



Annex H

Air Quality Study



AIR QUALITY IMPACT ASSESSMENT

WARKWORTH EXTENSION PROJECT

Mitchell McLennan

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EXECUTIVE SUMMARY

This report has been prepared by PAEHolmes for Mitchell McLennan on behalf of Warkworth Mining Limited (WML) (referred to hereafter as the Proponent). It provides an assessment of the potential for impact as a consequence of the proposed extension to mining at the Warkworth open-cut mine (referred to hereafter as Warkworth Mine).

The proposed Warkworth Extension is for a 21-year period during which Run of Mine (ROM) coal is planned to be produced at a maximum rate of 18 million tonnes per annum (Mtpa). It includes directing rejects to the adjacent Mount Thorley mine and continuation of the Mount Thorley Coal Preparation Plant from June 2017 to 2031 (i.e. beyond the date in which the Mount Thorley consent is due to expire).

Detailed mine and project planning has been undertaken with indicative stages throughout the 21-year life. As the mine plan between years is relatively consistent, modelling has been conducted at years 2, 9, and 21 to predict potential impacts from initial mining, the period in which mining is forecast to intersect Saddleback Ridge and the last year of mining furthest to the west.

Predictions of air quality impacts considered the effects of surrounding mines as well as other non-mining and non-modelled sources of dust. Model predictions at privately-owned residential receptors were compared with applicable air quality criteria. Predictions equal to or below the criteria indicate an acceptable air quality impact.

Analysis of the dispersion modelling results indicates that the proposed Warkworth Extension project would exceed DECCW impact assessment criteria at up to 25 nearby privately owned receptors for 24-hour PM₁₀, at up to four privately owned residences for annual average PM₁₀, and at up to two privately owned receptors for deposited dust.

Further analysis of the 24-hour PM₁₀ dispersion modelling results indicates that the proposed Warkworth Extension project would exceed DoP project assessment criteria at up to four privately owned receptors, as follows: receptors 109 in Year 2, receptors 77, 78, 102 and 109 in Year 9, and receptors 77, 78, 102 and 109 in Year 21. (Note that receptor 102, is Warkworth Hall which would have lower exposure duration.)

Warkworth Mine will take steps to mitigate and manage potential dust impacts associated with the project through a range of controls and continued monitoring of air quality in the area surrounding the mine.

The main sources of greenhouse gas emissions identified from the proposal would be: the end use of the coal, fugitive emissions, diesel, electricity and explosives use, and transport of coal. The total estimated emissions generated from the Warkworth Extension are 750.5 Mt of carbon dioxide equivalent [CO₂-e]. The average annual emissions is calculated to be 35.7 Mt per year, expressed as a proportion of global CO₂-e atmospheric load [3,000 gigatonnes], the Warkworth Extension would contribute 0.001% annually. Thus, the proposal itself would have no noticeable effect on global warming.

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1 INTRODUCTION

This report has been prepared by PAEHolmes for Mitchell McLennan on behalf of Warkworth Mining Limited (WML) (referred to hereafter as the Proponent). It provides an assessment of the potential for impact as a consequence of the proposed extension to mining at the Warkworth open-cut mine (referred to hereafter as Warkworth Mine).

The proposed Warkworth Extension is for a 21-year period during which Run of Mine (ROM) coal is planned to be produced at a maximum rate of 18 million tonnes per annum (Mtpa). It includes transporting rejects to the adjacent Mount Thorley mine and continuation of the Mount Thorley Coal Preparation Plant from June 2017 to 2031 (i.e. beyond the date in which the Mount Thorley consent is due to expire).

The assessment generally follows the conventional procedures outlined by the NSW Department of Environment, Climate Change and Water (NSW DECCW) in its document titled "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**DEC, 2005**) (referred to hereafter as DECCW Approved Methods) and contemporary standards adopted by the Department of Planning in recent project approvals that lie outside of this document. A computer-based dispersion model is used, with local meteorological data and estimates of dust emissions, as the best available scientific tool to predict the concentration and deposition rate of particulate matter from the proposed Warkworth Extension and other mines expected to be operating concurrently with Warkworth Mine.

1.1 Scope of work

The scope of work for this study includes:

- A description of the project focussing on aspects relevant for air quality;
- A review of meteorological conditions in the area;
- A review of air quality monitoring data undertaken with a view to describing existing air quality conditions and establishing background air quality;
- An analysis of the project and dust emissions inventories for representative stages in the life of the mine;
- A description of the modelling approach used to predict the concentrations of particulate matter and dust deposition for comparison with ambient air quality assessment criteria;
- Predicted dispersion and dust fallout patterns due to emissions from the proposed modifications;
- Predicted cumulative effects with other mining operations and existing sources of dust;
- Consideration of dust mitigation and management measures to minimise dust emissions; and
- A review of greenhouse gas emissions generated from the proposal.

2 PROJECT DESCRIPTION

2.1 The existing site

Warkworth Mine is approximately 15 km southwest of Singleton and approximately 5 km east-northeast of the township of Bulga in the NSW Hunter Valley. The location and mine lease of the project area is shown in **Figure 2.1**. The site is surrounded by other mining operations including Mount Thorley, Wambo, Bulga and Hunter Valley Operations South mines.

The nearest sensitive receptors to the Warkworth mine are also shown in **Figure 2.1**. Identification labels have been given to each residence and are provided in tabular form with figure reference in **Appendix A**. They show coordinates and identification label for each of the residences considered in this assessment. It should be noted that residences have been identified by the proponent by air photo interpretation with field verification limited to publicly accessible locations. The locations are regarded as representative and it may be possible that some properties may be missed and others incorrectly identified as receptors when they are not. This is inherent with the methods that are available for residence mapping. Contours are provided to capture any of these anomalies.

The mine site is typically rural grassland and woodland with moderately hilly terrain. A significant terrain feature of the area is the steep escarpment along the edge of the valley to the west of Bulga. **Figure 2.2** presents a pseudo 3-dimensional terrain plot of the area surrounding the site.

2.2 Proposed development

The proposed Warkworth Extension is for continuation of open-cut mining to the west for a period of 21 years and to extract a maximum of 18 Mtpa of ROM coal per year. Mining will progress in a general east to west direction with overburden deposited in emplacement areas behind the general progression of mining within Warkworth Mine but also within the Mount Thorley Mine to the south.

Detailed mine and project planning has been undertaken with indicative stages throughout the 21-year life. As the mine plan between years is relatively consistent, modelling has been conducted at years 2, 9, and 21 to predict potential impacts from initial mining, the period in which mining is forecast to intersect Saddleback Ridge and the last year of mining furthest to the west.

Upgrades to existing infrastructure are also planned and aging equipment will be replaced to allow for improved mining efficiencies.

Mining activities will involve a combination of draglines, truck and shovel operations. The ROM coal will be transported to either the Warkworth Coal Preparation Plant (CPP) or the Mount Thorley CPP for processing, similar to current practices. Small quantities of ROM coal may bypass the washing process at Warkworth CPP depending on customer requirements. Transport of coal to Mount Thorley CPP is via the existing bridge over Putty Road. The ROM coal from Mount Thorley Mine can also be transported to Warkworth CPP if required. Coal from the Warkworth CPP may be transported via conveyor to either the Mount Thorley Coal Loader or to Redbank Power Station. Coal loaded onto trains at the Mount Thorley Coal Loader is transported to Newcastle for export.

The Mount Thorley CPP has land use approval under the Mount Thorley consent; however the proposed Warkworth Extension includes continuing the operation of the Mount Thorley Coal Preparation Plant beyond the expiry of the Mount Thorley consent in June 2017.

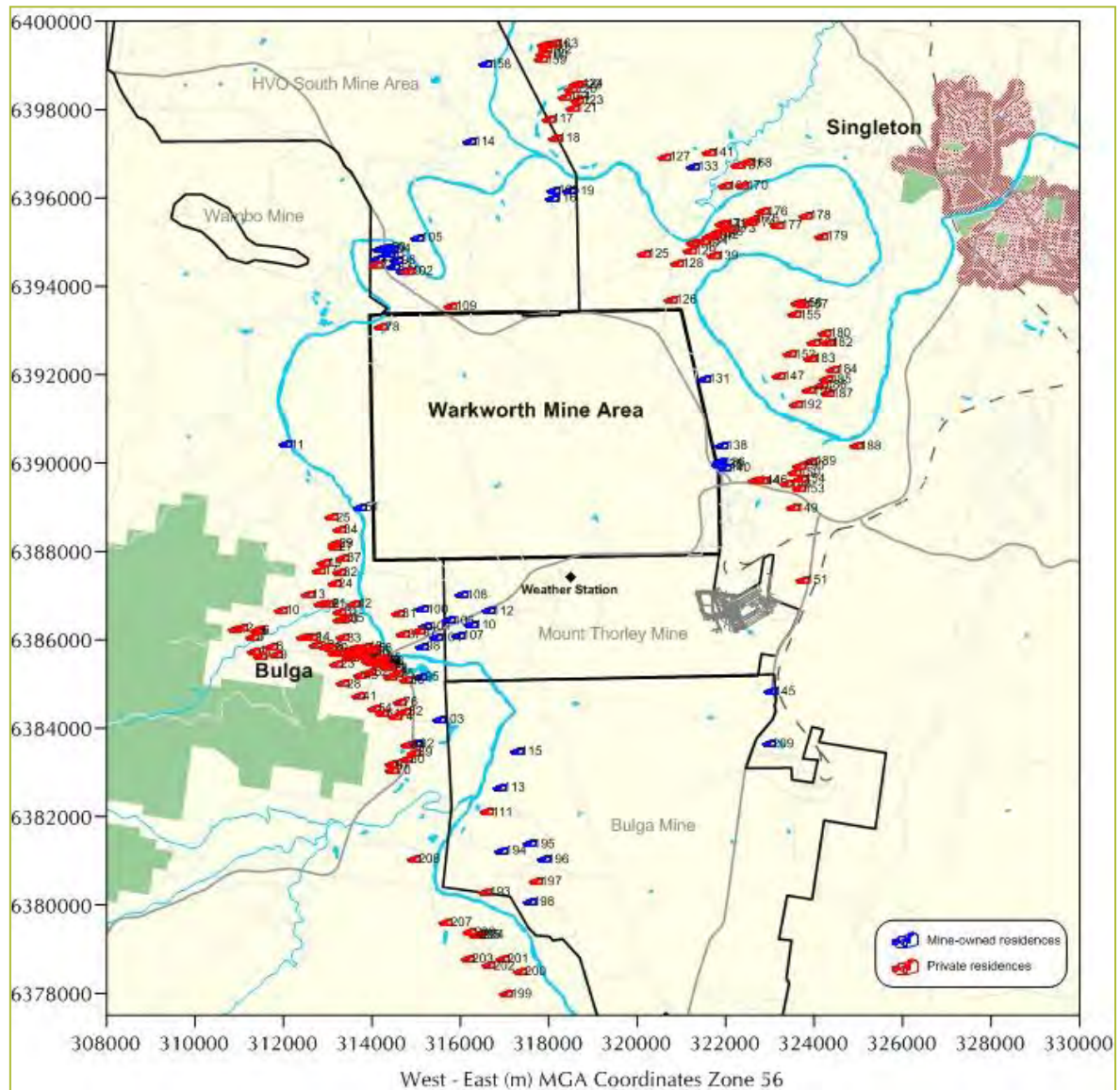


Figure 2.1: Warkworth Extension Project Area

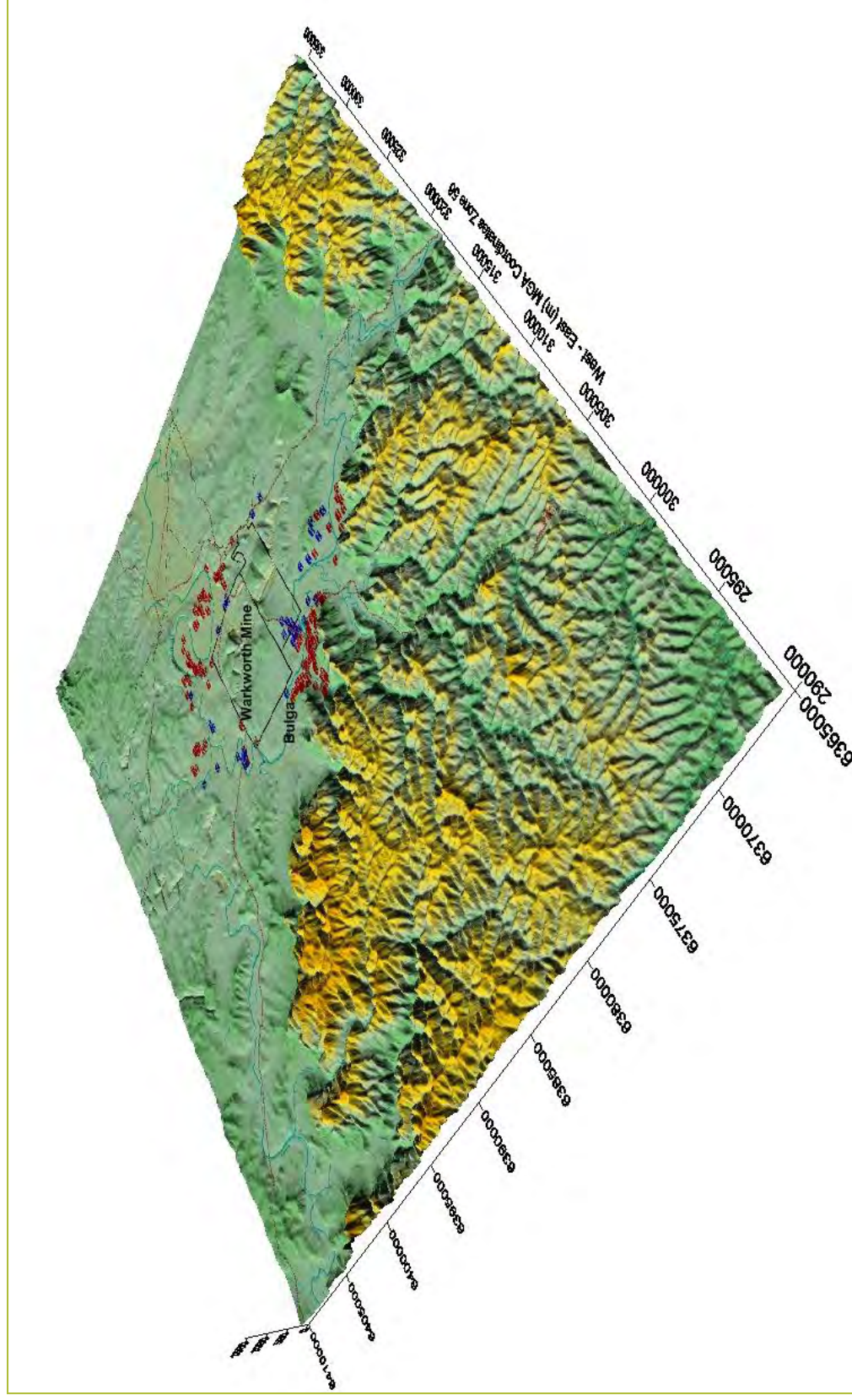


Figure 2.2: Pseudo 3D-plot of terrain surrounding Project Area

3 AIR QUALITY ASSESSMENT CRITERIA

Extraction of coal requires the clearing of land and excavation of overburden material to recover the coal by heavy earth moving equipment. These activities generate fugitive dust emissions in the form of particulate matter described as total suspended particulate matter (TSP)^a, particulate matter with equivalent aerodynamic diameters 10 μm or less (PM_{10})^b and particles with equivalent aerodynamic diameters of 2.5 μm and less ($\text{PM}_{2.5}$).

In addition, combustion engines from vehicles also release air emissions through vehicle exhausts, including carbon monoxide (CO) and minor quantities of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). These are the relevant emissions that are considered in this air quality assessment.

In practice, emissions of CO, SO_2 and NO_2 will occur from diesel-powered equipment. Emissions on open cut mines are comparatively small and too widely dispersed to give rise to significant off-site concentrations. For this reason these pollutants are not considered further in this report.

This section provides information on the air quality criteria used to assess the predicted impacts of the project. The assessment criteria provide benchmarks, which are intended to protect the community against the adverse effects of air pollutants. These criteria generally reflect current Australian community standards for the protection of health and protection against nuisance effects. To assist in interpreting the significance of predicted concentration and deposition levels, some background discussion on the potential harmful effects of dust is provided below.

3.1 Particulate matter

PM consists of dust particles of varying size and composition. The potential for harmful effects on human health is dependent on size and/or chemical composition.

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 refer to measures of the total mass of all particles suspended in air. This is referred to as Total Suspended Particulate matter (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 health-based assessment criteria used by DECCW have, to a large extent, been developed by reference to epidemiological studies undertaken in urban areas with large populations where the primary pollutants are the products of combustion. This means that, in contrast to dust of crustal^c origin, the particulate matter from urban areas would be composed of smaller particles and would generally contain acidic and carcinogenic substances that are associated with combustion. The indication therefore is that particulate matter of crustal origin, such as dust from mining, may be less harmful to health as it contains a smaller fraction of fine particulate

^a TSP refers to all particles suspended in air. In practice, the upper size range is typically 30 μm .

^b PM_{10} refers to all particles with equivalent aerodynamic diameters of less than 10 μm , that is, all particles that behave aerodynamically in the same way as spherical particles with a unit density.

^c Crustal dust refers to dust generated from materials derived from the earth's crust.

matter, (e.g. $PM_{2.5}$ and PM_{10}) and also relatively less matter containing acidic and carcinogenic substances.

Just as PM_{10} particles are a sub-component of TSP, so $PM_{2.5}$ particles are a sub-component of PM_{10} and therefore a sub-component of TSP. $PM_{2.5}$ are fine particles with aerodynamic diameters of $2.5\text{ }\mu\text{m}$ or less that can penetrate deep into the respiratory system and there is evidence that particles in this size range are more harmful than the coarser component of PM_{10} namely the 2.5 to $10\text{ }\mu\text{m}$ fraction.

Mining emissions will also include particles from diesel exhausts in activities where diesel powered equipment is used. Thus mining generates particles in all the above size categories, namely $PM_{2.5}$, PM_{10} and TSP. However, the great majority of the particles from mining operations are due to the abrasion or crushing of rock and coal and general disturbance of dusty material. As such most of the emissions will be larger than $2.5\text{ }\mu\text{m}$. This is in contrast to particles found in bushfire smoke, or in the atmosphere in urban areas, where many of the particles are the result of combustion processes. A study of the distribution of particle sizes near (10 to 200 m) mining dust sources was undertaken on behalf of the State Pollution Control Commission (SPCC – now EPA) in 1986. The average of approximately 120 samples showed that $PM_{2.5}$ comprised 4.7% of the TSP, and PM_{10} comprised 39.1% of the TSP in the samples (**SPCC, 1986**). Thus, although emissions of $PM_{2.5}$ do occur from mining the percentages of the emissions in this size range are small and in practice the concentrations of $PM_{2.5}$ in the vicinity of mining dust sources are likely to be low compared with internationally recognised goals.

In May 2003, NEPC released a variation to the NEPM (**NEPC, 2003**) to include advisory reporting standards for $PM_{2.5}$. The advisory reporting standards for $PM_{2.5}$ are a maximum 24-hour average of $25\text{ }\mu\text{g}/\text{m}^3$ and an annual average of $8\text{ }\mu\text{g}/\text{m}^3$. The aim of the reporting standard was to gather sufficient data nationally to facilitate the review of the Air Quality NEPM which commenced in 2005 and was due to be completed during 2006. The review would include a protocol setting out monitoring and reporting requirements for particles as $PM_{2.5}$. In November 2009, NEPC released a consultation draft for the proposed approach to setting national air quality goals, however at present; there is no time line for the states to attain compliance with any $PM_{2.5}$ goals.

At this stage, the advisory reporting $PM_{2.5}$ standards are not part of the NSW DECCW assessment criteria, however predictions have been made as to the likely contribution that emissions from the proposed Warkworth Extension would make to ambient $PM_{2.5}$ concentrations. These predictions are provided as isopleth figures in **Appendix B**, with the proposed advisory standard shown in red.

Table 3.1 and **Table 3.3** summarise the air quality goals that are relevant to this study. The air quality goals for TSP and annual average PM_{10} relate to the total dust burden in the air and not just the dust from the project. In other words, consideration of background dust levels needs to be made when using these goals to assess potential impacts. This is discussed further in **Section 4.3**.

Where mining projects are committed to best practice mitigation and management measures, the 24-hour average PM_{10} dust contribution from the project is applied by government to assess the potential for adverse impacts. For such projects, the practice, as demonstrated in contemporary project approvals is for DECCW to apply the maximum 24-hour average PM_{10} level in any year to assess the potential for impacts from the project, and for the Department of Planning to invoke requirements for acquisition, negotiated agreements and the like if this criterion is exceeded on more than 5 days in any year (a 98.6 percentile level of compliance).

Table 3.1: Air quality standards / goals for particulate concentrations

Pollutant	Averaging period	Standard / Goal	Agency
Total suspended particulates (TSP)	Annual mean	90 $\mu\text{g}/\text{m}^3$	• NHMRC
Particulate matter with an equivalent aerodynamic diameter less than 10 μm (PM_{10})	24-hour maximum	50 $\mu\text{g}/\text{m}^3$	• NSW DECCW impact assessment criteria; • NEPM reporting goal, allows five exceedences per year for bushfires and dust storms;
	Annual mean	30 $\mu\text{g}/\text{m}^3$	• NSW DECCW impact assessment criteria; • DoP acquisition criteria

Notes: $\mu\text{g}/\text{m}^3$ – micrograms per cubic metre, μm – micrometre;

3.1.1 Department of Planning Acquisition Criterion for Particulate Matter

While the DECCW applies the maximum 24-hour average PM_{10} level in any year to assess the potential for impacts from the project, the Department of Planning (DoP) in contemporary project approvals have invoked requirements for acquisition, negotiated agreements and the like if the DECCW criterion is exceeded on more than 5 days in any year (a 98.6 percentile level of compliance). This DoP criterion and also that for annual average PM_{10} , are outlined in **Table 3.2**.

Table 3.2: DoP acquisition criterion for Particulate matter

Pollutant	Averaging period	Criterion	Percentile	Condition
Particulate matter (PM_{10})	24-hour maximum	50 $\mu\text{g}/\text{m}^3$	98.6	Incremental
	24-hour maximum	150 $\mu\text{g}/\text{m}^3$	99	Total
	Annual	30 $\mu\text{g}/\text{m}^3$	-	Total
TSP	Annual	90 $\mu\text{g}/\text{m}^3$	-	Total

Notes: $\mu\text{g}/\text{m}^3$ – micrograms per cubic metre, μm – micrometre;

3.2 Dust deposition

In addition to an assessment for potential health impacts, airborne dust is also assessed due to the potential to cause nuisance by depositing on surfaces. **Table 3.3** shows the criteria for maximum acceptable increases in dust deposition over existing dust levels from an amenity perspective (**DEC, 2005**).

Table 3.3: DECCW criteria for insoluble dust deposition

Pollutant	Averaging period	Maximum increase in deposited dust	Maximum total deposited dust
Deposited dust	Annual	2 $\text{g}/\text{m}^2/\text{month}$	4 $\text{g}/\text{m}^2/\text{month}$

4 EXISTING ENVIRONMENT

This section describes the dispersion meteorology, local climate conditions and existing dust levels in the area surrounding Warkworth mine.

4.1 Dispersion meteorology

The Gaussian dispersion model used for this assessment (see **Section 6**) requires information about the dispersion characteristics of the area. In particular, data is required for wind speed, wind direction, atmospheric stability class^d and mixing height^e.

DECCW has specified requirements for meteorological data that are used for air dispersion modelling in their DECCW Approved Methods. The requirements are as follows:

- Data must span at least one year;
- Data must be 90% complete; and
- Data must be representative of the area in which emissions are modelled.

Meteorological data are collected at a number of sites in the area. The most relevant of these is the Charlton Ridge meteorological station operated by Warkworth Mine at the site marked "weather station" on **Figure 2.1**.

Good quality weather data are quite important in this situation, given the relatively close proximity of Bulga and the potential complication of steep escarpments near the edge of the valley nearby.

Annual and seasonal windroses prepared from data collected for the period 2006 to 2008 from the Charlton Ridge meteorological station were examined and are presented in **Figure 4.1** to **Figure 4.3**.

Analysis of the Charlton Ridge data shows that the wind fields for the three consecutive years examined are generally consistent with each other, which is expected as the meteorology of an area generally does not change significantly from year to year. The pattern of winds presented in the windroses is typical of seasonal wind patterns experienced in the Hunter Valley.

A detailed assessment and validation of three consecutive years of meteorological data was conducted however due to the differences between the Charlton ridge data and data used in the last Warkworth Coal Mine assessment (**Holmes Air Sciences, 2002**) which was from a different site. Validation of the data obtained from Charlton Ridge meteorological station was undertaken for a period of three weeks by installing two further metrological station on the adjacent ridge and in the valley between the mine and Bulga. This validation, discussions with staff and analysis of the earlier years of data revealed that the Charlton Ridge data are representative of the prevailing conditions in the area and that the earlier data are not

^d In dispersion modelling, stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford stability class assignment scheme, as used in this study, there are six stability classes A through to F. Class A relates to unstable conditions such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions.

^e The term mixing height refers to the height of the turbulent layer of air near the earth's surface into which ground-level emissions will be rapidly mixed. A plume emitted above the mixed-layer will remain isolated from the ground until such time as the mixed-layer reaches the height of the plume. The height of the mixed-layer is controlled mainly by convection (resulting from solar heating of the ground) and by mechanically generated turbulence as the wind blows over the rough ground.

representative as the earlier station was not well sited. It is noted that this potential issue was mentioned in the previous 2002 assessment.

For the purposes of this assessment, meteorological data collected from Charlton Ridge for 2008 have been used as the most accurate data set representative of typical weather conditions in the area.

Analysis of the 2008 windroses show the most common winds on an annual basis are from the north-northwest and the south-southeast. Very few winds originate from the northeast and southwest quadrants. During summer, winds predominately occur from the southeast quadrant with winds from the south-southeast being most dominant. In autumn the dominant wind occurs from the south-southeast with a small portion of winds from the northwest. Winds during the winter months are from the north-northwest and northwest with a small portion from the south. During spring the dominant wind direction is from the north-northwest with an even portion of winds ranging from the south to the east-southeast.

The mean wind speed for the Charlton Ridge meteorological station in 2008 was 3.32 m/s and the percentage of calms (wind speeds less than 0.5 m/s) was 1.5%.

To use the wind data to assess dispersion, it is also necessary to have data on atmospheric stability. The term atmospheric stability refers to the dispersive capacity of the atmosphere. In this study a classification scheme referred to as the Pasquill-Gifford scheme has been used. The Pasquill-Gifford scheme classifies the atmosphere into six (sometimes seven) classes A to F (or G in the extended scheme);

- Class A occurs in the day with light winds and strong solar radiation with strong convection; dispersion is rapid.
- Class D, also known as “neutral conditions” occurs with moderate to strong winds and/or overcast skies; again dispersion is rapid.
- Class F (and G) occurs under light winds with clear skies at night. These conditions are conducive to the formation of ground-based inversions and as such, dispersion is slow.
- Classes B and C are intermediate between A and D, and E is intermediate between D and F.

Table 4.1: Frequency of occurrence of stability classes

Stability Class	Percentage Frequency (%)		
	2006	2007	2008
A	7.2	7.2	6.7
B	4.4	4.5	5.0
C	11.5	11.2	14.5
D	58.2	59.1	55.4
E	13.7	13.1	12.6
F	5.0	4.9	5.8
Total	100	100	100

Table 4.1 shows the frequency of occurrence of the stability categories expected in the area for the years 2006 to 2008. Overall, stability class D occurs for the greatest proportion of time in the surrounding area. D class stability is characterised by rapid dispersion. Joint wind speed, wind direction and stability class frequency tables for the Charlton Ridge meteorological station data for the year 2008 are provided in **Appendix C**.

Mixing height was determined using a scheme defined by **Powell (1976)** for day-time conditions and an approach described by **Venkatram, (1980)** for night-time conditions. These two methods provide a good estimate of mixing height in the absence of upper air data.

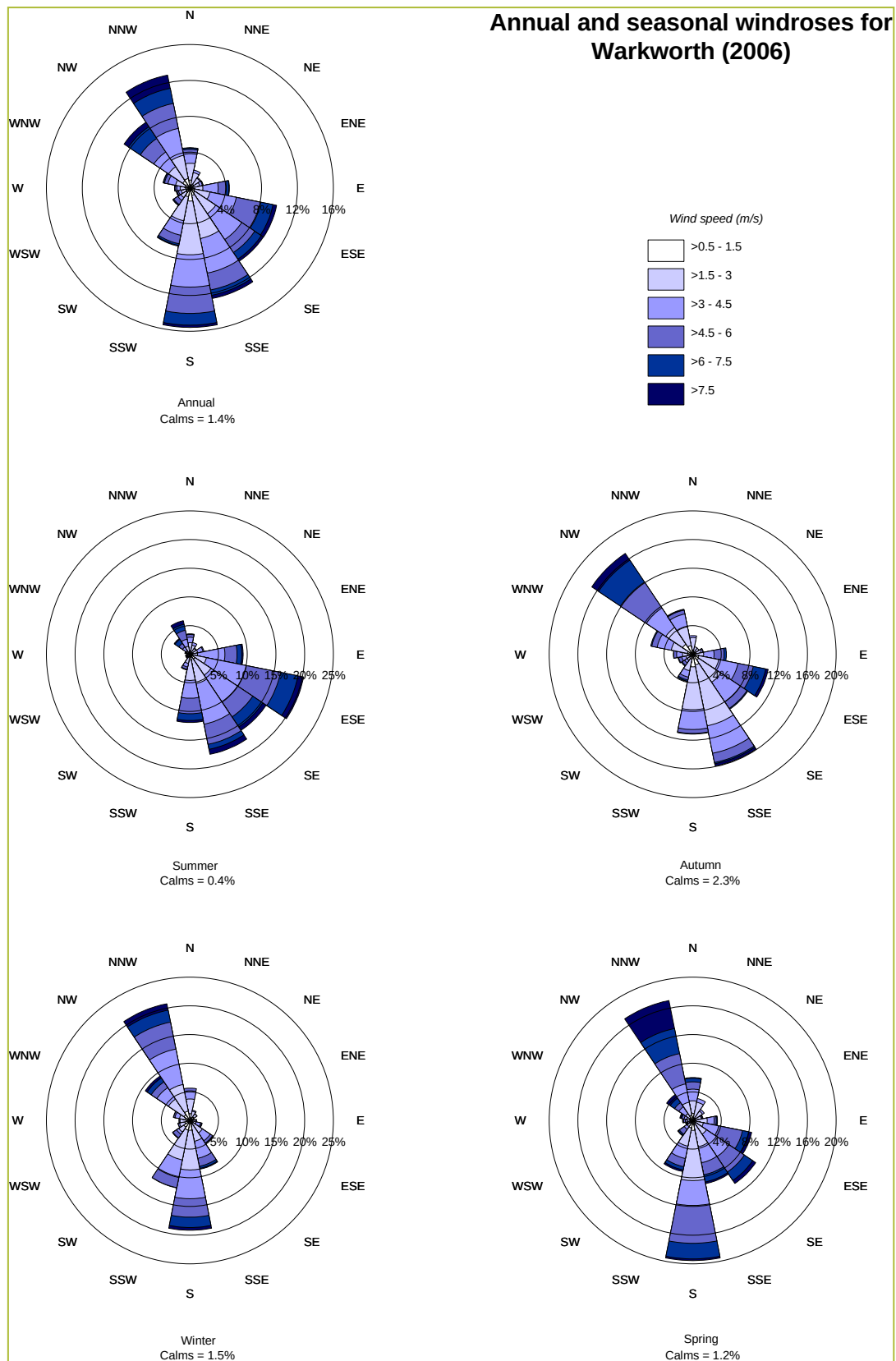


Figure 4.1: Annual and seasonal windroses for Warkworth (2006)

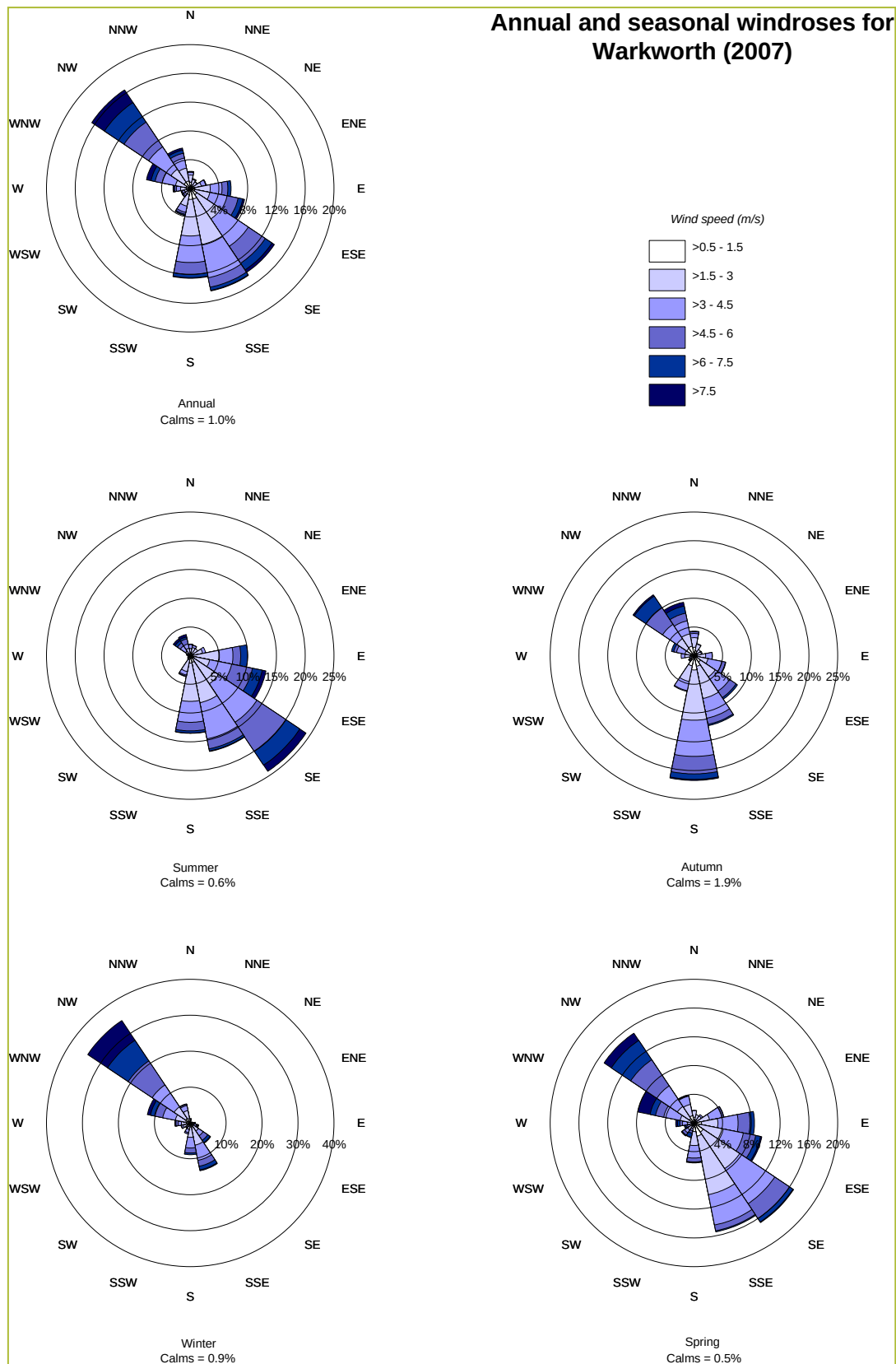


Figure 4.2: Annual and seasonal windroses for Warkworth (2007)

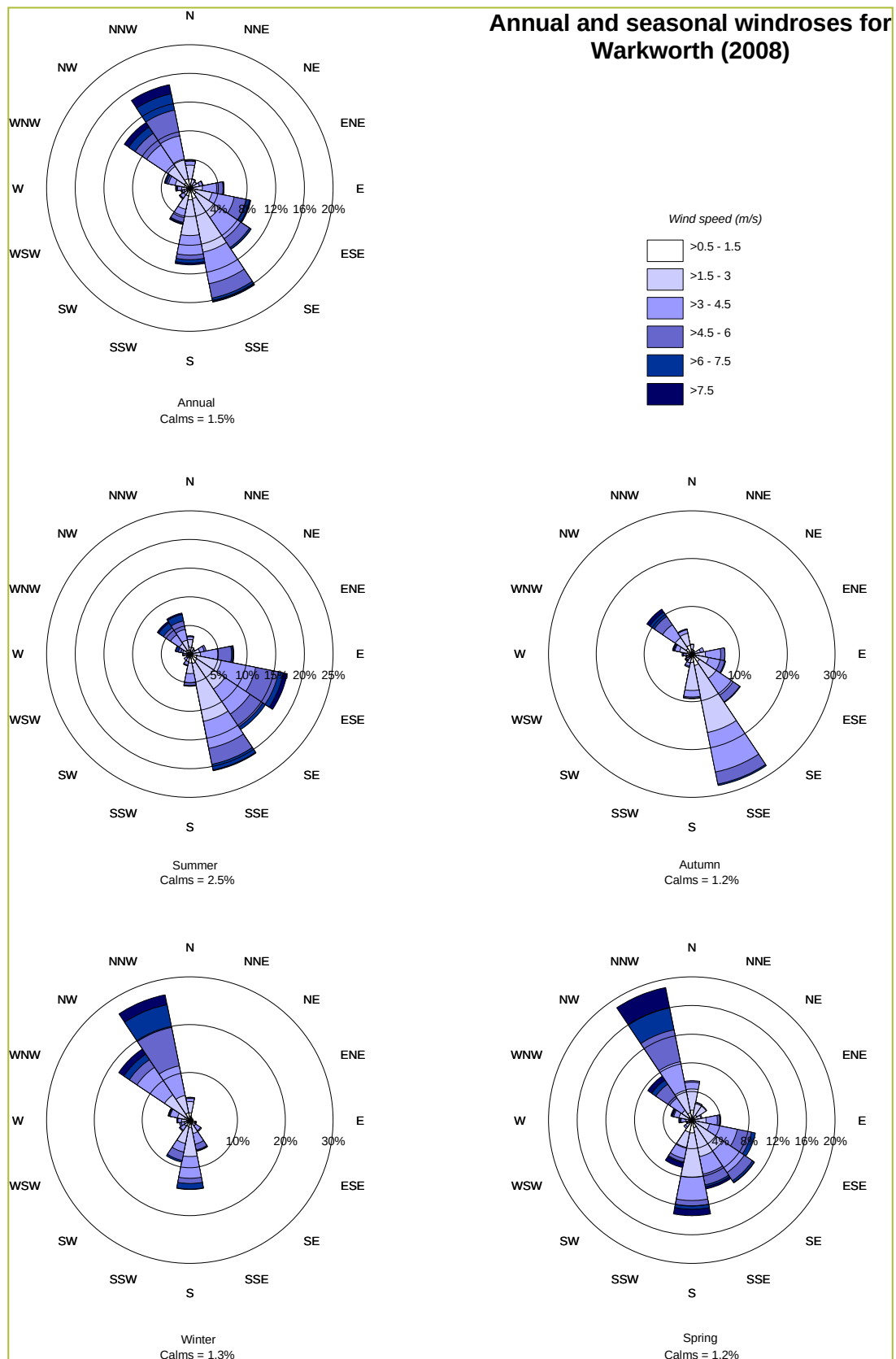


Figure 4.3: Annual and seasonal windroses for Warkworth (2008)

4.2 Climate data

Climatic data are available from the Bureau of Meteorology monitoring station at Singleton Army Base (Station Number 061275) located approximately 9 km east of Warkworth mine. Data were collected for this station for 21 years during the period 1969 to 1990 (**Bureau of Meteorology, 2009**). The station provides information on the long-term average values of climatic elements such as temperature and rainfall and the number of raindays per year etc.

Table 4.2 presents a summary of temperature and rainfall data for the Singleton Army Base station. Temperature data consist of monthly averages of 9am and 3pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean rainfall and the average number of raindays per month.

The annual average maximum and minimum temperatures at Singleton Army Base are 24.4°C and 12°C respectively. On average January is the hottest month with an average maximum temperature of 30.6°C. July is the coldest month, with average minimum temperature of 5.4°C.

Rainfall data collected at Singleton Army Base show that January is the wettest month, with an average rainfall of 94.3 mm. The average annual rainfall is 720.4 mm with an annual average of 78.4 raindays.

Table 4.2: Temperature and rainfall data from Singleton Army Base

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Dry-bulb Temperatures (°C)													
Dry-bulb	22.6	22.0	21.1	17.7	13.8	10.6	9.6	11.4	15.5	19.1	19.8	22.5	17.1
3 pm Mean Dry-bulb Temperatures (°C)													
Dry-bulb	28.6	27.7	26.5	23.4	19.8	16.7	16.2	18.3	21.1	24.1	25.4	28.5	23.0
Daily Maximum Temperature (°C)													
Mean	30.6	29.6	28.1	24.8	21.0	17.7	17.1	19.2	22.2	25.4	27.4	30.2	24.4
Daily Minimum Temperature (°C)													
Mean	17.6	17.8	16.0	12.8	9.7	6.8	5.4	6.3	8.8	11.8	14.1	16.6	12.0
Rainfall (mm)													
Mean	94.3	88.9	72.7	58.4	59.7	37.9	28.2	37.1	45.3	69.1	68.3	63.0	720.4
Raindays (Number)													
Mean	8.0	7.7	7.7	6.3	6.3	5.4	4.9	5.1	5.7	7.1	7.7	6.5	78.4

Station number 061275; Commenced: 1969; Last record: 1990; Latitude (deg S): -32.61; Longitude (deg E): 151.17

Source: **Bureau of Meteorology (2009)**

4.3 Existing air quality

4.3.1 Introduction

Air quality standards and goals refer to pollutant levels that include the contribution from specific projects and existing sources. To fully assess the potential impacts of a proposed development against all relevant air quality standards and goals (see **Section 3**) it is necessary to characterise the existing or background conditions.

Data from the existing monitoring programs in the area surrounding the Warkworth mine which were collected since January 2007 were reviewed for this report. The locations of the air quality monitoring sites are shown in **Figure 4.4**.

The air quality monitoring network consists of 11 dust deposition gauges and eight High Volume Air Samplers (HVAS), six which measure TSP and two of which are fitted with size-selective inlets to measure concentrations of PM₁₀. The instruments are located on private land surrounding the mine site.

In addition to these monitors, four Tapered Element Oscillating Microbalances (TEOM) measure PM₁₀ concentrations in real-time and an additional 18 dust deposition gauges are used for internal dust monitoring purposes.

The monitors measure dust deposition rates and the TSP and PM₁₀ concentration levels in the air due to emissions from all sources that contribute to dust in the area. These sources include emissions from existing mining at the Warkworth open cut mine, emissions from neighbouring mines, agricultural activities and other emission sources in the area.

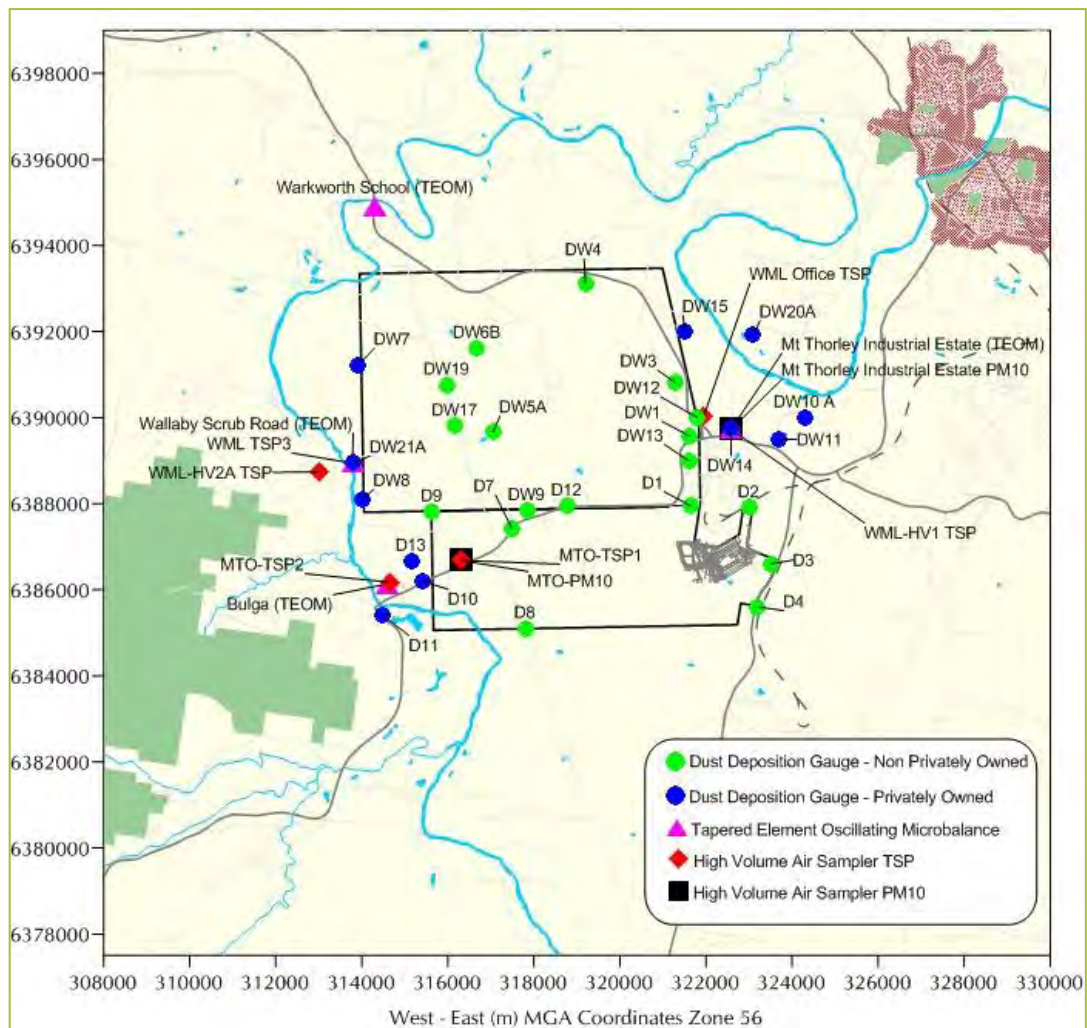


Figure 4.4: Location of dust and TSP monitoring sites

4.3.2 Dust deposition

Dust deposition data from January 2007 to August 2009 have been reviewed for this study. The current Warkworth monitoring network consists of 11 dust deposition monitors located on private land (refer to **Figure 4.4** for the locations). The network is designed to measure existing dust deposition rates in the vicinity of the mine. Dust deposition is measured using a simple device consisting of a funnel and bottle to measure the rate at which dust settles onto the surface over periods approximating one month.

The monitoring results for the relevant gauges have been provided by Warkworth Mine and are outlined in **Appendix D**. The results measure total dust levels in the area of the gauge, including the contribution for the existing Warkworth mine, adjacent mines, agricultural and other dust sources.

Table 4.3 summarises the dust deposition levels monitored at Warkworth from January 2007 to August 2009.

Field notes that accompany the monitoring data indicate that some of the samples were contaminated with material such as bird droppings, insects or plant matter. This is a relatively common occurrence for this type of monitoring, and accordingly, contaminated samples have been excluded from the reported annual average results.

Table 4.3: Annual Average Insoluble Deposition (g/m²/month)

Gauge	2007	2008	2009*
DW7	2.6	1.8	1.7
DW8	1.5	1.2	1.2
DW10 A	2.0	1.3	1.4
DW11	1.7	2.1	1.7
DW14	1.9	2.4	1.7
DW15	2.1	2.3	1.8
DW20A	1.3	1.3	1.2
DW21A	2.2**	1.4	1.1
D10	1.6	1.6	1.5
D11	1.2	1.2	1.3
D13	1.7	1.8	1.6
Average	1.8	1.7	1.5

*Results available up to August 2009

**Dust gauge DW21A was commissioned in November 2007; hence only 2 months of data is available for 2007

Typically in the Hunter Valley, land that is relatively remote from a particular source of dust such as mines would experience annual average dust deposition levels around 0.5 g/m²/month. Thus, gauges recording levels in this range can generally be considered to be free from the effects of mining dust.

All gauges recorded an annual average insoluble deposition level of less than the criteria of 4 g/m²/month.

Warkworth Mine also maintains an internal network of dust deposition gauges to monitor levels near the mine to assist with characterising the sources and areas of dust generation. A summary of results are provided in **Table 4.4** below. These gauges record relatively high dust deposition levels in comparison to the gauges near receptors. This is because the internal gauges are situated close to mining activities and trafficked areas (see **Figure 4.4**). The internal gauges therefore provide diagnostic data rather than data that would be used to assess whether the DECCW's 4 g/m²/month (annual average) criterion is being met or not.

Table 4.4: Annual Average Dust Deposition (g/m²/month)

Gauge	2007	2008	2009*
D1	3.2	5.6	-**
D12	3.9	6.2	-**
D2	2.2	2.3	1.3
D3	2.2	2.6	2.0
D4	3.9	3.5	2.1
D7	2.2	1.8	1.9
D8	2.1	2.3	1.6
D9	1.6	1.8	2.2
DW1	3.5	3.6	2.3
DW13	3.3	3.6	2.3
DW12	2.6	2.5	1.8
DW17	1.9	1.9	1.7
DW19	2.3	2.3	1.8
DW3	2.5	2.8	2.2
DW4	2.0	2.2	2.2
DW5	1.9	2.3	2.4
DW6A	3.5	3.0	4.2
DW9	2.2	2.1	1.4
Average	2.6	2.9	2.1

*Results available up to August 2009

**insufficient data available

4.3.3 Particulate Matter Concentrations (TSP and PM₁₀)

4.3.3.1 TSP

The main sources of particulate matter in the wider area include active mining areas on the site, other nearby mines and agricultural activities, with minor emissions from traffic on unsealed roads and local anthropogenic activities such as wood heating. Activities occurring within the Mount Thorley Industrial area also have potential to generate particulate matter. The unmined portions of the proposed Warkworth mine extension are predominantly grassland and woodland and therefore are currently only a minor source of particulate matter.

TSP concentrations in the area surrounding the Warkworth mine are monitored at six locations (see **Figure 4.4**). Measurements are made over a 24-hour period, every sixth day to ensure measurements are not always collected on the same day; using a High Volume Air Sampler (HVAS) in accordance with AS 2724.3 1987 (Australian Standards, 1984). The results, for the period January 2007 to August 2009 are summarised in **Table 4.5** below and are presented in **Figure 4.5**. The data are presented in full in **Appendix D**.

The calendar year annual average TSP concentration for each of the six monitors is below the DECCW's 90 µg/m³ criterion for all years reviewed.

Table 4.5: Annual Average TSP levels (µg/m³)

Monitor	Annual Mean (µg/m ³)		
	2007	2008	2009*
WML HV1 TSP	72.1	62.2	63.8
WML HV2A TSP	38.2	35.2	33.1
MTO-TSP2	38.3	37.6	37.8
MTO-TSP1	41.4	38.5	36.9
WML Office TSP	77.7	66.1	66.2
WML TSP3	-	35.2**	34.9
Average	53.5	45.8	45.5

*Results available till August 2009

**HVAS monitor; WML TSP3 commissioned 15/02/2008

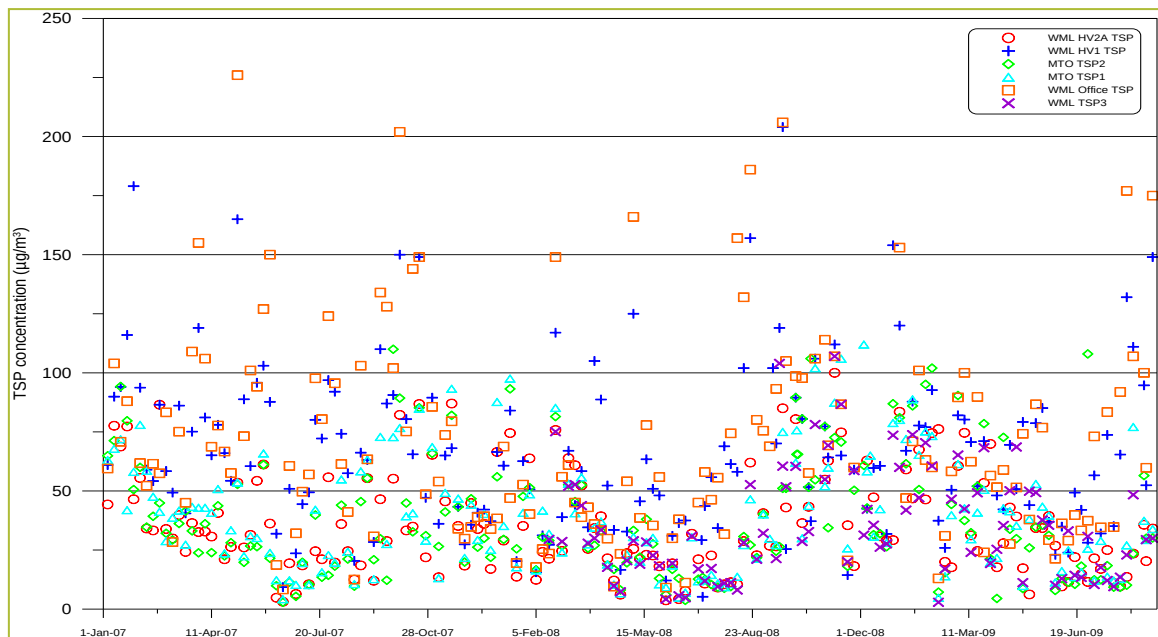


Figure 4.5: HVAS 24-hour average TSP concentrations

The highest recorded 24-hour TSP concentration was $226 \mu\text{g}/\text{m}^3$; recorded at the WML Office TSP monitoring station on 5 May 2007. Meteorological data for this day show that the average wind speed for the day was approximately 2.7 m/s with a dominant wind direction from the southeast. By comparison, WML HV1 TSP monitoring station, located approximately 0.7 km east-southeast of WML Office TSP, was upwind during this event and also recorded an elevated reading of $165 \mu\text{g}/\text{m}^3$. This would indicate that dust levels were regionally elevated during this event and not a direct result of emissions generated from Warkworth mine.

For the most recent monitoring data collected in 2009, the maximum 24-hour TSP concentration was $177 \mu\text{g}/\text{m}^3$, recorded on 4th August 2009 at WML Office TSP monitoring station. The WML HV1 TSP monitoring station recorded a similar high reading on this day of $132 \mu\text{g}/\text{m}^3$. Other sites did not record elevated concentrations on this day, suggesting this was a localised event. For this day, the meteorological data show that winds were moderate with an average speed of 2.0 m/s, and the dominant wind direction was from the south-southeast. This indicates Warkworth mine operations were not attributable to this elevated reading.

The WML Office TSP and WML HV1 TSP monitoring stations show the highest readings, which would be expected as the location of these monitors is near local sources of dust.

4.3.3.2 PM_{10}

The air quality monitoring network for Warkworth Mine includes monitoring of PM_{10} with size-selective inlet heads attached to two HVAS monitors. Additional real-time PM_{10} monitoring using TEOMs is also conducted as part of the internal monitoring scheme for Warkworth Mine. Four monitoring stations have been setup around the general vicinity of the mine and enable the mine to monitor PM_{10} levels on a day-by-day basis.

A summary of the PM_{10} data is presented in **Table 4.6** and results are shown graphically in **Figure 4.6**. The data are presented in full in **Appendix D**.

Table 4.6: Annual Average PM₁₀ (µg/m³)

Monitor	Monitor type	Annual Mean (µg/m ³)			24-hour Maximum (µg/m ³)		
		2007	2008	2009 ^a	2007	2008	2009
MTO-PM10	HVAS	16.7	15.2	14.7	41.8	47.5	41.7
Mt Thorley Industrial Estate PM10	HVAS	26.7	27.1	27.8	75.2	98.4	74.6
Wallaby Scrub Road ^b	TEOM	-	-	-	-	71.9	-
Mt Thorley Industrial Estate TEOM ^c	TEOM	-	-	-	-	68.8	-
Bulga ^d	TEOM	-	-	-	52.0	55.8	-
Warkworth School ^e	TEOM	-	-	-	-	63.6	-
Average		21.7	21.2	21.2	-	-	-

a) HVAS results available till August 2009

b) Monitoring period from 10/05/2008 to 31/12/2008

c) Monitoring period from 21/11/2008 to 31/12/2008

d) Monitoring period from 1/01/2007 to 23/04/2008

e) Monitoring period from 1/08/2008 to 31/12/2008

From **Figure 4.6** it can be seen that, generally, the PM₁₀ concentrations in the area are lowest in the cooler, winter months when the prevailing winds are from the north-west, and highest in the warmer, summer months when the prevailing winds are most likely to be from the south-east.

To date, the annual average PM₁₀ concentrations are below the DECCW goal of 30 µg/m³.

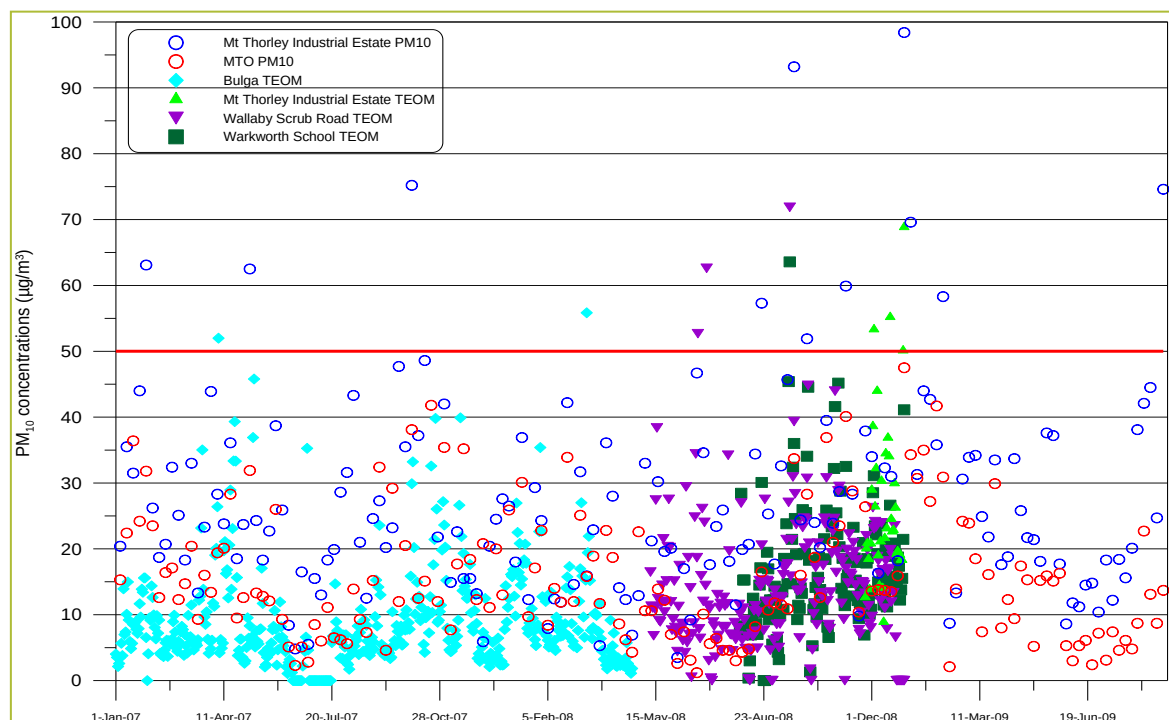


Figure 4.6: HVAS 24-hour PM₁₀ concentrations

The HVAS and TEOM monitors located near the Mount Thorley Industrial Estate record higher values of PM₁₀ than the monitors at other locations. It would appear that these monitors may be directly influenced by dust generating activities taking place locally at the Mount Thorley Industrial Estate as opposed to impacts from the Warkworth Mine itself.

5 ESTIMATED DUST EMISSIONS

Dust emissions arise from various sources within open-cut coal mines. Total dust emissions were estimated by analysing the types of dust generating activities taking place at the site for three mine stage years (the three key years over the mine life).

For predictive modelling, emissions from dust generating sources associated with a proposed development are estimated and are referred to as emission factors. These emission factors allow for the various sources of a proposed development to be simulated in the modelling.

Emission factors developed both locally and by the US EPA were used to estimate the amount of dust produced by each activity. For mining operations, the study draws on US EPA emission factors. The emission factors applied are considered to be the most applicable and representative for determining dust generation rates for the proposed activities. The fraction of fine, inhalable and coarse particles for each activity were taken into account in the dispersion modelling.

The assessment considered three mine plan years to represent the proposed extension. The years represent the early stage of mining that may have greatest influence on receptors to the east, the middle stage when the mine may have greatest effect towards the north and the final stage, when the mine is at maximum capacity and nearest Bulga Village and would have greatest impacts there.

The three key mine plan years were analysed to determine haul road distances and routes, stockpile and pit areas, equipment operating hours, truck sizes and other details that are necessary to estimate dust emissions for each year. All significant dust generating activities from the proposed operations have been identified and dust emission estimates for the three mine plan years are presented below in **Table 5.1**.

Further details of the methods used in calculating the dust emissions are presented in **Appendix E**. The estimated emissions take account of proposed air pollution controls including passive controls such as those inbuilt into the mine plan, including stockpile size and alignment, length of haul roads and active controls which include the intensity of watering, extent of rehabilitation, etc. Significant effort was made to optimise the mine plan to minimise dust emissions. Further discussion on this is provided in **Section** Error! Reference source not found..

In addition to contributions from the proposed Warkworth Extension, all nearby approved mining operations were included in the modelling to assess cumulative effects. Emissions from other approved mines in the area were derived from estimates provided in air quality impact assessments in the public domain. The total estimated annual TSP emission from approved nearby mines is presented in **Table 5.2**. For the years where there is no estimated annual TSP, it is assumed (as per their current consent) that the other mines no longer operate.

The cumulative impacts presented in the study include an allowance for background dust levels to represent the contribution from other non-modelled sources such as distant mining activity, agricultural activity and the land generally. The modelled contribution from these sources has been increased in this study compared to past assessments to more accurately reflect the actual background dust levels in the Hunter Valley, and to ensure that total dust levels are not underestimated.

It should be emphasised that cumulative impacts depend on the scheduling of mine development outlined in reports in the public domain. Many of the studies present an assessment of worst case effects and are based on specific years of that mine's operation that frequently do not coincide with the three worst case years assessed for this project. Thus the actual scheduling of other mine activity and impacts is likely to differ in scale and time. A conservative approach has been adopted in this study whereby the estimated maximum value of TSP for the other mining operations was adopted, where applicable.

Table 5.1: Estimated TSP Emissions (kg/year)

Activity	Year 2	Year 9	Year 21
OB- Stripping topsoil	3,500	3,500	3,500
OB - Drilling	33,224	28,539	33,002
OB - Blasting	413,822	413,822	413,822
OB - Sh/Ex/FELs loading	150,027	324,369	308,100
OB - Dragline	1,246,376	1,178,966	891,663
OB - Hauling to emplacement area (Warkworth)	2,009,976	4,813,704	4,724,665
OB - Emplacing at area (Warkworth)	150,027	324,369	308,100
OB - Hauling to emplacement area (Mt Thorley)	-	-	1,500,000
OB - Emplacing at area (Mt Thorley)	-	-	72,775
OB - Dozers in Pit	921,615	791,749	700,424
OB - Dozers on Dump & Rehabilitation	848,163	798,426	978,130
CL - Drilling	14,797	12,950	14,018
CL - Blasting	18,040	18,040	18,040
CL - Dozers ripping coal	151,317	132,431	143,360
CL - Sh/Ex/FELs loading	779,773	933,591	1,010,608
CL - Hauling to Warkworth CPP	328,940	437,585	691,579
CL - Emplacing at Warkworth CPP	2,430	2,909	3,149
CL - Rehandle at Warkworth CPP	194	218	236
CL - Loading rejects at Warkworth CPP	599	660	613
CL - Hauling rejects from Warkworth CPP	133,501	147,099	136,816
CL - Emplacing rejects at Mt Thorley	599	660	613
CL - Hauling to Mt Thorley CPP	55,554	892,674	1,184,211
CL - Emplacing at Mt Thorley CPP	2,430	2,909	3,149
CL - Rehandle at Mt Thorley CPP	194	218	236
CL - Loading rejects at Mt Thorley CPP	722	534	685
CL - Hauling rejects from Mt Thorley CPP	53,691	39,673	67,942
CL - Emplacing rejects at Mt Thorley	722	534	685
WE - OB dump area (Warkworth)	2,071,448	1,327,155	-
WE - OB dump area (Warkworth + Mt Thorley)	-	-	1,305,237
WE - Pit area (Warkworth)	1,137,574	991,961	1,369,493
WE - Stockpiles	122,640	122,640	122,640
Grading roads	37,740	43,132	43,132
Total	10,689,636	13,785,016	16,050,626

(OB – overburden, CL – coal, WE – Wind erosion)

Table 5.2: Estimated TSP Emissions from nearby mining operations (kg/year)

Mine	Year 2	Year 9	Year 21
Wambo	5,128,262	5,128,262	-
Mount Thorley	8,600,918	-	-
HVO South	10,902,098	7,568,834	-
Bulga	5,380,417	2,648,745	-

5.1 Mine Plan Optimisation

To reduce potential dust impacts, significant iterative constraints modelling and scrutiny of the mine plans was conducted over some months. Items that were taken into consideration included the alignment and length of haul roads, potential use of chemical stabilizers on haul roads, evaluation of wind erosion of exposed areas and the number of blasts undertaken per year.

The alignment and length of haul roads were found to be a significant source of dust emissions. Constraints modelling evaluation of the proposed mine plan found that dust impacts in the Bulga area would be lower by retaining existing haul routes, even though these were slightly longer and therefore more costly to the mine operation than the proposed routes.

The dragline operation was also considered. Whilst significant improvements are theoretically possible, the results achievable in practice are likely to vary greatly according to the operator at the time, or indeed the same operator between days. Because of this it was not considered to be feasible to adopt a less conservative (more restrictive) operational procedure.

Exposed areas are sources of dust if activity regularly takes place on them. Wind erosion areas were found to be a significant dust source in the original mine plans, and the proposed total exposed areas at any time were significantly reduced in the final mine plan.

The use of chemical stabilizers on haul roads is generally considered capable of reducing unmitigated dust emissions from haul roads by up to 85 per cent, in comparison to a 75 per cent reduction that is achievable through good practice watering. Evaluation of this approach found that the potential risks and additional costs outweighed the potential benefit.

The number blasts on overburden was another potential factor that had been considered. It was found that only a minor reduction in dust impacts was achievable, and blasts did not need to be restricted further.

6 ASSESSMENT APPROACH

The assessment generally follows the DECCW Approved Methods which specify how assessments based on air dispersion models should be undertaken. The Approved Methods include guidelines for the preparation of meteorological data to be used in dispersion models and relevant air quality impact criteria (see **Section 3**).

This assessment generally follows the guidelines in the approved methods, but deviates in relation to the use of the ISCMOD model instead of the AUSPLUME, CALPUFF and TAPM models which are named in the approved methods. The ISCMOD model has been specially developed from the US EPA's ISCST3 model which provides for greater accuracy with the prediction of short-term PM₁₀ concentrations compared to the models referenced in the DECCW Approved Methods. The use of ISCMOD has been accepted for use in NSW by the DECCW for a number of years for recently completed mining and quarry assessments, including mining projects in the Hunter Valley.

ISCMOD was derived from the ISCST3 model by applying changes to the horizontal and vertical dispersion curves following recommendations made by the American Meteorological Society (AMS) Expert Panel on Dispersion Curves (**Hanna et al., 1977**) (see **Holmes Air Sciences, 2007**). The ISCST3 model is fully described in the user manual and the accompanying technical description (**US EPA, 1985**). The modelling used three particle-size categories (0 to 2.5 µm - referred to as PM_{2.5}, 2.5 to 10 µm - referred to as CM (coarse matter) and 10 to 30 µm - referred to as the Rest). Emission rates of TSP were calculated using emission factors derived from **US EPA (1985)** and **SPCC (1983)** (see **Appendix E**).

The distribution of particles was been derived from measurements in the **SPCC (1986)** study. The distribution of particles in each particle size range is as follows:

- PM_{2.5} (FP) is 4.68% of TSP;
- PM_{2.5-10} (CM) is 34.4% of TSP; and
- PM₁₀₋₃₀ (Rest) is 60.92% of TSP.

Each source in the group was assumed to emit at the full TSP emission rate and to deposit from the plume in accordance with the deposition rate appropriate for particles with an aerodynamic diameter equal to the geometric mean of the limits of the particle size range, except for the PM_{2.5} group, which was assumed to have a particle size of 1 µm. The predicted concentration in the three plot output files for each group were then combined according to the weightings in the dot points above to determine the concentration of PM₁₀ and TSP.

The ISCST3 model also has the capacity to take into account dust emissions that vary in time, or with meteorological conditions. This has proved particularly useful for simulating emissions on mining or quarry operations where wind speed is an important factor in determining the rate at which dust is generated.

For the current study, the operations were represented by a series of volume sources located according to the location of activities for the modelled scenarios (see **Figures 6.1 – 6.3**). Estimates of emissions for each source were developed on an hourly time step taking into account the activities that would take place at that location. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of activity and the wind speed. It is important to do this to ensure that long-term average emission rates are not combined with worst-case dispersion conditions, which are associated with light winds. Light winds at a mine site would correspond with periods of low dust generation (because wind

erosion and other wind-dependent emissions rates would be low) and also correspond with periods of poor dispersion. If these measures are not taken then the model has the potential to significantly overstate impacts.

For cumulative modelling, each neighbouring mine was treated as a number of volume sources. These were located at the apparent points of major emissions as estimated from the publicly available information of the pits and/or major dust sources on the mine or facility.

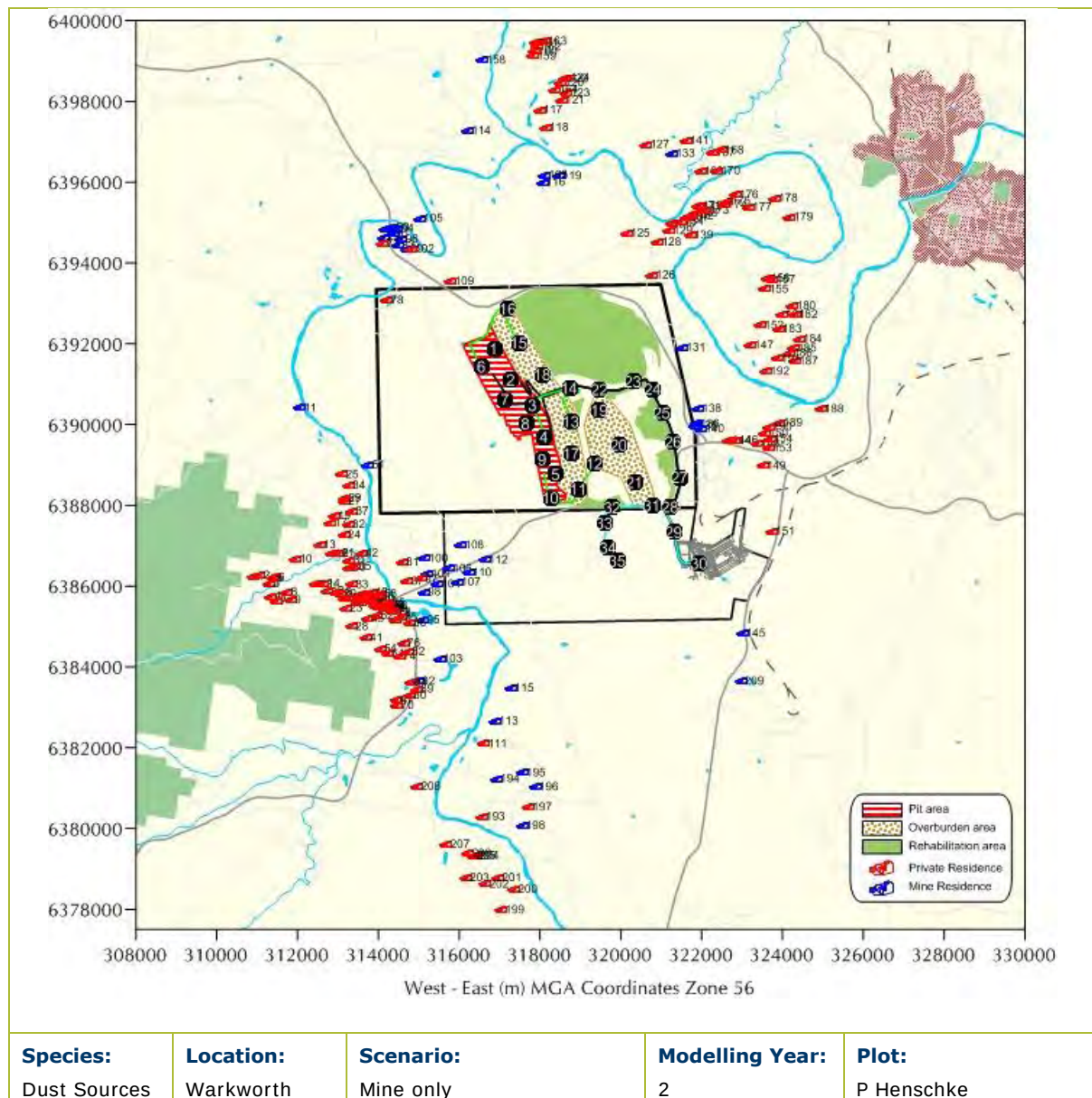


Figure 6.1: Location of modelled dust sources – Year 2

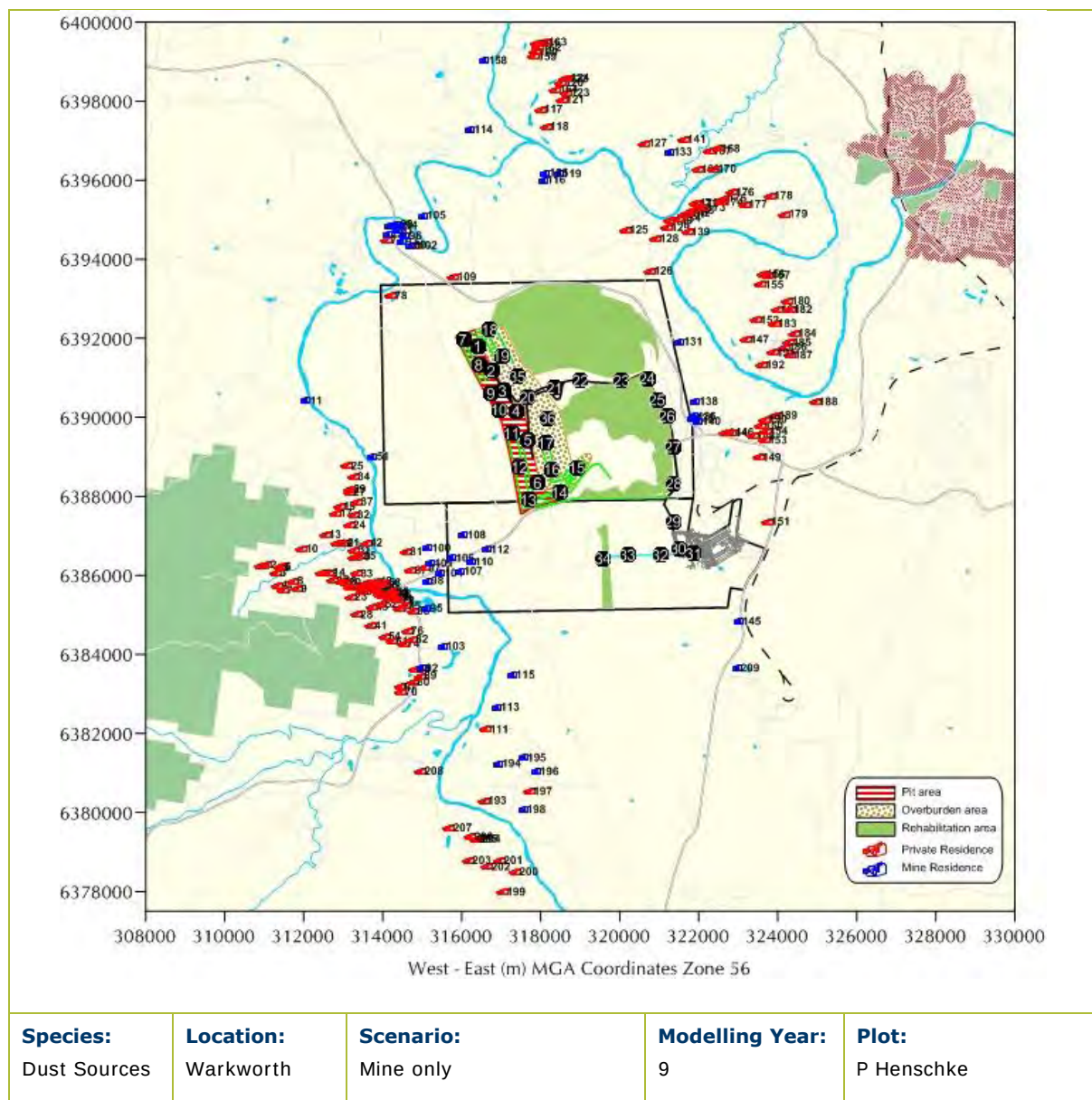


Figure 6.2: Location of modelled dust sources – Year 9

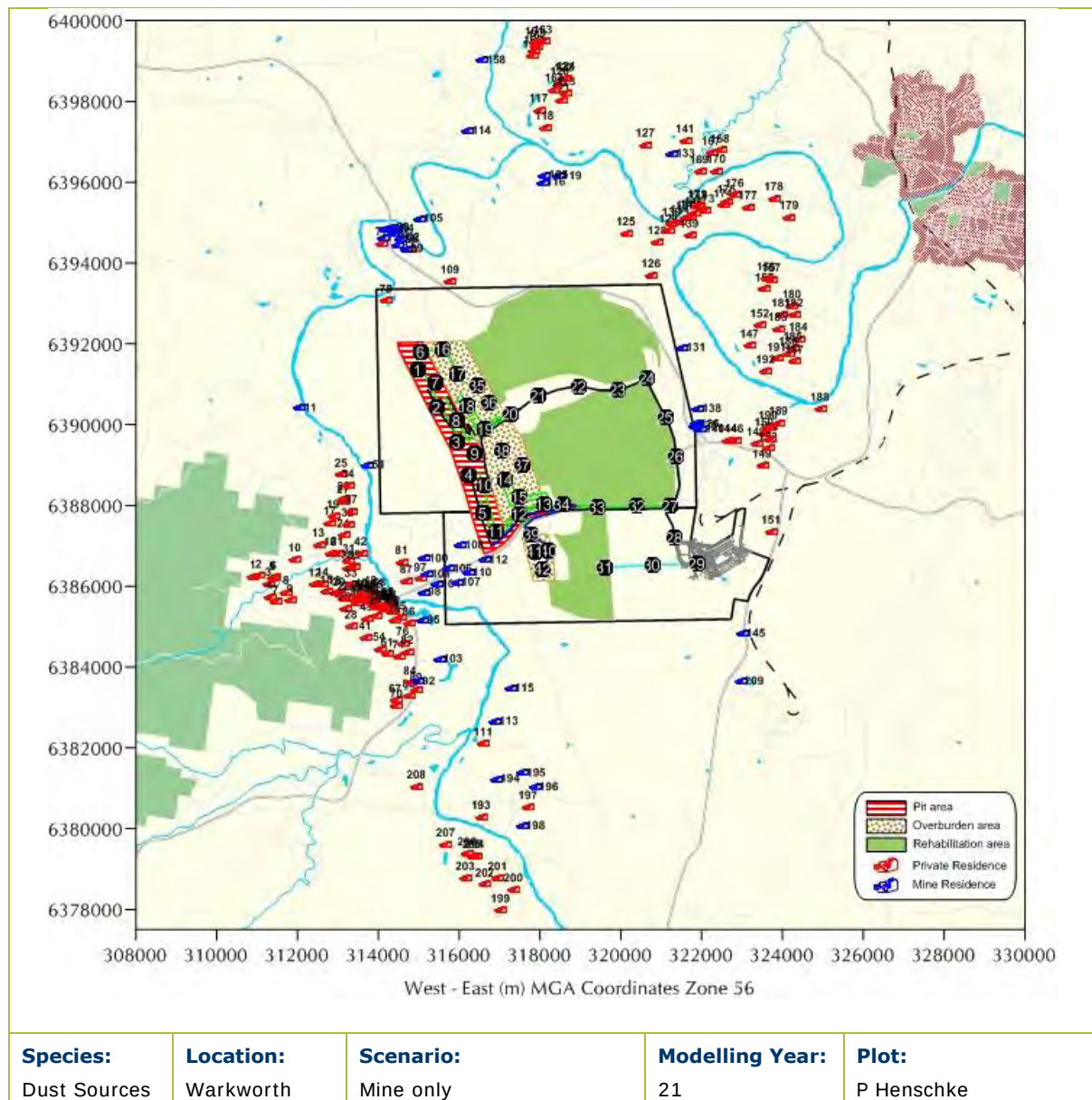


Figure 6.3: Location of modelled dust sources – Year 21

Dust concentrations and deposition rates were predicted over the modelling domain shown in **Figure 2.1** with the mine site located approximately in the centre. Predictions were made at approximately 660 discrete receptors, including residential locations. The locations of these receptors were chosen to provide finer resolution closer to the dust sources and near sensitive areas whilst still maintaining acceptable model run times.

Modelling used the meteorological data discussed in **Section 4.1** and the dust emission estimates from **Section 5** operating 24 hours per day. **Appendix F** provides a summary of the estimated dust emissions.

To assess the potential air quality impacts of the proposed Warkworth Extension alone, the activities associated with the proposal were modelled in isolation. Contour plots were created from the results to visually present the contribution of the proposed mine activities to local air quality, tables were prepared to present the modelled predictions accurately at each receptor, and calculations of the number of days above impact assessment criteria were made for

receptors where impacts were predicted. The predictions were then compared to the relevant 24-hour PM₁₀ assessment criteria in order to assess potential impacts.

To assess cumulative impacts, modelling results are presented which consider the contribution of surrounding mines in the area as well as other local sources of dust. The Warkworth Extension model results were added to predicted levels of annual average TSP, PM₁₀ and dust deposition due to emissions from other mines. In addition, the contribution of other non-modelled mines and dust sources in the area was included through the use of a constant background level for annual average TSP, PM₁₀ and dust deposition (see **Section 6.1**).

Modelled sources from mines other than the proposed Warkworth Extension were considered in three classes as follows:

1. Wind erosion sources
2. Wind sensitive sources
3. Wind insensitive sources

6.1 Accounting for background dust levels

As Warkworth mining operations are currently active, the background levels for the area were estimated by modelling the mining activities from Warkworth, Mount Thorley, Wambo and HVO South during 2008 and comparing the model results with the measured values from the monitoring stations surrounding Warkworth Mine. The predicted results are lower than those measured at the monitoring stations. This is due to the contribution from other not accounted dust sources (wind erosion for open areas, agriculture, etc.). The difference of the measured and predicted particulate concentrations and dust depositions provides a realistic uniform background level and has been used in this assessment.

For non-modelled dust sources, the estimated uniform constant background levels for annual average TSP, PM₁₀ and dust deposition were as follows:

- 31 µg/m³ for annual average TSP;
- 5 µg/m³ for annual average PM₁₀; and
- 1 g/m²/month for annual average dust deposition.

Historically, a value of 10 µg/m³ has been used to account for non-modelled sources of TSP. A study for Hunter Valley Operations (**Holmes Air Sciences, 2007**) examined model predictions and measurements and found that the non-modelled contribution to annual average TSP levels could be higher than 10 µg/m³. It is believed that the explanation for the higher non-modelled TSP contribution is that TSP measurements are dominated by localised activities with a high coarse particle fraction. The same argument applies to dust deposition measurements. By contrast, particles in the PM₁₀ size range remain in the atmosphere for much longer than the coarse fraction of TSP and so travel much further. The result is a more uniform distribution of PM₁₀ concentration. From an air dispersion modelling perspective it is not possible to account for all localised activities, such as ploughing of fields, cattle grazing, farming activities and the like. A revision to the assumed uniform constant background TSP level was therefore considered to be appropriate. Based on the monitoring data, the estimated value of 31 µg/m³ was determined more suitable instead of 10 µg/m³.

6.2 Model evaluation

6.2.1 Preamble

Elevated short-term (24-hour) PM₁₀ concentrations under adverse weather conditions can occur when conditions are calm and dust emitted from mining disperses very slowly, or during dry windy conditions when dust from wind erosion can increase significantly. Both situations present a challenge to model accurately.

A typical strong wind episode occurs after prolonged dry periods when fine dust may build up on surfaces and is available for re-suspension when the wind speed is sufficiently high (typically above 5 m/s). Heavy rain can wash this dust into low lying sheltered areas where it is not easily re-suspended, and light rain or heavy dew may not wash such dust away but can form a surface crust which is then resistant to wind erosion for some time.

Assuming that dust is available for suspension then the quantity of loose material that will be re-suspended will depend on the strength of the wind. As the wind builds strength, so will the size of the particles that can be re-suspended and a greater proportion of the loose material can become airborne. After the wind has blown at a particular strength for a period of time, all the material that can be moved at that particular wind speed will be blown away and the erosion potential of the surface at that wind speed will be exhausted. The wind speed will either need to increase for additional dust to be generated or the erodible material will need to be replenished.

A further question that needs to be addressed is the sizes of particles that are re-suspended during these types of episodes. The process by which particulate matter becomes airborne is complicated. In practice very fine particles project only very small cross-sections into the wind and although they have very low mass they are not easily removed from the surface. However, if, as is almost always the case in mining environments the fine particles are mixed with coarser particles, then the movement of coarser particles (which do not project into the wind) facilitates the movement of the finer particles by colliding with them and lifting them into the air stream. However, quantifying these processes so that they can be modelled is extremely complex.

6.2.2 Review of 24-hour PM₁₀ concentrations

To assess the accuracy of the predicted 24-hour PM₁₀ dust concentrations from the proposed Warkworth Extension, the measured maximum 24-hour average PM₁₀ concentrations in the period 1st January 2008 to 31st December 2008 were compared with the maximum predicted result for the same period at the TSP and PM₁₀ monitors surrounding the existing Warkworth Mine. The locations of these monitors are shown in **Figure 4.4**.

It was assumed that PM₁₀ constitutes 40% of the measured TSP concentrations in this area. The results of this analysis are presented in **Table 6.1**.

For the HVAS TSP and PM₁₀ monitors, data for the entire year were available. Monitoring data for 2008 from the TEOM monitors were available at Wallaby Scrub Road (10/05/2008 to 31/12/2008), Mt Thorley Industrial Estate (21/11/2008 to 31/12/2008), Bulga (1/01/2007 to 23/04/2008) and Warkworth School (1/08/2008 to 31/12/2008).

Table 6.1: Comparison of maximum measured (or inferred) with maximum predicted 24-hour PM₁₀ concentrations, 2008.

Site	Maximum predicted 24-hour PM ₁₀ (µg/m ³)	Maximum measured or inferred 24-hour PM ₁₀ (µg/m ³)	Ratio of predicted to measured concentration
MTO-PM10	106	48*	2.2
Mt Thorley Industrial Estate PM10	90	98*	0.9
WML TSP3	64	107 x 0.4 = 43	1.5
MTO-TSP2	47	106 x 0.4 = 42	1.1
WML HV1 TSP	91	204 x 0.4 = 82	1.1
WML HV2A TSP	65	100 x 0.4 = 40	1.6
WML Office TSP	105	206 x 0.4 = 82	1.3
MTO-TSP1	106	112 x 0.4 = 45	2.4
Warkworth School (TEOM)	76	64*	1.2
Wallaby Scrub Road (TEOM)	64	72*	0.9
Mt Thorley Industrial Estate (TEOM)	90	69*	1.3
Bulga (TEOM)	46	56*	0.8
Average			1.4

*Direct measurement of PM₁₀

Comparison of the maximum predicted 24-hour PM₁₀ concentrations with the maximum measured levels indicates that the average extent of the model over prediction is at least a factor of 1.4. That is, the model predictions appear to over-predict 24-hour PM₁₀ concentrations by at least some 140% on average, (and without factoring in the further overestimation that would arise if one considers that the measured levels include dust from other mines and other sources that have not been modelled).

If this factor were applied to the modelling results presented in **Section 7.3** of this report (i.e. if the modelled results were adjusted by dividing by 1.4 as an adjustment for the over-predictions), the number of residences that exceed the DECCW PM₁₀ criterion of 50 µg/m³ criterion would reduce from 22 residences to 16 residences.

It is important to note that the reasons for the over predictions under worst-case conditions are not fully understood but are common and inherent within accepted modelling practice. The over- predictions occur across a wide range of model types. It is likely that they are a result of complexities in emissions estimations under very windy conditions and the difficulty in simulating dispersions under very calm conditions, both of which are unfavourable conditions, that can lead to elevated ground-level concentrations.

Other possible reasons for this variation may be due to the location of the actual measured PM₁₀ concentrations. The ratios of predicted to measured concentrations show a range of 2.4 to 0.8 over all the monitors. The monitors located to the east of the existing Warkworth Mine and adjacent to the Mount Thorley Industrial Estate, namely WML HV1 TSP, Mount Thorley Industrial Estate PM10 and Mount Thorley Industrial Estate (TEOM) all have relatively low ratios 1.1, 0.9 and 1.3 respectively. These monitors are located in an area that contains dust generating activities which may have directly influenced the measurement of PM₁₀.

Monitors located to the west of the Warkworth mine and generally situated in areas close to residences and away from any significant dust generating activities have higher ratios, namely MTO-TSP1, MTO-PM10, WML-HV2a TSP and WML TSP3. These monitors have ratios of 2.4, 2.2, 1.6 and 1.5 respectively.

Examination of the monitors MTO-TSP1 and MTO-PM10, the most secluded from any human induced dust generating activity, shows the average ratio is 2.3. Applying this to the modelled

results would result in a reduction of the predicted exceedences to levels that affect only 4 residences in year 2031.

The evaluation presented in this section is provided for technical reviewers to appreciate how the model predicts 24-hour PM₁₀ concentrations. The results presented in **Section 7.3** have not been adjusted by any factor. This evaluation indicates that there is potential for the model to over-predict the maximum 24-hour PM₁₀ concentrations.

It is important to note that modelling is undertaken as the best available scientific tool to predict potential impacts. Monitoring is ultimately required to verify the predictions.

7 ASSESSMENT OF POTENTIAL IMPACTS

7.1 Introduction

Dust concentrations and deposition rates for the selected years of assessment are presented as isopleth diagrams in **Appendix G** showing the following:

1. Predicted annual average PM₁₀ concentration;
2. Predicted annual average TSP concentration;
3. Predicted annual average dust deposition;
4. Predicted cumulative annual average PM₁₀ concentration;
5. Predicted cumulative annual average TSP concentration; and
6. Predicted cumulative annual average dust deposition.

It is important to note that the isopleth figures are presented to provide a visual representation of the predicted impacts. To produce the isopleths it is necessary to make interpolations, and as a result the isopleths will not always match exactly with predicted impacts at any specific location. The actual predicted impacts at receptors are presented in tabular form.

Contour plots of the maximum 24-hour PM₁₀ concentration have not been presented as such plots cannot be reasonably presented to show the dispersion pattern for any particular day, but would show the highest modelled predicted 24-hour average concentrations that occurred at any point for the worst day in the year.

To assist in assessing the potential impacts on air quality in detail, the dispersion model results are presented in tabular form (**Table 7.1** to **Table 7.3**) showing the modelled predictions at each of the nearest privately-owned and mined-owned residential receptors.

7.2 Assessment criteria

The air quality criteria applied to assess potential impact on air quality are specified in **Section 3** and are listed in **Table 3.1** and **Table 3.3**.

The relevant assessment criteria are:

- 50 µg/m³ for 24-hour PM₁₀ for the proposed Warkworth Extension;
- 30 µg/m³ for annual average PM₁₀ due to the proposed Warkworth Extension and other sources;
- 90 µg/m³ for annual average TSP concentrations due to the proposed Warkworth Extension and other sources;
- Up to 2 g/m²/month for annual average deposition (insoluble solids) due to the proposed Warkworth Extension; and
- 4 g/m²/month for annual predicted cumulative deposition (insoluble solids) due to the proposed Warkworth Extension and other sources.

7.3 Model predictions

7.3.1 Year 2

7.3.1.1 Predicted maximum 24-hour average PM_{10} concentrations

Tabulated model results for Year 2 are presented in **Table 7.2** below. The relevant DECCW impact assessment criterion for maximum 24-hour average PM_{10} concentrations is $50 \mu\text{g}/\text{m}^3$.

Privately owned residences predicted to experience a 24-hour average PM_{10} concentration above the DECCW criterion in Year 2 are residences 78, 102, 109 and 197.

To facilitate DoP assessment, further analysis was conducted on privately owned residences 78, 102, 109 and 197 to determine the number of days that the $50 \mu\text{g}/\text{m}^3$ criterion would be exceeded. The results are presented in **Table 7.1**.

Table 7.1: Analysis of Year 2, 24-hour average PM_{10} concentrations

Residence ID	Number of days exceeding	DoP 98.6 percentile Criterion (5 days)
78	2	Below
102	2	Below
109	25	Above
197	1	Below

A review of **Table 7.1** indicates that predictions for residences 78, 102 and 197 are below the DoP criteria, whereas predictions for residence 109 are above.

7.3.1.2 Predicted annual average PM_{10} concentrations

Figure G.1 shows the predicted annual average PM_{10} concentrations for Year 2 due to emissions from Warkworth Extension alone. The figure is provided for information only as the criteria apply to total ambient levels. **Figure G.4** shows the predicted cumulative annual PM_{10} concentrations from the Warkworth Mine and other sources.

Privately owned residences predicted to experience cumulative annual average PM_{10} concentrations above the $30 \mu\text{g}/\text{m}^3$ in Year 2 are residences 77, 102 and 109.

7.3.1.3 Predicted annual average TSP concentrations

Figure G.2 shows the predicted annual average TSP concentrations due to emissions from the proposed Warkworth Extension alone in Year 2. The figure is provided for information only as the criterion of $90 \mu\text{g}/\text{m}^3$ applies to total ambient levels. **Figure G.5** shows the predicted annual average TSP concentration for Warkworth mine and other sources.

No residences are predicted to experience cumulative annual average TSP concentrations above $90 \mu\text{g}/\text{m}^3$ in Year 2.

7.3.1.4 Predicted annual average dust deposition (insoluble solids)

Figure G.3 shows the predicted annual average dust deposition rate for Year 2 for the proposed Warkworth Extension alone. The assessment criterion is $2 \text{ g}/\text{m}^2/\text{month}$ (annual average).

No residences are predicted to experience annual average dust deposition levels as a consequence of the proposed Warkworth Extension that are above $2 \text{ g}/\text{m}^2/\text{month}$ in Year 2.

Figure G.6 shows the predicted annual average dust deposition rate for Year 2 for the proposed Warkworth Extension considered with other sources. The assessment criterion is 4 g/m²/month (annual average).

No residences are predicted to experience cumulative annual average dust deposition levels due to the proposed Warkworth Extension and other sources above 4 g/m²/month in Year 2.

Table 7.2: Modelling predictions Year 2

ID	Easting	Northing	PM ₁₀ 24hr (µg/m³)	PM ₁₀ Annual (µg/m³)		TSP Annual (µg/m³)		Dust Deposition (g/m²/month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
Private Residences									
1	310903	6386238	10	1	9	1	36	0.0	1.2
2	311055	6386261	11	1	10	1	36	0.0	1.2
3	311295	6386059	11	1	10	1	36	0.0	1.2
4	311336	6385751	10	1	10	1	36	0.0	1.2
5	311384	6386200	11	1	10	1	36	0.0	1.2
6	311422	6386223	11	1	10	1	36	0.0	1.2
7	311470	6385618	10	1	10	1	36	0.0	1.2
8	311735	6385855	11	1	10	1	36	0.0	1.2
9	311832	6385649	11	1	10	1	36	0.0	1.2
10	311950	6386665	12	1	11	1	37	0.0	1.2
12	312442	6386044	12	1	11	1	37	0.0	1.2
13	312532	6387028	13	1	12	1	38	0.0	1.3
14	312632	6386066	13	1	11	1	38	0.0	1.2
15	312729	6385875	13	1	11	1	37	0.0	1.2
16	312822	6386804	15	1	12	1	38	0.0	1.3
17	312814	6387573	16	1	13	1	40	0.0	1.4
18	312935	6385847	14	1	11	1	38	0.0	1.3
19	312900	6387741	16	1	13	2	40	0.0	1.4
20	313041	6385812	14	1	11	1	38	0.0	1.3
21	312998	6386821	16	1	12	1	39	0.0	1.3
22	313169	6385713	14	1	11	1	38	0.0	1.3
23	313193	6385453	14	1	11	1	38	0.0	1.2
24	313145	6387267	16	1	13	1	40	0.0	1.4
25	313091	6388764	21	2	15	2	42	0.1	1.5
26	313266	6385706	14	1	12	1	38	0.0	1.3
27	313151	6388111	18	2	14	2	41	0.1	1.5
28	313335	6385003	15	1	11	1	37	0.0	1.2
29	313160	6388183	19	2	14	2	41	0.1	1.5
30	313270	6386465	16	1	12	1	39	0.0	1.3
31	313281	6386646	16	1	12	1	39	0.0	1.4
32	313252	6387528	17	1	14	2	40	0.0	1.4
33	313338	6386039	15	1	12	1	38	0.0	1.3
34	313265	6388491	20	2	15	2	42	0.1	1.5
35	313406	6386485	16	1	12	1	39	0.0	1.4
36	313473	6385589	15	1	12	1	38	0.0	1.3
37	313345	6387861	17	2	14	2	41	0.1	1.5
38	313489	6385650	15	1	12	1	38	0.0	1.3
39	313511	6385747	15	1	12	1	38	0.0	1.3
40	313595	6385794	15	1	12	1	39	0.0	1.3
41	313690	6384726	16	1	11	1	38	0.0	1.2
42	313580	6386816	18	1	13	1	40	0.0	1.4
43	313658	6385668	16	1	12	1	39	0.0	1.3
44	313658	6385708	16	1	12	1	39	0.0	1.3
45	313725	6385198	16	1	12	1	38	0.0	1.3
46	313798	6385640	16	1	12	1	39	0.0	1.3
47	313793	6385729	16	1	12	1	39	0.0	1.3
48	313823	6385853	16	1	12	1	39	0.0	1.3
49	313872	6385678	16	1	12	1	39	0.0	1.3
50	313898	6385517	16	1	12	1	39	0.0	1.3

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
52	313956	6385265	17	1	12	1	38	0.0	1.3
53	313965	6385488	17	1	12	1	39	0.0	1.3
54	314037	6384456	15	1	11	1	38	0.0	1.2
55	313981	6385757	17	1	12	1	39	0.0	1.3
56	314005	6385480	17	1	12	1	39	0.0	1.3
57	314055	6385470	17	1	12	1	39	0.0	1.3
58	314046	6385804	17	1	13	1	39	0.0	1.4
59	314088	6385479	17	1	12	1	39	0.0	1.3
60	314128	6385459	17	1	12	1	39	0.0	1.3
61	314231	6384325	14	1	11	1	38	0.0	1.2
62	314225	6385443	17	1	13	1	39	0.0	1.3
63	314229	6385540	17	1	13	1	39	0.0	1.4
64	314242	6385504	17	1	13	1	39	0.0	1.3
65	314239	6385584	17	1	13	1	39	0.0	1.4
66	314258	6385447	17	1	13	1	39	0.0	1.3
67	314434	6383176	12	1	10	1	37	0.0	1.2
68	314306	6385515	17	1	13	1	39	0.0	1.4
69	314329	6385371	17	1	13	1	39	0.0	1.3
70	314462	6383042	12	1	10	1	36	0.0	1.2
71	314354	6385377	18	1	13	1	39	0.0	1.3
72	314392	6385359	18	1	13	1	39	0.0	1.3
73	314407	6385160	17	1	12	1	39	0.0	1.3
74	314514	6384263	14	1	11	1	38	0.0	1.3
75	314546	6385220	17	1	13	1	39	0.0	1.3
76	314618	6384591	15	1	12	1	38	0.0	1.3
77	314103	6394482	50	7	31	7	59	0.4	2.5
78	314203	6393069	65	7	30	8	60	0.5	3.0
80	314769	6383296	13	1	11	1	37	0.0	1.2
81	314590	6386597	18	2	15	2	42	0.0	1.6
82	314734	6384379	15	1	12	1	38	0.0	1.3
84	314796	6383618	14	1	11	1	37	0.0	1.2
86	314767	6385091	17	1	13	1	40	0.0	1.4
87	314711	6386122	19	1	14	2	41	0.0	1.5
89	314951	6383454	13	1	11	1	37	0.0	1.2
97	315058	6386183	20	2	15	2	42	0.0	1.6
102	314803	6394347	65	9	32	10	61	0.6	2.7
109	315789	6393545	102	19	41	22	70	1.5	2.7
111	316609	6382098	27	2	12	2	38	0.0	1.2
117	317982	6397794	34	6	22	7	49	0.2	1.5
118	318128	6397356	35	7	22	7	48	0.2	1.3
120	318504	6398457	31	5	19	5	46	0.2	1.4
121	318530	6398039	34	6	20	6	47	0.2	1.5
122	318608	6398554	31	5	19	5	46	0.2	1.4
123	318658	6398205	33	5	19	6	46	0.2	1.4
124	318655	6398582	31	5	19	5	45	0.1	1.4
125	320142	6394738	42	6	22	7	49	0.3	1.6
126	320764	6393699	41	6	21	6	48	0.2	1.6
127	320624	6396932	31	4	16	4	43	0.1	1.3
128	320916	6394511	36	5	19	5	46	0.2	1.4
129	321192	6394796	32	4	17	4	44	0.1	1.4
130	321271	6394970	30	4	17	4	43	0.1	1.3

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
134	321472	6395034	28	3	16	4	43	0.1	1.3
137	321617	6395135	26	3	15	3	42	0.1	1.3
139	321707	6394686	27	3	16	3	42	0.1	1.3
141	321604	6397030	21	3	14	3	40	0.1	1.2
142	321715	6395167	25	3	15	3	42	0.1	1.3
143	321817	6395230	24	3	15	3	41	0.1	1.3
144	322654	6389614	42	5	18	5	45	0.2	1.5
146	322820	6389611	39	4	17	5	44	0.2	1.4
147	323200	6391960	26	2	14	3	40	0.1	1.2
148	323360	6389527	32	3	15	4	42	0.1	1.3
149	323510	6388982	31	4	15	4	42	0.1	1.3
150	323560	6389775	31	3	14	3	41	0.1	1.3
151	323731	6387355	30	4	15	4	42	0.2	1.4
152	323454	6392457	23	2	13	2	39	0.1	1.2
153	323662	6389415	30	3	14	3	41	0.1	1.3
154	323680	6389650	30	3	14	3	40	0.1	1.3
155	323567	6393350	22	2	12	2	39	0.0	1.2
156	323610	6393617	21	2	12	2	38	0.0	1.2
157	323739	6393594	21	2	12	2	38	0.0	1.2
159	317824	6399125	28	5	20	5	47	0.1	1.6
160	317852	6399235	27	5	20	5	48	0.1	1.6
161	317878	6399446	26	5	20	5	47	0.1	1.5
162	317940	6399347	27	5	20	5	47	0.1	1.6
163	318089	6399489	26	5	20	5	48	0.1	1.8
164	318370	6398295	31	5	20	6	47	0.2	1.5
167	322254	6396725	17	2	13	2	39	0.1	1.2
168	322468	6396793	16	2	13	2	39	0.1	1.2
169	321959	6396271	20	3	14	3	40	0.1	1.2
170	322379	6396285	18	2	13	2	39	0.1	1.2
171	321905	6395411	23	3	14	3	41	0.1	1.2
172	321925	6395400	23	3	14	3	41	0.1	1.2
173	322099	6395301	22	3	14	3	41	0.1	1.2
174	322545	6395438	19	2	13	2	39	0.1	1.2
175	322633	6395534	19	2	13	2	39	0.1	1.2
176	322830	6395688	18	2	12	2	39	0.1	1.2
177	323156	6395384	18	2	12	2	38	0.1	1.2
178	323801	6395607	16	1	11	2	37	0.0	1.1
179	324177	6395141	17	1	11	1	37	0.0	1.1
180	324246	6392934	19	2	11	2	38	0.0	1.1
181	323983	6392725	21	2	12	2	38	0.0	1.2
182	324296	6392725	20	2	11	2	38	0.0	1.1
183	323903	6392368	22	2	12	2	38	0.0	1.2
184	324407	6392127	21	2	11	2	38	0.0	1.1
185	324272	6391894	21	2	12	2	38	0.0	1.2
186	324164	6391772	21	2	12	2	38	0.0	1.2
187	324308	6391565	20	2	11	2	38	0.0	1.2
188	324940	6390387	20	2	11	2	37	0.0	1.2
189	323916	6390047	26	3	13	3	39	0.1	1.2
190	323658	6389942	29	3	14	3	40	0.1	1.3
191	323873	6391630	22	2	12	2	39	0.1	1.2
192	323595	6391320	24	2	13	2	39	0.1	1.2

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
193	316563	6380295	23	1	10	1	36	0.0	1.1
197	317697	6380527	55	2	12	2	39	0.0	1.2
199	317041	6377999	30	1	8	1	34	0.0	1.0
200	317355	6378491	38	1	9	1	35	0.0	1.1
201	316959	6378791	30	1	9	1	35	0.0	1.1
202	316645	6378627	23	1	9	1	35	0.0	1.0
203	316166	6378778	14	1	8	1	35	0.0	1.1
204	316412	6379324	19	1	9	1	35	0.0	1.1
205	316207	6379379	15	1	9	1	35	0.0	1.1
206	316330	6379324	17	1	9	1	35	0.0	1.1
207	315688	6379611	10	1	9	1	35	0.0	1.1
208	314950	6381046	8	1	9	1	35	0.0	1.1
Mine Residences									
11	312058	6390414	17	2	16	2	42	0.1	1.5
51	313744	6389001	24	2	17	3	44	0.1	1.7
79	314121	6394634	50	7	31	7	59	0.4	2.4
83	314144	6394841	50	7	31	7	59	0.4	2.4
90	314344	6394886	53	7	31	8	59	0.4	2.5
91	314359	6394718	54	7	31	8	59	0.4	2.5
92	314985	6383647	14	1	11	1	38	0.0	1.2
93	314481	6394444	57	8	31	9	59	0.5	2.4
94	314463	6394855	55	8	31	8	59	0.4	2.4
95	315097	6385163	17	1	14	2	40	0.0	1.4
96	314571	6394587	59	8	31	9	60	0.5	2.5
98	315125	6385857	20	2	15	2	42	0.0	1.5
99	314699	6394352	63	9	31	10	60	0.6	2.5
100	315144	6386684	21	2	17	2	44	0.0	1.7
101	315208	6386297	21	2	16	2	43	0.0	1.7
103	315505	6384205	16	1	13	1	39	0.0	1.3
104	315463	6386048	21	2	16	2	44	0.0	1.7
105	315017	6395104	52	10	39	11	66	0.5	3.2
106	315742	6386435	23	2	19	2	46	0.1	1.9
107	315949	6386105	23	2	19	3	46	0.1	1.9
108	316037	6387020	28	3	23	3	51	0.1	2.2
110	316226	6386333	25	3	21	3	49	0.1	2.1
112	316629	6386649	45	4	27	4	56	0.1	2.7
113	316882	6382664	38	2	13	2	40	0.0	1.3
114	316208	6397277	41	7	42	8	73	0.3	3.4
115	317271	6383479	57	3	17	3	44	0.1	1.5
116	318052	6396001	49	10	34	10	63	0.4	3.0
119	318452	6396156	48	8	24	9	51	0.3	1.5
131	321519	6391910	38	5	20	5	47	0.2	1.6
133	321261	6396710	24	3	15	3	41	0.1	1.2
135	321816	6389971	64	7	23	8	50	0.4	1.8
136	321862	6390017	61	7	22	8	50	0.4	1.8
138	321914	6390390	51	6	21	6	48	0.3	1.6
140	321981	6389895	60	6	22	7	49	0.4	1.7
145	322998	6384833	62	5	22	5	49	0.6	2.0
158	316576	6399021	29	5	23	5	50	0.2	1.2
165	318110	6396180	46	9	26	10	52	0.4	1.4
194	316918	6381238	35	2	11	2	37	0.0	1.1

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu- lative	Mine only	Cumu- lative	Mine only	Cumu- lative
			<i>Assessment criteria</i>						
			50	-	30	-	90	2.0	4.0
195	317560	6381402	57	2	13	2	39	0.0	1.1
196	317875	6381033	63	2	13	2	39	0.0	1.1
198	317533	6380076	49	2	11	2	37	0.0	1.1
209	322959	6383657	52	4	28	5	58	0.5	3.0

7.3.2 Year 9

7.3.2.1 Predicted maximum 24-hour average PM_{10} concentrations

A summary of the model results for Year 9 are presented in **Table 7.4** below. The relevant DECCW impact assessment criterion for maximum 24-hour average PM_{10} concentrations is $50 \mu\text{g}/\text{m}^3$.

Privately owned residences predicted to experience a 24-hour average concentration above the DECCW criterion in Year 9 are residences 77, 78, 102, 109, 111, 117, 118, 121, 123, 126, 144, 146, 193 and 197.

To facilitate DoP assessment, further analysis was conducted on privately owned residences 77, 78, 102, 109, 111, 117, 118, 121, 123, 126, 144, 146, 193 and 197 to determine the number of days that the $50 \mu\text{g}/\text{m}^3$ criterion would be exceeded. The results are presented in **Table 7.3**.

Table 7.3: Analysis of Year 9, 24-hour average PM_{10} concentrations

Residence ID	Number of days exceeding	DoP 98.6 percentile Criterion (5 days)
77	10	Above
78	13	Above
102	28	Above
109	106	Above
111	2	Below
117	1	Below
118	1	Below
121	1	Below
123	1	Below
126	1	Below
144	1	Below
146	1	Below
193	2	Below
197	2	Below

A review of **Table 7.3** indicates that predictions for residences 111, 117, 118, 121, 123, 126, 144, 146, 193 and 197 are below the DoP criteria of 5 days exceedances, whereas predictions for residences 77, 78, 102 and 109 are above.

7.3.2.2 Predicted annual average PM_{10} concentrations

Figure G.7 shows the predicted annual average PM_{10} concentrations for Year 9 due to emissions from the proposed Warkworth Extension alone. This figure is provided for information only as the criterion of $30 \mu\text{g}/\text{m}^3$ applies to total ambient levels. **Figure G.10** shows the predicted cumulative annual PM_{10} concentrations from the proposed Warkworth Extension and other sources.

Privately owned residences predicted to experience cumulative annual average PM_{10} concentrations above $30 \mu\text{g}/\text{m}^3$ in Year 9 are residences 78, 102 and 109.

7.3.2.3 Predicted annual average TSP concentrations

Figure G.8 shows the predicted annual average TSP concentrations due to emissions from the proposed Warkworth Extension alone in Year 9. The figure is provided for information only as the criterion of $90 \mu\text{g}/\text{m}^3$ applies to total ambient levels. **Figure G.11** shows the predicted annual average TSP concentration for the proposed Warkworth Extension and other sources.

No residences are predicted to experience cumulative annual average TSP concentrations above $90 \mu\text{g}/\text{m}^3$ in Year 9.

7.3.2.4 Predicted annual average dust deposition (insoluble solids)

Figure G.9 shows the predicted annual average dust deposition rate for Year 9 for Warkworth Mine alone. The assessment criterion is $2 \text{ g}/\text{m}^2/\text{month}$ (annual average).

One privately owned residence is predicted to experience annual average dust deposition levels due to the proposed Warkworth Extension that are above $2 \text{ g}/\text{m}^2/\text{month}$ in Year 9; Residence 109.

Figure G.12 shows the predicted annual average dust deposition rate for Year 9 for the proposed Warkworth Extension considered with other sources. The assessment criterion is $4 \text{ g}/\text{m}^2/\text{month}$ (annual average).

No residences are predicted to experience cumulative annual average dust deposition levels due to the proposed Warkworth Extension and other sources above $4 \text{ g}/\text{m}^2/\text{month}$.

Table 7.4: Modelling predictions Year 9

ID	Easting	Northing	PM ₁₀ 24hr (µg/m³)	PM ₁₀ Annual (µg/m³)		TSP Annual (µg/m³)		Dust Deposition (g/m²/month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
Private Residences									
1	310903	6386238	16	1	8	1	35	0.0	1.1
2	311055	6386261	17	1	9	1	35	0.0	1.1
3	311295	6386059	17	1	9	1	35	0.0	1.1
4	311336	6385751	17	1	8	1	35	0.0	1.1
5	311384	6386200	17	1	9	1	35	0.0	1.1
6	311422	6386223	17	1	9	1	35	0.0	1.1
7	311470	6385618	17	1	8	1	35	0.0	1.1
8	311735	6385855	18	1	9	1	35	0.0	1.1
9	311832	6385649	18	1	9	1	35	0.0	1.1
10	311950	6386665	20	2	9	2	36	0.0	1.1
12	312442	6386044	22	2	9	2	36	0.0	1.1
13	312532	6387028	23	2	10	2	37	0.1	1.2
14	312632	6386066	23	2	9	2	36	0.0	1.1
15	312729	6385875	23	2	9	2	36	0.0	1.1
16	312822	6386804	27	2	10	2	37	0.1	1.2
17	312814	6387573	24	2	11	3	37	0.1	1.2
18	312935	6385847	23	2	9	2	36	0.0	1.1
19	312900	6387741	24	3	11	3	38	0.1	1.2
20	313041	6385812	24	2	10	2	36	0.0	1.1
21	312998	6386821	28	2	10	2	37	0.1	1.2
22	313169	6385713	23	2	10	2	36	0.0	1.1
23	313193	6385453	23	2	9	2	36	0.0	1.1
24	313145	6387267	30	2	11	3	37	0.1	1.2
25	313091	6388764	28	3	13	3	40	0.2	1.3
26	313266	6385706	23	2	10	2	36	0.0	1.1
27	313151	6388111	26	3	12	3	39	0.1	1.3
28	313335	6385003	20	2	9	2	35	0.0	1.1
29	313160	6388183	27	3	12	3	39	0.1	1.3
30	313270	6386465	28	2	10	2	37	0.0	1.2
31	313281	6386646	29	2	10	2	37	0.1	1.2
32	313252	6387528	30	3	11	3	38	0.1	1.2
33	313338	6386039	24	2	10	2	36	0.0	1.1
34	313265	6388491	28	3	13	3	39	0.1	1.3
35	313406	6386485	28	2	10	2	37	0.1	1.2
36	313473	6385589	23	2	10	2	36	0.0	1.1
37	313345	6387861	28	3	12	3	38	0.1	1.3
38	313489	6385650	23	2	10	2	36	0.0	1.1
39	313511	6385747	23	2	10	2	36	0.0	1.1
40	313595	6385794	24	2	10	2	36	0.0	1.1
41	313690	6384726	22	2	9	2	35	0.0	1.1
42	313580	6386816	32	2	11	3	37	0.1	1.2
43	313658	6385668	23	2	10	2	36	0.0	1.1
44	313658	6385708	23	2	10	2	36	0.0	1.1
45	313725	6385198	21	2	10	2	36	0.0	1.1
46	313798	6385640	23	2	10	2	36	0.0	1.2
47	313793	6385729	24	2	10	2	36	0.0	1.2
48	313823	6385853	24	2	10	2	36	0.0	1.2
49	313872	6385678	24	2	10	2	36	0.0	1.2
50	313898	6385517	23	2	10	2	36	0.0	1.2

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
52	313956	6385265	23	2	10	2	36	0.0	1.1
53	313965	6385488	23	2	10	2	36	0.0	1.2
54	314037	6384456	23	2	9	2	36	0.0	1.1
55	313981	6385757	24	2	10	2	36	0.0	1.2
56	314005	6385480	23	2	10	2	36	0.0	1.2
57	314055	6385470	23	2	10	2	36	0.0	1.2
58	314046	6385804	24	2	10	2	37	0.0	1.2
59	314088	6385479	23	2	10	2	36	0.0	1.2
60	314128	6385459	23	2	10	2	36	0.0	1.2
61	314231	6384325	22	2	9	2	36	0.0	1.1
62	314225	6385443	24	2	10	2	36	0.0	1.2
63	314229	6385540	24	2	10	2	37	0.0	1.2
64	314242	6385504	24	2	10	2	37	0.0	1.2
65	314239	6385584	24	2	10	2	37	0.0	1.2
66	314258	6385447	24	2	10	2	36	0.0	1.2
67	314434	6383176	19	2	9	2	35	0.0	1.1
68	314306	6385515	24	2	10	2	37	0.0	1.2
69	314329	6385371	25	2	10	2	37	0.0	1.2
70	314462	6383042	19	2	9	2	35	0.0	1.1
71	314354	6385377	25	2	10	2	37	0.0	1.2
72	314392	6385359	25	2	10	2	37	0.0	1.2
73	314407	6385160	25	2	10	2	36	0.0	1.2
74	314514	6384263	22	2	10	2	36	0.0	1.1
75	314546	6385220	26	2	10	2	37	0.0	1.2
76	314618	6384591	23	2	10	2	36	0.0	1.2
77	314103	6394482	93	13	30	14	59	0.7	2.5
78	314203	6393069	119	14	32	16	62	1.0	3.2
80	314769	6383296	20	2	9	2	35	0.0	1.1
81	314590	6386597	28	3	12	3	38	0.1	1.2
82	314734	6384379	23	2	10	2	36	0.0	1.2
84	314796	6383618	21	2	9	2	36	0.0	1.1
86	314767	6385091	26	2	10	3	37	0.0	1.2
87	314711	6386122	28	3	11	3	38	0.1	1.2
89	314951	6383454	20	2	9	2	36	0.0	1.1
97	315058	6386183	30	3	12	3	39	0.1	1.2
102	314803	6394347	107	18	34	21	63	1.1	2.9
109	315789	6393545	179	40	53	46	86	2.9	4.0
111	316609	6382098	73	3	11	3	37	0.1	1.2
117	317982	6397794	53	8	18	9	45	0.2	1.4
118	318128	6397356	58	9	18	9	45	0.3	1.3
120	318504	6398457	49	7	16	7	42	0.2	1.3
121	318530	6398039	53	7	16	8	43	0.2	1.3
122	318608	6398554	49	7	15	7	42	0.2	1.3
123	318658	6398205	51	7	16	7	42	0.2	1.3
124	318655	6398582	49	6	15	7	42	0.2	1.3
125	320142	6394738	50	7	16	7	43	0.2	1.4
126	320764	6393699	55	7	16	7	42	0.2	1.4
127	320624	6396932	32	5	13	5	39	0.1	1.2
128	320916	6394511	49	6	14	6	41	0.2	1.3
129	321192	6394796	44	5	13	5	39	0.1	1.2
130	321271	6394970	42	5	13	5	39	0.1	1.2

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
134	321472	6395034	40	4	12	5	39	0.1	1.2
137	321617	6395135	38	4	12	4	38	0.1	1.2
139	321707	6394686	40	4	12	4	38	0.1	1.2
141	321604	6397030	24	4	11	4	37	0.1	1.1
142	321715	6395167	37	4	12	4	38	0.1	1.2
143	321817	6395230	35	4	11	4	38	0.1	1.2
144	322654	6389614	64	7	15	7	42	0.2	1.4
146	322820	6389611	58	6	15	6	41	0.2	1.3
147	323200	6391960	30	3	11	4	37	0.1	1.2
148	323360	6389527	44	5	13	5	39	0.1	1.2
149	323510	6388982	40	5	13	5	39	0.2	1.3
150	323560	6389775	42	4	12	4	38	0.1	1.2
151	323731	6387355	44	5	13	5	39	0.2	1.3
152	323454	6392457	29	3	10	3	37	0.1	1.1
153	323662	6389415	41	4	12	5	38	0.1	1.2
154	323680	6389650	41	4	12	4	38	0.1	1.2
155	323567	6393350	27	3	10	3	36	0.1	1.1
156	323610	6393617	27	2	10	3	36	0.1	1.1
157	323739	6393594	26	2	10	3	36	0.1	1.1
159	317824	6399125	39	7	16	7	43	0.2	1.4
160	317852	6399235	39	7	16	7	43	0.2	1.4
161	317878	6399446	38	6	16	7	43	0.2	1.4
162	317940	6399347	39	6	16	7	43	0.2	1.4
163	318089	6399489	39	6	16	6	43	0.1	1.5
164	318370	6398295	50	7	16	7	43	0.2	1.3
167	322254	6396725	23	3	10	3	36	0.1	1.1
168	322468	6396793	22	3	10	3	36	0.1	1.1
169	321959	6396271	27	3	11	3	37	0.1	1.1
170	322379	6396285	26	3	10	3	36	0.1	1.1
171	321905	6395411	33	4	11	4	37	0.1	1.2
172	321925	6395400	33	4	11	4	37	0.1	1.2
173	322099	6395301	33	3	11	4	37	0.1	1.1
174	322545	6395438	30	3	10	3	37	0.1	1.1
175	322633	6395534	29	3	10	3	36	0.1	1.1
176	322830	6395688	27	3	10	3	36	0.1	1.1
177	323156	6395384	27	3	10	3	36	0.1	1.1
178	323801	6395607	24	2	9	2	35	0.0	1.1
179	324177	6395141	24	2	9	2	35	0.0	1.1
180	324246	6392934	24	2	9	2	36	0.0	1.1
181	323983	6392725	25	2	10	3	36	0.0	1.1
182	324296	6392725	24	2	9	2	36	0.0	1.1
183	323903	6392368	26	3	10	3	36	0.1	1.1
184	324407	6392127	25	2	10	2	36	0.0	1.1
185	324272	6391894	26	3	10	3	36	0.1	1.1
186	324164	6391772	26	3	10	3	36	0.1	1.1
187	324308	6391565	26	3	10	3	36	0.1	1.1
188	324940	6390387	26	3	10	3	36	0.1	1.1
189	323916	6390047	36	4	11	4	37	0.1	1.2
190	323658	6389942	40	4	12	4	38	0.1	1.2
191	323873	6391630	28	3	8	3	37	0.1	1.1
192	323595	6391320	30	3	8	3	37	0.1	1.1

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
193	316563	6380295	59	2	9	3	35	0.0	1.1
197	317697	6380527	88	3	10	3	37	0.1	1.1
199	317041	6377999	35	1	8	2	34	0.0	1.0
200	317355	6378491	50	2	8	2	34	0.0	1.1
201	316959	6378791	46	2	8	2	34	0.0	1.1
202	316645	6378627	38	2	8	2	34	0.0	1.0
203	316166	6378778	28	1	8	2	34	0.0	1.0
204	316412	6379324	36	2	8	2	34	0.0	1.1
205	316207	6379379	34	2	8	2	34	0.0	1.1
206	316330	6379324	31	2	8	2	34	0.0	1.1
207	315688	6379611	19	1	8	1	34	0.0	1.1
208	314950	6381046	14	1	8	2	34	0.0	1.1
Mine Residences									
11	312058	6390414	33	3	14	4	41	0.2	1.4
51	313744	6389001	33	4	14	5	41	0.2	1.5
79	314121	6394634	92	13	30	14	59	0.7	2.5
83	314144	6394841	90	13	30	14	59	0.7	2.4
90	314344	6394886	89	14	30	15	58	0.7	2.4
91	314359	6394718	95	14	31	16	59	0.8	2.5
92	314985	6383647	21	2	10	2	36	0.0	1.1
93	314481	6394444	104	15	31	17	60	0.9	2.5
94	314463	6394855	89	15	30	16	59	0.8	2.4
95	315097	6385163	27	3	11	3	37	0.1	1.2
96	314571	6394587	99	16	31	18	60	0.9	2.6
98	315125	6385857	29	3	12	3	38	0.1	1.2
99	314699	6394352	109	18	33	19	62	1.0	2.7
100	315144	6386684	32	4	13	4	39	0.1	1.3
101	315208	6386297	32	3	12	4	39	0.1	1.3
103	315505	6384205	24	3	11	3	37	0.1	1.2
104	315463	6386048	32	4	13	4	39	0.1	1.3
105	315017	6395104	89	17	37	19	69	0.9	4.3
106	315742	6386435	36	5	14	5	41	0.1	1.3
107	315949	6386105	50	5	14	5	41	0.1	1.3
108	316037	6387020	65	6	16	7	43	0.2	1.4
110	316226	6386333	84	6	16	6	43	0.1	1.4
112	316629	6386649	140	8	19	9	46	0.2	1.5
113	316882	6382664	93	4	12	4	38	0.1	1.2
114	316208	6397277	57	10	31	11	60	0.4	2.8
115	317271	6383479	126	5	14	5	41	0.1	1.4
116	318052	6396001	74	12	26	12	57	0.4	3.2
119	318452	6396156	67	10	19	11	45	0.3	1.2
131	321519	6391910	50	7	16	8	43	0.3	1.4
133	321261	6396710	26	4	12	4	38	0.1	1.2
135	321816	6389971	90	11	21	13	49	0.6	1.9
136	321862	6390017	85	11	20	12	48	0.5	1.7
138	321914	6390390	76	9	18	10	46	0.3	1.5
140	321981	6389895	85	10	19	11	47	0.5	1.7
145	322998	6384833	76	6	16	7	43	0.5	1.7
158	316576	6399021	40	7	18	8	45	0.2	1.2
165	318110	6396180	71	11	21	12	47	0.4	1.3
194	316918	6381238	80	3	10	3	36	0.1	1.1

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu- lative	Mine only	Cumu- lative	Mine only	Cumu- lative
			<i>Assessment criteria</i>						
			50	-	30	-	90	2.0	4.0
195	317560	6381402	99	4	11	4	37	0.1	1.1
196	317875	6381033	91	3	11	4	37	0.1	1.1
198	317533	6380076	83	3	10	3	36	0.1	1.1
209	322959	6383657	82	6	19	6	47	0.4	2.0

7.3.3 Year 21

7.3.3.1 Predicted maximum 24-hour average PM₁₀ concentrations

Tabulated model results for Year 21 are presented in **Table 7.6** below. The relevant DECCW impact assessment criterion for maximum 24-hour average PM₁₀ concentrations is 50 µg/m³.

Privately-owned residences predicted to experience a 24-hour average concentration above the DECCW criterion in Year 21 are residences 77, 78, 81, 97, 102, 109, 111, 117, 118, 144, 146, 193, 197, 199, 200, 201, 202, 203, 204, 205, 206 and 207.

To facilitate DoP assessment, further analysis was conducted on privately owned residences 77, 78, 81, 97, 102, 109, 111, 117, 118, 144, 146, 193, 197, 199, 200, 201, 202, 203, 204, 205, 206 and 207 to determine the number of days that the 50 µg/m³ criterion would be exceeded. The results are presented in **Table 7.5**.

Table 7.5: Analysis of Year 21, 24-hour average PM₁₀ concentrations

Residence ID	Number of days exceeding	DoP 98.6 th percentile Criterion (5 days)
77	42	Above
78	83	Above
81	1	Below
97	3	Below
102	55	Above
109	73	Above
111	3	Below
117	1	Below
118	1	Below
144	1	Below
146	1	Below
193	2	Below
197	2	Below
199	2	Below
200	2	Below
201	2	Below
202	2	Below
203	2	Below
204	2	Below
205	2	Below
206	2	Below
207	2	Below

A review of **Table 7.5** indicates that four properties exceed the DoP criteria for 5 days or more including residences 77, 78, 102 and 109.

7.3.3.2 Predicted annual average PM₁₀ concentrations

Figure G.13 shows the predicted annual average PM₁₀ concentrations for Year 21 due to emissions from the proposed Warkworth Extension alone. The figure is provided for information only as the criterion of 30 µg/m³ applies to total ambient levels. **Figure G.16** shows the predicted cumulative annual PM₁₀ concentrations from the proposed Warkworth Extension and other sources.

Privately owned residences predicted to experience cumulative annual average PM₁₀ concentrations above 30 µg/m³ in Year 21 are Residences 78, 102 and 109.

7.3.3.3 Predicted annual average TSP concentrations

Figure G.14 shows the predicted annual average TSP concentrations due to emissions from the proposed Warkworth Extension alone in Year 21. The figure is provided for information only as the criterion of $90 \mu\text{g}/\text{m}^3$ applies to total ambient levels. **Figure G.17** shows the predicted annual average TSP concentration for Warkworth mine and other sources.

No residences are predicted to experience cumulative annual average TSP concentrations above $90 \mu\text{g}/\text{m}^3$ in Year 21.

7.3.3.4 Predicted annual average dust deposition (insoluble solids)

Figure G.15 shows the predicted annual average dust deposition rate for Year 21 for the Warkworth Extension alone. The assessment criterion is $2 \text{ g}/\text{m}^2/\text{month}$ (annual average).

One privately owned residence, Residence 78, is predicted to experience annual average dust deposition levels due to Warkworth Mine that are above $2 \text{ g}/\text{m}^2/\text{month}$ in Year 21.

Figure G.18 shows the predicted annual average dust deposition rate for Year 21 for the proposed Warkworth Extension considered with other sources. The assessment criterion is $4 \text{ g}/\text{m}^2/\text{month}$ (annual average).

No residences are predicted to experience cumulative annual average dust deposition levels due to the proposed Warkworth Extension and other sources above $4 \text{ g}/\text{m}^2/\text{month}$ in Year 21.

Table 7.6: Modelling predictions Year 21

ID	Easting	Northing	PM ₁₀ 24hr (µg/m³)	PM ₁₀ Annual (µg/m³)		TSP Annual (µg/m³)		Dust Deposition (g/m²/month)	
			Mine only	Mine only	Cumu- lative	Mine only	Cumu- lative	Mine only	Cumu- lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
Private Residences									
1	310903	6386238	25	2	7	2	33	0.1	1.1
2	311055	6386261	26	2	7	2	33	0.1	1.1
3	311295	6386059	27	2	7	2	33	0.1	1.1
4	311336	6385751	24	2	7	2	33	0.1	1.1
5	311384	6386200	27	2	7	2	33	0.1	1.1
6	311422	6386223	28	2	7	2	33	0.1	1.1
7	311470	6385618	24	2	7	2	33	0.0	1.0
8	311735	6385855	27	2	7	2	33	0.1	1.1
9	311832	6385649	26	2	7	2	33	0.1	1.1
10	311950	6386665	30	3	8	3	34	0.1	1.1
12	312442	6386044	31	3	8	3	34	0.1	1.1
13	312532	6387028	33	3	8	4	35	0.1	1.1
14	312632	6386066	31	3	8	3	34	0.1	1.1
15	312729	6385875	30	3	8	3	34	0.1	1.1
16	312822	6386804	36	3	8	4	35	0.1	1.1
17	312814	6387573	36	4	9	4	35	0.2	1.2
18	312935	6385847	30	3	8	3	34	0.1	1.1
19	312900	6387741	36	4	9	5	36	0.2	1.2
20	313041	6385812	30	3	8	3	34	0.1	1.1
21	312998	6386821	38	4	9	4	35	0.1	1.1
22	313169	6385713	30	3	8	3	34	0.1	1.1
23	313193	6385453	30	3	8	3	34	0.1	1.1
24	313145	6387267	37	4	9	5	36	0.2	1.2
25	313091	6388764	43	6	11	7	38	0.4	1.4
26	313266	6385706	30	3	8	3	34	0.1	1.1
27	313151	6388111	38	5	10	6	37	0.3	1.3
28	313335	6385003	30	3	8	3	34	0.1	1.1
29	313160	6388183	38	5	10	6	37	0.3	1.3
30	313270	6386465	41	4	9	4	35	0.1	1.1
31	313281	6386646	42	4	9	4	35	0.1	1.1
32	313252	6387528	40	5	10	5	36	0.2	1.2
33	313338	6386039	33	3	8	3	34	0.1	1.1
34	313265	6388491	43	6	11	7	38	0.4	1.4
35	313406	6386485	43	4	9	4	35	0.1	1.1
36	313473	6385589	32	3	8	3	34	0.1	1.1
37	313345	6387861	41	5	10	6	37	0.3	1.3
38	313489	6385650	32	3	8	3	34	0.1	1.1
39	313511	6385747	32	3	8	3	34	0.1	1.1
40	313595	6385794	33	3	8	4	35	0.1	1.1
41	313690	6384726	30	3	8	3	34	0.1	1.1
42	313580	6386816	46	4	9	5	36	0.2	1.2
43	313658	6385668	34	3	8	3	34	0.1	1.1
44	313658	6385708	34	3	8	4	35	0.1	1.1
45	313725	6385198	33	3	8	3	34	0.1	1.1
46	313798	6385640	36	3	8	4	35	0.1	1.1
47	313793	6385729	35	3	8	4	35	0.1	1.1
48	313823	6385853	35	4	9	4	35	0.1	1.1
49	313872	6385678	36	3	8	4	35	0.1	1.1
50	313898	6385517	37	3	8	4	35	0.1	1.1

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
52	313956	6385265	34	3	8	4	35	0.1	1.1
53	313965	6385488	37	3	8	4	35	0.1	1.1
54	314037	6384456	32	3	8	3	34	0.1	1.1
55	313981	6385757	38	4	9	4	35	0.1	1.1
56	314005	6385480	37	4	9	4	35	0.1	1.1
57	314055	6385470	37	4	9	4	35	0.1	1.1
58	314046	6385804	39	4	9	4	35	0.1	1.1
59	314088	6385479	37	4	9	4	35	0.1	1.1
60	314128	6385459	37	4	9	4	35	0.1	1.1
61	314231	6384325	31	3	8	3	34	0.1	1.1
62	314225	6385443	37	4	9	4	35	0.1	1.1
63	314229	6385540	39	4	9	4	35	0.1	1.1
64	314242	6385504	38	4	9	4	35	0.1	1.1
65	314239	6385584	39	4	9	4	35	0.1	1.1
66	314258	6385447	37	4	9	4	35	0.1	1.1
67	314434	6383176	25	3	8	3	34	0.1	1.1
68	314306	6385515	38	4	9	4	35	0.1	1.1
69	314329	6385371	35	4	9	4	35	0.1	1.1
70	314462	6383042	25	3	8	3	34	0.1	1.1
71	314354	6385377	35	4	9	4	35	0.1	1.1
72	314392	6385359	35	4	9	4	35	0.1	1.1
73	314407	6385160	36	4	9	4	35	0.1	1.1
74	314514	6384263	32	3	8	4	35	0.1	1.1
75	314546	6385220	38	4	9	5	36	0.1	1.1
76	314618	6384591	36	4	9	4	35	0.1	1.1
77	314103	6394482	103	21	26	23	54	1.1	2.1
78	314203	6393069	173	32	37	37	68	2.3	3.3
80	314769	6383296	37	3	8	3	34	0.1	1.1
81	314590	6386597	56	6	11	7	38	0.2	1.2
82	314734	6384379	37	4	9	4	35	0.1	1.1
84	314796	6383618	39	3	8	4	35	0.1	1.1
86	314767	6385091	42	5	10	5	36	0.1	1.1
87	314711	6386122	48	6	11	6	37	0.2	1.2
89	314951	6383454	47	4	9	4	35	0.1	1.1
97	315058	6386183	77	7	12	8	39	0.2	1.2
102	314803	6394347	112	24	29	26	57	1.3	2.3
109	315789	6393545	131	32	37	36	67	1.8	2.8
111	316609	6382098	133	5	10	6	37	0.1	1.1
117	317982	6397794	53	7	12	8	39	0.2	1.2
118	318128	6397356	55	8	13	8	39	0.2	1.2
120	318504	6398457	48	6	11	6	37	0.1	1.1
121	318530	6398039	49	6	11	7	38	0.2	1.2
122	318608	6398554	47	6	11	6	37	0.1	1.1
123	318658	6398205	48	6	11	6	37	0.1	1.1
124	318655	6398582	47	6	11	6	37	0.1	1.1
125	320142	6394738	43	6	11	6	37	0.2	1.2
126	320764	6393699	46	6	11	6	37	0.2	1.2
127	320624	6396932	28	4	9	4	35	0.1	1.1
128	320916	6394511	40	5	10	5	36	0.1	1.1
129	321192	6394796	37	4	9	5	36	0.1	1.1
130	321271	6394970	35	4	9	4	35	0.1	1.1

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
134	321472	6395034	34	4	9	4	35	0.1	1.1
137	321617	6395135	32	4	9	4	35	0.1	1.1
139	321707	6394686	34	4	9	4	35	0.1	1.1
141	321604	6397030	23	3	8	3	34	0.1	1.1
142	321715	6395167	32	4	9	4	35	0.1	1.1
143	321817	6395230	31	3	8	4	35	0.1	1.1
144	322654	6389614	58	5	10	6	37	0.2	1.2
146	322820	6389611	54	5	10	5	36	0.2	1.2
147	323200	6391960	29	3	8	3	34	0.1	1.1
148	323360	6389527	42	4	9	4	35	0.1	1.1
149	323510	6388982	38	4	9	4	35	0.1	1.1
150	323560	6389775	41	4	9	4	35	0.1	1.1
151	323731	6387355	40	4	9	5	36	0.2	1.2
152	323454	6392457	29	3	8	3	34	0.1	1.1
153	323662	6389415	37	4	9	4	35	0.1	1.1
154	323680	6389650	38	3	8	4	35	0.1	1.1
155	323567	6393350	28	2	7	3	34	0.0	1.0
156	323610	6393617	27	2	7	2	33	0.0	1.0
157	323739	6393594	27	2	7	2	33	0.0	1.0
159	317824	6399125	45	6	11	6	37	0.1	1.1
160	317852	6399235	45	6	11	6	37	0.1	1.1
161	317878	6399446	43	6	11	6	37	0.1	1.1
162	317940	6399347	44	6	11	6	37	0.1	1.1
163	318089	6399489	44	6	11	6	37	0.1	1.1
164	318370	6398295	49	6	11	7	38	0.2	1.2
167	322254	6396725	22	3	8	3	34	0.1	1.1
168	322468	6396793	21	3	8	3	34	0.1	1.1
169	321959	6396271	25	3	8	3	34	0.1	1.1
170	322379	6396285	23	3	8	3	34	0.1	1.1
171	321905	6395411	29	3	8	3	34	0.1	1.1
172	321925	6395400	29	3	8	3	34	0.1	1.1
173	322099	6395301	29	3	8	3	34	0.1	1.1
174	322545	6395438	26	3	8	3	34	0.1	1.1
175	322633	6395534	26	3	8	3	34	0.1	1.1
176	322830	6395688	24	3	8	3	34	0.1	1.1
177	323156	6395384	25	2	7	2	33	0.0	1.0
178	323801	6395607	22	2	7	2	33	0.0	1.0
179	324177	6395141	22	2	7	2	33	0.0	1.0
180	324246	6392934	25	2	7	2	33	0.0	1.0
181	323983	6392725	26	2	7	2	33	0.0	1.0
182	324296	6392725	24	2	7	2	33	0.0	1.0
183	323903	6392368	26	2	7	3	34	0.0	1.0
184	324407	6392127	24	2	7	2	33	0.0	1.0
185	324272	6391894	24	2	7	2	33	0.0	1.0
186	324164	6391772	25	2	7	3	34	0.0	1.0
187	324308	6391565	25	2	7	2	33	0.0	1.0
188	324940	6390387	27	2	7	2	33	0.0	1.0
189	323916	6390047	35	3	8	3	34	0.1	1.1
190	323658	6389942	39	3	8	4	35	0.1	1.1
191	323873	6391630	26	3	8	3	34	0.1	1.1
192	323595	6391320	27	3	8	3	34	0.1	1.1

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu-lative	Mine only	Cumu-lative	Mine only	Cumu-lative
			Assessment criteria						
			50	-	30	-	90	2.0	4.0
193	316563	6380295	101	4	9	4	35	0.1	1.1
197	317697	6380527	74	4	9	5	36	0.1	1.1
199	317041	6377999	75	3	8	3	34	0.1	1.1
200	317355	6378491	72	3	8	3	34	0.1	1.1
201	316959	6378791	83	3	8	3	34	0.1	1.1
202	316645	6378627	83	3	8	3	34	0.1	1.1
203	316166	6378778	76	3	8	3	34	0.1	1.1
204	316412	6379324	87	3	8	3	34	0.1	1.1
205	316207	6379379	82	3	8	3	34	0.1	1.1
206	316330	6379324	85	3	8	3	34	0.1	1.1
207	315688	6379611	64	3	8	3	34	0.1	1.1
208	314950	6381046	39	3	8	3	34	0.0	1.0
Mine Residences									
11	312058	6390414	50	6	11	8	39	0.4	1.4
51	313744	6389001	60	9	14	9	40	0.6	1.6
79	314121	6394634	100	20	25	15	46	1.0	2.0
83	314144	6394841	95	19	24	14	45	0.9	1.9
90	314344	6394886	94	19	24	14	45	0.9	1.9
91	314359	6394718	99	20	25	15	46	1.0	2.0
92	314985	6383647	50	4	9	9	40	0.1	1.1
93	314481	6394444	108	22	27	16	47	1.2	2.2
94	314463	6394855	94	19	24	14	45	0.9	1.9
95	315097	6385163	69	5	10	11	42	0.1	1.1
96	314571	6394587	101	21	26	15	46	1.1	2.1
98	315125	6385857	79	7	12	13	44	0.2	1.2
99	314699	6394352	109	24	29	16	47	1.3	2.3
100	315144	6386684	95	9	14	15	46	0.3	1.3
101	315208	6386297	94	8	13	15	46	0.2	1.2
103	315505	6384205	89	5	10	15	46	0.1	1.1
104	315463	6386048	113	9	14	18	49	0.2	1.2
105	315017	6395104	93	18	23	14	45	0.8	1.8
106	315742	6386435	145	12	17	22	53	0.4	1.4
107	315949	6386105	162	12	17	25	56	0.4	1.4
108	316037	6387020	214	20	25	31	62	1.1	2.1
110	316226	6386333	216	16	21	32	63	0.6	1.6
112	316629	6386649	395	29	34	54	85	1.8	2.8
113	316882	6382664	146	6	11	24	55	0.2	1.2
114	316208	6397277	54	10	15	8	39	0.3	1.3
115	317271	6383479	133	8	13	21	52	0.4	1.4
116	318052	6396001	62	9	14	8	39	0.3	1.3
119	318452	6396156	57	8	13	8	39	0.2	1.2
131	321519	6391910	49	6	11	7	38	0.2	1.2
133	321261	6396710	25	4	9	4	35	0.1	1.1
135	321816	6389971	71	9	14	10	41	0.5	1.5
136	321862	6390017	65	8	13	9	40	0.4	1.4
138	321914	6390390	59	7	12	9	40	0.3	1.3
140	321981	6389895	66	8	13	10	41	0.3	1.3
145	322998	6384833	37	6	11	6	37	0.4	1.4
158	316576	6399021	40	7	12	7	38	0.2	1.2
165	318110	6396180	60	9	14	8	39	0.3	1.3
194	316918	6381238	115	5	10	20	51	0.1	1.1

ID	Easting	Northing	PM ₁₀ 24hr (µg/m ³)	PM ₁₀ Annual (µg/m ³)		TSP Annual (µg/m ³)		Dust Deposition (g/m ² /month)	
			Mine only	Mine only	Cumu- lative	Mine only	Cumu- lative	Mine only	Cumu- lative
			<i>Assessment criteria</i>						
			50	-	30	-	90	2.0	4.0
195	317560	6381402	88	5	10	15	46	0.2	1.2
196	317875	6381033	69	5	10	12	43	0.2	1.2
198	317533	6380076	78	4	9	14	45	0.1	1.1
209	322959	6383657	60	5	10	8	39	0.3	1.3

7.4 Summary of impacted residences

Table 7.7 summarises the residences where the impacts are predicted to exceed the assessment criteria. The 24-hour criterion due to the Project alone has been compared with both DECCW criteria of $50 \mu\text{g}/\text{m}^3$ at the 100th percentile, and the Department of Planning acquisition criterion of $50 \mu\text{g}/\text{m}^3$ at the 98.6th percentile.

Table 7.7: Summary of residences and years where impacts are predicted to exceed assessment criteria

ID	PM ₁₀		TSP ($\mu\text{g}/\text{m}^3$)	Dust deposition ($\text{g}/\text{m}^2/\text{month}$)	
	Averaging period			Annual	
	24-hour	Annual	Annual	Project alone	Project & other sources
	Project alone	Project & other sources	Project & other sources	Project alone	Project & other sources
	Impact Assessment Criteria				
	50	30	90	2	4
	Percentile				
	100 th	98.6 th	100 th	100 th	100 th
77	Year 2 Year 9 Year 21	Year 9 Year 21	Year 2	-	-
78 ^(a)	Year 2 Year 9 Year 21	Year 9 Year 21	Year 9 Year 21	-	Year 21
81	Year 21	-	-	-	-
97	Year 21	-	-	-	-
102 ^(b)	Year 2 Year 9 Year 21	Year 9 Year 21	Year 2 Year 9	-	-
109	Year 2 Year 9 Year 21	Year 2 Year 9 Year 21	Year 2 Year 9 Year 21	-	Year 9
111	Year 9 Year 21	-	-	-	-
117	Year 9 Year 21	-	-	-	-
118	Year 9 Year 21	-	-	-	-
121	Year 9	-	-	-	-
123	Year 9	-	-	-	-
126	Year 9	-	-	-	-
144	Year 9 Year 21	-	-	-	-
146	Year 9 Year 21	-	-	-	-
193	Year 9 Year 21	-	-	-	-
197	Year 2 Year 9 Year 21	-	-	-	-
199	Year 21	-	-	-	-
200	Year 21	-	-	-	-
201	Year 21	-	-	-	-
202	Year 21	-	-	-	-
203	Year 21	-	-	-	-
204	Year 21	-	-	-	-
205	Year 21	-	-	-	-
206	Year 21	-	-	-	-
207	Year 21	-	-	-	-

Notes:

- a) The residence at this location is currently uninhabitable.
- b) Receiver 102 is the Warkworth Hall

8 MITIGATION AND MONITORING

8.1 Introduction

The proposed mining activities will generate dust. It is therefore prudent to take reasonable and practicable measures to prevent or minimise dust impacts at surrounding receptors. Warkworth Mine currently has a dust emission management and control procedure in place, and this section supplements the current mitigation controls.

8.2 Proposed dust management and control procedures

The following procedures are proposed to minimise dust emissions from the proposed Warkworth Extension.

Dust from the proposed Warkworth Extension can be generated from two primary sources, these being:

- Wind-blown dust from exposed areas; and
- Dust generated by mining activities.

Table 8.1 and **Table 8.2** list the different sources of wind-blown and mining-generated dust respectively, and the proposed controls.

Table 8.1: 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 / stockpiles	Maintain coal handling areas / stockpiles in a moist condition to minimise wind-blown and traffic-generated dust.
ROM Coal Stockpiles	Have available water sprays on ROM coal stockpiles and use sprays to reduce airborne dust, as required.

Table 8.2: Mine-generated dust and controls

Source	Control procedures
Haul Road Dust	All roads and trafficked areas will be watered as required using water trucks 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 3 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. Restriction of blasting during unfavorable weather conditions will occur, where practicable.

8.3 Monitoring

The locations of the current monitoring stations are shown on **Figure 4.4**. It is expected that the existing monitoring network would need only minor changes to allow the mine to manage dust emissions and verify environmental performance.

The proposed modifications to the existing network would be to:

- Attach a PM₁₀ monitoring head to the existing HVAS TSP monitor nominally at WML TSP3.
- Relocate Mount Thorley Industrial Estate PM₁₀ HVAS monitor and WML-HV1 TSP monitor further north, away from any dust generating activities in the industrial estate, say near Residence 128.
- It is also proposed to install a new HVAS with PM₁₀ monitoring head in the southern areas of Bulga.

New and relocated air quality monitors would be sited to avoid locations where nearby activities generate significant local dust; such as near dirt roads, exposed areas and active agricultural land.

9 GREENHOUSE GAS EMISSIONS

9.1 Introduction

In November 2006, the NSW Land and Environment Court handed down a landmark decision (the judgement of Her Honour Pain J in the matter of *Gray v The Minister for Planning and ors NSWLEC 720*) which requires all new industrial developments to undertake a global warming impact study following the principles of ecologically sustainable development (ESD).

For the purposes of this report, the ESD principles have been taken to be those defined by the Department of Planning (**DUAP, 2000**), which are as follows.

1. The precautionary principle – namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
2. Inter-generational equity – namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
3. Conservation of biological diversity and ecological integrity.
4. Improved valuation and pricing of environmental resources.

This section examines the scientific principles that relate to greenhouse gases (GHG) and the global warming effect and estimates emissions of GHGs associated with the proposed Warkworth Extension. It is demonstrated that when all categories (that is, Scopes 1, 2 and 3) of GHG emissions from the Project are taken into account, the Project will comply with the principles of ESD.

Scope 1 and Scope 2 are direct emissions from the actual operation of the proposed Warkworth Extension, whereas Scope 3 are indirect emissions that would result from the off-site transport and burning of the coal produced by the proposed Warkworth Extension.

For this assessment, the greenhouse calculations were based on all operations at the proposed Warkworth Extension during the 21-year life.

9.2 Science of global warming

The technical assessment reports produced approximately every five years by the Intergovernmental Panel on Climate Change (IPCC) are regarded as the most authoritative and comprehensive documents dealing with the science of global warming. To date, the IPCC has published five technical assessment reports, the most recent being in 2007 (**IPCC, 2007**). These documents represent the scientific community's consensus view on climate change. They also provide a useful database to help to understand the significance of various human activities in the context of climate change. They include quantitative information on the production and fate of greenhouse gases and estimates of the expected increases in global temperatures for a range of feasible future. These scenarios are chosen to illustrate the range of uncertainty in the predictions of temperature increases.

The Garnaut Climate Change Review, commissioned by Australia's Commonwealth, State and Territory governments, released a final report in September 2008 which suggested that emissions are tracking the upper bounds of the scenarios modelled by the IPCC (**Garnaut, 2008**).

The temperature of the earth's atmosphere is determined almost entirely^f by the balance between radiation received from the sun and that re-radiated to outer space (see for example **IPCC, 2001**).

The parts of the radiation spectrum through which the earth can re-radiate and lose energy to outer space depends on the composition of the atmosphere. Certain gases including water vapour, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and a range of other gases absorb electromagnetic energy in the infrared spectrum. Solar radiation from the sun contains most of its energy in the infrared, visible and ultraviolet parts of the spectrum.

Sunlight passes through the atmosphere and warms both the atmosphere and the earth's surface. Clouds and the earth's surface directly reflect some of the sun's radiation back to space, but much of the sun's radiation is absorbed by the earth's surface and some by the atmosphere, which are warmed. The warmed earth and its atmosphere then re-radiate this energy back to space. For the average global temperature to remain constant, the incoming radiation from the sun must be balanced by the outgoing energy radiated from the earth and atmosphere.

Global warming (and associated climate change) is considered to occur because of the changing composition of the atmosphere, namely the increasing concentrations of GHGs, in particular CO₂, CH₄ and N₂O. These gases reduce the parts of the electromagnetic spectrum through which energy can be re-radiated from the earth. In response, the earth's temperature must increase to allow the rate of energy loss from the earth to increase and thereby allow the incoming and outgoing radiation to be brought back into balance.

In summary, GHGs absorb electromagnetic energy and change the radiation balance of the earth causing the temperature to increase so that the radiation balance is restored.

Without the presence of any GHGs, the earth's average temperature would be extremely cold (-18 °C) (**Seinfeld and Pandis, 1998**) and most of the planet would be uninhabitable. However, the effect of increasing greenhouse gases is to change existing climates and this may place stresses on current ecological systems that have adapted to current climate regimes.

Increasing concentrations of CO₂, CH₄ and other GHGs may cause the temperature of the atmosphere to increase but, because the earth transports heat from the equator towards the poles in a complicated way via ocean currents and winds, the precise effect of increasing concentrations is difficult to estimate for any particular location.

Increasing concentrations of CO₂ and CH₄ are largely attributable to growth in the worldwide use of fossil fuels to provide energy for increasing populations, which also have increasing per capita consumptions of energy. However, land clearing on a global scale is also an important cause in changes to CO₂ concentrations.

9.3 Quantifying greenhouse effects

Scientific publications sometimes refer to the quantity of carbon stored in the atmosphere or may refer to the equivalent quantity of carbon dioxide. In this context, 1.0 tonne (t) of carbon is the same as 3.67 t of CO₂. Most of the analysis in this report will refer to CO₂ rather than carbon, as this appears to be the most common approach used in Australia.

^f The words "almost entirely" are used because the residual heat from the earth's formation and from the decay of radioactive elements in the earth have some effect on the earth's temperature.

The estimated quantity of carbon dioxide stored in the atmosphere now is approximately 3,000 Gigatonnes (Gt). The International Energy Agency estimates that in 2007, global emissions of CO₂ from burning fossil fuels were 28,962 Mt, of which Australia's emissions of CO₂ from burning fossil fuels were 396.3 Mt CO₂ (i.e. approximately 1.4% of the global anthropogenic, or human-related, total) (**IEA, 2009**).

Because the relationship between global warming and greenhouse gas concentrations is not linear⁹ there is no accepted method to determine the contribution that a given emission of greenhouse gases might make to global warming.

To understand this point it is useful to consider the following discussion from Section 1.3.1 of the Third Scientific Assessment Report prepared by the IPCC (**IPCC, 1996**).

"The amount of carbon dioxide in the atmosphere has increased by more than 25% in the past century and since the beginning of the industrial revolution, an increase which is known to be in large part due to the combustion of fossil fuels and the removal of forests (Chapter 2 [of the report]). In the absence of controls, projections are that the future rate of increase in carbon dioxide amount may accelerate and concentrations could double from pre-industrial values within the next 50 to 100 years (IPCC, 1994).

The increased amount of carbon dioxide is leading to climate change and will produce, on average, a global warming of the Earth's surface because of its enhanced greenhouse effect – although the magnitude and significance of the effects are not yet fully resolved. If, for instance, the amount of carbon dioxide in the atmosphere were suddenly doubled, but with other things remaining the same, the outgoing long-wave radiation would be reduced by about 4 Wm⁻². To restore the radiative balance, the atmosphere must warm up and, in the absence of other changes, the warming at the surface and throughout the troposphere would be about 1.2 °C. However, many other factors will change, and various feedbacks come into play (see Section 1.4.1 [of the report]), so the best estimate of the average global warming for doubled carbon dioxide is 2.5 °C (IPCC, 1990). Such a change is very large by historical standards and would be associated with major climate changes around the world.

Note if carbon dioxide were removed from the atmosphere altogether, the change in outgoing radiation would be about 30 Wm⁻² – 7 to 8 times as big as the change for doubling – and the magnitude of the temperature change would be similarly enhanced. The reason is that the carbon dioxide absorption is saturated over part of the spectral region where it absorbs, so the amount of absorption changes at a much smaller rate than the concentration of the gas (Chapter 2 [of the report]). If the concentrations of carbon dioxide are more than doubled, then the relationship between radiative forcing and concentration is such that each further doubling provides a further radiative forcing of about 4 Wm⁻²."

9.4 Greenhouse gas inventories

Greenhouse gas inventories are calculated according to a number of different methods. The procedures specified under the Kyoto Protocol United Nations Framework Convention on Climate Change are the most common.

The protocol nominates the following GHGs:

⁹ The warming effect of a given quantity of greenhouse gases to the atmosphere is less and less as the concentration become higher and higher.

- Carbon dioxide (CO₂);
- Methane (CH₄);
- Nitrous oxide (N₂O);
- Hydrofluorocarbons (HFCs); and
- Perfluorocarbons (PFCs).

From the point of view of Warkworth Mine, only CO₂, CH₄ and N₂O are relevant.

Gases CO₂ and N₂O are formed and released during the combustion of gaseous, liquid and solid fuels. They are liberated when fuels are burnt in diesel powered equipment and in the generation of electrical energy that will be used by the proposed Warkworth Extension. Methane is released as a fugitive emission during the extraction of coal.

Inventories of greenhouse gas emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as warming potentials) and emission factors take into account the global warming potentials of the gases created during combustion.

The global warming potentials assumed by Department of Climate Change (DCC) (**DCC, 2009a**) are as follows;

- CO₂ – 1.
- CH₄ – 21.
- N₂O – 310.

When the global warming potentials are applied to the estimated emissions then the resulting estimate is referred to in terms of CO₂-equivalent (CO₂-e) emissions.

9.5 Emission factors

The National Greenhouse Accounts (NGA) Factors published by the DCC (**DCC, 2009a**) have been used to convert fuel usage and electricity consumption into CO₂-e emissions. The relevant emission factors are summarised in **Table 9.1**.

Table 9.1: Summary of greenhouse gas emission factors

Type of Fuel and Electricity		Emission factor		GHG	Scope	Source
Diesel - on-site activities ^(a)		69.2	kg CO ₂ -e/GJ	CO ₂	1	Table 3 DCC, 2009a
		0.1	kg CO ₂ -e/GJ	CH ₄	1	
		0.2	kg CO ₂ -e/GJ	N ₂ O	1	
		5.3	kg CO ₂ -e/GJ	-(^b)	3	Table 38 DCC, 2009a
		38.6	GJ/kL	Energy content factor		
Explosives use ^(c)	ANFO	0.17	t CO ₂ -e/tonne	-	1	Table 4 DCC, 2008
	Heavy ANFO	0.18	t CO ₂ -e/tonne	-	1	Table 4 DCC, 2008
	Emulsion	0.17	t CO ₂ -e/tonne	-	1	Table 4 DCC, 2008
Electricity ^(d)		0.89	kg CO ₂ -e/kWh	-	2	Table 5 DCC, 2009a
		0.18	kg CO ₂ -e/kWh	-	3	Table 39 DCC, 2009a
Extraction of coal		0.045	t CO ₂ -e/tonne ROM	CH ₄	1	Table 8 DCC 2009a
Transport of Coal (Rail)		11 ^(e)	t CO ₂ -e/Mt.km	-	3	Warkworth Mine
Transport of Coal (Ship)		^(f)	t CO ₂ -e/Mt.km	-	3	Warkworth Mine

Notes:

- ^(a) The emission factors for diesel use include Scope 1 emission (i.e. those activities associated with actual use of fuel) and Scope 3 emissions (those associated the production, processing and transport of diesel fuel to the site).
- ^(b) Refers to all equivalent greenhouse gases where applicable.
- ^(c) As the calculation of emissions from explosives use are no longer required under the NGER reporting requirements, the GHG emissions factor for explosives use has been removed from NGA Factors published June 2009 (**DCC, 2009a**). Therefore the factors published in February 2008 (**DCC, 2008**) have been used.
- ^(d) The emission factors for electrical energy include Scope 2 emissions (i.e. those associated with generating the electricity) and Scope 3 emissions (those associated with producing the fuel for the power station and the distribution losses involved in delivering electricity to the mine).
- ^(e) The emission factor associated with the transport of coal via rail has been obtained from the Proponent.
- ^(f) The emission factor associated with the transport of coal using ships has been provided by the Proponent. This varies depending on type of ship used (see **Section 9.7**).

9.6 Warkworth Mine greenhouse emissions

The CO₂-equivalent (CO₂-e) emissions from the proposed Warkworth Extension will result from the following sources:

- The extraction and processing of the coal due to fugitive emissions from mined coal seams, the combustion of diesel fuel (used in diesel-powered equipment, in blasting and to power the diesel generators) and use of electrical energy.
- The transport of the product coal to the Port of Newcastle and the transport of the product coal overseas.
- The combustion of the product coal in power generating facilities.

Further information is provided in the following sections.

9.6.1 Emissions from extraction and processing

Information was provided by the Proponent on the estimated usage of electrical energy, explosives and diesel fuel over the life of the mine. **Table 9.2** summarises the information provided. The information provided in **Table 9.2** is based on projected operational practices, it is noted that there is some variation in the annual energy efficiency of the mine throughout the lifetime. This variation is due to an initial “ramp-up” period prior to the mine reaching its maximum extractable capacity of 18 Mtpa of ROM coal.

Table 9.2: Summary of electricity, explosives and diesel use for Warkworth Mine

Year	ROM Coal (t)	Electricity use (MWh)	Explosives use (t)			Diesel use (kl)
			ANFO	Heavy ANFO	Emulsion	
1	12,782,397	160,057	26,902	14,159	15,984	74,609
2	13,888,585	163,746	26,499	14,185	15,799	73,154
3	12,765,342	194,219	30,501	16,032	18,205	80,477
4	12,480,971	194,536	34,675	18,935	20,598	100,810
5	11,348,662	203,795	35,237	19,257	20,904	102,627
6	16,974,805	197,589	31,547	17,049	18,902	89,339
7	18,000,000	191,030	29,207	16,027	17,602	85,408
8	18,000,000	192,330	29,040	16,029	17,503	87,551
9	16,628,239	191,400	26,955	14,641	16,384	78,285
10	18,000,000	161,386	24,048	13,048	14,483	67,475
11	18,000,000	166,016	24,719	13,422	14,855	69,462
12	15,824,149	175,811	23,881	12,804	14,414	66,800
13	17,049,969	171,277	24,302	13,023	14,610	67,303
14	16,194,273	168,088	26,814	14,699	15,989	76,730
15	17,626,955	168,680	27,668	15,240	16,446	78,884
16	18,000,000	176,753	28,084	15,436	16,699	79,741
17	17,429,435	176,410	28,110	15,436	16,724	79,640
18	18,000,000	152,998	26,054	14,718	15,432	77,331
19	17,760,496	149,374	27,776	15,629	16,291	80,401
20	17,634,188	144,150	27,675	15,693	16,204	81,765
21	18,000,000	170,658	28,309	15,824	16,853	83,235

Table 9.3 summarises the estimated annual average CO₂-e emissions from the proposed Warkworth Extension due to extraction and processing using the above emissions factors.

Table 9.3: Summary of estimated CO₂ emissions from mining and processing of coal from Warkworth Extension Project (tonnes/year)

Year	CO ₂ e from electrical energy usage			CO ₂ e from diesel usage		CO ₂ e from blasting (ANFO)			CO ₂ e from blasting (Heavy ANFO)		CO ₂ e from blasting (Emulsion)		CO ₂ e from CH ₄ released during mining		Total	
	Scope 2	Scope 3	Scope 1	Scope 2	Scope 3	Scope 1	Scope 2	Scope 3	Scope 1	Scope 2	Scope 1	Scope 2	Scope 1	Scope 2	Scope 1, 2 & 3	Scope 1, 2 & 3
1	142,451	28,810	200,153	15,263	15,263	2,549	4,573	2,549	2,549	2,717	575,208	971,724	575,208	971,724	971,724	971,724
2	145,734	29,474	196,251	14,966	14,966	2,553	4,505	14,966	2,553	2,686	624,986	1,021,156	624,986	1,021,156	1,021,156	1,021,156
3	172,855	34,959	215,896	16,464	16,464	2,886	5,185	215,896	2,886	3,095	574,440	1,025,781	574,440	1,025,781	1,025,781	1,025,781
4	173,137	35,017	270,443	20,624	20,624	3,408	5,895	270,443	3,408	3,502	561,644	1,073,669	561,644	1,073,669	1,073,669	1,073,669
5	181,377	36,683	275,319	20,996	20,996	3,466	5,990	275,319	3,466	3,554	510,690	1,038,074	510,690	1,038,074	1,038,074	1,038,074
6	175,854	35,566	239,670	18,277	18,277	3,069	5,363	239,670	3,069	3,213	763,866	1,244,878	763,866	1,244,878	1,244,878	1,244,878
7	170,017	34,385	229,125	17,473	17,473	2,885	4,965	229,125	2,885	2,992	830,461	1,271,842	830,461	1,271,842	1,271,842	1,271,842
8	171,174	34,619	234,874	17,911	17,911	2,885	4,937	234,874	2,885	2,976	811,308	1,279,376	811,308	1,279,376	1,279,376	1,279,376
9	170,346	34,452	210,014	16,015	16,015	2,635	4,582	210,014	2,635	2,785	748,271	1,189,101	748,271	1,189,101	1,189,101	1,189,101
10	143,634	29,049	181,016	13,804	13,804	2,349	4,088	181,016	2,349	2,462	812,585	1,186,402	812,585	1,186,402	1,186,402	1,186,402
11	147,754	29,883	186,345	14,210	14,210	2,416	4,202	186,345	2,416	2,525	810,216	1,197,335	810,216	1,197,335	1,197,335	1,197,335
12	156,472	31,646	179,204	13,666	13,666	2,305	4,060	179,204	2,305	2,450	712,087	1,101,889	712,087	1,101,889	1,101,889	1,101,889
13	152,436	30,830	180,554	13,769	13,769	2,344	4,131	180,554	2,344	2,484	767,249	1,153,796	767,249	1,153,796	1,153,796	1,153,796
14	149,598	30,256	205,844	15,697	15,697	2,646	4,558	205,844	2,646	2,718	728,742	1,140,060	728,742	1,140,060	1,140,060	1,140,060
15	150,125	30,362	211,623	16,138	16,138	2,743	4,704	211,623	2,743	2,796	793,213	1,211,704	793,213	1,211,704	1,211,704	1,211,704
16	157,310	31,815	213,922	16,313	16,313	2,779	4,774	213,922	2,779	2,839	810,000	1,239,752	810,000	1,239,752	1,239,752	1,239,752
17	157,005	31,754	213,651	16,293	16,293	2,778	4,779	213,651	2,778	2,843	784,325	1,213,427	784,325	1,213,427	1,213,427	1,213,427
18	136,168	27,540	207,455	15,820	15,820	2,649	4,429	207,455	2,649	2,624	810,000	1,206,686	810,000	1,206,686	1,206,686	1,206,686
19	132,943	26,887	215,692	16,448	16,448	2,813	4,722	215,692	2,813	2,770	799,222	1,201,498	799,222	1,201,498	1,201,498	1,201,498
20	128,294	25,947	219,351	16,727	16,727	2,825	4,705	219,351	2,825	2,755	793,538	1,194,142	793,538	1,194,142	1,194,142	1,194,142
21	151,886	30,718	223,294	17,028	17,028	2,848	4,813	223,294	2,848	2,865	810,000	1,243,452	810,000	1,243,452	1,243,452	1,243,452
Total	3,266,570	660,655	4,509,695	343,905	343,905	57,832	99,960	343,905	57,832	59,650	15,432,051	24,405,747	15,432,051	24,405,747	24,405,747	24,405,747

9.7 Emissions from transport and burning of product coal

9.7.1 Emissions from off-site transport of product coal

It has been estimated that 95 per cent of the product coal will be transported to the Port of Newcastle by rail for export to overseas customers. The remaining five per cent will be sold domestically. This section estimates the emissions generated from the transport of the product coal, a discussion on the use of the product coal is provided in **Section 9.7.2**.

For the purpose of this analysis, it is assumed that all coal carried by rail to the Port of Newcastle will travel a distance of approximately 85 km (one way). Information provided by Warkworth Mine gives the CO₂-e emission rate for rail transport as 11 t CO₂-e/Mt.km.

Table 9.4 summarises CO₂ emissions from transporting the product coal from the project site to the Port of Newcastle. We have conservatively assumed that emissions generated from the return journey will be the same.

Table 9.4: Summary of estimated CO₂-e emissions from transport of product coal for export (t/y)

Year	Product coal for export (t/y)	Total CO ₂ -e from rail transport to the Port of Newcastle (t)	Total CO ₂ -e from rail transport to Warkworth Mine (t)
1	9,038,986	8,451	8,451
2	9,592,677	8,969	8,969
3	11,370,282	10,631	10,631
4	12,677,568	11,854	11,854
5	12,243,294	11,447	11,447
6	12,479,120	11,668	11,668
7	12,537,256	11,722	11,722
8	12,475,361	11,664	11,664
9	12,388,771	11,584	11,584
10	9,770,567	9,135	9,135
11	10,012,259	9,361	9,361
12	10,442,733	9,764	9,764
13	10,056,326	9,403	9,403
14	9,944,130	9,298	9,298
15	9,956,311	9,309	9,309
16	10,345,619	9,673	9,673
17	10,333,331	9,662	9,662
18	9,694,821	9,065	9,065
19	9,025,296	8,439	8,439
20	8,945,840	8,364	8,364
21	11,060,935	10,342	10,342
Total	215,352,498	209,806	209,806

Shipping information was provided by the Proponent and is summarised in **Table 9.5**. It details the approximate distance travelled, the type of ship used and the associated emission factor for each ship in 2008. The percentage of product coal distributed to each of these destinations has been calculated from the tonnage of coal carried by each ship. It has been assumed for this assessment that the product distribution for 2008 will apply over the life of the mine. It should

be noted that the final destinations and uses of the coal will vary over the life of the mine and is difficult to assume.

Table 9.5: Summary of Product Coal transport to overseas customers

Destination	Ship type	Approximate Distance (km)	Emission Factor (t CO ₂ -e/Mt.km)	Percentage of total product coal distribution (based on 2008 figures)
Europe	Panamax	21,000	3.459	2.1
	Bulk Carrier	21,000	2.09	4.6
Asia	Handy	6,500	5.422	1.1
	Panamax	6,500	3.459	57.3
	Bulk Carrier	6,500	2.09	34.9

Source: Warkworth Mine

Using the information provided in **Table 9.5**, CO₂-e emissions have been estimated for the life of the mine and are presented in **Table 9.6**. Conservatively we have also assumed that emissions generated from the return journey are equal to the emissions generated during the transport.

Table 9.6: Summary of estimated CO₂-e emissions from transport of product coal overseas (t)

Year	Europe			Asia		Return Journey	Total CO ₂ -e emissions (t)
	Panamax	Bulk Carrier	Handy	Panamax	Bulk Carrier		
1	13,854	18,170	3,600	116,490	42,806	194,920	389,840
2	14,703	19,283	3,820	123,626	45,428	206,860	413,720
3	17,427	22,856	4,528	146,535	53,847	245,193	490,386
4	19,431	25,484	5,049	163,383	60,038	273,384	546,769
5	18,765	24,611	4,876	157,786	57,981	264,019	528,038
6	19,127	25,085	4,970	160,825	59,098	269,104	538,209
7	19,216	25,202	4,993	161,574	59,373	270,358	540,716
8	19,121	25,077	4,968	160,777	59,080	269,023	538,046
9	18,988	24,903	4,934	159,661	58,670	267,156	534,312
10	14,975	19,640	3,891	125,919	46,271	210,696	421,392
11	15,346	20,126	3,987	129,033	47,415	215,908	431,815
12	16,005	20,992	4,159	134,581	49,454	225,191	450,382
13	15,413	20,215	4,005	129,601	47,624	216,858	433,716
14	15,241	19,989	3,960	128,155	47,093	214,439	428,877
15	15,260	20,014	3,965	128,312	47,150	214,702	429,403
16	15,857	20,796	4,120	133,330	48,994	223,097	446,194
17	15,838	20,772	4,115	133,171	48,936	222,832	445,664
18	14,859	19,488	3,861	124,942	45,912	209,063	418,125
19	13,833	18,142	3,594	116,314	42,741	194,625	389,249
20	13,711	17,983	3,563	115,290	42,365	192,911	385,823
21	16,953	22,234	4,405	142,548	52,382	238,522	477,044
Total	343,923	451,062	89,363	2,891,853	1,062,658	4,838,861	9,677,720

9.7.2 Emissions from use of coal

The Proponent's customers will make use of the coal, and there will inevitably be GHG emissions associated with the end use given coal is used to create energy. The adopted convention is that these emissions for the use of the coal are attributed to the user of the coal not the producer,

however, to address the judgement of her Honour Pain J in the matter of *Gray v The Minister for Planning*, estimates of the GHG emissions associated with the use of the coal have been made.

The convention of not including these emissions avoids double counting of the emissions: leaving the accounting of the emissions from the use of the coal to the end user is also desirable as emissions due to the end use depend on how the coal is used to produce energy and any control measures that might be in place. Various methods of burning will be used by different customers. As most coal from the proposed Warkworth Extension is to be exported, any assessment of greenhouse emissions by its use in those other jurisdictions will be speculative and potentially unreliable.

Approximately 5% of the coal would be conveyed to and burnt at Redbank power station. The remainder of the product coal will be exported overseas, as the final use of the product coal is unknown and will vary over the life of the mine, it is not possible to accurately calculate the resultant emissions. As a conservative estimate we have assumed that half of the product coal exported overseas will be used for power generation and the remainder used in steel manufacture.

The quantity of CO₂ emitted can be estimated with a reasonable degree of reliability if the carbon content of the coal is known. It is reasonable to assume that all the carbon will be converted to CO₂ and that minor emissions of CO will be converted to CO₂ reasonably rapidly (in 1 to 4 months) (**Seinfeld and Pandis, 1998**). There will, however, be some uncertainty as to the production of N₂O, which depends not only on the nitrogen content in the fuel but the temperature of the combustion process. Some small quantity of carbon will also be retained in the ash from combustion in power stations.

For the approximate 5% of the coal used at Redbank, it is assumed that these emissions are equivalent to a power station in NSW burning black coal. Thus the emissions were estimated using the NGA emission factor of 88.43 kg CO₂-equivalent/GJ and an energy content factor of 27 GJ/t (Table 1, Scope 1 of **DCC, 2009a**).

Table 9.7 summarises the estimated CO₂ emissions for each year of the proposed Warkworth Extension operation due to usage of the product coal at the Redbank Power Station.

Table 9.7: Summary of estimated CO₂-e emissions from usage of coal at Redbank (t)

Year	Coal used at Redbank power station (t)	CO ₂ -e from power production (t)
1	475,736	1,135,872
2	504,878	1,205,451
3	598,436	1,428,832
4	667,240	1,593,110
5	644,384	1,538,537
6	656,796	1,568,172
7	659,856	1,575,478
8	656,598	1,567,700
9	652,041	1,556,819
10	514,240	1,227,805
11	526,961	1,258,177
12	549,618	1,312,272
13	529,280	1,263,715
14	523,375	1,249,616
15	524,016	1,251,147
16	544,506	1,300,069
17	543,860	1,298,524
18	510,254	1,218,287
19	475,016	1,134,152
20	470,834	1,124,167
21	582,154	1,389,958
Total	11,334,342	27,061,988

For the coal exported overseas, it has been conservatively estimated that half of this coal is used in power generation. Estimations of the CO₂-e emission generated at power stations overseas are difficult to obtain. For the purposes of this assessment we have taken the emissions equivalent for a power station in NSW burning black coal. The emission factors have been mentioned previously above. **Table 9.8** summarises the CO₂-e emissions generated by overseas customers in a power station.

Table 9.8: Summary of estimated CO₂-e emissions from usage of coal at overseas power stations (t)

Year	Coal used at Overseas power station (t)	CO ₂ -e from power production (t)
1	4,519,493	10,790,787
2	4,796,339	11,451,786
3	5,685,141	13,573,900
4	6,338,784	15,134,545
5	6,121,647	14,616,106
6	6,239,560	14,897,635
7	6,268,628	14,967,039
8	6,237,681	14,893,149
9	6,194,385	14,789,776
10	4,885,283	11,664,152
11	5,006,130	11,952,685
12	5,221,367	12,466,587
13	5,028,163	12,005,292
14	4,972,065	11,871,352
15	4,978,155	11,885,894
16	5,172,810	12,350,652
17	5,166,666	12,335,982
18	4,847,410	11,573,726
19	4,512,648	10,774,443
20	4,472,920	10,679,589
21	5,530,467	13,204,599
Total	112,195,742	267,879,676

For the coal used in steel manufacture we have taken a mass balance approach to estimate the CO₂-e emissions generated. This approach is very conservative assuming that all the carbon used will be converted to CO₂, where in reality some of the carbon will be captured in the steel. The approach outlined in the NGA Factors requires detailed information to be provided by the steel manufacturer which is difficult to obtain.

Table 9.9 summarises the estimated CO₂-e emissions generated by the usage of coal by overseas customers in steel manufacture.

Table 9.9: Summary of estimated CO₂-e emissions from usage of coal in overseas steel manufacture (t)

Year	Coal used in overseas steel manufacture (t)	CO ₂ -e from steel manufacture (t)
1	4,519,493	16,571,475
2	4,796,339	17,586,575
3	5,685,141	20,845,518
4	6,338,784	23,242,209
5	6,121,647	22,446,040
6	6,239,560	22,878,386
7	6,268,628	22,984,969
8	6,237,681	22,871,496
9	6,194,385	22,712,746
10	4,885,283	17,912,706
11	5,006,130	18,355,808
12	5,221,367	19,145,011
13	5,028,163	18,436,597
14	4,972,065	18,230,904
15	4,978,155	18,253,236
16	5,172,810	18,966,969
17	5,166,666	18,944,441
18	4,847,410	17,773,838
19	4,512,648	16,546,376
20	4,472,920	16,400,708
21	5,530,467	20,278,381
Total	112,195,742	411,384,389

9.8 Total CO₂-equivalent Emissions

Table 9.10 summarises the total emissions from all sources.

Table 9.10: Summary of total estimated CO₂-e emissions all sources (t)

Year	CO ₂ -e Mining and extraction (t)			CO ₂ -e Transport of product coal - rail and ship (t)	CO ₂ -e Usage of product coal (t)	CO ₂ -e Total (t)	
	Scope 1	Scope 2	Scope 3	Scope 3	Scope 3	Scope 1 & 2	Scope 3
1	785,200	142,451	44,074	406,743	28,498,134	927,651	28,948,951
2	830,981	145,734	44,440	431,658	30,243,813	976,715	30,719,911
3	801,503	172,855	51,423	511,648	35,848,250	974,358	36,411,321
4	844,891	173,137	55,640	570,474	39,969,863	1,018,029	40,595,978
5	799,018	181,377	57,679	550,933	38,600,683	980,396	39,209,294
6	1,015,181	175,854	53,843	561,545	39,344,194	1,191,035	39,959,581
7	1,049,967	170,017	51,858	564,161	39,527,485	1,219,984	40,143,504
8	1,055,671	171,174	52,531	561,375	39,332,345	1,226,845	39,946,251
9	968,288	170,346	50,467	557,479	39,059,341	1,138,634	39,667,287
10	999,915	143,634	42,854	439,663	30,804,663	1,143,549	31,287,180
11	1,005,488	147,754	44,093	450,539	31,566,671	1,153,242	32,061,303
12	900,105	156,472	45,312	469,910	32,923,871	1,056,577	33,439,093
13	956,761	152,436	44,599	452,522	31,705,604	1,109,198	32,202,725
14	944,508	149,598	45,953	447,473	31,351,872	1,094,107	31,845,298
15	1,015,078	150,125	46,501	448,021	31,390,277	1,165,204	31,884,798
16	1,034,314	157,310	48,129	465,540	32,617,689	1,191,624	33,131,358
17	1,008,376	157,005	48,047	464,987	32,578,947	1,165,381	33,091,981
18	1,027,157	136,168	43,360	436,255	30,565,851	1,163,326	31,045,466
19	1,025,219	132,943	43,336	406,127	28,454,971	1,158,163	28,904,434
20	1,023,174	128,294	42,675	402,551	28,204,464	1,151,467	28,649,690
21	1,043,820	151,886	47,747	497,728	34,872,938	1,195,705	35,418,412
Total (Mt)						23.4	718.6
Annual average (Mt/y)						742	35.3

Section 9.10 compares these emissions on a local and global scale.

9.9 Important additional considerations

While it is possible to assess the significance of these emissions by comparing them with other sources of greenhouse gases, it is also important to note that the efficiency with which the coal is used is also very important. All other things being equal^h, global CO₂-e emissions could be halved if power station efficiencies were doubled, or halved if the efficiency by which end users' consumed electricity was doubled or waste was reduced and so on.

Different customers will use the coal in power plants of different thermal efficiencies. The Australian Coal Association provides some typical statistics for power station efficiencies on their web site (**ACA, 2006**).

The web site notes the following:

^h Population remaining fixed and the per capita consumption of energy being fixed.

"Industry has continuously striven to increase efficiencies of conventional plant; for example, the average thermal efficiency of US power stations has increased from 5% in 1900, to around 35% currently. In China, most power plants are relatively small, average efficiency is about 28% compared to an OECD average of 38%. New conventional [pulverised fuel] PF power plants achieve above 40% efficiency.

Advanced modern plants use specially developed high strength alloy steels, which enable the use of supercritical and ultra-supercritical steam (pressures >248 bar and temperatures >566°C) and can achieve, depending on location, close to 45% efficiency.

Application of new advanced materials to PF power plant should enable efficiencies of 55% to be achieved in the future. This results in corresponding reductions in CO₂ emissions as less fuel is used per unit of electricity generated".

The Proponent does not propose, nor does it seek approval, to burn any of the coal produced directly.

9.10 Contribution of greenhouse gas emissions from Warkworth Mine to State, National and global emissions

This section discusses the contribution of the proposed Warkworth Extension to global emissions. Because the relationship between global warming and greenhouse gas concentrations is not linearⁱ, there is no accepted method to determine the contribution that a given emission of greenhouse gases might make to global warming.

To understand this point, it is useful to consider the discussion from Section 1.3.1 of the Third Scientific Assessment Report prepared by the IPCC (**IPCC, 1996**), which was provided earlier in **Section 9.3**.

At any point in time, it would be reasonably simple to compare the estimated emission of CO₂-e from the various activities with the 3,000 Gt of CO₂-e currently estimated to be stored in the atmosphere. On this basis, average annual emissions over the lifetime of the proposed Warkworth Extension from the mining and use of coal (including mining, transporting the coal to the Port of Newcastle and overseas, and usage of the coal) are estimated to be 0.001% of the current global CO₂-e atmospheric load. Thus, the proposed Warkworth Extension could be considered to contribute 0.001% to the increase in global temperatures caused by the increase in greenhouse gas emissions as they are currently. This invites the question as to what temperature rise might be attributed to the GHG emissions from the proposed Warkworth Extension.

Based on the IPCC estimate that a doubling of the CO₂-e concentration in the atmosphere would lead to a 2.5°C increase in global average temperature (see **Section 9.3**), and that the current global CO₂-e load is approximately 3,000 Gt, it can be estimated that the annual average emissions (Scope 1, 2 and 3) during the life of proposed Warkworth Extension (including mining, transporting the coal to the Port of Newcastle and overseas and usage of the coal) could lead to an annual increase in global temperature of 0.00003 °C $[(3.6 \times 10^7 / 3,000 \times 10^9) \times 2.5^\circ\text{C}]$.

The total CO₂-e emissions for the State of NSW in 2007 were 162.7 Mt CO₂ -e (**DCC, 2009b**). The average annual emissions estimated for the lifetime of the proposed Warkworth Extension

ⁱ The warming effect of a given quantity of greenhouse gases to the atmosphere is less and less as the concentration become higher and higher (see **Section 9.3**).

(Scope 1 and 2) is 1.11 Mt CO₂-e. This equals approximately 0.68% of the total emissions for NSW in 2007.

In 2007, Australia's total greenhouse gas emissions were estimated at 541.2 Mt CO₂-e (**DCC, 2009b**) When comparing emissions for (Scope 1 and 2) associated with the Warkworth Extension project, the predicted increase is 0.2% of total 2007 Australian emissions.

The GHG contribution to world emissions from CO₂-e emissions produced from the Warkworth Extension is an increase of 0.001%, when comparing emissions for the full fuel cycle (i.e. Scope 1, 2 and 3) to the current global CO₂-e load of approximately 3,000 Gt CO₂-e (**UNFCCC, 2009**).

Based on the above, there are not likely to be any measurable environmental effects due to the emissions of GHGs from the proposed Warkworth Extension, i.e. the contribution of the project on GHG emissions is minor. Given this, it is clear that Warkworth Mine will comply with the principles of ESD.

In practice, of course, the effects of global warming and associated climate change are the cumulative effect of many thousands of such sources and it is the cumulative effects that pose a threat to ESD principles.

9.11 Greenhouse gas emissions management

The Warkworth Extension project intends to adopt various mitigation measures and energy efficiency plans to help reduce their overall greenhouse gas emissions.

These measures include the implementation of a detailed energy monitoring programme, monitoring the electricity and diesel usage on-site to identify main sources of greenhouse gas emissions and initiate appropriate greenhouse gas reduction mechanisms. This will ensure diesel powered equipment is regularly maintained to operate at peak efficiency.

A coal seam methane pilot project to capture methane trapped in the coal seam prior to mining is also considered. This will allow the conversion of methane to carbon dioxide before it is released to the atmosphere, leading to reduction in overall greenhouse gas emissions. This project will also include accurate monitoring of the residual coal seam methane to determine site specific emission factors for the mine.

In addition it will fund research programs to develop advanced technologies focusing on reducing greenhouse gas emissions and carbon capture technologies.

Presently the viability of these actions have not been confirmed and these measures do not form part of this application.

10 SUMMARY AND CONCLUSIONS

This study assesses the potential impacts on air quality from the proposed Warkworth Extension. Dispersion modelling was used to predict off-site dust concentration and dust deposition levels that may arise due to the project. The modelling took account of local meteorology and terrain and used dust emission estimates of the proposed activities over three key mining scenarios to predict dust levels at off-site receptor locations.

Predictions of air quality impacts considered the effects of surrounding mines as well as other non-mining and non-modelled sources of dust. Model predictions at privately-owned residential receptors were compared with applicable air quality criteria. Predictions equal to or below the criteria indicate an acceptable air quality impact.

Analysis of the dispersion modelling results indicates that the proposed Warkworth Extension project would exceed DECCW impact assessment criteria at up to 25 nearby privately owned receptors for 24-hour PM_{10} , at up to four privately owned residences for annual average PM_{10} , and at up to two privately owned receptors for deposited dust.

Analysis of the dispersion modelling results indicates that the proposed Warkworth Extension project would exceed DoP project assessment criteria at up to four privately owned receptors, as follows: receptors 109 in Year 2, receptors 77, 78, 102 and 109 in Year 9, and receptors 77, 78, 102 and 109 in Year 21.

Warkworth Mine will take steps to mitigate and manage potential dust impacts associated with the project through a range of controls and continued monitoring of air quality in the area surrounding the mine.

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Appendix A: Receptor details

Table A.1: Receptor details

Receptor ID	MGA Zone 55	
	Easting (m)	Northing (m)
1	310903	6386238
2	311055	6386261
3	311295	6386059
4	311336	6385751
5	311384	6386200
6	311422	6386223
7	311470	6385618
8	311735	6385855
9	311832	6385649
10	311950	6386665
11	312058	6390414
12	312442	6386044
13	312532	6387028
14	312632	6386066
15	312729	6385875
16	312822	6386804
17	312814	6387573
18	312935	6385847
19	312900	6387741
20	313041	6385812
21	312998	6386821
22	313169	6385713
23	313193	6385453
24	313145	6387267
25	313091	6388764
26	313266	6385706
27	313151	6388111
28	313335	6385003
29	313160	6388183
30	313270	6386465
31	313281	6386646
32	313252	6387528
33	313338	6386039
34	313265	6388491
35	313406	6386485
36	313473	6385589
37	313345	6387861
38	313489	6385650
39	313511	6385747
40	313595	6385794
41	313690	6384726
42	313580	6386816
43	313658	6385668
44	313658	6385708
45	313725	6385198
46	313798	6385640
47	313793	6385729
48	313823	6385853
49	313872	6385678
50	313898	6385517
51	313744	6389001
52	313956	6385265
53	313965	6385488
54	314037	6384456

MGA Zone 55		
Receptor ID	Easting (m)	Northing (m)
55	313981	6385757
56	314005	6385480
57	314055	6385470
58	314046	6385804
59	314088	6385479
60	314128	6385459
61	314231	6384325
62	314225	6385443
63	314229	6385540
64	314242	6385504
65	314239	6385584
66	314258	6385447
67	314434	6383176
68	314306	6385515
69	314329	6385371
70	314462	6383042
71	314354	6385377
72	314392	6385359
73	314407	6385160
74	314514	6384263
75	314546	6385220
76	314618	6384591
77	314103	6394482
78	314203	6393069
79	314121	6394634
80	314769	6383296
81	314590	6386597
82	314734	6384379
83	314144	6394841
84	314796	6383618
86	314767	6385091
87	314711	6386122
89	314951	6383454
90	314344	6394886
91	314359	6394718
92	314985	6383647
93	314481	6394444
94	314463	6394855
95	315097	6385163
96	314571	6394587
97	315058	6386183
98	315125	6385857
99	314699	6394352
100	315144	6386684
101	315208	6386297
102	314803	6394347
103	315505	6384205
104	315463	6386048
105	315017	6395104
106	315742	6386435
107	315949	6386105
108	316037	6387020
109	315789	6393545
110	316226	6386333
111	316609	6382098

MGA Zone 55		
Receptor ID	Easting (m)	Northing (m)
112	316629	6386649
113	316882	6382664
114	316208	6397277
115	317271	6383479
116	318052	6396001
117	317982	6397794
118	318128	6397356
119	318452	6396156
120	318504	6398457
121	318530	6398039
122	318608	6398554
123	318658	6398205
124	318655	6398582
125	320142	6394738
126	320764	6393699
127	320624	6396932
128	320916	6394511
129	321192	6394796
130	321271	6394970
131	321519	6391910
133	321261	6396711
134	321472	6395034
135	321816	6389971
136	321862	6390017
137	321617	6395135
138	321914	6390390
139	321707	6394686
140	321981	6389895
141	321604	6397030
142	321715	6395167
143	321817	6395230
144	322654	6389614
145	322998	6384833
146	322820	6389611
147	323200	6391960
148	323360	6389527
149	323510	6388982
150	323560	6389775
151	323731	6387355
152	323454	6392457
153	323662	6389415
154	323680	6389650
155	323567	6393350
156	323610	6393617
157	323739	6393594
158	316576	6399021
159	317824	6399125
160	317852	6399235
161	317878	6399446
162	317940	6399347
163	318089	6399489
164	318370	6398295
165	318110	6396180
166	318621	6394019
167	322254	6396725

MGA Zone 55		
Receptor ID	Easting (m)	Northing (m)
168	322468	6396793
169	321959	6396271
170	322379	6396285
171	321905	6395411
172	321925	6395400
173	322099	6395301
174	322545	6395438
175	322633	6395534
176	322830	6395688
177	323156	6395384
178	323801	6395607
179	324177	6395141
180	324246	6392934
181	323983	6392725
182	324296	6392725
183	323903	6392368
184	324407	6392127
185	324272	6391894
186	324164	6391772
187	324308	6391565
188	324940	6390387
189	323916	6390047
190	323658	6389942
191	323873	6391630
192	323595	6391320
193	316558	6380293
194	316918	6381236
195	317561	6381382
196	317877	6381030
197	317716	6380532
198	317549	6380075
199	317036	6377983
200	317360	6378494
201	316963	6378778
202	316649	6378621
203	316167	6378781
204	316407	6379326
205	316333	6379327
206	316214	6379385
207	315682	6379608
208	314955	6381041
209	322962	6383649

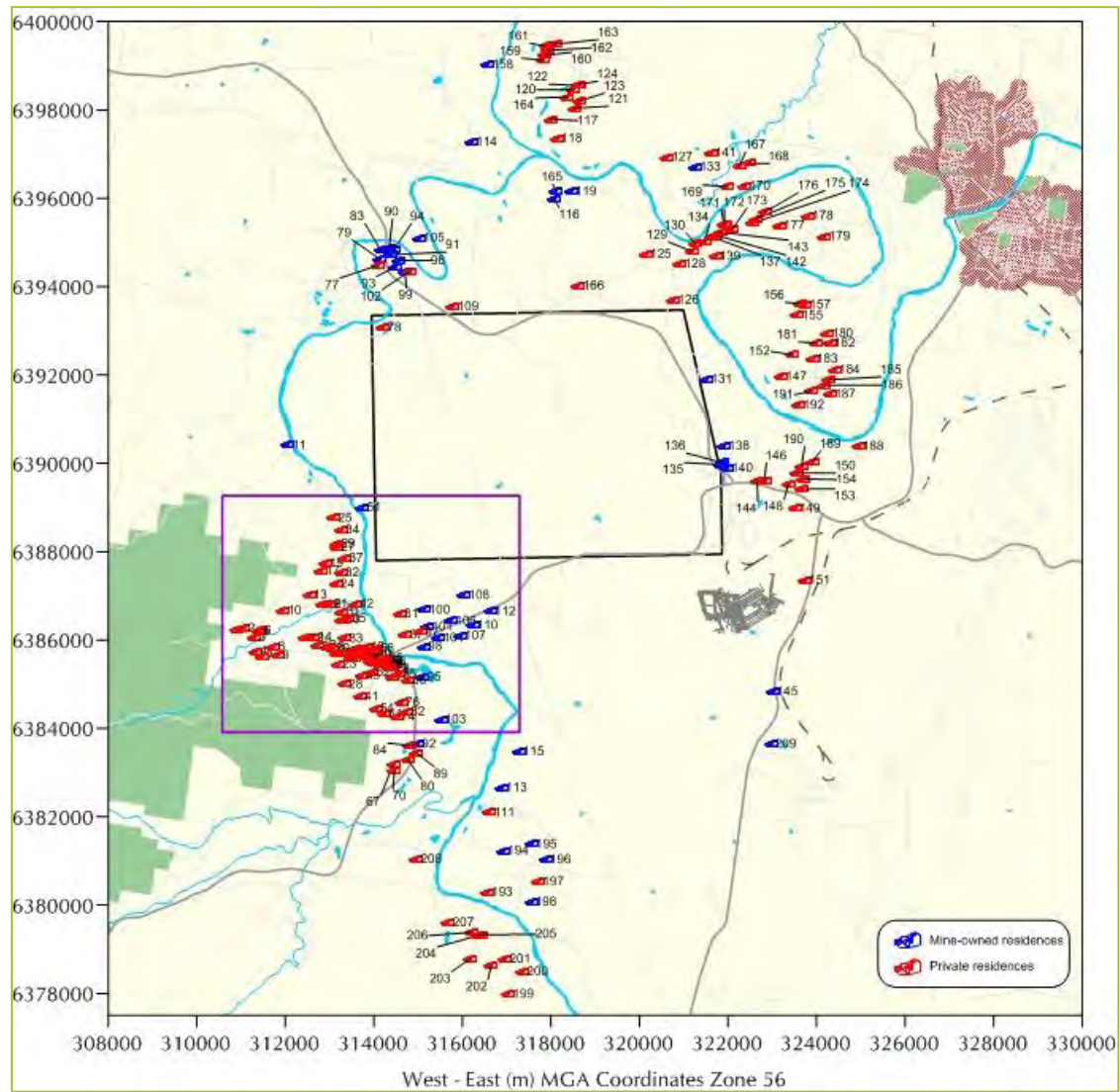


Figure A.1: Receptor location plan

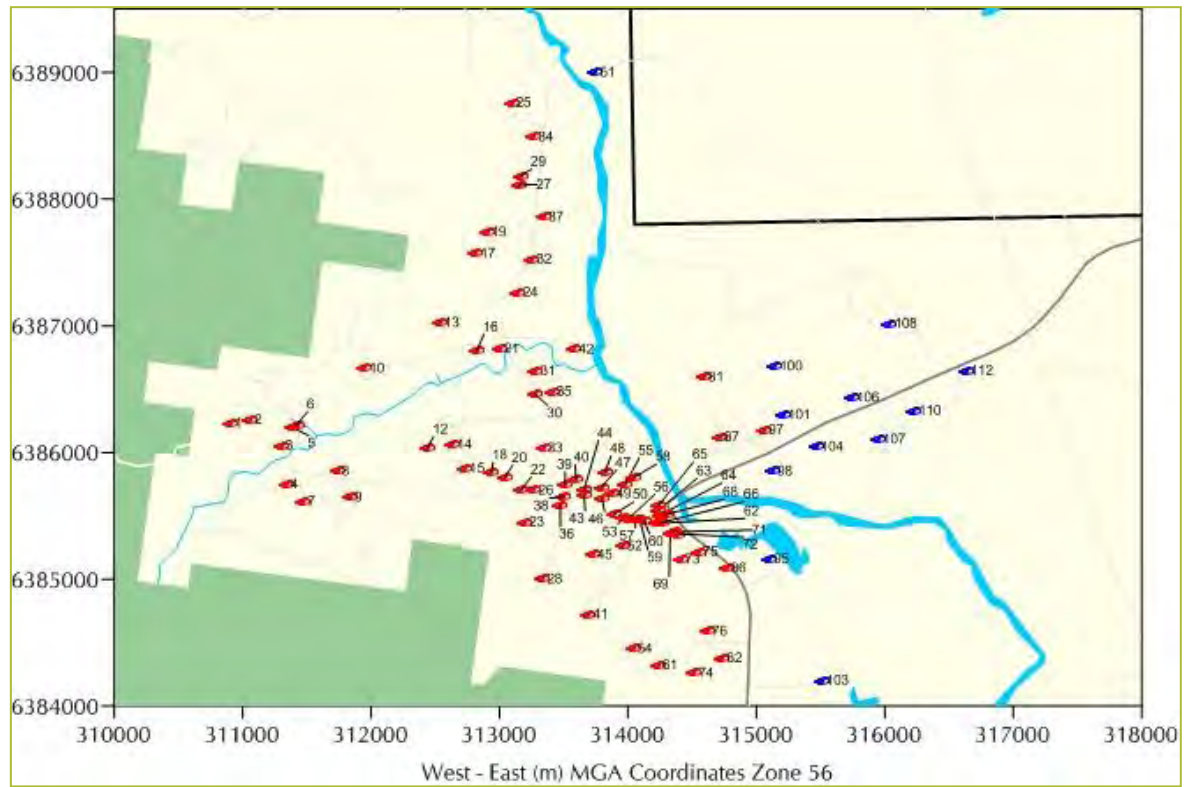


Figure A.2: Bulga receptor location plan

Appendix B: Predicted PM_{2.5} emissions from mining sources

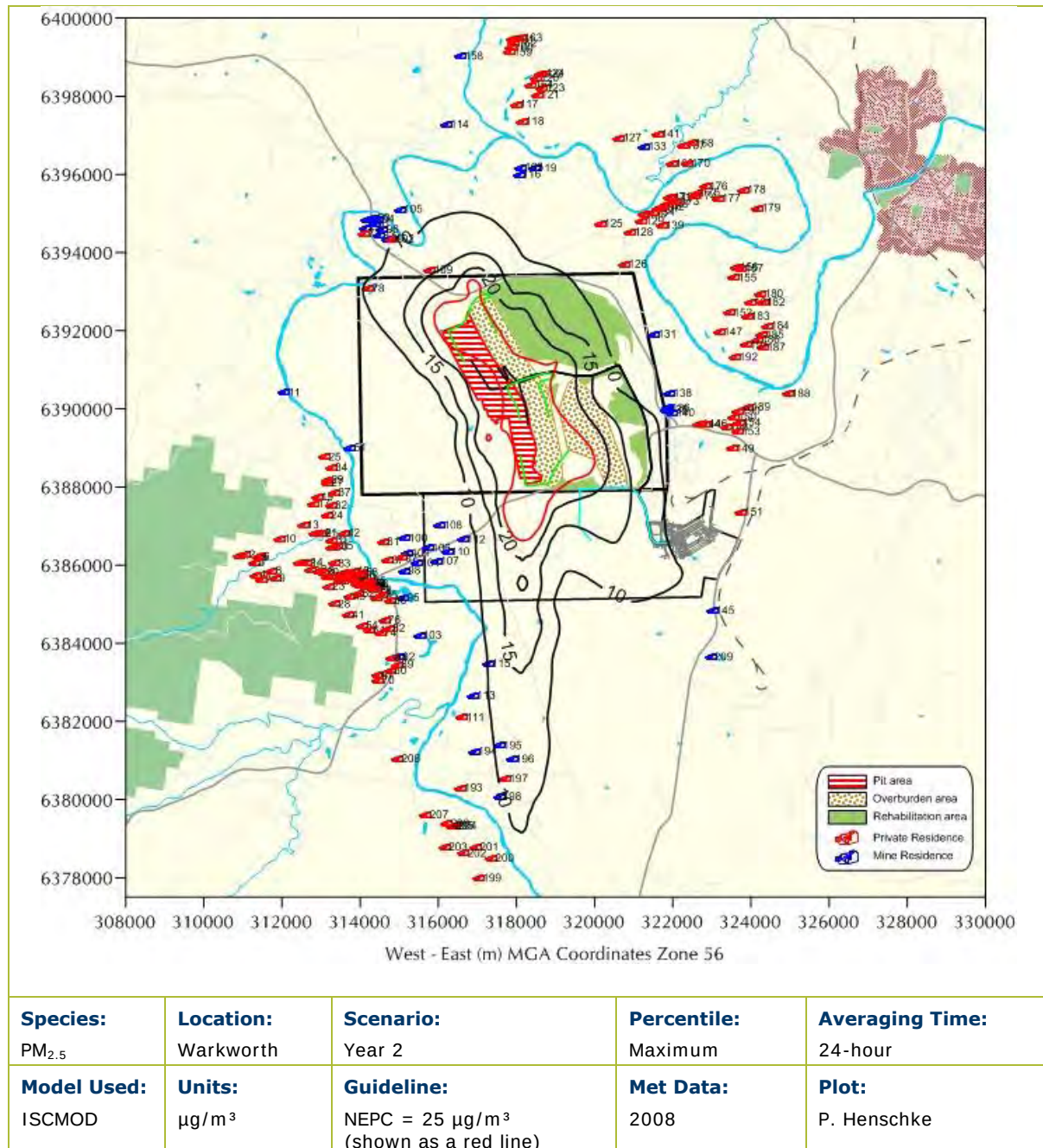


Figure B.1: Predicted 24-hour average PM_{2.5} concentrations due to emissions from Warkworth Extension Project in Year 2

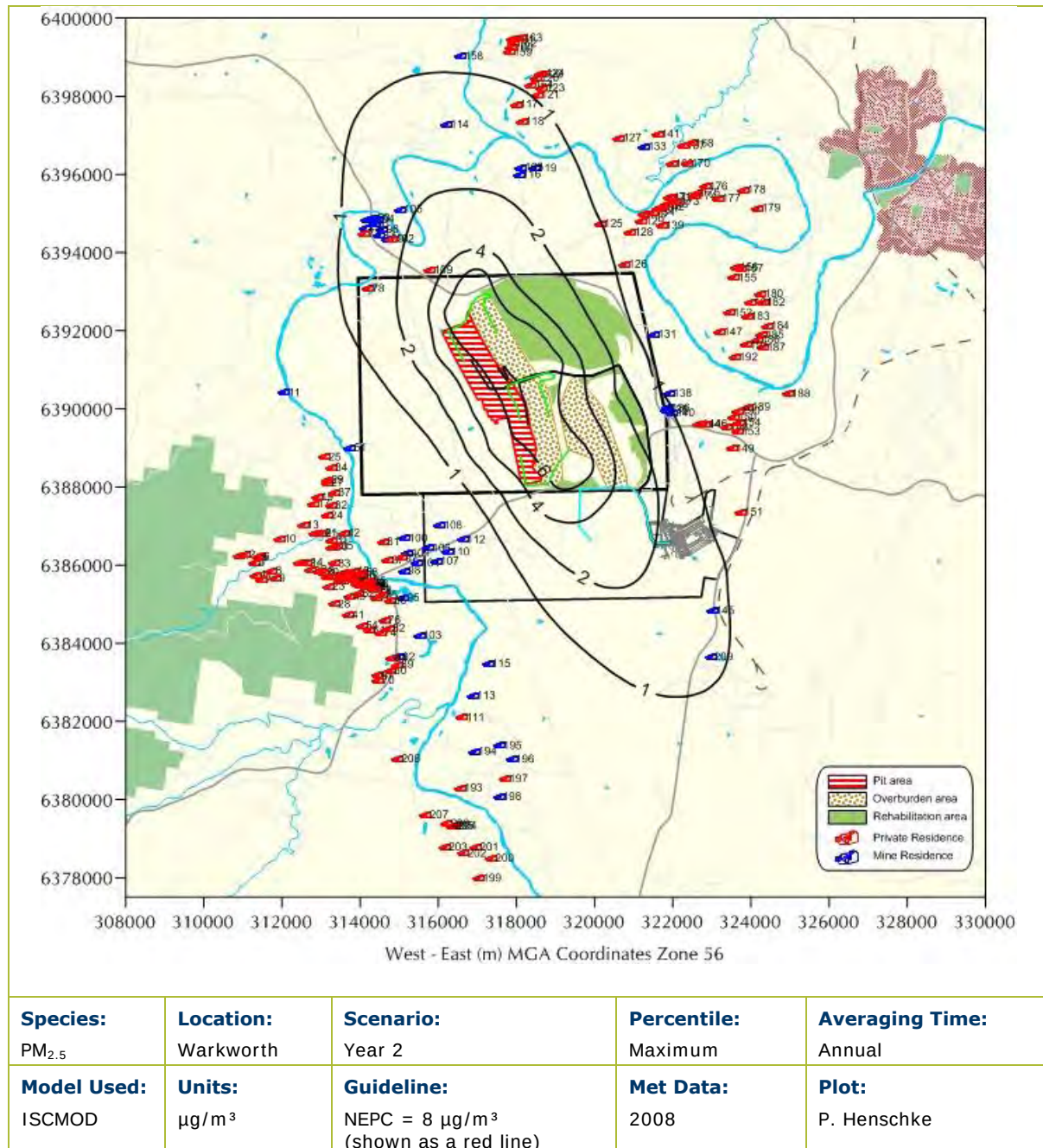


Figure B.2: Predicted Annual average PM_{2.5} concentrations due to emissions from Warkworth Extension Project in Year 2

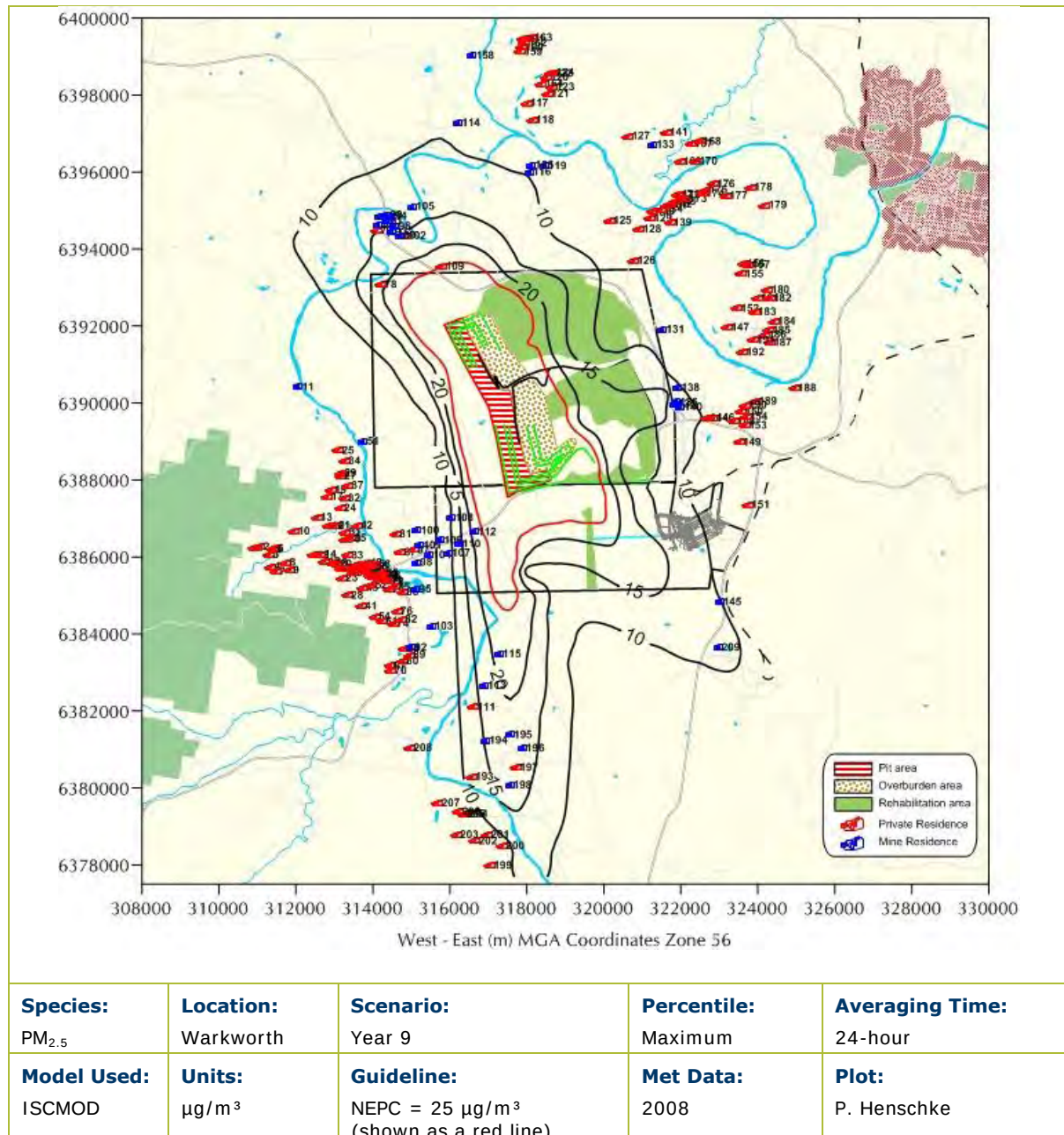


Figure B.3: Predicted 24-hour average PM_{2.5} concentrations due to emissions from Warkworth Extension Project in Year 9

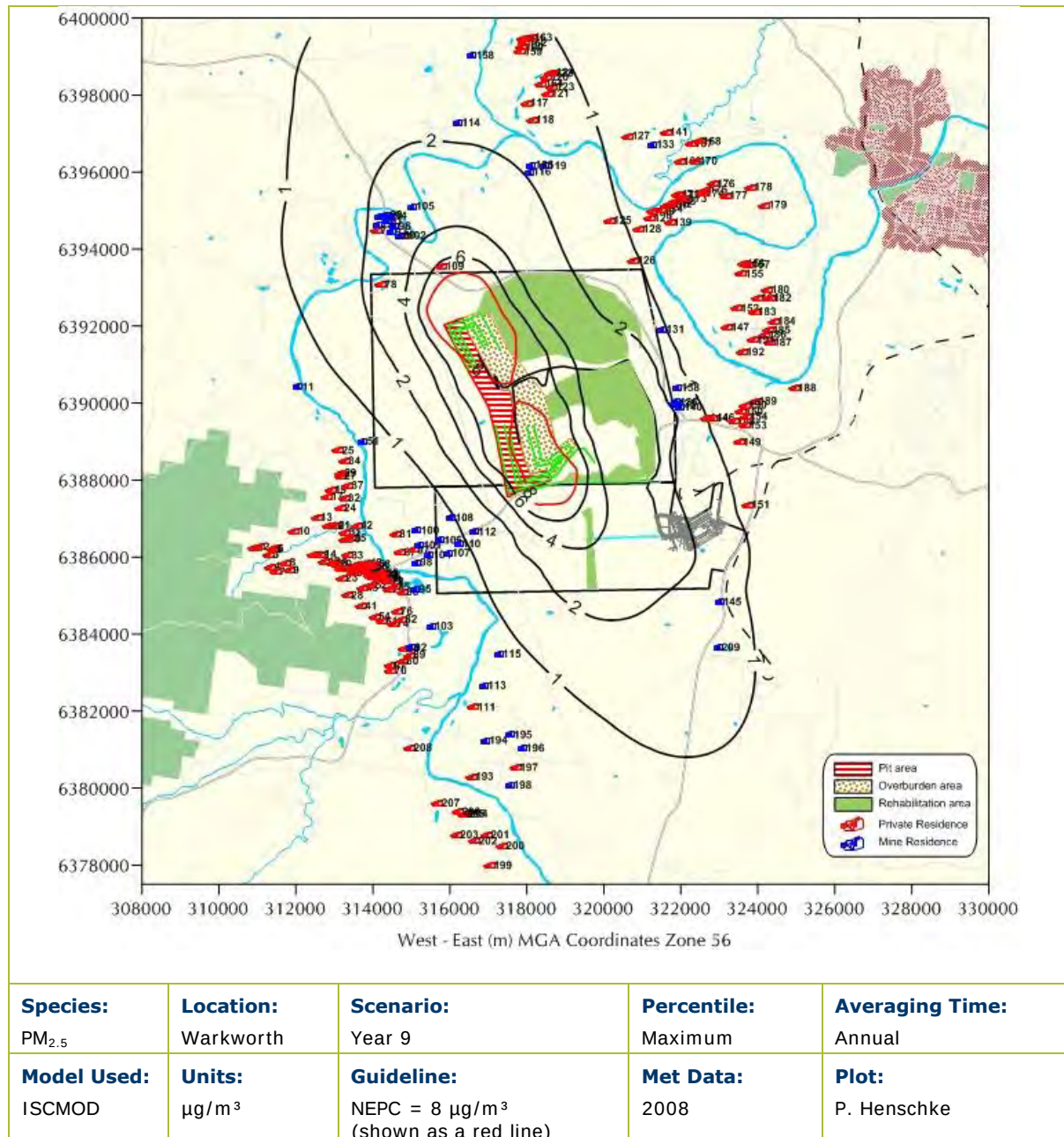


Figure B.4: Predicted Annual average PM_{2.5} concentrations due to emissions from Warkworth Extension Project in Year 9

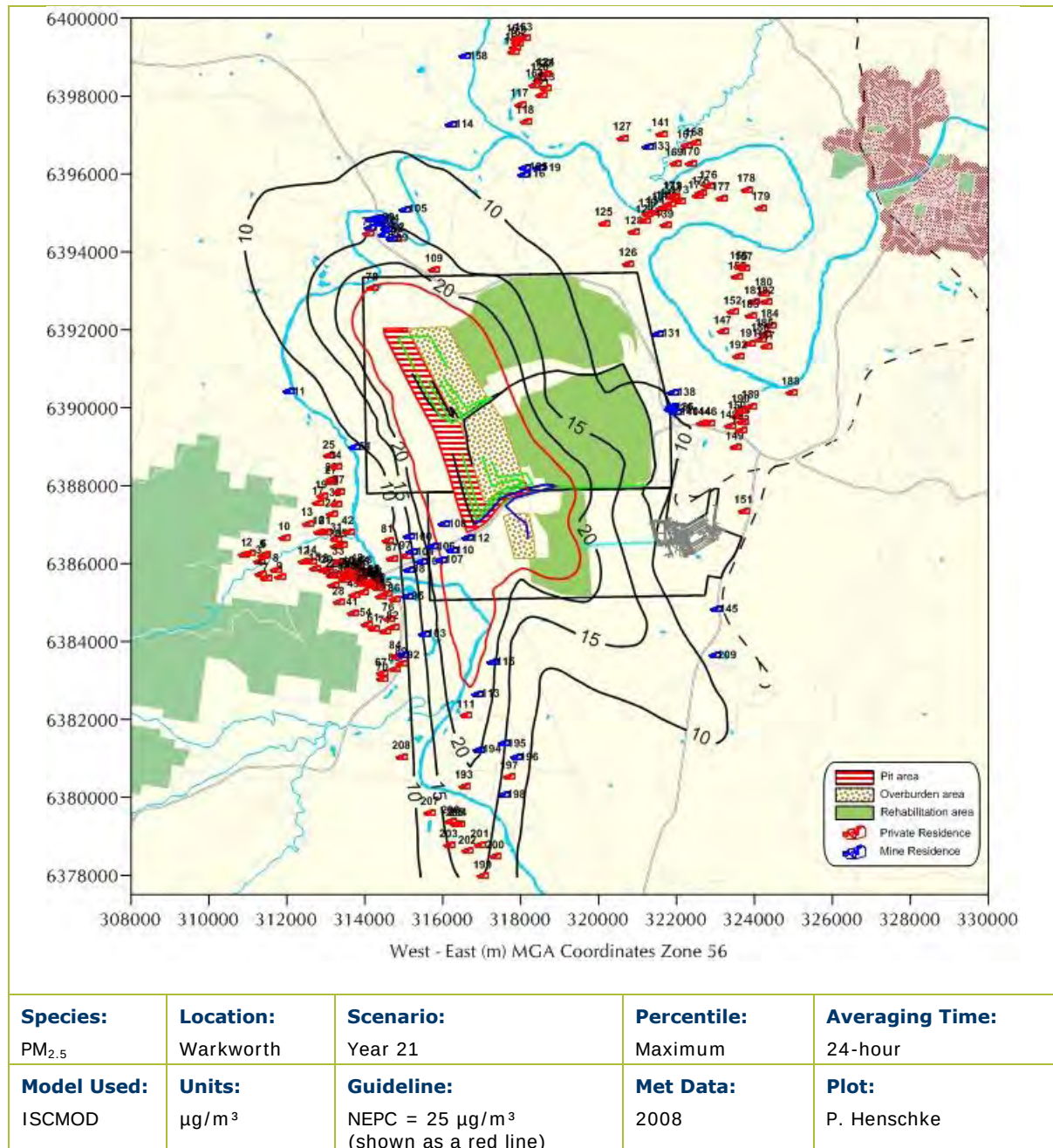


Figure B.5: Predicted 24-hour average PM_{2.5} concentrations due to emissions from Warkworth Extension Project in Year 21

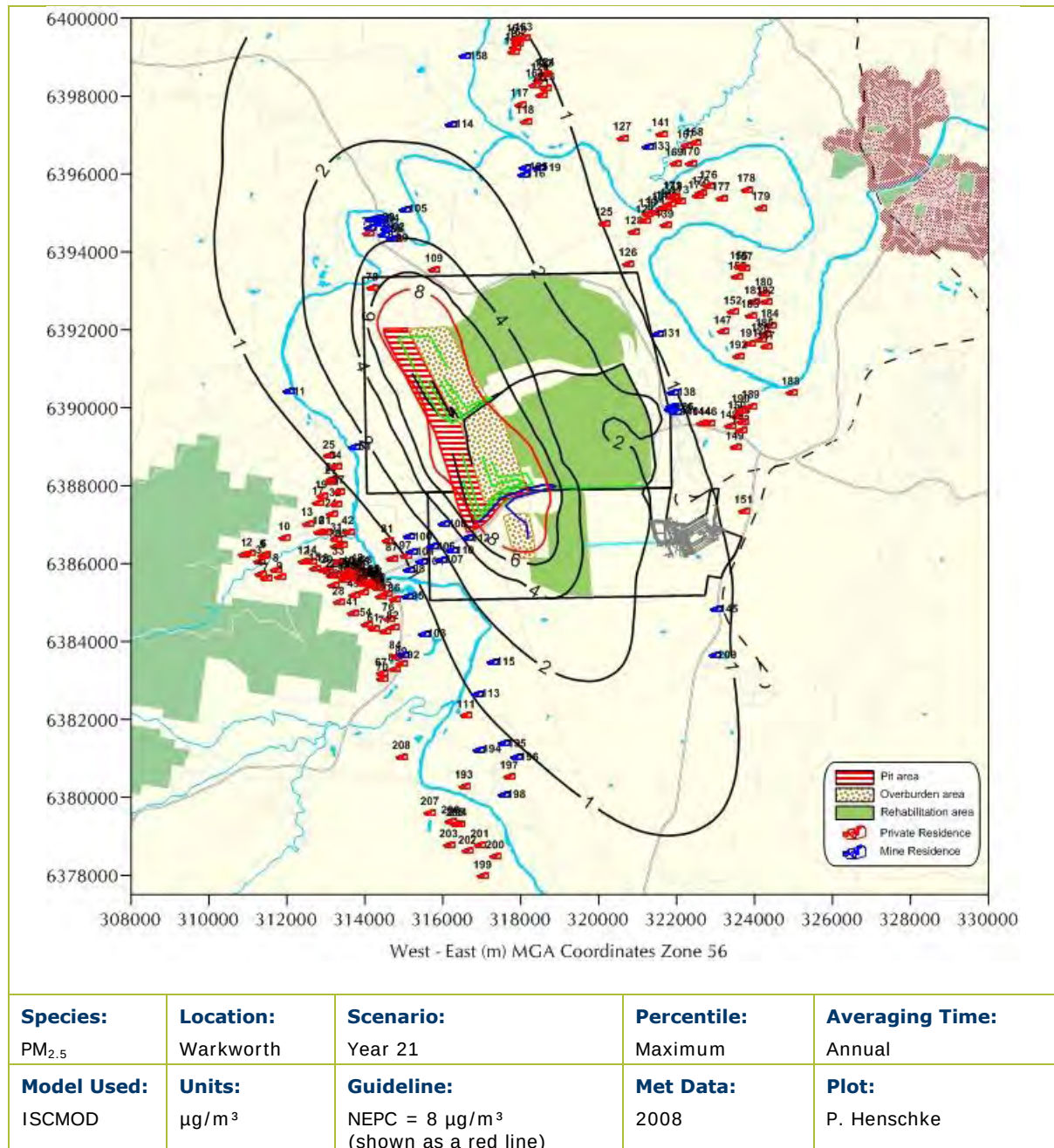


Figure B.6: Predicted Annual average PM_{2.5} concentrations due to emissions from Warkworth Extension Project in Year 21

Appendix C: Joint wind speed, wind direction and stability class tables for Warkworth meteorological station

STATISTICS FOR FILE: C:\Jobs\Mt Thorley\met\2008.isc
 MONTHS: All
 HOURS : All
 OPTION: Frequency

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)									
	0.50	1.50	3.00	4.50	6.00	7.50	9.00	GREATER	
WIND	TO	TO	TO	TO	TO	TO	TO	THAN	
SECTOR	1.50	3.00	4.50	6.00	7.50	9.00	10.50	10.50	TOTAL
NNE	0.001763	0.004532	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006295
NE	0.002140	0.003651	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005791
ENE	0.001385	0.004280	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005665
E	0.001259	0.003651	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004910
ESE	0.001888	0.003777	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005665
SE	0.002644	0.003273	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005917
SSE	0.002392	0.002266	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004658
S	0.001763	0.001259	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003022
SSW	0.001637	0.001007	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002644
SW	0.000881	0.000504	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001385
WSW	0.000504	0.000629	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001133
W	0.000252	0.000252	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000504
WNW	0.001007	0.000629	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001637
NW	0.002392	0.001133	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003525
NNW	0.002140	0.003147	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005288
N	0.003399	0.003399	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006798
CALM									0.002518
TOTAL	0.027446	0.037391	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.067355
MEAN WIND SPEED (m/s) = 1.62									
NUMBER OF OBSERVATIONS = 535									

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)									
	0.50	1.50	3.00	4.50	6.00	7.50	9.00	GREATER	
WIND	TO	TO	TO	TO	TO	TO	TO	THAN	
SECTOR	1.50	3.00	4.50	6.00	7.50	9.00	10.50	10.50	TOTAL
NNE	0.000252	0.001385	0.000252	0.000000	0.000000	0.000000	0.000000	0.000000	0.001888
NE	0.000000	0.000126	0.000126	0.000000	0.000000	0.000000	0.000000	0.000000	0.000252
ENE	0.000252	0.000629	0.001385	0.000000	0.000000	0.000000	0.000000	0.000000	0.002266
E	0.000378	0.001385	0.002896	0.000000	0.000000	0.000000	0.000000	0.000000	0.004658
ESE	0.000378	0.003147	0.002770	0.000000	0.000000	0.000000	0.000000	0.000000	0.006295
SE	0.000755	0.003147	0.000755	0.000000	0.000000	0.000000	0.000000	0.000000	0.004658
SSE	0.001259	0.002518	0.000755	0.000000	0.000000	0.000000	0.000000	0.000000	0.004532
S	0.001007	0.000881	0.000504	0.000000	0.000000	0.000000	0.000000	0.000000	0.002392
SSW	0.000504	0.000504	0.000755	0.000000	0.000000	0.000000	0.000000	0.000000	0.001763
SW	0.000000	0.000252	0.000629	0.000000	0.000000	0.000000	0.000000	0.000000	0.000881
WSW	0.000629	0.000126	0.000252	0.000000	0.000000	0.000000	0.000000	0.000000	0.001007
W	0.000252	0.000126	0.000629	0.000000	0.000000	0.000000	0.000000	0.000000	0.001007
WNW	0.000504	0.001007	0.001007	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
NW	0.000252	0.002014	0.002266	0.000000	0.000000	0.000000	0.000000	0.000000	0.004532
NNW	0.001259	0.003777	0.001888	0.000000	0.000000	0.000000	0.000000	0.000000	0.006924
N	0.001133	0.001763	0.000755	0.000000	0.000000	0.000000	0.000000	0.000000	0.003651
CALM									0.000755
TOTAL	0.008813	0.022787	0.017626	0.000000	0.000000	0.000000	0.000000	0.000000	0.049981
MEAN WIND SPEED (m/s) = 2.45									
NUMBER OF OBSERVATIONS = 397									

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)									
	0.50	1.50	3.00	4.50	6.00	7.50	9.00	GREATER	
WIND	TO	TO	TO	TO	TO	TO	TO	THAN	
SECTOR	1.50	3.00	4.50	6.00	7.50	9.00	10.50	10.50	TOTAL
NNE	0.000378	0.000881	0.000126	0.000000	0.000000	0.000000	0.000000	0.000000	0.001385
NE	0.000000	0.000126	0.000126	0.000000	0.000000	0.000000	0.000000	0.000000	0.000252
ENE	0.000252	0.000252	0.000629	0.000252	0.000000	0.000000	0.000000	0.000000	0.001385
E	0.000126	0.001385	0.004029	0.003273	0.000000	0.000000	0.000000	0.000000	0.008813
ESE	0.000629	0.002392	0.007554	0.004658	0.000000	0.000000	0.000000	0.000000	0.015234
SE	0.000629	0.004155	0.008057	0.005665	0.000000	0.000000	0.000000	0.000000	0.018507
SSE	0.001259	0.007428	0.009442	0.006043	0.000000	0.000000	0.000000	0.000000	0.024172
S	0.001637	0.002644	0.003525	0.001511	0.000000	0.000000	0.000000	0.000000	0.009316
SSW	0.001007	0.000629	0.001511	0.000378	0.000000	0.000000	0.000000	0.000000	0.003525
SW	0.000629	0.000126	0.001007	0.000755	0.000000	0.000000	0.000000	0.000000	0.002518
WSW	0.000126	0.000252	0.000881	0.000378	0.000000	0.000000	0.000000	0.000000	0.001637
W	0.000378	0.000252	0.000252	0.000629	0.000000	0.000000	0.000000	0.000000	0.001511
WNW	0.000378	0.000629	0.001763	0.001385	0.000000	0.000000	0.000000	0.000000	0.004155
NW	0.000629	0.004280	0.006169	0.007932	0.000000	0.000000	0.000000	0.000000	0.019010
NNW	0.001888	0.005162	0.008939	0.008687	0.000000	0.000000	0.000000	0.000000	0.024676
N	0.001637	0.004658	0.002014	0.000126	0.000000	0.000000	0.000000	0.000000	0.008435
CALM									0.000629
TOTAL	0.011583	0.035251	0.056024	0.041672	0.000000	0.000000	0.000000	0.000000	0.145159
MEAN WIND SPEED (m/s) = 3.61									
NUMBER OF OBSERVATIONS = 1153									

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)									
	0.50	1.50	3.00	4.50	6.00	7.50	9.00	GREATER	
WIND	TO	TO	TO	TO	TO	TO	TO	THAN	
SECTOR	1.50	3.00	4.50	6.00	7.50	9.00	10.50	10.50	TOTAL
NNE	0.000252	0.001007	0.000378	0.000126	0.000000	0.000000	0.000000	0.000000	0.001763
NE	0.000378	0.000252	0.000126	0.000000	0.000000	0.000000	0.000000	0.000000	0.000755
ENE	0.000252	0.001511	0.002266	0.000504	0.000000	0.000000	0.000000	0.000000	0.004532
E	0.000629	0.003273	0.011960	0.005288	0.000881	0.000126	0.000000	0.000000	0.022158
ESE	0.002014	0.013093	0.022032	0.013471	0.004406	0.001888	0.000126	0.000000	0.057031
SE	0.002518	0.021654	0.025179	0.008309	0.002770	0.000126	0.000000	0.000000	0.060556
SSE	0.004029	0.048470	0.035125	0.014982	0.004406	0.001133	0.000252	0.000000	0.108397
S	0.004910	0.027697	0.019892	0.004784	0.004658	0.002266	0.000252	0.000000	0.064459
SSW	0.002770	0.008687	0.007680	0.005539	0.001511	0.001385	0.000126	0.000000	0.027697
SW	0.000881	0.002140	0.003147	0.000378	0.000126	0.000126	0.000000	0.000000	0.006798
WSW	0.000378	0.001511	0.001511	0.001007	0.000252	0.000126	0.000000	0.000126	0.004910
W	0.000378	0.002644	0.004406	0.000755	0.001133	0.000252	0.000000	0.000000	0.009568
WNW	0.001259	0.005539	0.004658	0.001007	0.002518	0.001007	0.000126	0.000000	0.016115
NW	0.002770	0.008435	0.016115	0.010449	0.009694	0.004406	0.002266	0.000881	0.055017
NNW	0.002644	0.011079	0.020269	0.028075	0.024172	0.008309	0.003903	0.001007	0.099459
N	0.003147	0.004784	0.002392	0.001133	0.000126	0.000126	0.000000	0.000000	0.011708
CALM									0.002770
TOTAL	0.029208	0.161778	0.177137	0.095808	0.056654	0.021277	0.007050	0.002014	0.553695
MEAN WIND SPEED (m/s) = 3.98									
NUMBER OF OBSERVATIONS = 4398									

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)									
	0.50	1.50	3.00	4.50	6.00	7.50	9.00	GREATER	
WIND	TO	TO	TO	TO	TO	TO	TO	THAN	
SECTOR	1.50	3.00	4.50	6.00	7.50	9.00	10.50	10.50	TOTAL
NNE	0.000252	0.001259	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001511
NE	0.000252	0.000881	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001133
ENE	0.000126	0.001888	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002014
E	0.000378	0.001259	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001637
ESE	0.001007	0.002140	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003147
SE	0.001888	0.004280	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006169
SSE	0.003903	0.015234	0.001637	0.000000	0.000000	0.000000	0.000000	0.000000	0.020773
S	0.003022	0.015611	0.003147	0.000126	0.000000	0.000000	0.000000	0.000000	0.021906
SSW	0.002140	0.008309	0.002014	0.000881	0.000000	0.000000	0.000000	0.000000	0.013345
SW	0.001007	0.001133	0.000755	0.000000	0.000000	0.000000	0.000000	0.000000	0.002896
WSW	0.001133	0.000629	0.000252	0.000000	0.000000	0.000000	0.000000	0.000000	0.002014
W	0.002014	0.001763	0.000252	0.000000	0.000000	0.000000	0.000000	0.000000	0.004029
WNW	0.001637	0.003147	0.001763	0.000000	0.000000	0.000000	0.000000	0.000000	0.006547
NW	0.001259	0.008813	0.009442	0.000378	0.000000	0.000000	0.000000	0.000000	0.019892
NNW	0.003022	0.003777	0.003777	0.000378	0.000000	0.000000	0.000000	0.000000	0.010953
N	0.002140	0.003399	0.000504	0.000000	0.000000	0.000000	0.000000	0.000000	0.006043
CALM									0.001511
TOTAL	0.025179	0.073524	0.023543	0.001763	0.000000	0.000000	0.000000	0.000000	0.125519
MEAN WIND SPEED (m/s) = 2.28									
NUMBER OF OBSERVATIONS = 997									

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)									
	0.50	1.50	3.00	4.50	6.00	7.50	9.00	GREATER	
WIND	TO	TO	TO	TO	TO	TO	TO	THAN	
SECTOR	1.50	3.00	4.50	6.00	7.50	9.00	10.50	10.50	TOTAL
NNE	0.000755	0.000629	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001385
NE	0.001763	0.001259	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003022
ENE	0.001133	0.001385	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
E	0.000881	0.001133	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002014
ESE	0.001259	0.000378	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001637
SE	0.001133	0.001259	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002392
SSE	0.001763	0.001133	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002896
S	0.003651	0.001385	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005036
SSW	0.003022	0.001385	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004406
SW	0.001888	0.001007	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002896
WSW	0.002392	0.000755	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003147
W	0.001259	0.001888	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003147
WNW	0.003147	0.002518	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005665
NW	0.002266	0.001763	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004029
NNW	0.002392	0.001763	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004155
N	0.001763	0.001007	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002770
CALM									0.007176
TOTAL	0.030467	0.020647	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.058290
MEAN WIND SPEED (m/s) = 1.27									
NUMBER OF OBSERVATIONS = 463									

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

	0.50	1.50	3.00	4.50	6.00	7.50	9.00	GREATER	
WIND	TO	TO	TO	TO	TO	TO	TO	THAN	
SECTOR	1.50	3.00	4.50	6.00	7.50	9.00	10.50	10.50	TOTAL
NNE	0.003651	0.009694	0.000755	0.000126	0.000000	0.000000	0.000000	0.000000	0.014226
NE	0.004532	0.006295	0.000378	0.000000	0.000000	0.000000	0.000000	0.000000	0.011205
ENE	0.003399	0.009946	0.004280	0.000755	0.000000	0.000000	0.000000	0.000000	0.018381
E	0.003651	0.012086	0.018885	0.008561	0.000881	0.000126	0.000000	0.000000	0.044190
ESE	0.007176	0.024928	0.032356	0.018129	0.004406	0.001888	0.000126	0.000000	0.089009
SE	0.009568	0.037769	0.033992	0.013975	0.002770	0.000126	0.000000	0.000000	0.098200
SSE	0.014604	0.077049	0.046960	0.021025	0.004406	0.001133	0.000252	0.000000	0.165429
S	0.015989	0.049478	0.027068	0.006421	0.004658	0.002266	0.000252	0.000000	0.106131
SSW	0.011079	0.020521	0.011960	0.006798	0.001511	0.001385	0.000126	0.000000	0.053380
SW	0.005288	0.005162	0.005539	0.001133	0.000126	0.000126	0.000000	0.000000	0.017374
WSW	0.005162	0.003903	0.002896	0.001385	0.000252	0.000126	0.000000	0.000126	0.013849
W	0.004532	0.006924	0.005539	0.001385	0.001133	0.000252	0.000000	0.000000	0.019766
WNW	0.007932	0.013471	0.009190	0.002392	0.002518	0.001007	0.000126	0.000000	0.036636
NW	0.009568	0.026438	0.033992	0.018759	0.009694	0.004406	0.002266	0.000881	0.106005
NNW	0.013345	0.028705	0.034873	0.037140	0.024172	0.008309	0.003903	0.001007	0.151454
N	0.013219	0.019010	0.005665	0.001259	0.000126	0.000126	0.000000	0.000000	0.039406
CALM									0.015359
TOTAL	0.132695	0.351379	0.274330	0.139242	0.056654	0.021277	0.007050	0.002014	1.000000
MEAN WIND SPEED (m/s)	= 3.32								
NUMBER OF OBSERVATIONS	= 7943								

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

A : 6.7%
B : 5.0%
C : 14.5%
D : 55.4%
E : 12.6%
F : 5.8%

STABILITY CLASS BY HOUR OF DAY

Hour	A	B	C	D	E	F
01	0000	0000	0000	0204	0093	0034
02	0000	0000	0000	0218	0079	0034
03	0000	0000	0000	0210	0084	0037
04	0000	0000	0000	0214	0085	0032
05	0000	0000	0000	0205	0086	0040
06	0004	0002	0012	0202	0069	0042
07	0011	0018	0028	0198	0050	0026
08	0028	0018	0078	0207	0000	0000
09	0038	0031	0096	0166	0000	0000
10	0057	0038	0118	0118	0000	0000
11	0065	0040	0127	0099	0000	0000
12	0075	0047	0119	0090	0000	0000
13	0069	0053	0124	0085	0000	0000
14	0062	0052	0125	0092	0000	0000
15	0058	0039	0136	0098	0000	0000
16	0046	0036	0121	0117	0005	0006
17	0022	0023	0069	0181	0022	0014
18	0000	0000	0000	0252	0047	0032
19	0000	0000	0000	0265	0041	0025
20	0000	0000	0000	0255	0054	0022
21	0000	0000	0000	0251	0060	0020
22	0000	0000	0000	0224	0074	0033
23	0000	0000	0000	0225	0072	0034
24	0000	0000	0000	0222	0076	0032

STABILITY CLASS BY MIXING HEIGHT

Mixing height	A	B	C	D	E	F
<=500 m	0052	0045	0103	0760	0959	0422
<=1000 m	0197	0143	0482	1418	0009	0004
<=1500 m	0286	0209	0568	1505	0029	0037
<=2000 m	0000	0000	0000	0493	0000	0000
<=3000 m	0000	0000	0000	0216	0000	0000
>3000 m	0000	0000	0000	0006	0000	0000

MIXING HEIGHT BY HOUR OF DAY

	0000 to	0100 to	0200 to	0400 to	0800 to	1600 to	Greater than
Hour	0100	0200	0400	0800	1600	3200	3200
01	0032	0070	0028	0043	0116	0042	0000
02	0034	0061	0028	0043	0124	0041	0000
03	0035	0061	0033	0049	0121	0032	0000
04	0032	0066	0028	0050	0115	0040	0000
05	0096	0046	0033	0043	0085	0028	0000
06	0070	0098	0083	0016	0044	0020	0000
07	0109	0052	0106	0064	0000	0000	0000
08	0000	0052	0121	0158	0000	0000	0000
09	0000	0000	0086	0172	0073	0000	0000
10	0000	0000	0000	0199	0132	0000	0000
11	0000	0000	0000	0130	0201	0000	0000
12	0000	0000	0000	0087	0244	0000	0000
13	0000	0000	0000	0000	0331	0000	0000
14	0000	0000	0000	0000	0331	0000	0000
15	0000	0000	0000	0000	0331	0000	0000
16	0000	0000	0000	0000	0331	0000	0000
17	0002	0003	0001	0006	0305	0014	0000
18	0003	0019	0019	0014	0245	0031	0000
19	0016	0038	0012	0023	0150	0092	0000
20	0016	0043	0017	0027	0155	0073	0000
21	0016	0051	0019	0036	0163	0046	0000
22	0030	0060	0020	0041	0134	0046	0000
23	0031	0058	0022	0048	0129	0043	0000
24	0027	0068	0020	0047	0119	0049	0000

Appendix D: Dust deposition and particulate monitoring data

Table G.1: Monitored dust deposition (insoluble solids) levels from the Warkworth Mine monitoring network – g/m²/month

Month	D1	D10	D11	D12	D13	D2	D3	D4	D7	D8	D9
Jan-07	4.8	3.4	2	3.5	3.3	2.5	1.6	3.4	4	3.4	2.4
Feb-07	3 *	2.5	2	3.4	1.7		1.2	2.2	2.8	1.8	2
Mar-07	4.9 *	1.5	1.2	4.8	2.3	3.2*	3.1*	4.4*	2.3	3.2	2
Apr-07	3.8 *	1.9	1.3	4.3	1.7	3.5*	3*	3.4	1.8	2.3	1.6
May-07	6.5*	1.4	0.9	4.2	1.6	4.3*	3.2*	3.1*	2.1	1.4	1.7
Jun-07	9.7*	1.1	0.9		0.8	4.7*	4.3*	3.9	2.6	1	0.9
Jul-07	3.6*	0.6	0.5	4.2*	1.3	1.7	2.3*	2.1	0.9	0.9	2.1
Aug-07	5.7*	1.3	1.3	6.7	2.2	5*	5.2*	6.5	2.1	1.7	2.2
Sep-07	5.6*	2.1	1	5.4*	1.9	3.9*	2.4*	4	2.4	2.9	1.1
Oct-07	3.9*	1	1.9	2.2	1.5	6*	4.6	3*	2.5	2.6	0.9
Nov-07	2.6	1	0.6	1.7	0.9	2.2	1.7	0.9	1.7	1.8	1.2
Dec-07	2.1	1.9	0.9	3.9	1.5	2.3	1.8	8.4	1.2	2.4	1.5
Jan-08	2.5	2.9	2.5	3.1	2.2	1.8	1.1	3.4	2.1	5.2	3.2
Feb-08	3.9*	1.2	0.4	2.3	0.7*	2.1	1.2	1.7*	1.6	2.5	1.4
Mar-08	3.5*	1.4	0.2	1.9	2.1	1.5	1.7	2.1	1.3	2.5	1.5
Apr-08	3.7*	1.8	0.3	0.8	1.5	1.9	2	2.5	1.5	2.5	1
May-08	7	2.2	1.5	14.9	1.9	2.3	3.3	3.3*	2.8	2.4	2.2
Jun-08	3.2*	0.6	1.1	9.7	0.5	1.8	1.3	1.9	1.1	0.9	0.9
Jul-08	6.6	0.8	1.6	16.3*	1.5	3.4	4.3	4.2	1.8	1.4	1.3
Aug-08	6.1	1	0.9	14.1	1.5	4.4*	6.4	6.8	1.4	1	2.2
Sep-08	9.2*	2.1	1.6	10.5*	1.8	3.4	3.3*	3.7	2.6	3.5*	3.5
Oct-08	18.6*	3.3*	2	11.6*	3.8*	4.2*	4.3*	12.3*	4*	3.9*	0.5
Nov-08	6.3*	3.4*	1.2	12.4*	2.5	3.7*	4.3*	4.3*		3.5*	3.2*
Dec-08	8.2*	3.1*	1.1	3	2.3	3.2*	2.4	3.3*	4.5*	4*	3.6*
Jan-09	5*	3.5*	9.7*	9.5*	3.3*	3*	2.4	4.4*	3.7*	5.8*	4.8*
Feb-09	2.5*	2.2	1.9		2.6	1.9	1.8	1.5	1.6	6.9*	2.3
Mar-09	8.8*	3.3*	3.9*	8.5	3*	1	1.9	1.8		5.2*	5.4*
Apr-09	3.6*	2.1	1.3	10.1*	1.7	1	2	2.5	2.8	3.2*	3.3*
May-09	4.4*	1.4	0.8	6.5*	1.9	5.7*	5.1*	2.7	2.3	1.9	2.3
Jun-09	9.7*	1.1	1.7	8.9*	1.1	3.5*	4.5*	4.3*	2.2	2.1	3*
Jul-09	5.4*	0.7	3.4*		0.6	8.9*	3.1*		1.1	0.9	1.7
Aug-09	10*	1.2	1	13.8*	1.5	3*	4.8*	5.8*	1.4	1.6	2.5

Month	DW1	DW10A	DW11	DW13	DW12	DW14	DW15	DW17	DW19	DW20a	DW21a
Jan-07	5	1.6	1.7	2.3	2	2.5	1.5	2.5	2.7	2.2	
Feb-07	4*	1.6	1.7	2.8	3	2	1.8	1.3	2.6	1.7	
Mar-07	2.5	2.4	1.4	3*	3.2*	2.8	4.1	2.5	1.8	1.9	
Apr-07	4.1	4.4*	3.2*	4.1	3.8	2.6*	3.6	2.9	2.2	1.5	
May-07	4.6	2.4	1.5	12.2*	5.9*	2.3	2	1.4	2.2	1	
Jun-07	2.2	2.1	5.6*	6.4	5.6*	4.6*	2.2	1	4	1.3	
Jul-07	4.9*		0.7	1.8	2		0.8	0.7	1.6	0.5	
Aug-07	5.8*	1.7	2.2	4.4	3.2*	0.7	2.4	2.8	2.4	1.2	
Sep-07	5.9	1.9	2.8	4.4	3.4*	2.6	2.8	2.5	3.4*	1.1	
Oct-07	2.3	2.4	0.7	2.2	1.3	2	0.9	1.5	1.5	0.8	
Nov-07	2	1.8	1	2.5	3.4	0.8	1.1	1.9	1.4	1.3	2.1
Dec-07	2.7	2	3.6	2.4	2.8	1.5	2.3	1.8	3.1	1.6	2.3
Jan-08	4.2	1.3	2	1.8	1.3	1.5	3	2.2	2.3	7.9*	1.4
Feb-08	2.7*	1.1	1.7*	1.4	1.4*	2.5	1.2*	1.6*	2.4*	1.3	2.5
Mar-08	1.6	3*	1.7	2	3.1*	1.8	3.8*	2.5	1.2	1.5	0.7
Apr-08	4.5	1.2	0.7	4.6	2.9	1.1	2.6	1.5	2	0.6	0.8
May-08	4.2*	7.3*	3.3*	4.7	3.1*	4.5	3.2*	2	2.8	1	1.7
Jun-08	1.1	0.9	1.8	2.2	1.6	3.6*	1.3	1	1.2	0.9	0.7
Jul-08	5.4	1.3	1.6	4.8	4.2	3.6	1.8	1.8	3.2	1.1	0.8
Aug-08	4.6	1.4	2.9	5.9	4.6*	2.1	2.7	2.1	2.2	1.5	1
Sep-08	6.7*	5.1*	2.6	4.6	4.4*	2	3.3*	2.2	3.2	1.5	2.1
Oct-08	5.9*	2.2	2.3	5.7*	3.8*	3.3*	3.3*	4.2*	4.2*	1.7	
Nov-08	33.8*	0.8	1.3	5.1*	4.9*	3.4*	5.1*	4.7*	3.6*	1.5	1.6
Dec-08	3.6*	3.9*	3.8			2.6	3.2*			1.3	2.6
Jan-09	3.1*	3.4*	2*	5.9*	2.4*	2*	2.2*	4.2*	4.3*	3.1*	3*
Feb-09	1.9	0.8	1.5	1.7	1.1	1.9	1.7	2.1	2.4	0.9	1.3
Mar-09	5.9*	3.9*	2.5	3.6*	3.3*	2.8		2.3		2	1.8
Apr-09	3.1*	2.2	1.3	2.4	2	0.9	1.2	3*	2.2	0.8	1.1
May-09	2.3	3.2*	1.6	2.3	2.1	1.1	2.3	1.9	3.2*	1.2	1.4
Jun-09	7.8*	1.6	1.5	4.8*	2.5	3.4*	2.8	1.4	1.1	1.1	0.9
Jul-09	2.6	0.9	1.2	2.6	1.5	1.9	1.3	0.8	1.1	0.4	0.5
Aug-09	3.9*	1.5	2	4.5*	5.2*	4.5*	1.6	1.4	2.2	2	0.9

Month	DW3	DW4	DW5	DW6A	DW7	DW8	DW9
Jan-07	3	2.2	2.4	7.2	3.3	2.5	4.4
Feb-07	2.1	1.4	2.5	7.2*	2.9	2	2.2
Mar-07	1.5	2.5	2.7	3.3*	2.7	1.6	2.9
Apr-07	4.5*	3.2	5.2*	6.8*	3.4	1.4	2.9
May-07	3.5*		2.3	4.8*	2.3	1.5	2.4
Jun-07	2.6	1.9	1.3	3.7*	1.7	1.3	1.5
Jul-07	3.2*	2.2	1.8	1.4	1.9	0.8	0.7
Aug-07	4.8	3.8*	2	2.2	3.6	1.3	1.4
Sep-07	3.6*	1.3	1.3	4.4	4.1	1.6	5*
Oct-07	1.7	1.7	1.8*	2.9	2.1	1.4	1.4
Nov-07	1.9	2.1	1.3	4.5*	1.3	0.9	3
Dec-07	2.3	1.7	1.8	2.7	2.4	1.5	1.6
Jan-08	1.9	2.9	2.2	3.8	1.1	0.9	2.1
Feb-08	2.2	3	3*	3.1	1.5	1.1	1.9
Mar-08	3.7	2.1	2.8	2.5	1.5	1.2	1.7
Apr-08	4.2	1.8	1.7	2.5	1.2	0.7	1.2
May-08	4.6*	2.3	3.5*	4.1*	2.5	1.2	4.1
Jun-08	1.8	2	1.1	3	1.3	0.6	1.3
Jul-08	4.3*	2	3.2	3.1	2	0.9	2.4
Aug-08	6.5*	3	2.5	2.8	2.9	0.9	1.4
Sep-08	4.6*		2.5	3.5*	2.5	1.2	
Oct-08	3.9*	2.1	4.6*	6.5*	3.5*	2.2	3.6*
Nov-08	3.1*	1.5	5.2*	9.1*	4.2*	2.3	2.8
Dec-08	3.8*	1.9	3.8*	8.1*	4.2*	8.2*	2.3
Jan-09	2.8*	3*	7*	8.5*	3.9*	4.3*	2.5*
Feb-09	1.1	3.8*	1.8	6.3*	1.8	4.4*	1.8
Mar-09	3.1*	3.8*	3.3*	6.5	3.1*	2.3	1
Apr-09	2	1.5	2.4	5.6*	2.3	1.6	1.8
May-09	2.5	3	3.5*	4.3	1.8	0.9	1.3
Jun-09	3.3*	2.6	3.5	6.4*	2	1.2	1.5
Jul-09	3.3	1.5	1.7	2.3	1.2	0.6	0.8
Aug-09	5.3*	3.6*	2.8	3.5	1.3	0.8	1.9

Table G.2: TSP Monitoring Data from Warkworth Mine monitoring network - $\mu\text{g}/\text{m}^3$

Date	Kimes WML-HV1	Lambkins WML-HV2	MTO - TSP2	MTO -TSP1	WML Office TSP	WML-TSP3
5/01/2007	61	44.3	64.9	63.1	59.5	
11/01/2007	89.9	77.6	71.3	67.9	104	
17/01/2007	94	68.8	94.2	71.9	70.8	
23/01/2007	116	77.3	79.7	41.9	88	
29/01/2007	179	46.5	50.6	58.1		
4/02/2007	93.7	55.5	60	78	61.8	
10/02/2007	59	34.1	34.7	58.6	52.2	
16/02/2007	54.2	33.3	39.3	47.6	61.5	
22/02/2007	86.5	86.5	44.9	41.2	57.5	
28/02/2007	58.4	33.9	32.1	28.8	83.3	
6/03/2007	49.3	29.9	29.3	38.7	28.4	
12/03/2007	86.1	39.8	36.2	41.7	75.1	
18/03/2007	40.5	24.2	41.5	27.3	45	
24/03/2007	75.1	36.4	33.1	43.3	109	
30/03/2007	119	32.6	23.8	42.9	155	
5/04/2007	81.1	32.8	36.1	42.9	106	
11/04/2007	65.1	30.7	23.9	40.8	68.7	
17/04/2007	78	40.7	43.7	50.8	77.7	
23/04/2007	66	21.1	22.5	23.6	66.7	
29/04/2007	54.3	26.3	28.1	33.4	57.6	
5/05/2007	165	53.5	52.8	53.6	226	
11/05/2007	88.8	26.1	19.8	22.4	73.2	
17/05/2007	60.5	31.4	26.7	30.9	101	
23/05/2007	95.8	54.3	26.4	30.1	94.1	
29/05/2007	103	61.2	61.1	65.9	127	
4/06/2007	87.7	36.2	21.5	23.8	150	
10/06/2007	31.9	4.8	9.9	12.3	18.7	
16/06/2007	9.3	3.1	2.9	4.2	8.3	
22/06/2007	50.9	19.4	11.4	12.2	60.6	
28/06/2007	23.6	6.4	5.4	10.3	32.1	
4/07/2007	44.4	18.5	19.8	19.5	49.7	
10/07/2007	49.4	10.5	10.4	10.2	57	
16/07/2007	80.1	24.5	39.8	42.1	97.7	
22/07/2007	72.2	21.1	13.5	15.6	80.4	
28/07/2007	96.9	55.8	14.3	22.9	124	
3/08/2007	92	19.7	18.2	19.7	95.6	
9/08/2007	74.2	36	44	54.9	61.4	
15/08/2007	57.5	24.5	21.2	24.3	41.1	
21/08/2007	20.4	12.5	9.7	10.6	12.5	
27/08/2007	66.2	18.5	45.5	58.3	103	
2/09/2007	63.1	55.4	55.4	63.2	63.4	
8/09/2007	28.4	12	20.9	12.7	30.8	
14/09/2007	110	46.5	29.8	72.9	134	
20/09/2007	87	28.8	12.2	27.6	128	
26/09/2007	90.6	55.2	110	72.8	102	
2/10/2007	150	82.2	89.3	76.7	202	

Date	Kimes WML-HV1	Lambkins WML-HV2	MTO - TSP2	MTO -TSP1	WML Office TSP	WML-TSP3
8/10/2007	80.4	33.3	44.9	39.3	75.2	
14/10/2007	65.5	34.9	32.7	40.6	144	
20/10/2007	149	86.8	85.2	84.9	149	
26/10/2007	47.1	21.9	31.1	29	48.6	
1/11/2007	89.5	65.3	65.9	68.6	85.6	
7/11/2007	36.1	13.5	26.5	13.1	54	
13/11/2007	65	45.6	41.1	49.2	73.7	
19/11/2007	68.1	87	82	93.3	79.5	
25/11/2007	43.3	35.2	43.3	46.8	34	
1/12/2007	27.4	18.4	19.9	21.7	29.8	
7/12/2007	35.7	44.9	46.7	44.2	34.8	
13/12/2007	40.8	33.9	26.2	29.3	38.9	
19/12/2007	42.1	36.1	30	40.3	39.3	
25/12/2007	37.2	17	21.9	25.1	33.9	
31/12/2007	66.5	66.5	56	87.7	38.4	
6/01/2008	60.7	29	29.5	35.2	68.8	
12/01/2008	84	74.5	93.2	97.6	47	
18/01/2008	20.3	13.7	25.5	17.7	19.5	
24/01/2008	62.6	35.2	47.7	40.8	52.7	
30/01/2008	50.7	63.8	51.4	48.6	40.2	
5/02/2008	15.6	12.4	16.6	16.4	17.8	
11/02/2008	31.2	24.2	30.4	41.7	25.4	
17/02/2008	27.2	21.3	29	31.9	23.5	29.5
23/02/2008	117	75.8	81.5	85.2	149	75.1
29/02/2008	38.9	24.6	26.8	24	56	28.6
6/03/2008	67	63.9	52.6	53.1	61	52
12/03/2008	44	60.9	45.5	40.6	45.1	52.7
18/03/2008	58.4	52.3	52.5	55.8	38.9	43.8
24/03/2008	34.6	25.5	25.8	27.4	43.1	27.9
30/03/2008	105	34.3	27	34.5	36	30
5/04/2008	88.7	39.3	33.1	37.1	33.4	33.5
11/04/2008	52.3	21.5	18.7	18.9	29.8	17.7
17/04/2008	33.5	12.1	16.8	10.4	9.5	9.8
23/04/2008	16.6	6.1	8.1	6.7	23.4	7.3
29/04/2008	32.8	23.7	19.6	23.1	54.1	20.5
5/05/2008	125	25.5	33.3	30.5	166	28.9
11/05/2008	45.6	21.2	22	20.1	38.6	19
17/05/2008	63.4	23	38	28.4	77.9	28.4
23/05/2008	50.9	22.7	27.6	30.2	35.4	22.7
29/05/2008	48.1	18.1	13	10.5	55.9	18.3
4/06/2008	12.1	3.7	6.1	9.2	9.1	4.2
10/06/2008	31	19.4	16.8	18.5	30	19.4
16/06/2008	36.4	4.2	13	4.9	38	5.6
22/06/2008	37.5	7.7	3.7	7	11.2	4.8
28/06/2008		31.9		30.4		30.9
4/07/2008		21.1	12.7	11.8	45.1	17
7/07/2008	29.2					
8/07/2008	5.2		13.4			
10/07/2008	43.6	10.8	12.4	12.3	58	11.9
16/07/2008	55.8	22.7	10.4	14.5	46.3	17.2
22/07/2008	34.3	9.1	9.2	10.9	55.6	9.5

Date	Kimes WML-HV1	Lambkins WML-HV2	MTO - TSP2	MTO -TSP1	WML Office TSP	WML-TSP3
28/07/2008	68.9	10.5	8.8	9.3	31.7	11
3/08/2008	61.4	11.4	9.5	10.6	74.4	11.2
9/08/2008	58.1	10.4		13.7	157	8.1
15/08/2008	102	28.8	30.7	27.1	132	28.1
21/08/2008	157	62	27.1	46.5	186	52.7
27/08/2008		22.8	21.8	21.3	80.1	21.1
2/09/2008		40.6	40.2	40.1	75.5	32.1
8/09/2008		26.8		29.8	68.9	
11/09/2008	102					
14/09/2008	70.1	26.5	24.5	27.1	93.2	21.4
17/09/2008	119		26.4			104
20/09/2008	204	85	51.1	75	206	60.5
23/09/2008	25.4	43	51.1		105	51.8
2/10/2008	89.5	80.4	89.5	62	98.6	60.4
3/10/2008			65.5	75.7		
4/10/2008			65.5			
8/10/2008	80.5	36.4	80.5	30	97.8	28.6
14/10/2008	51.6	43.3	51.6	43.7	57.6	32.8
16/10/2008	37.2		106			
20/10/2008	106		54.7	102	106	78.1
29/10/2008	77.3	54.8	77.3	52	114	54.9
1/11/2008	64.2	62.8	34.4	59.9	69.3	69.3
7/11/2008	112	100	72.6	87.4	107	107
13/11/2008	65	74.8	70.7	106	86.7	86.7
19/11/2008	14.4	35.5	18.1	25.7	20.6	20
25/11/2008	59	18.2	50.3		59.9	58.6
4/12/2008			60.8	112		31.3
7/12/2008	42.5	62.9	42.8	58.3		42.2
10/12/2008				65		
13/12/2008	59.7	47.3	31.5	30.7		35.5
19/12/2008	60.6	30.8	31.9	42.3		26.2
25/12/2008	31.8	29.1	26.4	28.1		27.6
31/12/2008	154	29.2	86.9	78.8		73.6
6/01/2009	120	83.5	81	80.1	153	60
12/01/2009	67	59.1	61.5	72	47	41.9
18/01/2009	87.8	46.8	86	88.8	71	73.8
24/01/2009	77.7	67.5	50.6	65.3	101	47.1
30/01/2009	77	46.4	95.1	75.2	63.1	70.4
5/02/2009	92.7	74.5	102	73.3	60	60.6
11/02/2009	37.4	76.2	7.2	4.8	13	2.9
17/02/2009	25.9	20	15.4	13.9	31	17
23/02/2009	50.5	17.7	44.3	39.8	58.3	46.5
1/03/2009	82	60.6	90.4	61.4	89.6	65.2
7/03/2009	80.2	74.6	37.5	42.7	100	42.4
13/03/2009	70.7	31.2	32.3	29.6	62.4	24
19/03/2009	52	24.6	52	40.9	89.8	49.2
25/03/2009	71.1	53.4	78.5	50.5	24	68.3
31/03/2009	21.1	69.9	21.3	19.7	56.5	19.3
6/04/2009	48.1	17.7	4.5	21.7	51.6	25.3
12/04/2009	42.2	27.9	72.7	42.6	58.9	35.4
18/04/2009	69.5	43	33.8	41.4	27.6	50.1
24/04/2009	50.8	39.2	29.8	35.3	51.5	68.6
30/04/2009	79.2	17.3	8.7	9.8	74.2	11.2
6/05/2009	44	6.2	25.9	38.1	37.9	49.9
12/05/2009	78.7	34.3	34.7	53	86.7	49.3

Date	Kimes WML-HV1	Lambkins WML-HV2	MTO - TSP2	MTO -TSP1	WML Office TSP	WML-TSP3
18/05/2009	85.1	34.3	35.5	43.4	76.8	37.7
24/05/2009	36.9	39.4	31.2	39.6	29.2	35.5
30/05/2009	23	26.8	7.9	11.3	21.3	10.1
5/06/2009	34.9	9.6	12.9	16.1	36.3	12.9
11/06/2009	23.9	11.5	11.3	24.9	29	33.1
17/06/2009	49.3	22	10.5	13.6	39.8	14.3
23/06/2009	42	14.8	18.2	15.7	33.3	13.4
29/06/2009	28.1	11.5	108	25.6	37.4	30.8
5/07/2009	56.6	21.5	12.4	12.1	73.1	10.4
11/07/2009	32	17	12.4	28.9	34.6	17.6
17/07/2009	73.7	25	18.4	13.8	83.4	12.1
23/07/2009	35.1	11.1	9.3	12.1	34.7	9.5
29/07/2009	65.4	9.7	9.2	12.9	91.9	13.5
4/08/2009	132	13.6	10.1	27	177	22.9
10/08/2009	111	23.5	23.4	77.1	107	48.4
20/08/2009	94.7	35.7	56.5	37.4	100	
22/08/2009	52.4	20.3	30	29.3	59.8	29.4
28/08/2009	149	34.1	30.1	33.9	175	30

Table G.3: PM₁₀ Monitoring data from Warkworth Mine monitoring network - µg/m³

Date	MTO - PM10	Kimes PM10	Date	MTO - PM10	Kimes PM10
5/01/2007	15.3	20.4	14/09/2007	29.2	23.2
11/01/2007	22.4	35.5	20/09/2007	12	47.7
17/01/2007	36.4	31.5	26/09/2007	20.5	35.5
23/01/2007	24.2	44	2/10/2007	38.1	75.2
29/01/2007	31.8	63.1	8/10/2007	12.5	37.2
4/02/2007	23.5	26.2	14/10/2007	15.1	48.6
10/02/2007	12.6	18.7	20/10/2007	41.8	
16/02/2007	16.4	20.7	26/10/2007	12	21.8
22/02/2007	17.1	32.4	1/11/2007	35.4	42
28/02/2007	12.3	25.1	7/11/2007	7.7	14.9
6/03/2007	14.7	18.3	13/11/2007	17.7	22.6
12/03/2007	20.4	33	19/11/2007	35.2	15.5
18/03/2007	9.3	13.3	25/11/2007	18.4	15.5
24/03/2007	16	23.3	1/12/2007	12.3	13.2
30/03/2007	13.4	43.9	7/12/2007	20.8	5.9
5/04/2007	19.4	28.3	13/12/2007	11.1	20.4
11/04/2007	20.1	23.8	19/12/2007	20	24.5
17/04/2007	28.3	36.1	25/12/2007	13	27.6
23/04/2007	9.5	18.5	31/12/2007	25.9	26.5
29/04/2007	12.6	23.7	6/01/2008		18
5/05/2007	31.9	62.5	12/01/2008	30.1	36.9
11/05/2007	13.3	24.3	18/01/2008	9.7	12.3
17/05/2007	12.8	18.3	24/01/2008	17.1	29.3
23/05/2007	12.1	22.7	30/01/2008	22.8	24.3
29/05/2007	26	38.7	5/02/2008	8.4	7.9
4/06/2007	9.3	25.9	11/02/2008	14	12.4
10/06/2007	5.1	8.4	17/02/2008	11.9	11.9
16/06/2007	2.3	4.8	23/02/2008	33.9	42.2
22/06/2007	5.1	16.5	29/02/2008	12	14.6
28/06/2007	2.8	5.5	6/03/2008	25.1	31.7
4/07/2007	8.5	15.5	12/03/2008	15.8	15.9
10/07/2007	6	13	18/03/2008	18.9	22.9
16/07/2007	11.1	18.3	24/03/2008	11.7	5.3
22/07/2007	6.5	19.9	30/03/2008	22.8	36.1
28/07/2007	6.2	28.6	5/04/2008	18.7	28
3/08/2007	5.6	31.6	11/04/2008	8.6	14.1
9/08/2007	13.9	43.3	17/04/2008	6.2	12.3
15/08/2007	9.3	21	23/04/2008	4.3	6.9
21/08/2007	7.3	12.5	29/04/2008	22.6	12.9
27/08/2007	15.2	24.6	5/05/2008	10.6	33
2/09/2007	32.4	27.3	11/05/2008	10.6	21.2
8/09/2007	4.6	20.2	17/05/2008	13.9	30.2
29/05/2008	7	20.1	11/02/2009	2.1	8.7
4/06/2008	2.6	3.5	17/02/2009	13.9	13.3
10/06/2008	7.4	17	23/02/2009	24.2	30.6
16/06/2008	3.1	9.2	1/03/2009	23.9	33.9
22/06/2008	1.2	46.7	7/03/2009	18.5	34.2
28/06/2008	10.1	34.6	13/03/2009	7.4	24.9
4/07/2008	5.6	17.6	19/03/2009	16.1	21.8
10/07/2008	6.4	23.4	25/03/2009	29.9	33.5
16/07/2008	4.6	25.9	31/03/2009	8	17.6
22/07/2008	4.6	18.1	6/04/2009	12.3	18.8
28/07/2008	3	11.5	12/04/2009	9.4	33.7
3/08/2008	4.3	19.9	18/04/2009	17.4	25.8
9/08/2008	4.8	20.7	24/04/2009	15.3	21.7

Date	MTO - PM10	Kimes PM10	Date	MTO - PM10	Kimes PM10
15/08/2008	8.2	34.4	30/04/2009	5.2	21.4
21/08/2008	16.5	57.3	6/05/2009	15.2	18.1
27/08/2008	10.7	25.3	12/05/2009	15.9	37.6
2/09/2008	11.8	17.7	18/05/2009	15.1	37.2
8/09/2008	11.5	32.6	24/05/2009	16.3	17.7
14/09/2008	10.9	45.7	30/05/2009	5.3	8.6
20/09/2008	33.7	93.2	5/06/2009	3	11.8
26/09/2008	16	24.4	11/06/2009	5.3	11.2
2/10/2008	28.3	51.9	17/06/2009	6.1	14.5
9/10/2008	18.7	24	23/06/2009	2.4	14.8
14/10/2008	12.6	20.2	29/06/2009	7.2	10.4
20/10/2008	36.9	39.5	6/07/2009	3.1	18.3
26/10/2008	21	23.9	12/07/2009	7.4	12.2
1/11/2008	23.5	28.7	18/07/2009	4.6	18.4
7/11/2008	40.1	59.9	24/07/2009	6.1	15.6
13/11/2008	28.8	28.3	30/07/2009	4.8	20.1
19/11/2008	10.4	9.8	4/08/2009	8.7	38.1
25/11/2008	26.4	37.9	10/08/2009	22.7	42.1
1/12/2008	13.6	34	16/08/2009	13.1	44.5
7/12/2008	13.8	16.3	22/08/2009	8.7	24.7
13/12/2008	13.7	32.3	28/08/2009	13.7	74.6
19/12/2008	13.5	31	11/02/2009	2.1	8.7
25/12/2008	15.9	18.2	17/02/2009	13.9	13.3
31/12/2008	47.5	98.4	23/02/2009	24.2	30.6
6/01/2009	34.3	69.6	1/03/2009	23.9	33.9
12/01/2009	30.7	31.3	7/03/2009	18.5	34.2
18/01/2009	35	44	13/03/2009	7.4	24.9
24/01/2009	27.2	42.7	19/03/2009	16.1	21.8
30/01/2009	41.7	35.8	25/03/2009	29.9	33.5
5/02/2009	30.9	58.3	31/03/2009	8	17.6

Appendix E: Emission calculations

The dust emissions from the mine have been estimated from the operational description of the proposed mining activities provided by Warkworth Mine. Emission factor equations that relate the quantity of dust liberated from particular activities to the intensity of the activity and the properties of the material being handled and/or the prevailing meteorological conditions are used to estimate the emissions. Estimated emissions are presented for all significant dust generating activities associated with the operations. The relevant emission factors used for the study are described below.

Overburden

Stripping topsoil

Emissions of Total Suspended Particles (TSP) were estimated using the emission factor for top soil removal of 14 kg per scraper hour (**SPCC, 1983**).

Drilling overburden

Emissions from drilling operation were estimated using the emission factor for drilling of 0.59 kg/hole (**USEPA, 1985**).

Blasting overburden

Emissions from blasting overburden were estimated using the following emission factor equation (**USEPA, 1985**):

Equation 1

$$EF = 0.00022 \times A^{1.5}$$

where:

EF	=	Emission factor for TSP from blasting	(kg/blast)
A	=	Area to be blasted	(m ²)

Dragline operation

Emissions from Dragline operation were estimated using the following emission factor equation (**USEPA, 1985**):

Equation 2

$$EF = \frac{0.0046 d^{1.1}}{M^{0.3}}$$

where:

EF	=	Emission factor for TSP from blasting	(kg/blast)
d	=	Drop distance	(m)
M	=	Moisture content	(%)

Loading/emplacing overburden

Loading overburden to trucks will generate emissions of TSP. The rate of emission is dependent on the wind speed and the moisture content of the overburden. Emissions were estimated using the following emission factor equation (**USEPA, 1985**):

Equation 3

$$EF = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2} \right)^{1.3}}{\left(\frac{M}{2} \right)^{1.4}} \right)$$

where:

EF	=	Emission factor for TSP from loading overburden to trucks	(kg/tonne)
k	=	Particulate size specific factor for batch loading operations ($k_{TSP} = 0.74$)	(kg/tonne)
U	=	Wind speed	(m/s)
M	=	Moisture content of material loaded	(%)

Hauling overburden on unsealed surfaces

The uncontrolled emission factor for vehicles travelling on unsealed road is estimated to be 4 kg/VKT (**SPCC, 1983**). **Buoncore and Davis (1992)** show the level of control that can be achieved through the application of water and or chemical stabilisers. Controls of up to 95% can be achieved provided the moisture content of the surface material is maintained at 9%. For the current assessment a control of 75% has been assumed.

Dozers on overburden

Emissions from dozers on overburden have been calculated using the US EPA emission factor equation (**US EPA, 1985**). The equation is as follows:

Equation 4

$$EF = 2.6 \times \frac{S^{1.2}}{M^{1.3}}$$

EF	=	Emission factor for TSP from dozer operation on overburden	(kg/hour)
S	=	Silt content	(%)
M	=	Moisture content of material loaded	(%)

Coal

Drilling

Same as overburden drilling.

Blasting

Same as overburden blasting.

Dozers ripping on coal

Emissions from dozers on coal have been calculated using the US EPA emission factor equation (**US EPA, 1985**). The equation is as follows:

Equation 5

$$EF = 35.6 \times \frac{S^{1.2}}{M^{1.4}}$$

EF	=	Emission factor for TSP from dozer operation on overburden	(kg/hour)
S	=	Silt content	(%)
M	=	Moisture content of material loaded	(%)

Loading coal to trucks

Emissions from dozers on coal have been calculated using the US EPA emission factor equation (US EPA, 1985). The equation is as follows:

Equation 6

$$EF = \frac{0.580}{M^{1.2}}$$

EF	=	Emission factor for TSP from loading operation on coal	(kg/hour)
M	=	Moisture content of material loaded	(%)

Hauling coal on unsealed surface

Same as hauling overburden on unsealed surface.

Wind erosion/conveying coal

Emissions of TSP from wind erosion and conveying were estimated using the emission factor for exposed areas of 0.4 kg/ha/hr (**SPCC, 1983**).

Grading roads

Estimated TSP emissions from grading roads have been made using the US EPA (1985 and updates) emission factor equation:

Equation 7

$$EF = 0.0034 \times S^{2.5}$$

where,

EF	=	Emission factor for TSP from grading operation on overburden	(kg/VKT)
S	=	Speed of grader	(km/hr)

Appendix F: Emission inventories

Table F.1: Emission Inventory for Warkworth Extension Project – Year 2

ACTIVITY	TSP emission/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units
OB - Stripping topsoil	3,500		250 h/y		kg/h						
OB - Drilling	33,224		56,312 holes/y	14.000000	kg/hole						
OB - Blasting	413,822		362 blasts/y	1143.155330	kg/blast	30000	Area of blast in square metres				
OB - Sh/Ex/FELs loading	150,027		74,214,511 t/y	0.0020215	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	2	moisture content in %		
OB - Dragline	1,246,376		39,227,651 bcm	0.0317729	kg/bcm	7	drop distance in metres	2	moisture content in %		
OB - Hauling to emplacement area	2,009,976		74,214,511 t/y	0.1083333	kg/t	240	t/truck load	7	km/return trip	4.0	kg/VKT
OB - Emplacing at area	150,027		74,214,511 t/y	0.00202	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	2	moisture content in %		
OB - Dozers in Pit	921,615		55,070 h/y	16.7353328	kg/h	10	silt content in %	2	moisture content in %		
OB - Dozers on Dump & Rehabilitation	848,163		50,681 h/y	16.7353328	kg/h	10	silt content in %	2	moisture content in %		
CL - Drilling	14,797		25,080 holes/y	0.5900000	kg/hole						
CL - Blasting	18,040		82 blasts/y	220.0000000	kg/blast	10000	Area of blast in square metres				
CL - Dozers ripping coal	151,317		5,344 h/y	28.3152712	kg/h	8	silt content in %	7	moisture content in %		
CL - Sh/Ex/FELs loading	779,773		13,888,585 t/y	0.0561449	kg/t			7	moisture content in %		
CL - Hauling to Warkworth CPP	328,940		6,944,293 t/y	0.1894737	kg/t	190	t/truck load	9	km/return trip	4.0	kg/VKT
CL - Emplacing at Warkworth CPP	2,430		6,944,293 t/y	0.00035	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	7	moisture content in %		
CL - Rehandle at Warkworth CPP	194		555,543 t/y	0.00035	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	7	moisture content in %		
CL - Loading rejects at Warkworth CPP	599		2,818,345 t/y	0.00021	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	10	moisture content in %		
CL - Hauling rejects from Warkworth CPP	133,501		2,818,345 t/y	0.1894737	kg/t	190	t/truck load	9	km/return trip	4.0	kg/VKT
CL - Emplacing rejects at Mt Thorley	599		2,818,345 t/y	0.00021	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	10	moisture content in %		
CL - Hauling to Mt Thorley CPP	55,554		6,944,293 t/y	0.4000000	kg/t	190	t/truck load	19	km/return trip	4.0	kg/VKT
CL - Emplacing at Mt Thorley CPP	2,430		6,944,293 t/y	0.00035	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	7	moisture content in %		
CL - Rehandle at Mt Thorley CPP	194		555,543 t/y	0.00035	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	7	moisture content in %		
CL - Loading rejects at Mt Thorley CPP	722		3,400,401 t/y	0.00021	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	10	moisture content in %		
CL - Hauling rejects from Mt Thorley CPP	53,691		3,400,401 t/y	0.0631579	kg/t	190	t/truck load	3	km/return trip	4.0	kg/VKT
CL - Emplacing rejects at Mt Thorley	722		3,400,401 t/y	0.00021	kg/t	1.707	average of (wind speed/2.2)*1.3 in m/s	10	moisture content in %		
WE - OB dump area (Warkworth)	2,071,448		591 ha	0.4000000	kg/ha/h	8760	t/y				
WE - Pit area (Warkworth)	1,137,574		325 ha	0.4000000	kg/ha/h	8760	t/y				
WE - Stockpiles	122,640		35 ha	0.4000000	kg/ha/h	8760	t/y				
Grading roads	37,740		8,760 hours	0.6154657	kg/VKT	8	speed km/h	7	Number of Graders		

Table F.2: Emission Inventory for Warkworth Extension Project – Year 9

ACTIVITY	TSP emission/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units
OB - Stripping topsoil	3,500		250 h/y								
OB - Drilling	28,539		48,372 holes/y	14,0000000	kg/hole						
OB - Blasting	413,922		363 blasts/y	1143,1535330	kg/blast	30000	Area of blast in square metres				
OB - Sh/Ex/FELs loading	324,369		160,456,800 t/y	0.0020215	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	2	moisture content in %		
OB - Dragline	1,178,966		37,106,039 bcm	0.0317729	kg/bcm	7	drop distance in metres	2	moisture content in %		
OB - Hauling to emplacement area	4,813,704		160,456,800 t/y	0.1200000	kg/t	240	t/truck load	7	km/return trip		4.0 kg/ΔKT
OB - Emplacing at area	324,369		160,456,800 t/y	0.00202	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	2	moisture content in %		
OB - Dozers in pit	791,749		47708 h/y	16,7353328	kg/h	10	silt content in %	2	moisture content in %		
OB - Dozers on Dump & Rehabilitation	798,426		47708 h/y	16,7353328	kg/h	10	silt content in %	2	moisture content in %		
CL - Drilling	12,950		21949 holes/y	0.5900000	kg/hole						
CL - Blasting	18,040		82 blasts/y	220,0000000	kg/blast	10,000	Area of blast in square metres				
CL - Dozers ripping coal	132,431		4677 h/y	28,3152712	kg/h	8	silt content in %	7	moisture content in %		
CL - Sh/Ex/FELs loading	933,591		16,628,239 t/y	0.0561449	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	7	moisture content in %		
CL - Hauling to Warkworth CPP	437,585		8,314,120 t/y	0.2105263	kg/t	190	t/truck load	10	km/return trip		4.0 kg/ΔKT
CL - Emplacing at Warkworth CPP	2,909		8,314,120 t/y	0.00035	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	7	moisture content in %		
CL - Rehandle at Warkworth CPP	218		623,559 t/y	0.00035	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	7	moisture content in %		
CL - Loading rejects at Warkworth CPP	660		3105418 t/y	0.00021	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	10	moisture content in %		
CL - Hauling rejects from Warkworth CPP	147,099		3105418 t/y	0.1894737	kg/t	190	t/truck load	9	km/return trip		4.0 kg/ΔKT
CL - Emplacing rejects at Mt Thorley	660		3105418 t/y	0.00021	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	10	moisture content in %		
CL - Hauling to Mt Thorley CPP	892,674		8,314,120 t/y	0.4294737	kg/t	190	t/truck load	20	km/return trip		4.0 kg/ΔKT
CL - Emplacing at Mt Thorley CPP	2,909		8,314,120 t/y	0.00035	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	7	moisture content in %		
CL - Rehandle at Mt Thorley CPP	218		623,559 t/y	0.00035	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	7	moisture content in %		
CL - Loading rejects at Mt Thorley CPP	534		2512642 t/y	0.00021	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	10	moisture content in %		
CL - Hauling rejects from Mt Thorley CPP	39,673		2512642 t/y	0.0631579	kg/t	190	t/truck load	3	km/return trip		4.0 kg/ΔKT
CL - Emplacing rejects at Mt Thorley	534		2512642 t/y	0.00021	kg/t	1,707	average of (wind speed/2.2)*1.3 in m/s	10	moisture content in %		
WE - OB dump area (Warkworth)	1,327,155		379 ha	0.4000000	kg/ha/h	8760	h/y				
WE - Pit area (Warkworth)	991,961		283 ha	0.4000000	kg/ha/h	8760	h/y				
WE - Stockpiles	122,640		35 ha	0.4000000	kg/ha/h	8760	h/y				
Grading roads	43,132		8760 hours	0.6154657	kg/ΔKT	8	speed km/h	8	Number of Graders		

Table F.3: Emission Inventory for Warkworth Extension Project – Year 21

ACTIVITY	TSP emission/year	Intensity	units	Emission factor	Variable 1	Variable 2	Variable 3	units
OB- Stripping topsoil	3,500	250	h/y	14,000,000 kg/h				
OB - Drilling	33,002	55936	holes/y	0.590000 kg/blast				
OB - Blasting	413,822	362	blasts/y	1143.1535330 kg/blast	30000 Area of blast in square metres			
OB - Sh/Ex/FELS loading	380,875	188,408.537	h/y	0.0020215 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	2 moisture content in %		
OB - Dragline	891,663	28,063.649	bcm	0.0317729 kg/bcm	7 drop distance in metres	2 moisture content in %		
OB - Hauling to emplacement area	5,840,665	188,408.537	h/y	0.1240000 kg/t	240 t/truck load	7 km/return trip		
OB - Emplacing at area	380,875	188,408.537	h/y	0.002021 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	2 moisture content in %		
OB - Dozers in Pit	700,424	41853	h/y	16.7353328 kg/h	10 silt content in %	2 moisture content in %		
OB - Dozers on Dump & Rehabilitation	978,130	58447	h/y	16.7353328 kg/h	10 silt content in %	2 moisture content in %		
CL - Drilling	14,018	23760	holes/y	0.5900000 kg/blast				
CL - Blasting	18,040	82	blasts/y	220.0000000 kg/blast	10000 Area of blast in square metres			
CL - Dozers ripping coal	143,360	5063	h/y	28.3152712 kg/h	8 silt content in %	7 moisture content in %		
CL - Sh/Ex/FELS loading	1,010,608	18,000,000	h/y	0.0561449 kg/t	190 t/truck load	7 moisture content in %		
CL - Hauling to Warkworth CPP	691,579	9,000,000	h/y	0.3073684 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	15 km/return trip		4.0 kg/VKT
CL - Emplacing at Warkworth CPP	3,149	9,000,000	h/y	0.00035 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	7 moisture content in %		
CL - Rehandle at Warkworth CPP	236	675,000	h/y	0.00035 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	7 moisture content in %		
CL - Loading rejects at Warkworth CPP	613	2888346	h/y	0.00021 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	10 moisture content in %		
CL - Hauling rejects from Warkworth CPP	136,816	2888346	h/y	0.1894737 kg/t	190 t/truck load	9 km/return trip		4.0 kg/VKT
CL - Emplacing rejects at Mt Thorley	613	2888346	h/y	0.00021 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	10 moisture content in %		
CL - Hauling to Mt Thorley CPP	1,184,211	9,000,000	h/y	0.5263158 kg/t	190 t/truck load	25 km/return trip		4.0 kg/VKT
CL - Emplacing at Mt Thorley CPP	3,149	9,000,000	h/y	0.00035 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	7 moisture content in %		
CL - Rehandle at Mt Thorley CPP	236	675,000	h/y	0.00035 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	7 moisture content in %		
CL - Loading rejects at Mt Thorley CPP	685	3227255	h/y	0.00021 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	10 moisture content in %		
CL - Hauling rejects from Mt Thorley CPP	67,942	3227255	h/y	0.0842105 kg/t	190 t/truck load	4 km/return trip		4.0 kg/VKT
CL - Emplacing rejects at Mt Thorley	685	3227255	h/y	0.00021 kg/t	1.707 average of (wind speed/2.2) ^{1.3} in m/s	10 moisture content in %		
WE - OB dump area (Warkworth)	1,131,770	461	ha	0.4000000 kg/ha/h	8760 h/y			
WE - Pit area (Warkworth)	1,369,493	391	ha	0.4000000 kg/ha/h	8760 h/y			
WE - Stockpiles	122,640	35	ha	0.4000000 kg/ha/h	8760 h/y			
Grading roads	43,132	8760	hours	0.6154657 kg/VKT	8 speed km/h	8 Number of Graders		

Appendix G: Contour plots

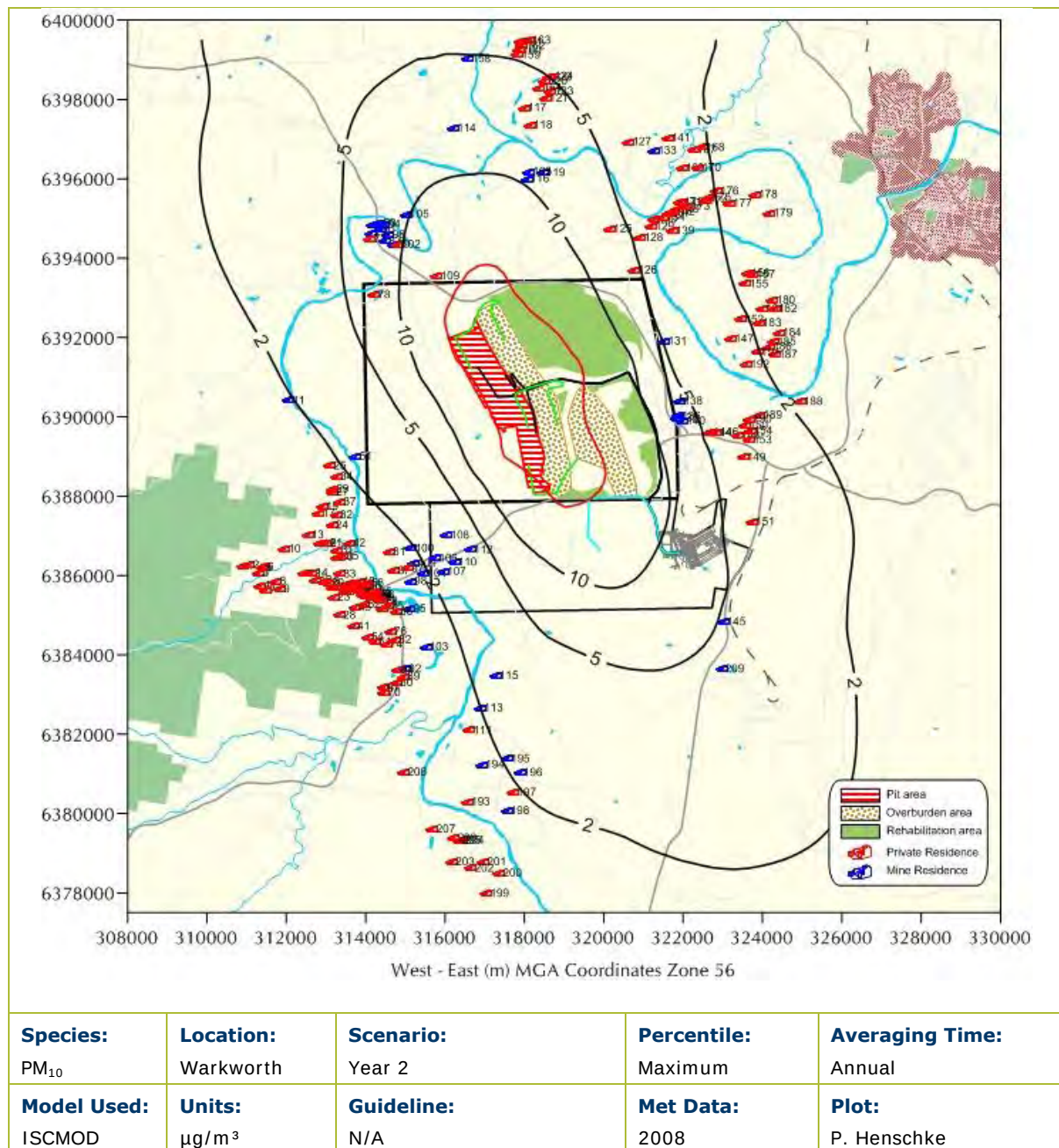


Figure G.1: Predicted Annual average PM₁₀ concentrations due to emissions from Warkworth Extension Project in Year 2

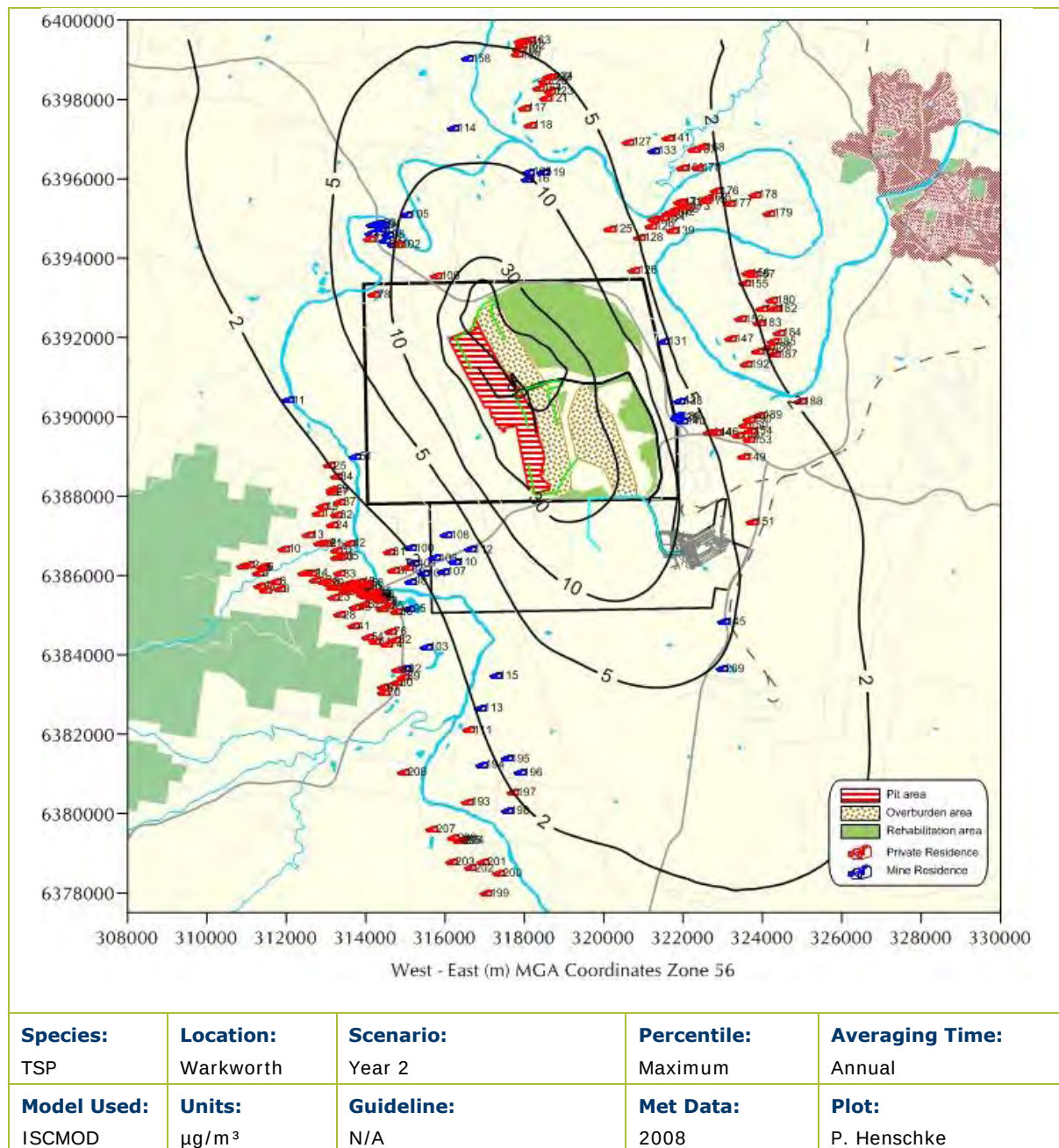


Figure G.2: Predicted Annual average TSP concentrations due to emissions from Warkworth Extension Project in Year 2

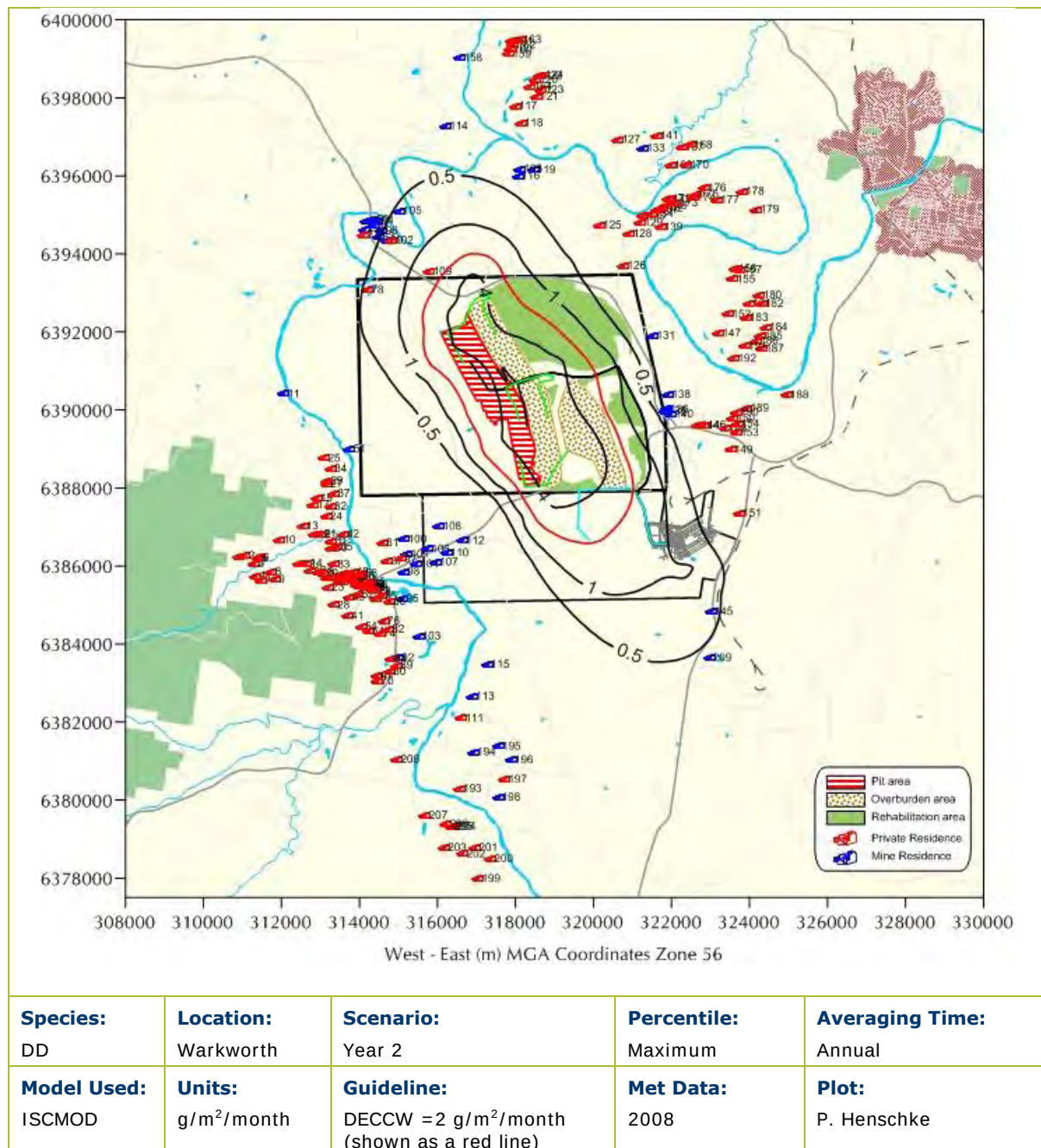


Figure G.3: Predicted Annual average dust deposition concentrations due to emissions from Warkworth Extension Project in Year 2

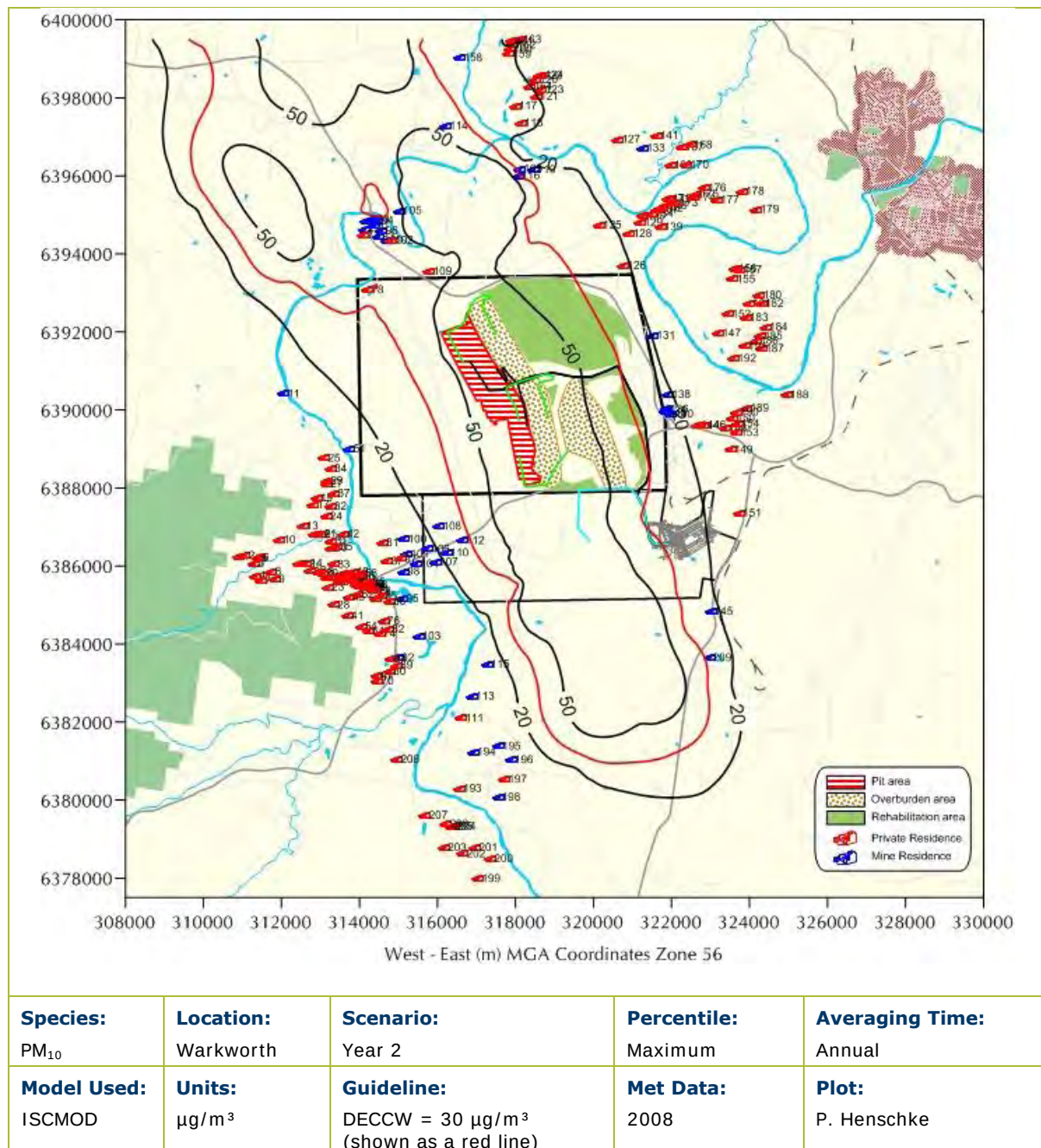


Figure G.4: Predicted Annual average PM₁₀ concentrations due to emissions from Warkworth Extension Project and other sources in Year 2

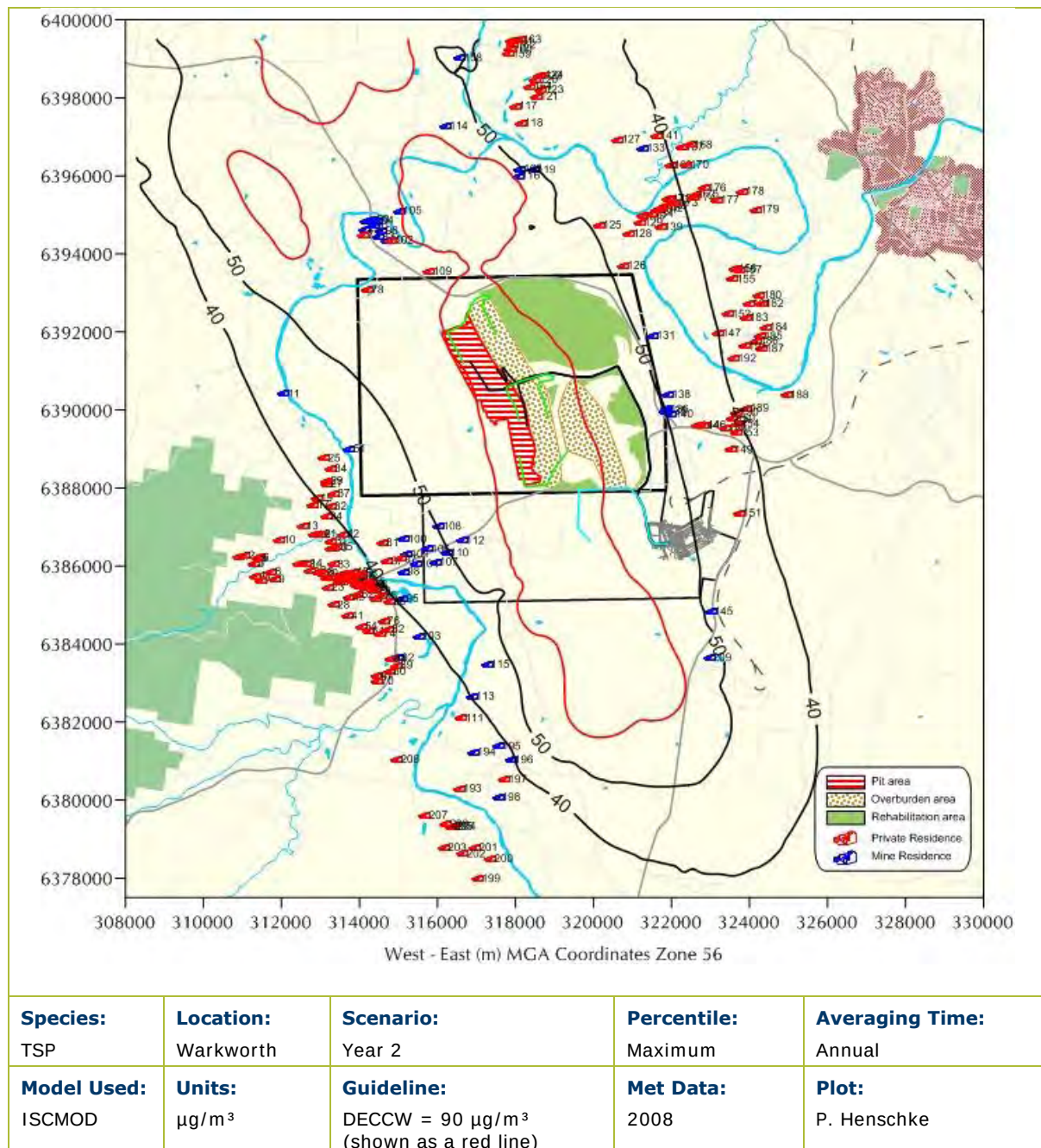


Figure G.5: Predicted Annual average TSP concentrations due to emissions from Warkworth Extension Project and other ssources in Year 2

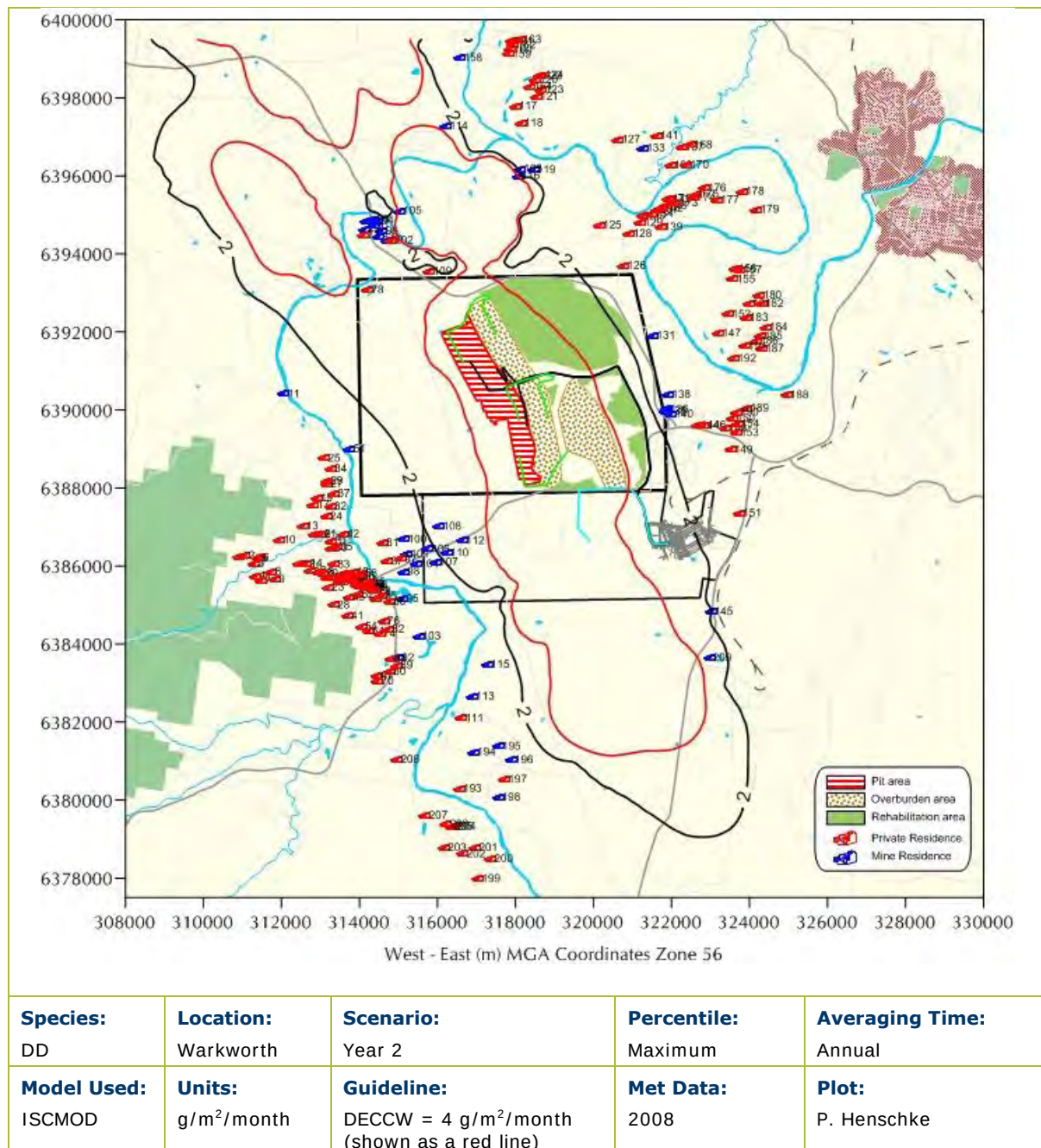


Figure G.6: Predicted Annual average dust deposition concentrations due to emissions from Warkworth Extension Project and other sources in Year 2

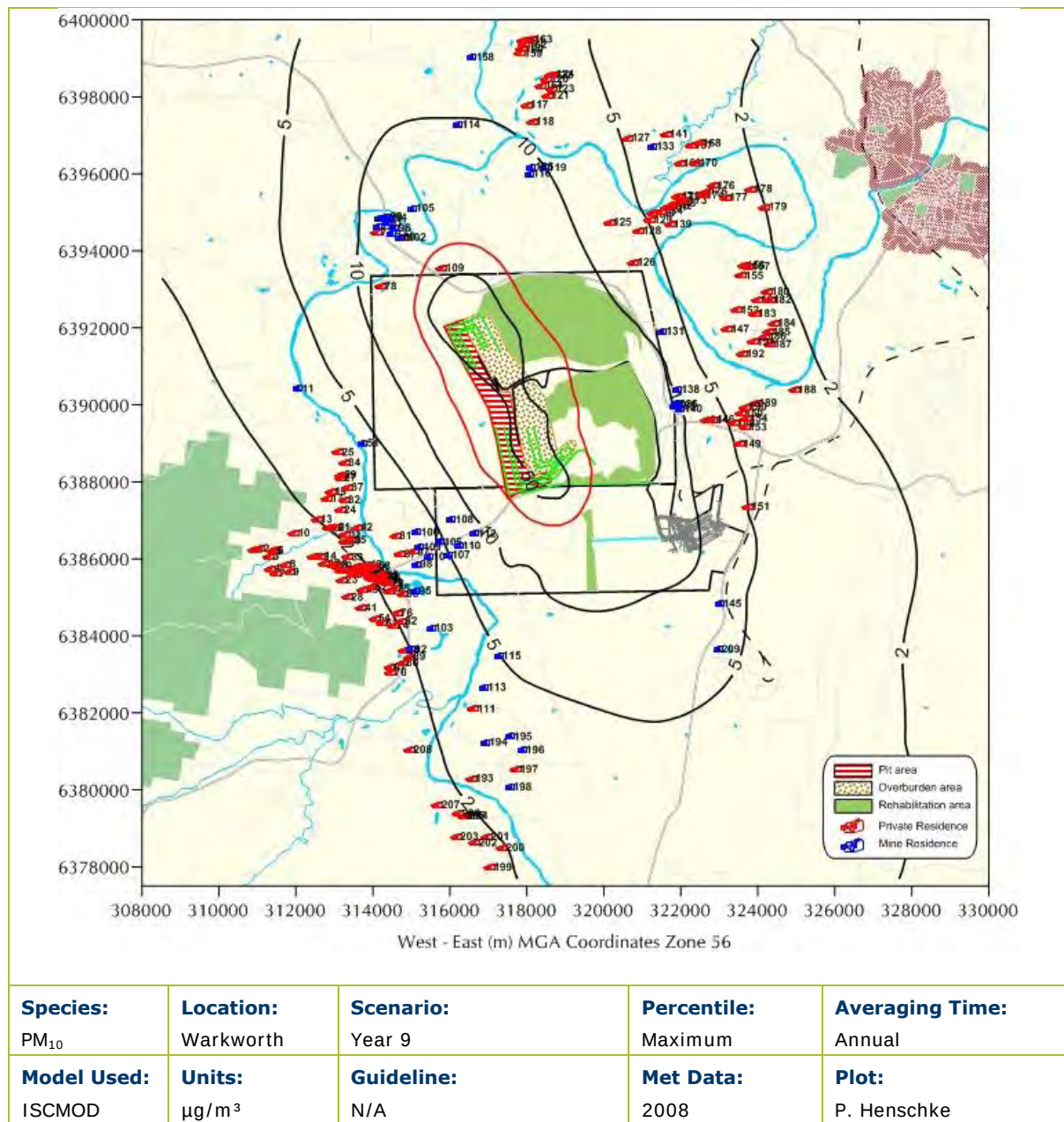


Figure G.7: Predicted Annual average PM₁₀ concentrations due to emissions from Warkworth Extension Project in Year 9

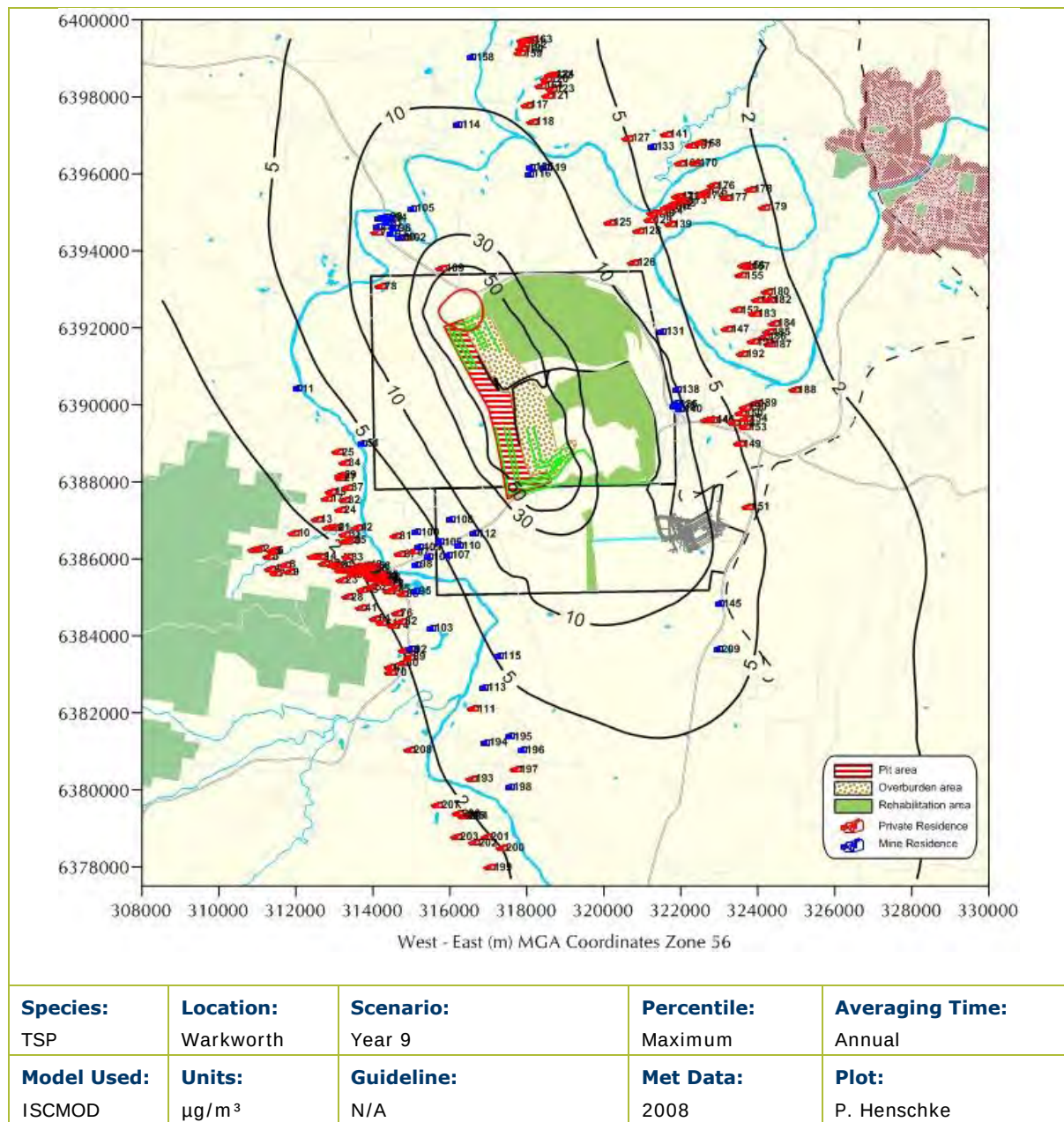


Figure G.8: Predicted Annual average TSP concentrations due to emissions from Warkworth Extension Project in Year 9

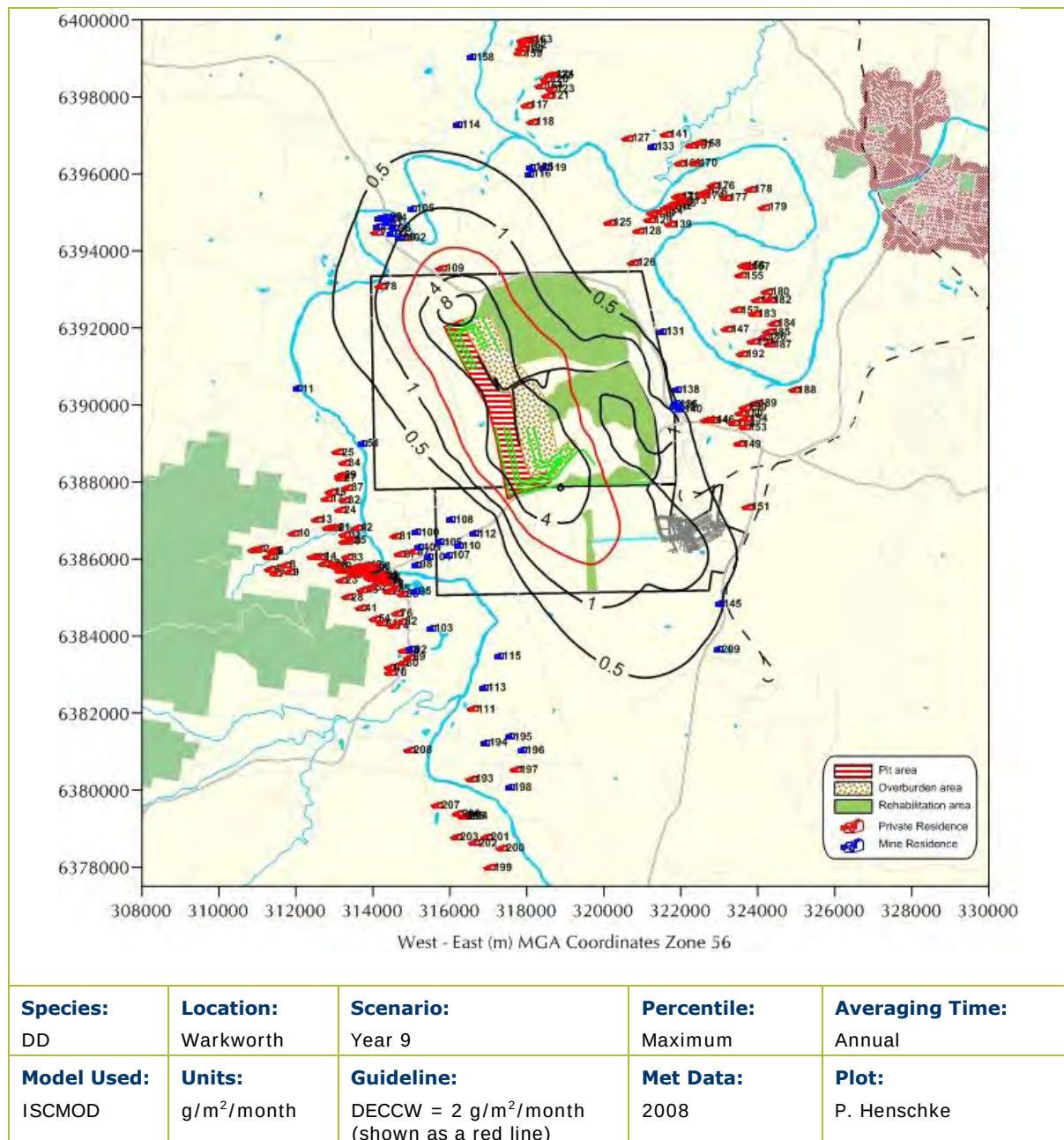


Figure G.9: Predicted Annual average dust deposition concentrations due to emissions from Warkworth Extension Project in Year 9

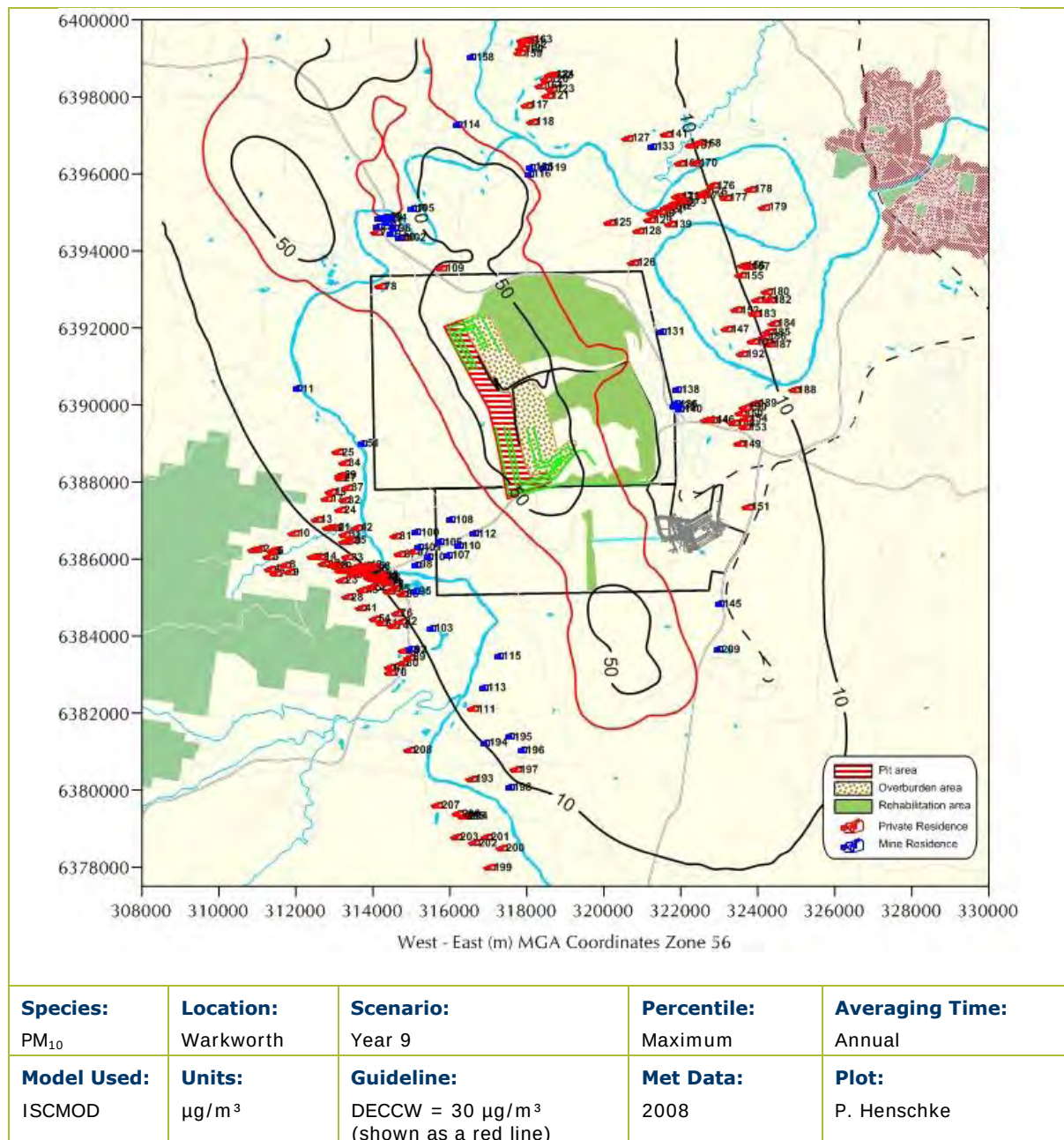


Figure G.10: Predicted Annual average PM₁₀ concentrations due to emissions from Warkworth Extension Project and other sources in Year 9

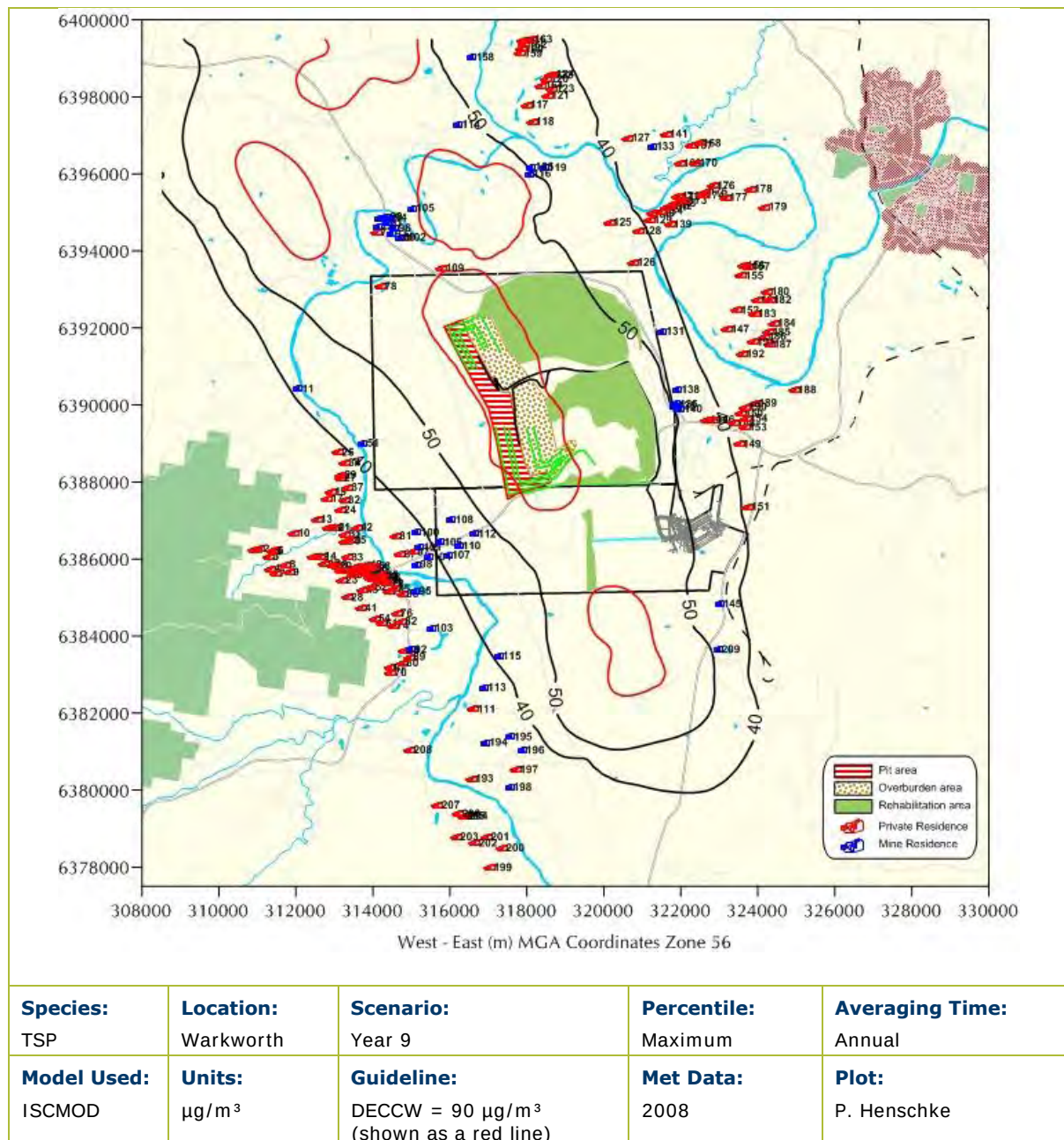


Figure G.11: Predicted Annual average TSP concentrations due to emissions from Warkworth Extension Project and other sources in Year 9

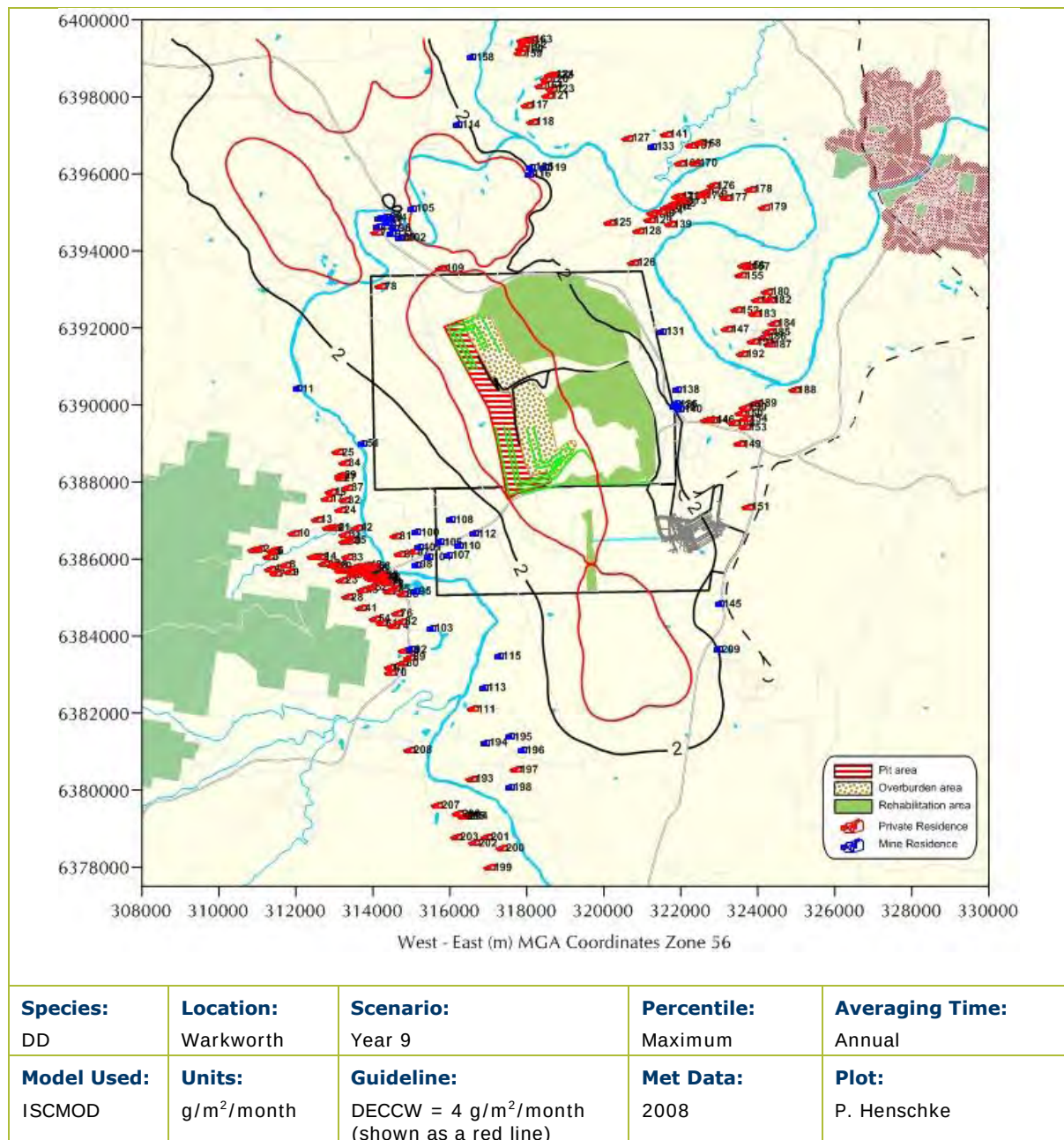


Figure G.12: Predicted Annual average dust deposition concentrations due to emissions from Warkworth Extension Project and other sources in Year 9

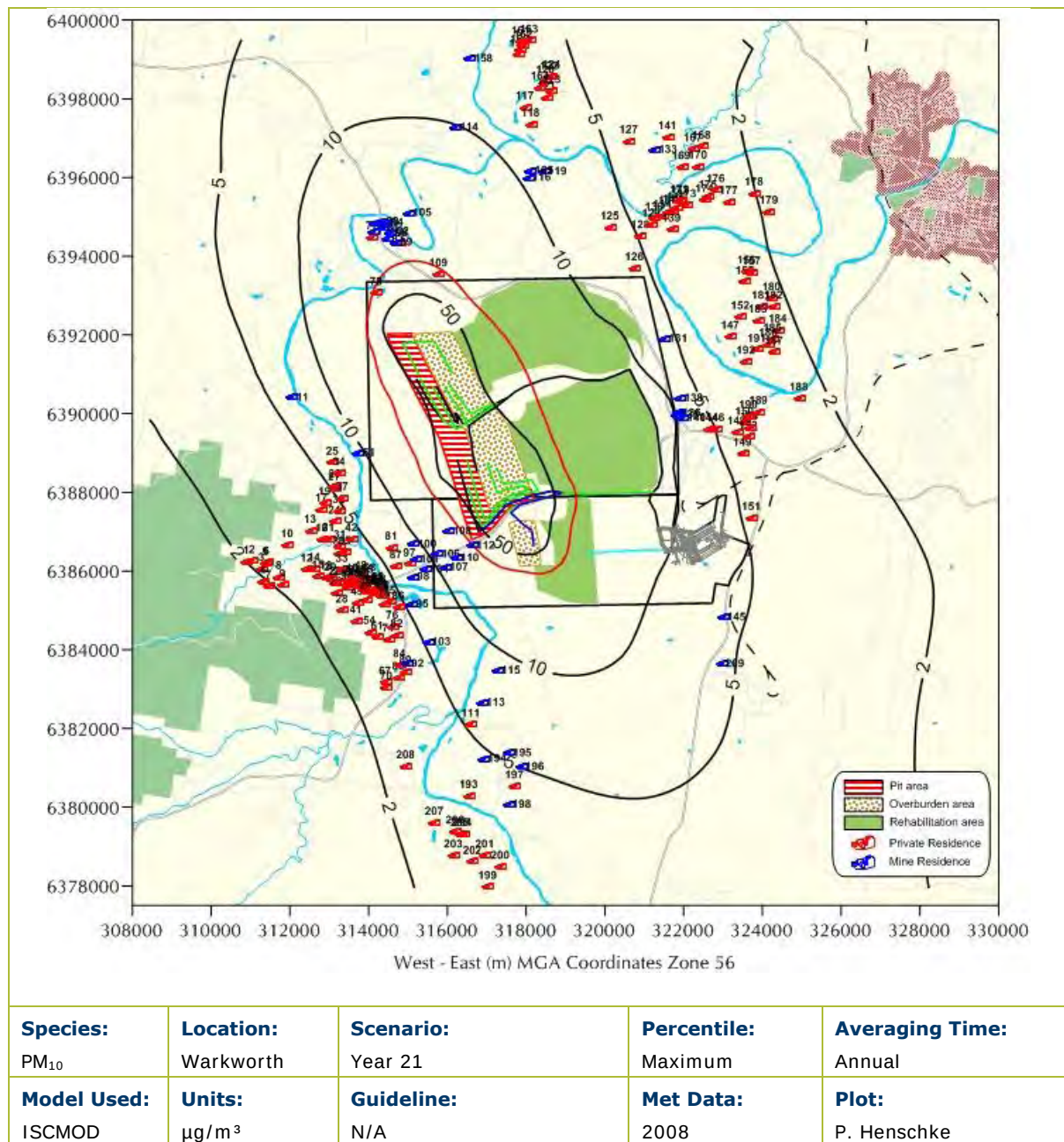


Figure G.13: Predicted Annual average PM₁₀ concentrations due to emissions from Warkworth Extension Project in Year 21

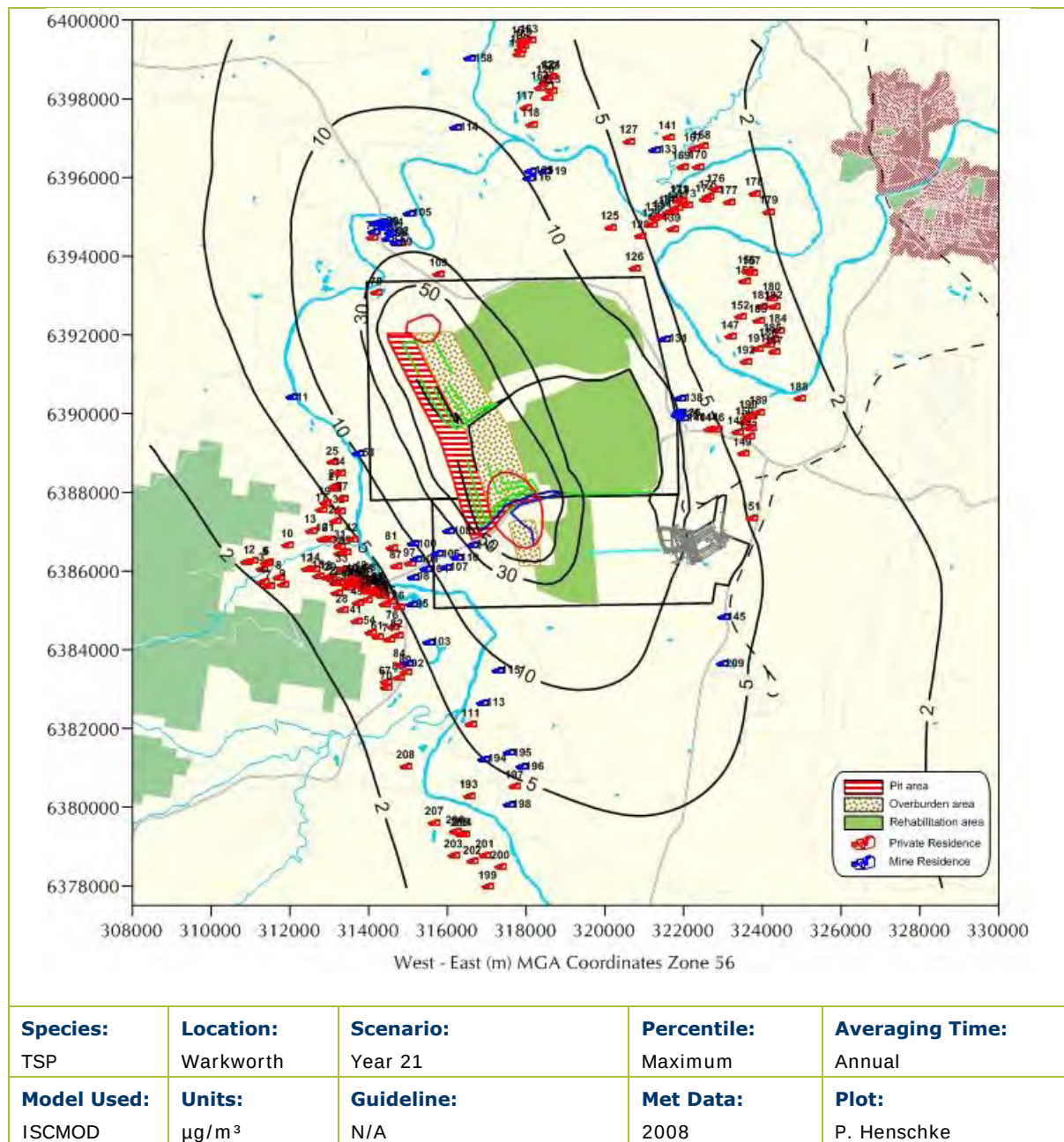


Figure G.14: Predicted Annual average TSP concentrations due to emissions from Warkworth Extension Project in Year 21

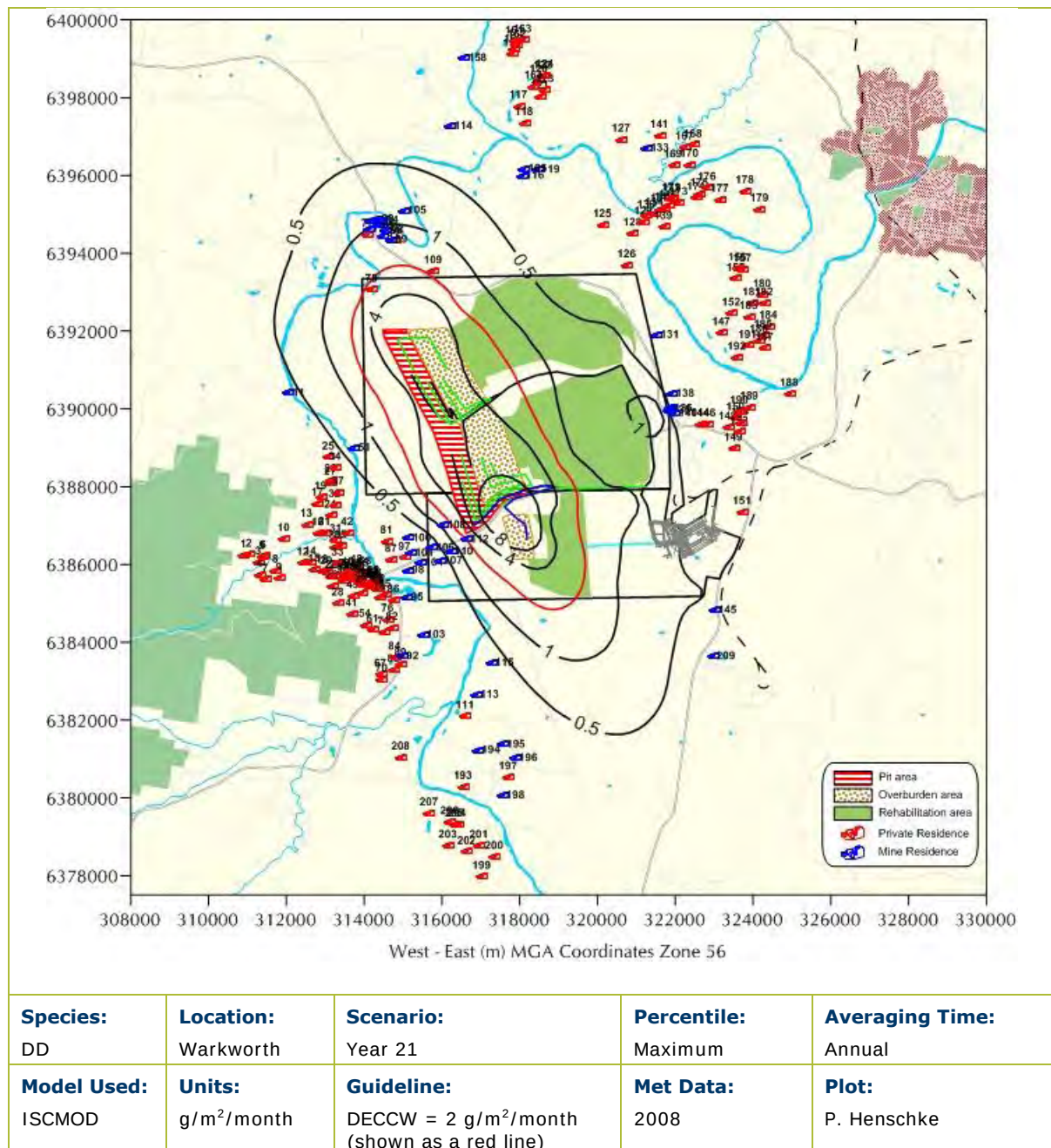


Figure G.15: Predicted Annual average dust deposition concentrations due to emissions from Warkworth Extension Project in Year 21

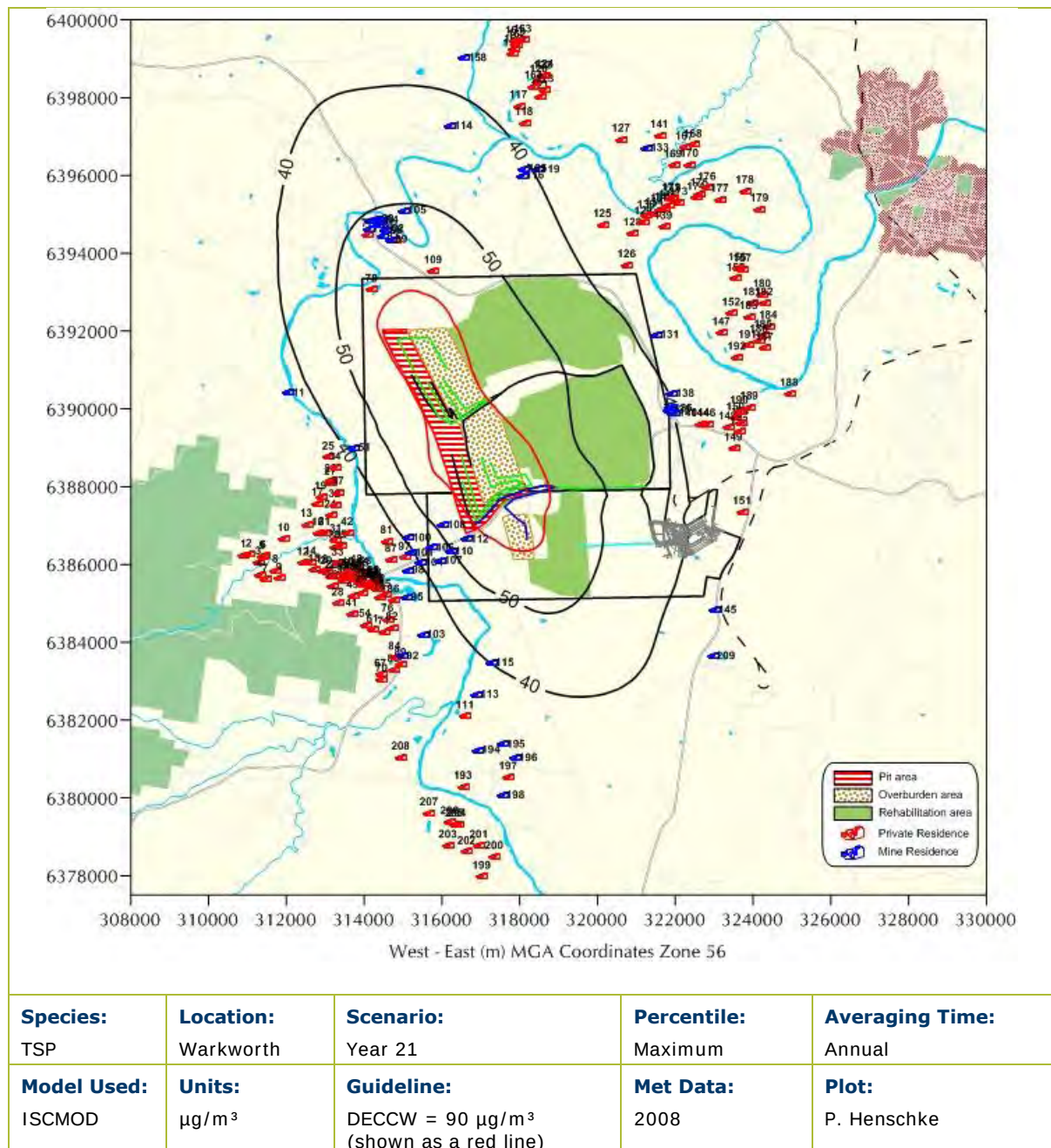


Figure G.17: Predicted Annual average TSP concentrations due to emissions from Warkworth Extension Project and other sources in Year 21

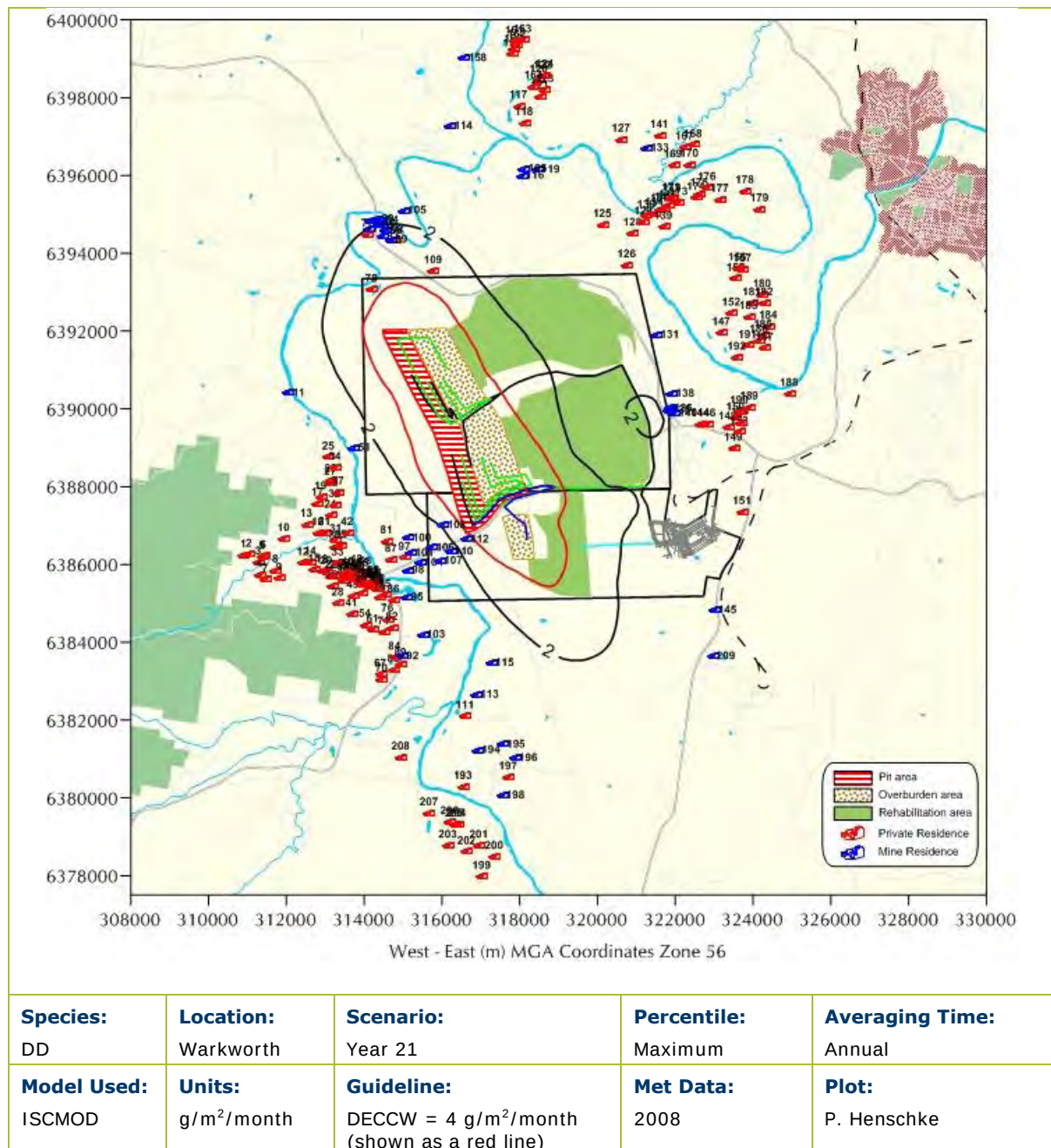


Figure G.18: Predicted Annual average dust deposition concentrations due to emissions from Warkworth Extension Project and other sources in Year 21

