July 2003

Attendance: WNAC Representatives: Barbara Foot, David Foot, Luke Hicky.
AASC Consultant: Dave Johnston.

Consultants Introduction

The Consultant, Dave Johnston (AASC) explained the results of the archaeological study in further detail, specifically the landform categorisation used. A number of the key sites including the two European scarred trees were inspected and the representatives were invited to inspect any areas they wanted specifically to look at. Discussions on the likely impacts of the proposed mining works on the sites and general area were also held. A copy of the draft archaeological survey report was provided to Barbara Foot and a copy was mailed to Robert Lester.

Discussion / Issues and Recommendations Identified

(LH/All) Concerns for rehabilitation were raised. "Are rehabilitation plans in place for this area, at the end of the mine's working existence?"

(All) Concern was expressed for the overall regions revegetation. "Money should be put aside for this."

(All) "Our heritage and our sites are very important to us."

(LH) "The water table and river system, are important, the EPA Act allows companies to dump their table water, and therefore by-products, into the river in times of flood."

(LH/All) "Our livelihood is at threat,… swimming, fishing… we can't swim now as the water is too toxic."

(LH/All) "The River is the lifeblood of our lives,… it is our heritage and significant to us!" "Not just West Pit, we are concerned about all the mines' impacts on the environment."

(LH/All) "We would like to see a long term Aboriginal employment strategy with all Coal & Allied mines."

(LH/All) "We need to look at the bigger picture." "We have to protect our children's future,… our heritage,… employment opportunities,… we should not just see the smaller picture."

(All) "We would like to see the Emu Creek site fenced fully."

(All) "We want to see a research design regarding the sub-surface Potential Archaeological Deposit at Emu Creek and Farrells Creek, from the archaeologist."

(All) "We would like to see some sub-surface archaeological monitoring program carried out at these two site locations. "A research design of grader scrapes at 5cm spits to be carried out to salvage the artefacts which are of cultural significance to us."

(All) "The sites will be destroyed so we want to maximise the collection and protection of our culturally significant artefacts."

(All) "We would like Coal & Allied to finance the housing (ie. Cultural Centre) of the artefacts found within their project locations." "We would like to develop a cooperative approach with Coal & Allied to manage / store, the collected artefacts appropriately." "We need to find a common ground."

[Luke Hicky identified a possible scarred tree immediately on the north side of the northern access road at the following location: (E310999 N6409813 WGS 84). The tree is dead and has collapsed against another tree. The tree is in very poor condition due to the extent of weathering and exfoliation. The possible scar is in particularly poor condition and is difficult to determine due also to the extent of weathering, exfoliation and insect damage. The field team informed Sarah Fish of Coal & Allied about the location of the tree and its possible scarring. While acknowledging the difficulty in accurately determining the origin of the damage to the tree, an archaeological opinion has suggested that the scar is most likely due to natural processes of weathering and decay which have initiated at a branch tear. The Aboriginal Stakeholder Representatives have requested a meeting with Coal & Allied to discuss the scars authenticity further. The tree was immediately sign posted and subsequently fenced.]

(All) "We would like the possible scarred tree moved and put in place to preserve it." "The tree should stay until the need arises for it to be removed under a Permit." "The tree should be fenced immediately with an appropriate buffer zone."

(All) "We would like the area around the possible scarred tree raked to search for any artefacts."

(BF) [While standing near the possible scarred tree] "I've sensed there is something of 'mens' significance' near to the access road, closer to the West Pit end."

(BF) "Senior Aboriginal men should be present for any Aboriginal heritage works to be carried out in this far northwestern corner of the project area to ensure cultural safety."

[The area could not be specifically defined by Mrs Foot and may be outside the far northwestern portion of the project area. Mrs Foot indicated that there was no reason for the proposed project not to go ahead but she wanted to ensure the cultural safety of any Aboriginal heritage workers carrying out any proposed heritage works in this far western corner of the project area. Mrs Foot stated the possible scarred tree was not associated with her sense of the 'mens' significance area'.]

(All) The Representatives stated that they agreed that the original two scarred trees identified were of European origin.

(All) The Representatives expressed gratitude to Coal & Allied for carrying out the project and for the site inspection.

5.2.4 Consultation with the Upper Hunter Tribal Council (UHTC)

Background Liaison

An initial introduction meeting with Victor Perry, Coordinator of the UHTC was organised by Sarah Fish of Coal & Allied and held on the 29 May 2003. Rhoda Perry a Wonnarua Elder was also present. A brief description of the project was provided and Victor indicated his organisation would meet with the Consultant to discuss the project at a date to be determined in the coming weeks. A meeting date was subsequently confirmed following further phone discussions.

Initial Project Consultation Meeting

Date: 11 July 2003

Attendance: UHTC Representative: Victor Perry.
AASC Consultant: Dave Johnston

Consultant's Introduction

The Consultant, Dave Johnston (AASC) explained the objectives of the project and the background as to how Coal & Allied had initiated the project.

Discussion / Issues and Recommendations Identified

(VP) Disagrees with the project process because Native Title isn't being represented or given its proper stand. "NSW NPWS should recognise Traditional Owners in every 'country,' especially in regards to land and cultural heritage management."

(VP) "Failing that, if there are no Traditional Owners left then its ok for the general Aboriginal community to comment as there is a natural understanding they then have a role."

(VP) "People need to justify their association and knowledge,… there are no checks and measures."

(VP) Victor justifies his right to speak as a Wonnarua Traditional Owner, and has the authority to speak by his mother and generations of ancestors through the Wonnarua people.

(VP) In regards to protocols for projects such as this, Victor wants to see Traditional Owner recognition.

(VP) "I disagree with the holistic approach of NSW NPWS to include everyone in heritage assessments and representations."

(VP) Victor stated that he didn't want to inspect the site as he had been involved with the archaeological project and was aware of the area.

(VP) In regards to his organisation's recommendations for the West Pit Extension, Victor states, "its significance is related to land usage practices,… it is a general camping area."

(VP) "A point which is frustrating, is that you can't expand outside a square box." " You can't say or speculate significance on an area that is a general camping area, unless further evidence comes to light."

(VP) "In 1797, whites were in Newcastle."

(VP) "From a Traditional Owner point of view, a loss of country is the most hurtful consequence of coal mining, in particular open cut mining." "It causes distress to Traditional Owner's because of the breaking of continuity to the land,.. with spiritual, visual, physical connection."

(VP) "Significance is a personal thing." "A shared significant area such as an initiation ground is a type of site which has a known general understanding which everyone can know (I appreciate that we all know the significance of the word ceremonial)." "General landscapes such as camp sites are living areas where people lived, played, camped, where they were taught." "What ever is left makes them resource valuable."

(VP) "The discovery and protection of sites is very important, particularly within the mine areas where destruction is common."

(VP) "Movement within the Valley is encapsulated by the mountains and land management practices and maintenance of country is still important and is evidenced by the location of sites and important places."

(VP) "The ancestral Wonnarua were expert knappers of stone (knowledge holders) as these sites do indicate." "We need to foster that knowledge and protect the associations with our heritage by maintaining and continuing stone tool practices." "It is alright to dig up artefacts to protect them from mining impacts but it is much better to utilise the technology by continuing stone tool making practices."

(VP) "Cultural maintenance should be an outcome,.. I would like to see stone knapping courses and training available."

(VP) "Our family have continuing cultural continuity to this area." "It is a long recorded heritage, which continues today through our present generations."

(VP) "Cultural heritage management should be discussed further." "Burials are occurring along creek lines and further management procedures should be set in place." "If ancestral remains are located a Consent to destroy and removal will not be given until management options are considered by Wonnarua Elders."

(VP) 'In relation to important burial, initiation and ceremonial sites, Elders should lead negotiations and provide many recommendations." "This should occur in all cases related to those matters." "This example should be the model that excludes the inclusion principle the NSW NPWS is currently espousing." "This model should be adopted by NSW NPWS."

(VP) "A point to stress to NSW NPWS – I believe people who don't have traditional affiliations should not have a say in heritage decisions." "People should bring their evidence to the table." "There could be another Hindmarsh affair, as there is the danger of people with no knowledge creating history" "If there is no connection, people should be saying zip."

(VP) "With regards to recommendations for this project, any creek lines of good deposition are now subject to monitoring." "Both sides of the creek should be subsurface grader scrapped, 100m each side or at least where artefacts still exist." "This would be to salvage artefacts and monitor for ancestral remains."

[Victor stated that he will be preparing a response specifically on the archaeological report for this project.]

[No site inspection was carried out by the UHTC as Victor was familiar with the project area having worked there during the archaeological survey.]

5.2.5 Consultation with the Lower Wonnarua Tribal Consultancy Pty Limited

Background Liaison

The Consultant had some difficulty initially contacting Barry Anderson, Director of the Lower Wonnarua Tribal Consultancy Pty Limited due to his work commitments. Upon being contacted Barry stated that his organisation would like to be involved in the project and a tentative date was set to have a meeting and carry out a site inspection.

Initial Project Consultation Meeting

Date: 24 July 2003

Attendance: Lower Wonnarua Tribal Consultancy Pty Limited Representative: Barry Anderson.
AASC Consultant: Dave Johnston.

Consultant's Introduction

Due to the Consultant being unable to contact Barry Anderson early on in the project it was arranged for the Lower Wonnarua Tribal Consultancy Pty Limited to meet with the Consultant at a combined meeting and field inspection with Ungooroo. The Consultant, Dave Johnston (AASC) had a chance to meet Barry Anderson at the Ungooroo office where he explained the objectives of the project and the background as to how Coal & Allied had initiated the project. The pair were able to speak further on the drive up to the mine site for the site inspection with the Ungooroo Representatives.

Discussion / Issues and Recommendations Identified

(BA) Lower Wonnarua Tribal Consultancy Pty Limited are happy to be involved in the project and see that it is a good opportunity for Aboriginal Representatives to have a say in their heritage other than just through an archaeological study.

(BA) Barry expressed satisfaction with the proposed project methodology.

(BA) Notes would be written by the Consultant, regarding consultations and recommendations and checked with Barry for ratification. No tape recording was to occur.

Note: Refer to the Discussion / Issues and Recommendations Identified at the combined Ungooroo and Lower Wonnarua Tribal Consultancy Pty Limited site inspection and meeting (Section 5.2.1) for further results.

5.2.6 Consultation with the Lower Hunter Wonnarua Council Incorporated (LHWC)

Date: 9 July 2003

Background Liaison / Discussion / Issues and Recommendations Identified

After a couple of attempts the Consultant contacted Lea-Ann Miller, contact Representative for the LHWC, by phone on the 9th July 2003. A brief description of the project was provided. Lea-Ann informed the Consultant that the Lower and Upper Hunter Wonnarua Councils had originally been formed to deal with heritage projects in their respective areas of the Hunter Valley. Lea-Ann informed the Consultant the project area lay outside their organisations boundaries and that they would be staying within their original designated boundaries and so did not require involvement in this project.

Lea-Ann Miller thanked the Consultant for informing their organisation about the project and that she would inform her father, Tom Miller about it. If Tom had any questions, she stated she would get him to contact the Consultant, who he knows. The Consultants' contact details were provided. No further inquiries were made by the LHWC to the Consultant.

6. ABORIGINAL SOCIAL SIGNIFICANCE VALUES IDENTIFIED / DISCUSSION

The Aboriginal Stakeholder meetings and site inspections, identified no new sites of great Aboriginal social significance. A possible 'Mens' Area', was felt to exist by Mrs Barbara Foot, a Wonnarua Elder at an unspecified location possibly outside or just within the far north western boundaries of the project area. Apart from recommending senior Aboriginal men carry out any heritage works required for that section of the project area, so as to be culturally safe, there are no further management requirements for this area and no impediments for future mining operations here.

A possible scarred tree was identified by the WNAC Representatives next to the northern access road which has potential Aboriginal significance. Future meetings between the Aboriginal Stakeholders and the Coal & Allied archaeologist will allow final determination of the authenticity of the scars' origin. This will allow a final determination of the Aboriginal social value and mitigation strategy to be proposed if necessary. At present the majority of the Aboriginal Stakeholders would like to see the possible scarred tree remain fenced.

A number of the Representatives felt that the soil deposits near the creek areas within the project area could possibly contain burials. There is the view that many generations of ancestors not only lived but also died in their traditional country. Ancestors were buried but there are no grave stones as such to identify them. Burials have been identified at other locations in the region and it is generally known that areas with sufficient soil or sand deposits, often associated with creek banks may be potential burial locations. A number of the Representatives stated that they would like to see an archaeological subsurface program of some sort carried out at the two creek site locations to also check for the presence of burials. The argument for a program of archaeological subsurface testing of some kind to be carried out to meet this concern was that later mining excavation works would most probably not allow for the identification of any burials that may be present and that if ancestral remains happened to be identified by mining staff, they would probably have been destroyed or damaged and their original location not able to be identified. Therefore, a number of the Aboriginal Stakeholder Representatives felt that it is important to carry out subsurface investigations early on, to minimise the risk of potential burials being located during initial mining operations.

The issue which needs to be discussed by all parties relates to the nature and scale of future subsurface archaeological testing and salvage. A number of suggested methodologies have been identified by the Aboriginal Stakeholder organisations and these, along with Coal & Allied's issues need to be discussed by all parties. Coal & Allied are proposing to carry out this consultation process.

While no sites of high Aboriginal social significance were identified during this study, the project certainly allowed the Aboriginal Stakeholders an opportunity to express their social significance values for their heritage in general. Five of the organisations expressed their gratitude to Coal & Allied for carrying out this project. The results of the consultations identified that the Aboriginal Stakeholders have a number of known sites and places in the general region which are of great significance or of value to them. Some of these places and sites hold 'traditional' significance such as the identified Dreaming sites (eg. Baiame's Cave) and bora ground, while others hold 'historic significance' (eg. old family swimming and fishing locations).

What has also been identified clearly as a result of the current consultations is the 'contemporary' significance the Aboriginal Stakeholders hold generally, towards those sites and places that are evidence of their ancestors' day to day occupation of this region. These 'archaeological' sites, representing camping locations and or 'people activity' sites of some sort (eg. axe grinding sites) are of value or significance to varying degrees to all the Aboriginal Stakeholders consulted here. The values the Aboriginal Stakeholders hold towards these sites and the associated artefacts and what they represent, is heightened in the mining lease areas in particular, because the nature of the mining impacts generally means these sites have been and will continue to be destroyed.

The Aboriginal Stakeholders do hold a range of social values towards their archaeological sites and the associated artefacts. In general, the artefact scatter sites and the associated artefacts are culturally significant to all the Aboriginal Stakeholder organisations as cultural reminders of their and their ancestors physical and spiritual connection to their traditional land. As the identified sites will be destroyed by the impact of the mine operations, the majority of the Representatives require a thorough salvage and excavation program. This process is recommended by the Aboriginal Stakeholders so as to professionally record the sites for future educational purposes and to salvage as best as possible, their socially significant artefacts which they do not want destroyed unnecessarily.

The views and recommendations of the Aboriginal Stakeholders identified in this Social Values study should come as no surprise to those familiar with the Upper Hunter Valley Aboriginal Communities' heritage views and aspirations. Many Aboriginal communities in urban areas hold similar social values towards their tangible and intangible heritage. The issue long identified and faced by Traditional Owners and other Aboriginal Stakeholders has been and continues to be, "how, as a minority stakeholder group, do we ensure that our heritage values are appropriately identified, recorded and given due consideration in the assessment and management planning process". It can be seen partially as an ethical issue and one that requires those carrying out heritage assessments to be mindful of differing community significance values. As McBryde states:

> There is now a new arena in which all of us may develop innovative perspectives based on understanding and acceptance of values important to others in our society, and held to be present in the heritage places we investigate and protect as researchers or managers.
>
> Such developments must be active processes, interactive with those concerned. Token recognition of the existence of other values is hardly sufficient. We must accept what cannot appropriately be shared, listening to those other 'voices' in the debate and respecting their messages.

(McBryde 1994:8)

The innovative approach adopted by Coal & Allied in commissioning this project has allowed the Aboriginal Stakeholders to document their 'social values' pertaining to this project area and in general, an opportunity, which the majority of the Aboriginal Stakeholder Organisations have expressed their gratitude for.

The information documented in this report as a result of the consultation process should be of great interest to all the Aboriginal Stakeholder organisations themselves, as well as to Coal & Allied and NSW NPWS as a future Aboriginal heritage management reference for the Upper Hunter Valley.

7. RECOMMENDATIONS

Five of the six Aboriginal Stakeholder organisations actively involved in the project expressed gratitude to Coal & Allied for carrying out this project. For the majority of the groups, the project and process is one they strongly support largely because it allows for Aboriginal people's' active involvement and addresses Aboriginal heritage concerns and recommendations. These five Hunter Valley Aboriginal organisations would like to see similar Aboriginal Social Significance projects being carried out for other heritage assessment projects in the region.

The recommendations identified by each Aboriginal Representative group for this project are listed previously within their specific section of the report.

In regards to this reports' overall recommendations, the Consultant has reviewed each of the Aboriginal organisation's issues and recommendations raised and has identified specific overlapping recommendations, relevant to this social values study.

The recommendations below are separated into two sections. Firstly, there are general recommendations identified through consultations with the Aboriginal Stakeholders regarding the findings of this social values assessment and relating to the proposed West Pit Extension area. Secondly, the Aboriginal Stakeholder's general recommendations relating to the archaeological project results which were also discussed during this project are presented.

7.1 Recommendations Relating to the Social Values Assessment

1. Other than the sites identified during the archaeological survey, the Aboriginal Stakeholders' identified possible scarred tree and the possible nearby presence of a 'Mens' Area' identified by Mrs Foot, no further Aboriginal sites or areas of significance were identified by the Aboriginal Representative organisations. As such, other than the specific recommendations identified here, there are no other Aboriginal heritage management requirements which would constrain the proposed mining works.

2. While the presence of a 'Men's Area' was identified by Senior Elder, Mrs Barbara Foot, within or near to the northeastern boundaries of the proposed West Pit extension, no specific location was identified. As such, Mrs Foot (representing herself and the WNAC) states that there are no constraints to the proposed mining works but that senior Aboriginal men should be involved with any heritage works planned for that general far northwestern corner of the project area. Specifically, north of the access road and west from the possible scarred tree. The consensus among the majority of the other organisations consulted is that they respect and support the recommendations of Mrs Barbara Foot.

3. Regarding the possible scarred tree, the Aboriginal Stakeholder Representatives have requested a meeting with Coal & Allied to discuss the scars' authenticity. Initial recommendations identified by the Aboriginal Stakeholders regarding the tree's salvage removal will need to be re-established following further on site discussions with Coal & Allied's archaeologist and the Aboriginal Stakeholder Representatives. Coal & Allied have committed to holding future negotiations with the Aboriginal Stakeholder organisations regarding this issue. Until a final decision is made as to whether the tree scar is of Aboriginal origin, and whether it is to be salvaged or not, the tree should remain fenced and protected.

4. While the structure of some of the Aboriginal organisations consulted included constituents of the wider Aboriginal community who are not necessarily Traditional Owners of the region, all the organisations had members who identified as Traditional Owners of the region. As such, it is recommended that Coal & Allied continues to liaise with all of the following six Aboriginal Stakeholder organisations, via their designated Representatives, for this project:

i. WNAC
ii. UHTC
iii. Lower Wonnarua Tribal Consultancy Pty Limited
iv. UAC
v. WLALC
vi. CCHVAC

7.2 Recommendations Relating to the Archaeological Study Results

1. There are no sites currently identified within the West Pit extension which the Aboriginal Stakeholder Representatives' require to be permanently protected.

2. The Aboriginal Stakeholder Representatives' require all the identified sites to remained fenced until salvage collected.

3. The current southwestern fenced site boundary at Emu Creek is not in line with the actual extent of the surface artefact distribution. The majority of the Aboriginal Stakeholder Representatives would like the fencing extended out further to the south to completely encompass the known boundaries of the site. This would include the fencing and closure of the current vehicle access track that runs through the site and across the creek. The view is that if the site is to be fenced and protected prior to salvage, it should be done completely and fully.

4. The Aboriginal Stakeholder Representatives' require all identified surface sites containing stone artefacts to be salvaged collected and recorded prior to destruction.

5. It is the view of the majority of the Aboriginal Stakeholder Representatives' that there is potential for Aboriginal subsurface cultural material and possibly burials to exist at the Emu Creek and Farrells Creek site locations. As such, they recommend that a site identification / recording and salvaging program should be carried out at these locations. All the Aboriginal Stakeholder Representative organisations have stated that their sites and the associated artefacts are socially significant to them as physical cultural reminders of their 'peoples' association and utilisation of this area. As the impact of the proposed mining activity in this project area will destroy the sites forever, the majority of the Aboriginal

Stakeholder organisations recommend a thorough subsurface archaeological recording of these two site locations for their permanent records and an appropriate salvage program of the associated artefacts to be carried out.

It is recommended that consultation meetings be carried out between Coal & Allied and the Aboriginal Stakeholder Representatives to discuss and agree upon a subsurface archaeological recording and salvage program to be carried out at the Emu Creek and Farrells Creek site locations.

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APPENDIX 1

Aboriginal Stakeholder Organisation Letters

John Matthews & Margaret Matthews
31 Mitchell Street
MUSWELLBROOK NSW 2333
PHONE: 02 6541 1397
FAX: 25 September 2003 02 6541 1392
MOBILE: 0439 676 900
HERITAGE & CULTURE CONSULTANTS

**COMBINED COUNCIL
HUNTER VALLEY
ABORIGINAL CORPORATION**

Dave Johnston
Australian Archaeological
Survey Consultants Pty Ltd
GPO Box 943
Canberra ACT 2601

Dear Mr Johnston

Re: West Pit Extension Aboriginal Social Values Assessment Project and Report

We the representatives of the Combined Council Hunter Valley Aboriginal Corporation acknowledge our involvement in the above mentioned project. We confirm the consultations carried out and our recommendations documented in this report.

A project of this nature is supported by our organisation as it ensures that our heritage values and management recommendations are documented and presented.

Yours sincerely

Margaret Matthews
Chairperson

WONNARUA NATION
HUNTER VALLEY
OUR BELONGING PLACE

Wonnarua Nation Aboriginal Corporation

ABN No 50 012 829 925.

26 September 2003

Attention Mr David Johnston
Australian Archaeological
Survey Consultants Pty Ltd
GPO Box 943
Canberra ACT 2601

Re:
West Pit Extension Aboriginal Social Values Assessment Project and Report

Dear Mr Johnston
This letter is to confirm that the Wonnarua Nation's Representatives were involved in the Social Significance assessment project. Our members appreciated the opportunity to have had our heritage views discussed and documented for the project area. We confirm the recommendations that we have identified in this report and look forward to further consultations with Coal & Allied regarding the future management and salvage requirements we have regarding our identified sites in the project area.

Yours sincerely
B.A. Foot

Mrs Barbara Foot
Elder representative
Wonnarua Nation Aboriginal Corporation

PO Box 3066 Singleton Delivery Centre
Singleton NSW 2330

Ph: 02 6572 1077
Fax: 02 6571 4364

FROM : 'AASC SEP-26-2003 17:16 FROM:JL... 0262478702 0262478702 Sep. 30 2003 09:18AM P3 TO:0262485562 P:2

Upper Hunter Wonnarua Council Inc
Po Box 184
17/174 John Street
SINGLETON NSW 2330
PH; 02 65714888
FX; 02 65714889
ABN: 24 070 620 198

David Johnston
Australian Archaeological Survey Consultants Pty Ltd

26th September 2003

RE: SOCIAL VALUES ASSESSMENT - WEST PIT

Dear David
Thank you for your E-Mail dated the 25th of September 2003 regarding the above West Pit Report.

The Upper Hunter Wonnarua Council has reviewed the document with the opinion that what you have written is a true account of our consultation meeting regarding the West Pit Aboriginal Social Significance Statement.

We have no objections as to what has been recorded.

With Regards

Victor Perry
Cultural Heritage Manager
Upper Hunter Wonnarua Council

John Matthews & Margaret Matthews
31 Mitchell Street
MUSWELLBROOK NSW 2333
PHONE: 02 65411397
FAX: 02 65411392
MOBILE: 0439 676 900
HERITAGE & CULTURE CONSULTANTS

**COMBINED COUNCIL
HUNTER VALLEY
ABORIGINAL CORPORATION**

25 September 2003

Dave Johnston
Australian Archaeological
Survey Consultants Pty Ltd
GPO Box 943
Canberra ACT 2601

Dear Mr Johnston

Re: West Pit Extension Aboriginal Social Values Assessment Project and Report

We the representatives of the Combined Council Hunter Valley Aboriginal Corporation acknowledge our involvement in the above mentioned project. We confirm the consultations carried out and our recommendations documented in this report.

A project of this nature is supported by our organisation as it ensures that our heritage values and management recommendations are documented and presented.

Yours sincerely

Margaret Matthews
Chairperson

PART L

aboriginal cultural heritage study

L

Extension of West Pit, Hunter Valley Operations
Archaeological Assessment

Coal & Allied Operations Pty Ltd
PO Box 315
Singleton NSW 2330

Final Report

2002043

Australian Museum Business Services
No. 1 Stanley Lane East Sydney, NSW 2010
Ph (02) 9320 6311, Fax (02) 9380-6964
URL: www.amonline.gov.au/ambs
andrewc@austmus.gov.au

October 2003

Project team

Australian Museum

Project Manager .... Andrew Collis
Field Archaeologists .... Gavin Martin
.... Andrew Collis

Huonbrook Environment and Heritage Pty Ltd

Geomorphologist, Field Survey .... Dr Philip Hughes

Report Authors .... Andrew Collis
.... Gavin Martin
.... Dr Philip Hughes

Acknowledgments

AMBS would like to thank the following people who provided advice and assistance in the preparation of this report:

Victor Perry, a representative of the Wonnarua Nation Aboriginal Corporation, who attended the archaeological planning session and participated in the survey;

Tracey Skene, a representative of the Upper Hunter Wonnarua Council, attended the archaeological planning session and participated in the survey;

John Waters, a representative of the Lower Wonnarua Tribal Council, who participated in the survey;

Beverley van Vliet who attended the archaeological planning session and participated in the survey, Rodney Matthews who attended the planning session, and Darrell Matthews, who participated in the survey, all representatives of the Wanaruah Local Aboriginal Land Council;

Allan Paget who attended the archaeological planning session and participated in the survey, and Graham Ward who attended the planning session, both representatives of the Ungooroo Aboriginal Corporation;

Margrit Koettig, archaeologist National Parks and Wildlife Service, who provided comments and advice on survey strategy, and

Sarah Fish, Dianne Markham, Steve Bullman and Nik Senapati of Coal & Allied, who provided information regarding the proposed development and Hunter Valley operations.

Executive summary

Coal & Allied (CNA) propose to extend the Hunter Valley Operations West Pit (formerly known as Howick Mine) from the existing open cut pit east to the Belt Line Road. This extension will impact on archaeological resources. An archaeological investigation of the proposed extension area was undertaken by Australian Museum Business Services (AMBS) in order to locate archaeological resources and assess the impacts of extending mining operations in this area.

An archaeological survey was conducted during December 2002 over a period of five days. Eleven previously unrecorded archaeological sites were recorded during the survey (WPE 1 – WPE 11). A number of these sites incorporated known sites.

Based on the archaeological survey and assessment of low to moderate archaeological significance (of sites WPE 1 and WPE 2) and Aboriginal cultural assessment of the extension area, the following recommendations are provided:

It is recommended that prior to the development of the extension area a cultural salvage be undertaken. A cultural salvage may involve collection and excavation within any areas deemed appropriate by the Aboriginal community. Sites WPE 1 and WPE 2, which contain large numbers of artefacts, including a variety of stone tool types, are likely target areas.

Given the number of Aboriginal community groups involved in the management process and the assessment of low to moderate archaeological significance, it may be appropriate for an archaeologist to develop a salvage program in consultation with the community groups. Artefacts collected could then be lodged with the Australian Museum providing equal access to all community groups and the scientific community. Alternatively, in accordance with the recommendations made by some of the Aboriginal community groups, CNA should consider developing a Keeping Place in which the artefacts could be kept.

All identified **Aboriginal sites should be protected** (i.e. remain fenced) until such time as their salvage takes place. Note that the fencing along the southern boundary of Emu Creek should be extended to the south to encompass the full surface extent of the site.

The extent and scope of **salvage work should be determined in full consultation with the local Aboriginal community**.

In consideration of the social values identified in or near the West Pit extension area, **senior Aboriginal men should be involved with any heritage works proposed in the far north western portion of the study area**.

CNA should **continue to liaise with the Aboriginal Stakeholder Representatives** on issues identified through the study, including the possible scarred tree.

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1 Introduction

Coal & Allied (CNA) propose to extend the Hunter Valley Operations West Pit (formerly known as Howick Mine) from the existing open cut pit east to the Belt Line Road. This extension will impact on archaeological resources. An archaeological investigation of the proposed extension area was undertaken by Australian Museum Business Services (AMBS) in order to locate archaeological resources and assess the impacts of extending mining operations in this area. This report contributes to the environmental impact statement (EIS) for extension of mining operations into this area. It details the archaeological investigation and assessment, and provides management recommendations.

2 Description of proposed development

The proposed development is an extension of existing West Pit mining operations. It is proposed that the pit be extended east to the Belt Line Road. Under the proposal West Pit will continue to operate as an open cut, multi seam dragline operation over a period of 21 years.

The proposed extension area comprises approximately 307 hectares east of the existing development consent boundary for the mine covered by EL5243, ML1406 and a portion of ML1428 and CML4. The EIS study area (comprising two discreet areas) is shown on Figure 1. The study area considered in the archaeological assessment comprises that land within EL5243 north of Lemington Road and ML1406, a total area of approximately 240 hectares (Figure 2). The remaining 67 hectares is not included in the study area because CNA already have development consent for this area.

3 Objectives

The study had three primary objectives:

1. to undertake an archaeological assessment in accordance with NPWS IDA guidelines and the NPWS Aboriginal Cultural Heritage Standards and Guidelines Kit 1997;

2. to assist in the preparation of the Aboriginal cultural heritage assessment, through consultation with the local Aboriginal community groups in order to identify the cultural values of Aboriginal sites or places within the study area; and

3. to provide recommendations that are appropriate in light of both archaeological and Aboriginal cultural significance assessment of the study area.

Figure 1: The EIS study area

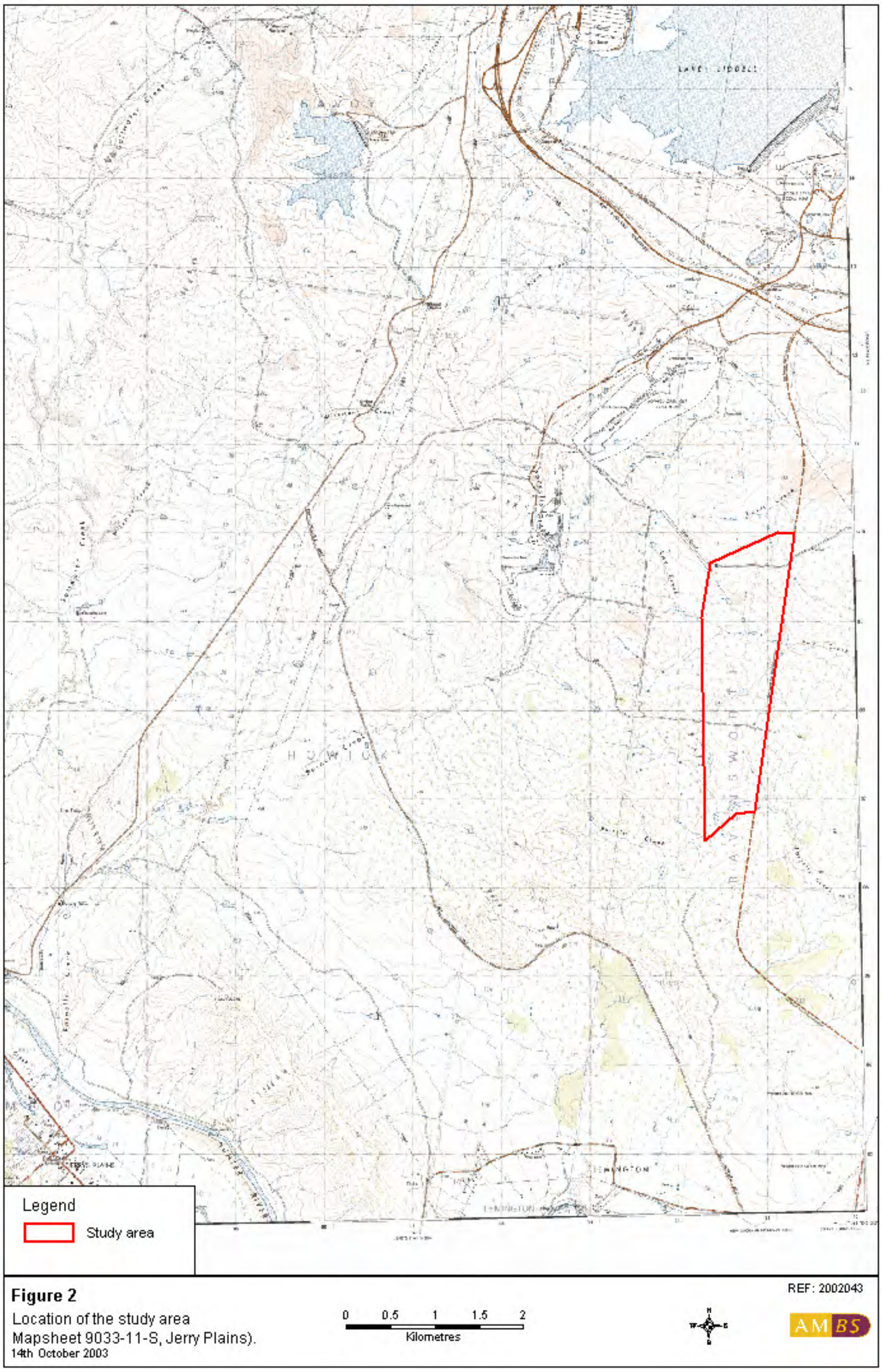

Figure 2: Location of the study area (Mapsheet 9033-11-S, Jerrys Plains)

Archaeological assessment involved:

- evaluation of background information and the development of a predictive model for the study area landscape;

- geomorphological investigation of the study area designed to 1) divide the area into a number of landform zones deemed likely to have different archaeological patterns, and 2) identify areas of archaeological potential (including areas which may have stratified deposit or provide information about occupation during the late Pleistocene/early Holocene period);

- locating and recording archaeological sites and any areas of archaeological potential during a survey of the study area; and

- assessment of archaeological significance using established heritage assessment criteria (The Burra Charter and NPWS guidelines).

The archaeological investigation of the extension area effectively provided Aboriginal community groups with a detailed description of archaeological sites that occur within the extension area. Participation in the archaeological survey also provided community groups an opportunity to assess the context of known archaeological resources and to identify other aspects of the study area that may have cultural significance.

Following Integrated Development Assessment (IDA) guidelines, the archaeological and Aboriginal cultural significance assessments were integrated by providing recommendations that are appropriate in light of both assessments. The primary document used to formulate recommendations for heritage places was the Burra Charter.

4 Aboriginal community consultation

The following Aboriginal community groups were consulted and involved throughout this study:

- Wonnarua Nation Aboriginal Corporation (WNAC);

- Upper Hunter Wonnarua Council (UHWC);

- Lower Wonnarua Tribal Council (LWTC);

- Wanaruah Local Aboriginal Land Council (WLALC); and

- Ungooroo Aboriginal Corporation (UAC).

CNA notified these groups regarding the proposed development and invited each to participate in the process of archaeological and cultural assessment of the proposed extension area. An archaeological planning session (or workshop) was organised by CNA. The workshop provided the opportunity for CNA to detail the proposed development, and for community groups to give feedback on the proposed archaeological survey strategy. Representatives from each group, with the exception of LWTC, attended the workshop. Representatives from the NPWS were also invited to attend but were unavailable. The Upper Hunter Combined Council (UHCC) was not established as a group at the time of the survey and therefore was only consulted after the survey was conducted.

Representatives from five groups participated in the archaeological survey: Victor Perry (WNAC), Tracey Skene (UHWC), John Waters (LWTC), Beverley van Vliet and Darrell Matthews (WLALC), and Allan Paget (UAC).

After receiving a draft report from AMBS detailing the results of the archaeological survey and assessment, each group provided CNA with a cultural assessment of the extension area via a Aboriginal cultural heritage report produced by Environment Resource Management (ERM) and Australian Archaeology Survey Consultants (AASC).

5 Background information

This section provides background information relevant to the interpretation of archaeological resources within the study area. Background information provides the basis for archaeological assessment and the context in which to develop appropriate management options. For this study background information includes a description of the environmental setting, past and present land use that may have impacted on archaeological resources and a review of previous archaeological investigations (both in the local area and in the wider Hunter Valley region). A brief account of Aboriginal occupation of the Hunter Valley via ethnohistorical records is also provided.

5.1 Environmental setting

5.1.1 Central Lowlands

The study area is situated in the Central Lowlands of the Hunter Valley. This country is characterised by low rolling hills on weak sedimentary rocks with local relief in any given locality generally less than one hundred metres (Galloway 1963:92). A myriad of small creeks feed into the Hunter River and its major tributaries. Vegetation was probably once dominated by open woodland (Grey Box, Slaty Gum, Ironbark, Bulloak and Kurrajong) and grassland (Dean-Jones and Mitchell 1993; see also recent vegetation surveys of the local area by ERM (1999) and AMBS (1995)). Today the Central Lowlands is a patchwork of cleared grazing land, woodland (much of it regrowth), vineyards and coal mines, with a long history of European land use. Available aerial photographs show the area was cleared for grazing since at least 1958.

Some knowledge of the environment, particularly the vegetation, before European settlement is useful for archaeological interpretation. Unfortunately, in many areas of the Hunter Valley (including the study area) it is difficult to reconstruct pre-European vegetation. A review of historic records however does provide a general picture. Phytolith analysis may also provide some information about past vegetation communities.

5.1.1.1 Early observations of the landscape

In 1819 John Howe, Chief Constable at Windsor, took a small party of seven men including an Aboriginal guide, to explore the country to the north and assess its potential for the new colony (Wood 1972). In early November 1819, Howe reached the banks of the Hunter River at its junction with Doyle's Creek. From this point he travelled downstream for a day and a half passing (St) Patrick's Plains and Jerrys Plains below the current study area, which he was to name on a return trip the following year (Wood 1972: 13). Along the way Howe made several observations of the country visible from the river margin.

Upon reaching a tributary of Doyle's Creek, Howe remarked that a thick brush of pine (prob. *Allocasuarina* sp.) surrounded its banks, the trees seldom exceeding five or six inches in diameter (Howe 1819). The Hunter floodplains were heavily grassed for about three-quarters of a mile on either side, some parts of it he thought, were the equal of any meadowland in England. The land on both sides of the river he described as,

> very fine and a great part of it may be cultivated without felling a tree, even the high land is well clothed with grass and lightly timbered, tho' much thicker than the low ground… one spot I think, exceeds 50 acres with not 20 trees on it and very fine ground
>
> Howe 1819: 12

Returning to the region in 1820, Howe described the country down river of Patrick's Plains as very like that further upstream but with more timber (Wood 1972: 13). To supplement his supplies, Howe shot kangaroo including a rock wallaby and caught freshwater perch in the river - which he noted occurred in great numbers (Howe 1819: 12). Other casual observations of the region and nearby areas made during the nineteenth century also describe the countryside as predominantly consisting of open woodland interspersed with extensive swathes of native grasses (Brayshaw 1986).

5.1.1.2 Plant species identified from phytolith analysis

Phytoliths are silica bodies deposited in plants during their life and vary in size and shape between different plant species. They can survive for long periods of time in soil deposits and thus can provide some information about the historic patterns of vegetation in an area.

A microscopic examination of sediment samples taken in the course of a previous archaeological study at West Pit (Barton 2001) revealed a phytolith assemblage that reflects the modern vegetation of open woodland and grassy understorey. Phytolith types from grass species were the most common (Fullagar *et al.* 2001: 7) including several species of known economic importance to Aboriginal people, *Themeda australis* and *Panicum* sp. Both plants are very common in the phytolith samples and are known to have been ground on flat grindstones, the wet paste used as a source of carbohydrate. The leaves and stems of some grass species could also have been used in fibre manufacture (Gott 1997). Tree and shrub communities were identified by the major Family groups present in the study area including Myrtaceae (e.g. *Eucalyptus crebra*, *E. molucanna*, *Angophora floribunda*, *Melaleuca decora*), Fabaceae (e.g. *Acacia* sp.), and Euphorbiaceae (e.g. *Euphorbia drummondii*).

5.1.2 Historical land use

From 1825 most of the lands fronting the known parts of the upper Hunter River, which would have included Patrick's Plains and Jerry's Plains to the immediate south of the study area, had been allocated as land grants or reserved for purchase (Wood 1972: 49). By 1828 the major pastoral activity in the region was the grazing of sheep and cattle; settlers attracted by the wide grassy valleys and plains of the Upper Hunter (Wood 1972). Throughout the region tree clearance by ringbarking to increase grass growth was common (Dean-Jones & Mitchell 1993: 24). Throughout the late 1820s numbers of sheep and cattle increased and in 1833 the impact of overgrazing was noted; the country described as wretched and almost destitute of grass (Boydell 1830-1835 in Wood 1972: 302). Recent land use practices involve further evidence of tree clearance, dam construction, and related episodes of soil erosion (Hughes 2000) and coal mining operations.

5.1.3 Local environment

The survey area consists predominantly of undulating to hilly terrain formed on Permian sedimentary rocks of the Singleton Coal Measures (Ps). The extreme southern end of the area is crossed by Farrells Creek and the northern part by Emu Creek, both flowing to the east. Several minor tributaries of these two creeks drain parts of the area. In particular the central part of the study area is crossed by a large tributary of Emu Creek, the two joining a few hundred metres east of the eastern boundary.

The vegetation cover over much of the area is grassland (some of it improved pasture), either completely without trees or under open Eucalyptus woodland. Virtually the whole property appears to have been cultivated (presumably by ripping) for pasture improvement, despite the generally thin soils. In some of the groves of open woodland there are piles of rock removed from the paddocks during land clearing and cultivation. The only dense grove of trees is along the 300 m stretch of the main northern tributary of Farrells Creek (Survey Area 2A – see below).

5.2 Ethnohistory

Ethnographic information available for the study area is of a very general nature with few direct or detailed observations of Aboriginal life in the upper reaches of the Hunter River. For example, John Howe (1819: 14) only notes the presence of five Aborigines crossing the river about half a mile from his exploration party and of a single individual who made a fleeting appearance in the brush. Brayshaw (1986) has compiled a detailed culture history based on archival records and museum collections which provides a general picture of land and resource use during the period of European expansion into the area after 1820.

The sons of settler William Ogilvie, who took up lands at Merton in 1825, spent time with the Aboriginal tribe living nearby and who were presumably employed as hands on the Ogilvie station (Wood 1972: 152). Wood (1972) presents accounts of a range of foraging activities undertaken including tracking and stalking game on the flats and hills, hunting possum, pursing kangaroo with dogs, shooting plains turkey and pigeons, collecting native honey, and fishing for perch with spears and hook and line (Wood 1972: 152).

There is little other direct evidence of plant use in the region, most comments relating to the coastal tribes along the lower Hunter River (Brayshaw 1986: 74). Possibly consumed in the region were Bungwall Fern (*Blechnum sp.*), Pencil Yam (*Dioscorea transversa*), the stems of Giant Lily (*Doryanthus excelsa*), seeds of Cycads like *Macrozamia spiralis*, fruit of Native Cherry (*Exocarpus cupressiformis*) and Red Kurrajong (*Brachychiton heterophyllus*). A range of other fruit, corms and tubers are also referred to generically as forming an important part of the diet (Brayshaw 1986: 75). William Ogilvie furnishes us with anecdotal evidence about the richness of Hunter Valley resources and the time spent foraging, stating that two hours a day climbing for possums or fishing would supply enough food for the day (Wood 1972:151).

Brayshaw (1986) has documented a wide range of technology from the region including bark canoes, yamsticks or digging sticks, composite spears for fishing and hunting, spear throwers, bark drinking vessels, shields, clubs, boomerangs, fire-sticks, basalt hatchets, European axes, and shell and glass scrapers. Cord made from the bark of Cabbage-Tree Palm (*Livistona australis*) and Kurrajong (*Brachychiton populneus*) was an important component of their technology. Plant cord was used for making terrestrial hunting nets and fishing nets, making fishing line, binding and repairing bark canoes, tying up bark containers, and hafting stone axes and spear heads with grass-tree resin. Other perishable items included kangaroo bone awls, cloaks of kangaroo and possum skin, sinew thread, and belts of possum fur.

There is little information on the techniques of food preparation. The rhizome of Bungwall Fern was roasted in ashes then pounded to paste between two stones. Giant Lily was also roasted and sometimes made into a cake. Macrozamia seeds were soaked in creek or swamp water for several days, pounded and then roasted. Seeds of Kurrajong were roasted or ground. There is some evidence that grass seeds were gathered and ground (Wood 1972: 112). Wood (1972: 153) writes that all cooking was either by boiling or baking in hot ashes, or through the use of an excavated oven lined with stones.

5.3 Archaeology

5.3.1 Archaeological investigations in the Hunter Valley

Archaeological research has been conducted in the upper Hunter Valley since the first half of the 20th Century (McCarthy and Davidson 1943, McCarthy 1943, Moore 1970, Moore 1981), initially by archaeologists from the Australian Museum (Fred McCarthy and David Moore). McCarthy and Moore located and collected artefact scatters adjacent to the Hunter River. The material occurred along the terrace and was particularly abundant at Gowrie (McCarthy and Davidson 1943). In the 1960s Moore carried out archaeological excavation of rock shelters at Sandy Hollow, Milbrodale and Bobadeen. An archaeological survey was undertaken by Moore from the confluence of Wollombi Brook and the Hunter River, to Singleton (Moore 1970). Artefacts were found at the 200ft (60m) contour in eroded contexts, at several sites, particularly ‘Gowrie terrace’.

From the late 1970s an increasing number of archaeological surveys and investigations have been carried out in the Hunter Valley for environmental impact studies and site management purposes. This has followed the introduction of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The EP&A Act initiated pro-active archaeological survey and assessment, which tied in with the site protection and consent processes of the *National Parks and Wildlife Act 1974*. Previous studies differ in size and scale and are generally area specific, that is, concentrating on areas of land proposed for development, particularly areas proposed for coal mining.

Archaeological investigations for environmental impact assessment purposes were initially based largely on surface survey. In more recent times excavation has played a greater role, more so in mitigation of impacts through salvage than in assessment of sites. Both survey and excavations have revealed a rich archaeological record characterised by backed artefacts and the products from their manufacture in open archaeological deposits. Other implements such as portable grindstones and stone hatchet heads (axes) are present but are less common. The vast majority of sites are open archaeological deposits, with other site types such as grinding grooves and scarred trees also having been recorded.

5.3.2 Regional issues

Archaeological interest has focused on stone technology, the chronology of Aboriginal occupation, and the distribution of Aboriginal sites within the landscape. Major technological studies have referenced Hiscock's study of the Sandy Hollow rockshelter and sites on Mt Arthur North (Hiscock 1986). Hiscock distinguished between the technological systems employed from different levels of the Sandy Hollow rockshelter site excavated by Moore in the 1960s (Moore 1970). Hiscock's study attempted a chronological distinction between open sites through identification of technological features held in common with dated levels from the Sandy Hollow excavation. Hiscock's primary purpose in the study was as a response to the intensification debate in Australian archaeology in the 1980s and later studies have questioned the efficacy of Hiscock's methods (Baker 1992) or of technological attribute analysis in general (Koettig 1994).

Aboriginal site excavations have become more prolific in the Central Lowlands since the early 1990s when archaeological inquiry advanced beyond discovering the range of artefacts at sites and general location of archaeological evidence. The discovery of high spatial integrity of archaeological evidence in some areas led to an increasing interest in "intra-site" spatial patterning (Koettig 1994).

The focus of recent archaeological work in the Hunter Valley is moving away from technological description of artefact assemblages and towards two issues:

1. settlement patterns as reflected in differential use of landform units (e.g. Kuskie 1999); and

2. antiquity of occupation and chronological change (e.g. AMBS 2002).

The present study focuses on the use of the landscape and settlement patterns, as the study area proved to have little or no potential to address the issue of antiquity or chronological change in the archaeological record.

5.3.3 Models of Aboriginal land use

One of the aims of this study is to attempt to define the nature of occupation over the local landscape. As a consequence, the nature of assemblage sampling has focused upon 'landform zones' rather than particular 'sites' as is traditional in most archaeological consulting projects *(site remains the unit of recording archaeological material to comply with current legislation and NPWS recording requirements*). The intent of this strategy is to highlight variation between assemblages at a large scale, treating assemblages as a continuous scatter of material across the landscape. In doing this, an attempt is being made to identify variation within artefact assemblages that correspond with variation in the general patterns of landscape use. It is not 'sites' *per se* that are the focus of attention, but the nature of activities that can be identified through the analysis of stone artefact distributions. Many of the surveys and salvage projects previously conducted throughout the Hunter Valley have focused on large exposed areas or areas where sites are thought to occur (along drainage lines). It is only recently that a clearer (less biased) picture of site and artefact distributions is beginning to emerge, which might enable the archaeology of the Hunter Valley to be understood within a behavioural framework.

5.3.3.1 A Model of Forager Settlement

A forager settlement pattern may be an appropriate model for viewing the archaeology of the upper Hunter Valley. This model suggests that the relative distribution of *residential base* sites and *activity location* sites should reflect the foraging radius associated with occupation in an area. A general model of foraging distinguishing the residential "home base" site with peripheral "activity locations" as presented by Foley (1981) is shown below (Figure 3). The right frame shows the archaeological outcome of the structured activities illustrated in the left frame.

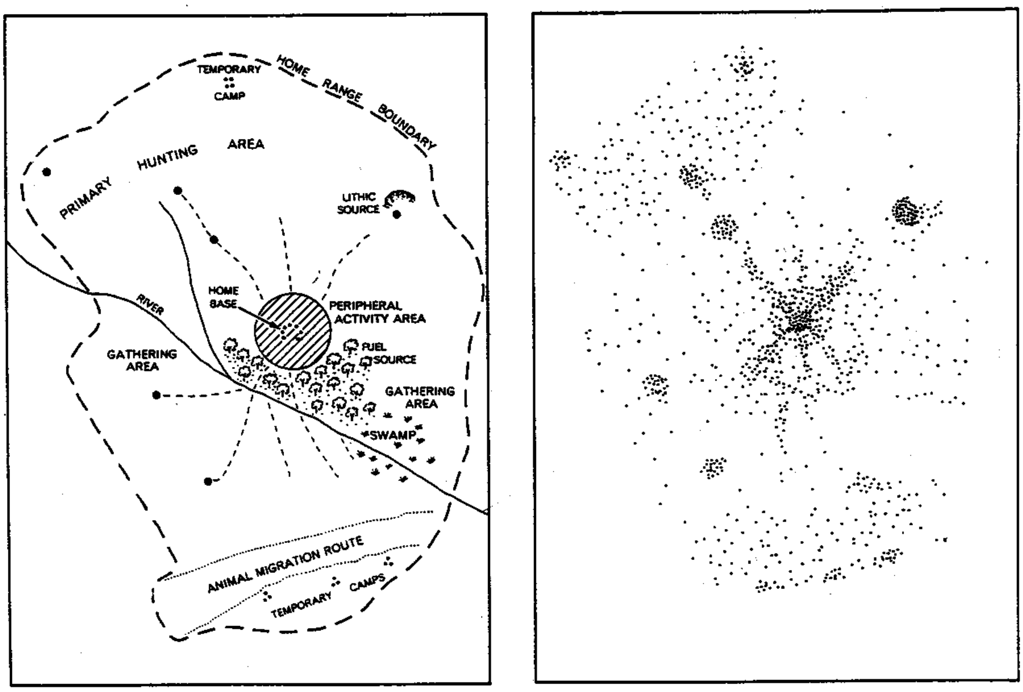

Figure 3: Foraging Model from Foley 1981

Tasks undertaken at activity location sites will vary and so the archaeological evidence associated with specific activities or tasks, for example resource extraction, will characterise individual *activity location* sites. *Activity locations* are not likely to contain features reflecting protracted camping, for example: hearths and in situ heat treatment of flaking stone are not anticipated. *Activity locations* occur within the foraging radius of a residential site.

Residential sites (also referred to as *residential bases* or *base camps*) are more likely to occur in parts of the landscape with good access to the widest range of subsistence resources, and with the greatest relative amenity for camping within the local area. Such locations will be protected from cold winds, favour protected sunlit locations and be close to reliable and renewable resources, principally fresh water. Creek valleys with reliable freshwater appear to offer such protected locations and are favoured over exposed floodplain and high riverbank locations for residential sites (the reverse may be true if access to resources is greater from a riverbank context). The degree of environmental reliability (e.g. permanent water as opposed to intermittent streams) may influence the rate of return to sites and hence the complexity of evidence. Higher order streams may have been a more reliable location attracting more frequent residential camping visits than an intermittent creek valley in extreme environmental conditions such as drought.

A foraging group, such as a family or extended family group, occupying a residential base for a typical stay of a few days will move regularly as subsistence resources are harvested and depleted within the foraging radius. Binford (1980) proposes a model of systematic movement by the foraging group in a leapfrog fashion, "leaping" beyond the previous foraging radius to establish a new residential base and new undepleted foraging radius. This “half-radius” pattern of residential mobility and landscape use is illustrated below (Figure 4, taken from Ebert 1992).

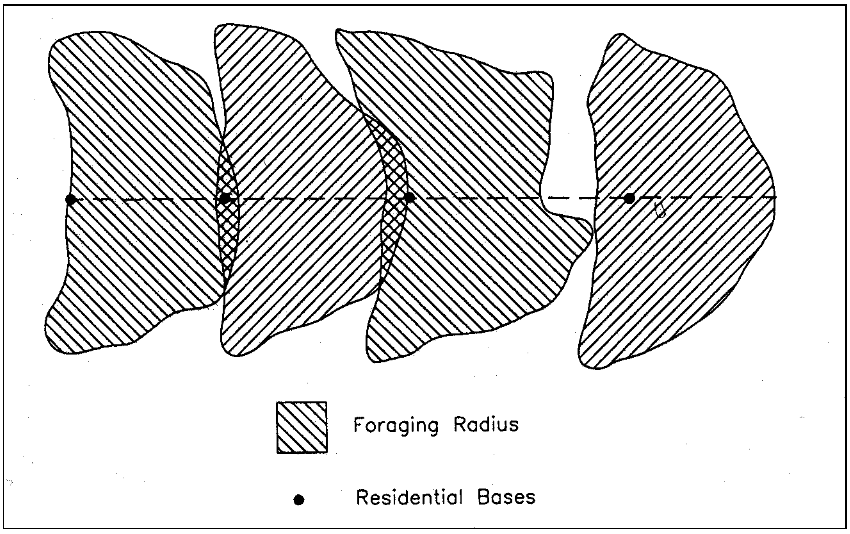

Figure 4: Foraging Model from Ebert 1992

An alternate view is a full radius pattern. The size of the foraging radius may be equated with the "site exploitation territory" estimated by Renfrew and Bahn after Higgs and Vita-Finzi (1972) to be around 10 km radius or the area within 2 hours walk (Renfrew and Bahn 1991).

Larger gatherings of clan or tribal groups would occur possibly once or twice a year at places used for ceremonies. There is some local evidence of these kinds of activities. The area around Baiame cave at Milbrodale, around 20 km south of the study area, has been referred to by the local Aboriginal community as one such location. A Bora ground is also located near Wollombi Brook, around 16 km south of the current study area.

It appears that, in the upper Hunter Valley, the creek valley floors of the Central Lowlands formed the focus of *residential base* occupation. Sequential positioning of foraging radii along these creek valleys over several millennia would have resulted in a continuous archaeological distribution close to creeks reflecting domestic and maintenance activities in a *residential base* context. Archaeological evidence on the upper slopes, ridge lines and less domestically amenable areas up to several kilometres from the residential base would reflect resource gathering *activity locations*. The commonly reported pattern of archaeological evidence in the Upper Hunter whereby artefact distributions are concentrated close to creeks and highly dispersed away from the creek can be explained by this model. Apparent departures from the model present significant opportunities for research. Such departures occur for example where artefacts are sparsely distributed along a creek line and there are no concentrations. Such evidence challenges the notion of concentrated knapping floors along all creeks in the Hunter Valley. Concentrations of artefacts in areas of high environmental exposure (e.g. with negligible protection from prevailing winds) also deserve close scrutiny, for example Site 37-5-63 on Hunter Valley Operations North mine. It appears that the resource richness of the immediate area of this site, including a local stone source, a small meander cut-off rich in ribbon lily to the immediate north and immediate access to deep water holes in the Hunter River, may have resulted in an *activity location* with very highly concentrated artefactual material. Differences in the local environment of each site may influence the strategic use of each site. In addition, it was argued that the main reason for the concentration of artefacts at this location was that it was a discrete sand dune (Hughes 1997).

The mobility of prehistoric foragers as defined by Binford (1980) can be measured in many different ways (Kelly 1983, 1988). The most common way of gauging human mobility in foraging populations has been to investigate the diversity and richness of assemblages (a measure of site complexity), in terms of the number and range of artefact types found both within, and between, sites (Shott 1986, Andrefsky 1998). In general, it is assumed that a site representing an activity location of foragers with high mobility will show a low diversity of artefact types (based on the premise that the site serves a few specific and focussed activities). A site representing extended stays or a residential function, however, will have a greater diversity (richness) of artefacts representing a greater range in activities performed on the site in the immediate area.

Nelson (1991) notes that "at residences, materials should include all stages of manufacture… and tools broken in manufacture". Therefore, where group mobility is high and campsites are frequently shifted about the landscape, assemblages are not expected to contain facilities (such as heat treatment pits), and the wide array of implements discarded at places of extended occupation. Since the number of activities requiring the use of stone tools in any one location is likely to be restricted, assemblages should reflect this and contain fewer implement classes. It may also be the case that the location of particular activities cannot be predicted, adding to the increased dispersal of material over the landscape. If individuals are opting to carry a number of stone tools during hunting and gathering forays into the landscape rather than manufacture tools at task locations, a high number of used tools should be recovered from these low density and dispersed assemblages.

5.3.3.2 A general model of occupation in the Hunter Valley

In a recent study, Kuskie and Kamminga (2000) have established a general model of occupation strategies for the Central Lowlands and lower Hunter region primarily based upon ethnographic research (refer to Table 1). This model is useful as a starting point and makes a general set of predictions for the lower Hunter that is consistent with other studies (e.g. Nelson 1991, Thomas 1983). Primarily, the Kuskie and Kamminga (2000) model distinguishes between short-term or extended occupation and makes some predictions about the likely location of different foraging and settlement activities. Combining this information with a general review of assemblage contents from a sample of excavated sites within the Hunter Valley, a baseline of settlement activities may be determined (Barton 2001). While the model may be challenged in its detail it does provide a number of archaeological expectations that may be tested.

For example, the presence of features requiring a considerable labour investment such as stone-lined ovens or heat-treatment pits are likely to occur at places where occupation occurred for extended periods. The presence of grindstones is also a reliable indicator of low mobility and extended occupation. Seed-grinding requires a large investment of time and effort (Cane 1989). In most ethnographic examples, seed-grinding is an activity that takes places over an entire day to provide adequate energetic returns (Cane 1989, Edwards and O'Connell 1995).

Where group mobility was high and campsites were frequently shifted about the landscape, artefact assemblages are not expected to contain elements such as grindstones, heat-treatment pits, ovens and the diversity of implements frequently discarded at places of extended residential occupation. It may also have been the case that the location of particular activities could not be predicted by tool users, adding to the increased low density dispersal of artefacts over the landscape. Also, if individuals were opting to carry a number of stone tools during hunting and gathering forays into the landscape and maintain these tools rather than manufacture new tools at each task location, the ratio of used tools to unworn flakes in these assemblages should be high.

Table 1: Occupation Model for the Central Lowlands and Lower Hunter Valley from Kuskie and Kamminga (2000)

Occupation pattern	Activity location	Proximity to water	Proximity to food resources	Archaeological expectations
Transitory movement	All landscape zones, but frequently on ridge and spur crests, watercourses and valley flats	Not important	Not important	Assemblages of low density and diversity Evidence of tool maintenance and repair Knapping
Hunting and/or gathering without camping	All landscape zones	Not important	Near food source	Assemblages of low density and diversity Evidence of tool maintenance and repair High frequency of used tools discarded Knapping
Camping by small parties	Frequently associated with permanent or temporary water	Nearby	Near food source	Assemblages of low-moderate density and diversity Evidence of tool maintenance and repair Hearths
Nuclear family base camp	Level or gently undulating ground	Nearby reliable source	Near food source	Assemblages of high density and diversity Evidence of tool manufacture and casual knapping Facilities such as heat treatment pits and stone lined ovens Grindstones present
Community base camp	Level or gently undulating ground	Nearby reliable source	Near food source	Assemblages of high density and diversity Evidence of tool manufacture and casual knapping Facilities such as hearths and stone lined ovens Grindstones and ochre present Evidence of heat treatment

5.3.4 Archaeological investigations in the local area

There have been many archaeological surveys undertaken in and around the study area. The first documented survey was undertaken by Dyall (1976) as part of an EIS for the Electricity Commission's Mt Arthur Project. Dyall's survey covered a large area of the Central Lowlands including the study area. This section focuses on subsequent surveys within two areas that are in the immediate vicinity of, or include, the study area: West Pit (formerly Howick Mine) and Carrington Pit (Figure 5). A review of investigations of two large sites that are located a few kilometres south of the study area is also provided: Site 37-5-63 in Hunter Valley Operations North Pit and Site 37-5-166 in Cheshunt Pit (on the south side of the Hunter River).

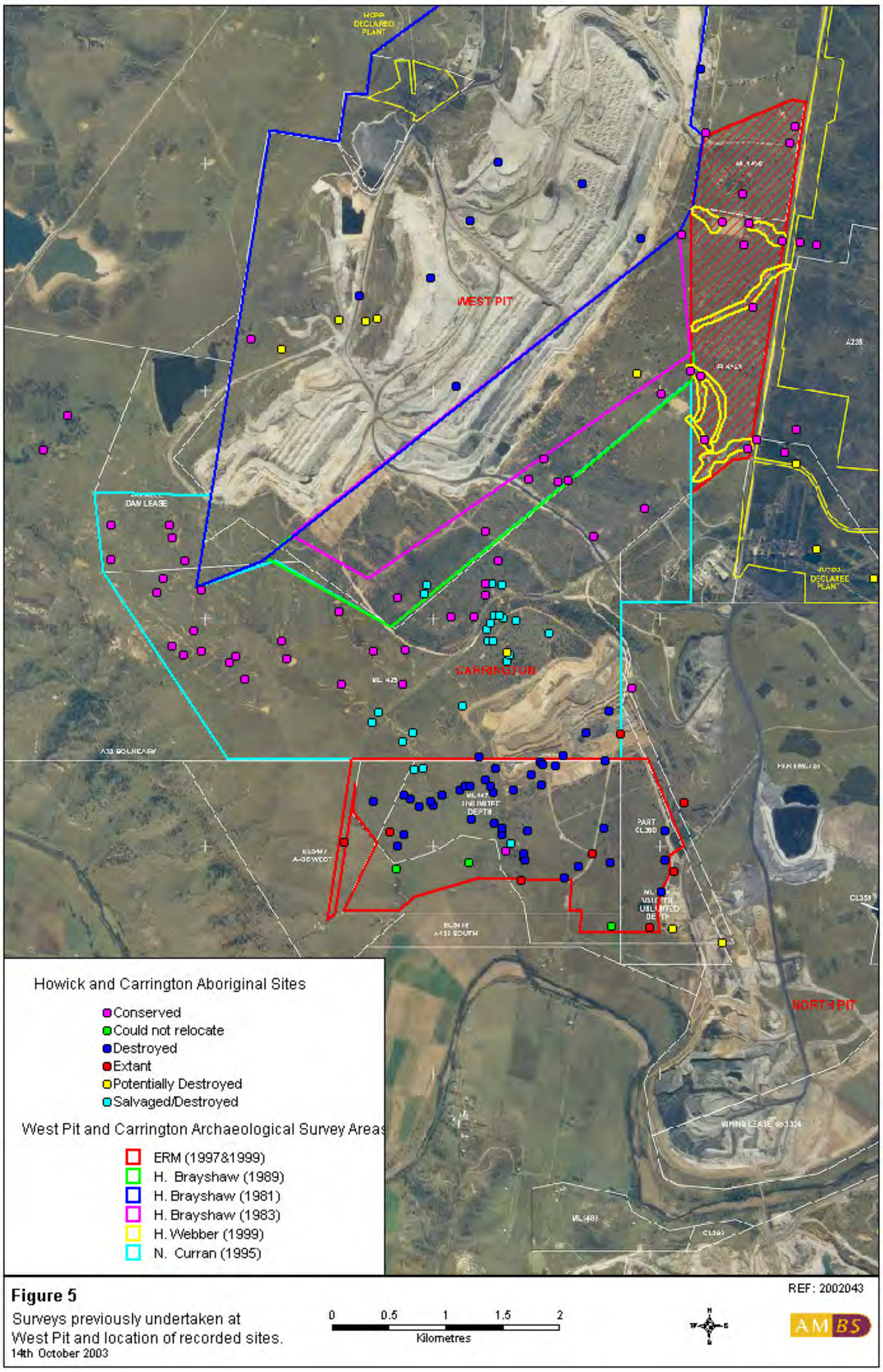

Figure 5: Surveys previously undertaken at West Pit and location of recorded sites

5.3.4.1 West Pit

Archaeological surveys have previously been carried out on the West Pit Mine Lease by Brayshaw (1981, 1983 and 1989), and ERM Mitchell McCotter (1995). These have been to assess the impact of various stages of extensions to mining operations. None of the sites recorded during these surveys are located in the study area.

Brayshaw (1981) recorded nine open artefact scatter sites (designated A to I). One site was found on Davis Creek (a tributary of Bayswater Creek) and eight were along Parnells Creek and its tributaries. Most sites contained around 20 artefacts or less. One site had more than 100 artefacts. Only one formal "tool type" was found, a geometric microlith.

Brayshaw (1983) recorded two sites. One (site J) was on an eroded western bank of Parnells Creek and comprised five artefacts in an area 50x2m. All were flakes and flaked pieces of mudstone. One flake had visible retouch/usewear. The other site (site K) also contained five artefacts comprising flakes and flaked pieces of indurated mudstone, silcrete and quartz. There were no artefacts at this site with visible retouch or usewear. The site was in a gully junction on a tributary of Farrells Creek. All artefacts appeared to originate from the Unit A soils.

Brayshaw (1989) recorded six sites (designated sites L-Q) and found more artefacts at the previously recorded site K. All sites were surface scatters of stone artefacts originating from the Unit A. Three sites were located on Farrells Creek. One site was on a tributary of Farrells Creek. Two sites were located on a ridge. Another isolated artefact (IF1) was also found during the survey, on a tributary of Farrells Creek. The majority of sites had less than 20 artefacts. Site K was re-recorded as containing 27 artefacts in two exposures. One site (site L) was estimated to contain between 100–150 artefacts, mostly silcrete. However, this estimate may be too high as the site was also described as containing silcrete gravels which could have been used as a raw material source and many of the pieces showed evidence of disturbance and breakage. Raw materials included silcrete, mudstone, quartz and a few pieces of chert. Artefact types comprised mostly unmodified flakes and flaked pieces with a small number of cores and modified artefacts. No backed artefacts or diagnostic artefact types were found. It was also considered 'unlikely that more detailed investigation of these particular sites would add significantly to the information recorded' (Brayshaw 1989:10). Therefore, it was recommended that consent to destroy should be applied for and issued by the NPWS (without further archaeological investigation).

Curran (ERM Mitchell McCotter 1995) carried out an archaeological survey of the Howick Mine Lease (Authorisation 72) as part of an Environmental Impact Statement. Twenty-six open artefact scatter sites were recorded, mostly along creek lines (designated HC1-HC26). None of these sites are located in the present study area. It was concluded that there appeared to be a "trend in site occurrence throughout the western end of part A72, particularly along drainage lines" (ERM Mitchell McCotter 1995:13).

The majority of sites comprised up to 56 artefacts, with only four sites having less than 10 artefacts. Six sites had between 100 artefacts and just over 500 artefacts. One site contained over 1,000 artefacts. Raw materials were predominantly mudstone and silcrete with smaller quantities of quartz, chert, porcellanite and quartzite recorded. Artefact types were predominantly flakes and flaked pieces, with a few examples of cores. No diagnostic artefact types or modified artefacts were described, however, details on artefact types at each site were not consistently provided in the report.

Higher numbers of artefacts were recorded at sites HC15, HC16, HC17, HC18, HC20 and HC21. It was concluded this represented occupation concentrated along three parallel drainage lines from Parnells Creek towards the Hunter River. HC17 was determined to have the highest significance of all sites recorded within the Howick Lease. This site was a large, rich concentration of artefacts and contained a series of knapping floors of various raw materials. It was concluded by Curran (ERM Mitchell McCotter 1995:22) that site HC17 'can increase our knowledge of the process of stone tool manufacture in association with other sites in the local area'. Further archaeological investigation of the site was recommended.

Curran recommended further investigation of HC15, HC16, HC17, HC18, HC20, HC21 and HC23 to determine the significance of 'that part of [authorisation] A72'. In addition, it was recommended that 'further archaeological investigations of part A72 would place the study area into a regional context and improve knowledge of land use and exploitation of the natural resources by the Aboriginal people, particularly in areas adjacent with the Hunter River' (ERM Mitchell McCotter 1995:22).

Consent to Destroy was recommended for sites HC1 – HC14, HC19, HC22 and HC24 – HC26.

Unfortunately, the Curran report provided little detail about the sites. The only consistently recorded information was artefact numbers and raw material types. There is some reference to artefact types being "predominantly" flakes and flaked pieces, however, there is no real useful information on artefact types. The site sketch plans show the distribution of artefacts, however detail was restricted to raw material type. In reviewing this report, NPWS determined that the existing archaeological documentation was not sufficient to consider the significance of sites nor could NPWS assess whether conservation or Consent to Destroy was warranted. As a result, NPWS recommended further assessment before a determination on these could be made.

In response to NPWS recommendations, AMBS (2000) were commissioned to reinvestigate those sites previously recorded by Curran (ERM Mitchell McCotter 1995) in the southern part of the West Pit lease. These sites included HC21, HC23 – HC26 and an additional site HC101. The aims of this study were to record additional site information, particularly in relation to the artefact assemblages; inspect additional areas in the southern part of West Pit for fresh exposures; and compare findings with sites recorded at the adjacent Carrington Mine site.

The survey recorded a total of 179 artefacts from seven sites with low to very low surface densities. Artefact analysis recorded general similarities between all recorded sites in terms of raw materials and artefact types. The major difference between assemblages was the recording of several sandstone grindstone fragments from HC21 and HC24 on the lower flats. At the time of the 2000 survey, HC22 could not be relocated.

Salvage excavations and surface artefact collections were subsequently undertaken by AMBS at sites HC21, HC23, HC24 and HC101 recovering a total of 644 artefacts (Barton 2001). HC21was interpreted as a residential base camp, where analysis of the flake assemblage determined a range of activities including blade manufacture and the production of geometrics (2001:6). Usewear and residue analysis identified plant, wood and skin working. Sites HC23, HC24 and HC101 contained lower densities of stone artefacts and analysis of stone artefacts from these sites indicated the locations may have been a focus for intermittent short-term use (2001:6).

HLA Envirosciences undertook an archaeological survey at Cumnock, in an area that overlaps with West Pit (Stuart 1996). The survey area (214 hectares) was divided into two landform zones: “ridges and slopes” and “valleys”. Twenty-three artefact scatters, fourteen isolated artefacts and a scarred tree were located. As discussed in Section 5.3.5.2 two of these sites were recorded in the present study area. Most sites recorded were small scatters of “about ten mudstone flakes”. The results indicated that most artefacts and sites occur in valleys. They also indicated that artefact scatters are more likely to occur in valleys than on ridges and slopes, and conversely that isolated artefacts are more likely to occur on ridge and slopes than in valleys.

5.3.4.2 Carrington

Surveys of the proposed Carrington Mine (which adjoins West Pit) carried out in 1997 and 1999 recorded 46 archaeological sites (ERM Mitchell McCotter 1999a Figure 3). Additional site recording has recently taken place (ERM Mitchell McCotter 1999b) through which a number of the previously recorded sites have been “linked”. Fifteen of the original 46 sites were revisited and one other site was recorded. The sites are all open stone artefact scatters, with two being described as silcrete source sites (CM2 and CM37) and one being a large tool production site (CM39). The area was also considered to be potentially significant given colluvial deposits downslope of CM2 which may be of Pleistocene age. This latter area has subsequently been test excavated by Hughes and Hiscock (2000) (see below).

Sites were found in all landscape units, specified as low ridge, hillslopes, higher flats and lower flats. The low ridge contained the source site CM2 and a spread of artefacts across the unit. Very few sites were found in the hillslopes landscape unit, mostly open artefact scatters and isolated artefacts, however, the unit also contained the other source site (CM37) on a relict Tertiary river terrace. Both the higher flats and the lower flats landscape units contained open artefact scatters and isolated finds. Site frequency and artefact density in sites was low across the entire Carrington landscape (ERM, Hughes and Hiscock 2000). Artefact density was especially low in the hillslopes landscape unit, estimated to be less than $0.01/m^2$ (excluding the source site). Artefact densities in the other landscape units consisted of $0.01/m^2$ on the lower flats, $0.02/m^2$ on the higher flats and $0.03/m^2$ on the low ridge (excluding the source site).

Site assemblages, excluding the two silcrete source sites, were generally dominated by mudstone followed by silcrete with a small proportion of other raw materials. In some sites mudstone and silcrete were co-dominant while in others silcrete was strongly dominant. Overall, the silcrete source sites were not considered to be a primary source of raw material for the sites recorded across the Carrington Mine landscape (ERM, Hughes and Hiscock 2000). Other raw materials present were chert, quartz, quartzite and igneous rock.

Formal tool types recorded in the entire artefact assemblage consisted of anvils, blades, choppers, ground edge axes, hammerstones, backed artefacts, points and scrapers. Other knapping remains included cores, flakes and fragments. Fragments were defined as 'all other flaked pieces which were obviously worked but had no distinct percussion marks' (ERM Mitchell McCotter 1999b: 3.6). Hughes and Hiscock have indicated that artefact counts at CM2 and CM37 are likely to be inflated due to the presence of naturally heat-fractured rock at the source areas (ERM, Hughes and Hiscock 2000). Both source sites CM37 and CM2 had cores which could be reduced further and other silcrete boulders not utilised (ERM Mitchell McCotter 1999b: 4.12).

The lack of small tools i.e. scrapers, points or microliths at CM37 was argued to indicate that the site was primarily used for the collection of stone material and primary reduction of material. Recovered from this assemblage was a large number of anvils and several hammerstones, considered to have been used in the removal of flakes from the cores (ERM Mitchell McCotter 1999b: 4.14). In contrast, the CM2 source site and the low ridge area also had characteristics which suggested material had been reduced at those locations. A higher number of scrapers, the presence of a ground edge axe and marginally higher numbers of cores on the low ridge was taken to indicate a possible preference for tool manufacture and general occupation of the low ridge areas.

The Carrington Mine report considers that the alluvial flats did not have potential for significant archaeological deposits (ERM Mitchell McCotter 1999b: 4.16). The stability of the drainage lines in the alluvial flats area suggests that the artefact concentrations represent activity locations rather than factors of erosional exposure resulting from channel migration. The poorly developed network of shallow ephemeral drainage lines (probably of late Holocene age) may have acted as a 'slight focus of occupation' (ERM, Hughes and Hiscock 2000). The concentrations of artefacts were still very sparse in this area and artefacts were not observed in the channel walls. Therefore, it was concluded that 'it is possible that the flats may contain some subsurface material, however the likelihood of finding such material is extremely low' (ERM Mitchell McCotter 1999b: 4.17).

The majority of sites recorded were believed to be of mid to late Holocene age, with the exception of one location (site CM-CD1), at the base of the western slope of the low ridge, where test excavation found artefacts likely to be of late Pleistocene or early Holocene age (Hughes and Hiscock 2000). This older site is rare for the Hunter Valley region.

It was recommended that application for Consent to Destroy be made for sites CM2-18, CM20-31, CM33-49 and CM54. A sample collection of artefacts across each of the landscape units and additional recording at CM2 in relation to the identification of naturally fractured rock were recommended. Sites CM1, CM19 and CM32 were outside the proposed mine plan and therefore not affected by the Carrington mine proposal. The Carrington Mine layout has been modified to exclude the area containing potential Late Pleistocene/ early Holocene artefacts.

5.3.4.3 Site 37-5-63 and Site 37-5-166

Approximately four kilometres south east of West Pit, a large site with a high density of artefacts (NPWS Site 37-5-63) was situated immediately north of the Hunter River on Coal & Allied's Hunter Valley No.1 North Pit. This site had been investigated over a number of years, culminating in salvage excavation (Brayshaw and Haglund 1983, Haglund 1993, Rich 1993, Paton 1996). The site was estimated to cover at least 24 hectares. The principal activity at the site was the reduction of river cobbles to make stone artefacts. However, the presence of retouched artefacts, backed artefacts with usewear, ochre and a resin hafted flaked piece suggested a range of other on-site activities, including the production of organic implements. Several discrete activity areas associated with primary artefact production were identified. These were used for specialised processes such as backed artefact knapping and retouching larger tools. There were also a variety of approaches to backed artefact production.

Major portions of the site had been significantly disturbed by bioturbation and land use practices, including extensive ploughing and vehicle use. A geomorphological assessment (Hughes 1997) revealed that it was unlikely that artefact bearing deposits retained stratigraphic integrity. The soils did not have a duplex profile and there were no alluvial sediments. It appeared that artefacts had been deposited after late Pleistocene/ early Holocene sands accumulated at the site. Therefore, rather than representing an 'in situ' stratified sequence of occupation, it was a series of deflated archaeological layers (Hughes 1997). Consent to Destroy has since been issued by NPWS.

South of Site 37-5-63 on the opposite side of the Hunter River another large site with a high density and diversity of artefacts (NPWS Site 37-5-166) was situated on a sand dune close to the bank of the river. Hughes and Shawcross (2001) recovered samples of artefacts for analysis from grader scrapes totalling 750m^2 (where 380 artefacts or 0.5 artefacts/m^2 were recovered), and from immediately adjacent excavations totalling 11m^2 (from which 822 artefacts or 75/m^2 were recovered). Like the site on the dune across the river to the north, this assemblage had been severely disturbed by bioturbation. A major difference between the two sites was in the proportions of raw material. In Site 37-5-166 90 percent of the artefacts were made of indurated mudstone and 5 percent of silcrete, whereas in Site 37-5-63 57 percent were indurated mudstone and 27 percent silcrete.

There are apparently relatively few records of archaeological materials being found close to or directly on the banks of the Hunter River, compared with the very large numbers of often rich sites having been found along its major tributary creeks. These two dune sites close to the Hunter River demonstrate at least that sand dunes close to the river provided a focus for repeated Aboriginal use and occupation.

5.3.5 Archaeological resources within the study area

The Aboriginal Heritage Information Management System indicates that four sites are located within the study area. These sites were recorded by Dyall (1976) and Stuart (1996). A number of other sites have been recorded by Webber (1999) and a list of known archaeological sites provided to AMBS by CNA include three sites within the study area. Details of these sites are provided below (see also Table 2) and shown on Figure 6.

Table 2: Previously recorded sites within the study area

Site name	NPWS #	Site type	Recorder
Emu Creek	37-2-0038	Artefact scatter	Dyall (1976), Webber (1999)
Lower Emu Creek	37-2-0144	Artefact scatter	Dyall (1976),
CUM-1	37-2-0894	Artefact scatter	Stuart (1996)
CUM-3	37-2-0896	Isolated artefact	Stuart (1996)
HEE1	37-2-1964	Artefact Scatter	Webber (1999).
HEE2	37-2-1965	Possible scarred tree	Webber (1999)
HEE3	37-2-1966	Isolated artefact	Webber (1999)
HEE4	37-2-1967	Isolated artefact	Webber (1999)
CUM 41	37-2-0805	Artefact scatter	Webber (1999), Stuart (1996)*
TG	NR	No information available	No information available
TH	NR	No information available	No information available
TD	NR	No information available	No information available

Note: NR = not registered with NPWS, * report not available at NPWS

5.3.5.1 Dyall's sites

Dyall (1976) recorded three sites along Emu Creek. Two artefact scatters, (Upper Emu Creek sites), are located near the upper reaches of Emu Creek, in, or in the immediate vicinity of, the study area. A third artefact scatter (the Lower Emu Creek site) is located in the lower reaches of Emu Creek about three kilometres south east of the upper Emu Creek sites. Note that these three sites (originally recorded on two site-recording forms) have been registered at NPWS as six separate sites. This is probably the result of transcription errors, the fact that hand written and typed versions of the site forms exist, and perhaps also errors in the conversion of Dyall's grid references into AMG coordinates. The locations of the Emu Creek sites provided by NPWS should not be regarded as precise.

All stone artefacts (visible atfrom each of the Emu Creek sites were collected by Dyall and lodged with the Australian Museum. Dyall's description of the two assemblages are provided below:

> Upper Emu Creek (189 artefacts from two discrete site locations)
> Total collection yielded 165 waste flakes (74 chert, 50 acid volcanics 41 quartz), 7 flaking cores (2 chert, 2 acid volcanics, 2 quartz, 1 coarse siliceous), 17 stone implements (12 scrapers, 1 simple blade, 1 hammer, 1 heavy cleaver, and 2 edge ground axes).
>
> Lower Emu Creek (200 artefacts)
> A total collection in 1976 yielded 171 waste flakes (109 chert, 27 acid volcanics 22 quartz, 13 other); 8 flaking cores (4 chert, 3 acid volcanics, 1 other); 27 implements (13 scrapers 8 simple blades, 6 Bondi points).

Note that Dyall used the term "chert" for the material most archaeologists today call mudstone (or silicified tuff), and "acid volcanics" for silcrete.

5.3.5.2 Stuart's sites

Two sites were recorded by Stuart (1996) as being located within the study area: one isolated artefact, CUM3, and a small artefact scatter CUM1. CUM3 was recorded as a single mudstone core on a ridge top, and CUM1 as a small scatter of about ten mudstone flakes along a road. Site descriptions indicate that the locations provided may not be precise. For example, the location provided for CUM3 is not on a ridge top.

5.3.5.3 Webber's sites

In addition to the archaeological surveys outlined in Section 5.3.4.1, an inspection of EL5243 was undertaken by ERM in order to identify potential archaeological issues for the proposed mine extension. Results of this inspection were reported in a letter to Howick Coal (Webber 1999). Six sites were located during the inspection: three artefact scatters, two isolated artefacts and one "possible scarred tree" (two of the artefacts scatters were identified as previously recorded sites Lower Emu Creek and CUM 41):

1. HEE1, a small scatter of 2 artefacts in an eroded area of a tributary of Farrells Creek;

2. HEE2, a "possible scarred tree";

3. HEE3, a large tuff flake with backing near Emu Creek;

4. HEE4, a white chert flake located near a tributary of Emu Creek;

5. Lower Emu Creek, a large artefact scatter along Emu Creek in an area of about 250 mx30 m (estimated 40,000 artefacts on exposed area and within deposit), some artefacts "exhibited backing and retouch/usewear", raw materials included mudstone, tuff and silcrete; and

6. CUM41 a large artefact scatter along Farrells Creek in an area of about 500 mx30 m (estimated 10,000 artefacts on exposed area and within deposit), artefacts included cores and artefacts with "backing and retouch/usewear".

5.3.5.4 Other sites

Records of TD, TG and TH are not registered with NPWS and no information about these sites, other than their locations, is available. Information was provided to AMBS by CNA.

Figure 6: Previously recorded sites within the study area

6 Methodology

The process of archaeological assessment can be divided into three stages. A first stage involves developing a sampling strategy, a second stage involves conducting the survey and a third stage involves interpreting the survey results and assessing site significance. This section details the methodology used to develop the survey strategy and to conduct the survey.

6.1 Sampling strategy

Geomorphological investigation of the study area was undertaken prior to and during the archaeological survey. It involved studying topographical and geological maps and an inspection of the study area. The results of the investigation were used to devise a sampling strategy for the survey and are crucial for the interpretation of the survey results.

The geomorphological investigation divided the study area into four landform zones: main creek valleys, tributary creeks, valley side slopes and ridge crests (descriptions of landform zones and further division of the landscape are detailed in Section 7.1). The study area was further divided into survey areas each equating to one of these zones. All survey areas were surveyed on foot (pedestrian survey). Survey areas on valley side slopes were also inspected from 4WD vehicles (vehicular survey). Survey coverage in areas in main creek valleys, tributary creeks and ridge crests was 100%. Pedestrian survey coverage on valley side slopes was approximately 50%. Vehicular survey of the valley side slopes ensured that all areas of exposure (see definition below) were inspected and increased the survey coverage of this landform zone to 100%.

6.2 Field methodology

6.2.1 Effective survey coverage

Effective survey coverage was calculated following the NPWS Aboriginal Cultural Heritage Standards & Guidelines Kit. This value provides a measure of the "detectibility" of the potential archaeological material over an area. Definitions used for visibility and exposure are provide below:

Visibility: the proportion of bare ground that might reveal artefacts (i.e. ground not obscured by grass cover, leaf litter or other vegetation or sediment) within a surveyed area.

Exposure: areas in which the topsoil has been eroded or removed to reveal the subsoil or bedrock (an area of exposure may have some intact subsoil within it, however some subsoil or bedrock must be visible).

All areas of exposure were recorded, whether they contained artefacts or not.

6.2.2 Site definition and recording

The locations of all artefacts, or artefact concentrations, were recorded as Aboriginal object locations. These locations were grouped into sites based on the survey area (and therefore the landform zone) in which they occur. This approach is consistent with the study's aim of investigating variation between assemblages at a large scale, which may correspond to general patterns of landscape use.

6.2.3 Artefact identification and recording

Flaked stone artefacts have a number of diagnostic features that distinguish them from naturally occurring stone (Cotterell and Kamminga 1987). Features such as negative and positive bulbs of percussion ring cracks, ripple marks, terminations and errailure scars are all indicative of flaked stone artefacts. The criterion used in identifying flaked stone artefacts during this survey was one or more of these features.

Heat shattered fragments do not have diagnostic flake features and were identified by raw material (exotic stone that does not originate from the site and which is the same as the artefactual material) and features indicative of heat exposure (e.g. crenated surfaces, crazing). Heat shattered fragments are considered artefacts in this analysis as they derive either from flaked artefacts or material transported to the site.

Non-flaked stone artefacts, such as grindstones and anvils, were identified by the presence of pitting or abraded surfaces.

Artefacts were categorised using a technological framework (following Hiscock 2001). Raw material type, size and the proportion of cortex were also recorded. All recorded variables are listed in Table 3 below.

Table 3: Artefact attributes recorded in the field

Variable	Attribute
Artefact type	Flake (complete, proximal fragment of broken flake, other broken flake) Core Retouched flake Flaked piece Heat shatter Ground artefact
Raw material	Mudstone Silcrete Quartz Igneous Petrified wood Banded chert Fine grained siliceous Porcellanite Quartzite
Size class	10 mm size classes
Heat exposure	Yes/No
Cortex	% cortex
Notes	Notes included typological categories (e.g. backed artefact, thumbnail scraper, scraper, edge ground axe, axe/chopper), use wear, etc.

Note: definitions are provided in glossary

7 Results

7.1 Geomorphology

7.1.1 Landform Zones and Survey Areas

While the field archaeological survey was in progress Philip Hughes undertook a geomorphological investigation of the study area. In consultation with the Field Archaeologists, the study area was divided into a number of Landform Zones deemed likely to have different archaeological patterns. In carrying out the archaeological survey the study area was divided into a number of Survey Areas which equated with the Landform Zones. The larger Survey Areas were subdivided into sub-areas where this was deemed to be warranted. The location and extent of these survey areas (and landform zones) are shown in Figure 7.

The following Survey Areas and subcategories were defined, and their locations are shown on Figure 7.

Landform Zone	Survey Area
Main creek valleys	1A and 1B
Tributary creeks	2A-G
Valley side slopes facing major creeks	3Aa-e
Valley side slopes facing minor creeks	3Ba-g
Ridge crests	4A-C

Two sections of hillslope facing both major and minor creeks north of Survey Areas 1A and 2E respectively were too small to meaningfully subdivide. Only the southern one was surveyed, and the survey coverage data have been included 50% each in Survey Area 3A and 3B.

The physical characteristics of each of the Survey Areas/Landform Zones examined during the survey phase are described below.

7.1.1.1 Landform Zone 1: Main Creek Valleys

1A: Farrells Creek Valley

Landform: The valley floor of creek is on average about 100 m wide and its margins are defined by a sharp break in slope at the foot of the bedrock slopes either side. It includes the lower reaches of the small re-entrant valleys of tributary drainage lines joining the main creek from the south. Parts of the valley floor have been severely disturbed by dams and there is patchy erosion along and behind the creek banks. The valley is filled with Quaternary colluvium and alluvium on which a typical duplex soil sequence has formed, as described below. The creek channel is incised discontinuously into the fill.

Soils: On eroded areas duplex soils are exposed. These have brownish silty fine sand topsoils (Unit A) 50 mm to 100 mm thick unconformably overlying weathered mottled reddish sandy clays, probably of Pleistocene age (Unit B). The topsoils are very stone-free and the subsoils have a very low stone content.

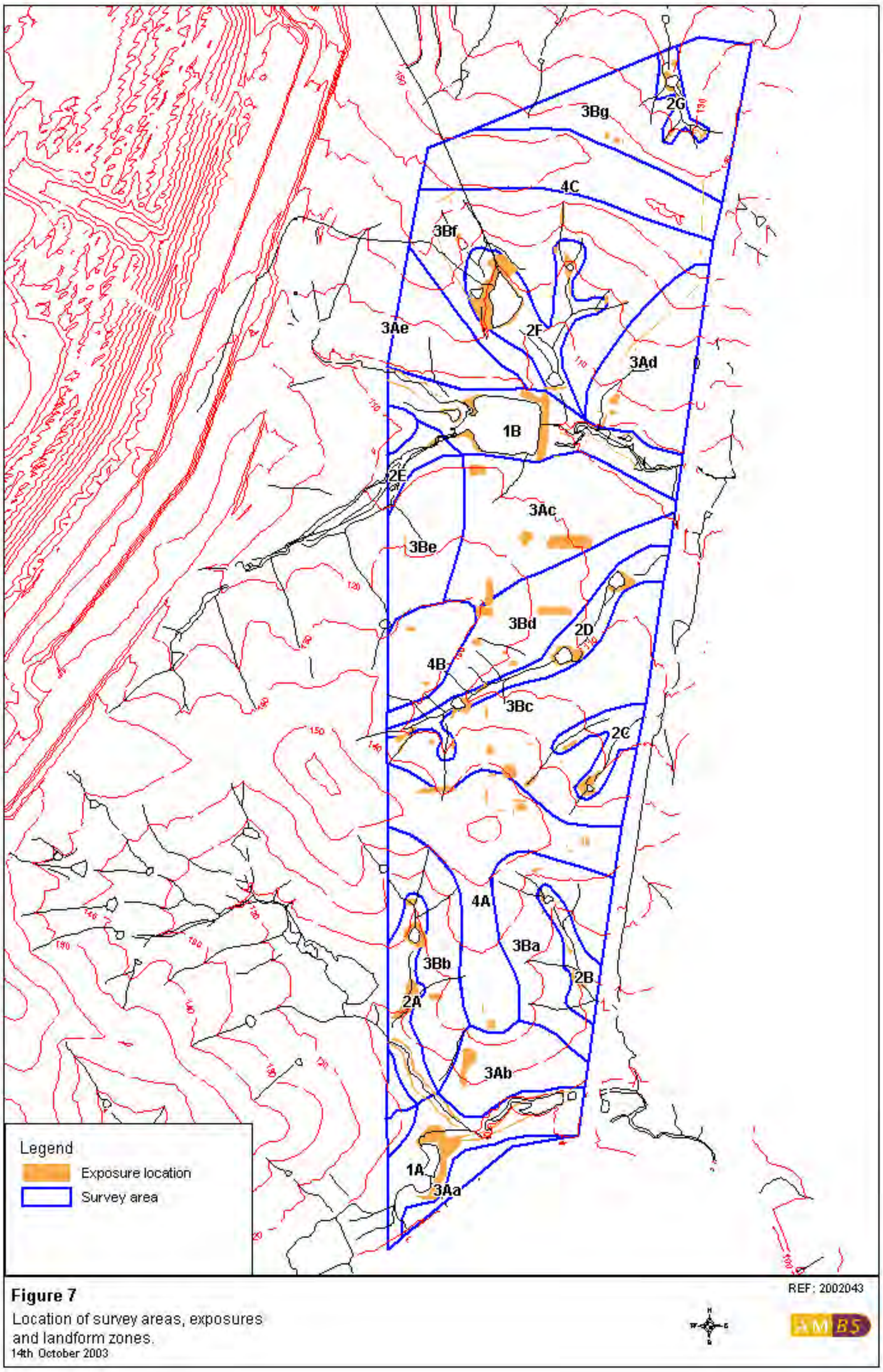

Figure 7: Location of survey areas, exposures and landform zones

1B: Emu Creek Valley

Landform: The valley floor of creek is on average about 100 m wide and its margins are defined by a sharp break in slope at the foot of the bedrock slopes either side. Parts of the valley floor have been severely disturbed by dams, especially at the western end, and there is extensive erosion along and behind the creek banks. The valley is filled with Quaternary colluvium and alluvium on which a typical duplex soil sequence has formed, as described below. Downstream of the dams, the creek channel is incised continuously into the fill. The incision deepens downstream and for its easternmost 150 m or so it forms a gully up to 2.5 m deep with a dendritic network of erosion rills and small gullies along its steep banks.

Soils: On eroded areas duplex soils are exposed. Like along Farrells Creek, these have brownish silty fine sand topsoils (Unit A) on average 100 mm to 150 mm thick unconformably overlying weathered mottled reddish sandy clays, probably of Pleistocene age (Unit B). Both the topsoils and the subsoils have small amounts of gravel throughout.

7.1.1.2 Landform Zone 2: Tributary Creek Valleys

Landform: Seven such tributary creek valleys were defined. They generally had narrow valley floors (less than 20 m wide) which sloped upwards away from the centreline at less than 3^{o}. The channels between dams were generally discontinuous. The edges of the valley were most often marked by an abrupt break in slope but in the case of the larger tributaries they were sometimes U-shaped. In such cases the edge of the valley was defined as a level no more than 5 m above the valley centre line.

Soils: Downstream of some of the dams the valley floors were mantled with thin layers of modern sediment, beneath which the original soils could not be observed. Elsewhere in eroded exposure sequences of duplex soils on thin stony colluvium (usually less than 1 m) were revealed. The sandy topsoils were usually less than 150 mm thick. Bedrock was sometime exposed in the channel beds, but rarely away from the channels on the valley floor.

7.1.1.3 Landform Zone 3: Valley Side Slopes

Landforms and geology: The slopes range from moderately steep (especially in the south) to gentle. Cobbles derived from the weathering of the local sandstone crop out widely and on many slopes (including some gentle slopes) there are flat outcrops of massive quartzose sandstone and conglomeratic sandstone.

Soil: The topsoils are generally thin (less than 50 mm, grayish, sandy and stony). Where there are eroded exposures weathered mottled sandy clay subsoils 200-400 mm thick overlying sandstone were sometimes seen. On some of the footslopes poorly developed duplex soils on very stony colluvium was observed. At one point along the north side of Emu Creek rock duplex soils were seen to lens out upslope from a soil sequence more than 1.5 m thick on the valley floor to bedrock outcrop 40 m away from and 4 m above the floor of the valley. The soil material became increasingly stony upslope, especially in the B horizon.

7.1.1.4 Landform Zone 4: Ridge Crests

Flat to slightly undulating landsurfaces with a marked break of slope around their margins. The geology and soils are the same as for the mid and upper slopes of Landform Zone 3.

7.1.2 Potential for stratified/dateable archaeological sites

The potential for stratified/dateable archaeological sites, especially of early Holocene to late Pleistocene age, is negligible.

On the ridge crests and the valley side slopes which comprise most of the study area the thickness of soil which might contain archaeological materials is generally no more than about 50 mm thick. These soils have virtually no potential to contain stratified/dateable archaeological sites.

Elsewhere duplex soils have formed on colluvium/alluvium along creek lines and the adjacent footslopes. The ‘A horizons’ (referred to by Hughes as Unit A) are commonly 50 mm to 150 mm thick. For the same reasons argued by Hughes for duplex soils at Warkworth West (AMBS 2002: 19-23), the potential for the duplex soils at West Pit to contain stratified/dateable archaeological sites, especially of early Holocene to late Pleistocene age, is negligible. In summary, these arguments are as follows:

Following on from the work of Mitchell and his colleagues on the origin of hillslope duplex soils in the Sydney Basin, Dean-Jones and Mitchell (1993: Section 4.1) considered that in the Hunter region duplex or texture contrast soils are the result of superposition of two unlike materials through the action of contemporary lateral movement of sediments down the slope. Fluvial hillslope processes create the discontinuity present between the A and B horizons which are in effect two distinct strata, which are time transgressive rather than genetic soil horizons.

Their research has demonstrated the importance of rainsplash (raindrop agitated surface flow) as the main sediment transport mechanism operating on slopes. However this alone is not enough to generate a texture contrast and such profiles only develop where slope transport combines with rapid rates of shallow bioturbation (especially by ants, termites and earthworms). Combined, these processes allow the winnowing of the fine fraction of the surface soil, which is then carried downslope as suspended sediment in the rainwash, thus effectively coarsening the A horizon relative to the B horizon (see also Humphreys and Mitchell 1983). These processes commonly lead to the formation of stone layers or lines between the A and B horizons, as stones larger than the diameters of the burrows of the bioturbating organisms ‘sink’ through the soil with time.

Dean-Jones and Mitchell (1993: Section 4.1.3) concluded that if the genesis model for duplex soils they outlined was accepted, the critical implications for archaeology were:

Duplex soils (presumably especially the A horizons) do not necessarily indicate great age. ‘Mature’ texture-contrast profiles can develop in a few centuries and they consider (1993: 76) that A horizon materials in duplex soils in the region are probably between 200 and 3,000 years old, rather than 20,000 to 30,000 years old.

Open sites on duplex soils can never be truly stratified in a chronologically useful sense.

Stone artefacts will behave in the same way as natural stones on a hillslope and will be subjected to surface dispersion, downslope movement and differential burial or exposure by bioturbation. They may become incorporated into stone lines.

Intact or relatively undisturbed hearths provide the best prospects for dating open sites in these contexts. All other dates, especially those based on detrital charcoal, are likely to be spurious.

The questions arises, 'what archaeological signature may remain in these duplex soils? Hughes considers that most if not all B horizon materials in these duplex soils have no or negligible archaeological potential, if only because of their inferred early age. It is likely that from the beginning of occupation of the Hunter region artefacts would have been discarded on to A horizon soils essentially the same as those that occur today. Any stone artefacts of late Pleistocene to early Holocene age which were not completely transported from the slopes would have been left as a lag at or just above the junction between the A and B horizons. These would then have become incorporated in the basal levels of present A horizons, which are probably mid to late Holocene in age.

It follows that unless the A horizons are thick (at least 300 mm) and incorporate *in situ* older, dateable deposits in their basal levels, it will not be possible stratigraphically to distinguish older artefact assemblages from mid to late Holocene assemblages. In thin A horizons it is likely to be difficult to distinguish with certainty using artefact typology any early assemblages which might be present.

7.2 Survey coverage

The archaeological survey was conducted over a period of five days during December 2002. The survey achieved 100% coverage of the study area. The effective coverage was calculated as 1.6%. Table 4 details survey coverage for each survey area and landform zone and location of exposures are shown in Figure 7. Details of visibility and exposure used to calculate survey coverage within each area is provided in Appendix A.

Table 4: Survey coverage

Survey Area/Landform Zone	Area (sq m)	Effective coverage (sq m)	% of survey area
1. Main Creek Valleys			
1A	91,660	7,408	8.1
1B	121,600	7,667	6.3
Sub-total Main Creek Valleys	**213,260**	**15,075**	**7.1**
2. Tributaries			
2A	47,480	2,626	5.5
2B	26,140	1,298	5.0
2C	29,590	165	0.6
2D	113,200	3,398	3.0
2E	19,330	116	0.6
2F	78,670	1,069	1.4
2G	17,310	1,037	6.0
Sub-total Tributaries	**331,720**	**9,709**	**2.9**
3A. Slopes facing Major Creeks			
3Aa	20,770	0	0.0
3Ab	80,210	660	0.8
3Ac	167,000	2,457	1.4
3Ad	111,100	1,460	1.3
3Ae	71,650	0	0.0
Sub-total Slopes facing Major Creeks	**450,730**	**4,577**	**1.0**
3B. Slopes Facing Minor Creeks			
3Ba	113,900	197	0.2
3Bb	100,026	402	0.4
3Bc	211,800	2,161	1.0
3Bd	113,200	2,061	1.8
3Be	80,430	141	0.2
3Bf	241,000	1,173	0.5
3Bg	147,200	424	0.3
Sub-total Slopes Facing Minor Creeks	**1,007,556**	**6,559**	**0.7**
(3A and 3B. All slopes)	**(1,458,286)**	**(11,136)**	**(0.8)**
4. Ridge Crests			
4A	178,700	2,504	1.4
4B	52,680	432	0.8
4C	132,600	173	0.1
Sub-total Ridge Crests	**363,980**	**3,109**	**0.9**
TOTAL	**2,367,246**	**39,029**	**1.6**

7.3 Aboriginal objects and sites

A total of 979 artefacts was recorded during the survey. Artefacts occur in 36 discrete areas or locations, referred to here as locations of Aboriginal objects (Table 5). Most locations are represented by single artefacts. All locations (with one exception, location 15) are within areas of exposure. In a number of cases (e.g. along Emu

Creek and Farrells Creek) locations of Aboriginal objects are equivalent to areas of exposure.

These locations of Aboriginal objects were subsequently aggregated into larger areas defined as sites for the purpose of description and interpretation. All locations fall within eleven survey areas, which equate to eleven sites (WPE1 – 11). These sites are described below (see also Table 6, Figure 8). A complete list of site contents (detailing all recorded artefacts) is provided in Appendix B.

Table 5: Locations of Aboriginal objects

Location #	Landform zone	Survey area	Easting	Northing	Area	Artefact count
1	Tributary creeks	2A	310352	6407084		1
2	Tributary creeks	2A	310367	6406971	270	18
3	Valley side slopes	3Bc	310645	6407892		1
4	Valley side slopes	3Ab	310744	6407138	150	17
5	Valley side slopes	3Ab	310501	6407003	1	2
6	Valley side slopes	3Ab	310513	6407069	4	5
7	Valley side slopes	3Ab	310502	6407093	1	3
8	Valley side slopes	3Bc	310558	6407951		1
9	Ridge crests	4A	310643	6470810		1
10	Ridge crests	4A	310532	6470322		1
11	Ridge crests	4A	310549	6407203		1
12	Ridge crests	4A	310785	6407675		1
13	Ridge crests	4A	310795	6407665		1
14	Ridge crests	4A	310595	6407775	1	2
15	Valley side slopes	3Ab	310569	6406960		1
16	Valley side slopes	3Bc	310671	6407860	40	4
17a	Main creek valleys	1B			1,660	133
17b	Main creek valleys	1B			4,973	131
17c	Main creek valleys	1B			6,197	146
18	Valley side slopes	3Ac	310737	6408791	8	4
19	Valley side slopes	3Bc	310441	6408036	36	7
20	Valley side slopes	3Ac	310710	6408550	4	3
21	Valley side slopes	3Ac	310457	6408400		1
22	Valley side slopes	3Bc	310688	6408345	1	2
23	Valley side slopes	3Bc	310395	6407970		1
24	Tributary creeks	2D	310430	6407930		1
25	Valley side slopes	3Ac	310510	6408750		1
26	Valley side slopes	3Ac	310550	6408775	25	3
27	Valley side slopes	3Bc	310619	6408199		3
28	Valley side slopes	3Ad	310872	6408906	4	12
29	Valley side slopes	3Ad	310853	6408919	52	10
30	Main creek valleys	1A			14,293	437
31	Valley side slopes	3Ad	310905	6408962	74	3
32	Valley side slopes	3Ad	310934	6409044		1
33	Valley side slopes	3Ad	310891	6408921	100	17
34	Tributary creeks	2G	311035	6409719	8	1
35	Tributary creeks	2G	311141	6409733		1
36	Valley side slopes	3Ad	310907	6409059		1

Table 6: Site descriptions

Site #	Site type	Landform	Boundary Definition*	Location of Ab. object	Area m^2	Vis %	Exp %	Artefacts recorded
WPE 1	Artefact scatter	Major creek	1A	30	91,660	10.6	11.7	437
WPE 2	Artefact scatter	Major creek	1B	17a, 17b, 17c	121,600	6.8	9.2	410
WPE 3	Artefact scatter	Tributary	2A	1, 2	47,480	7.7	11.9	19
WPE 4	Artefact scatter	Tributary	2D	24	19,330	4.0	6.0	1
WPE 5	Artefact scatter	Tributary	2G	34, 35	17,310	6.8	15.1	2
WPE 6	Artefact scatter	Slope	3Ab	4, 5, 6, 7, 15	80,210	0.9	3.6	28
WPE 7	Artefact scatter	Slope	3Ac	18, 20, 21, 25, 26	175,255	2.6	5.1	12
WPE 8	Artefact scatter	Slope	3Ad	28, 29, 31, 32, 33, 36	111,100	2.0	2.5	44
WPE 9	Artefact scatter	Slope	3Bc	3, 8, 16, 19, 23	211,800	1.3	1.8	14
WPE 10	Artefact scatter	Slope	3Bd	22, 27	113,200	2.4	3.3	5
WPE 11	Artefact scatter	Ridge crest	4A	9, 10, 11, 12, 13, 14	178,700	1.7	2.4	7

Note: see appendix A for full details of sites content

7.3.1 Site WPE 1 – Farrells Creek (Survey Area 1A)

This site is an artefact scatter extending along Farrells Creek where this creek passes through the study area (Plate 1). The site has been disturbed by gully erosion and erosion associated with the creek, by dam construction in the east and west of the site, and by cattle erosion. A total of 437 artefacts was recorded (Table 7). Artefacts include flakes, cores, retouched flakes (including backed artefacts, a thumbnail scraper) and an edge ground axe (Plate 2). Most artefacts are concentrated around the periphery of the western dam and in an area south west of this dam, however artefacts occur in all areas of exposure. The average artefact density within these (exposed) areas is 0.38 artefacts/m^{2}. A number of knapping floors within the site were identified (defined here as concentrations of artefacts derived from the same material/core(s), at least some of which can be refitted/conjoined). Unit A of duplex soils at the site is relatively shallow, approximately 50 mm to 100 mm in depth (Plate 2). The potential for artefact concentrations to occur within Unit A of these soils is high. Artefact densities are likely to be greatest near the western dam.

Table 7: WPE 1 artefacts

	Raw material					
Type	**Mudstone**	**Silcrete**	**Quartz**	**Igneous**	**Other***	**Total**
Flake			10	1	10	338
Complete flake	*150*	*30*	*6*	*1*	*6*	
Br. flake (prox.)	*43*	*16*	*3*			
Br. flake (other)	*49*	*30*	*1*		*3*	
Flaked piece	12	5			*2*	29
Core	13	7	2		1	23
Retouched flake	12	5		1	1	19
Backed artefact	*4*	*2*				
Thumbnail					*1*	
Scraper	*1*	*2*		*1*		
Core/Ground				1		1
Edge ground axe				*1*		
Heat Shatter	11	15			1	27
Total	294	110	14	3	19	437

* Other includes petrified wood, banded chert, fine grained siliceous, porcellanite and quartzite

7.3.2 Site WPE 2 – Emu Creek (Survey Area 1B)

This site is an artefact scatter extending along Emu Creek where this creek passes through the study area (Plate 3). The scatter continues to the west of the study area boundary and presumably east of the Belt Line Road. The site has been disturbed by gully erosion and erosion associated with the creek, by dam construction, and cattle erosion. Artefacts occur in all exposures along the creek. A dam wall and a mound to the north east of the wall, probably made during dam construction, was recorded as a single large exposure. These features were almost certainly made with the creek line deposit (from the area where the dam is located) therefore artefacts recorded here may have been displaced up to 200 metres. A total of 410 artefacts was recorded (Table 8). Artefacts include flakes, cores, retouched flakes, and two flaked axes or choppers (Plate 4). The average artefact density within areas of exposure is 0.54 artefacts/m^2 Unit A of duplex soils at the site is relatively shallow, approximately 100 mm to 150 mm in depth (Plate 5). The potential for artefact concentrations to occur within Unit A of these soils is high.

Table 8: WPE 2 artefacts

	Raw material					
Type	**Mudstone**	**Silcrete**	**Quartz**	**Igneous**	**Other**	**Total**
Flake	149	48	8	3	6	214
Complete	*89*	*23*	*3*	*3*	*2*	
Br. flake (prox.)	*17*	*9*	*1*		*1*	
Br. flake (other)	*43*	*16*	*4*		*3*	
Core	5	4	1	2	2	14
Axe/Chopper				*2*		
Retouched flake	5					5
Flaked piece	8	4	5	1		18
Heat shatter	10	2				12
Total	177	58	14	6	8	263

Notes: artefacts recorded on dam wall and associated mound were counted only and are not included in this table; other include petrified wood, banded chert, fine grained siliceous and porcellanite.

7.3.3 Site WPE 3 (Survey Area 2A)

This site is a sparse artefact scatter located on tributary of Farrells Creek (Plate 6). Most artefacts recorded (18 of 19) occur in a relatively small area near Emu Creek. Artefacts include flakes and retouched flakes (Table 9). A large mudstone core at this site has been ground along one edge (Plate 7). There is some potential for artefacts to occur within the Unit A of duplex soils (which is less than 50 mm in depth at this location), however artefact densities are likely to be low.

Table 9: WPE 3 artefacts

	Raw material				
Type	**Mudstone**	**Silcrete**	**Igneous**	**Quartz**	**Total**
Flake	5	5	1	2	13
Complete flake	*5*	*2*	*1*		
Br. flake (prox.)		*1*		*1*	
Br. flake (other)		*2*		*1*	
Axe flake			*1*		
Core/Ground	1				1
Retouched flake	1				1
Scraper	*1*				
Flaked piece		1			1
Heat shatter	2	1			3
Total	9	7	1	2	19

7.3.4 Site WPE 4 (Survey Area 2D)

Site WPE 4 is a sparse artefact scatter located on a tributary of Emu Creek (Plate 8). A single silcrete flake was recorded at a small arm of the tributary in the south west part of the site. Webber (1999) recorded a single flake about 400 m further down the tributary at this site.

7.3.5 Site WPE 5 (Survey Area 2G)

Site WPE 5 is a sparse artefact scatter located on a tributary of Davis Creek at the extreme northern end of the study area (Plate 9). Two artefacts, a broken mudstone flake and a large retouched flake, were recorded near the upper reaches of this tributary.

7.3.6 Site WPE 6 (Survey Area 3Ab)

Site WPE 6 is a sparse artefact scatter located on a valley side slope facing Farrells Creek (Plate 10). A total of 28 artefacts was recorded at this site. Most of these (17) are located within a small exposure in the north east of the site. Other artefacts were more dispersed and were recorded in the west of the site, where the slope faces both Farrells Creek and a northern tributary. Details of artefacts recorded are provided in Table 10.

Table 10: WPE 6 artefacts

	Raw material			
Type	**Mudstone**	**Silcrete**	**FGS**	**Total**
Flake				13
Complete flake	*6*			
Br. flake (prox.)	*1*		*1*	
Br. flake (other)	*5*			
Core	2	1		3
Retouched flake	1			1
Flaked piece	2			2
Heat shatter	4	5		9
Total	21	6	1	28

7.3.7 Site WPE 7 (Survey Area 3Ac)

Site WPE 7 is a sparse artefact scatter located on a valley side slope facing Emu Creek (Plate 11). A total of 12 artefacts was recorded at this site (Table 11).

Table 11: WPE 7 artefacts

	Raw material					
Type	**Igneous**	**Mudstone**	**Porcellanite**	**Quartz**	**Silcrete**	**Total**
Flake		4	1	1	3	9
Complete flake		*3*		*1*	*2*	
Br. flake (other)		*1*	*1*			
Br. flake (prox.)					*1*	
Core	1					1
Flaked piece		1		1		2
Total	1	5	1	2	3	12

7.3.8 Site WPE 8 (Survey Area 3Ad)

Site WPE 8 is a sparse artefact scatter located on a valley side slope facing Emu Creek (Plate 12). A total of 44 artefacts was recorded (Table 12). Most artefacts occurred on a series of exposures in the south of the site near Emu Creek. Artefacts recorded include two backed artefacts and one large fragment of an edge ground axe.

Table 12: WPE 8 artefacts

	Raw material				
Type	**Mudstone**	**Silcrete**	**Quartz**	**Igneous**	**Total**
Flake	21	7	4	1	33
Complete flake	*14*	*5*	*2*		
Br. flake (prox.)	*3*	*1*	*2*		
Br. flake (other)	*4*	*1*		*1*	
Flaked piece	3		1		4
Retouched flake	2	2			4
Backed artefact	*1*	*1*			
Ground				1	1
Edge ground axe				*1*	
Heat shatter	1	1			2
Total	27	10	5	2	44

7.3.9 Site WPE 9 (Survey Area 3Bc)

Site WPE 9 is a sparse artefact scatter located on a valley slope facing a tributary of Emu Creek (Plate 13). A total of 14 artefacts was recorded (Table 13). These artefacts occur in the south west of the site either close to the tributary creek or near the ridge crest to the south.

Table 13: WPE 9 artefacts

	Raw material			
Type	**Silcrete**	**Mudstone**	**Petrified wood**	**Total**
Flake	5	2	1	7
Complete flake	*3*			
Br. flake (other)	*2*	*1*	*1*	
Br. flake (prox.)		*1*		
Flaked piece		2	2	4
Heat shatter	1	1		2
Total	6	5	3	14

7.3.10 Site WPE 10 (Survey Area 3Bd)

Site WPE 10 is a sparse artefact scatter located on a valley slope facing a minor tributary of Emu Creek (Plate 14). A total of 5 artefacts was recorded in 2 exposures, one in the centre of the site, the other close to the minor tributary (Table 14).

Table 14: WPE 10 artefacts

	Raw material			
Type	**Mudstone**	**Silcrete**	**Quartzite**	**Total**
Flake	2		1	
Complete flake	*2*		*1*	*3*
Flaked piece	1	1		2
Total	3	1	1	5

7.3.11 Site WPE 11 (Survey Area 4A)

Site WPE 11 is a sparse artefact scatter on the ridge crest north of Farrells Creek (Plate 15). A total of seven artefacts was recorded on six areas of exposure (Table 15).

Table 15: WPE 11 artefacts

	Raw material			
Type	**Mudstone**	**Quartz**	**Silcrete**	**Total**
Flake	3			3
Complete flake	*1*			
Br. flake (other)	*2*			
Core	2		1	3
Flaked piece		1		1
Total	5	1	1	7

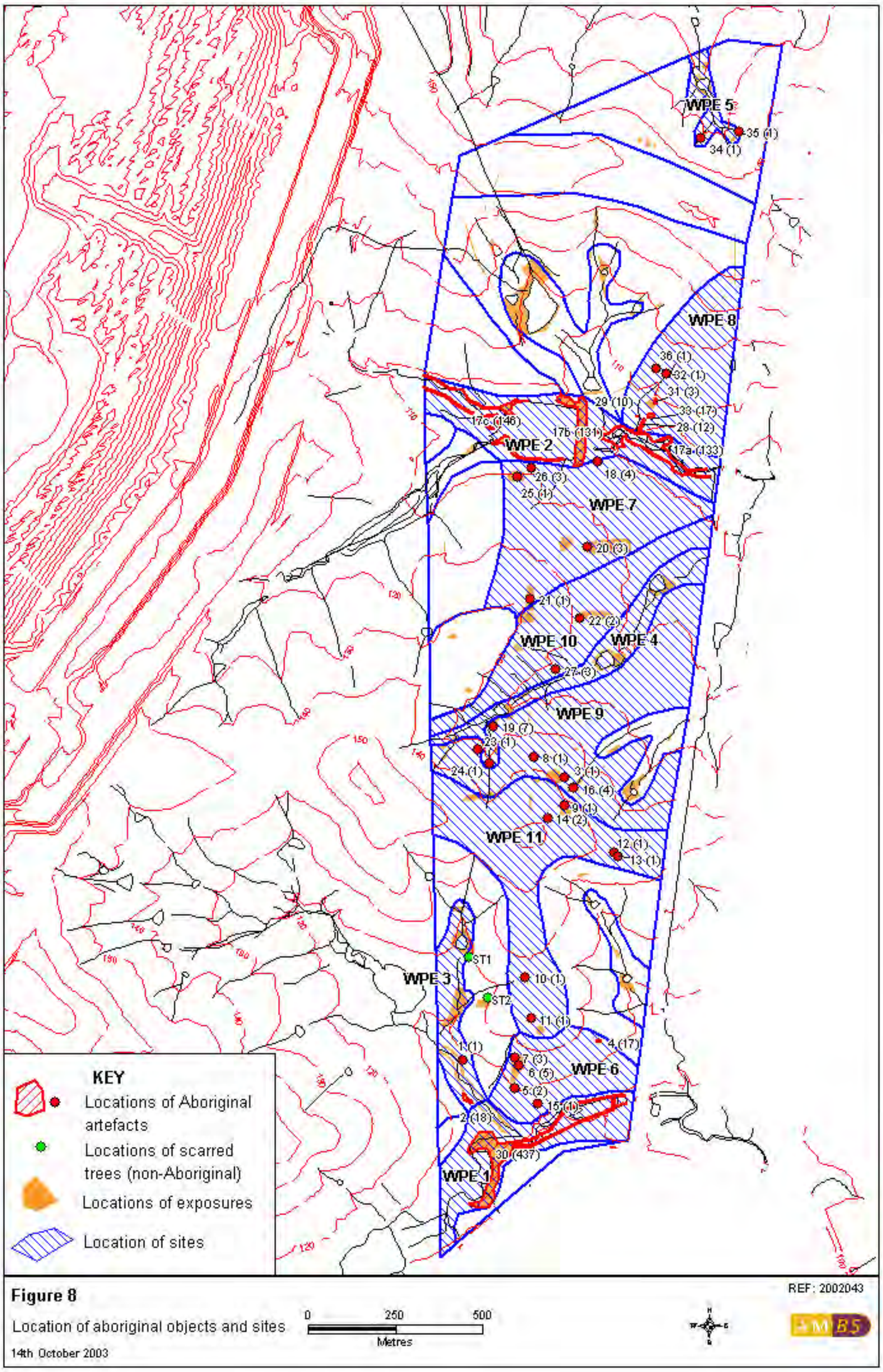

Figure 8: Location of Aboriginal objects and sites

7.3.12 Scarred trees

Two trees with deep scars were recorded during the survey. One of these is the "possible scarred tree" previously recorded by Webber (1999), ST1; the other is a nearby tree about 100 metres south, ST2. Both trees are located in survey area 2Bb. Pastoralists probably scarred the trees, neither is considered to be an Aboriginal scarred tree.

ST1 is a healthy Ironbark with dbh approximately 0.70 metres. The scar is small (approximately 650 mm long and 320 mm wide with the area of dead wood that remains exposed 420 mm by 80 mm) and situated about 490 mm from the ground surface. Regrowth appears to be relatively recent, as it is not deep and sap is present around its periphery. There is a steel axe cut in the dead wood of the scar. This cut is partly obscured by regrowth (Plate 16).

ST2 is an Ironbark with dbh approximately 1.20 metres. The scar is situated approximately 200 mm from the ground surface on a larger area of dead wood. It is irregular in shape, approximately 500 mm long and 300 mm wide. Regrowth associated with this scar is dead and about 70 mm thick. A steel axe cut in the centre of the scar is partly obscured by regrowth (Plate 17).

Neither scar is considered to be Aboriginal in origin. The scar on ST1 appears to be quite recent. The scar on ST2 is very low to the ground and irregular in shape, which is not typical of scars made by Aboriginal people.

8 Discussion

The survey results clearly indicate that the archaeology within the study area is typical of the archaeology of the Central Lowlands. Most archaeological material is located along the creek lines with the remaining material dispersed across the landscape. This section focuses on characterising this pattern of artefact distribution and the nature of the stone artefact assemblage in more detail by comparing the assemblages from different landform zones. It also aims to use the survey results as a test of the model outlined in Section 5.3.3.

8.1 Variation between Landform Zones

8.1.1 Artefact density

Most archaeological material in the study area (87%) occurs within the main creek valleys of Farrells Creek and Emu Creek. This pattern is not simply the result of erosion and disturbance associated with the creek lines - when visibility and exposure are taken into account the results indicate much higher artefact densities in the main creek valleys than in other landform zones (Table 16). The next highest densities were on valley side slopes facing these two major creeks. Further analyses of the results also indicate that different types of behaviour occurred within different landform zones.

Table 16: Artefact densities

Landform zone	Effective survey coverage (sq m)	Number of artefacts	Artefact density (artefacts/hectare)
Main creek valleys	15,075	701	465
Farrells	*7,408*	*437*	*590*
Emu	*7,667*	*410*	*535*
Tributary creeks	9,709	22	23
Valley side slopes	11,136	103	93
Facing major creeks	*4,577*	*84*	*184*
Facing minor creeks	*6,559*	*19*	*29*
Ridge crests	3,109	7	23

8.1.2 Artefact distribution

While calculated artefact densities suggest that creek lines, and to a lesser extent their associated valley side slopes, were more intensively used than other landform zones, the location of artefacts and densities within specific areas suggest different types of occupation. The sites along creek lines are large artefact scatters with some areas of quite high artefact density. Sites on slopes, ridge crests and minor tributaries are generally very sparse scatters across large areas (typically sites of this type have been recorded in other studies as series of isolated finds). This spatial patterning suggests creek lines were the focus of prolonged activity – used as areas for stone tool production and camping, and that other areas were not used intensively - or at least not as a focus for activities that involved stone tool production.

There are a number of exceptions to this pattern. Aboriginal object locations 2 and 4, north of Farrells Creek, and a cluster of locations north of Emu Creek (28, 29 and 33) each represent locations of relatively discrete artefact concentration of 10 or more artefacts. These concentrations all occur quite close to creek lines and may be associated with occupation at creek line sites.

8.1.3 Artefact types and raw material

Other aspects of the assemblages from the different landform zones also have the potential to indicate different activities and patterns of occupation. Tables 17, 18 and 19 show proportions of artefact types and raw material within assemblages from the different landform zones, subdivisions of valleys side slopes and from Farrells Creek and Emu Creek.

Table 17: Artefact types recorded within Landform Zones

	Landform Zone									
Type	**1**		**2**		**3**		**4**		**Total**	
Complete flake	313	45%	9	41%	39	38%	1	14%	362	43%
Broken flake (proximal)	90	13%	2	9%	10	10%		0%	102	12%
Broken flake (other)	149	21%	4	18%	17	17%	2	29%	172	21%
Core	37	5%		0%	4	4%	3	43%	44	5%
Retouched flake	24	3%	2	9%	5	5%		0%	31	4%
Core/Ground	1	0%	1	5%		0%		0%	2	0%
Flaked piece	48	7%	1	5%	14	14%	1	14%	64	8%
Ground		0%		0%	1	1%		0%	1	0%
Heat shatter	39	6%	3	14%	13	13%		0%	55	7%
Total	701	100%	22	100%	103	100%	7	100%	833	100%

Table 18: Raw material recorded within Landform Zones

	Landform Zone									
Raw material	**1**		**2**		**3**		**4**		**Total**	
Mudstone	472	67%	11	50%	61	59%	5	71%	549	66%
Silcrete	168	24%	8	36%	26	25%	1	14%	203	24%
Quartz	28	4%	2	9%	7	7%	1	14%	38	5%
Igneous	6	1%	1	5%	1	1%		0%	8	1%
Banded chert	7	1%		0%		0%		0%	7	1%
Black tuff	3	0%		0%	2	2%		0%	5	1%
Chert	1	0%		0%		0%		0%	1	0%
FGS	9	1%		0%	1	1%		0%	10	1%
Porcellanite	2	0%		0%	1	1%		0%	3	0%
Petrified wood	3	0%		0%	3	3%		0%	6	1%
Quartzite	2	0%		0%	1	1%		0%	3	0%
Total	701	100%	22	100%	103	100%	7	100%	833	100%

Table 19: Artefact types recorded within Landform Zones 1 and 3

	Landform Zone			
Type	**1A**	**1B**	**3A**	**3B**
Complete flake	44%	45%	39%	32%
Broken flake (proximal)	14%	11%	11%	5%
Broken flake (other)	19%	25%	15%	21%
Core	5%	5%	5%	0%
Retouched flake	4%	2%	6%	0%
Core/Ground	0%	0%	0%	0%
Flaked piece	7%	7%	10%	32%
Ground	0%	0%	1%	0%
Heat shatter	6%	5%	13%	11%
Sample size	437	264	84	19

Table 20: Artefact types and raw material recorded within Landform Zones

	Landform Zone			
Raw material	**1A**	**1B**	**3A**	**3B**
Mudstone	67%	67%	63%	42%
Silcrete	25%	22%	23%	37%
Quartz	3%	5%	8%	0%
Igneous	1%	1%	1%	0%
Banded chert	2%	0%	0%	0%
Black tuff	0%	1%	2%	0%
Chert	0%	0%	0%	0%
FGS	1%	2%	1%	0%
Porcellanite	0%	0%	1%	0%
Petrified wood	0%	0%	0%	16%
Quartzite	0%	0%	0%	5%
Sample size	437	264	84	19

Differences in the assemblages are difficult to interpret mainly because of the small size of assemblages from Landform Zone 2 (tributary creeks), Landform Zone 3B (valley side slopes facing minor creeks) and Landform Zone 4 (ridge crests). There is a high proportion of retouched flakes on tributary creeks and high proportion of cores on ridge crests, but only 22, 19 and 7 artefacts respectively were recorded in these landform zones. The composition of assemblages from main creek valleys and valley side slopes, both in terms of artefact types and raw material are very similar. There are some differences between assemblages from subdivisions of Landform Zone 3 (valley side slopes). The assemblage from valley side slopes facing major creeks is more diverse, in terms of artefact types and raw material, than the assemblage from valley side slopes facing minor tributaries. But again, only a small total of artefacts was recorded on the slopes facing minor tributaries

Because of the small sample size of archaeological information from several of the landform zones (specifically the tributary creeks (2), valley side slopes facing minor creeks (3B) and ridge crests (4)), it has not proved possible to differentiate with any confidence between the artefact types and raw materials in these three different zones, nor to compare them with the other zones where the sample size is larger. All that can be said is that as a group the low densities of artefacts in Landform Zones 2, 3B and 4 probably reflects relatively less use of these areas, rather than any different type of use.

8.1.4 Artefact size

The size of artefacts from different landform zones do vary (Table 21). Artefacts recorded on ridge crests and along tributaries are on average larger than artefacts recorded in other landform zones. Artefacts along major creek valleys and slopes are similar in size. This result is unexpected given that the creek lines are the focus of activity and stone tool production and should therefore contain assemblages with a high proportion of small artefacts. The most likely explanation for this result is that a large proportion of the assemblage from the valley side slopes derive from a number of locations near creek lines – these artefacts may represent tool production and be associated with occupation of the creek line (see Section 8.1.2). It is also possible that the small component of assemblages from the main creek valleys was not detected, either because it was obscured by sediment or because it has been washed down stream.

Table 21: Size of artefacts

	Landform Zone				
Size class (cm)	**1**	**2**	**3**	**4**	**Total**
0-1	4%	0%	5%	0%	4%
1-2	23%	5%	30%	29%	24%
2-3	33%	41%	33%	14%	33%
3-4	20%	0%	15%	0%	18%
4-5	12%	36%	10%	0%	12%
5-6	4%	9%	3%	0%	4%
6-7	2%	0%	2%	0%	2%
7-8	1%	5%	1%	29%	1%
8-9	0%	5%	1%	0%	0%
9-10	0%	0%	0%	14%	0%
10-11	0%	0%	0%	0%	0%
11-12	0%	0%	1%	0%	0%
14-15	0%	0%	0%	0%	0%
no information	1%	0%	0%	14%	1%
Sample size	701	22	103	7	833

8.2 Testing the model

The results of the survey provide some support for the archaeological model (detailed in Section 5.3.3). The model proposes that archaeological material can be explained by sequential positioning of foraging radii along creek valleys over several millennia. This pattern of settlement and mobility would result in a continuous archaeological distribution close to creeks, reflecting domestic and maintenance activities in a residential base context. On upper slopes and ridgelines and areas away from creek lines archaeological material will reflect resource gathering activity locations. As discussed above (Section 8.1) survey results strongly suggest that major creek lines were the focus of activity and of prolonged occupation and other landform zones may predominantly reflect transitory movement over the landscape and possibly short-term activity locations.

The model also makes a number of predictions that might distinguish between residential base camps from other short term activity locations.

8.2.1 Evidence of extended periods of occupation

The model predicts that creek line sites will reflect residential sites or base camps and will therefore contain some evidence of prolonged periods of occupation. This evidence may come in a number of forms. Site diversity may indicate the variety of activity types that occurred at a site. It is expected that base camps will be the sites of a wide variety of activities whereas resource gathering activity locations will be sites of only one activity. Diversity of creek line sites therefore will be higher than sites in other landform zones.

The results do indicate greater diversity at creek line sites. Table 22 provides counts of raw material types and artefact types in different landform zones (a simple measure of site diversity). Sites along major creek lines are more diverse, but (as discussed in Section 8.1) this could simply be a consequence of relatively small number of artefacts recorded in other landform zones.

Table 22: Counts of raw material types and artefact types

	Landform Zone							
Count	**1**	**2**	**3**	**4**	**1A**	**1B**	**3A**	**3B**
Raw material	11	4	9	3	9	9	7	4
Type	8	5	5	2	7	4	5	1
Artefacts	701	22	103	7	437	264	84	19

Extended occupation may also be indicated by particular artefact types and archaeological features within sites, such as grindstones, mullers, hearths and heat treatment pits. None of these artefacts or features were found along the major creek lines or anywhere else in the study area.

The survey results do not provide strong evidence of long term occupation within any of the survey areas. Artefact densities and the pattern of artefact distribution do suggest the main creek valleys were more intensively used than other landform zones and may represent short term base camps or "camping by small parties" (Table 1). Both Farrells Creek and Emu Creek are ephemeral and it is possible that they were rarely suited to prolonged periods of occupation. Sites along Bayswater Creek (about three kilometres east of the study area), and the Hunter River (about 4 kilometres south of the study area) may have been preferred, as they were more likely to provide a reliable water supply and other associated resources.

8.2.2 Usewear

The model predicts that sites away from creek lines will contain a higher proportion of used and retouched artefacts than sites in the main creek valleys. Individuals may have opted to carry a number of stone tools during hunting and gathering forays into the landscape rather than manufacture tools at task locations, therefore a high number of used tools should be recovered from these low density and dispersed assemblages. The survey results do indicate that a higher proportion of artefacts in the minor tributaries is used (9.1%) than the proportion of artefacts in the main creek valleys (1.4%), but this is not significant given the small sample size. Note that 9.1% represents only two artefacts with macroscopic usewear recorded in one location (Aboriginal object location 2) on a minor tributary near Farrells Creek. One used artefact was recorded on the valley side facing Emu Creek (Survey Area 3Ad), representing 1.0% of the assemblage from this landform zone. The proportion of retouched artefacts recorded in different landform zones is also not significantly different (see Table 19).

9 Significance Assessment

9.1 Criteria

Significance assessment is one of the primary steps in the process of cultural heritage management. Not all heritage places are equally significant and not all are worthy of equal consideration and management (Sullivan and Bowdler 1984, Pearson and Sullivan 1995). Once sufficient evidence has been compiled about a place, archaeological site, or landscape, the preparation of a statement of significance provides the necessary contextual framework to identify management objectives.

The Burra Charter (Australia ICOMOS Burra Charter 1999) provides guidelines for the assessment of cultural significance of heritage places. The Burra Charter identifies four types of cultural value: aesthetic, historic, scientific and social. The cultural significance of most Aboriginal sites is due largely to their social and scientific value. Social value of Aboriginal sites is assessed by Aboriginal communities. Scientific value is assessed by archaeologists.

9.1.1 Scientific significance

Scientific significance refers to the potential of a site to address current research questions. The Burra Charter equates scientific value with research value:

> The scientific or research value of a place will depend on the importance of the data involved, on its rarity, quality or representativeness, and on the degree to which the place may contribute further substantial information
>
> Burra Charter 1999:12

Research value refers to the potential a site or object has for addressing research questions. Research questions may be set within a local, regional or even a broader context and may relate to any aspect of past human behaviour. Questions may also relate to methodological and theoretical issues. Other interrelated aspects of cultural heritage sites or objects are also considered when assessing scientific significance, e.g. representativeness, uniqueness, the state of preservation (refer to NPWS 1997). These aspects are important in as far as they impact on the research potential of a heritage place, site or object.

High significance is generally attributed to sites which are rare or unique and whose loss would affect our ability to understand an aspect of past Aboriginal occupation of an area. Medium significance is attributed to sites, which provide information on an established research question. Low significance is attributed to sites, which cannot contribute new information about past Aboriginal use/occupation of an area.

Significance assessment provides the basis for management recommendations. As a general rule:

- Sites that are assessed as having low significance may not warrant protection against the impact of development or land use, nor do they warrant the implementation of mitigation measures prior to the impact of development or other land use.

- Sites that are assessed as moderately significant may not warrant protection against the impact of development or land use. However they may warrant the implementation of mitigation measures (which may include further archaeological investigation) prior to the impact of development or other land use.

- Sites that are assessed as highly significant do warrant protection against the impact of development or land use.

9.1.2 Social significance

This area of assessment concerns the value(s) of a site or feature particular community groups, in this case the local Aboriginal community. Aspects of social significance are relevant to sites, items and landscapes that are important or have become important to the local Aboriginal community. This importance involves both traditional links with specific areas as well as an overall concern by Aboriginal people for sites generally and their continued protection.

9.2 Assessment

9.2.1 Archaeological/Scientific Significance

Archaeological resources within the study area are typical of archaeological resources found in other areas of the Central Lowlands. The pattern of artefact distribution across the landscape, the types of artefacts, and raw materials that occur conform with previous investigations in nearby areas. No rare or unusual archaeological sites or features, such as stratified sites, mounds, art sites, Aboriginal scarred/carved trees or grinding grooves, were identified within the study area.

Most sites recorded during the survey, including sites WPE 3, WPE 4, WPE 5, WPE 6 WPE 7, WPE 8, WPE 9, WPE 10 and WPE 11, are very sparse artefact scatters which were arbitrarily defined using survey area boundaries. These sites are comprised of low numbers of artefacts. The thin soils on which they occur have very low archaeological potential. These sites have little potential to contribute additional information to current research questions of antiquity and chronological change or landscape use and settlement patterns. These sites are considered to be of **low archaeological significance**.

Sites WPE 1, along Farrells Creek, and WPE 2, along Emu Creek, are large artefact scatters with high numbers of artefacts. Three axes were recorded on these sites. Axes are not common implement types, presumably because many of them have been collected since European settlement. Both sites have intact archaeological deposit with potential to contain many thousands of artefacts. The deposit is unlikely to be stratified and the artefacts within it have little potential to contribute additional information to current research question of antiquity and chronological change. They also have limited potential to contribute additional information to address the research question of landscape use. The number of artefacts at these sites is substantial and therefore the sites may have the potential to address research questions related to stone artefact manufacture and taphonomy. They may also have the potential to address future research questions. However sites similar to WPE 1 and WPE 2 are common and similar information may be obtained from the excavation of many other sites or from assemblages already salvaged from similar sites in the Central Lowlands. These two sites are therefore assessed to be of **low to moderate archaeological significance**.

The study area overall is considered to be of **low to moderate archaeological significance**. It has limited potential to contribute additional information to any current research question beyond the detailed recording undertaken during this survey.

9.2.2 Aboriginal Cultural/Social Significance

Australian Archaeological Survey Consultants Pty Ltd (2003) carried out an Aboriginal cultural heritage assessment of the proposed extension area as part of the EIS being managed by Environment Resource Management (ERM). The results of that assessment have been integrated in this archaeological report, as is required as part of the Integrated Development Assessment (IDA) process. As a result, the recommendations relating to Aboriginal heritage for the extension of mining operations at HVO West Pit is based on an assessment of both archaeological and cultural values. The details provided in section 9.2.2 are based on the AASC report (2003) and recommendations integrated in section 11 below.

The Aboriginal Stakeholder strategy and social values assessment was carried out by Dave Johnston, an Indigenous Archaeologist and Director of Australian Archaeological Survey Consultants Pty Limited (AASC). It involved Aboriginal community consultation and assessment of social values in relation to Aboriginal heritage.

The area considered in the Aboriginal social values assessment was the same as for the archaeological assessment (comprising land within EL5243 north of Lemington Road and ML1406).

The aim of the cultural heritage assessment was to:
- identify the existing knowledge about Aboriginal sites in the West Pit study area;
- identify the appropriate community organisations and knowledge holders;
- develop an appropriate mode of consultation and relevant protocols (e.g. informal conversation, formal meeting, site visit);
- recognise differing rights to speak - negotiating traditional owners versus out of country Aboriginal peoples' rights to speak and associated concerns;
- ascertain the social values of the study area as a whole and the heritage places it contains to the various groups; and
- provide a negotiated agreement on documentation of those values in a report.

AASC's (2003) full report is contained within the EIS prepared by ERM (2003).

9.2.2.1 Community Consultation

AASC identified a number of Hunter Valley Aboriginal Representative organisations relevant to the project area and who wanted to be involved in the project. Consultation with these groups involved meetings, and telephone consultations. In addition, a number of site visits were held to discuss issues on-site. Meetings with the Aboriginal stakeholder organisations were carried out from late May through to September 2003.

The aim of consultation was to allow Aboriginal people with a right to speak for the area to identify if there were specific Aboriginal 'social values' related to the project area, and if so, to have input into the development of specific management recommendations if required. The discussions focused on both the general landscape, and therefore any tangible or intangible cultural heritage, in the project area as well as the archaeological sites recorded in the extension area.

There were eight Aboriginal organisations and representatives consulted as part of the study by AASC, comprising:

- Wonnarua Nations Aboriginal Corporation (WNAC) (representatives included Robert Lester, Barbara Foot, David Foot and Luke Hickey);
- Upper Hunter Tribal Council (UHTC) (represented by Victor Perry and Rhoda Perry);
- Lower Wonnarua Tribal Consultancy Pty Limited (represented by Barry Anderson);
- Ungooroo Aboriginal Corporation (UAC) (representatives included Graham Ward, Rhonda Ward, Allan Paget and Samantha Ward);
- Wanaruah Local Aboriginal Land Council (WLALC) (coordinator Noel Downs and representatives Trevor Griffiths, Beverley van Vliet, Carl Hedgers and Roger Matthews);
- Lower Hunter Wonnarua Council Incorporated (LHWC) (Lea-Ann Miller);
- Combined Council Hunter Valley Aboriginal Corporation (CCHVAC) (representatives included Margaret Matthews, John Matthews, Darrell Matthews, Christine Matthews, Michael Matthews and Tony Matthews);
- Barbara Foot, a senior Wonnarua Elder, (while a member of WNAC, was individually consulted given her extensive cultural knowledge and as she is in the process of establishing a new Aboriginal organisation, the 'Wonnarua Custodians', although it has not yet been registered).

The LHWC, while initially consulted, did not continue to be involved through the study, as Lea-Anne Miller indicated that the organisation was currently concentrating on working in the lower half of the Hunter Valley.

There were no other individuals identified as being Aboriginal Stakeholders who should be consulted as part of the study.

Note that there were no letters from the Aboriginal groups consulted attached to the AASC report provided to AMBS, therefore the statement of cultural significance and recommendations have been taken on the basis that the AASC (2003) report accurately reflects the views and recommendations made by the Aboriginal community regarding the West Pit extension area.

9.2.2.2 Aboriginal social significance and values

Defining social value

The AASC assessment generally followed the Burra Charter definition of social value as embracing “the qualities for which a place has become a focus of spiritual, political, national or other cultural sentiment to a majority or minority group”, focusing specifically on the identifiable Aboriginal custodial (or historically associated) representative groups/organisations/individuals views regarding Aboriginal ‘social values’.

In addition, Pearson’s and Sullivan’s (1995:19) definitions for Aboriginal significance were also taken into account:

> Aboriginal significance may be:
>
> *traditional:* the place may be a sacred, or important religious site; for example, a place that has an important association with a cultural hero, or a place where a ceremony is or was held
>
> *historic:* the place may be important in post-European Aboriginal history—it may tell the story of Aboriginal contact with Europeans, or their subsequent history—a massacre site like Myall Creek (NSW) or a cemetery or an Aboriginal mission may be such a place
>
> *contemporary:* the place may be a site with no traditional associations—it may be an archaeological site unknown to present Aborigines; but it may, when discovered, acquire importance to Aborigines because of what it symbolizes, and because it tells them about their past; for instance, sites at Lake Mungo (NSW), among the earliest known human occupation sites in Australia, are obviously of importance to Aborigines, though discovered and interpreted by archaeologists.

Identified Social Significance and Values

The social significance assessment (AASC 2003) identified a number of sites of social significance and value to the local Aboriginal community. These include:

- a possible “Men’s Area”;
- a possible scarred tree; and
- the deposits adjacent to the two creeklines, which may contain burials.

A number of issues were also considered to have social significance, including:

- the general need for archaeological test and salvage excavations, the scope of which should be determined in consultation with the Aboriginal Stakeholder organisations;
- other sites in the region, including places of traditional, historic and contemporary significance; and
- archaeological sites being evidence of the ancestors’ occupation of the region, representing both a physical and spiritual connection with the traditional land.

The values and associated recommendations are discussed below.

There were no additional sites of great Aboriginal social significance identified in the study area through the Aboriginal Stakeholder meetings and site inspections. Barbara Foot felt a possible “Men’s Area” may exist at an unspecified location either outside or just within the far north western boundaries of the study area. It was recommended that senior Aboriginal men carry out any heritage works required for that part of the study area, so as to be culturally safe. However, it was not considered to be a constraint to future mining operations in this area and no additional management requirements were made.

A possible scarred tree was identified by the WNAC representatives adjacent to the northern access road. This was considered to have potential Aboriginal significance, but requires final determination of the Aboriginal social value and mitigation strategy if necessary, following a judgment of the origin of the scar by an archaeologist. However, the majority of the Aboriginal Stakeholders currently want the tree to remain fenced.

Representatives of a number of the groups expressed that the soil deposits near the creeks could possibly contain burials. Many generations of ancestors were buried in their traditional country, but there are generally no grave markers to identify specific locations. Burials have been found in the region in areas with sufficient soil or sand deposits, often associated with creek banks. Given this, an archaeological subsurface testing program of the two creeks was recommended by a number of the representatives, to specifically check for the presence of burials. Up-front investigation was considered to be important as later mining activities are unlikely to allow for the identification of any burials that may be present. In addition, any ancestral remains that may be found during mining works would probably have already been destroyed or damaged and their original location may not able to be identified.

The Aboriginal Stakeholder organisations expressed they want to be involved in discussing the nature and scale of future subsurface archaeological testing and salvage. Methodologies were suggested by some of the organisations. Coal & Allied propose to continue the consultation process regarding this issue.

The study revealed that the Aboriginal Stakeholders have a number of known sites and places in the region which are of great significance or value to them. These include sites of 'traditional' significance, such as the identified Dreaming sites (eg. Baiame's Cave) and the bora ground near Wollombi Brook. Other sites discussed hold 'historic significance', including old family swimming and fishing locations.

The study also revealed that Aboriginal sites clearly hold 'contemporary' significance to the Aboriginal Stakeholders. Sites and places are generally considered to have value as evidence of their ancestors' day to day occupation of the region. The archaeological sites represent camping locations and/or places where people carried out certain activities, such as axe grinding. The artefact scatter sites and the artefacts themselves are generally culturally significant to the Aboriginal Stakeholder organisations as cultural reminders of their and their ancestors' physical and spiritual connection to their traditional land.

The archaeological sites were considered to have value or significance to varying degrees to all the Aboriginal Stakeholders consulted as part of the study. What was clear, however, was that the value of these sites, the artefacts they contain and what they represent to the Aboriginal Stakeholders is increased in mining lease areas, because of the extent of impact mining has had and will continue to have on sites.

The sites located in the West Pit extension area will be destroyed by the mine operations. Given this, the majority of the Representatives expressed that a substantial salvage collection and excavation program would be required. This process was also recommended so they can record the sites for future educational purposes and to salvage their socially significant artefacts which they do not want to be destroyed unnecessarily through mining operations.

While there were no sites of high Aboriginal social significance identified during the study, a number of the organisations specifically expressed their gratitude to Coal & Allied for the opportunity to say the social significance values for their heritage in general.

9.2.2.3 Recommendations

The recommendations made by the Aboriginal community fall into three general categories, including:

- general recommendations;
- recommendations regarding the social values assessment, specifically regarding the proposed extension of mining operations; and
- recommendations relating to the results of the archaeological assessment of the West Pit extension area.

General Recommendation

The Aboriginal Stakeholder organisations recommend similar Aboriginal Social Significance projects be carried out for other heritage assessment projects in the region. The project was considered to be a success as it allowed for Aboriginal people to be actively involved and address Aboriginal heritage concerns.

Recommendations relating to the Social Values Assessment

1. Other than the sites identified during the archaeological survey, the possible scarred tree identified by the Aboriginal Stakeholders and the possible “Men’s Area” identified by Barbara Foot, no further Aboriginal sites or areas of significance were identified by the Aboriginal Representative organisations. As such, provided the recommendations made by the Aboriginal community are followed, there are no additional Aboriginal heritage management requirements or constraints to the proposed extension of mining operations.

2. While the presence of a “Men’s Area” was identified within or near the north western boundaries of the proposed West Pit extension area, no specific location was identified. As such, there are no specific constraints to the proposed mining operations in this area. However, it was recommended that senior Aboriginal men should be involved with any heritage works proposed in the far north western corner of the study area, specifically, north of the access road and west of the possible scarred tree.

3. Regarding the possible scarred tree, the Aboriginal Stakeholder Representatives have requested a meeting with Coal & Allied and further assessment to confirm if the scar is of Aboriginal origin. Initial recommendations identified by the Aboriginal Stakeholders regarding the tree's removal (i.e. salvage) will therefore be re-negotiated following further on-site discussions. Coal & Allied have committed to holding future discussions. Until this issue is resolved, it was recommended that the tree should remain fenced and protected.

4. In terms of continuing consultation, it was recommended that Coal & Allied continue to liaise with the six Aboriginal Stakeholder organisations consulted as part of the project, which include both Traditional Owners of the region and members of the wider Aboriginal community (it should be noted that each organisation has members who identified as Traditional Owners). Contact should be made through the designated Representatives of:
   i. WNAC;
   ii. UHTC;
   iii. Lower Wonnarua Tribal Consultancy Pty Limited;
   iv. UAC;
   v. WLALC; and
   vi. CCHVAC.

Recommendations relating to the archaeological study results

1. There are no sites currently identified within the West Pit extension area which the Aboriginal Stakeholders indicated should be permanently protected.

2. All identified archaeological sites should remained fenced until they are salvaged (collection or excavation).

3. The fencing of the site along Emu Creek should be extended to the south, as it does not currently incorporate the extent of the surface artefact distribution. This should include fencing and closure of the vehicle access track that presently runs through the site and across the creek. The view expressed by the Aboriginal Stakeholders is that if the site is to be fenced and protected prior to salvage, it should be done completely and fully.

4. All identified surface sites containing stone artefacts are to be recorded and salvaged (collection or excavation) prior to destruction.

5. A site identification, recording and salvaging program should be carried out at the Emu Creek and Farrells Creek site locations, given the potential for Aboriginal subsurface cultural material and possibly burials.

   The Aboriginal Stakeholder organisations have indicated that the sites and the associated artefacts are socially significant as physical cultural reminders of their people's association with and utilisation of this area. As the extension of mining operations will destroy these sites forever, it was recommended that a thorough subsurface archaeological excavation of these two site locations be carried out to provide for a permanent record of the sites and an appropriate salvage program of the associated artefacts.

It was recommended that consultation continue between Coal & Allied and the Aboriginal Stakeholder Representatives to negotiate an appropriate subsurface archaeological testing and salvage program of the Emu Creek and Farrells Creek site locations.

10 Impact Assessment

10.1 Development Impacts

Extension of West Pit east of the current consent boundary to the Belt Line Road will impact on the known and potential archaeological resource. Sites that will be impacted by the proposed extension are shown in Figure 8 and are listed in Section 10.4 below. There are no development alternatives or options for conservation within the extension area.

10.2 Legislative Obligations

In New South Wales, items of Aboriginal heritage are protected under the *National Parks and Wildlife Act 1974.*

Under the Act, an "Aboriginal object" (formally known as "relic") is defined as "any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises New South Wales, being habitation before or concurrent with (or both) the occupation of that area by persons of non-Aboriginal extraction, and includes Aboriginal remains". As such, "objects" are confined to physical evidence and are commonly referred to as Aboriginal sites.

All "objects" are protected under section 90 of the Act. It is an offence to destroy, deface or damage an Aboriginal site without the prior consent of the Director-General of NPWS.

The NPW Act does not provide protection for spiritual areas or natural mythological areas that have no physical remains of Aboriginal occupation, unless they have been declared an Aboriginal Place under section 84 of the Act. An Aboriginal Place is a place which has been declared as such by the Minister for the Environment because it has been shown that the place is or was of special significance to Aboriginal culture. It may or may not contain physical objects.

Development consent does not equate to a consent to destroy an Aboriginal object or Aboriginal Place (section 90 consent) issued under the NPW Act. A consent to destroy is required to be granted by the NPWS before an Aboriginal site or Aboriginal Place can be disturbed. Failure to obtain this consent may result in prosecution.

10.3 Section 90 Consent Required

Sites that will be impacted by the proposed mine extension will require section 90 consent under the National Parks and Wildlife Act 1974. These sites are listed in Table 23 following.

Table 23: Sites requiring Section 90 consent prior to development

Site name	NPWS Site #	Site type	Survey area	Notes
WPE 1		Artefact scatter	1A	
WPE 2		Artefact scatter	1B	
WPE 3		Artefact scatter	2A	
WPE 4		Artefact scatter	2D	
WPE 5		Artefact scatter	2G	
WPE 6		Artefact scatter	3Ab	
WPE 7		Artefact scatter	3Ac	
WPE 8		Artefact scatter	3Ad	
WPE 9		Artefact scatter	3Bc	
WPE 10		Artefact scatter	3Bd	
WPE 11		Artefact scatter	4A	
HEE 1	37-2-1964	Artefact scatter	2A	Within boundary of WPE 3
HEE 2	37-2-1965	Scarred tree	3Bb	Reassessed as non-Aboriginal, i.e. not a site
HEE 3	37-2-1966	Isolated artefact	1B	Within boundary of WPE 2
HEE 4	37-2-1967	Isolated artefact	3Bc	Within boundary of WPE 9
Emu Creek	37-2-0038	Artefact scatter	3Ac	Within boundary of WPE 7
Lower Emu Creek	37-2-0144	Artefact scatter	1B	Within boundary of WPE 2
CUM-1	37-2-0894	Artefact scatter	4C	Not relocated
CUM-3	37-2-0896	Isolated find	2G	Within boundary of WPE 5
CUM 41	37-2-0805	Artefact scatter	1A	Within boundary of WPE 1

11 Recommendations

Based on the archaeological survey and assessment of low to moderate archaeological significance (of sites WPE 1 and WPE 2) and Aboriginal cultural assessment of the extension area, the following recommendations are provided:

It is recommended that prior to the development of the extension area a cultural salvage be undertaken. A cultural salvage may involve collection and excavation within any areas deemed appropriate by the Aboriginal community. Sites WPE 1 and WPE 2, which contain large numbers of artefacts, including a variety of stone tool types, are likely target areas.

Given the number of Aboriginal community groups involved in the management process and the assessment of low to moderate archaeological significance, it may be appropriate for an archaeologist to develop a salvage program in consultation with the community groups. Artefacts collected could then be lodged with the Australian Museum providing equal access to all community groups and the scientific community. Alternatively, in accordance with the recommendations made by some of the Aboriginal community groups, CNA should consider developing a Keeping Place in which the artefacts could be kept.

All identified **Aboriginal sites should be protected** (i.e. remain fenced) until such time as their salvage takes place. Note that the fencing along the southern boundary of Emu Creek should be extended to the south to encompass the full surface extent of the site.

The extent and scope of **salvage work should be determined in full consultation with the local Aboriginal community**.

In consideration of the social values identified in or near the West Pit extension area, **senior Aboriginal men should be involved with any heritage works proposed in the far north western portion of the study area**.

CNA should **continue to liaise with the Aboriginal Stakeholder Representatives** on issues identified through the study, including the possible scarred tree.

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Appendix A – Survey Coverage

Exp.ID	Survey area	Vis.%	Exp.%	Dimensions (m)	Area (sq m)	Effective coverage	Landform
Exp1	1a	70	80	480x120	12,840	7190.4	Main creek valley (Farrells Creek)
Exp2b	1a	50	30	c.100x10 & 100x10	1,453	217.95	Main creek valley (Farrells Creek)
Exp49a	1b	70	90	irregular (c.340x10)	1660	1045.8	Main creek valley (Emu Creek)
Exp49b	1b	30	70	irregular (c.450x120)	4,973	1044.33	Main creek valley (Emu Creek)
Exp49c	1b	90	100	irregular (c.200x90)	6197	5577.3	Main creek valley (Emu Creek)
Exp15	2a	40	70	35x15	525	147	Tributary creek
Exp16	2a	60	100	40x60	2400	1440	Tributary creek
Exp17	2a	70	100	8x5	40	28	Tributary creek
Exp18	2a	30	100	100x20	2000	600	Tributary creek
Exp2a	2a	50	30	c.200x10 & 200x10	2,741	411.15	Tributary creek
Exp20	2b	80	100	irregular (c.70x20)	1,172	937.6	Tributary creek
Exp21	2b	20	100	irregular (c.40x15)	331	66.2	Tributary creek
Exp22	2b	80	100	5x15	75	60	Tributary creek
Exp23	2b	70	100	irregular (c.40x15)	335	234.5	Tributary creek
Exp3	2c	20	100	c.110x30	173	34.5	Tributary creek
Exp4	2c	20	100	20x10	200	40	Tributary creek
Exp5	2c	30	100	30x10	300	90	Tributary creek
Exp63	2d	100	100	6x8	48	48	Tributary creek
Exp64a	2d	50	90	30x10	300	135	Tributary creek
Exp64b	2d	100	100	4x3	12	12	Tributary creek
Exp70	2d	50	60	60x60	3600	1080	Tributary creek
Exp72	2d	60	100	50x30	1500	900	Tributary creek
Exp74	2d	30	60	50x15	750	135	Tributary creek
Exp76	2d	50	80	40x40	1600	640	Tributary creek
Exp77	2d	40	70	80x20	1600	448	Tributary creek
Exp48	2e	80	20	irregular (c.50x20)	722	115.52	Tributary creek
Exp106	2f	60	20	irregular (120x20)	1,434	172.08	Tributary creek
Exp107	2f	20	60	20x10	200	24	Tributary creek
Exp108	2f	90	100	20x5	100	90	Tributary creek
Exp110	2f	40	10	irregular (210x150	11,370	454.8	Tributary creek
Exp84	2f	50	100	65x10	650	325	Tributary creek
Exp88	2f	30	10	15x8	120	3.6	Tributary creek
Exp100	2g	60	90	9x5	45	24.3	Tributary creek
Exp101	2g	20	30	30x20	176	10.56	Tributary creek
Exp102	2g	90	100	8x4	32	28.8	Tributary creek
Exp103	2g	50	100	30x7	210	105	Tributary creek
Exp96	2g	50	80	40x10	400	160	Tributary creek
Exp97	2g	40	90	20x16	320	115.2	Tributary creek
Exp98	2g	40	90	irregular (110x40)	1,448	521.28	Tributary creek
Exp99	2g	20	90	40x10	400	72	Tributary creek
Exp19	3Ab	60	80	14x11	154	73.92	Slope facing major creek
Exp28	3Ab	40	70	10x7	70	19.6	Slope facing major creek
Exp29	3Ab	40	100	15x6	90	36	Slope facing major creek
Exp31	3Ab	20	90	irregular (110x35)	2,895	521.1	Slope facing major creek
Exp47	3Ab	40	100	6x4	24	9.6	Slope facing major creek
Exp50	3Ac	70	70	25X3	75	36.75	Slope facing major creek
Exp51	3Ac	100	50	2X30	60	30	Slope facing major creek
Exp53	3Ac	30	80	125X40	5000	1200	Slope facing major creek

Exp54	3Ac	30	90	40X40	1600	432	Slope facing major creek
Exp55	3Ac	40	90	80X20	1600	576	Slope facing major creek
Exp68	3Ac	100	100	50x30 (3 areas)	1500	102	Slope facing major creek
Exp69	3Ac	100	100	10x8	80	80	Slope facing major creek
Exp111	3Ad	90	90	16x5	80	64.8	Slope facing major creek
Exp112	3Ad	50	90	9x14	126	56.7	Slope facing major creek
Exp117	3Ad	80	40	760x2	1,530	489.6	Slope facing major creek
Exp81	3Ad	80	100	34x7	238	190.4	Slope facing major creek
Exp82	3Ad	90	100	13x4	52	46.8	Slope facing major creek
Exp83	3Ad	20	100	40x30	1200	240	Slope facing major creek
Exp85	3Ad	90	100	16x8	128	115.2	Slope facing major creek
Exp86	3Ad	90	100	9x6	54	48.6	Slope facing major creek
Exp87	3Ad	80	100	20x13	260	208	Slope facing major creek
Exp24	3Ba	70	100	10x10	100	70	Slope facing minor creek
Exp25	3Ba	70	100	irregular (c.30x7)	181	126.7	Slope facing minor creek
Exp12	3Bb	60	100	5x8	40	24	Slope facing minor creek
Exp13	3Bb	90	100	7x7	49	44.1	Slope facing minor creek
Exp14	3Bb	60	80	80x0.5	40	19.2	Slope facing minor creek
Exp30	3Bb	60	100	8x3	24	14.4	Slope facing minor creek
Exp37	3Bb	70	50	4 small, 40x20	860	300	Slope facing minor creek
Exp10	3Bc	70	80	15x60	900	504	Slope facing minor creek
Exp11	3Bc	80	40	0.5x50	25	8	Slope facing minor creek
Exp32	3Bc	50	90	40x5	200	90	Slope facing minor creek
Exp33	3Bc	70	80	20x30	600	336	Slope facing minor creek
Exp42	3Bc	50	50	20x10	200	50	Slope facing minor creek
Exp52	3Bc	60	50	10X10	100	30	Slope facing minor creek
Exp6	3Bc	50	100	13x11	143	71.5	Slope facing minor creek
Exp62	3Bc	80	100	20X20	400	320	Slope facing minor creek
Exp71	3Bc	90	100	10x5	50	45	Slope facing minor creek
Exp78	3Bc	30	70	40x10	400	84	Slope facing minor creek
Exp79	3Bc	90	100	8x8	64	57.6	Slope facing minor creek
Exp8	3Bc	40	70	50x40	2000	560	Slope facing minor creek
Exp9	3Bc	60	50	3x5	15	4.5	Slope facing minor creek
Exp57	3Bd	60	70	50X30	1500	630	Slope facing minor creek
Exp58	3Bd	50	80	100X25	2500	1000	Slope facing minor creek
Exp59	3Bd	50	50	25X20	500	125	Slope facing minor creek
Exp60	3Bd	60	80	15X10	150	72	Slope facing minor creek
Exp73	3Bd	70	100	20x15	300	210	Slope facing minor creek
Exp75	3Bd	60	100	5x20	40	24	Slope facing minor creek
Exp66	3Be	100	100	15x4	60	60	Slope facing minor creek
Exp67	3Be	50	90	60x3	180	81	Slope facing minor creek
Exp104	3Bf	80	90	20x5	100	72	Slope facing minor creek
Exp105	3Bf	50	70	20x10	200	70	Slope facing minor creek
Exp109	3Bf	20	90	40x15	600	108	Slope facing minor creek
Exp113	3Bf	30	90	35x45	1575	425.25	Slope facing minor creek
Exp114	3Bf	90	70	270x0.25	67.5	42.525	Slope facing minor creek
Exp115	3Bf	90	20	25X5	125	22.5	Slope facing minor creek
Exp116b	3Bf	90	80	4x60	240	172.8	Slope facing minor creek
Exp89	3Bf	80	100	25x13	325	260	Slope facing minor creek
Exp90	3Bg	50	100	15x5	75	37.5	Slope facing minor creek
Exp91	3Bg	20	100	13x5	65	13	Slope facing minor creek
Exp92	3Bg	80	100	8x4	24	19.2	Slope facing minor creek

Exp93	3Bg	60	90	20x20	400	216	Slope facing minor creek
Exp94	3Bg	50	60	20x15	300	90	Slope facing minor creek
Exp95	3Bg	60	80	20x5	100	48	Slope facing minor creek
Exp26	4a	20	100	20x10	200	40	Ridge crest
Exp27	4a	20	60	30x30	900	108	Ridge crest
Exp34	4a	100	100	40x5	200	200	Ridge crest
Exp35	4a	70	90	45x6	270	170.1	Ridge crest
Exp36	4a	70	50	30x20	600	210	Ridge crest
Exp38a	4a	80	100	60x1	60	48	Ridge crest
Exp38b	4a	80	100	70x0.5	35	28	Ridge crest
Exp39	4a	100	100	400x0.5	200	200	Ridge crest
Exp40	4a	100	100	10x10	10	10	Ridge crest
Exp41	4a	100	100	2 x epx 10x10 & 30x10	400	400	Ridge crest
Exp43a	4a	60	80	10x10	100	48	Ridge crest
Exp43b	4a	40	60	14x10	140	33.6	Ridge crest
Exp44	4a	100	100	30x5	150	150	Ridge crest
Exp45	4a	100	100	20x4	80	80	Ridge crest
Exp46	4a	70	100	14x8	112	78.4	Ridge crest
Exp56	4a	100	100	15X2	30	30	Ridge crest
Exp61	4a	50	50	30X20	600	150	Ridge crest
Exp7	4a	60	100	20x10	200	120	Ridge crest
Exp80	4a	40	100	50x20	1000	400	Ridge crest
Exp65	4b	80	90	40x15	600	432	Ridge crest
Exp116a	4c	90	80	4x60	240	172.8	Ridge crest

Appendix B – Site Contents

Abbreviations

Raw Material:

M	Mudstone
S	Silcrete
Q	Quartz
PW	Petrified wood
IG	Igneous
BT	Black tuff
PC	Porcellanite
QZT	Quartzite
BC	Banded chert
C	Chert
FGS	Fine grained siliceous

Artefact Type:

F	Flake (Complete)
BFP	Broken flake (Proximal fragment)
BFO	Broken flake (Other fragment)
C	Core
RF	Retouched flake
FP	Flaked piece
HS	Heat shatter
G	Ground artefact

Site	Exp ID	Artefact type	Use	Raw material	Size Class (cm)	Cortex	Heat exp.	Notes
1A	30	BFO		BC	2_3	0		
1A	30	BFO		BC	2_3	0		
1A	30	F		BC	2_3	0		
1A	30	RF		BC	2_3	0		Thumbnail - very lustrous- heat treated material?
1A	30	FP		BC	3_4	5		
1A	30	C		BC	4_5	0		PW?
1A	30	F		BC	3_4	0		
1A	30	F		FGS	5_6	0	Y	
1A	30	FP		FGS	1_2	0		
1A	30	BFO		FGS	2_3	0		
1A	30	F		FGS	3_4	0		
1A	30	RF		IGN	4_5	0		Large end scraper - fine grained igneous with phenocrysts
1A	30	F		IGN	7_8	0		Porphyritic volcanic rock (felspar porphyry)
1A	30	CG	Y	IGN	10_11	0		Edge ground axe - volcanic
1A	30	F		M	1_2	0		
1A	30	F		M	1_2	10		
1A	30	F		M	1_2	0		
1A	30	F		M	1_2	0		
1A	30	FP		M	0_1	0		
1A	30	BFO		M	1_2	0		
1A	30	FP		M	0_1	0		
1A	30	BFO		M	2_3	0		
1A	30	BFO		M	0_1	0		
1A	30	BFO		M	0_1	0		
1A	30	BFO		M	1_2	0		
1A	30	BFO		M	1_2	0		
1A	30	BFP		M	2_3	0		
1A	30	BFP		M	2_3	30		
1A	30	BFP		M	1_2	0		
1A	30	BFO		M	1_2	0		
1A	30	BFP		M	1_2	0		
1A	30	BFP		M	2_3	0		
1A	30	FP		M	3_4	0		
1A	30	BFO		M	3_4	0		
1A	30	FP		M	2_3	0		
1A	30	F		M	2_3	0		

1A	30	F		M	2_3	0		
1A	30	F		M	2_3	0		
1A	30	BFO		M	1_2	0		
1A	30	F		M	4_5	0		
1A	30	F		M	2_3	0		
1A	30	BFO		M	3_4	0		
1A	30	BFO		M	3_4	0		
1A	30	F		M	2_3	0		
1A	30	BFP		M	1_2	0		
1A	30	FP		M	0_1	0		
1A	30	F		M	2_3	70		
1A	30	BFP		M	1_2	0		
1A	30	BFP		M	1_2	0		
1A	30	F		M	2_3	0	Y	
1A	30	BFP		M	2_3	0		
1A	30	BFP		M	1_2	0		
1A	30	F		M	2_3	0		
1A	30	F		M	4_5	0		
1A	30	F		M	3_4	0		
1A	30	BFO		M	1_2	0		
1A	30	BFO		M	2_3	0		
1A	30	F		M	1_2	0		
1A	30	F		M	1_2	0		
1A	30	BFO		M	2_3	0		
1A	30	BFP		M	2_3	0		
1A	30	C		M	2_3	0		
1A	30	FP		M	1_2	0		
1A	30	F		M	6_7	10		
1A	30	BFP		M	2_3	10		
1A	30	F		M	3_4	0	Y	
1A	30	F		M	2_3	0	Y	
1A	30	BFO		M	1_2	0		
1A	30	HS		M	4_5	50	Y	
1A	30	HS		M	3_4	10	Y	
1A	30	F		M	4_5	30		
1A	30	HS		M	5_6	20	Y	
1A	30	F		M	5_6	50		
1A	30	C		M	7_8	50		
1A	30	RF		M	1_2	20		Backed blade - broken
1A	30	F		M	2_3	0	Y	
1A	30	BFP		M	1_2	0		
1A	30	BFO		M	1_2	0		
1A	30	F		M	4_5	0		
1A	30	BFP		M	2_3	0		
1A	30	BFP		M	2_3	0		Redirecting flake
1A	30	F		M	4_5	0		
1A	30	FP		M	2_3	0		
1A	30	BFO		M	3_4	0		Redirecting flake
1A	30	F		M	4_5	5		
1A	30	F		M	1_2	0		
1A	30	BFO		M	4_5	0	Y	
1A	30	F		M	4_5	60		
1A	30	F		M	1_2	30		

1A	30	F		M	1_2	0		
1A	30	C		M	3_4	0		Multiplatfom
1A	30	F		M	2_3	0		
1A	30	F		M	4_5	50		
1A	30	F		M	3_4	40		
1A	30	F		M	3_4	0		
1A	30	F		M	4_5	0		
1A	30	F		M	3_4	90		
1A	30	F		M	1_2	0		
1A	30	FP		M	3_4	0	Y	
1A	30	F		M	4_5	10		
1A	30	C		M	3_4	10		
1A	30	F		M	1_2	0		
1A	30	RF		M	3_4	0		
1A	30	F		M	2_3	0		
1A	30	F		M	1_2	0		
1A	30	F		M	2_3	0		
1A	30	FP		M	2_3	10		
1A	30	BFO		M	0_1	0		
1A	30	F		M	2_3	0		
1A	30	HS		M	4_5	70	Y	
1A	30	F		M	5_6	40		
1A	30	RF		M	4_5	60	Y	Broken end scraper
1A	30	RF		M	2_3	0		"Core"
1A	30	F		M	3_4	0		
1A	30	BFP		M	2_3	0		
1A	30	RF		M	4_5	30		
1A	30	FP		M	2_3	0		
1A	30	FP		M	3_4	0		
1A	30	F		M	1_2	0		
1A	30	F	Y	M	4_5	0		Use (or fine retouch) on distal margin
1A	30	BFP		M	5_6	30		
1A	30	F		M	4_5	90		
1A	30	F		M	3_4	0		
1A	30	F		M	3_4	90		
1A	30	F		M	4_5	20		LCS
1A	30	BFP		M	2_3	0		
1A	30	F		M	2_3	50		
1A	30	BFP		M	2_3	90		
1A	30	HS		M	1_2	0	Y	
1A	30	C		M	4_5	50		
1A	30	F		M	3_4	0		
1A	30	F		M	2_3	0	Y	
1A	30	F		M	3_4	0		
1A	30	C		M	3_4	0		
1A	30	F		M	2_3	0		
1A	30	BFP		M	1_2	0		
1A	30	F		M	2_3	0	Y	
1A	30	F		M	3_4	10		
1A	30	HS		M	3_4	0	Y	
1A	30	F		M	2_3	20		
1A	30	F		M	1_2	0		
1A	30	HS		M	4_5	0	Y	

1A	30	F		M	5_6	10		
1A	30	F		M	3_4	60		
1A	30	HS		M	3_4	20	Y	Red mudstone knapping floor
1A	30	F		M	1_2	0		Red mudstone knapping floor
1A	30	F		M	2_3	0		Red mudstone knapping floor
1A	30	F		M	3_4	0		Red mudstone knapping floor Redirected Flake
1A	30	F		M	1_2	0		Red mudstone knapping floor
1A	30	BFP		M	1_2	0		Red mudstone knapping floor
1A	30	F		M	2_3	0		Red mudstone knapping floor
1A	30	BFP		M	2_3	0		Red mudstone knapping floor
1A	30	RF		M	2_3	0		Red mudstone knapping floor
1A	30	BFP		M	1_2	0		Red mudstone knapping floor
1A	30	BFP		M	1_2	0		Red mudstone knapping floor
1A	30	F		M	0_1	0		Red mudstone knapping floor
1A	30	BFO		M	0_1	0		Red mudstone knapping floor
1A	30	BFO		M	3_4	0		Red mudstone knapping floor
1A	30	BFP		M	2_3	0		Red mudstone knapping floor
1A	30	F		M	3_4	30		Red mudstone knapping floor
1A	30	C		M	4_5	0		Red mudstone knapping floor
1A	30	BFP		M	4_5	0		Red mudstone knapping floor
1A	30	F		M	5_6	0		Red mudstone knapping floor
1A	30	BFP		M	2_3	90		Red mudstone knapping floor
1A	30	F		M	2_3	0		Red mudstone knapping floor Redirected Flake
1A	30	C		M	5_6	10		Red mudstone knapping floor Conjoin
1A	30	F		M	4_5	0		Red mudstone knapping floor Conjoin
1A	30	F		M	3_4	0		Red mudstone knapping floor Conjoin
1A	30	F		M	1_2	0		Red mudstone knapping floor
1A	30	BFP		M	1_2	0		Red mudstone knapping floor
1A	30	F		M	3_4	0		
1A	30	BFP		M	2_3	0		
1A	30	F		M	2_3	0		
1A	30	BFP		M	1_2	0		
1A	30	BFP		M	1_2	90		
1A	30	BFO		M	0_1	0		
1A	30	HS		M	2_3	50	Y	
1A	30	BFO		M	1_2	0		
1A	30	F		M	2_3	0		
1A	30	BFP		M	2_3	0		
1A	30	F		M	5_6	20		
1A	30	F		M	2_3	0		
1A	30	BFO		M	1_2	0		
1A	30	BFP		M	3_4	80		
1A	30	HS		M	3_4	20	Y	
1A	30	BFP		M	2_3	0		
1A	30	F		M	3_4	0	Y	
1A	30	F		M	5_6	50		
1A	30	F		M	3_4	40		
1A	30	C		M	4_5	60		
1A	30	F		M	3_4	20		
1A	30	F		M	4_5	0		
1A	30	F	Y	M	4_5	0		Used
1A	30	F		M	4_5	0		
1A	30	F		M	2_3	50		

1A	30	F		M	2_3	0		LCS
1A	30	BFO		M	3_4	0		
1A	30	BFO		M	2_3	0		
1A	30	F		M	4_5	0		
1A	30	F		M	5_6	50		
1A	30	F		M	4_5	0		
1A	30	F		M	2_3	0		
1A	30	F		M	2_3	0		
1A	30	BFO		M	3_4	0		
1A	30	BFP		M	3_4	0		
1A	30	BFO		M	3_4	0		
1A	30	BFP		M	2_3	0		
1A	30	BFP		M	2_3	0		
1A	30	C		M	4_5	20		Unidirectional
1A	30	BFO		M	3_4	50		
1A	30	BFP		M	3_4	0		
1A	30	RF	Y	M	4_5	90		Primary flake used on both margins
1A	30	F		M	2_3	0		LCS
1A	30	F		M	1_2	0		
1A	30	F		M	2_3	0		
1A	30	F		M	4_5	0		LCS
1A	30	F		M	3_4	50		
1A	30	BFP		M	3_4	20		
1A	30	F		M	2_3	0		
1A	30	F		M	5_6	0		
1A	30	F		M	2_3	0		
1A	30	F		M	5_6	50	Y	
1A	30	F		M	2_3	0		
1A	30	F		M	3_4	0	Y	
1A	30	F		M	3_4	0		
1A	30	F		M	3_4	0		
1A	30	F		M	1_2	0		
1A	30	FP		M	1_2	0		
1A	30	F		M	4_5	20		
1A	30	F		M	1_2	0		
1A	30	HS		M	4_5	0	Y	
1A	30	F		M	3_4	0		
1A	30	F		M	3_4	0		
1A	30	F		M	6_7	30		
1A	30	F		M	2_3	0		
1A	30	BFO		M	1_2	0		
1A	30	RF	Y	M	2_3	5		Backed artefact - complete Bondi with use along cord
1A	30	RF		M	2_3	10		Backed artefact - broken - proximal
1A	30	FP		M	2_3	5	Y	
1A	30	F		M	2_3	0		
1A	30	BFP		M	2_3	0		
1A	30	BFO		M	3_4	0		
1A	30	BFO		M	2_3	0		
1A	30	BFO		M	2_3	0		
1A	30	F		M	4_5	40		
1A	30	RF		M	2_3	5		"Core" - large flake removed most of venteral surface
1A	30	F		M	2_3	70		
1A	30	C		M	7_8	10		

1A	30	F		M	4_5	0		
1A	30	F		M	3_4	50		
1A	30	F		M	1_2	0		
1A	30	BFO		M	2_3	10		
1A	30	BFO		M	2_3	50		
1A	30	FP		M	3_4	30		
1A	30	F		M	2_3	0		
1A	30	C		M	4_5	5		
1A	30	F		M	1_2	0		
1A	30	F		M	3_4	0		Grey banded chert
1A	30	F		M	1_2	0		Grey banded chert
1A	30	F		M	6_7	70	Y	
1A	30	F		M	3_4	0		
1A	30	F		M	4_5	90		
1A	30	F		M	3_4	30		
1A	30	F		M	1_2	0		
1A	30	F		M	2_3	10		
1A	30	FP		M	4_5	0		
1A	30	BFO		M	1_2	60		
1A	30	F		M	2_3	0		
1A	30	BFO		M	2_3	0	Y	
1A	30	F		M	3_4	5		
1A	30	F		M	4_5	20		
1A	30	F		M	2_3	10		
1A	30	BFO		M	1_2	0		Grey banded chert
1A	30	F		M	1_2	0		
1A	30	F		M	3_4	0		
1A	30	F		M	2_3	5		
1A	30	BFO		M	2_3	0		
1A	30	F		M	1_2	0		
1A	30	BFO		M	1_2	0		
1A	30	BFO		M	2_3	0		
1A	30	BFO		M	2_3	0		
1A	30	F		M	2_3	5		
1A	30	FP		M	2_3	50		
1A	30	F		M	1_2	0		
1A	30	BFO	Y	M	2_3	0		Notched/used on lateral margin
1A	30	F		M	2_3	0		
1A	30	F		M	2_3	0		
1A	30	C		M	5_6	0		
1A	30	F		M	5_6	0		
1A	30	RF		M	3_4	20		"Core"
1A	30	F		M	4_5	0		
1A	30	F		M	5_6	20		
1A	30	BFO		M	1_2	0		
1A	30	BFO		M	2_3	0		
1A	30	BFO		M	2_3	0		
1A	30	BFO		M	4_5	60		
1A	30	RF		M	2_3	30		Backed artefact - distal fragment with tip missing
1A	30	BFP		M	2_3	30		
1A	30	BFP		M	1_2	0		
1A	30	F		M	2_3	0		
1A	30	F		M	1_2	10		

1A	30	BFO		M	2_3	0		
1A	30	F		M	2_3	0		
1A	30	F		M	4_5	0		
1A	30	F		M	1_2	0		
1A	30	F		M	2_3	0		
1A	30	BFP		M	2_3	0		
1A	30	BFO		M	2_3	0	Y	
1A	30	FP		PORC	3_4	0	Y	
1A	30	FP		PW	3_4	0	Y	
1A	30	HS		PW	3_4	0	Y	
1A	30	F		Q	2_3	0		
1A	30	BFP		Q	0_1	0		
1A	30	F		Q	3_4	0		
1A	30	F		Q	2_3	0		
1A	30	F		Q	1_2	0		
1A	30	BFP		Q	1_2	0		
1A	30	FP		Q	1_2	0		
1A	30	C		Q	3_4	0		Asymmetrical
1A	30	BFP		Q	1_2	0		
1A	30	C		Q	3_4	0		Multidirectional
1A	30	F		Q	2_3	30		
1A	30	F		Q	2_3	10		
1A	30	FP		Q	2_3	0		
1A	30	BFO		Q	1_2	20		
1A	30	F		QZT	2_3	0		
1A	30	F		QZT	3_4	0		
1A	30	HS		S	4_5	0	Y	
1A	30	F		S	3_4	90		
1A	30	BFP		S	no info	no info		LCS conjoin (break)
1A	30	BFO		S	no info	no info		conjoin (break)
1A	30	HS		S	6_7	0	Y	
1A	30	BFO		S	0_1	0		
1A	30	HS		S	4_5	50	Y	
1A	30	RF		S	4_5	0		Scraper - broken - retouched on distal margin
1A	30	BFP		S	1_2	0		
1A	30	BFO		S	3_4	0		
1A	30	BFO		S	1_2	0		
1A	30	F		S	3_4	0		
1A	30	C		S	5_6	0		Multidirectional
1A	30	HS		S	3_4	0	Y	
1A	30	BFO		S	3_4	0		
1A	30	F		S	4_5	0		
1A	30	BFO		S	2_3	0		
1A	30	BFO		S	2_3	0		
1A	30	F		S	3_4	0		LCS
1A	30	BFP		S	2_3	0		
1A	30	BFO		S	2_3	0		
1A	30	F		S	1_2	0		
1A	30	HS		S	6_7	0	Y	
1A	30	BFO		S	3_4	0		
1A	30	BFO		S	1_2	0		
1A	30	BFO		S	3_4	0		
1A	30	BFP		S	2_3	0		

1A	30	C		S	4_5	40		Multiplatfom
1A	30	F		S	4_5	0	Y	
1A	30	RF		S	2_3	0		Backed artefact
1A	30	RF		S	3_4	0		Backed artefact
1A	30	FP		S	0_1	0		
1A	30	BFP		S	0_1	0		
1A	30	BFO		S	1_2	0		
1A	30	F		S	3_4	0		
1A	30	FP		S	4_5	40		
1A	30	C		S	4_5	0	Y	Broken
1A	30	F		S	4_5	10		
1A	30	BFO		S	5_6	20		
1A	30	BFP		S	2_3	0		
1A	30	BFP		S	2_3	0		
1A	30	BFP		S	2_3	0		
1A	30	FP		S	2_3	50		
1A	30	C		S	3_4	30	Y	Broken
1A	30	C		S	3_4	0		
1A	30	F		S	3_4	0		
1A	30	F		S	2_3	0		
1A	30	BFO		S	2_3	0		
1A	30	C		S	3_4	0		
1A	30	C		S	4_5	0		
1A	30	F		S	4_5	0		
1A	30	F		S	2_3	0		
1A	30	BFO		S	2_3	0		
1A	30	BFO		S	2_3	0		
1A	30	BFP		S	2_3	0		
1A	30	F		S	3_4	0		
1A	30	F		S	3_4	0		
1A	30	BFP		S	2_3	0		
1A	30	BFP		S	0_1	0		
1A	30	F		S	2_3	0		
1A	30	F		S	2_3	30		
1A	30	HS		S	5_6	70	Y	
1A	30	BFP		S	3_4	0		
1A	30	BFO		S	2_3	0		
1A	30	BFO		S	2_3	0	Y	
1A	30	F		S	3_4	10		
1A	30	FP		S	4_5	0	Y	
1A	30	HS		S	3_4	0	Y	
1A	30	HS		S	2_3	0	Y	
1A	30	F		S	3_4	0		
1A	30	F		S	2_3	0		
1A	30	HS		S	2_3	0	Y	
1A	30	RF		S	3_4	0		“Core” - one flake scar on ventral
1A	30	F		S	2_3	0		
1A	30	F		S	3_4	0		
1A	30	BFO		S	1_2	0		
1A	30	BFO		S	2_3	0		
1A	30	F		S	4_5	0		
1A	30	HS		S	2_3	0	Y	
1A	30	BFO		S	2_3	0		

1A	30	HS		S	3_4	0	Y	
1A	30	RF		S	1_2	0		Scraper- broken end scraper - distal portion
1A	30	BFO		S	3_4	20		
1A	30	F		S	3_4	0		
1A	30	BFP		S	4_5	0		
1A	30	HS		S	3_4	0	Y	
1A	30	BFP		S	2_3	5		
1A	30	BFO		S	2_3	0		
1A	30	HS		S	3_4	0	Y	
1A	30	BFO		S	2_3	0		
1A	30	F		S	4_5	5		
1A	30	FP		S	1_2	30		Very lustrous
1A	30	F		S	5_6	0		
1A	30	F		S	3_4	0	Y	
1A	30	BFO		S	1_2	0		Very lustrous
1A	30	BFP		S	2_3	0		
1A	30	BFP		S	2_3	0		
1A	30	BFO		S	1_2	0		
1A	30	F		S	2_3	0		
1A	30	BFO		S	3_4	0		
1A	30	F		S	2_3	0		
1A	30	BFO		S	2_3	0		
1A	30	BFO		S	2_3	0	Y	
1A	30	HS		S	4_5	0	Y	
1A	30	HS		S	5_6	0	Y	
1A	30	FP		S	2_3	0		
1A	30	F		S	4_5	0		
1A	30	F		S	2_3	0		
1A	30	FP		S	3_4	20	Y	
1A	30	BFO		S	2_3	0		
1B	17a	FP		BT	2_3	0		
1B	17a	F		BT	2_3	0		
1B	17a	F		BT	3_4	5		
1B	17a	C		C	2_3	20		Flaked river cobble
1B	17a	C		FGS	3_4	0		
1B	17a	BFO		FGS	1_2	0		
1B	17a	F		IGN	8_9	20		
1B	17a	C	Y	IGN	14_15	70		Axe/chopper - NOT ground - FGVolcanic
1B	17a	F		M	2_3	30		
1B	17a	F		M	1_2	0		
1B	17a	BFO		M	3_4	5		
1B	17a	F		M	5_6	50		
1B	17a	RF		M	4_5	0		Retouch to lateral margin and 2 scars on ventral
1B	17a	F		M	3_4	0		
1B	17a	F		M	4_5	0		
1B	17a	BFO		M	2_3	0		
1B	17a	FP		M	2_3	0		
1B	17a	F		M	3_4	0		
1B	17a	F		M	4_5	0		
1B	17a	F		M	2_3	0		
1B	17a	BFO		M	2_3	0		
1B	17a	F		M	4_5	20		
1B	17a	F		M	2_3	0		

1B	17a	F		M	2_3	0		
1B	17a	BFO		M	0_1	0		
1B	17a	F		M	1_2	0		
1B	17a	BFP		M	1_2	0		
1B	17a	BFO		M	0_1	0		
1B	17a	BFP		M	no info	no info		Conjoin set of 2 artefacts (break)
1B	17a	BFO		M	no info	no info		Conjoin set of 2 artefacts (break)
1B	17a	BFO		M	no info	no info		Conjoin set of 3 artefacts (break)
1B	17a	BFO		M	no info	no info		Conjoin set of 3 artefacts (break)
1B	17a	BFO		M	no info	no info		Conjoin set of 3 artefacts (break)
1B	17a	F		M	1_2	0		
1B	17a	F		M	2_3	0		
1B	17a	F		M	2_3	0		
1B	17a	F		M	2_3	0		
1B	17a	F		M	2_3	0		
1B	17a	BFO		M	2_3	0		
1B	17a	FP		M	2_3	0		
1B	17a	FP		M	2_3	0		
1B	17a	FP		M	2_3	0		
1B	17a	F		M	1_2	0		
1B	17a	F		M	0_1	0		
1B	17a	F		M	1_2	0		
1B	17a	BFP		M	1_2	0		
1B	17a	BFO		M	0_1	0		
1B	17a	F		M	5_6	30		
1B	17a	F		M	1_2	0		
1B	17a	F		M	4_5	5		
1B	17a	F		M	1_2	0		
1B	17a	HS		M	1_2	20		
1B	17a	BFO		M	1_2	0		
1B	17a	F		M	3_4	0		
1B	17a	C	Y	M	7_8	40		"Core tool" small usewear flakes
1B	17a	F		M	2_3	0		
1B	17a	F		M	6_7	40		
1B	17a	F		M	6_7	0		
1B	17a	HS		M	7_8	50	Y	
1B	17a	F		M	2_3	0		
1B	17a	BFO		M	3_4	0		
1B	17a	F		M	2_3	0		
1B	17a	F		M	5_6	0		
1B	17a	F		M	2_3	0		
1B	17a	HS		M	4_5	0	Y	
1B	17a	BFO		M	2_3	0		
1B	17a	F		M	3_4	0		
1B	17a	BFP		M	2_3	0		
1B	17a	BFO		M	1_2	0		
1B	17a	F		M	2_3	0		
1B	17a	HS		M	2_3	0		
1B	17a	F		M	3_4	30		
1B	17a	F		M	3_4	0		
1B	17a	F		M	4_5	0		
1B	17a	F		M	2_3	0		
1B	17a	F		M	3_4	0		

1B	17a	F		M	6_7	10		
1B	17a	RF		M	3_4	5		Burinate
1B	17a	RF		M	4_5	70		Banded mudstone/chert
1B	17a	BFO		M	1_2	0		
1B	17a	HS		M	1_2	0	Y	
1B	17a	FP		M	0_1	0		
1B	17a	F		M	4_5	0		
1B	17a	F		M	3_4	80		LCS
1B	17a	BFO		M	1_2	0		
1B	17a	F		M	3_4	0		
1B	17a	BFP		M	2_3	10		
1B	17a	F		M	3_4	0		
1B	17a	F		M	6_7	0		
1B	17a	F		M	3_4	0		
1B	17a	F		PORC	3_4	0		
1B	17a	F		PW	1_2	0		
1B	17a	BFP		Q	1_2	0		
1B	17a	FP		Q	1_2	0		
1B	17a	BFP		S	3_4	10		
1B	17a	F		S	1_2	0		
1B	17a	F		S	1_2	0		
1B	17a	HS		S	2_3	0		
1B	17a	HS		S	1_2	0		
1B	17a	F		S	2_3	40		
1B	17a	BFO		S	2_3	10		
1B	17a	F		S	2_3	0		
1B	17a	F		S	2_3	0		
1B	17a	BFP		S	1_2	0		
1B	17a	F		S	2_3	0		
1B	17a	BFO		S	1_2	0		
1B	17a	FP		S	0_1	0		
1B	17a	C		S	5_6	5		
1B	17a	C		S	4_5	0		
1B	17a	F		S	2_3	0		
1B	17a	BFO		S	1_2	0		
1B	17a	F		S	1_2	0		
1B	17a	FP		S	2_3	0		
1B	17a	BFP		S	1_2	0		
1B	17a	BFO		S	2_3	10		
1B	17a	F		S	3_4	0		
1B	17a	F		S	2_3	0		
1B	17a	BFO		S	2_3	0		
1B	17a	F		S	4_5	0		
1B	17a	F		S	2_3	0		
1B	17a	BFO		S	1_2	0		
1B	17a	F		S	2_3	0		
1B	17a	F		S	1_2	0		
1B	17a	BFP		S	6_7	40		
1B	17a	F		S	5_6	50		
1B	17a	F		S	4_5	0		
1B	17a	F		S	5_6	0		
1B	17a	C		S	3_4	0		
1B	17a	FP		S	2_3	0		

1B	17a	BFO		S	3_4	0		
1B	17a	C		S	4_5	0		
1B	17a	BFO		S	1_2	0		
1B	17a	F		S	3_4	0		
1B	17b	BFP		FGS	3_4	0		Conjoin (break)
1B	17b	BFO		FGS	3_4	10		Conjoin (break)
1B	17b	BFO		FGS	2_3	0		Conjoin (break)
1B	17b	C	Y	IGN	9_10	50		Axe/chopper - NOT ground
1B	17b	F		M	3_4	0		
1B	17b	F		M	4_5	100		
1B	17b	BFP		M	2_3	0		
1B	17b	F		M	3_4	0		
1B	17b	F		M	5_6	90		
1B	17b	BFP		M	1_2	0		
1B	17b	F		M	3_4	80		
1B	17b	C		M	4_5	0		
1B	17b	HS		M	2_3	0		
1B	17b	F		M	1_2	0		
1B	17b	BFO		M	0_1	0		
1B	17b	BFP		M	2_3	0		
1B	17b	F		M	2_3	70		
1B	17b	BFO		M	2_3	0	Y	
1B	17b	F		M	2_3	20		
1B	17b	BFO		M	1_2	0		
1B	17b	FP		M	1_2	10		
1B	17b	C		M	2_3	0		
1B	17b	BFO		M	0_1	0		
1B	17b	F		M	1_2	0		
1B	17b	HS		M	0_1	30		
1B	17b	F		M	3_4	10		
1B	17b	C		M	7_8	40		Conjoin (flaked)
1B	17b	BFO		M	2_3	0		Conjoin (flaked/broken)
1B	17b	BFP		M	1_2	0		Conjoin (flaked/broken)
1B	17b	FP		M	2_3	0		
1B	17b	F		M	2_3	0		
1B	17b	BFP		M	3_4	0		
1B	17b	BFP		M	2_3	20		
1B	17b	BFP		M	2_3	0		
1B	17b	BFP		M	1_2	0		
1B	17b	BFO		M	1_2	0		
1B	17b	BFO		M	2_3	30		
1B	17b	F		M	1_2	0		
1B	17b	BFO		M	1_2	0		
1B	17b	BFO		M	2_3	0		
1B	17b	BFP		M	1_2	20		
1B	17b	BFO	Y	M	2_3	0		Usewear along lateral margin
1B	17b	F		M	4_5	40		
1B	17b	BFO		M	1_2	0		
1B	17b	BFO		M	2_3	0		
1B	17b	F		M	3_4	0		
1B	17b	F		M	3_4	5		
1B	17b	F		M	1_2	90		
1B	17b	F		M	3_4	10		

1B	17b	BFP		M	2_3			
1B	17b	C		M	6_7	40		
1B	17b	BFO		M	2_3	0		
1B	17b	BFO		M	1_2	0		
1B	17b	BFO		M	1_2	0		
1B	17b	F		M	1_2	0		
1B	17b	FP		M	0_1	0		
1B	17b	HS		M	1_2	0	Y	
1B	17b	BFO		M	1_2	0		
1B	17b	RF		M	2_3	0		Retouch along one lateral margin - conjoin (break)
1B	17b	RF		M	1_2	0		Retouch along one lateral margin - conjoin (break)
1B	17b	BFO		M	1_2	0		
1B	17b	HS		M	1_2	0	Y	
1B	17b	BFO		M	0_1	0		
1B	17b	BFO		M	2_3	0		
1B	17b	F		M	1_2	0		
1B	17b	BFO		M	1_2	0		
1B	17b	F		M	1_2	0		
1B	17b	F		M	1_2	0		
1B	17b	BFO		M	1_2	0		
1B	17b	F		M	1_2	0		
1B	17b	F		M	4_5	0		
1B	17b	F		M	1_2	0		
1B	17b	F		M	2_3	0		
1B	17b	F		M	2_3	0		
1B	17b	F		M	4_5	20		
1B	17b	F		M	2_3	0		
1B	17b	F		M	7_8	0		
1B	17b	F		M	3_4	0		
1B	17b	F		M	5_6	20		
1B	17b	F		M	3_4	5		
1B	17b	F		M	1_2	0		
1B	17b	F		M	2_3	0		
1B	17b	BFO		M	2_3	0		
1B	17b	F		M	1_2	0		
1B	17b	F		M	1_2	0		
1B	17b	BFO		M	7_8	10		
1B	17b	BFP		M	2_3	0		
1B	17b	F		M	2_3	0		
1B	17b	F		M	4_5	0		
1B	17b	BFP		M	1_2	0		
1B	17b	BFO		M	1_2	0		
1B	17b	BFO		M	1_2	0		
1B	17b	HS		M	2_3	0		
1B	17b	BFO		M	1_2	0		
1B	17b	F		M	3_4	0		
1B	17b	F		M	3_4	0		
1B	17b	F		M	3_4	0		
1B	17b	F		M	1_2	0		
1B	17b	F		M	3_4	10		
1B	17b	FP		M	1_2	0	Y	
1B	17b	BFO		Q	1_2	0		
1B	17b	FP		Q	3_4	0		

1B	17b	BFO		Q	2_3	0		
1B	17b	F		Q	2_3	90		
1B	17b	FP		Q	2_3	0		
1B	17b	F		Q	2_3	0		
1B	17b	C		Q	3_4	0		
1B	17b	F		Q	2_3	0		
1B	17b	FP		Q	1_2	0		
1B	17b	BFO		Q	1_2	0		
1B	17b	BFO		Q	1_2	0		
1B	17b	FP		Q	1_2	0		
1B	17b	F		S	4_5	60		
1B	17b	F		S	6_7	0		
1B	17b	BFP		S	1_2	0		
1B	17b	F		S	3_4	0		
1B	17b	BFP		S	1_2	0		
1B	17b	BFP		S	1_2	0		
1B	17b	BFO		S	0_1	0		
1B	17b	BFO		S	1_2	0		
1B	17b	BFP		S	1_2	0		
1B	17b	FP		S	1_2	0		
1B	17b	BFO		S	1_2	0		
1B	17b	BFP		S	1_2	0		
1B	17b	F		S	1_2	0		
1B	17b	BFO		S	1_2	0		
1B	17b	BFO		S	2_3	0		
1B	17b	BFO		S	0_1	0		
1B	17b	BFO		S	1_2	0		
1B	17b	F		S	10_11	0		
1B	17b	BFO		S	1_2	0		
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	

1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	

1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	

1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
1B	17c	no info		no info	no info	no info	no info	
2A	1	F		M	4_5	0		
2A	2	F	Y	IGN	4_5	0		Axe flake - ground dorsal fg volcanic
2A	2	F		M	4_5	0		
2A	2	CG	Y	M	8_9	30		Ground edge similar to axe - also similar damage to axe use
2A	2	HS		M	2_3	0	Y	
2A	2	HS		M	2_3	0	Y	
2A	2	F		M	5_6	10		
2A	2	F	Y	M	2_3	0		Use on distal margin
2A	2	RF		M	4_5	20	Y	Robust side-end scraper
2A	2	F		M	2_3	0		
2A	2	BFP		Q	2_3	0		
2A	2	BFO		Q	2_3	0		
2A	2	F		S	1_2	0		
2A	2	HS		S	5_6	40	Y	
2A	2	BFP		S	2_3	0		
2A	2	BFO		S	2_3	0		
2A	2	BFO		S	2_3	0		
2A	2	F		S	4_5	0		
2A	2	FP		S	4_5	0	Y	
2D	24	F		S	4_5	0		
2G	34	RF		M	7_8	0		"Core"
2G	35	BFO		M	4_5	20		
3AB	4	HS		M	4_5	0	Y	
3AB	4	F		M	4_5	0		
3AB	4	BFO		M	1_2	0		
3AB	4	C		M	4_5	0		Multiplatform
3AB	4	BFO		M	2_3	0		
3AB	4	FP		M	1_2	0		
3AB	4	HS		M	1_2	0	Y	
3AB	4	F		M	2_3	0		
3AB	4	HS		M	2_3	0	Y	
3AB	4	F		M	1_2	0		
3AB	4	FP		M	1_2	0		
3AB	4	BFP		M	1_2	0		
3AB	4	BFO		M	3_4	0		
3AB	4	F		M	2_3	0		

3AB	4	C		M	3_4	0		Single platform
3AB	4	RF		M	4_5	0		Robust flake with retouch on distal margin
3AB	4	BFO		M	2_3	0		
3AB	5	BFO		M	1_2	0		
3AB	5	HS		M	3_4	0	Y	
3AB	6	F		M	3_4	0		
3AB	6	HS		S	8_9	40	Y	
3AB	6	HS		S	2_3	30	Y	
3AB	6	HS		S	1_2	0	Y	
3AB	6	HS		S	1_2	0	Y	
3AB	7	BFP		FGS	2_3	0		
3AB	7	F		M	2_3	0		
3AB	7	HS		S	4_5	40	Y	
3AB	15	C		S	11_12	5		
3AC	18	C		BT	6_7	0		Very weathered - patina over entire core
3AC	18	F		M	3_4	0		
3AC	18	BFO		M	2_3	0		
3AC	18	BFO		PORC	4_5	0		
3AC	20	F		S	1_2	0		
3AC	20	F		S	1_2	0		
3AC	20	BFP		S	1_2	0		
3AC	21	F		M	4_5	90		
3AC	25	FP		M	0_1	0		
3AC	26	F		M	4_5	5		
3AC	26	F		Q	2_3	5		
3AC	26	FP		Q	0_1	0		
3AD	28	G		BT	5_6	0		Large ground fragment of cutting edge, weathered
3AD	28	BFO		IGN	5_6	10		
3AD	28	BFO		M	3_4	0		
3AD	28	BFP		M	5_6	10		
3AD	28	BFP		M	2_3	20		
3AD	28	RF		M	2_3	0		Backed artefact
3AD	28	F		M	0_1	0		
3AD	28	F		M	2_3	0		
3AD	28	F		M	3_4	5		
3AD	28	BFO		S	3_4	0	Y	
3AD	28	BFP		S	2_3	0		
3AD	28	RF		S	1_2	0		Backed artefact - distal portion of Bondi
3AD	29	F		M	3_4	90		
3AD	29	BFO		M	2_3	0		
3AD	29	F		M	2_3	0		
3AD	29	F		M	2_3	0		
3AD	29	FP		M	1_2	0		
3AD	29	F		M	1_2	0		
3AD	29	HS		S	3_4	0	Y	
3AD	29	F		S	3_4	0		
3AD	29	F		S	2_3	0		
3AD	29	F		S	1_2	0		
3AD	31	F		M	2_3	5		
3AD	31	F		M	4_5	0		
3AD	31	F		S	2_3	0		
3AD	32	F		M	7_8	5		
3AD	33	F		M	2_3	10		

3AD	33	BFO		M	1_2	0		
3AD	33	F		M	1_2	0		
3AD	33	BFP		M	1_2	0		
3AD	33	FP		M	1_2	20		
3AD	33	HS		M	2_3	0	Y	
3AD	33	F		M	2_3	0		
3AD	33	F		M	2_3	0		
3AD	33	FP		M	1_2	0		
3AD	33	RF		M	2_3	70		Retouch along proximal and distal margins
3AD	33	BFP		Q	1_2	0		
3AD	33	FP		Q	2_3	0		
3AD	33	F		Q	1_2	0		
3AD	33	F		Q	0_1	0		
3AD	33	BFP		Q	1_2	0		
3AD	33	F		S	2_3	0		
3AD	33	RF		S	6_7	0		Retouch along right lateral and distal margin
3AD	36	BFO		M	3_4	0	Y	
3BC	3	FP		M	1_2	40	Y	
3BC	8	FP		M	4_5	30		
3BC	16	HS		M	2_3	0	Y	
3BC	16	BFO		M	1_2	0		
3BC	16	HS		S	1_2	0	Y	
3BC	16	F		S	2_3	0		
3BC	19	BFP		M	2_3	0		
3BC	19	FP		PW	2_3	0	Y	
3BC	19	BFO		PW	2_3	0		
3BC	19	FP		PW	2_3	0	Y	
3BC	19	F		S	2_3	0		
3BC	19	BFO		S	1_2	0		
3BC	19	BFO		S	1_2	0		
3BC	23	F		S	3_4	10		
3BD	22	F		M	3_4	0		
3BD	22	FP		S	1_2	0		
3BD	27	F		M	1_2	0		LCS
3BD	27	FP		M	0_1	0		
3BD	27	F		QZT	3_4	0		
4A	9	BFO		M	1_2	0		
4A	10	FP		Q	2_3	0		
4A	11	F		M	no info	no info		
4A	12	C		M	7_8	50		
4A	13	C		S	7_8	2		
4A	14	C		M	9_10	20		
4A	14	BFO		M	1_2	0		

Appendix C – Photographs

Plate 1: Site WPE 1 (Farrells Creek) heading northeast

Plate 2: Soil profile at WPE 1

Plate 3: WPE 2 (Emu Creek), near eastern boundary of study area, heading west

Plate 4: Soil profile at WPE 2

Plate 5: Axe/chopper from Site WPE 2

Plate 6: WPE 3, Location 1, heading west

Plate 7: Ground mudstone core from site WPE 3

Plate 8: Site WPE 4

Plate 9: WPE 5, Location 34, heading south

Plate 10: WPE 6, Location 11, heading west

Plate 11: WPE 7, Location 18, heading south

Plate 12: WPE 8, Location 29, heading south west

Plate 13: WPE 9, Location 8, heading north east

Plate 14: WPE 10, Location 27, heading north east

Plate 15: WPE 11, Location 12, heading west

Plate 16: Scarred tree, ST1, scar faces north (not considered to be Aboriginal in origin)

Plate 17: Scarred tree, ST2, scar faces south east (not considered to be Aboriginal in origin)

Appendix D – Glossary

artefact – any object which has been used, modified or made by people. All artefacts identified in this study are made of stone.

artefact type - broad classes used to categorise and describe artefacts. For this study classes were defined according to diagnostic features and were: flake, core, retouched flake (of which backed artefact is a sub-class) and flaked piece.

assemblage - the name given to encompass the entire collection of artefacts recovered by archaeologists, invariably classified into diagnostic items used to describe the material culture.

backed - when one margin of a flake is retouched at a steep angle, and that margin is opposite a sharp edge. The steep margin is formed by bi-polar or hammer and anvil knapping.

backed artefact - a class of artefact employed by archaeologists to describe artefacts which are backed. Divided in to sub-classes based on general form : Asymmetric and Geometric.

chert - a cryptocrystalline siliceous sedimentary stone; banded chert has distinctive banded appearance and my be difficult to distinguish from petrified wood

conjoin - the process of physically refitting artefacts back together.

core - an artefact which has only negative scars from flake removal, and thus no ventral surface.

cortex - the weathered outer portion of a stone, often somewhat discoloured and coarser compared than the unweathered raw material.

diversity – used to describe variation within an assemblage or site. A very simple measure of diversity used in this study was a count of different raw materials and artefact types.

flake - an artefact which has technologically diagnostic features and a ventral surface.

flaked piece - an artefact which has technologically diagnostic features but is unidentifiable as either a flake or a core.

heat shatter - stone which has been reduced by exposure to heat. This stone can be identified by a number of features which include discolouration, texture changes and pot-lidding.

mudstone: a fine-grained siliceous sedimentary rock ideal for the manufacture of stone tools. Mudstone has been variously identified as indurated mudstone, and rhyolitic or silicified tuff (e.g. Hiscock and Shawcross 2000, Kuskie and Kamminga 2000). The material is variable but these terms probably reflect archaeologist's preferred name as much as the petrology of the material. As mudstone or indurated mudstone is most commonly used to describe this raw material and is a more inclusive term, mudstone is used here.

knapping floor – an area where knapping (reduction of stone) has taken place (also referred to as a reduction floor or reduction area), defined in this study as a concentration of artefacts derived from the same raw material/core(s) at least some of which can be refitted.

manuport - an object which has been moved by a person or people.

procurement - the process of obtaining raw material for reduction.

quartz - a crystalline form of silica.

raw material - the type of stone from which artefacts are made. Raw material identified in this study include mudstone, silcrete, quartz, chert, petrified wood, banded chert, fine grained siliceous, porcellanite and quartzite.

reduction - the process of removing stone flakes from another pieces of stone. Generally this is performed by striking one rock with another (hard hammer percussion) to remove a flake.

retouch - retouch is when a flake is removed after the manufacture of the original flake. This sequence can be observed when a flake scar is present and encroaches over the ventral surface and thus must have been made after the initial flake removal. Recorded whether retouch was absent or present on the artefact.

silcrete - a silicified sedimentary rock, often with fine inclusions or grains in a cryptocrystalline matrix. Silcrete is sometimes heat treated to improve its flaking quality (Flenniken and White 1983). Heat treatment and heat exposure will also affect the stone in terms of colour (which may become red) and lustre (surfaces knapped after heat treatment are more lustrous) and surface quality (potlidding crenation and crazing may occur). Heat treatment can not be easily distinguished from heat exposure (Rowney and White 1997, Mercieca 2000).

size class - measured in 10 mm increments.

taphonomy - the study of the processes (both natural and cultural) which effect the deposition and preservation of both the artefacts and the site itself.

technology - a form of artefact analysis which is based upon the knapping/ manufacturing process, commonly used to subsequently infer behaviour patterns, cultural-selection and responses to raw material or the environment.

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Prepared by
Environmental Resources Management Australia Pty Ltd
Building C, 33 Saunders Street, Pyrmont
New South Wales 2009
Australia

Locked Bag 24 Broadway
New South Wales 2007
Australia

Telephone 02 8584 8888
Facsimile 02 8584 8800
Web www.erm.com

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Volume 2 Technical Reports (Part F-H)

Volume 3 Technical Reports (Part I-L)

Volume 4 Environmental Impact Statement Figures