

# Appendix E **Air quality assessment**



Incitec Pivot Cockle Creek  
Site Redevelopment  
Stages 2 to 4  
Air Quality Assessment

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## Executive Summary

The Air Quality Assessment for the proposed Incitec Fertiliser Limited Cockle Creek Site (hereafter, "the IFL site") Stage 2 to Stage 4 Redevelopment comprised three main components, namely: (i) baseline environment characterisation, (ii) air quality assessment of remediation operations, and (iii) recommendation of management measures to reduce emission potentials and air quality monitoring to track ambient air pollutant concentrations during remediation.

Stage 1 of the remediation will involve groundwater recovery and treatment along the northwest site boundary and will not require significant site preparation or contaminated soil excavation. Stages 2 to 4 are the major stages of the remediation works, involving excavation, transport and placement of significant quantities of contaminated site soils into the proposed engineered containment cell in addition to building demolition and associated waste management. Detailed descriptions of currently proposed Stage 1 to 4 activities are given in the RAP.

A stand-alone environmental assessment and associated Air Quality Assessment has been prepared previously for Stage 1. Therefore, no further assessment of this stage is provided within this document.

The present quantitative assessment of emissions and resultant ambient air pollutant levels therefore relates to activities anticipated under **Stage 2, Stage 3** and **Stage 4** of the project.

## Existing Air Quality Environment

Industrial and mining activities operating within 5 km of the IFL site include Pasminco Cockle Creek Smelter (PCCS) remediation operations, West Wallsend Colliery, Macquarie Coal Preparation Plant, Inghams Cardiff Feedmill and Works Infrastructure.

Due to the proximity and nature of the PCCS remediation operations, these operations hold the greatest potential for cumulative impacts. PCCS remediation operations and containment cell construction are scheduled to continue throughout 2009 and 2010, with completion by mid 2011. Stage 2 of the proposed IFL site remediation is scheduled to start in January 2010. Thus the potential exists for overlap in the PCCS and IFL Cockle Creek remediation works. Stage 3 and Stage 4 operations at the IFL site are only likely to be initiated in 2012 and 2013 respectively when Pasminco's remediation operations are expected to have been completed.

A range of monitoring data sets are available and were used in the characterisation of the existing air quality at the Project Site from IFL and PCCS. Site-specific information from the IFL and PCCS stations were only used for the post 2003 period. Prior to this date air pollution concentrations were significantly higher due to the operations of the Pasminco Smelter. The closure of the Pasminco Smelter in September 2003 and implementation of additional dust mitigation measures resulted in significant reductions in particulate and heavy metal concentrations and deposition rates. It is further noted that air pollution concentrations recorded during the 2007 to 2009 period are likely to have been influenced by the PCCS site remediation activities.

The IFL Cockle Creek facility which has contributed to ambient air pollutant concentrations including fine particulate, phosphate and fluoride concentrations and dust deposition was closed on 15 January 2009. To assess the potential reduction in background levels as a result of the closure of the plant reference, specific reference was made to air quality monitoring data for the post-closure period. The duration of such data was restricted due to the plant closure being recent, and generally confined to the latter half of January 2009 for Total Suspended Particulate (TSP) and dust deposition and up until 20 February 2009 for particulate matter less than 10 microns (PM<sub>10</sub>) data.

Background suspended particulate and heavy metal concentrations estimated for use in the assessment of cumulative air quality impacts are given in the tables below.

Particulate is characterised as three size fractions; total suspended particulate (TSP), and particulate less than or equal to 10 and 2.5 microns in aerodynamic diameter (PM<sub>10</sub> and PM<sub>2.5</sub> respectively).

In the characterisation of ambient TSP and PM<sub>10</sub> concentrations reference was made to measurements made during the 2004 to February 2009 period (as available). Based on the most recent TSP measurements made at stations in the immediate vicinity of the IFL Cockle Creek facility it is conceivable that the recent (mid January 2009) closure of this plant could have reduced airborne particulate concentrations. An insufficient period of TSP data are available, and PM<sub>10</sub> levels not recorded in this area, making it impossible to accurately conclude whether current TSP and PM<sub>10</sub> levels are lower than those recorded historically. The characterisation of baseline airborne particulate within Boolaroo based on historical data is however considered to be a conservative estimate of current background levels.

<b>Background particulate concentrations for cumulative assessment purposes</b>			
<b>Averaging Period</b>	<b>Ambient TSP Concentrations</b>	<b>Ambient PM<sub>10</sub> Concentrations</b>	<b>Ambient PM<sub>2.5</sub> Concentrations</b>
Highest Daily Average	60 – 230 µg/m <sup>3</sup> (a)	45 - 65 µg/m <sup>3</sup>	25 – 30 µg/m <sup>3</sup>
Exceedances of Daily Limit	NA	0 – 2 days/year	0 – 2 days/year
Annual Average	25 – 50 µg/m <sup>3</sup> (a)	18-19 µg/m <sup>3</sup>	10 µg/m <sup>3</sup>
Exceedances of Annual Limit	None	None	All years exceed

(a) Based on the assessment of TSP concentrations measured during periods prior to and following closure of the IFL Cockle Creek facility in mid January 2009, 10% to 25% lower TSP levels were observed at monitoring stations situated in close proximity and to the south of the plant. The length of the period available for analysis is insufficient to demonstrate the reduction conclusively and PM<sub>10</sub> monitoring is not undertaken at these sites, but it is conceivable that closure of the IFL Plant will have reduced airborne particulate concentrations in this area. Current TSP and PM<sub>10</sub> concentrations may therefore be lower than have been characterised based on historical air quality monitoring information.

In characterising background concentrations of metals and metalloids, reference was primarily made to measurements made during the 2006 to 2007 period. Where no 2006-7

monitoring data were available reference was made to the most recent data available; this being 2003 data in the case of nickel and chromium and 2005 data in the case of copper (refer **Table 16**).

Average annual baseline dust deposition rates were observed to be in the range of 0.7 g/m<sup>2</sup>/month to 1.8 g/m<sup>2</sup>/month across all off-site IFL and PCCS monitoring sites.

## **Remediation Emissions**

Stages 2 to 4 are the major stages of the remediation works, involving excavation, transport and placement of significant quantities of contaminated site soils into the proposed engineered containment cell in addition to building demolition and associated waste management. Major sources of atmospheric emissions associated with Stages 2 to 4 will include:

- Excavation, material transfer and storage related emissions during the construction of the on-site 270,000 m<sup>3</sup> capacity containment cell.
- Excavation, handling, screening, stockpiling and placement of contaminated soils.
- Berm construction.
- Building demolition (including asbestos related issues).
- Recovery, transfer and placement of clean fill to establish post-remediation surface levels.
- Wind erosion of exposed and disturbed areas.
- Vehicle tailpipe releases.

The most significant sources of heavy metal releases are likely to be associated with the excavation, material handling and screening of contaminated soils, wind entrainment from stockpiled contaminated material and blow off from trucks while material is in transit.

To assess the maximum potential impact of the project, the Environmental Assessment as a whole assumes that Stages 2 to 4 will occur concurrently. This represents a reasonable worst-case assessment of the impacts of the proposed project, as based on current timing projections, periods may occur where activities are undertaken within each Stage of the project concurrently.

Accordingly, the emissions inventory and scenario modelling refers to Stage 2, Stage 3 and Stage 4 occurring concurrently.

## **Air Quality Assessment**

### **Suspended Particulate Concentrations**

Annual average concentrations for all size fractions were predicted to be low (less than 25% of the corresponding air quality goal). Taking background particulate concentrations into account it is not expected that Stage 2-4 operations will cumulatively give rise to levels above annual air quality goals.

Baseline air quality data indicate that exceedances of air quality goals given for maximum daily  $PM_{10}$  and advisory thresholds for daily  $PM_{2.5}$  already occur in the region on typically 1 to 2 days/year. In this region, such exceedances are primarily due to episodic emissions from bushfires or dust storms. It is therefore evident that limited potential exists for increments in ambient  $PM_{10}$  and  $PM_{2.5}$  concentrations.

Greater than 99% of predictions for incremental daily average  $PM_{10}$  concentrations at the nearest sensitive receptor sites (those on First Avenue, Boolaroo) are anticipated to be less than  $15\mu\text{g}/\text{m}^3$  (expressed as a 24-hour average). Given the low frequency of occurrence of predicted concentrations in excess of  $15\mu\text{g}/\text{m}^3$  at First Street (2 occasions), the likelihood that increments attributable to the project will cause any additional exceedance of the project air quality goal of  $50\mu\text{g}/\text{m}^3$  when combined with existing background air quality is deemed low (approximately one occasion).

The incremental maximum daily average  $PM_{2.5}$  concentrations at the nearest sensitive receptor sites due to concurrent Stage 2, Stage 3 and Stage 4 emissions are predicted to be of the order of 20% of the 24-hour air quality goal of  $25\mu\text{g}/\text{m}^3$  and as such are not anticipated to contribute to additional exceedances of this parameter.

### Dust Deposition

A maximum *incremental* annual average dust deposition rate of  $0.04\text{ g}/\text{m}^2/\text{month}$  was predicted to occur across the receptor locations due to concurrent Stage 2, Stage 3 and Stage 4 operations. This rate is well within the NSW DECC incremental dust deposition limit of  $2\text{g}/\text{m}^2/\text{month}$ . Taking background average dust deposition levels into account (estimated to be in the order of  $0.8$  to  $1.8\text{ g}/\text{m}^2/\text{month}$ ), maximum *cumulative* annual average dust deposition rates are expected to be within the NSW DECC cumulative dust deposition limit of  $4\text{g}/\text{m}^2/\text{month}$ .

### Heavy Metal Concentrations

High heavy metal concentrations have historically been measured to occur in the study area, with concentrations of lead, arsenic and cadmium noted to be of concern. Although levels of heavy metals have significantly reduced following closure of the PCCS lead smelter in 2003 and dust mitigation improvements, recently measured arsenic and cadmium concentrations remain elevated. Limited potential exists for increments in ambient concentrations of these metals due to the proposed project, although it is recognised that the project will ultimately reduce exposure potentials associated with the facility in the longer-term.

A review of maximum *incremental* 99.9<sup>th</sup> percentile hourly and annual average heavy metal concentrations predicted to occur due to concurrent Stage 2, Stage 3 and Stage 4 operations across all discrete receptor locations was undertaken. No exceedances of the relevant DECC impact assessment criteria for principal toxic air pollutants were predicted to occur. Predicted peak arsenic and cadmium concentrations comprise 28% and 34% of the DECC impact assessment criterion respectively.

The DECC air quality goal given for lead is specific for cumulative concentrations. Background lead concentrations are estimated to be in the range  $0.0135$  to  $0.1128\mu\text{g}/\text{m}^3$ . Given the comparatively low maximum increments in annual lead increments due to the proposed Project ( $0.0013\mu\text{g}/\text{m}^3$ ), the annual lead goal is not expected to be exceeded.

Maximum incremental Project-related concentrations and maximum background concentrations projected from monitoring data were summed to provide an approximation of potential maximum *cumulative* concentrations. Such concentrations were screened against widely applied inhalation health risk assessment criteria. Although projected cumulative arsenic and cadmium levels were noted to be elevated, primarily due to existing background concentrations, the levels of individual constituents were predicted to be within the inhalation health thresholds.

## Mitigation and Monitoring Recommendations

Dust mitigation measures assumed during the estimation of emissions for concurrent Stage 2, Stage 3 and Stage 4 operations were as follows:

- A control efficiency for wheel generated dust on unpaved roads of 75% is assumed. Preliminary modelling indicates that this is considered critical to achieving the project air quality goals, and that control efficiencies of the order of 50% will not be adequate to achieve these goals. Such a control efficiency is achievable through an effective wet or chemical suppression program, and is consistent with the application of water sprays to roads in excess of 2litres/m<sup>2</sup>/hour.
- Stockpiles are to be compressed and partially sealed by tracking over with machinery.
- It is proposed that the crusher be sited in the area of the Stage 2 cell, at a significant separation distance from the closest residential receptors at First Avenue, Boolaroo. Additionally, it is proposed that crushing activities are conducted only when low dust generating activities are being conducted, and is not conducted during early morning or late afternoon periods when inversion conditions may arise. The specification for the crusher is also proposed to include dust controls to a standard equivalent to water spraying during crushing. Alternatively, crushing of concrete may be conducted off-site, however this is not considered a good environmental outcome if on-site reuse of concrete materials is anticipated.
- Fill material in situ is kept adequately moist. Sensitivity analysis of the moisture content of the fill was conducted, indicating that moisture contents of the order of 15% may precipitate exceedances of project air quality goals. Geotechnical investigations to date (Golder Associates Pty Ltd, November 2008) indicate that average in situ fill moisture contents are of the order of 24%. The present assessment assumes some drying out of this material, and accordingly uses a moisture content of 20%.
- Fill materials would be sufficiently moist to prevent blow off of material during truck transit. Alternatively, freeboards will be increased or trucks covered.
- The potential for fill material being deposited on roadways and subsequently re-entrained by vehicles will be prevented through regulating the moisture content of material or the freeboard or covering of trucks.
- In the event that fill material is deposited it will be cleaned up in a timely manner to reduce entrainment potentials.

- Natural material stockpiles will be effectively seeded / covered before the material dries out.
- The potential for vehicle entrainment is reduced by minimising truck traffic and unpaved road lengths.

Further relevant control measures that should be considered but were not specifically included as control measures for the estimation of emissions include:

- A coordinated approach for containment cell construction to allow as much material as possible to be excavated, screened and placed directly in the cell without the need for temporary stockpiling and double handling.
- Minimisation of stockpiling (through increased direct placement), covering of stockpiles with plastic sheeting, application of stockpile wind screens, minimisation of exposed and disturbed surface areas, and various stabilisation methods.
- Use of wind screening at material transfer points.

The incorporation of the above in the management measures would further reduce the risk of adverse air quality impacts arising from the operations.

The above atmospheric dispersion modelling exercise has established that the most significant source of fugitive dust emissions from Stage 2 to 4 operations is likely to be vehicle entrainment during trucking of material, primarily from unpaved roads but also from paved roads (particularly if the silt loading on paved roads is not adequately controlled).

Unpaved road emissions could be controlled through minimising traffic volumes (e.g. through avoided double handling), wet or chemical suppression and speed regulation. Measures to address paved road emissions include the use of wheel washes or grizzlies to avoid material being tracked onto paved road surfaces, road sweeping or vacuuming, and stabilisation of road shoulders and adjoining unpaved roads.

It is anticipated that through the above dust mitigation and monitoring techniques (refer **Section 9.2**), incremental concentrations due to Stage 2-4 operations will be able to satisfy the project air quality goals.

### **Air Quality Monitoring**

It is acknowledged that while all reasonable dust control activities have been provided for, the site is within an area of elevated background air quality, with the local airshed likely to be impacted by the adjacent PCCS remediation activities.

A monitoring plan to manage PM<sub>10</sub> peaks is recommended to inform dust management planning and minimise the potential for cumulative impacts.

It is recommended that IFL should replace or modify the high volume sampler at First Street to allow for PM<sub>10</sub> monitoring at this location. PM<sub>10</sub> samples should be sent to an accredited laboratory for metals analysis.

In the event that regular exceedances of this parameter are witnessed, IFL may consider the introduction of a real-time, continuous PM<sub>10</sub> monitor be placed within the vicinity of the

sensitive receptors predicted to experience the highest impacts of this parameter (e.g. between 5 First Street and 20 First Street). Such an instrument would enable a proactive monitoring strategy utilising short-term trigger values at boundary monitor(s) to provide early warning of potentially unacceptable dust events, in this instance an exceedance of the 24-hour PM<sub>10</sub> goal.

The following further recommendations are made in respect of air quality monitoring for the IFL site remediation project:

- IFL dust deposition monitoring at sites DG1 to DG6 should be continued throughout the remediation project.
- IFL should cooperate with Pasminco in terms of data sharing and explore the potential of continuing the operations of certain of the long-term PCCS high volume sampler stations (and metals analysis) until the Cockle Creek remediation project is complete.

All compliance monitoring should be conducted in accordance with Australian Standards as referenced in the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* (DEC, 2005b).

Air pollution mitigation measures and air quality monitoring should be comprehensively documented within an Air Quality Management Plan.

## 1 Introduction

ENVIRON Australia Pty Ltd (hereafter, "ENVIRON") has been commissioned by Manidis Roberts Pty Ltd (hereafter, "Manidis Roberts") to undertake an Air Quality Assessment for the proposed Incitec Fertiliser Limited Cockle Creek Site (hereafter, "the IFL site") remediation.

IFL, a subsidiary of Incitec Pivot Limited (IPL), proposes to undertake remediation of their 15 ha Cockle Creek site, located within the township of Boolaroo, New South Wales (NSW). The proposed project includes Stages 2 to 4 of remediation. Stage 1 is part of a separate major project application. Stages 2 to 4 include the construction of a containment cell, removal and placement of contaminated soil in the cell, demolition of the site buildings and site restoration.

IFL is seeking approval from the Department of Planning (DoP) to carry out the proposed remediation works under Part 3A of the *Environmental Planning and Assessment Act 1979*. A project application and preliminary environmental assessment was lodged with the Department of Planning in February 2007, and the Director General's Requirements (DGRs) were issued on 8 March 2007.

The DGRs, as they relate to air quality, state the following:

*The Environmental Assessment must include a comprehensive assessment of the air quality impacts of the project in accordance with the Approved Methods for Modelling and Assessment of Air Pollutants in NSW (EPA, 2001). The Assessment must specifically focus on the impact of contaminants present on site such as heavy metals and particulates on ambient air quality, from a project-specific and a cumulative perspective. Consideration of the impacts of particulates must include ambient air quality and dust deposition implications. The Environmental Assessment must include details of proposed air quality monitoring during remediation, with consideration for monitoring dust and lead levels. The potential for sharing data and the cost of monitoring could be explored with the monitoring required for Pasma operations.*

It is noted that the Approved Methods for Modelling and Assessment of Air Pollutants in NSW was revised by the (now) NSW Department of Environment and Climate Change (DECC) in August 2005.

## 2 Project Overview

### 2.1 Site Description and Setting

The Cockle Creek site is located at Main Road, Boolaroo, NSW (**Figure 1**). The IFL site was used to manufacture and distribute fertiliser. Manufacturing operations ceased in January 2009 and distribution operations are expected to cease in late 2009.

The site is situated in a sloping section of Munibung Hill overlooking the Cockle Creek valley. The former Pasmenco Cockle Creek Smelter (PCCS) site is situated to the west of the IFL site. The PCCS site is currently being remediated, and, based on the published Master Plan, is intended for a range of future uses including residential settlement.



— Incitec Pivot Limited Cockle Creek Site

**Figure 1: Incitec Pivot Cockle Creek Site**

A dam is situated adjacent the south eastern portion of the site, although the dam itself is located outside of the site boundary. The dam wall however is located within the site boundary and consists predominantly of clayey fill material. A dam spill way occurs through the IFL site via the “six foot drain” and subsequently discharges down slope of the IFL site to Cockle Creek.

The IFL site comprises numerous buildings for manufacture and storage of fertiliser, liquids and products as well as administrative, maintenance and despatch buildings. Manufacturing operations ceased in January 2009. Storage of product and distribution will continue until late 2009. The site buildings and former processing plant will be removed during the remediation works.

## **2.2 Site History**

The site is located immediately to the east of the former Pasmaenco zinc and lead smelter. The site was originally part of the Pasmaenco facility (formerly the Sulphide Corporation), with the superphosphate manufacturing process commencing around 1913 and utilising sulphuric acid created as a by-product from the treatment of the smelter off gases. The production of sulphuric acid was and is still commonly undertaken at smelter facilities and limits the discharge of sulphur compounds to the environment, producing a valuable chemical precursor for manufacturing processes. One use is the combination of sulphuric acid with phosphate rock to produce superphosphate.

The available title information indicates that the site was sold to a predecessor of IFL (Australian Fertilisers Limited) in 1969. Pasmaenco continued to provide sulphuric acid to IFL for the manufacturing of superphosphate until 2003 when the smelter operations were shutdown. Sulphuric acid is currently sourced from the IFL Kooragang Island facility and stored on site. The sulphuric acid was formerly piped to the site from the Pasmaenco smelter via a rising main. Periodic failures of the rising main were reported anecdotally until it was relined on the IFL site in the early 1990s. The main was located aboveground or within culverts on the site so the potential for large unnoticed leaks from this source was considered to be relatively low. The more historical use of sulphuric acid within the site is poorly documented and considerable uncertainty exists on its distribution at the site.

The natural westerly sloping topography of the site has been altered to allow the construction of the existing site facility and infrastructure. Based on the available information, this required excavation into the hillside on the eastern section of the site in the vicinity of two storage sheds (Storage Sheds 3 and 4) and filling of the site slope in a series of steps to the west, providing multiple level surfaces across the site for the establishment of buildings and other infrastructure.

The filling of the site has occurred through the use of natural materials resulting from the excavation works in the west and the use of predominantly slag waste materials from the operation of the early smelter on the adjacent Pasmaenco site. The slag used as fill is typically fine grained and black, and is visible at the surface in the northern part of the IFL site. Investigations indicate that the slag forms a component of the fill materials rather than occurring as discrete layers and suggests the materials were mixed prior to or at the time of placement. The majority of the filling is reported to have occurred prior to the mid 1950s, with additional minor filling occurring prior to 1966 and later around the depression and north-western section of the site.

Relatively minor amounts of slag were reported to the east of the main plant. Elevated concentrations of heavy metals, particularly lead and zinc, but occasionally arsenic, nickel and cadmium are present in the slag impacted fill materials. The thickness of fill at the site

is typically two to three metres, except for the western edges of the site and the former creek bed below the dam wall where the fill and reworked colluvial materials is reported to extend to over 10 m in thickness. The volume of impacted material was estimated to be in the order of 200,000 m<sup>3</sup>.

Natural materials and reworked surface materials removed more recently during the construction of the sulphuric acid storage and access road were used as filling in the north western part of the site. The filling of parts of the depression and the low lying ground to the east of the southern drain was reportedly undertaken and incorporated inert wastes such as old plant machinery from the IFL and from PCCS sites.

The freshwater dam wall was reportedly constructed of predominantly natural clayey materials that are apparent in the dam face and has been confirmed by the site investigations in the vicinity of the dam wall.

### **2.3 Proposed Site Remediation**

The following information sources have provided the basis for the air quality assessment:

- The Conceptual Remediation Action Plan (hereafter the "RAP") outlined for the Cockle Creek site remediation (Revision 6, dated 23 October 2008) issued by Soil & Groundwater Consulting;
- the revised Stage 2 Project Description received from Manidis Roberts on 3 November 2008; and
- construction scheduling meetings held with Golder and Manidis Roberts.

The RAP identifies and delineates the contamination extent in soil and groundwater, and proposes the most appropriate management approach at the site. This approach is given as the consolidation and containment of all the soil and other materials unsuitable for use within a residential setting in isolation within a lined containment cell located on the northern portion of the site (within the site boundaries). Targeted and short term groundwater remediation is proposed for the northern area, within the proposed containment cell area, to reduce the contaminant mass present in the groundwater system prior to the installation of the containment cell.

A staged approach to the remediation program is proposed in the RAP to expedite approval and commencement of remediation works in certain portions of the site that are not affected by operational constraints and to address urgent environmental control requirements to accommodate the early stages of the PCCS remediation program. The current proposed stages of remediation are as follows:

- Stage 1 - Establishment of initial groundwater hotspot remediation
- Stage 2 - Cell construction / Northern Area Soil remediation
- Stage 3 - Decommissioning / demolition and soil remediation of central portion
- Stage 4 - Remediation of the filled gully on the southern portion of the site

This assessment has been undertaken for Stage 2 to 4 of remediation. Stage 1 is part of a separate assessment and major project application.

It is noted that Stages 2 to 4 will not progress in sequence and that such stages will overlap in terms of their timeframes. This is taken into account in the air quality assessment.

## **2.4 Project Scope for Air Quality Assessment Purposes**

The scope of study of the air quality assessment includes three main components, namely:

- (i) Baseline environment characterisation, specifically the selection of pertinent air quality criteria to use in the assessment, identification of sensitive receptors, and the description of the prevailing meteorology and air quality based on available data.
- (ii) Air quality assessment of remediation stages, including the establishment of an emissions inventory, air dispersion modelling to predict resultant air pollution levels, and assessment of such on the basis of the air quality criteria selected.
- (iii) Recommendation of management measures to reduce atmospheric emission potentials and air quality monitoring to track ambient air pollutant concentrations during remediation.

Stage 1 of the remediation will involve groundwater recovery and treatment along the northwest site boundary and will not require significant site preparation or contaminated soil excavation. Stages 2 to 4 are the major stages of the remediation works, involving excavation, transport and placement of significant quantities of contaminated site soils into the proposed engineered containment cell in addition to building demolition and associated waste management. Detailed descriptions of currently proposed Stage 1 to 4 activities are given in the RAP.

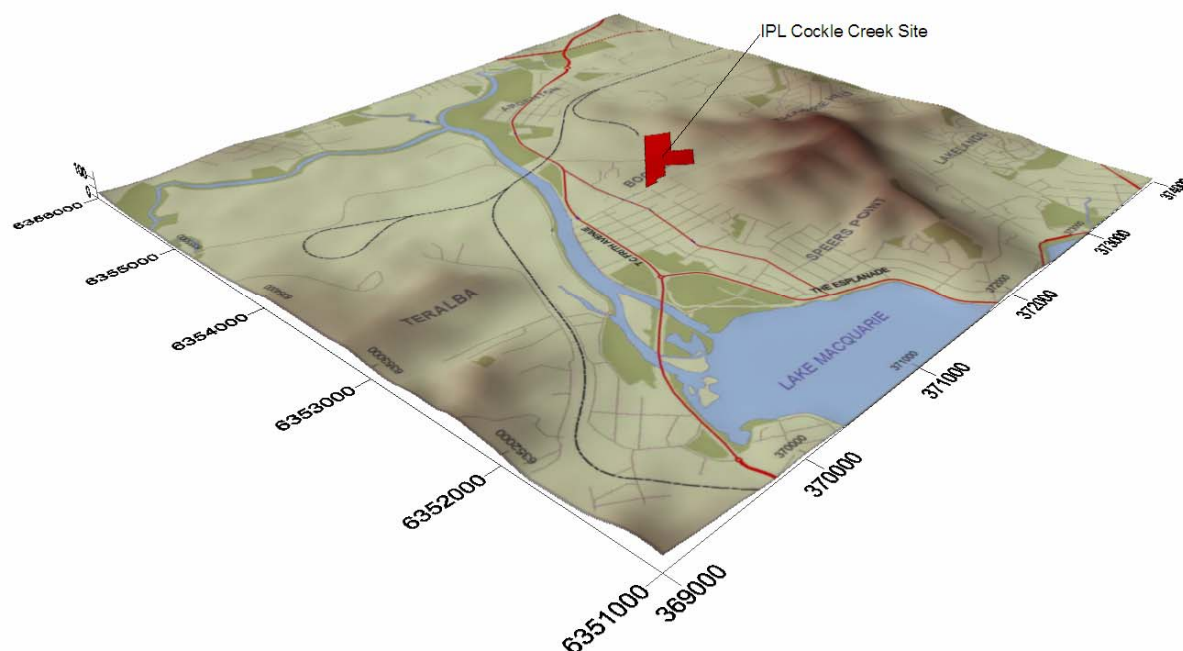
A stand-alone environmental assessment and associated Air Quality Assessment (ENVIRON document 823\_Cockle Creek Air\_V1 dated 25 July 2008, hereafter “the Stage 1 Air Assessment”) has been prepared previously for Stage 1. Therefore, no further assessment of this stage is provided within this document.

The present quantitative assessment of emissions and resultant ambient air pollutant levels therefore relates to activities anticipated under **Stage 2, Stage 3** and **Stage 4** of the project.

## **2.5 Topography**

The IFL site is located in a sloping section of Munibung Hill overlooking the Cockle Creek valley (**Figure 2**). Whilst the natural topography of the site is therefore consistent with a hill and valley type setting, the cut and fill techniques and the importation of fill material has left the site relatively flat to enable building development.

The peak of Munibung Hill occurs to the east of the site, with the topography steepening significantly to the east of the eastern site boundary. This area and the area to the west of the site are included in the adjacent former PCCS site.



**Figure 2: Topography of the IFL site study area**

The nearest surface water body is Cockle Creek, located approximately 580 m to the west of the south west corner of the site and approximately 780 m from the north west site corner. The main axis of the site is located at an angle to Cockle Creek with the site’s western boundary approximately falling on a northeast - southwest alignment. Cockle Creek discharges to Lake Macquarie, which lies approximately 1,600 m to the south of the site.

## 2.6 Nearest Residences

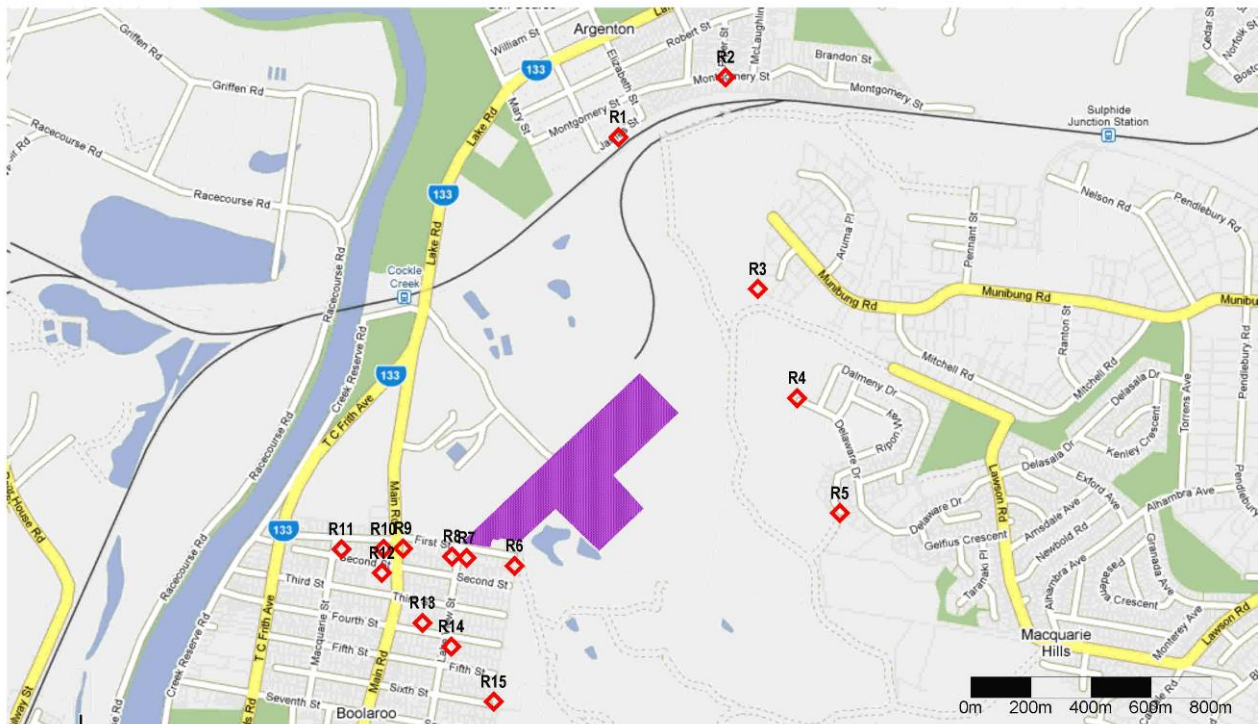
The residential area of Boolaroo is situated immediately south of the IFL site. Other residential areas in the vicinity include Argenton to the north and the suburb of Macquarie Hills to the east of Munibung Hill. The Cardiff Industrial Estate is situated to the northeast of the site and is characterised by large light industrial allotments.

Nearby potentially affected dwellings that are non-project related are presented in **Table 1** and illustrated in **Figure 3**. Receptor points R11 to R15 situated within Boolaroo were selected to coincide with PCCS long-term hi-volume particulate monitoring stations.

<b>Table 1 – Nearest potentially affected non-project related residential dwellings</b>			
<b>Residence # Identifier</b>	<b>Description</b>	<b>MGA Dwelling Coordinates</b>	
		<b>East (m)</b>	<b>North (m)</b>
R1	James St, Argenton	372,068	6,354,769
R2	Montgomery St, Argenton	372,425	6,354,968

Table 1 – Nearest potentially affected non-project related residential dwellings			
Residence # Identifier	Description	MGA Dwelling Coordinates	
		East (m)	North (m)
R3	Cardiff Industrial Estate	372068	6354769
R4	Delaware Dr, Macquarie Hills	372425	6354968
R5	Hillview Cr, Macquarie Hills	372532	6354264
R6	First St 1, Boolaroo	372663	6353901
R7	First St 2, Boolaroo	372805	6353518
R8	First St 3, Boolaroo	371722	6353343
R9	First St 4, Boolaroo	371562	6353369
R10	First St 5, Boolaroo	371514	6353374
R11	First St West, Boolaroo	371350	6353401
R12	Boolaroo School	371285	6353399
R13	Fourth St, Boolaroo	371145	6353398
R14	Lake View St, Boolaroo	371280	6353319
R15	Sixth St, Boolaroo	371415	6353153

# See Figure 3



**Figure 3: Non-project related residences in the vicinity of the IFL site study area**

### 3 Air Quality Goals

To be in compliance, proposed operations must demonstrate that cumulative air pollutant concentrations, taking into account incremental concentrations due to the operation's emissions and existing background concentrations, are within ambient air quality limits. Relevant ambient air quality criteria applicable to the proposed development are presented in Sections 3.1 to 3.3.

Although the DECC specifies impact assessment criteria for a range of toxins, such criteria are applicable exclusively for acute exposures to incremental concentrations due to the proposed development. To facilitate the evaluation of baseline air pollutant concentrations and chronic exposures reference may be made to inhalation toxicity thresholds published in health risk advisory databases such as the US-EPA Integrated Risk Information System (IRIS). Thresholds for non-carcinogenic compounds and cancer risk factors for carcinogens of interest in the current study are presented in Section 3.4.

#### 3.1 Air Quality Limits for Airborne Particulate Matter and Lead

The impact of particles on human health is largely dependent on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential for particles to be inhaled and deposited in the lung is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density. The deposition of particles in different regions of the respiratory system depends on their size.

The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. Larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. Smaller particles ( $PM_{10}$ ) pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane (Environment Canada, 1998; Dockery and Pope, 1993).

Air quality limits for particulates are typically given for various particle size fractions, including total suspended particulates (TSP), inhalable particulates or  $PM_{10}$  (i.e. particulates with an aerodynamic diameter of less than 10  $\mu m$ ), and respirable particulates or  $PM_{2.5}$  (i.e. particulate with an aerodynamic diameter of less than 2.5  $\mu m$ ). Although TSP is defined as all particulate with an aerodynamic diameter of less than 100  $\mu m$ , an effective upper limit of 30  $\mu m$  aerodynamic diameter is frequently assigned.  $PM_{10}$  and  $PM_{2.5}$  are of concern due to their health impact potential. Such fine particles are able to be deposited in, and cause damage to, the lower airways and gas-exchanging portions of the lung. Potential adverse health impacts associated with exposure to  $PM_{10}$  and  $PM_{2.5}$  include increased mortality from respiratory and cardiovascular diseases, chronic obstructive pulmonary disease, and heart disease and reduced lung capacity in asthmatic children.

Despite the international medical community not having been able to establish a threshold value for particulate matter below which there are no adverse health impacts, air quality limits are routinely issued for this pollutant, including by federal and state governments in Australia. Air quality limits issued by federal and NSW government for particulates are given in **Table 2**.

<b>Pollutant</b>	<b>Averaging Period</b>	<b>Concentration (µg/m<sup>3</sup>)</b>	<b>Reference</b>
TSP	annual	90	NSW DECC(a)(b)
PM <sub>10</sub>	24 hours	50	NSW DECC(a)
	24 hours	50(d)	NEPM(c)
	annual	30	NSW DECC(a)
PM <sub>2.5</sub>	24 hours	25	NEPM(e)
	Annual	8	NEPM(e)
Lead	Annual	0.5	NSW DECC(a)

- (a) DECC, 2005 *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*
- (b) DECC impact assessment goal based on the subsequently rescinded National Health and Medical Research Council (NHMRC) recommended goal.
- (c) NEPC, 2003, *National Environment Protection (Ambient Air Quality) Measure, as amended*.
- (d) Provision made for up to five exceedances of the limit per year.
- (e) Advisory reporting goal issued by the NEPC (NEPC, 2003).

Air quality goals for TSP were typically set prior to the development of an improved understanding of the relationship between health impacts and exposure to fine particulate concentrations, and have subsequently either been discarded or given reduced importance by countries internationally. The DECC TSP impact assessment goal is given as 90 µg/m<sup>3</sup> for an annual averaging period and is based on the goal recommended by the National Health and Medical Research Council (NHMRC) (DEC, 2005; NHMRC, 1996). (The NHMRC goals have subsequently been rescinded.)

The DECC's daily threshold for PM<sub>10</sub> was based on the National Environment Protection Measure (NEPM) reporting goal developed by the National Environmental Protection Council (NEPC) in 1998 for achievement within 10 years of commencement (NEPC, 2003). Although the threshold value of the DECC's 24-hour PM<sub>10</sub> reporting goal is equivalent to that of the NEPM reporting goal (i.e. 50 µg/m<sup>3</sup>), the NEPM reporting goal permits five exceedances per year whereas no provision is made for permissible frequencies within the DECC's impact assessment criteria. The impact assessment goal given by the DECC for annual PM<sub>10</sub> concentrations derives from the NSW Environmental Protection Agency (1998) publication *Action for Air: The NSW Government's 25-year Air Quality Management Plan*.

The DECC has not published an ambient air quality goal for PM<sub>2.5</sub>. Reference may however be made to the PM<sub>2.5</sub> advisory reporting standards and goals for issued by the NEPC (NEPC, 2003).

The DECC impact assessment criteria for lead is given in **Table 2**. Lead is a multi-targeted toxicant, causing a variety of effects at low dose levels. Brain damage, kidney damage, and gastrointestinal distress are seen from acute exposure to high levels of lead in humans. Chronic exposure to lead in humans results in effects on the blood, central nervous system, blood pressure, kidneys, and Vitamin D metabolism. Children are particularly sensitive to the chronic effects of lead, with slowed cognitive development, reduced growth and other effects reported. Whereas cognitive impacts of lead are not readily discernible on an individual basis, on a population basis, lead exposures have been noted to result in an IQ deficit in young children (<6 years of age) ranging from 2 to 4 points for each 10 µg/dL increment in blood lead levels (RAIS, 1997).

### 3.2 Dust Deposition Limits

Nuisance dust deposition is regulated through the stipulation of maximum permissible dust deposition rates. The DECC impact assessment goals for dust deposition are given in **Table 3** illustrating the allowable increment in dust deposition rates above ambient (background) dust deposition rates which would be acceptable so that dust nuisance could be avoided.

**Table 3 - Dust deposition goals published by the NSW DECC**

Pollutant	Maximum Increase in Dust Deposition	Maximum Total Dust Deposited Level
Deposited dust (assessed as insoluble solids)	2 g/m <sup>2</sup> /month	4 g/m <sup>2</sup> /month

Source: DEC, 2005 *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*.

### 3.3 DECC Impact Assessment Criteria for Toxic Air Pollutants

The DECC specifies impact assessment criteria for a range of principal and individual toxic air pollutants (DECC, 2005). A synopsis of the criteria relevant to metals of interest in the current study is given in **Table 4**.

The impact assessment criteria specified by the DECC (2005) for toxic air pollutants must be applied at and beyond the boundary of the facility, with the *incremental* impact (predicted impacts due to the pollutant source alone) for each pollutant reported for an averaging period of 1 hour.

**Table 4 – Impact assessment criteria for toxic air pollutants published by NSW DECC**

<b>Substance</b>	<b>Averaging Period</b>	<b>Impact Assessment Criteria (<math>\mu\text{g}/\text{m}^3</math>)</b>
Arsenic & compounds	1 hour	0.09
Cadmium & compounds	1 hour	0.018
Chromium III & compounds	1 hour	9.0
Chromium VI & compounds	1 hour	0.09
Copper dusts & mists	1 hour	18
Nickel & compounds	1 hour	0.18
Mercury inorganic	1 hour	1.8

Source: DEC, 2005 *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*.

## 4 Existing Air Quality Environment

The quantification of cumulative air pollution concentrations and the assessment of compliance with ambient air quality limits necessitate the characterisation of baseline air quality. Given that particulate matter and several heavy metals represent the primary emissions from the proposed remediation operations, it is pertinent that existing sources and ambient air pollutant concentrations of these pollutants be considered.

### 4.1 Existing Local Sources of Atmospheric Emissions

Industrial and mining activities operating within 5 km of the IFL Cockle Creek site which are listed as either National Pollutant Inventory (NPI) reporting activities or DECC licence holders are listed in **Table 5**.

**Table 5 – Industrial operations and mines situated within 5 km of the Project Site**

Facility Name	Distance from Site (Street Address)	Description
Pasminco Cockle Creek Smelter – remediation operations	Immediately west of site boundary	Previous lead smelter; site currently being remediated
West Wallsend Colliery	2.3 km WNW (End Railway St, Teralba)	Black coal mining
Macquarie Coal Preparation Plant	2.3 km WNW (End Railway St, Teralba)	Black coal handling
Inghams Cardiff Feedmill	2.1 km NW (48 Nelson Road Cardiff)	Prepared animal feed manufacturing
Works Infrastructure Teralba	3.8 km WSW (Rhondda Road, Teralba)	Asphalt operations
Boral Resources	1 km SW of site (65 Seventh St, Boolaroo)	Concrete batching

Due to the proximity and nature of the PCCS remediation operations, these operations hold the greatest potential for cumulative impacts. PCCS remediation operations and containment cell construction are scheduled to continue throughout 2009 and 2010, with completion by mid 2011 (based on information received from the Project Manager, Fitzwalter Group, 18 February 2009).

Stage 2 of the proposed IFL site remediation is only scheduled to start in January 2010. Thus the potential exists for overlap in the PCCS and IFL Cockle Creek remediation works. Stage 3 and Stage 4 operations are only likely to be initiated in 2012 and 2013 respectively when PCCS remediation operations are expected to have been completed.

Other potential sources of atmospheric emissions in the vicinity of the proposed project site include:

- Dust entrainment due to vehicle movements along unsealed roads and sealed roads with high silt loading levels;
- Vehicle exhaust and rail related emissions;
- Wind blown dust from open areas; and
- Episodic emissions from vegetation fires.

Fugitive dust from mining activities occurring further afield and long-range transport of fine particles and precursors are also expected to contribute to suspended particulate concentration in the study area.

#### 4.2 Monitoring Data Available for Baseline Air Quality Characterisation

Monitoring data sets which were made available and used in the characterisation of the existing air quality at the Project Site are given in **Table 6**. Permission was granted by the various data owners for the use of these data sets for the specific purpose of the assessment. The locations of the IFL and PCCS sampling stations are given in **Figure 4** and **Figure 5** respectively.

<b>Data Owner / Data Set</b>	<b>Sampling Sites</b>	<b>Parameters Measured</b>	<b>Monitoring Duration</b>
IFL HVAS	2 stations: 1 <sup>st</sup> Street Station  6 <sup>th</sup> Street Station	TSP and total phosphorus  Flouride (including total fluoride, acid soluble particulate fluoride, gaseous fluoride)	Oct 2004 – Jan 2009
IFL Dust Deposition	6 stations: DG1-DG6	Dust deposition	Jul 2006 – 5 <sup>th</sup> Jan 2009
PCCS HVAS	8 stations: Lake View; 4 <sup>th</sup> Street; Argenton; School; 1 <sup>st</sup> Str West; Boolaroo Bowling Club; 6 <sup>th</sup> Street	TSP, Pb, Cd, Cu, As, Se, Sb, Hg, Mn, Be, Tl, Cr, Ni concentrations	1994/6 – 2004/9
PCCS PM <sub>10</sub>	2 stations: South West Dam; Argenton	PM <sub>10</sub>	Oct 2007 Feb 2009
PCCS Dust Deposition	18 stations: 10 First St; 1 <sup>st</sup> St West; 4 <sup>th</sup> St; School; Argy Mon; Munibung North; Mine pump Station; Claypit East; Claypit North; Claypit West; CWE; DDA1; DDA2; EB1; INC1; INC2; EB2; EB3; Southwest Dam	Dust deposition, Lead deposition	Dustfall (Jan 1996/Aug 2007 – Feb 2008); Lead deposition (Oct 2005/Aug 2007 – Feb 2008)
DECC Wallsend	Wallsend Station (Australian Map Grid (AMG) coordinates* (km): 6359.4 northing, 375.5 easting and zone 56)	PM <sub>10</sub> , PM <sub>2.5</sub>	Oct – Dec 2007

HVAS – high volume air samplers

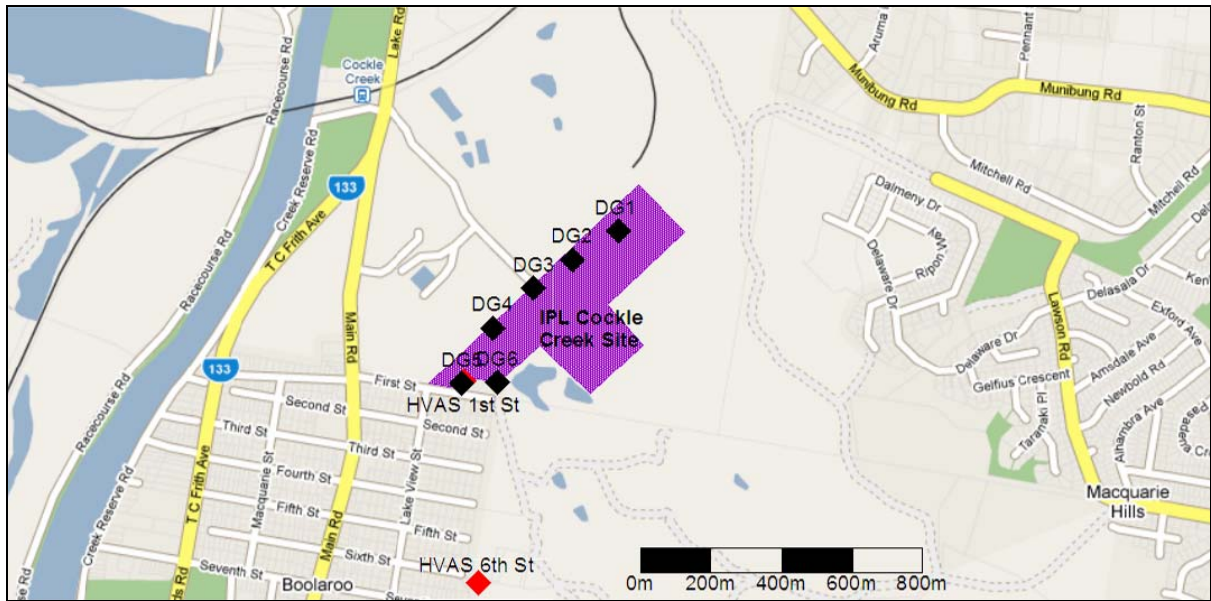


Figure 4: Locations of IFL monitoring stations

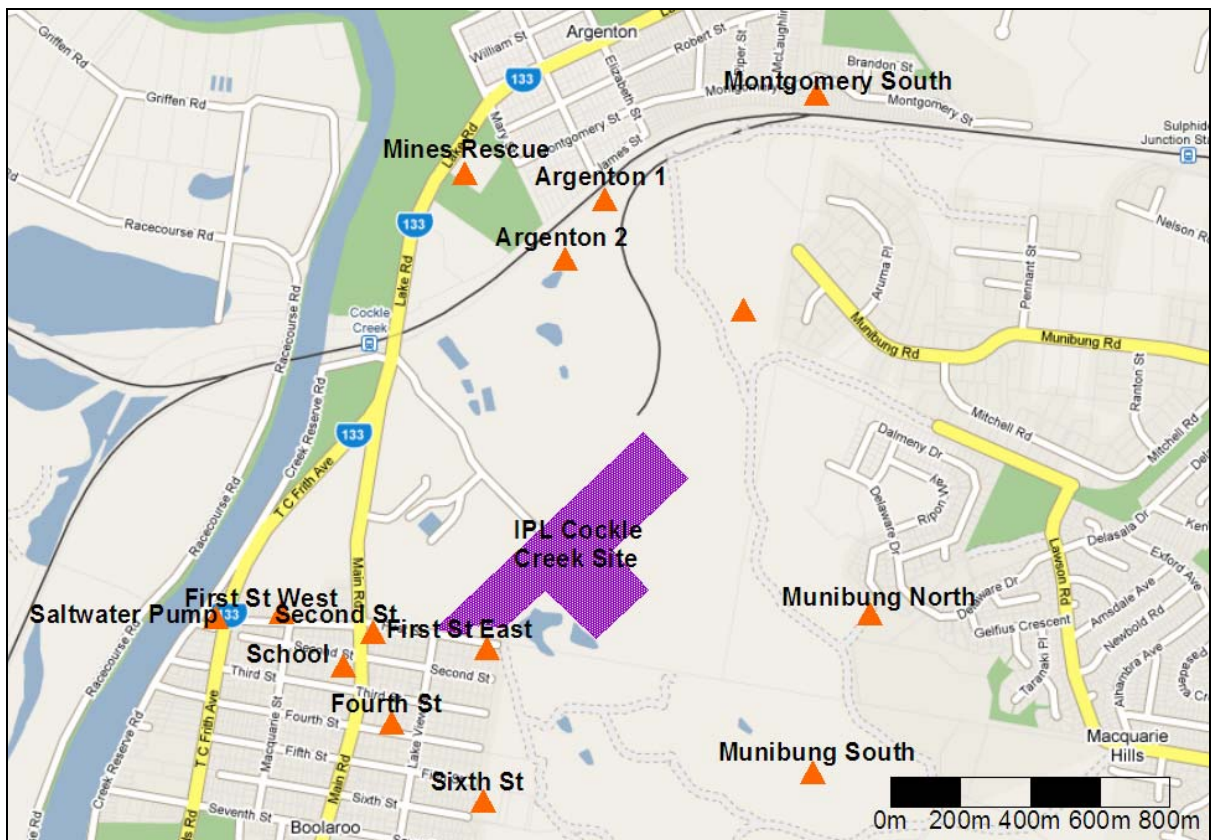


Figure 5: Locations of PCCS monitoring stations

Site-specific information from the IFL and PCCS stations were only used for the post 2003 period. Prior to this date air pollution concentrations were significantly higher due to the operations of the PCCS. The closure of the PCCS in September 2003 and implementation of additional dust mitigation measures resulted in significant reductions in particulate and heavy metal concentrations and deposition rates. Air pollution concentrations recorded during the 2007 and 2008 period are likely to have been influenced by the PCCS site remediation activities.

The IFL Cockle Creek facility which has contribute to ambient air pollutant concentrations including fine particulate, phosphate and fluoride concentrations and dust deposition was closed on 15 January 2009. To assess the potential reduction in background levels as a result of the closure of the plant reference, specific reference was made to air quality monitoring data for the post-closure period. The duration of such data was restricted due to the plant closure being recent, and generally confined to the latter half of January 2009 for TSP and dust deposition and up until 20 February 2009 for PM<sub>10</sub> data.

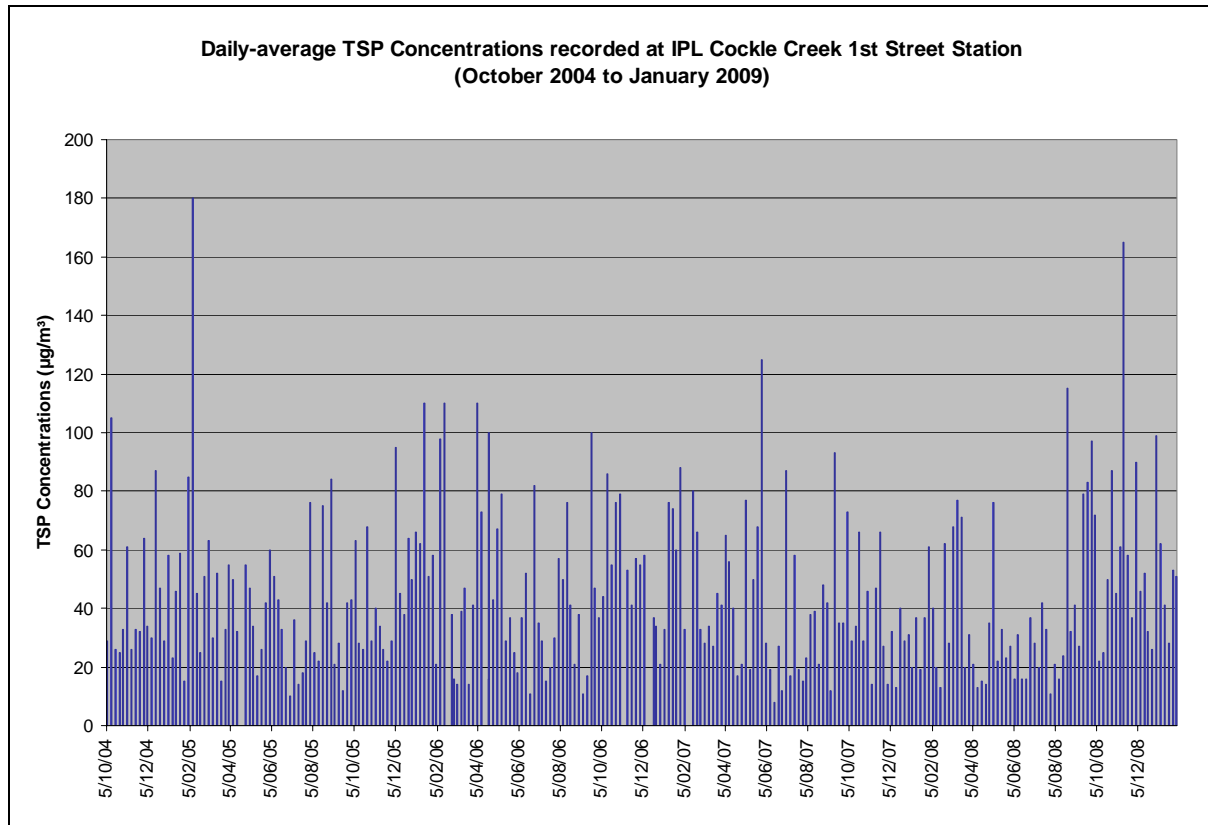
### 4.3 Ambient TSP Concentrations

A synopsis of highest daily and annual average TSP concentrations recorded at the IFL HVAS station and the PCCS HVAS stations are given **Table 7** and **Table 8** and depicted in **Figure 6**, **Figure 7** and **Figure 8**.

Despite PCCS remediation activities during 2007 and 2008, TSP concentrations recorded in the area were observed to be either similar to or lower than for previous years.

Maximum daily average TSP concentrations were recorded to be in the range of 70 µg/m<sup>3</sup> to 230 µg/m<sup>3</sup> and annual average TSP concentrations of the order of 30 µg/m<sup>3</sup> to 50 µg/m<sup>3</sup> across all PCCS and IFL monitoring stations over the period 2004 to 2007. No exceedances of the annual guideline value of 90 µg/m<sup>3</sup> were recorded at any of the stations during this period, with concentrations generally representing less than 50% of this limit during 2007.

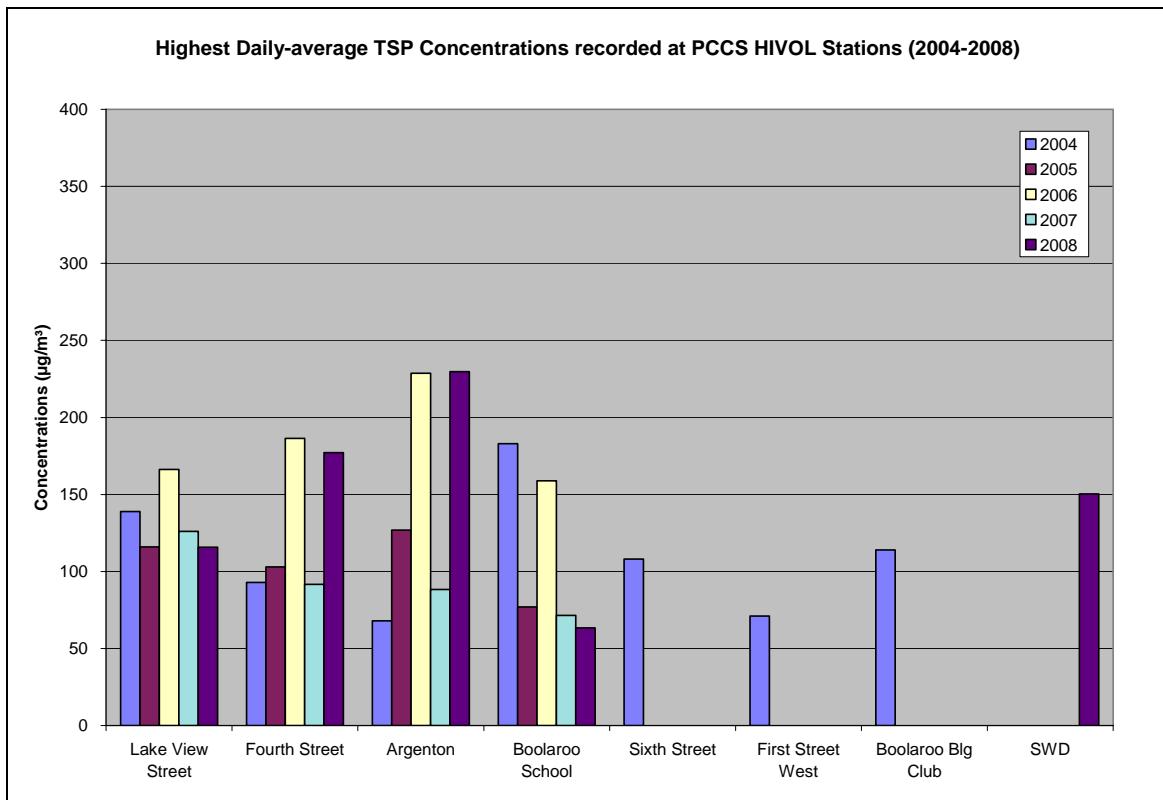
<b>Table 7 – Ambient TSP concentrations measured at IFL 1<sup>st</sup> Street HVAS Station</b>					
	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>
No. Data Days	15	60	59	60	61
Highest daily average concentration (µg/m <sup>3</sup> )	105	180	110	125	165
Annual average concentration (µg/m <sup>3</sup> )	44	43	49	42	43
Average as % of Annual Guideline of 90 µg/m <sup>3</sup>	49	48	54	47	48



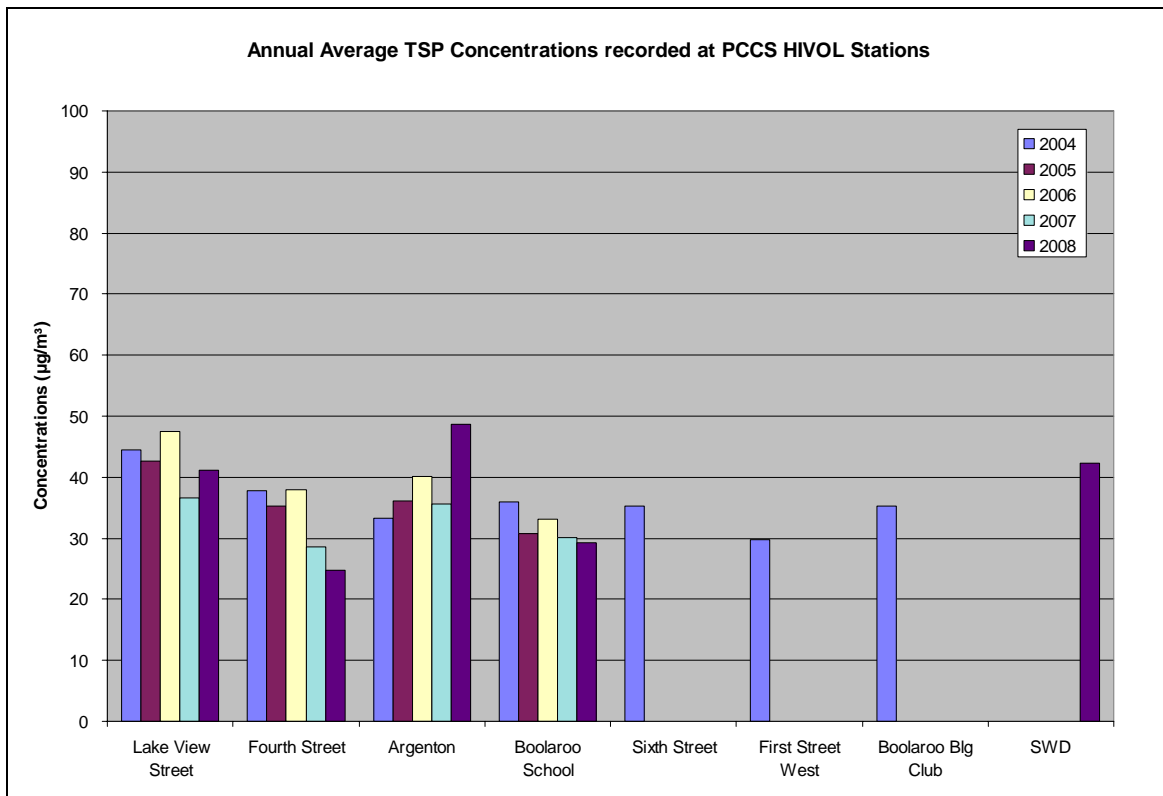
**Figure 6: TSP concentrations recorded at IFL Cockle Creek during Jan 2006 to Jan 2009**

**Table 8 – TSP concentrations measured at PCCS HVAS stations**

Station	Highest Daily Average TSP Concentrations (µg/m <sup>3</sup> )				
	2004	2005	2006	2007	2008
Lake View Street	139	116	166	126	116
Fourth Street	93	103	186	92	177
Argenton	68	127	229	88	230
Boolaroo School	183	77	159	71	63
Sixth Street	108				
First Street West	71				
Boolaroo Blg Club	114				
South West Dam (SWD)					150
	Annual Average TSP Concentrations (µg/m <sup>3</sup> )				
	2004	2005	2006	2007	2008
Lake View Street	44	43	47	37	41
Fourth Street	38	35	38	29	25
Argenton	33	36	40	36	49
Boolaroo School	36	31	33	30	29
Sixth Street	35				
First Street West	30				
Boolaroo Blg Club	35				
South West Dam (SWD)					42



**Figure 7: Highest daily-average TSP concentrations recorded at PCCS stations**



**Figure 8: Annual average TSP concentrations recorded at PCCS stations**

In assessing potential reductions in ambient air pollutant concentrations due to closure of the IFL Cockle Creek facility in January 2009, TSP concentrations recorded during January 2009 were compared with TSP concentrations recorded during January months of previous years (2004/5 to 2008).

A comparison of TSP concentrations recorded at the IFL 1<sup>st</sup> Street Station is given in **Table 9**, with TSP concentrations measured at PCCS HVAS Stations presented in **Table 10**.

**Table 9 – Comparison of January 2009 TSP concentrations measured at IFL 1<sup>st</sup> Street HVAS Station with concentrations measured during previous January months**

	January Months (2005 – 2008)	January 2009
Maximum daily ( $\mu\text{g}/\text{m}^3$ )	110	53
Median daily ( $\mu\text{g}/\text{m}^3$ )	58	46
Average daily ( $\mu\text{g}/\text{m}^3$ )	53	43

**Table 10 – Comparison of January 2009 TSP concentrations measured at PCCS HVAS Station with concentrations measured during previous January months**

Station	Average TSP Concentrations ( $\mu\text{g}/\text{m}^3$ )		Highest daily TSP Concentrations ( $\mu\text{g}/\text{m}^3$ )	
	January Months (2005 – 2008)	January 2009	January Months (2005 – 2008)	January 2009
Lake View Street	54	40	166	52
Fourth Street	44	40	186	71
Argenton	53	52	230	86
Boolaroo School	36	29	159	49
South West Dam	55	54	150	79

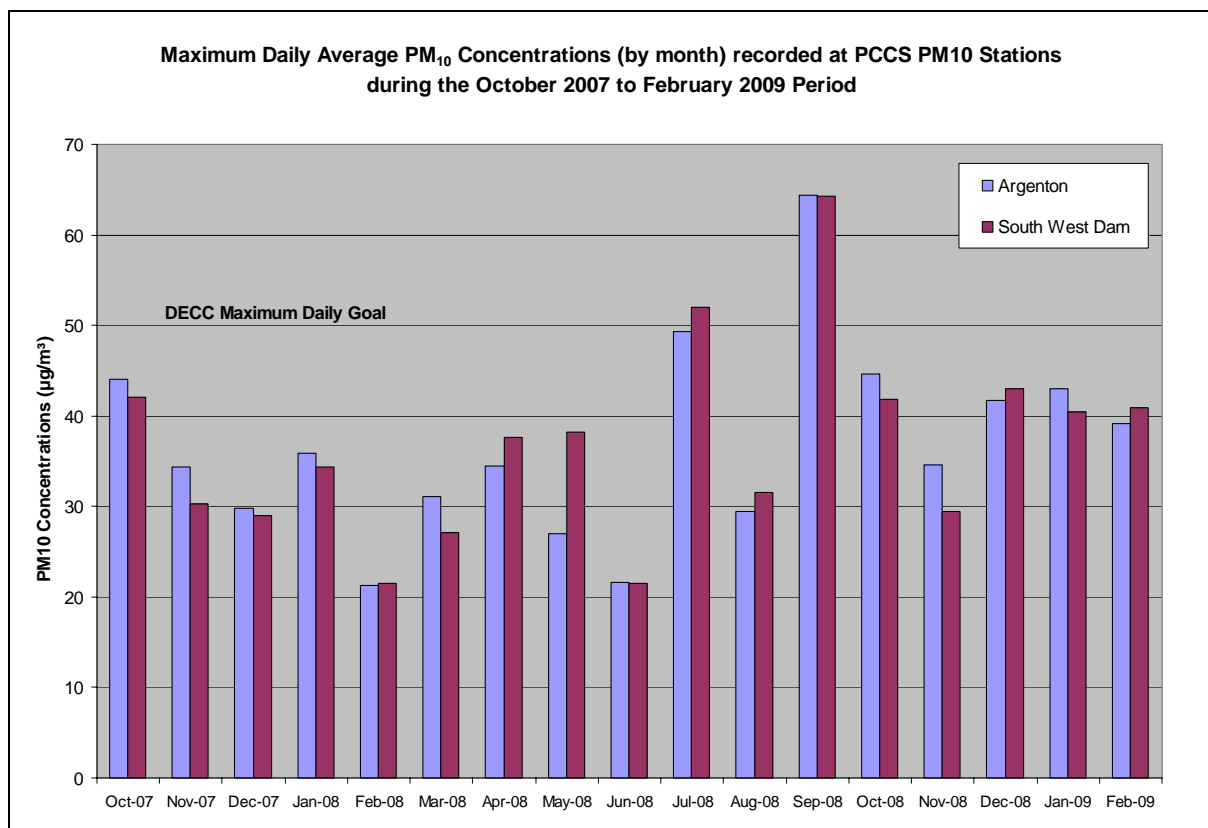
Stations situated closer to, and to the south of, the IFL Cockle Creek facility (ie. within Boolaroo), were noted to have recorded lower TSP concentrations during January 2009 when compared to average concentrations recorded during previous January months (2004/5 to 2008). On average TSP concentrations were in the range of  $5 \mu\text{g}/\text{m}^3$  to  $15 \mu\text{g}/\text{m}^3$  lower, potentially indicating a 10% to 25% reduction in TSP concentrations during the post-plant closure January period.

HVAS stations at Argenton and South West Dam (SWD), situated north of the IFL Cockle Creek facility and slightly further away, recorded average January 2009 concentrations of a similar magnitude to those recorded during January months during the 2004 to 2008 period. IFL Cockle Creek facility contributions to TSP concentrations at such sites were either lower than at other sites, or reductions in IFL Plant contributions have been offset by emissions from Pasmaenco remediation operations, which are situated closer to these sampling stations.

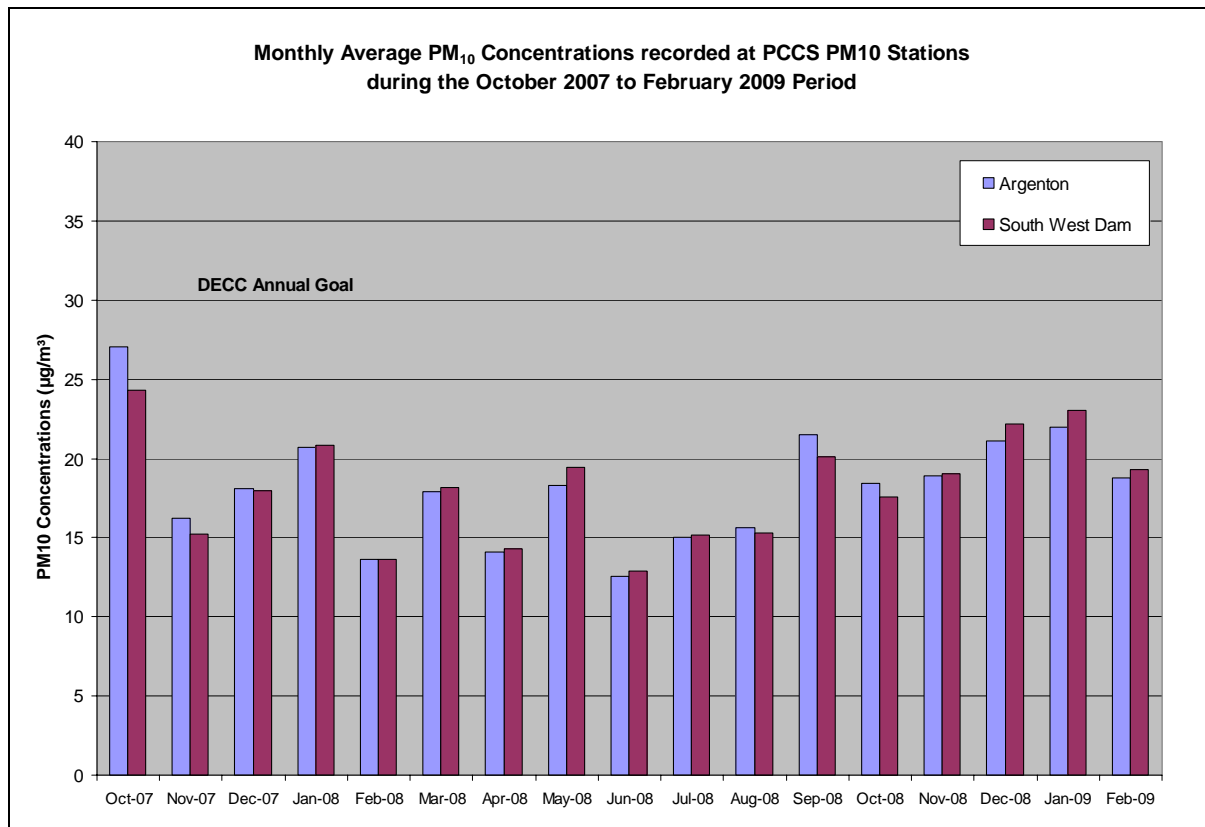
#### 4.4 Ambient PM<sub>10</sub> Concentrations

Site-specific PM<sub>10</sub> monitoring data were obtained for the October 2007 to February 2009 period for the PCCS SWD and Argenton Stations. The concentrations recorded at these stations compare closely (**Figure 9, Figure 10, Table 11**).

PM<sub>10</sub> concentrations were noted to exceed the DECC daily limit on one day at the Argenton Station and on two occasions at the SWD Station. Annual average PM<sub>10</sub> concentrations for 2008 represented less than 60% of the DECC annual limit.



**Figure 9: Maximum daily-average PM<sub>10</sub> concentrations for the PCCS South West Dam and Argenton Stations given by month for the period October 2007 to February 2009**



**Figure 10: Monthly average PM<sub>10</sub> concentrations for the PCCS South West Dam and Argenton Stations for the period October 2007 to February 2009**

**Table 11 – PM<sub>10</sub> concentrations measured at PCCS stations (2008)**

	<b>South West Dam</b>	<b>Argenton</b>
No. Data Days	365 (100% data availability)	356 (98% data availability)
Highest daily average concentration (µg/m <sup>3</sup> )	64	64
Annual average concentration (µg/m <sup>3</sup> )	17.5	17.6
Period (Oct to Dec 07) Average as % of Annual Guideline of 30 µg/m <sup>3</sup>	58%	59%

Note: PM<sub>10</sub> concentration measurements representing substantial outliers occurring immediately prior to or during instrument failures were omitted from the SWD Station dataset, following comparison of such data with coincident measurements recorded at the Argenton Station.

PM<sub>10</sub> concentrations measured at the Argenton and SWD stations during the January-February 2009 period were marginally higher than those recorded during the same period during 2008. This indicates that either that the IFL Cockle Creek facility had a negligible contribution to the PM<sub>10</sub> concentrations at these sites and/or that any reductions due to the

plant's closure in mid January 2009 were offset by increased contributions from other sources.

The site-specific PM<sub>10</sub> concentration data from the PCCS stations was found to compare well with the longer-term records from the DECC Wallsend Air Quality Station. The Wallsend Station is located approximately 7 km northeast of the IFL Cockle Creek Station.

A synopsis of the highest daily and annual average PM<sub>10</sub> concentrations recorded at Wallsend during the 2002 to 2006 period is given in **Table 12**, and illustrated in **Figure 11** for the July 2006 to June 2007 period. Exceedances of the daily maximum guideline value of 50 µg/m<sup>3</sup> occurred during three of the four years depicted, with such exceedances typically restricted to 1 to 2 days and usually associated with episodic events such as bushfires or dust storms.

<b>Year</b>	<b>Highest Daily Average (µg/m<sup>3</sup>)</b>	<b>Annual Average (µg/m<sup>3</sup>)</b>
2002	<b>157</b>	21.2
2003	<b>105</b>	17.7
2004	<b>53</b>	18.7
2005	46	18.7
2006	<b>51</b>	18.6

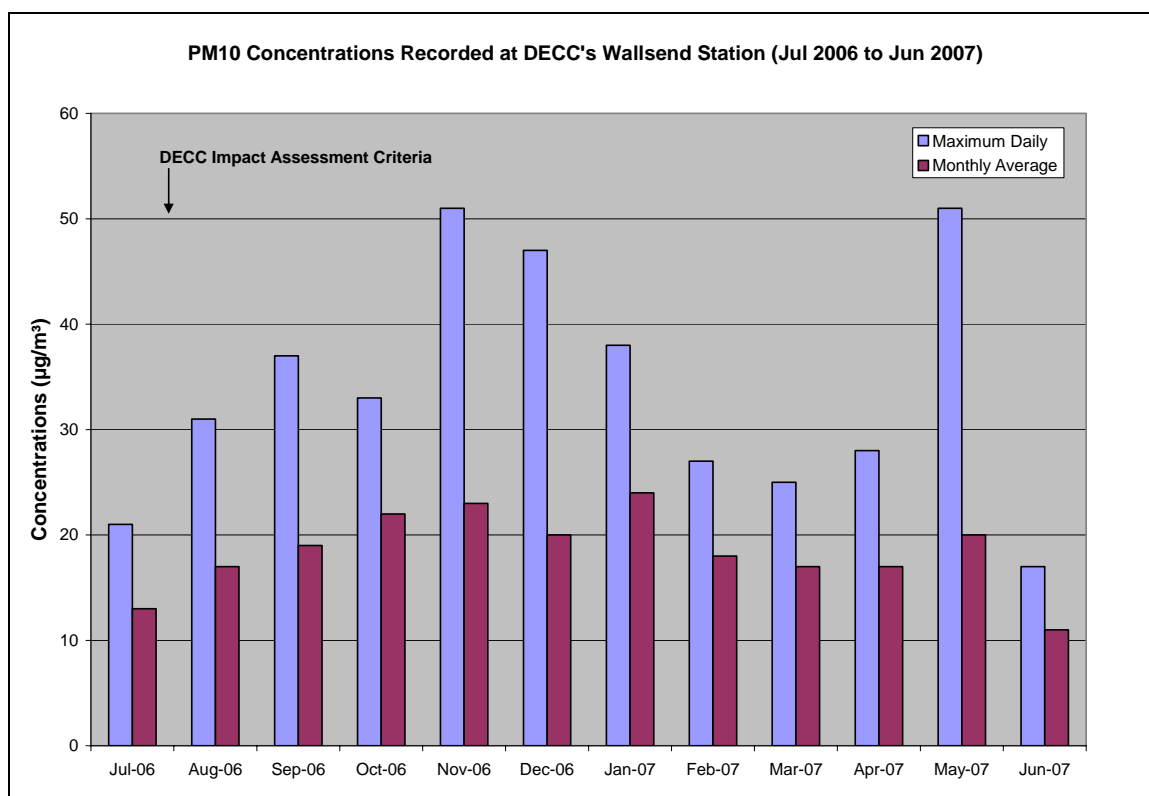


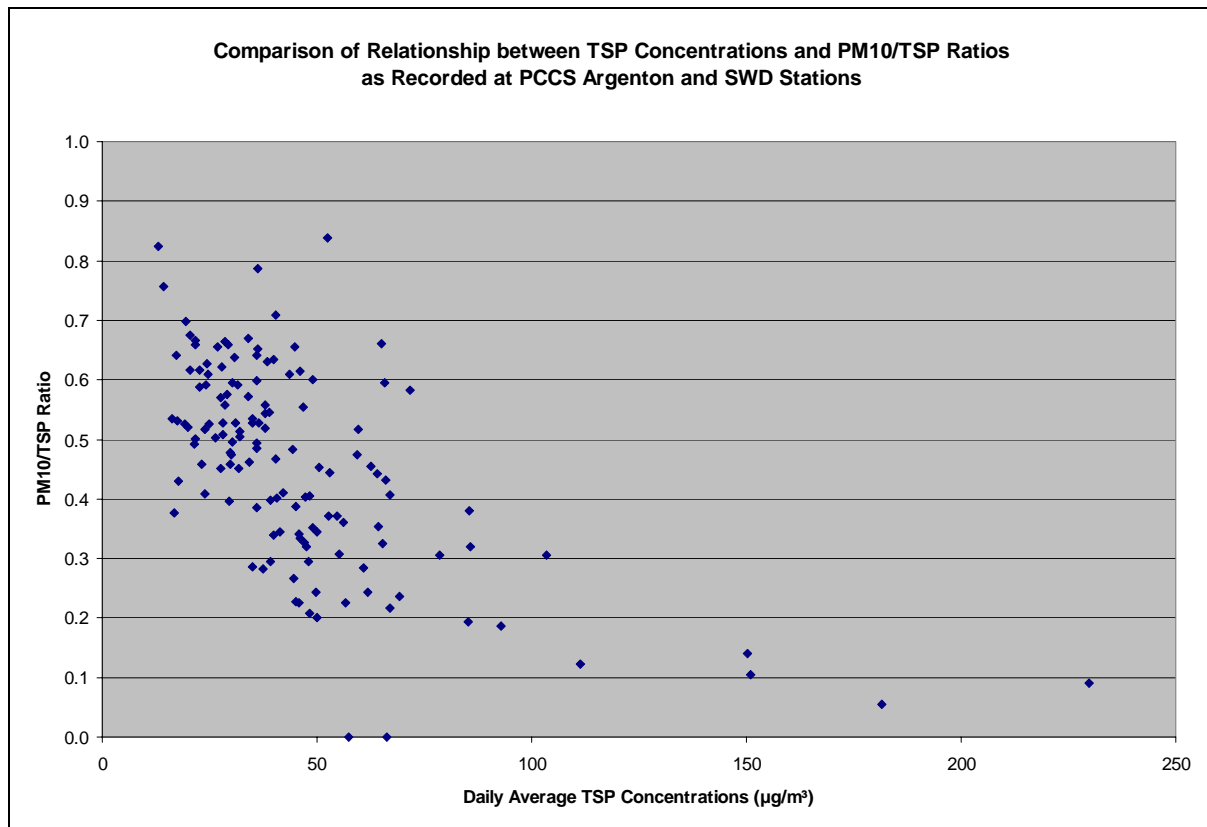
Figure 11: Ambient PM<sub>10</sub> concentrations recorded at DECC Wallsend Station

#### 4.5 PM<sub>10</sub> Concentrations as a Fraction of TSP Levels

The PM<sub>10</sub> component of TSP has been found to be typically in the range of 40% to 90%. Whereas the PM<sub>10</sub> fraction typically comprises 50% of TSP in areas not dominated by road traffic sources, the PM<sub>10</sub> fraction has been found to represent a more significant proportion of TSP (60% to 90%) in urban areas where traffic emissions are a significant source (US-EPA, 1996; CSIRO, 1999; Environment Canada, 1998).

Considering concentrations measured on coincident monitoring days at the PCCS Argenton and SWD TSP and PM<sub>10</sub> monitoring stations during the October 2007 to February 2009 period, PM<sub>10</sub> was noted to comprise, on average, 46% of TSP at the SWD Station and 56% at the Argenton Station. (Coincident TSP and PM<sub>10</sub> monitoring data was available for 79 data days on which to calculate ratios.)

It is important to note that peak TSP concentrations tended to coincide with lower PM<sub>10</sub> ratios, as is illustrated in **Figure 12**. Although the average PM<sub>10</sub>/TSP ratio is in the range of 0.46 to 0.56, it is notable that this ratio is typically less than 0.3 when daily average TSP concentrations exceed 100 µg/m<sup>3</sup>, and below 0.15 when TSP peaks above 150 µg/m<sup>3</sup>. This confirms that (larger sized) mechanically generated dust from fugitive sources are responsible for the peaks in TSP concentrations, with such peaks not coinciding with increments in PM<sub>10</sub> concentrations of the same order of magnitude.

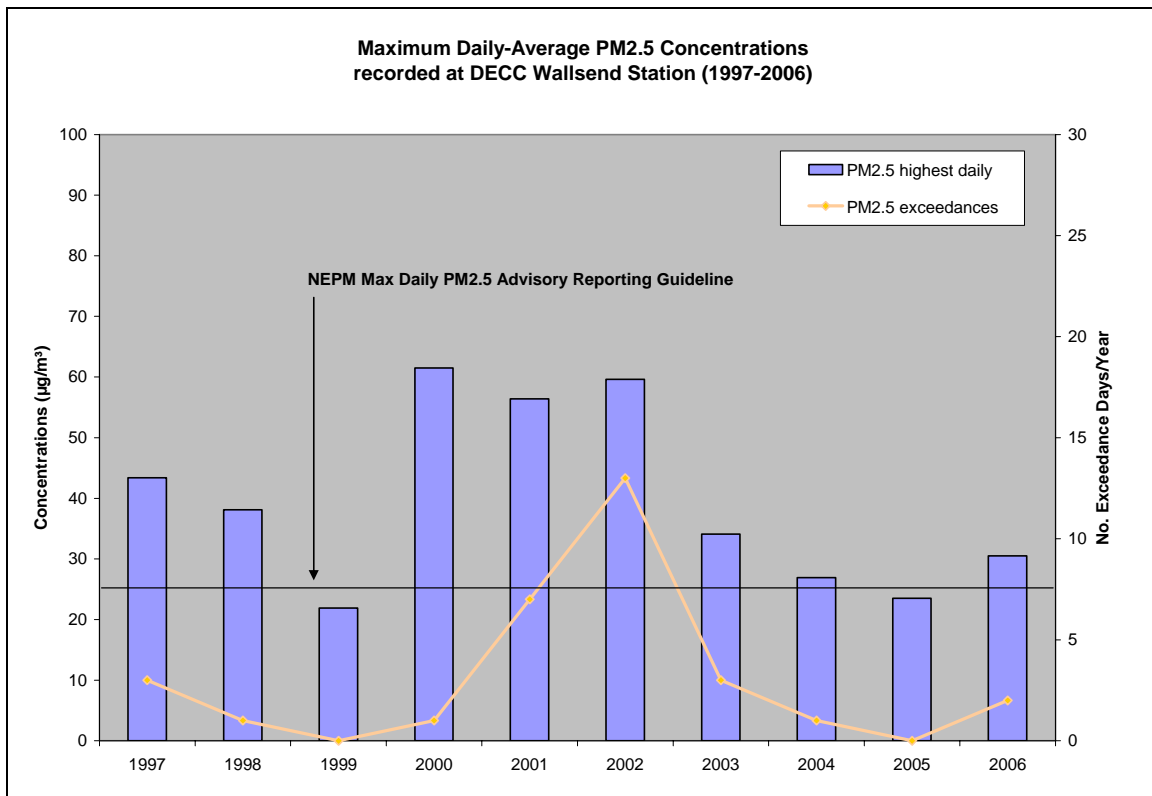


**Figure 12: Comparison of the relationship between TSP concentrations and PM<sub>10</sub>/TSP ratios as recorded at the PCCS Argenton and SWD Stations**

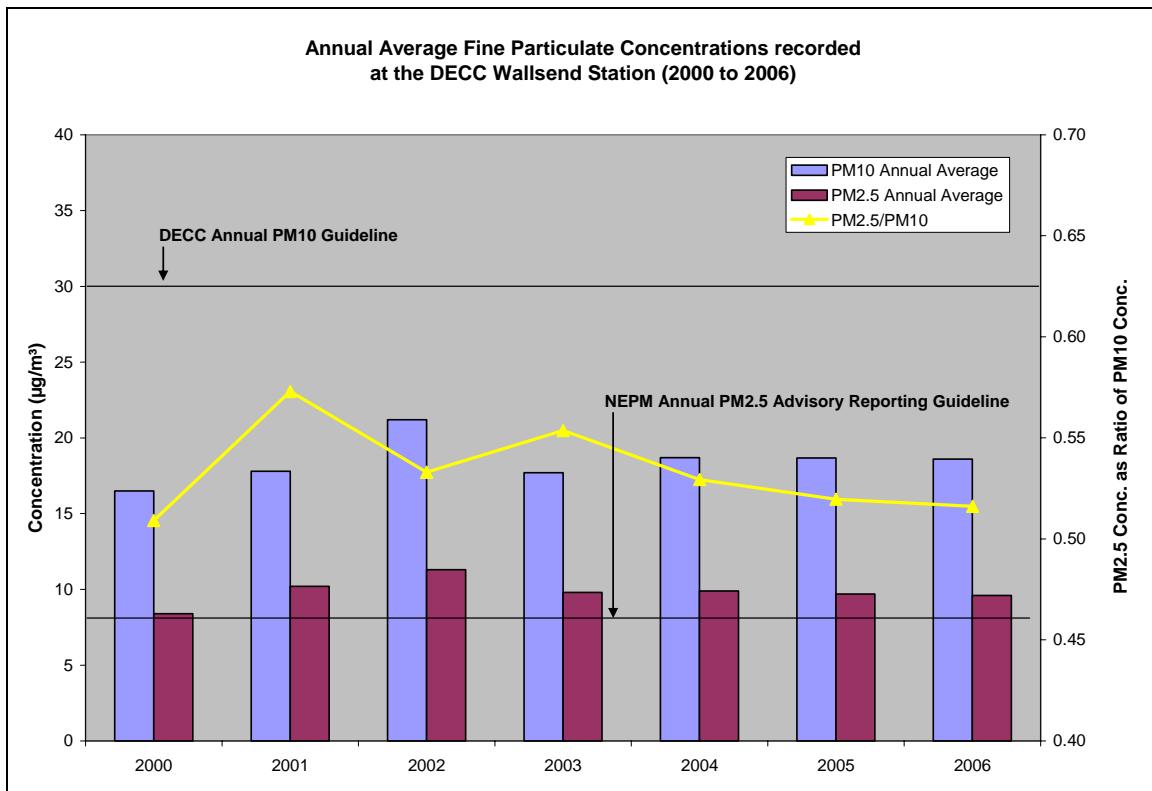
#### 4.6 Ambient PM<sub>2.5</sub> Concentrations

No site-specific PM<sub>2.5</sub> monitoring data were available with reference therefore being made to measurements from the DECC Wallsend Air Quality Station. Given that locally recorded PM<sub>10</sub> data compares well with equivalent data recorded at the Wallsend Air Quality Station, this is considered reasonable. Maximum daily and annual average PM<sub>2.5</sub> concentrations recorded at Wallsend are depicted in **Figure 13** and **Figure 14** respectively. Frequencies of exceedance of the NEPM daily guideline value of 25 µg/m<sup>3</sup> and average PM<sub>2.5</sub>/PM<sub>10</sub> ratios are also illustrated.

Annual PM<sub>2.5</sub> typically comprises of the order of 52% to 57% of PM<sub>10</sub> as measured at Wallsend. NEPM advisory reporting criteria stipulated for PM<sub>2.5</sub> is exceeded for both daily averages (0 to 13 days/year, up to 2 days per year during the post 2003 period) and annual averages (all years).



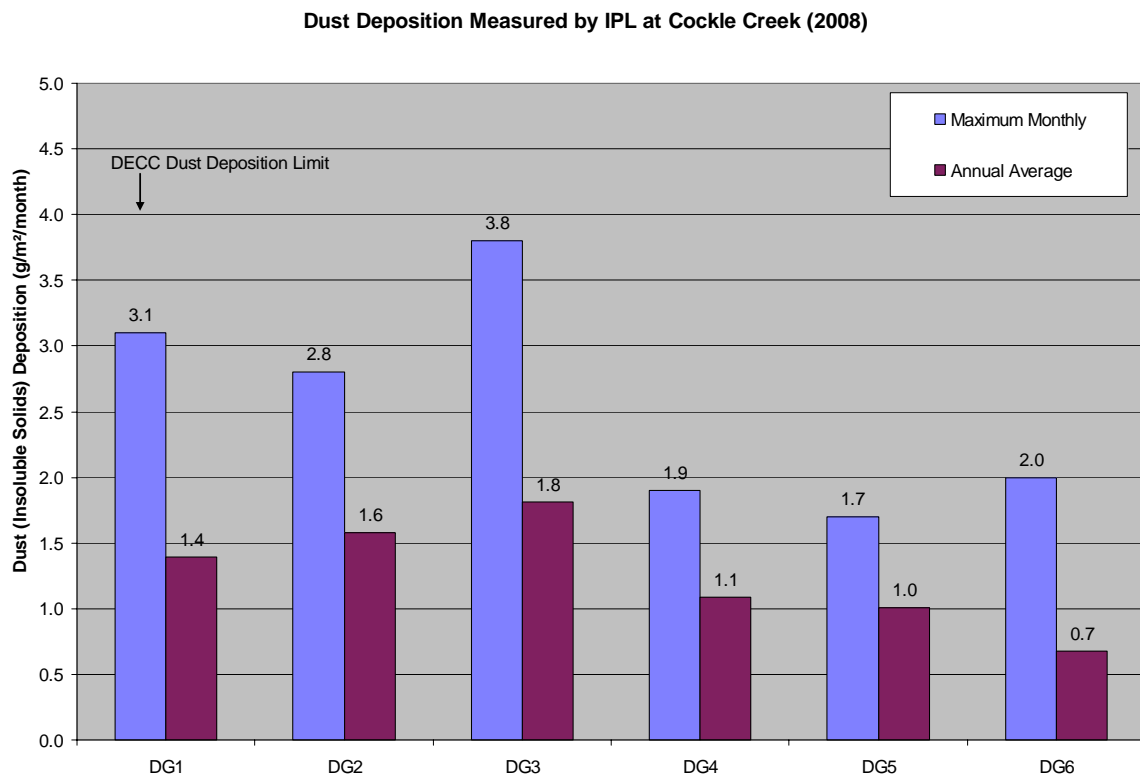
**Figure 13: Maximum daily-average PM<sub>2.5</sub> concentrations recorded at DECC Wallsend Station**



**Figure 14: Annual average PM<sub>10</sub> and PM<sub>2.5</sub> concentrations recorded at DECC Wallsend Station**

### 4.7 Dust Deposition

Dust deposition recorded at the IFL stations during the 2008 are illustrated in **Figure 15**. Annual average and maximum monthly dust deposition rates were measured to be within the DECC cumulative dust limit of 4 g/m<sup>2</sup>/month, with annual average dust deposition in the range of 0.7 to 1.8 g/m<sup>2</sup>/month.



**Figure 15: Dust deposition rates recorded at IFL stations (2008). Dust deposition given for 2007 for DG6 due to the unavailability of 2008 data for this station.**

Dust deposition rates recorded at PCCS stations located at sites nearer residential areas are given in **Table 13**. Although average dust deposition rates at these stations during 2007 were recorded to be within the cumulative dust deposition limit of 4 g/m<sup>2</sup>/month, deposition rates equivalent to or marginally above the limit did occur at the 4<sup>th</sup> Street, Mine Pump Station and School sampling sites. Significantly higher dust deposition rates were observed to occur within the PCCS site in close proximity to operations, e.g. peaks of 8.2 g/m<sup>2</sup>/month and average rates of 4.2 g/m<sup>2</sup>/month recorded at the Cardiff West Estate (CWE) station.

<b>Table 13 – Dust deposition measured at selected PCCS stations (2007)</b>		
<b>Year</b>	<b>Maximum Monthly (g/m<sup>2</sup>/month)</b>	<b>Annual Average (g/m<sup>2</sup>/month)</b>
10 First Street	2.7	1.2
1 <sup>st</sup> Street West	3.1	1.1
4 <sup>th</sup> Street	4.0	1.4
School	4.3	1.8
Argy Mon	2.2	0.9
Munibung North	2.4	1.1
Mine pump Station	4.0	1.5

#### 4.8 Ambient Metal Concentrations

The atmospheric migration of arsenic, cadmium and lead from point and diffuse sources from the PCCS premises to the suburbs of Boolaroo, Speer's Point and Argenton was noted in the EPA Remediation Order of 2003 issued to PCCS. Significant reductions in ambient air concentrations of heavy metals have been measured to occur at PCCS HVAS stations during the post-2003 period following closure of the smelter and actions taken in respect of the remediation order.

The focus of this assessment is to understand residual airborne concentrations which may result in cumulative risks in terms of inhalation exposures, with reference therefore being made to ambient air quality measurements for the 2004 to 2007 period.

Ambient heavy metals were recorded at PCCS HVAS stations and are therefore representative of all suspended size fractions rather than just the inhalable fraction. To facilitate comparisons with health-related thresholds, measured concentrations were multiplied by the average PM<sub>10</sub>/TSP ratio of 0.56 recorded in the area. The assumption being made is that this ratio would be representative for all metals (ref. Section 4.5). Heavy metal concentrations monitored for health assessment purposes are typically sampled in the PM<sub>10</sub> fraction both locally and abroad (DECC, 2003).

Projected ambient heavy metal concentrations in the <10 µm range for the 2004 to 2007 period are summarised in **Table 14** with exceedances of inhalation health risk criteria for toxic air pollutants flagged.

**Table 14 – Synopsis of heavy metal concentrations for the period 2004 to 2007**

Station	Averaging Period	Ambient Concentrations (µg/m <sup>3</sup> ) Estimated based on Measured Total Particulate Concentrations and Assumed PM <sub>10</sub> fraction of 0.56						Flags	
		Year	Pb	Zn	Cd	Cu	As		Hg
		Lake View Street	Average	2004	0.042	0.061	0.000		0.007
		2005	0.114	0.157	0.003	0.390	0.010	0.014	
		2006	0.110	0.117	0.004		0.004	0.002	
		2007	0.024	0.032	0.001		0.003	0.000	
	Maximum Daily	2004	0.263	0.325	0.006	0.042	0.064		
		2005	1.027	1.354	0.034	2.056	0.139	0.555	
		2006	1.259	1.326	0.061		0.009	0.019	
		2007	0.187	0.215	0.007		0.010	0.003	
Fourth St	Average	2004	0.017	0.032	0.000	0.008	0.024		
		2005	0.025	0.047	0.001	0.029	0.006	0.004	
		2006	0.055	0.064	0.003		0.004	0.001	
		2007	0.013	0.021	0.001		0.003	0.000	
	Maximum Daily	2004	0.118	0.213	0.006	0.045	<b>0.478</b>		
		2005	0.226	0.413	0.015	0.103	0.024	0.200	
		2006	0.449	0.487	0.067		0.024	0.012	
		2007	0.096	0.113	0.002		0.005	0.000	
BBC	Average	2004	0.012	0.023	0.000	0.039	<b>0.035</b>		
	Maximum Daily	2004	0.067	0.095	0.000	1.982	<b>1.150</b>		
First St West	Average	2004	0.016	0.036	0.000	0.009	0.017		
	Maximum Daily	2004	0.129	0.823	0.006	0.118	0.022		
Sixth St	Average	2004	0.011	0.021	0.000	0.035	0.024		
	Maximum Daily	2004	0.095	0.084	0.000	1.817	<b>0.417</b>		
BBC	Average	2004	0.015	0.025	0.000	0.007	0.017		
		2005	0.027	0.056	0.001	0.012	0.006	0.002	
		2006	0.042	0.055	0.002		0.003	0.001	
		2007	0.015	0.027	0.001		0.004	0.000	
	Maximum Daily	2004	0.084	0.101	0.000	0.096	0.049		
		2005	0.279	0.440	0.008	0.029	0.017	0.047	
		2006	0.372	0.385	0.036		0.012	0.004	
		2007	0.078	0.219	0.007		0.037	0.008	
Argenton	Average	2004	0.028	0.039	0.000	0.009	0.017		
		2005	0.039	0.060	0.001	0.022	0.006	0.001	
		2006	0.052	0.065	0.003		0.003	0.001	
		2007	0.058	0.082	0.002		0.004	0.000	
	Maximum Daily	2004	0.246	0.230	0.011	0.050	0.021		
		2005	0.239	0.482	0.007	0.073	0.019	0.005	
		2006	0.262	0.353	0.101		0.004	0.075	
		2007	0.465	0.632	0.015		0.019	0.001	

Flags:

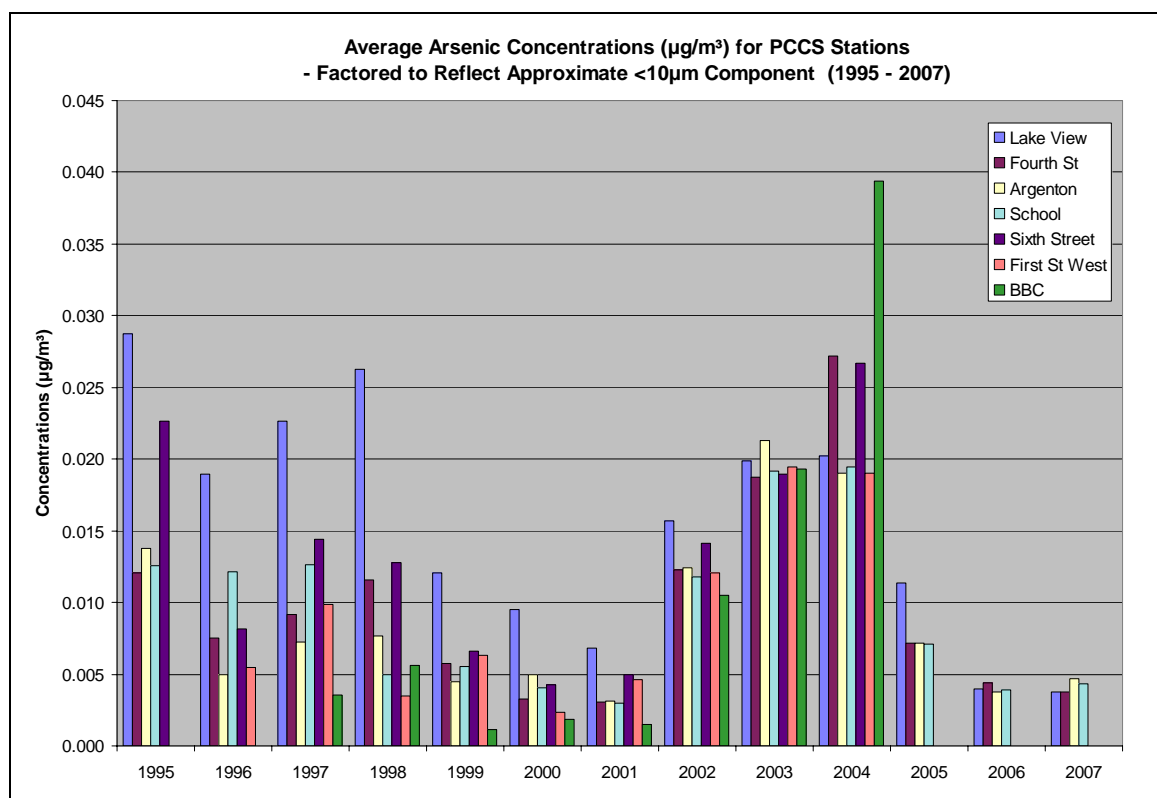
(a) Exceeds inhalation health risk criteria for toxic air pollutants.

Exceedances of inhalation health risk criteria for arsenic were estimated to occur at the Fourth Street, Boolaroo Bowling Club (BBC) and Sixth Street stations during 2004/5.

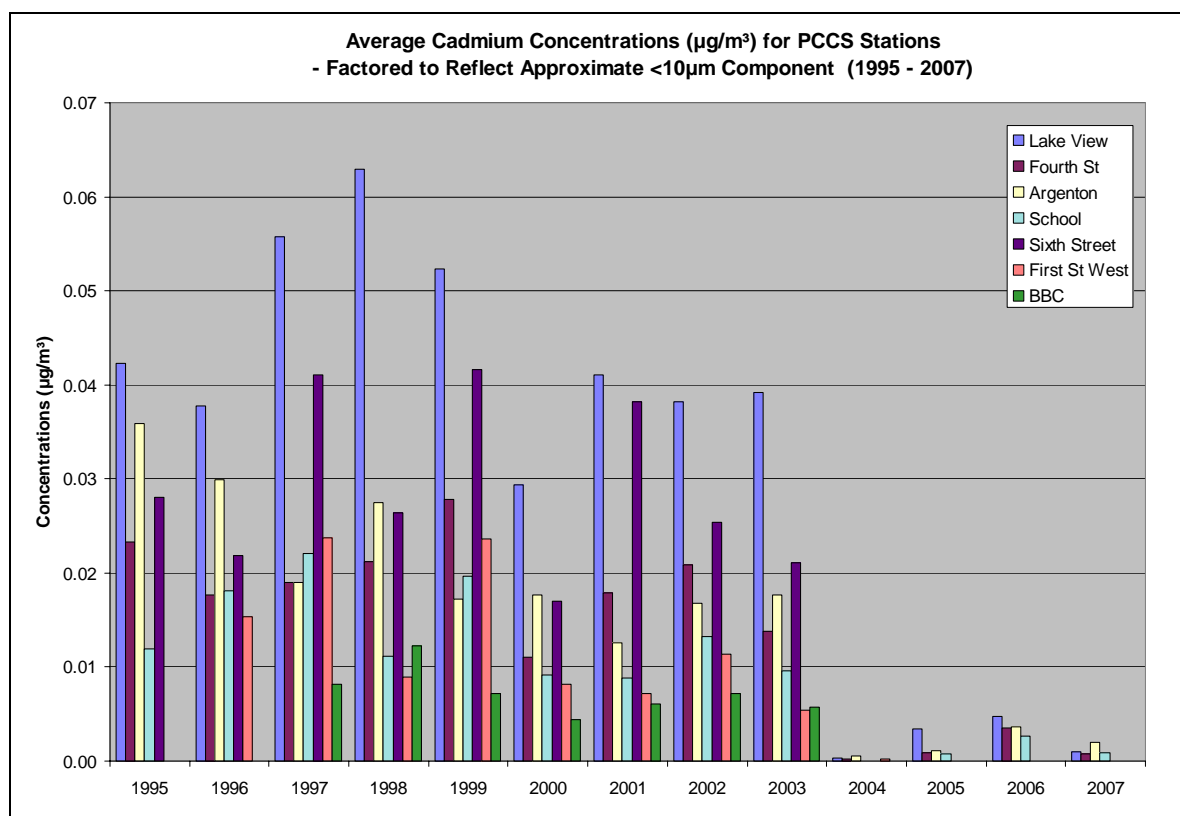
Following a peak in arsenic concentrations in 2004, significantly lower concentrations were recorded in subsequent years for stations with continued monitoring, including the Fourth Street station (**Figure 16**). It is anticipated that such reductions would also have occurred at the BBC and Sixth Street stations. No post-2005 arsenic monitoring data are however available for these stations to confirm this deduction.

Annual trends in airborne cadmium concentrations differ from arsenic in that the lowest concentrations were recorded in 2004 during the entire period of monitoring (**Figure 17**). Despite being significantly below pre-2004 years, cadmium concentrations recorded in 2006 were slightly above those measured for 2004, 2005 and 2007. The reason for this is unclear.

Cadmium and arsenic levels measured at Cockle Creek were noted to be significantly higher than the ranges measured by the NSW EPA in its screening survey of ambient metal concentrations in the Sydney, lower Hunter and Illawarra regions (NSW DEC, 2003).



**Figure 16: Average annual arsenic concentrations for PCCS HVAS Stations (factored to reflect <10µm fraction) for 1995 to 2007 period**



**Figure 17: Average annual cadmium concentrations for PCCS HVAS Stations (factored to reflect <10µm fraction) for 1995 to 2007 period**

Nickel and chromium levels, which are of interest in the current assessment, have not been measured in the 2004 to 2007 period with earlier monitoring of these substances having been discontinued. Reference was however made to measurements made at several of the monitoring stations for the period 1995 to 2003, with nickel and chromium levels recorded being noted to represent <10% of health screening thresholds.

*The current study focuses on residual airborne metal concentrations which could result in cumulative inhalation exposures as mentioned previously. It is noted that certain metals are bioaccumulative in humans and the environment and therefore that historical emissions may cause an ongoing risk despite recent reductions in emission and airborne concentrations. The assessment of multi-pathway risks due to historical and current metal concentrations present in various media is not within the scope of the assessment.*

#### 4.9 Background Air Quality Environment for Assessment Purposes

For the purposes of assessing the potential air quality impacts of the project, an estimate of background air quality parameters is required. For each pollutant and averaging period, the concentration range expected to be characteristic of baseline conditions was determined based on the monitoring data analysed as discussed in previous sections. Background suspended particulate and heavy metal concentrations are given in **Table 15** and **Table 16** respectively.

In the characterisation of ambient TSP and PM<sub>10</sub> concentrations reference was made to measurements made during the 2004 to 2009 period (as available). Based on the most recent TSP measurements made at stations in the immediate vicinity of the IFL Cockle Creek facility it is conceivable that the recent (mid January 2009) closure of this plant could have reduced airborne particulate concentrations. An insufficient period of TSP data are available, and PM<sub>10</sub> levels not recorded in this area, making it impossible to accurately conclude whether current TSP and PM<sub>10</sub> levels are lower than those recorded historically. The characterisation of baseline airborne particulate within Boolaroo based on historical data is however considered to be a conservative estimate of current background levels.

**Table 15 – Background particulate concentrations for cumulative assessment purposes**

<b>Averaging Period</b>	<b>Ambient TSP Concentrations</b>	<b>Ambient PM<sub>10</sub> Concentrations</b>	<b>Ambient PM<sub>2.5</sub> Concentrations</b>
Highest Daily Average	60 – 230 µg/m <sup>3</sup> (a)	45 - 65 µg/m <sup>3</sup>	25 – 30 µg/m <sup>3</sup>
Exceedances of Daily Limit	N/A	0 – 2 days/year	0 – 2 days/year
Annual Average	25 – 50 µg/m <sup>3</sup>	18-19 µg/m <sup>3</sup>	10 µg/m <sup>3</sup>
Exceedances of Annual Limit	None	None	All years exceed
Fraction of TSP	N/A	PM <sub>10</sub> on average 46% to 56% of TSP (based on site specific monitoring); with PM <sub>10</sub> comprising <30% for TSp concentrations above 100 µg/m <sup>3</sup> and <15% for TSP levels above 150 µg/m <sup>3</sup> .	PM <sub>2.5</sub> comprises 52% to 57% of PM <sub>10</sub> (thus estimated to comprise 33% to 36% of TSP)
Basis	Site-specific TSP monitoring data from IFL station and PCCS stations (7) for period 2004 to 2009	Site-specific PM <sub>10</sub> monitoring data for 2 PCCS stations (Oct 2007 to February 2009) and the DECC Wallsend Station (2002 – 2007)	No site-specific monitoring data. Reference made to DECC Wallsend Station PM <sub>2.5</sub> monitoring (2000 – 2006)

(a) Based on the assessment of TSP concentrations measured during periods prior to and following closure of the IFL Cockle Creek facility in mid January 2009, 10% to 25% lower TSP levels were observed at monitoring stations situated in close proximity and to the south of the plant. The length of the period available for analysis is insufficient to demonstrate the reduction conclusively and PM<sub>10</sub> monitoring is not undertaken at these sites, but it is conceivable that closure of the IFL Plant will have reduced airborne particulate concentrations in this area. Current TSP and PM<sub>10</sub> concentrations may therefore be lower than have been characterised based on historical air quality monitoring information.

In characterising background concentrations of metals and metalloids, reference was primarily made to measurements made during the 2006 to 2007 period. Where no 2006-7 monitoring data were available reference was made to the most recent data available; this being 2003 data in the case of nickel and chromium and 2005 data in the case of copper.

**Table 16 – Background heavy metal concentrations for cumulative assessment purposes**

<b>Substance</b>	<b>Maximum 24-hour Concentrations (µg/m³)</b>	<b>Range of Average Concentrations (µg/m³)</b>	<b>Basis</b>
Lead	1.26	0.013 – 0.110	Monitoring at PCCS HVAS stations for period 2006 - 2007
Zinc	1.33	0.021 – 0.117	
Cadmium	0.10	0.001 – 0.004	
Arsenic	0.04	0.003 – 0.004	
Mercury	0.07	0.0001 – 0.002	
Copper	2.06	0.012- 0.390	Monitoring across PCCS HVAS stations for 2005
Nickel	0.011	0.0018 – 0.0023	Monitoring across PCCS HVAS stations for 2003
Chromium	0.013	0.0017 – 0.0022	

Average annual baseline dust deposition rates were observed to be in the range of 0.7 g/m²/month to 1.8 g/m²/month across off-site IFL and PCCS monitoring sites.

## 5 Climate and Dispersion Meteorology

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading. Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, concurrent variations in the mixing depth, and shifts in the wind field (Oke, 2003; Sturman and Tapper, 2006).

Spatial variations, and diurnal and seasonal changes in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales. Atmospheric processes at macro- and meso-scales need therefore be taken into account to accurately parameterise the atmospheric dispersion potential of a particular area.

A qualitative description of the synoptic systems determining the macro-ventilation potential of the region is provided in **Section 5.1** based on a review of pertinent literature. An overview of the meso-scale meteorology of the study region is presented in **Section 5.2**. Climate statistics obtained from the Bureau of Meteorology's long-term weather station at Newcastle Nobbys Signal Station (Station number 061055), and hourly meteorological data obtained from the PCCS automatic weather station were used to characterise the climate and dispersion meteorology of the study area. The PCCS weather data was made available for use in the study in the form of the following three data sets:

- Annual 1995 data set formatted as an ISCST3 dispersion model meteorological input file, comprising hourly wind speed, wind direction, ambient temperature, stability class and mixing height. This data set was compiled by Holmes Air Sciences (2006) and used as the basis for the dispersion simulations undertaken for the air quality assessment for the remediation works at PCCS. (Annual data availability of 91%.)
- October 2007 to June 2008 data set, comprising 15 minute wind speed, wind direction, ambient temperature, sigma theta (measure of wind direction fluctuation), rainfall, relative humidity and solar radiation data. (Data availability of 62%.)
- June 2008 to November 2008 data set, comprising hourly wind speed and wind direction observations (Data availability of 99%).

### 5.1 Climate Statistics

Climate statistics from the Bureau of Meteorology's Newcastle Nobbys Signal Station (Station number 061055) for the period 1862 to 2008 are presented in **Table 17**.

<b>Table 17 – Climate statistics for study area (based on Newcastle Nobbys Signal Station, 32.92°S and 151.80°E, 33 m agl)</b>													
<b>Statistic Element</b>	<b>Jan</b>	<b>Feb</b>	<b>Mar</b>	<b>Apr</b>	<b>May</b>	<b>Jun</b>	<b>Jul</b>	<b>Aug</b>	<b>Sep</b>	<b>Oct</b>	<b>Nov</b>	<b>Dec</b>	<b>Annual</b>
Mean maximum temperature (Degrees C)	25.5	25.4	24.7	22.8	20	17.5	16.7	18	20.2	22.1	23.5	24.9	21.8
Highest temperature (Degrees C)	41.4	40.9	39	36.8	28.5	26.1	26.3	29.9	34.4	36.7	41	42	42
Lowest maximum temperature (Degrees C)	18.4	18.1	17.8	15.6	12.8	10.6	8.9	11.2	11.7	14	15.6	17.2	8.9
Mean number of days >= 30 Degrees C	2.7	1.9	1.5	0.6	0	0	0	0	0.5	1.8	2.4	2.9	14.3
Mean number of days >= 35 Degrees C	0.9	0.5	0.2	0	0	0	0	0	0	0.1	0.5	1	3.2
Mean number of days >= 40 Degrees C	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.2
Mean minimum temperature (Degrees C)	19.2	19.3	18.2	15.3	12	9.6	8.4	9.2	11.4	14	16.1	18	14.2
Lowest temperature (Degrees C)	12	10.3	11.1	7.4	4.7	3	1.8	3.3	5	6.5	7.2	11	1.8
Highest minimum temperature (Degrees C)	25.5	24	23.9	21.9	19.5	17.6	15.7	17.2	19.8	21	22.4	24	25.5
Mean rainfall (mm)	89.5	108	120.8	116.6	117.4	117.5	95	75.1	73	73.2	70.5	81.8	1140.3
Highest rainfall (mm)	404	559.2	544.4	546.4	441.3	495.8	351.1	545.3	283.1	277.5	203.9	326.5	1919.4
Lowest rainfall (mm)	2	0.5	2.8	0	2.1	0.8	0	0	0.8	4.6	2.4	4.6	596.9
Highest daily rainfall (mm)	144.8	252.7	283.7	231.1	181.9	209.8	118.6	168.9	157.5	96.5	103.7	177.5	283.7
Mean number of days of rain	11	11.1	12.2	11.9	12	11.6	10.7	10.2	9.9	10.7	10.6	10.5	132.4
Mean daily wind run (km)	577	561	535	522	491	544	541	543	561	575	585	594	553
Maximum wind gust speed (km/h)	121	141	137	115	171	152	139	135	131	141	145	130	171
Mean daily solar exposure (MJ/(m*m))	24.2	21.9	19	14.8	10.6	9	10	13.8	17.5	20.7	23.1	24.7	17.4
Mean number of clear days	6.3	5.3	6.4	7.4	6.9	7.5	9.7	10.8	9.3	7.4	5.5	6.3	88.8
Mean number of cloudy days	12.4	11.9	11.7	10.7	11.9	11.7	9.5	8.3	9	12.1	12.2	11.7	133.1
Mean 9am temperature (Degrees C)	21.9	21.8	20.8	18	14.6	12	10.9	12.1	15	17.9	19.5	21.1	17.1
Mean 9am wet bulb temperature (Degrees C)	19.3	19.5	18.4	15.7	12.7	10.3	8.9	9.8	12.1	14.6	16.4	18.2	14.7
Mean 9am dew point temperature (Degrees C)	17.7	18.3	16.9	14.1	10.9	8.4	6.6	7.1	9.2	11.6	14	16.2	12.6
Mean 9am relative humidity (%)	77	80	79	78	79	79	77	73	70	68	72	75	75
Mean 9am cloud cover (okas)	4.6	4.6	4.4	4.1	4.2	4.2	3.5	3.3	3.6	4.1	4.5	4.5	4.1
Mean 9am wind speed (km/h)	21	20.9	20.9	21.5	23.7	26.7	26.6	25.9	25.2	23.8	23.3	21.7	23.4
Mean 3pm temperature (Degrees C)	23.3	23.5	22.9	21.3	18.8	16.5	15.9	16.9	18.5	19.8	20.9	22.4	20.1
Mean 3pm wet bulb temperature (Degrees C)	19.9	20.3	19.5	17.3	14.9	12.7	11.7	12.3	13.9	15.7	17.2	18.9	16.2
Mean 3pm dew point temperature (Degrees C)	17.9	18.5	17.2	14.3	11.6	9.3	7.3	7.6	9.4	12.2	14.4	16.4	13
Mean 3pm relative humidity (%)	72	74	72	66	64	63	59	56	59	64	68	71	66
Mean 3pm cloud cover (oktas)	4.1	4.2	4.3	4.3	4.5	4.5	4.1	3.7	3.8	4.2	4.4	4.3	4.2
Mean 3pm wind speed (km/h)	33.4	32.8	30.7	28.1	26.3	28.5	29.2	30.7	34.2	34.6	35.6	35.4	31.6

Source: Bureau of Meteorology (2008)

## **5.2 Ambient Temperature**

Air temperature is important, both for determining the effect of plume buoyancy and determining the development of the mixing and inversion layers. The study area is characterised by a warm climate, with mean daily temperatures in the range of 14°C to 22°C based on the long-term record. Peaks occur during summer months with the highest temperatures typically being recorded in January to February. The lowest temperatures are usually experienced during July.

## **5.3 Rainfall and Evaporation**

Precipitation is important to air pollution studies since it represents an effective removal mechanism of atmospheric pollutants. Annual rainfall ranges from approximately 600 mm to 1900 mm, and is on average about 1140 mm. Although significant inter-annual variations in rainfall occur, intra-annual variations are small with rainfall occurring during all months of the year. The highest rainfall typically occurs during the February to June period (>100 mm/month). On average 132 rain days occur per year, ranging from about 10 during September to 12 in March.

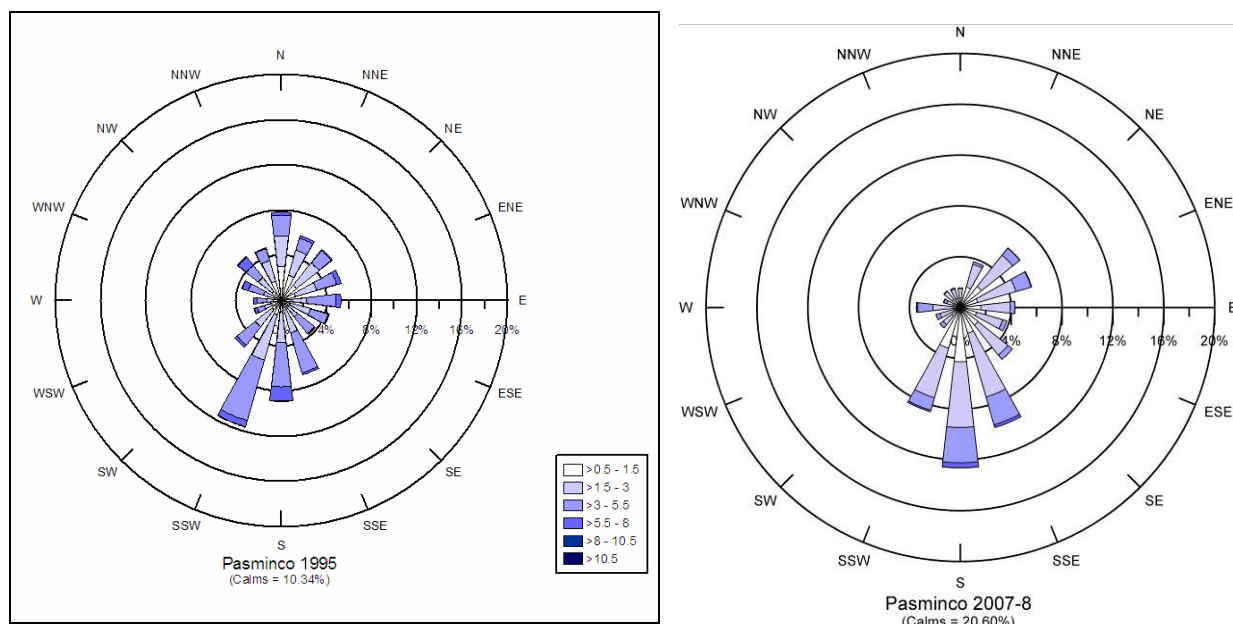
Evaporation is a function of ambient temperature, wind and the saturation deficit of the air. On average the region experiences a moderate water deficit with evaporation (1200 mm/year to 1400 mm/year) marginally exceeding rainfall. This moisture deficit may be more significant during drier, hotter years. This would need to be accounted for in the dust controls to be implemented for the proposed project which involve wet suppression of fugitive dust sources.

## **5.4 Prevailing Wind Regime**

Due to significant spatial variations in wind field, emphasis is placed on site-specific meteorological data in terms of characterising the local wind regime. At least one year of wind data is required to adequately characterise seasonal fluctuations in the wind field for analysis and dispersion modelling purposes.

While additional data is now available from the PCCS Automatic Weather Station (data obtained up to 22 November 2008), for consistency with the Stage 1 Air Assessment, emphasis was placed on the PCCS 1995 data set. Period-average wind roses were however generated for an equivalent period for both data sets to facilitate comparisons (**Figure 16**).

Distinct differences in the 1995 and November 2007 to November 2008 recorded wind fields were apparent. On average wind speeds in the latter data set were lower with a significantly greater frequency of calm wind conditions (<0.5 m/s) compared to the 1995 data set (10.3%). There were also differences in wind patterns with the prominent south, southwest and northerly winds apparent in the period-average 1995 data set being absent (in the case of northerly winds) or less prominent in the 2007-8 data set. For the purpose of the current assessment it was therefore decided to focus on the analysis and use of the 1995 data set due to its completeness and its prior use for the PCCS air quality impact study.



**Figure 18: Comparison of period average wind roses generated for the Nov 2007 to Nov 2008 and 1995 PCCS data sets**

Annual, seasonal and diurnal wind roses generated based on the PCCS 1995 dataset are given in **Appendix 1**. Airflow is dominated by northerly- and southerly-component winds, with northwest and south, southwest to southerly winds being most prevalent on an annual basis. Wind speeds are typically in the 1 m/s to 3 m/s range, with a mean annual wind speed of 2.5 m/s and calm conditions occurring 11.4% of the time.

Distinct seasonal shifts in the wind field are evident. During the summer months, wind speeds are higher and calm conditions less frequent (7.6%), with very prominent northerly and south, southwest airflow and a strong easterly flow component also being apparent. Autumn is characterised by comparatively weaker winds, a greater frequency of calms (12.2%) and primarily southerly (south, southwest to south, southeast) airflow. In the winter, the incidence of calm conditions increases further (14.9%) and the wind shifts significantly with northwest to west, northwest airflow prevailing. During spring wind velocities increase, calm periods are reduced to 10.5% and northwest and southwest to southerly airflow prevails.

Variations in the day time and night time airflow is not as varied as would be expected given the nature of the local terrain (Refer Section 2.5). Airflow from the northeast and south, southwest sectors are more prevalent during the night time, with northwest and south, southwest to southerly winds dominating day time airflow. The shift between northwest (up slope) winds during the day time and northeast (down slope) wind at night is characteristic of topographically induced diurnal circulations. Night times are characterised by relatively lower wind speeds and more frequent calm conditions (18%) when compared to the day time (4.8% calms) as may be expected.

## **5.5 Atmospheric Stability and Mixing Layer Depth**

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of flow due to the frictional drag of the earth's surface, or as result of the heat and moisture exchanges that take place at the surface (Stull, 1997; Oke, 2003). During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated subsidence inversion. Elevated inversions may occur for a variety of reasons including anticyclonic subsidence and the passage of frontal systems.

Radiative flux divergence during the night usually results in the establishment of ground-based inversions and the erosion of the mixing layer. Nighttimes are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds, hence less dilution potential. The mixed layer thus ranges in depth from a few metres (i.e. stable or neutral layers) during nighttimes to the base of the lowest-level elevated subsidence inversion during unstable, daytime conditions.

For low level, wind independent, continuous sources, the highest ground level concentrations tend to occur during stable nighttime conditions with pollutants accumulating close to the source. Sources characteristic of the proposed development are mostly low level, wind dependent and will generally coincide with periods of activity which occur during the day time. Atmospheric conditions conducive to peak ground level concentrations from such sources are more complicated and best characterised through the application of dispersion modelling in which temporal variations in atmospheric conditions and source profiles are adequately represented.

Meteorological parameters such as atmospheric stability class and mixing height are not routinely recorded and need to be derived or simulated. A range of methods are available for the generation of these parameters based on routinely measured parameters or through the use of prognostic modelling, e.g. The Air Pollution Model (TAPM) application. The PCCS 1995 meteorological data set did not however include the various measured parameters required for diagnostically calculating the site-specific stability regime and mixing depth (e.g. sigma theta and solar radiation). Furthermore, the application of TAPM was complicated due to the dated nature of the site-specific meteorological data set. It was therefore necessary to make reference to the atmospheric stability class and mixing depth data generated previously by Holmes Air Sciences (2006).

Holmes Air Sciences (2006) calculated the stability class using sigma-theta data according to the method recommended by the US-EPA. 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.

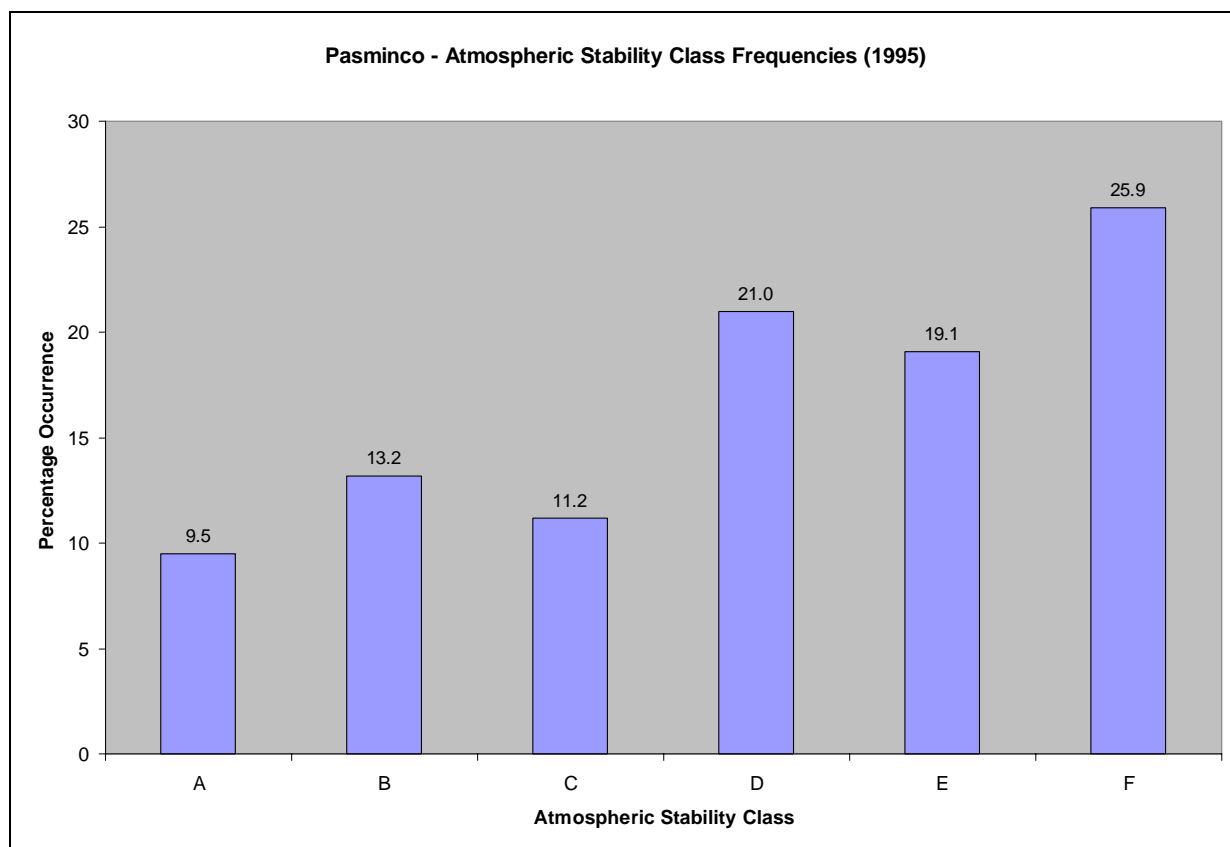
Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Turner assignment scheme identifies six Stability Classes, "A" to "F", to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions and are used as input into various air dispersion

models (**Table 18**). A synopsis of the frequencies of occurrence of specific atmospheric stability classes is given annually in **Figure 19** and seasonally in **Figure 20**.

**Table 18 - Description of atmospheric stability classes**

Atmospheric Stability Class	Category	Description
A	Very unstable	Low wind, clear skies, hot daytime conditions
B	Unstable	Clear skies, daytime conditions
C	Moderately unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

Results indicate a high frequency of very stable, stable and neutral conditions which are associated by dispersion potentials in the poor to moderate range. The higher frequency of very unstable conditions during summer months is indicative of the greater degree of convective mixing which occurs. Winter months are characterised by more stable conditions with the lower wind speeds and reduced surface heating resulting in lower levels of mechanical and convective turbulence respectively



**Figure 19: Frequency of occurrence of atmospheric stability classes for Pasminco (1995)**

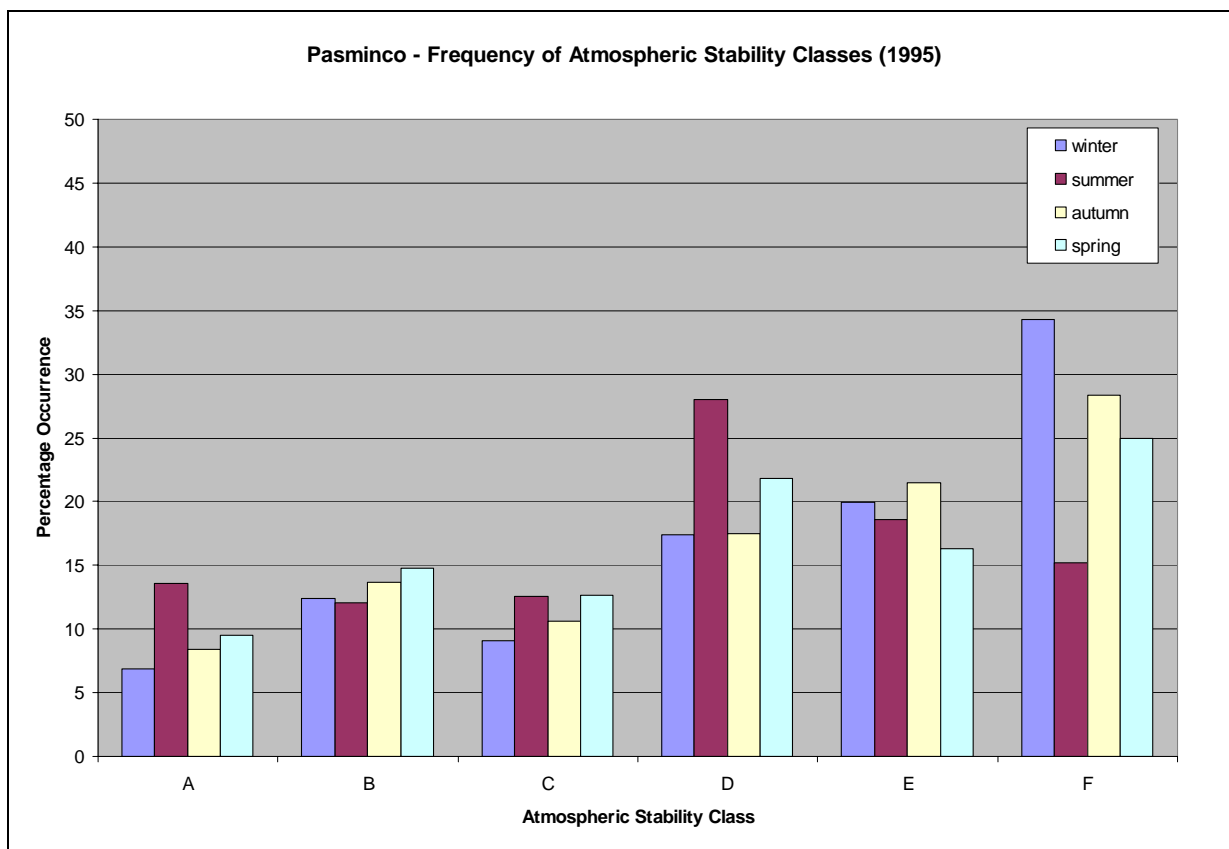
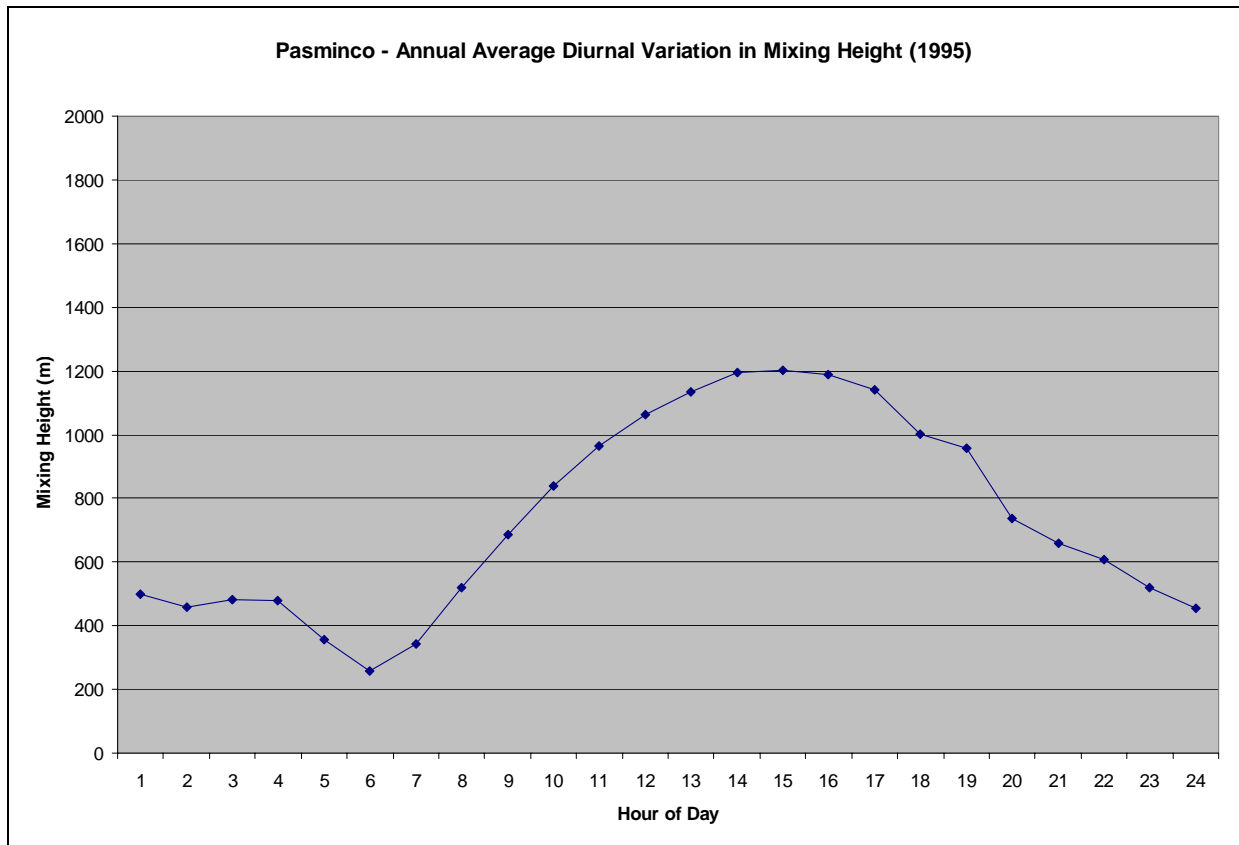


Figure 20: Seasonal stability class distribution for Pasminco (1995)

Average annual diurnal variations in maximum and average mixing depths for 1995 are illustrated in **Figure 21**. An increase in the mixing depth during the morning arising due to the onset of vertical mixing following sunrise is apparent with maximum mixing heights occurring in the mid to late afternoon due to the dissipation of ground-based temperature inversions and the growth of convective mixing layer.



**Figure 21: Average annual diurnal variation in mixing height for Pasminco (1995)**

## 6 Emissions Inventory

### 6.1 Project Staging

The current proposed stages of remediation relevant to the current assessment, and estimated timing of each, are given as follows:

Stage 2 -	Containment cell construction / Northern Area Soil remediation  Establishment of a containment cell and associated environmental controls in the northern portion of the site as a repository for contaminated site soils, including remediation of accessible fill material to the north of the operational areas of the facility.	Anticipated to commence January 2010. 53 month duration
Stage 3 -	Decommissioning / demolition and soil remediation of central portion  Decommissioning of the majority of site infrastructure once site operations are completed (including demolition of most structures), and remediation of underlying fill material across the central portion of the site.	Anticipated to commence January 2012. 29 month duration
Stage 4 -	Remediation of the filled gully on the southern portion of the site  Remediation of the filled gully in the southern portion of the site (and placement in the containment cell), including any final landform rehabilitation requirement to render the site suitable for future land use.	Anticipated to commence January 2013. 17 month duration

The above timings indicate that Stages 2-4 of the project are likely to be conducted concurrently over a 17 month period.

Accordingly, the emissions inventory and scenario modelling refers to Stage 2, Stage 3 and Stage 4 occurring concurrently. **Table 19** presents a summary of key parameters by stage.

**Table 19 – Summary of Key Parameters By Stage**

<b>Parameter</b>	<b>Stage 2</b>	<b>Stage 3</b>	<b>Stage 4</b>
Duration	January 2010 – May 2014 (53 Months)	January 2012 - May 2014 (29 Months)	Jan 2013 - May 2014 (17 Months)
Volume of Material to be Excavated	100,000m <sup>3</sup>	100,000m <sup>3</sup>	100,000m <sup>3</sup>
Internal Truck Movements	8,000 – 10,000	20,000 – 25,000	13,900
External Truck Movements	800	1,650 – 1,700	2,100
Waste Offsite	10,000m <sup>3</sup>	10,000m <sup>3</sup>	10,000m <sup>3</sup>
Crushing of Concrete	Possibly	Possibly	Possibly

To simulate worst-case activity rates, the 12-month period when all three stages are anticipated to be operational has been selected for modelling purposes. This reflects the period April 2013 – May 2014.

A description of Stage 2, Stage 3 and Stage 4 operations is thus provided in more detail below, along with assumptions made within the atmospheric emission inventory used for modelling purposes.

## **6.2 Description of Stage 2 Operations**

Stage 2 would involve the remediation of the contaminated fill and soil in the northern area of the site, and the progressive construction of the containment cell that will be the final repository for the contaminated material on-site.

The cell landform will generally be rectangular in shape, approximately 150 metres wide by 400 metres long, with a shaped northeast corner to allow for free surface water drainage around the cell. It would have a maximum site of 46 metres (AHD) and would be set back from property boundaries by ten to 20 metres on the east site, 20 metres on the north side, and 30 metres on the west side.

The excavation and construction of the containment cell would be the key tasks in Stage 2. The cell would be built progressively in sections, starting at the northern end of the site and working southwards. As each section of the cell is excavated, the material would be transferred to dedicated on-site stockpile areas, where materials would be screened. Following excavation and validation of the base of the cell in that section, installation of the cell lining system would begin. On completion of the lining system, the screened material would be placed in the cell, in the same order that construction of the cell occurred, such that the volume of stockpiled excavated material outside the cell is kept to a minimum throughout the cell construction process.

Stage 2 would also involve removal of some redundant concrete pavement, which would be either recycled off-site, or crushed on-site and placed within the cell. If the quality is suitable, options for on-site reuse of crushed concrete (eg. roadbase) will be considered in the context of future land use.

The northern part of Shed 4 may also be demolished as part of this stage. This would involve the removal of asbestos-containing materials, which would be stored and managed appropriately, potentially within the remaining portion of Shed 4, until disposed within the containment cell. It is anticipated that any removal of asbestos-containing materials will be undertaken under highly controlled conditions. As such, no modelling of off-site migration of asbestos has been undertaken, as this is assumed to be a prerequisite under normal operations.

Prior to construction commencing, site establishment activities would include the following:

- Mobilisation of site office and site amenities within existing IFL buildings, or demountable units as required.
- Construction of a sediment control dam and biofiltration system in the southwestern corner of the site.
- Preparation of stockpiling areas, including establishment of silt fencing and surface water run-off collection and treatment controls where appropriate.
- Excavation of approximately 25,000m<sup>3</sup> in the vicinity of the northern boundary of the site, and excavation of natural material along the perimeter to achieve suitable falls for passive drainage.
- Relocation of overhead power lines currently crossing the northeastern corner of the site to the site boundary to accommodate cell construction.
- Installation of a surface water collection pipe or culvert along the northeastern corner of the proposed cell area to direct surface water run-off around the construction site.

The base of the cell would be constructed below the current surface level, within the natural soil profile, beneath the excavated fill. The liner would be a geosynthetic composite liner, comprising high-density polyethylene geomembrane (welded in place), with an overlying geotextile cushion layer for puncture protection, and with an underlying geosynthetic clay liner and soil-bearing layer.

The capping system would consist of a geosynthetic composite cap with a linear low-density polyethylene geomembrane, an overlying drainage system and revegetation layer. Further details of the cap design may be found within the Conceptual RAP and Environmental Assessment document.

The materials to be placed in the cell are predominantly fill and soil contaminated with elevated concentrations of metals, phosphorous, and sulphates, as well as certain contaminated building materials from demolition of site structures. These materials are considered compatible with the proposed cell lining and capping materials.

The preliminary cell design allows for a cell volume of approximately 270,000 m<sup>3</sup>. This is generally consistent with previous conservative estimates of the volume of waste material requiring remediation at the Site. As the excavated material is previously placed fill, a significant difference between in-situ volume and volume after compaction in the cell is not anticipated. In the event that the volume of contaminated soil requiring placement in the containment cell is less than anticipated, the cell may be reduced in size by reducing the length, from south to north.

It is likely that compaction of the contaminated soil placed in the cell would achieve a relatively high density, approximately 95 per cent of standard maximum dry density. This would ensure that post-remediation settlement of the landform would be in the normal range for earthwork structures and would be able to be tolerated by the capping system.

Key construction elements during this stage include:

- Standard working hours throughout all stages would be: 7am to 6pm, Monday to Friday. If required, Saturday work hours would be 8am to 1pm.
- Construction machinery is likely to include the use of bulldozers (D8), 20-30 tonne excavators, 30-40 tonne articulated dump trucks and a water cart.
- Concrete crushing plant and mechanical screens have been incorporated within the atmospheric emission inventory.
- Total internal truck movements throughout Stage 2 would be approximately 8,000 – 10,000.
- Total external truck movements would be approximately 800.
- Waste produced is anticipated to be approximately 10,000 m<sup>3</sup> of screened oversize inert materials to be disposed off-site progressively.
- Total amount proposed to be excavated during Stage 2 is on the order of 100,000 m<sup>3</sup>.

### **6.3 Description of Stage 3 Operations**

Stage 3 would involve the demolition of all site buildings and infrastructure within the central area of the site. This would include removal of all manufacturing and storage facilities and hardstand areas not required for traffic movements as part of the remediation program.

Uncontaminated waste materials would be disposed off-site to appropriate handling or disposal facilities. It is expected that the asbestos-containing materials would be buried within an area of the containment cell to be established during Stage 3, pending appropriate approvals. If these approvals cannot be obtained, the materials would be disposed off-site to an appropriately licensed landfill.

Following removal of the site buildings and infrastructure, the contaminated soil materials from this area of the site would be excavated and placed within the containment cell. The final excavated site surface would undergo testing and be validated in accordance with the validation protocol as described in the RAP, and to the satisfaction of the Site Auditor.

Excavated material would be screened, and oversize inert material (metal, rock, rubble) would be segregated and either disposed of, or recycled off-site at an appropriate facility. Concrete may be crushed on site or recycled off-site.

### **6.4 Description of Stage 4 Operations**

Stage 4 would involve demolition of all remaining site infrastructure, particularly that occurring in the southern area of the Site.

Uncontaminated waste materials would be disposed off-site to appropriate handling or disposal facilities. It is expected that asbestos-containing materials would be buried within the containment cell, pending appropriate approvals. If these approvals cannot be obtained for on-site disposal within the cell, the asbestos containing materials would be disposed off-site to an appropriately licensed landfill.

Following removal of the site infrastructure, the contaminated soil materials from this area of the site, including those in the in-filled gully and the contaminated material within the dam wall, would be excavated and placed within the containment cell. The steep grade near the site boundary and the extension of fill materials in this area onto the Pasminco site would require liaison with the adjacent site operators to facilitate the effective removal of the contaminated soil from this area.

Excavated material would be screened, and oversize inert material would be segregated and either disposed of or recycled off-site at an appropriate facility. Concrete may be crushed on site or recycled off-site.

The final landform of this area of the site would approximate the previous natural site surface prior to the deposition of the waste fill materials from the smelter operations, aside from areas excavated for building construction. This would reinstate the former gully area across the southern section of the site, which may form a natural drainage course as part of the site redevelopment. It is anticipated that the dam occurring within the IFL property would not be required for future water management and would be removed as part of these works.

Key construction elements during this stage include:

- Machinery used would include 20-30 tonne excavators, 30-40 tonne articulated dump trucks., water cart, front-end loader/backhoe, concrete crushing plant and mechanical screen, dozer (to be shared with Stage 2 activities), bobcat with street sweeper attachment.
- Total internal truck movements would be approximately 13,900.
- Total external truck movements would be approximately 2,100.
- Waste produced would be in the order of 10,000 m<sup>3</sup> of deleterious material to be disposed off site progressively.
- Total amount to be excavated and stockpiled would be in the order of 100,000 m<sup>3</sup>.

Further information critical to the modelling of Stage 2, Stage 3 and Stage 4 operations is as follows:

- Natural material will be extracted and stockpiled for later backfill. Stockpiled material will be seeded with cover crops. Accordingly, while the handling of natural material has been incorporated within the emission inventory, wind erosion from natural material stockpiles has not been accounted for explicitly, as this source is assumed to be fully controlled.
- Four interim stockpiles of fill material are anticipated to be used at various points during Stage 2 and Stage 3 operations. For conservatism, Stockpiles 1 to 3 have been assumed to be active during the modelled operational scenario. A single

stockpile of fill material is anticipated during Stage 4. Stockpile heights are anticipated to be of the order of 4 – 6m.

- Average moisture content of the fill material is reported to be 24% based on geotechnical investigations undertaken to date by Golder Associates Pty Ltd. Given that this material is anticipated to lose moisture as it is handled, the moisture content has been modelled as 20%. A sensitivity analysis of this parameter was also undertaken using a value of 16% (refer Section 8).
- Average moisture content for natural material has been assumed to be 8%. This is considered to be highly conservative, and is representative of dried-out material being worked.
- Silt loading of 2 g/m<sup>2</sup> assumed for paved roads based on site observations and generic loadings for similar operations with controls in place (e.g. use of a road sweeper).
- Limited information was available regarding the likely locations of temporary unpaved road sections which would be used. The most likely routes given the existing road network layout and location of screens and excavation areas was assumed.
- Bulk densities for on-site materials are anticipated to be 1.3, 1.9 and 2.4 tonnes/m<sup>3</sup> for excavated fill, natural material and concrete respectively.
- In the estimation of heavy metal emissions, the content of the fill was conservatively assumed to comprise the heavy metal contents published in the Draft RAP as the 95% upper confidence level of the mean metal concentrations calculated across all fill soil samples (RAP, 23 October 2008, Revision 6, Table 4, page 26).

The following dust mitigation measures were confirmed or assumed during the estimation of emissions for Stage 2, Stage 3 and Stage 4 operations:

- A control efficiency for wheel generated dust on unpaved roads of 75% is assumed. Such a control efficiency is consistent with the application of water sprays to roads at a rate of greater than 2litres/m<sup>2</sup>/hour (EETM Mining, 2001).
- Stockpiles are to be compressed and partially sealed by tracking over with machinery. A control efficiency of 50% for this measure has been conservatively assigned, based upon professional judgement.
- The operation of the crusher has been assigned an emission factor corresponding to the primary crushing of high-moisture ore (EETM Mining, 2001). It is thus assumed that, as a minimum, controls equivalent to the use of water sprays to the crushing process are applied.
- Fill materials would be sufficiently moist to prevent blow off of material during truck transit. Alternatively, freeboards will be increased or trucks covered.
- The potential for fill material being deposited on roadways and subsequently re-entrained by vehicles will be prevented through regulating the moisture content of material or the freeboard or covering of trucks.
- In the event that fill material is deposited it will be cleaned up in a timely manner.

- Natural material stockpiles will be effectively seeded / covered before the material dries out.

## **6.5 Quantification of Stage 2, Stage 3 and Stage 4 Emissions**

Sources of atmospheric emissions associated with concurrent Stage 2, Stage 3 and Stage 4 operations were identified as including:

- Excavation and handling of fill and natural material.
- Excavators / Front End Loaders (FEL) on natural material and fill.
- Use of dozers on fill and natural material.
- Operation of Stage 2 and Stage 4 mechanical screens concurrently.
- Operation of a concrete crushing plant (shared between Stage 2, Stage 3 and Stage 4 requirements, with crusher location adjacent to the cell area and a capacity of 20m<sup>3</sup>/hour.
- Vehicle entrainment from paved and unpaved on-site roads due to the transfer of natural material to piles and the fill to/from the cell.
- Wind erosion from exposed areas.
- Vehicle tailpipe releases.

Vehicle exhaust emissions were considered a minor source due to the limited traffic movements and were therefore not quantified. Instead the assessment focused on the quantification of fugitive dust emissions and associated heavy metal releases.

Fugitive dust sources associated with proposed Stage 2, Stage 3 and Stage 4 operations were quantified through the application of Australian National Pollutant Inventory (NPI) emission estimation techniques and United States Environmental Protection Agency (US-EPA) AP-42 predictive emission factor equations. Particulate releases were quantified for various particle size fractions, with the Total Suspended Particulate (TSP) fraction being estimated and simulated to provide an indication of nuisance dust deposition rates. Fine particulates (PM<sub>10</sub> and PM<sub>2.5</sub>) were estimated and resultant concentrations simulated for the purpose of assessing compliance with air quality criteria which are protective of human health.

Emissions estimates for Stage 2, Stage 3 and Stage 4 operations, taking account of the above documented dust mitigation measures, are presented in **Table 20**. Information on the emission factors applied in the quantification of sources and the inputs used in predictive emission factor equations are also provided. Fugitive dust emissions associated with vehicle entrainment from both paved and unpaved haul road sections were estimated to comprise the main sources of emission after dust controls are applied.

**Table 20 - Estimated emissions for Stage 2, Stage 3 and Stage 4 operations**

Source	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Emission Factor Applied	Calculation Inputs
	kg/day	kg/day	kg/day		
Paved roads	19.57	3.32	0.35	US-EPA AP-42 Paved Roads (Section 13.2.1) (November 2006)	Silt loading of 2 g/m <sup>2</sup> assumed based on site observations and generic loadings for similar operations with controls in place. Vehicle kilometres travelled (VKT) estimated to be approximately 8.5 per day, assuming maximum volumes of material paved road section of ~275 m (Stage 2) ~150 m (Stage 3) and ~210 m (Stage 4). The mean vehicle weight was taken to be 48 tonnes (accounting for full and empty trips).
Unpaved roads	13.95	1.83	0.18	US-EPA AP-42 Unpaved Roads (Section 13.2.2) (November 2006)	The silt content of the road surface material was assumed to be 8.5%, given by the US-EPA as being characteristic of haul roads within quarry operations. The mean vehicle weight was taken to be 48 tonnes (accounting for full and empty trips). Vehicle kilometres travelled (VKT) estimated to be approximately 7.7 per day, assuming maximum volumes of material and unpaved road section of ~50 m (Stage 2) and ~50 m (Stage 4). No additional unpaved road sections anticipated for Stage 3. The dust control efficiency due to watering was assumed to be 75%.
Materials handling	1.33	0.39	0.04	US-EPA AP-42 Aggregate Handling (Section 13.2.4) (November 2006)	A mean wind speed of 2.5m/s (based on 1995 hourly measurements from PCCS Weather Station) was used in the calculations. Material moisture contents of 20% and 8% were assumed for fill and natural material
Excavator / Front End Loader operations	0.03	0.02	0.00	NPI EETM for Mining Version 2.3, Dec 2001	Excavators and Front End Loader conservatively assumed to operate 8 hours/day during remediation operational hours. One excavator is assumed to be dedicated to Stage 2 operations. One excavator and one front end loader is assumed to be dedicated to Stage 3 operations. Two excavators and a Front End Loader are assumed to be dedicated to Stage 4 operations.
Dozer operations	8.28	1.53	0.23	NPI EETM for Mining Version 2.3, Dec 2001	Dozers conservatively assumed to operate 6 hours/day during remediation operational hours. 95% of dozer operation is anticipated in the southern

<b>Table 20 - Estimated emissions for Stage 2, Stage 3 and Stage 4 operations</b>					
Source	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Emission Factor Applied	Calculation Inputs
	kg/day	kg/day	kg/day		
					portion of the Stage 2 cell, and 5% within Stage 4. No dozer activity is allocated for Stage 3. One dozer is assumed to be operational at any one time. Fill moisture and silt contents of 20% and 8.5% were assumed respectively.
Mechanical Screens	0.64	0.22	0.01	US-EPA AP-42 Crushed Stone Processing and Pulverized Mineral Processing (Section 11.19.2) (August 2004)	Emission factor selected corresponding to Controlled Emissions (using wet suppression or equivalent technique). One screen is assumed to service the Stage 2-3 excavated material (located adjacent to the Stage 2 cell). Another screen is assumed to service the Stage 4 excavated material.
Concrete Crushing	4.80	1.92	0.29	NPI EETM for Mining Version 2.3, Dec 2001	Emission factor corresponding to High Moisture Ores selected for concrete crushing, with the assumption that particulate controls are comparable to water spraying during crushing. Crusher to be sited in the area of the Stage 2 cell. Modelling conducted based on 8-hour/day operation of a crusher capacity of 20m <sup>3</sup> /hour.
Stockpile Wind Erosion	12.63	4.34	0.59	Wind dependant emission rates applied consistent with US-EPA AP-42 Industrial Wind Erosion (Section 13.2.5 (2006))	Four interim stockpiles of fill material are anticipated to be used at various points during Stage 2-3 operations. For conservatism, an area equivalent to the combined area of Stockpiles 1 to 3 has been assumed to be active during the modelled scenario. A single stockpile of fill material is anticipated during Stage 4.
<b>TOTAL</b>	<b>61.23</b>	<b>13.56</b>	<b>1.70</b>		

The emission estimates in **Table 20** were calculated based on average activity rates for each stage, whilst conservatively assuming that stages occur simultaneously. To assess peak daily emissions arising from maximum likely activity, detailed resource usage schedules were obtained for the project (Michael Staddon, Overhauls Australia Pty Ltd, 2 April 2009). Based on a review of the peak activity rates which are scheduled to occur intermittently, activity rates scheduled for one day in mid January 2013 were identified as constituting the greatest peak.

Mid January 2013 peak daily haul truck activity and material handling and storage were equivalent to the activity rates used in the emission estimates presented in **Table 20**. Utilisation rates of dozers, mechanical screens and excavators were however higher during this peak than the rates assumed in the emission estimates, as follows:

- Peak dozer operating times were 20 hours/day (double the operating hours assumed in the emission estimates);
- Peak mechanical screen usage was given as 30.4 hours/day (52% higher than the 20 hours/day used in the emission estimates); and
- Peak excavator use is estimated to be 85 hours/day (77% higher than the 48 hours/day used in the emission estimates).

Taking the above peak activity rates into account, it is estimated that highest maximum daily emissions throughout the entire operation would be 14% higher for TSP and PM<sub>2.5</sub> and 12% higher for PM<sub>10</sub>.

## 7 Dispersion Modelling Methodology and Results

### 7.1 Dispersion Model Selection and Application

Ausplume version 6.0 or later is the approved dispersion model for use in most simple, near-field applications in NSW, where coastal effects and complex terrain are of no concern (DEC, 2005). This model is based on the US EPA Industrial Source Complex Short Term model (ISCST3) which was the regulatory model for similar applications until recently replaced by AERMOD. AERMOD was identified as the most suitable model for application in the current project due to the source types and nature of terrain. Its use was discussed with, and approved by the DECC, pending adequate implementation.

Despite initially selecting AERMOD for application it became apparent that insufficient site-representative meteorological data was available to allow the model to be applied in a robust manner given that the model requires both surface and upper air meteorological data sets. The ability to either diagnostically or prognostically project the required additional meteorological fields was impeded by the surface meteorological data set available (Refer Section 5.5). It was therefore decided to apply the ISCST3 model for the following reasons:

- ISCST3 was previously applied in the air quality assessment undertaken by Holmes Air Sciences (2006) for the adjacent PCCS Remediation Project.
- Sufficient site-representative meteorological data was available to run the ISCST3 model in line with recommended requirements.

ISCST3 (EPA, 1996) is a steady state Gaussian Plume model applicable to multiple point, area and volume sources. Numerous evaluation studies have been undertaken for this model in the United States, with reported model accuracy varying from application to application. Given the nature of the current application it is expected that the range of uncertainty in model results would be in the range of -50% to 200%. The ISCST3 model has been noted to provide more conservative outputs (i.e. higher predicted concentrations) when compared to AERMOD for the sample applications.

Input data types required for the ISCST3 model include: meteorological data, source data, and information on the nature of the receptor grid. Source and emission data inputs to the model are given in **Section 6.5** and **Appendix 2**. The hourly average meteorological data set input for the modelling, which includes wind speed, wind direction, a measure of atmospheric turbulence, ambient air temperature and mixing height was based on the PCCS 1995 data set used in the Holmes Air Sciences (2006) study (Refer **Section 5**).

The dispersion of pollutants was modelled for an area covering 4 km (east – west) and 3 km (north – south). Gridded receptor points were specified at intervals of 50 m, with discrete receptor points also being specified for selected sensitive receptor points as listed in **Section 2.6**. The model simulates ground-level concentrations for each of the gridded and discrete receptor grid points.

## **7.2 Model Results**

Dispersion simulations were undertaken and results analysed for TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and a range of heavy metal concentrations and dust deposition. Incremental concentrations and deposition rates occurring due to concurrent Stage 2, Stage 3 and Stage 4 emissions were modelled. The potential for cumulative concentrations and deposition rates was assessed based on the background air quality levels established for the study area (Refer **Section 4.9**).

Results are presented in the following formats:

- Isopleth plots, illustrating spatial variations in incremental pollutant concentrations and dust deposition rates due to Stage 2, Stage 3 and Stage 4 operations, are provided in **Appendix 3**.
- Tabulated results of particulate concentration and dust deposition rates at discrete receptor points are presented and discussed in **Section 8** taking into account both incremental and cumulative concentrations.
- Tabulated results of incremental heavy metal concentrations due to Stage 2, Stage 3 and Stage 4 operations are given in **Appendix 4** for all discrete receptor locations. Maximum incremental heavy metal concentrations across such locations are summarised in **Section 8** and discussed within the context of known background levels.

Isopleth plots of the maximum daily average concentrations presented in **Appendix 3** do not represent the dispersion pattern on any individual day, but rather illustrate the maximum daily concentration that was simulated to be possible at each receptor point given the range of meteorological conditions occurring over the period modelled (1 year).

## 8 Air Quality Impact Assessment

The air quality assessment comprises an analysis of compliance with ambient air quality goals and the evaluation of the likelihood of impacts on human health and welfare and other aspects of the biophysical environment as a result of atmospheric emissions due to the proposed project.

### 8.1 Compliance with Ambient Air Quality Limits

Predicted incremental TSP, PM<sub>10</sub> and PM<sub>2.5</sub> concentrations and dust deposition due to maximum production operations are illustrated in **Appendix 3**, with incremental and cumulative concentrations predicted for the nearest receptor locations discussed in this section.

#### 8.1.1 Suspended Particulate Concentrations

*Incremental* highest daily and annual average particulate concentration simulated to occur at nearby receptor locations due to controlled, concurrent Stage 2, Stage 3 and Stage 4 operations are summarised in **Table 21** and are presented spatially as contours in **Appendix 3**.

Baseline air quality data indicates that exceedances of air quality goals given for maximum daily PM<sub>10</sub> and advisory thresholds for daily PM<sub>2.5</sub> already occur in the region on typically 1 to 2 days/year (**Table 15**). In this region, such exceedances are primarily due to episodic emissions from bushfires or dust storms. It is therefore evident that limited potential exists for increments in ambient PM<sub>10</sub> and PM<sub>2.5</sub> concentrations.

The recommended dust mitigation activities to derive this outcome are noted explicitly within **Section 9**. It is considered appropriate that these dust controls are implemented in the event that on-site activities are of the magnitude of the scenario modelled (concurrent Stage 2, Stage 3 and Stage 4 activities).

Annual average concentrations for all size fractions were predicted to be low (less than 25% of the corresponding air quality goal). Taking background particulate concentrations into account it is not expected that Stage 2-4 operations (**Table 15**) will cumulatively give rise to levels above annual air quality goals.

<b>Table 21 – Incremental suspended particulate concentrations due to Concurrent Stage 2, Stage 3 and Stage 4 operations at nearby sensitive receptors</b>						
	Receptors	TSP	PM <sub>10</sub>		PM <sub>2.5</sub>	
		Annual Average (µg/m <sup>3</sup> )	Highest Daily Average (µg/m <sup>3</sup> )	Annual Average (µg/m <sup>3</sup> )	Highest Daily Average (µg/m <sup>3</sup> )	Annual Average (µg/m <sup>3</sup> )
R1	James St, Argenton	0.8	3.4	0.3	0.3	0.0
R2	Montgomery St, Argenton	0.7	3.8	0.2	0.5	0.0
R3	Cardiff Industrial Estate	1.5	22.0	0.5	3.0	0.0
R4	Delaware Dr	0.7	5.8	0.3	0.7	0.0
R5	Hillview Cr, Macquarie Hills	0.9	4.6	0.3	0.4	0.0
R6	First St 1, Boolaroo	9.5	23.1	2.7	2.2	0.3
R7	First St 2, Boolaroo	5.1	16.5	1.7	2.1	0.1
R8	First St 3, Boolaroo	3.8	14.4	1.3	1.5	0.1
R9	First St 4, Boolaroo	2.2	21.8	0.7	2.7	0.1
R10	First St 5, Boolaroo	1.7	17.3	0.5	2.2	0.0
R11	First St West, Boolaroo	1.1	12.8	0.3	1.4	0.0
R12	Boolaroo School	1.5	15.8	0.5	1.5	0.0
R13	Fourth St, Boolaroo	1.9	7.9	0.7	0.6	0.1
R14	Lake View St, Boolaroo	2.1	10.9	0.7	1.5	0.1
R15	Sixth St, Boolaroo	2.4	24.8	0.8	1.8	0.1

Taking into account absolute peaks in on-site equipment usage, and assuming coincident worst-case meteorology, peak highest daily average PM<sub>10</sub> and PM<sub>2.5</sub> concentrations are estimated to be marginally higher than the concentrations given in **Table 21** (i.e. 25.9 µg/m<sup>3</sup> for PM<sub>10</sub> and 3.4 µg/m<sup>3</sup> for PM<sub>2.5</sub>).

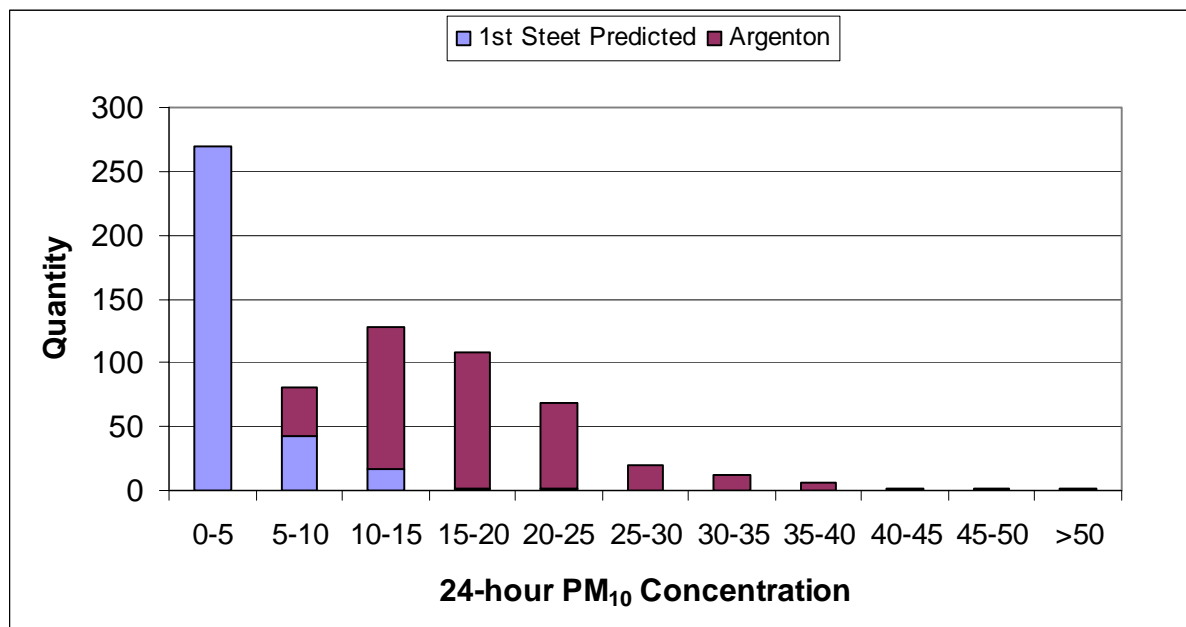
Given the conservative assumptions made in the modelling, the low probability of project-related peaks coinciding with maximums due to other sources at specific receptor sites, and the benefits of the project in terms of reducing future exposure potentials, this increment predicted is considered reasonable.

However, it is acknowledged that while all reasonable dust control activities have been provided, the present impacts only satisfy the project air quality goals when incremental impacts of the operation are considered in isolation.

Given that the present annual meteorological data set used for assessment purposes, it is not appropriate to examine concurrent predicted and observed PM<sub>10</sub> concentrations to establish the acceptability of cumulative impacts.

To determine the likelihood of exceedances of the 24-hour PM<sub>10</sub> goal following the addition of project-related air quality impacts, the frequency of occurrence of various predicted and observed concentrations may be examined.

**Figure 22** shows the frequency of occurrence of various 24-hour concentrations, both predicted at First St, Boolaroo, and observed from the Argenton TEOM site during the calendar year 2008.



**Figure 22: Frequency Distribution of Observed and Predicted 24-hour PM<sub>10</sub> Concentrations**

**Figure 22** indicates that greater than 99% of predictions at First Street Boolaroo are anticipated to be less than 15µg/m<sup>3</sup> (expressed as a 24-hour average). Given the low frequency of occurrence of predicted concentrations in excess of 15µg/m<sup>3</sup> at First Street (2 occasions), the likelihood that increments attributable to the project will cause any additional exceedance of the project air quality goal of 50µg/m<sup>3</sup> is deemed low (approximately one occasion).

Further, a management and monitoring plan for the PM<sub>10</sub> size fraction is also suggested to ensure adequate dust control is undertaken to protect the welfare of adjacent sensitive receptors. Details of such monitoring are provided in **Section 9**.

The incremental maximum daily average PM<sub>2.5</sub> concentrations at the nearest sensitive receptor sites due to concurrent Stage 2, Stage 3 and Stage 4 emissions are predicted to be of the order of 12% of the 24-hour air quality goal of 25 µg/m<sup>3</sup> and as such are not anticipated to contribute to additional exceedances of this parameter. In any event, it is anticipated that effective management of daily PM<sub>10</sub> concentrations (as suggested within **Section 9**) will act to appropriately control PM<sub>2.5</sub> concentrations over the same period.

### 8.1.2 Dust Deposition

A maximum *incremental* annual average dust deposition rate of 0.04 g/m<sup>2</sup>/month was predicted to occur across the receptor locations due to concurrent Stage 2, Stage 3 and Stage 4 operations. This rate is well within the NSW DECC incremental dust deposition limit of 2g/m<sup>2</sup>/month. Taking background average dust deposition levels into account (estimated to be in the order of 0.7 to 1.8 g/m<sup>2</sup>/month) (**Table 15**), maximum *cumulative* annual average dust deposition rates are expected to be within the NSW DECC cumulative dust deposition limit of 4g/m<sup>2</sup>/month.

Isopleth plots, illustrating spatial variations in incremental dust deposition rates due to concurrent Stage 2, Stage 3 and Stage 4 operations are provided in **Appendix 3**.

### 8.1.3 Heavy Metal Concentrations

High heavy metal concentrations have historically been measured to occur in the study area, with concentrations of lead, arsenic and cadmium noted to be of concern. Although levels of heavy metals have significantly reduced following closure of the PCCS lead smelter in 2003 and dust mitigation improvements, recently measured arsenic and cadmium concentrations remain elevated<sup>(1)</sup>. Limited potential exists for increments in ambient concentrations of these metals due to the proposed project, despite it being recognised that the project will reduce exposure potentials in the longer-term.

A synopsis of maximum *incremental* highest (99.9<sup>th</sup> percentile) hourly and annual average heavy metal concentrations predicted to occur due to concurrent, controlled Stage 2, Stage 3 and Stage 4 operations across all discrete receptor locations is given in **Table 22**, with reference made to relevant DECC impact assessment criteria. Such criteria are reported at the 99.9<sup>th</sup> percentile, consistent with Section 7.2.2 of the DECC's *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (AMMAAP, 2005). No exceedances of the relevant DECC impact assessment criteria for principal toxic air pollutants were predicted to occur. Predicted peak arsenic and cadmium concentrations comprise 28% and 34% of the DECC impact assessment criterion respectively.

The DECC air quality goal given for lead is specific for cumulative concentrations. Background lead concentrations are estimated to be in the range 0.013 to 0.11 µg/m<sup>3</sup> (**Table 16**). Given the comparatively low maximum increments in annual lead increments due to the proposed Project (0.0013 µg/m<sup>3</sup>), the annual lead goal is not expected to be exceeded.

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1 i.e. higher than the ranges measured by the NSW EPA in its screening survey of ambient metal concentrations in the Sydney, lower Hunter and Illawarra regions (NSW DEC, 2003)

**Table 22 – Maximum *incremental* 99.9<sup>th</sup> percentile hourly and annual average heavy metal concentrations predicted due to Concurrent Stage 2, Stage 3 and Stage 4 operations**

Substance	Predicted Maximum Incremental Concentrations Across Sensitive Receptors		DECC Assessment Criteria	
	Highest Hourly, 99.9 <sup>th</sup> Percentile (µg/m <sup>3</sup> )	Annual Average (µg/m <sup>3</sup> )	DECC Hourly Impact Assessment <sup>(a)</sup> Criteria (µg/m <sup>3</sup> )	DECC Annual Air Quality Goal <sup>(b)</sup> (µg/m <sup>3</sup> )
Arsenic	0.025	1.3 x 10 <sup>-4</sup>	0.09	NC
Cadmium	0.006	3.1 x 10 <sup>-5</sup>	0.018	NC
Chromium	0.002	1.1 x 10 <sup>-5</sup>	0.09	NC
Copper	0.040	2.0 x 10 <sup>-4</sup>	18	NC
Lead	0.255	1.3 x 10 <sup>-3</sup>	NC	0.5
Mercury	0.000	6.7 x 10 <sup>-7</sup>	1.8	NC
Nickel	0.002	1.1 x 10 <sup>-5</sup>	0.18	NC
Zinc	1.110	5.6 x 10 <sup>-3</sup>	NC	NC
Sulphate	0.080	4.0 x 10 <sup>-4</sup>	NC	NC

NC – no criteria specified

(a) Specified for evaluation of incremental concentrations due to proposed projects

(b) Specified for evaluation of cumulative concentrations

Project maximum cumulative concentrations based on highest concentrations due to the proposed Project (across sensitive receptor sites, Ref. **Table 22**) and maximum background concentrations projected from monitoring data (Ref. **Table 16**) are given in **Table 23** with reference made to widely used inhalation health risk assessment criteria. Although projected cumulative arsenic and cadmium levels were noted to be elevated, primarily due to existing background concentrations, the levels of individual constituents were predicted to be within the inhalation health thresholds.

**Table 23 – Maximum *cumulative* short-term peak and annual average heavy metal concentrations predicted due to Concurrent Stage 2, Stage 3 and Stage 4 operations**

Substance	Predicted Maximum Cumulative Concentrations(a)		Inhalation Health Risk Criteria	
	Short-term Peak (µg/m <sup>3</sup> )	Annual Average (µg/m <sup>3</sup> )	Acute Exposure Criteria (µg/m <sup>3</sup> )	Chronic Exposure Criteria (µg/m <sup>3</sup> )
Arsenic	0.099	0.004	0.19(b)	0.03(b)
Cadmium	0.117	0.004	NC	0.005(c)
Copper	2.156	0.390	100(b)	NC
Mercury	0.075	0.002	1.8(b)	0.09(b)
Nickel	0.016	0.002	6(b)	0.05(b)

Zinc	1.524	0.118	120(b)	NC
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NC – no criteria specified

- (a) Projected maximum cumulative concentrations based on highest concentrations due to the proposed project (across sensitive receptor sites, Ref. Table 22) and maximum background concentrations projected from monitoring data (Ref. Table 16).
- (b) California Environmental Protection Agency Office of Environmental Health Hazard Assessment (OEHHA) reference exposure levels (OEHHA, 2008).
- (c) World Health Organisation guideline (WHO, 2000).

Given the compliance of incremental metal concentrations with DECC assessment criteria and cumulative concentrations being projected to be within inhalation health risk criteria, it is not expected that a further health risk assessment would be required due to Project-related metal exposures.

## 9 Mitigation and Monitoring Recommendations

### 9.1 Mitigation for Stage 2 to Stage 4 Operations

Dust mitigation measures assumed during the estimation of emissions for concurrent Stage 2, Stage 3 and Stage 4 operations were as follows:

- A control efficiency for wheel generated dust on unpaved roads of 75% is assumed. Preliminary modelling indicates that this is considered critical to achieving the project air quality goals, and that control efficiencies of the order of 50% will not be adequate to achieve these goals. Such a control efficiency is achievable through an effective wet or chemical suppression program, and is consistent with the application of water sprays to roads in excess of 2litres/m<sup>2</sup>/hour.
- Stockpiles are to be compressed and partially sealed by tracking over with machinery.
- It is proposed that the crusher be sited in the area of the Stage 2 cell, at a significant separation distance from the closest residential receptors at First Avenue, Boolaroo. Additionally, it is proposed that crushing activities are conducted only when low dust generating activities are being conducted, and is not conducted during early morning or late afternoon periods when inversion conditions may arise. The specification for the crusher is also proposed to include dust controls to a standard equivalent to water spraying during crushing. Alternatively, crushing of concrete may be conducted off-site, however this is not considered a good environmental outcome if on-site reuse of concrete materials is anticipated.
- Fill material in situ is kept adequately moist. Sensitivity analysis of the moisture content of the fill was conducted, indicating that moisture contents of the order of 15% may precipitate exceedances of project air quality goals. Geotechnical investigations to date (Golder Associates Pty Ltd, November 2008) indicate that average in situ fill moisture contents are of the order of 24%. The present assessment assumes some drying out of this material, and accordingly uses a moisture content of 20%.
- Fill materials would be sufficiently moist to prevent blow off of material during truck transit. Alternatively, freeboards will be increased or trucks covered.
- The potential for fill material being deposited on roadways and subsequently re-entrained by vehicles will be prevented through regulating the moisture content of material or the freeboard or covering of trucks.
- In the event that fill material is deposited it will be cleaned up in a timely manner to reduce entrainment potentials.
- Natural material stockpiles will be effectively seeded / covered before the material dries out.
- The potential for vehicle entrainment is reduced by minimising truck traffic and unpaved road lengths.

Further relevant control measures that should be considered include:

- A coordinated approach for containment cell construction to allow as much material as possible to be excavated, screened and placed directly in the cell without the need for temporary stockpiling and double handling.
- Minimisation of stockpiling (through increased direct placement), covering of stockpiles with plastic sheeting, application of stockpile wind screens, minimisation of exposed and disturbed surface areas, and various stabilisation methods.
- Use of wind screening at material transfer points.

The incorporation of the above in the management measures would further reduce the risk of adverse air quality impacts arising from the operations.

The above atmospheric dispersion modelling exercise has established that the most significant source of fugitive dust emissions from Stage 2 to 4 operations is likely to be vehicle entrainment during trucking of material, primarily from unpaved roads but also from paved roads (particularly if the silt loading on paved roads is not adequately controlled).

Unpaved road emissions could be controlled through minimising traffic volumes (e.g. through avoided double handling), wet or chemical suppression and speed regulation. Measures to address paved road emissions include the use of wheel washes or grizzlies to avoid material being tracked onto paved road surfaces, road sweeping or vacuuming, and stabilisation of road shoulders and adjoining unpaved roads.

It is anticipated that through the above dust mitigation and monitoring techniques (refer **Section 9.2**), incremental concentrations due to Stage 2-4 operations will be able to satisfy the project air quality goals.

## 9.2 Air Quality Monitoring

It is acknowledged that while all reasonable dust control activities have been provided for, the site is within an area of elevated background air quality, with the local airshed likely to be impacted by the adjacent PCCS remediation activities.

A monitoring plan to manage PM<sub>10</sub> peaks is recommended to inform dust management planning and minimise the potential for cumulative impacts.

It is recommended that IFL should replace or modify the high volume sampler at First Street to allow for PM<sub>10</sub> monitoring at this location. PM<sub>10</sub> samples should be sent to an accredited laboratory for metals analysis.

In the event that regular exceedances of this parameter are witnessed, IFL may consider the introduction of a real-time, continuous PM<sub>10</sub> monitor be placed within the vicinity of the sensitive receptors predicted to experience the highest impacts of this parameter (e.g. between 5 First Street and 20 First Street). Such an instrument would enable a proactive monitoring strategy utilising short-term trigger values at boundary monitor(s) to provide early warning of potentially unacceptable dust events, in this instance an exceedance of the 24-hour PM<sub>10</sub> goal.

The following further recommendations are made in respect of air quality monitoring for the IFL site remediation project:

- IFL dust deposition monitoring at sites DG1 to DG6 should be continued throughout the remediation project.
- IFL should cooperate with Pasminco in terms of data sharing and explore the potential of continuing the operations of certain of the long-term PCCS high volume sampler stations (and metals analysis) until the Cockle Creek remediation project is complete.

All compliance monitoring should be conducted in accordance with Australian Standards as referenced in the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* (DECC, 2005b). Of specific relevance are:

- AS 3580.10.1-2003 *Methods for Sampling and Analysis of Ambient Air - Determination of Particulates - Deposited Matter - Gravimetric Method* (DEC Method AM-19); and
- AS 3580.9.6-2003 *Particulate Matter - PM10 - high volume sampler with size-selective inlet* (DEC Method AM-18).

### **9.3 Air Quality Management Plan**

Air pollution mitigation measures and air quality monitoring should be comprehensively documented within an Air Quality Management Plan.

## 10 References

The following documents and resources have been used in the production of this report:

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AS 3580.10.1-2003 *Methods for Sampling and Analysis of Ambient Air - Determination of Particulates - Deposited Matter - Gravimetric Method*.

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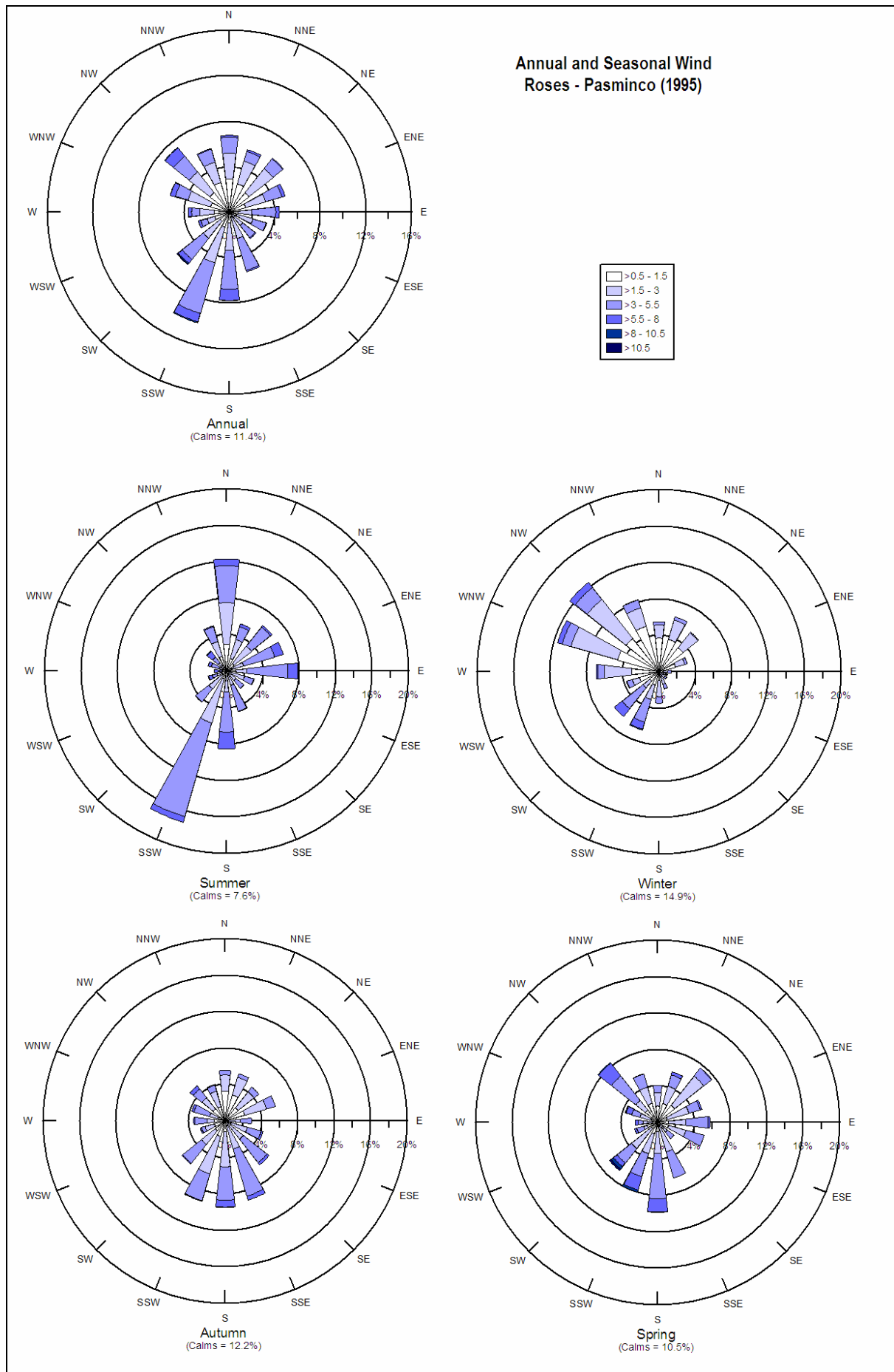
## 11 Glossary of Acronyms And Symbols

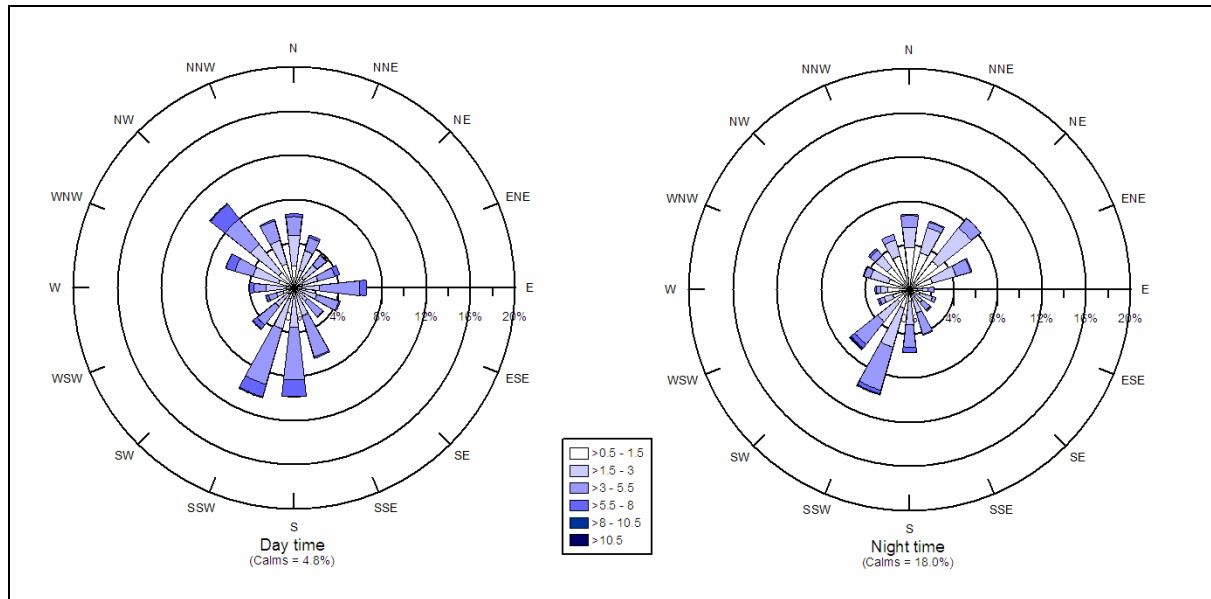
agl	above ground level
AMMAAP	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW,
ATSDR	US Federal Agency for Toxic Substances and Disease Registry
AWS	Automatic Weather Station
BoM	Australian Bureau of Meteorology
DECC	NSW Department of the Environment and Climate Change
EETM	Emission Estimation Technique Manual
ENVIRON	ENVIRON Australia Pty Ltd
ESL	Effect Screening Level, issued by TARA
HVAS	High volume air sampler
IFL	Incitec Fertilizer Limited
IPL	Incitec Pivot Limited
IRIS	USEPA Integrated Risk Information System
ISCST3	Industrial Source Complex Short Term model, Version 3
LOAEL	Lowest observed adverse effect level
mg	Milligram (g x 10 <sup>-3</sup> )
µg	Microgram (g x 10 <sup>-6</sup> )
µm	Micrometre or micron (metre x 10 <sup>-6</sup> )
m <sup>3</sup>	Cubic metre
RML	Minimum Risk Levels issued by ATSDR
Mtpa	Megatonnes per annum
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NOAEL	No observed adverse effect level
NPI	National Pollutant Inventory
OEHHA	California Office of Environmental Health Hazard Assessment
PCCS	Pasminco Cockle Creek Smelter
PM <sub>10</sub>	Particulate matter less than 10microns in aerodynamic diameter
PM <sub>2.5</sub>	Particulate matter less than 2.5microns in aerodynamic diameter
RAP	Conceptual Remediation Action Plan for the Cockle Creek Site Redevelopment (Revision 3, dated 1 July 2008) issued by Soil & Groundwater Consulting
REL	Reference Exposure Limits issued by the California OEHHA
RFC	Inhalation Reference Concentrations published by the USEPA IRIS
TAPM	"The Air Pollution Model"
TARA	Texas Natural Resource Conservation Commission Toxicology and Risk Assessment Division
TEOM	Tapered Element Oscillating Microbalance
The Project	Incitec Cockle Creek Site Remediation
TSP	Total Suspended Particulate
USEPA	United States Environmental Protection Agency
VKT	Vehicle kilometres travelled
WHO	World Health Organization

## Appendices

- Appendix 1 Wind Roses for Project Site – 1995
- Appendix 2 Incitec Cockle Creek Remediation Project Stage 1 Emissions Inventory
- Appendix 3 Incremental Suspended Particulate and Dust Deposition Isopleths  
(Concurrent Stage 2, Stage 3 and Stage 4)
- Appendix 4 Predicted Metal Concentrations at Discrete Receptor Sites (Concurrent Stage  
2, Stage 3 and Stage 4)

## **Appendix 1 Wind Roses for Project Site - 1995**





**Appendix 2  
Cockle Creek Project Stage 2, Stage 3 and  
Stage 4 Emissions Inventory and Source  
Locations**

IFL Cockle Creek Site Remediation – Stage 2 Emissions Inventory

Stage 2 Operations	Source ID	TSP Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	Emission Factor Units	Throughput (tonnes per hour)	Average number of km/hour	Working days / annum	Working hours / day	TSP / Dust Deposition Emission Rate (g/s)	PM10 Emission Rate (g/s)	PM <sub>2.5</sub> Emission Rate (g/s)
Excavator 1	E1	5.566E-05	2.632E-05	3.949E-06	kg/t	12	N/A	300	8	1.896E-04	8.968E-05	1.345E-05
Dozer	DR1	6.901E-01	1.271E-01	1.907E-02	kg/h	N/A	N/A	300	5.5	1.917E-01	3.531E-02	5.296E-03
Paved Roads	PVST2A	1.523E+00	2.919E-01	4.180E-02	kg/VKT	N/A	0.1	300	10	2.153E-02	4.125E-03	5.906E-04
Paved Roads	PVST2B	1.523E+00	2.919E-01	4.180E-02	kg/VKT	N/A	0.4	300	10	1.758E-01	3.368E-02	4.823E-03
Unpaved Roads	UPVST2	3.769E+00	1.077E+00	1.154E-01	kg/VKT	N/A	0.0	300	10	3.556E-02	1.016E-02	1.089E-03
Materials Handling - Fill	MHF1	5.566E-05	2.632E-05	3.949E-06	kg/t	10	N/A	300	10	1.517E-04	7.175E-05	1.076E-05
Materials Handling - Natural	MHN1	2.007E-04	9.495E-05	1.424E-05	kg/t	4	N/A	300	10	1.999E-04	9.455E-05	1.418E-05
Stockpile Wind Erosion	STK1	Temporally Varying - Wind Dependent				N/A	N/A	N/A	N/A			
Screening	SCR	1.100E-03	3.700E-04	2.500E-05	kg/t	28	N/A	300	10	8.477E-03	2.851E-03	1.927E-04

IFL Cockle Creek Site Remediation – Stage 3 Emissions Inventory

Stage 2 Operations	Source ID	TSP Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	Emission Factor Units	Throughput (tonnes per hour)	Average number of km/hour	Working days / annum	Working hours / day	TSP / Dust Deposition Emission Rate (g/s)	PM10 Emission Rate (g/s)	PM <sub>2.5</sub> Emission Rate (g/s)
Excavator 4	E4	5.566E-05	2.632E-05	3.949E-06	kg/t	22	N/A	300	8	3.465E-04	1.639E-04	2.458E-05
Paved Roads	PVST3	1.523E+00	2.919E-01	4.180E-02	kg/VKT	N/A	0.0	130	10	2.117E-01	1.716E-02	1.992E-04
Materials Handling - Fill	MHST3	5.566E-05	2.632E-05	3.949E-06	kg/t	41	N/A	130	10	6.397E-04	3.026E-04	4.539E-05

IFL Cockle Creek Site Remediation – Stage 4 Emissions Inventory

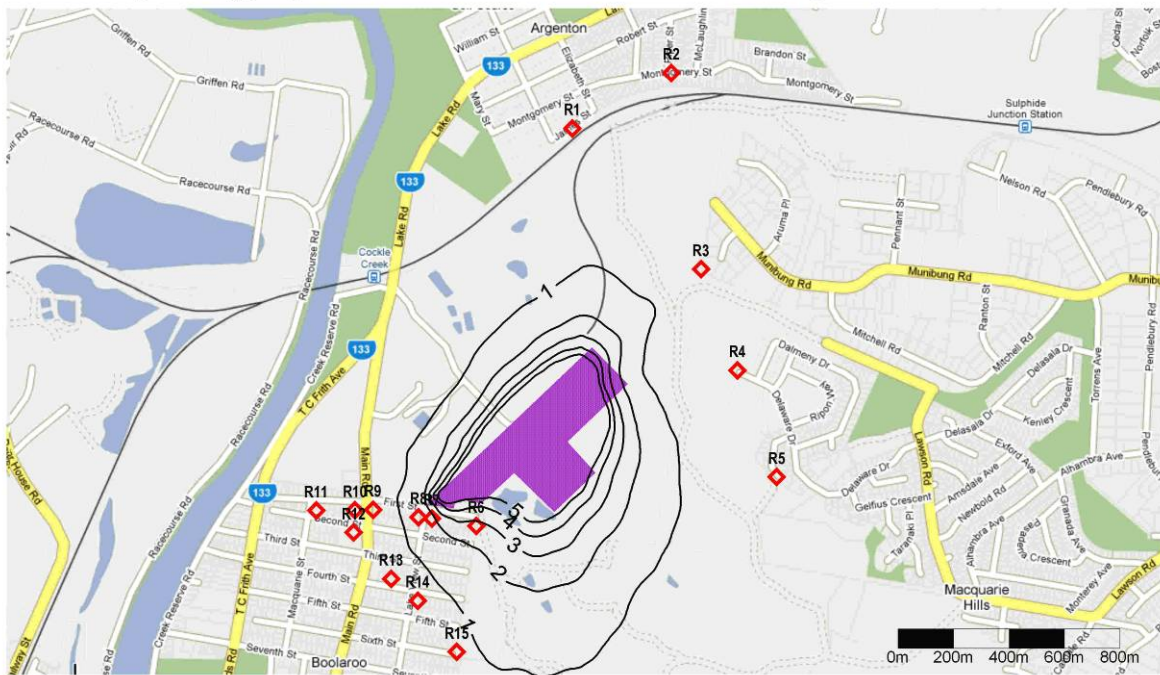
Stage 4 Operations	Source ID	TSP Emission Factor	PM10 Emission Factor	PM2.5 Emission Factor	Emission Factor Units	Throughput (tonnes per hour)	Average number of km/hour	Working days / annum	Working hours / day	TSP / Dust Deposition Emission Rate (g/s)	PM10 Emission Rate (g/s)	PM <sub>2.5</sub> Emission Rate (g/s)
Excavator 2	EX2	5.566E-05	2.632E-05	3.949E-06	kg/t	13	N/A	300	8	1.970E-04	9.320E-05	1.398E-05
Excavator 3	E3	5.566E-05	2.632E-05	3.949E-06	kg/t	13	N/A	300	8	1.970E-04	9.320E-05	1.398E-05
Dozer	DR2	6.901E-01	1.271E-01	1.907E-02	kg/h	N/A	N/A	300	0.5	1.917E-01	3.531E-02	5.296E-03
Paved Roads	PVST4A	1.523E+00	2.919E-01	4.180E-02	kg/VKT	N/A	0.0	300	10	1.892E-01	3.626E-02	5.192E-03
Paved Roads	PVST4B	1.523E+00	2.919E-01	4.180E-02	kg/VKT	N/A	0.0	300	10	6.920E-02	1.326E-02	1.899E-03
Unpaved Roads	UPVST4	3.769E+00	1.077E+00	1.154E-01	kg/VKT	N/A	0.0	300	10	8.561E-02	2.446E-02	2.621E-03
Crusher	CR	1.000E-02	4.000E-03	6.000E-04	kg/t	48	N/A	300	10	1.333E-01	5.333E-02	8.000E-03
Materials Handling - Fill	MHF2	5.566E-05	2.632E-05	3.949E-06	kg/t	31	N/A	300	10	4.729E-04	2.237E-04	3.355E-05
Stockpile Wind Erosion	STK2	Temporally Varying - Wind Dependent				N/A	N/A	N/A	N/A			
Screening	SCR2	1.100E-03	3.700E-04	2.500E-05	kg/t	31	N/A	300	10	9.346E-03	3.144E-03	2.124E-04
Front End Loader 1	FEL1	5.566E-05	2.632E-05	3.949E-06	kg/t	13	N/A	300	8	1.970E-04	9.320E-05	1.398E-05

**Appendix 3  
Incremental Suspended Particulate and  
Dust Deposition Isopleth Plots (Concurrent  
Stage 2, Stage 3 and Stage 4)**

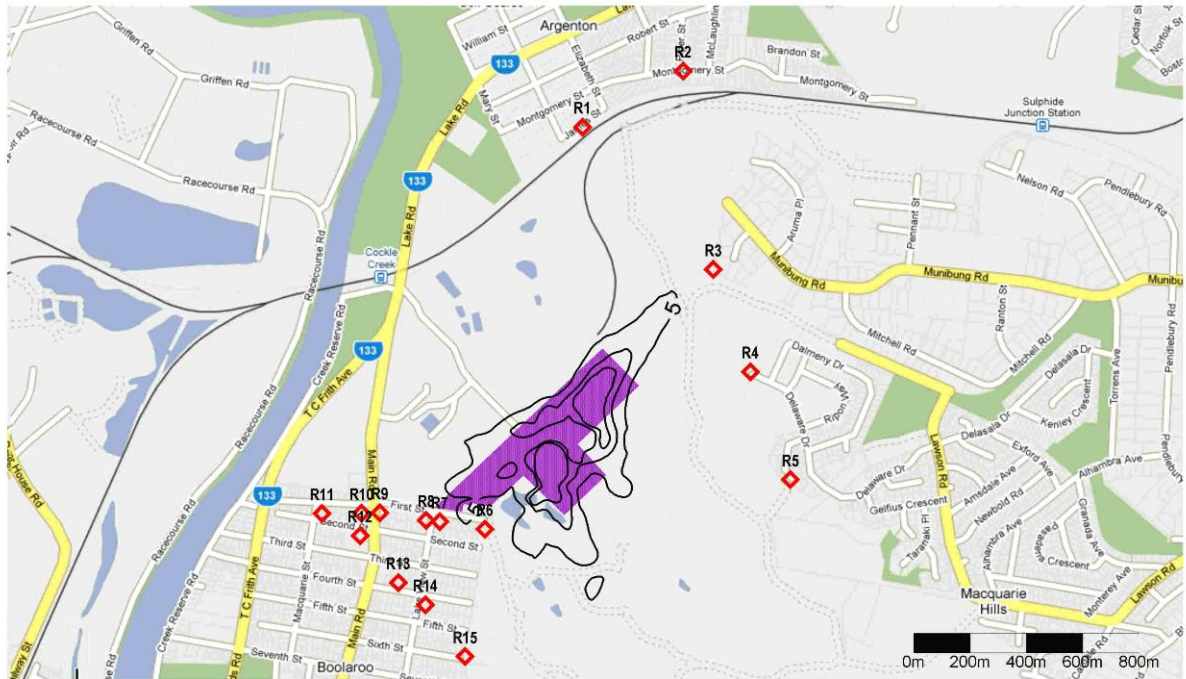
Maximum 24-hour Average PM10 ( $\mu\text{g}/\text{m}^3$ ) due to IPL Cockle Creek Remediation Concurrent Stages 2 to 4 Emissions



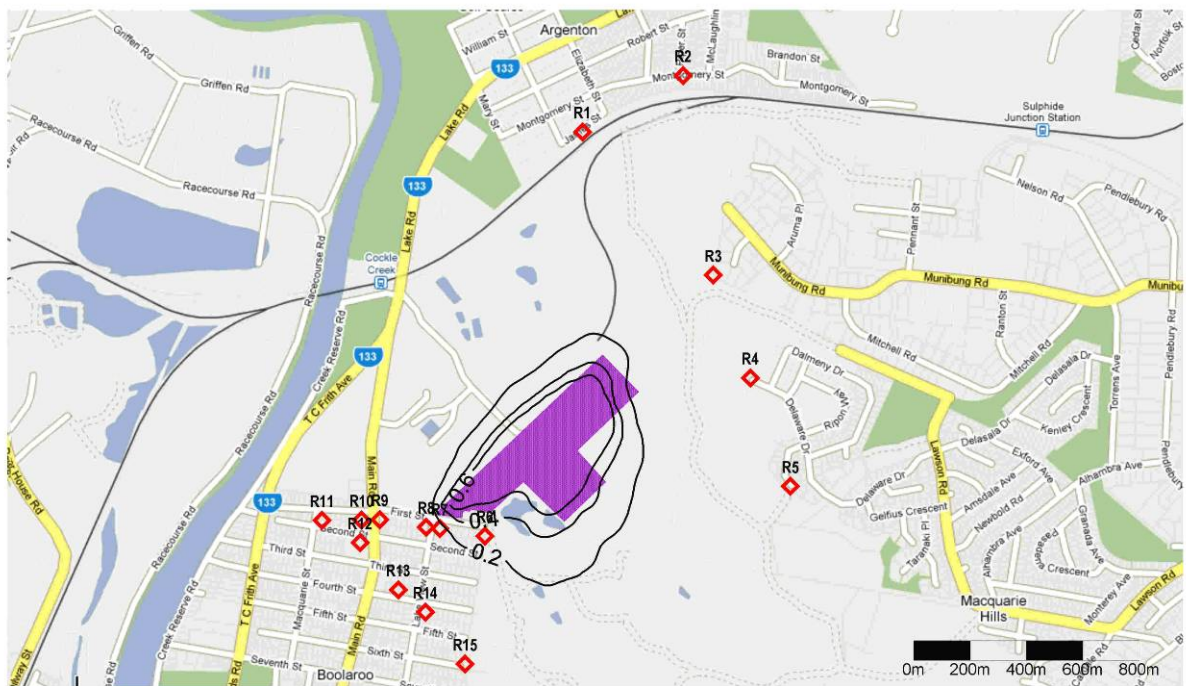
Annual Average PM10 ( $\mu\text{g}/\text{m}^3$ ) due to IPL Cockle Creek Remediation Concurrent Stages 2 to 4 Emissions



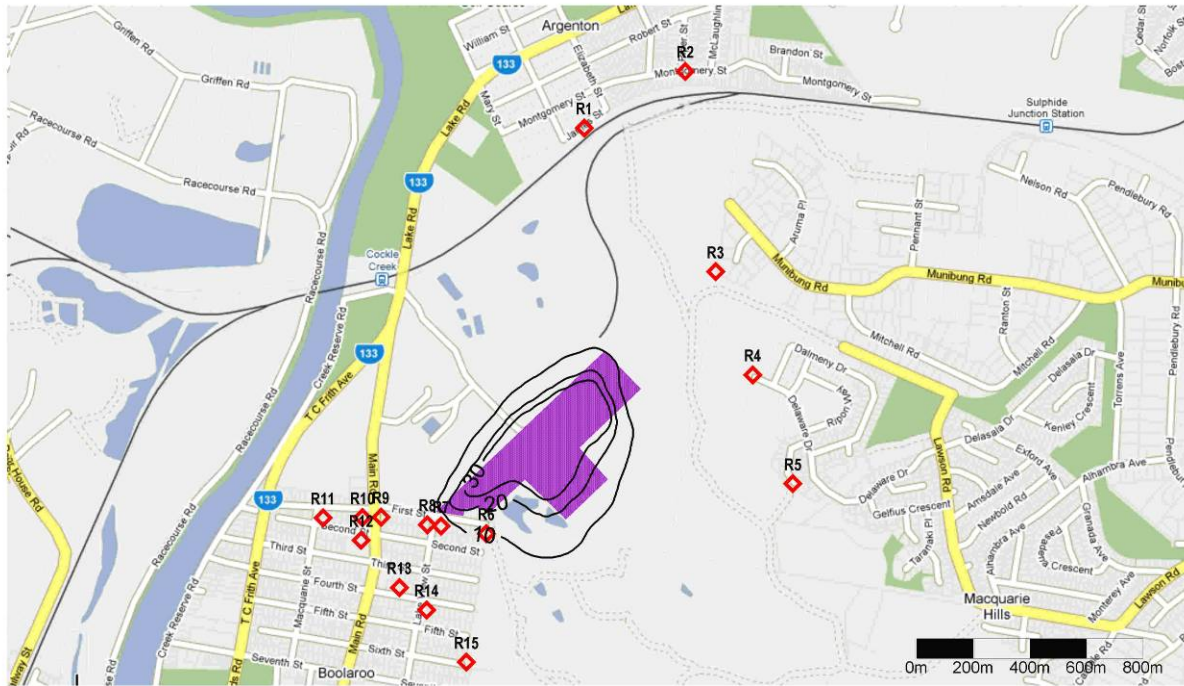
Maximum 24-hour Average PM2.5 ( $\mu\text{g}/\text{m}^3$ ) due to IPL Cockle Creek Remediation Concurrent Stages 2 to 4 Emissions



Annual Average PM2.5 ( $\mu\text{g}/\text{m}^3$ ) due to IPL Cockle Creek Remediation Concurrent Stages 2 to 4 Emissions



Annual Average TSP ( $\mu\text{g}/\text{m}^3$ ) due to IPL Cockle Creek Remediation Concurrent Stages 2 to 4 Emissions





**Appendix 4  
Heavy Metal Concentrations at Nearby  
Sensitive Receptor Sites (Stages 2 to 4)**

	Receptor Location	Highest Hourly Average Concentration ( $\mu\text{g}/\text{m}^3$ ) due to IFL Cockle Creek Remediation Project Concurrent Stage 2, Stage 3 and Stage 4 Emissions								
		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Sulphate
R1	James St, Argenton	1.1E-02	2.7E-03	9.0E-04	1.7E-02	1.1E-01	5.7E-05	9.3E-04	4.8E-01	3.5E-02
R2	Montgomery St, Argenton	1.3E-02	3.2E-03	1.1E-03	2.1E-02	1.3E-01	6.9E-05	1.1E-03	5.8E-01	4.2E-02
R3	Cardiff Industrial Estate	6.2E-02	1.5E-02	5.2E-03	1.0E-01	6.4E-01	3.3E-04	5.3E-03	2.8E+00	2.0E-01
R4	Delaware Dr, Macquarie Hills	3.2E-02	7.7E-03	2.6E-03	5.1E-02	3.2E-01	1.7E-04	2.7E-03	1.4E+00	1.0E-01
R5	Hillview Cr, Macquarie Hills	2.6E-02	6.3E-03	2.1E-03	4.2E-02	2.6E-01	1.4E-04	2.2E-03	1.1E+00	8.3E-02
R6	First St 1, Boolaroo	4.3E-02	1.1E-02	3.6E-03	7.0E-02	4.4E-01	2.3E-04	3.7E-03	1.9E+00	1.4E-01
R7	First St 2, Boolaroo	4.8E-02	1.2E-02	4.0E-03	7.7E-02	4.9E-01	2.5E-04	4.1E-03	2.1E+00	1.5E-01
R8	First St 3, Boolaroo	3.7E-02	9.0E-03	3.0E-03	5.9E-02	3.7E-01	1.9E-04	3.1E-03	1.6E+00	1.2E-01
R9	First St 4, Boolaroo	1.4E-02	3.4E-03	1.2E-03	2.3E-02	1.4E-01	7.4E-05	1.2E-03	6.2E-01	4.5E-02
R10	First St 5, Boolaroo	1.3E-02	3.2E-03	1.1E-03	2.1E-02	1.3E-01	6.9E-05	1.1E-03	5.8E-01	4.2E-02
R11	First St West, Boolaroo	1.0E-02	2.5E-03	8.5E-04	1.6E-02	1.0E-01	5.4E-05	8.8E-04	4.5E-01	3.3E-02
R12	Boolaroo School	1.7E-02	4.1E-03	1.4E-03	2.7E-02	1.7E-01	8.8E-05	1.4E-03	7.4E-01	5.3E-02
R13	Fourth St, Boolaroo	2.5E-02	6.2E-03	2.1E-03	4.1E-02	2.6E-01	1.3E-04	2.2E-03	1.1E+00	8.1E-02
R14	Lake View St, Boolaroo	4.0E-02	9.9E-03	3.4E-03	6.5E-02	4.1E-01	2.1E-04	3.5E-03	1.8E+00	1.3E-01
R15	Sixth St, Boolaroo	1.1E-02	2.6E-03	8.8E-04	1.7E-02	1.1E-01	5.6E-05	9.0E-04	4.7E-01	3.4E-02

	Receptor Location	Annual Average Concentration ( $\mu\text{g}/\text{m}^3$ ) due to IFL Cockle Creek Remediation Project Concurrent Stage 2, Stage 3 and Stage 4 Emissions								
		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Sulphate
R1	James St, Argenton	3.5E-05	8.5E-06	2.9E-06	5.6E-05	3.5E-04	1.8E-07	3.0E-06	1.5E-03	1.1E-04
R2	Montgomery St, Argenton	2.6E-05	6.3E-06	2.1E-06	4.1E-05	2.6E-04	1.3E-07	2.2E-06	1.1E-03	8.2E-05
R3	Cardiff Industrial Estate	9.9E-05	2.4E-05	8.2E-06	1.6E-04	1.0E-03	5.2E-07	8.5E-06	4.4E-03	3.2E-04
R4	Delaware Dr, Macquarie Hills	2.7E-05	6.7E-06	2.3E-06	4.4E-05	2.8E-04	1.4E-07	2.3E-06	1.2E-03	8.7E-05
R5	Hillview Cr, Macquarie Hills	3.2E-05	7.9E-06	2.7E-06	5.2E-05	3.3E-04	1.7E-07	2.7E-06	1.4E-03	1.0E-04
R6	First St 1, Boolaroo	1.3E-04	3.1E-05	1.1E-05	2.0E-04	1.3E-03	6.7E-07	1.1E-05	5.6E-03	4.0E-04
R7	First St 2, Boolaroo	6.3E-05	1.5E-05	5.2E-06	1.0E-04	6.4E-04	3.3E-07	5.3E-06	2.8E-03	2.0E-04
R8	First St 3, Boolaroo	4.4E-05	1.1E-05	3.7E-06	7.1E-05	4.5E-04	2.3E-07	3.8E-06	2.0E-03	1.4E-04
R9	First St 4, Boolaroo	2.9E-05	7.2E-06	2.4E-06	4.7E-05	3.0E-04	1.5E-07	2.5E-06	1.3E-03	9.3E-05
R10	First St 5, Boolaroo	2.4E-05	6.0E-06	2.0E-06	3.9E-05	2.5E-04	1.3E-07	2.1E-06	1.1E-03	7.8E-05
R11	First St West, Boolaroo	1.7E-05	4.1E-06	1.4E-06	2.7E-05	1.7E-04	8.9E-08	1.4E-06	7.5E-04	5.4E-05
R12	Boolaroo School	2.0E-05	4.8E-06	1.6E-06	3.1E-05	2.0E-04	1.0E-07	1.7E-06	8.7E-04	6.2E-05
R13	Fourth St, Boolaroo	1.4E-05	3.5E-06	1.2E-06	2.3E-05	1.4E-04	7.5E-08	1.2E-06	6.3E-04	4.5E-05
R14	Lake View St, Boolaroo	1.6E-05	4.0E-06	1.4E-06	2.6E-05	1.7E-04	8.6E-08	1.4E-06	7.2E-04	5.2E-05
R15	Sixth St, Boolaroo	1.7E-05	4.1E-06	1.4E-06	2.7E-05	1.7E-04	8.8E-08	1.4E-06	7.4E-04	5.3E-05

