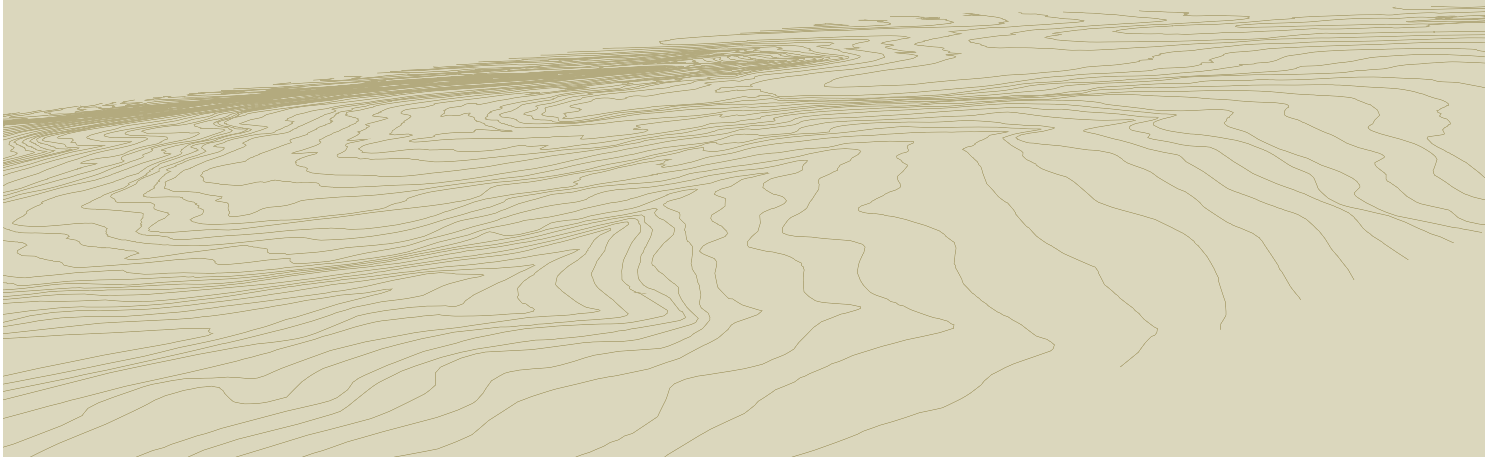
Appendix O

Holmes Air Sciences, 2009: Air Quality Assessment Report

ARMIDALE REGIONAL LANDFILL
Environmental Assessment



AIR QUALITY IMPACT ASSESSMENT - DRAFT
PROPOSED ARMIDALE LANDFILL

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Prepared for

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1 INTRODUCTION

This report has been prepared by Holmes Air Sciences on behalf of Maunsell Australia Pty Ltd. The purpose of the report is to assess the air quality impacts from the operation of a proposed landfill near Armidale, NSW. The report assesses the impact of dust and odour emissions from the proposed facility.

The report presents the results of computer-based dispersion modelling for the proposed landfill. The impacts of emissions have been assessed by comparing predicted odour and dust levels with relevant air quality criteria. Modelling was undertaken in accordance with the Department of Environment and Conservation "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (**NSW DEC, 2005**) using AUSPLUME version 6.0.

2 PROJECT DESCRIPTION

The proposed landfill will have a capacity of 750,000 tonnes, accommodating waste from Armidale City, Dumaresq and Uralla Shire Councils over a fifty year period. This equates to approximately 15,000 tonnes per year. This new facility will replace the existing landfill on Long Swamp Road. The existing waste transfer station will operate as the receival and recycling station for the proposed landfill.

The site of the proposed landfill is located approximately 12 km to the east of Armidale on Waterfall Way, as shown in **Figure 1**. The site comprises land from 'Edington' and 'Sherraloy' properties. **Figure 2** shows the layout of the proposed landfill including the proposed leachate pond and cell locations. The closest receivers to the project are to the south of the site (Crisp residence) and west of the site (Quaife residence). Other nearby receivers are located to the north and east of the site (Waters).

The proposed landfill will typically operate from 6am to 5:30pm Monday to Friday, and 8am to 6:30pm on weekends and public holidays. Construction hours will be from 7am to 5pm Monday to Friday and 8am to 5pm on Saturdays. Waste will be hauled to the site from the transfer station in 20 tonne transfer vehicles. Access roads up to the main landfill area from Waterfall Way will be sealed with an unsealed circuit around the tipping area. A wheel wash will be located at each end of the sealed access road.

Landfill activities will progress in a northerly direction through five cells as shown in **Figure 2**. While the cells are being filled, a daily cover will be placed over the waste overnight comprising material excavated on-site. A bulldozer will be used to shape the active tipping face and push the cover material. An excavator, compactor and bogie tipper will also be used on the site. Leachate material will be collected in a temporary pond to the east of the landfill, and in the final leachate pond after the completion of Cell 3. Cells will be capped and rehabilitated when the final height has been reached.

Dust will be generated primarily from vehicles on unpaved surfaces. A water cart will be used for dust suppression. Dumping of waste, shaping of the tipping face and wind erosion are also dust emitting activities.

While green waste and recycling material will be processed at the Long Swamp Road waste facility, the solid waste to be used for the landfill will still contain organic material. This will include paper, cardboard and wood products as well as putrescibles material. Whenever biodegradable material is deposited in a landfill site, landfill gas will be produced due to microbial activity. The majority of the landfill gas will consist of carbon dioxide and methane but there are also other trace gases produced. These include organic sulphides and volatile fatty acids which give the gas its characteristic odour. Landfill gas produced at the proposed landfill will be collected and treated over time during its operational life.

Odour from the landfill will be emitted from the active tipping face, leachate storage and risers, gas infrastructure, and daily and intermediate cover areas.

3 METEOROLOGY AND CLIMATE

The rate at which pollutants are dispersed is dependent on meteorological conditions including wind speed, wind direction, atmospheric stability class[1] and mixed-layer height[2]. This section describes the dispersion meteorology and climate of the study area. It provides information on prevailing wind patterns as well as historical data on temperature, humidity and rainfall. Hourly meteorological data are required by the dispersion model used in this study. The source of these data is discussed below.

3.1 Dispersion Meteorology

Meteorological data are collected by the Bureau of Meteorology at Armidale Airport using an automatic weather station. Cloud cover data was sourced from Glenn Innes from 2000. These data were used along with the concurrent wind speed data from Armidale Airport in 2000 to calculate hourly atmospheric stability using the method of **Turner** (**1970**).

Figure 4 presents annual and seasonal windroses compiled from wind speed data collected at the Armidale Airport in 2000. On an annual basis the winds are predominantly from the east, west and east-northeast. In summer and autumn, the easterly winds are the most common, while in winter the westerly winds dominate. In spring the winds are most often strong and from the west, however easterly and east-northeasterly winds are also common.

Stability is usually assigned according to six classes, A to F (see Footnote 1). The frequency of occurrence of each stability category expected in the Armidale area is shown in **Table 1**. The high frequency of D class stabilities (48.8%) indicates that emissions will disperse quickly for a significant proportion of the time. Joint wind speed, wind direction and stability class frequency tables for the 2000 data set are presented in **Appendix A**.

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

[2] The term mixed-layer height, refers to the height above the ground through which ground-based emissions will eventually be dispersed once a plume has been thoroughly mixed. An elevated plume, initially above the mixed-layer height will remain isolated from the ground until such time as the mixed-layer height reaches the height of the plume. In general the mixed-layer height will increase during the day as the sun causes convection to deepen the turbulent layer of the atmosphere close to the ground. Mixed-layer height will also increase if the wind speed increases because higher wind speeds will increase turbulence as the wind blows over the rough ground.

Table 1 – Frequency of occurrence of stability classes at Armidale	
Stability class	**Percentage frequency of occurrence**
A	1.9
B	8.2
C	14.1
D	48.8
E	11.4
F	15.6
Total	**100.0**

3.2 Climate

Table 2 presents average temperature, humidity and rainfall data from Armidale Airport (**Bureau of Meteorology, 2006**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean and median monthly rainfall and the average number of raindays per month.

The annual average maximum and minimum temperatures experienced at Armidale are 20.3°C and 7.1°C respectively. On average January is the hottest month with an average maximum temperature of 27.1°C. July is the coldest month, with average minimum temperature of 0.3°C.

The annual average humidity reading collected at 9 am from the Armidale site is 68 percent, and at 3 pm the annual average is 47 percent. The month with the highest humidity on average is June with a 9 am average of 80 percent, and the lowest is November with a 3 pm average of 41 percent.

Rainfall data collected at Armidale shows that January is the wettest month, with an average rainfall of 104.5 mm over 10 days. The average annual rainfall is 790.1 mm with an average of 109 raindays.

Figure 5 shows a plot of the monthly average temperature and rainfall over the year. The graph shows that there is a strong seasonal pattern for both temperature and rainfall, with most rainfall occurring in the warmer summer months.

Table 2 – Temperature, humidity and rainfall data for Armidale Airport

(Station number 56002; Commenced: 1857, Last record: 1997; Latitude (deg S): -30.5167; Longitude (deg E): 151.6681)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Dry-bulb and Wet-bulb Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	19.8	18.8	17.0	13.6	9.1	6.0	4.8	6.9	11.3	15.4	17.7	19.8	13.3
Wet-bulb	15.9	15.6	14.0	11.0	7.3	4.6	3.2	4.8	7.9	11.1	13.3	15.1	10.3
Humidity	65	70	71	72	78	80	77	71	61	58	58	59	68
3 pm Mean Dry-bulb and Wet-bulb Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	25.3	24.6	22.6	19.4	15.2	12.1	11.4	13.1	16.5	19.7	22.5	24.5	18.9
Wet-bulb	17.7	17.6	16.0	13.4	10.5	8.4	7.3	8.1	10.3	12.9	14.9	16.7	12.8
Humidity	45	48	48	48	53	58	53	47	42	43	41	43	47
Daily Maximum Temperature (°C)													
Mean	27.1	26.1	24.1	20.6	16.4	13.1	12.2	14.2	17.6	21.2	24.3	26.5	20.3
Daily Minimum Temperature (°C)													
Mean	13.4	13.3	11.3	7.5	3.9	1.6	0.3	1.1	3.7	7.0	9.8	12.2	7.1
Rainfall (mm)													
Mean	104.5	87.1	65.0	45.9	44.4	56.9	49.2	48.4	51.6	67.8	80.4	89.2	790.1
Median	91.6	72.3	53.9	39.4	35.2	48.3	43.3	42.0	47.0	62.2	75.0	80.2	767.7
Raindays (Number)													
Mean	10.3	9.7	9.5	7.9	8.3	9.9	8.9	8.5	7.7	9.0	9.3	10.0	108.9

Source: Bureau of Meteorology (2006)

3.3 Existing air quality

The project site is located in a rural agricultural area where background levels of pollution are typically low. Particulate matter comes from a multitude of sources and the concentration of particulates in the air is highly variable. The main source of particulate emissions will be from domestic wood fired heaters. Bushfires and wind-blown dust also have the potential to cause 24-hour average PM_{10} exceedances.

No air quality monitoring has been carried out specifically for this project, however as will be seen later in **Section 7.1**, the contribution of dust emissions from proposed activities to the local environment is predicted to be small. The existing background levels would be expected to be well within the current DEC criteria, except in extreme weather events such as dust storms and bushfires, when the 24-hour average PM_{10} goal may be exceeded.

4 AIR QUALITY ISSUES

4.1 Dust

The DEC has set out assessment procedures in a document entitled “Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales” (**NSW DEC, 2005**). This document includes methodology for the use of models and sets out relevant air quality criteria for PM_{10}, TSP, and dust deposition to be used in modelling assessments.

Table 3 and **Table 4** summarise the air quality assessment criteria that are relevant to this project. The air quality goals relate to the total dust burden in the air and not just the dust from the project.

Air quality at any particular location is determined by emissions from many sources, which will contribute various proportions to the overall pollutant burden in the air. This will depend on the location in relation to the dust source and on dispersion conditions and is particularly true in the case of particulate matter, where there are a large number of sources including agriculture, traffic, bushfires, wood fired heaters, and local and remote wind erosion sources.

Table 3 – NSW DEC criteria for particulate matter concentrations

POLLUTANT	STANDARD / GOAL	AVERAGING PERIOD	AGENCY
Total suspended particulate matter (TSP)	90 $\mu g/m^3$	Annual mean	National Health & Medical Research Council
Particulate matter < 10 μm (PM_{10})	50 $\mu g/m^3$	24-hour maximum	DEC
	30 $\mu g/m^3$	Annual mean	DEC long-term reporting goal
	50 $\mu g/m^3$	(24-hour average, 5 exceedances permitted per year)	National Environment Protection Council

In addition to health impacts, airborne dust also has the potential to cause nuisance impacts by depositing on surfaces. **Table 4** shows the maximum acceptable increase in dust deposition over the existing dust levels. The criteria for dust fallout levels are set to protect against nuisance impacts (**NSW DEC, 2005**).

Table 4 – NSW DEC criteria for dust fallout

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

4.2 Odour emissions

Odour is measured using panels of people who are presented with samples of odorous gas diluted with decreasing quantities of clean odour-free air. The panellists then note when the smell becomes detectable. Odour in the air is then quantified in terms of odour units which is the number of dilutions required to bring the odour to a level at which 50% of the panellists can just detect the odour, defined as one odour unit. This process is known as olfactometry.

The determination of air quality goals for odour and their use in the assessment of odour impacts is recognised as a difficult topic in air pollution science. The topic has received considerable attention in the past five years and the procedures for assessing odour impacts have been refined considerably.

Odour impacts are determined by several factors, the most important of which are:

- the **F**requency of the exposure
- the **I**ntensity of the odour
- the **D**uration of the odour episodes
- the **O**ffensiveness of the odour and
- the **L**ocation of the source (the so-called FIDOL factor)

In determining the offensiveness of an odour it needs to be recognised that for most odours the context in which an odour is perceived is also relevant. Some odours, for example the smell of sewage, hydrogen sulphide, butyric acid, and including landfill gas, are likely to be judged offensive regardless of the context in which they occur. Other odours such as the smell of jet fuel may be acceptable at an airport, but not in a house, and diesel exhaust may be acceptable near a busy road, but not in a restaurant.

Whether or not an individual considers an odour to be a nuisance will depend on the FIDOL factors outlined above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

The NSW DEC have developed a draft policy "*Assessment and Management of Odour from Stationary Sources in NSW"* (**NSW EPA, 2001**) which includes some recommendations for odour criteria. They have been refined by the DEC to take account of population density in the area. **Table 5** lists the odour certainty[3] thresholds, to be exceeded not more than 1% of the time, for different population densities (**NSW DEC, 2005**).

Table 5 – Odour performance criteria for the assessment of odour

Population of affected community	Odour performance criteria (nose response odour certainty units at the 99th percentile)
Single residence (≤ ~2)	7
~10	6
~ 30	5
~ 125	4
~ 500	3
Urban (~ 2000)	2

The difference between odour goals is based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area. The goals assume that 7 odour units at the 99th percentile would be acceptable to the average person, but as the number of exposed people increases there is a chance that sensitive individuals would be exposed. The goal of 2 odour units at the 99th percentile is considered to be acceptable for the whole population. The population density in the area around the site

[3] In the process of odour measurement, the odour certainty threshold is, by definition, the minimum concentration at which the panellist is certain they can detect the odour.

is equivalent to a single residence. On this basis the odour criterion of 7 ou has been applied to the project.

It is common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because Gaussian dispersion models are only able to directly predict concentrations over an averaging period of three-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a three-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

To determine more rigorously the ratio between the one-second peak concentrations and three-minute and longer period average concentrations (referred to as the peak to mean ratio) that might be predicted by a Gaussian dispersion model, the NSW DEC commissioned a study by **Katestone Scientific Pty Ltd (1995, 1998)**. This study recommended peak to mean ratios for a range of source types. The ratio is also dependent on atmospheric stability and the distance from the source. A summary table of these ratios is presented in **Appendix B.** In this case peak to mean factors for area sources in the near field are relevant. The peak to mean ratios are 2.5 for unstable to neutral atmosphere conditions and 2.3 for stable atmosphere conditions.

The NSW DEC publication 'Draft Policy: Assessment and Management of Odour from Stationary Sources in NSW' (**NSW EPA, 2001**) takes account of this peaking factor and the goals shown in **Table 5** are based on nose-response time.

5 EMISSION ESTIMATES

5.1 Situation Analysis

Scenarios have been chosen to represent activities that will be occurring at a point in time within Stages 0-10 years, 10-20 years and 40-50 years of the landfill as shown in Figure 3. The location of the excavation area, tipping face and daily cover within the active cell will change throughout each 10 year period. The tipping face has been calculated as being an area of 32 square meters for daily tipping, based on a 15,000 tonnes per annum assumption. The tipping face is the only area of exposed waste and will be exposed during operational hours of the landfill only. The tipping face will be covered at the end of the day.

The following three scenarios were modeled to predict the maximum dust impacts from the landfill:

0-10 years
- Tipping face in Cell 1, part b
- Daily cover in Cell 1, parts a and b
- Excavation in Cell 1, parts c and d
- Stockpile in western section of Cell 2

10-20 years
- Tipping face in Cell 2, part b
- Daily cover in Cell 2, parts a and b
- Excavation in Cell 2, parts c and d
- Stockpile in western section of Cell 3
- Intermediate cover over Cell 1

40-50 years
- Tipping face in Cell 5, part c
- Daily cover in Cell 5, parts c and d
- No excavation
- Stockpile to the north of the landfill

- Intermediate cover over Cell 5 parts a and b, and Cell 4
- Final cover over Cells 1, 2 and 3

5.2 Dust emissions

Dust emissions arise from various activities at landfills. Total dust emissions due to the operations of the proposed landfill have been estimated by analysing the excavation and landfilling operations for three stages of the proposal. Rates of excavation and landfilling for each stage have been adjusted to determine rates on a yearly basis.

Estimated dust emissions of Total Suspended Particulates (TSP) are presented in **Table 6**. To show how these values have been calculated, details of the calculations for Staging 10-20 years are presented in **Appendix C**. These estimates assume that 75% control of dust is achievable due to the watering of haul roads. Regular watering on unsealed haul routes has been assumed for the purposes of the dust emission calculations.

The operations which apply in each case have been combined with emission factors developed, both locally and by the US EPA, to estimate the amount of dust produced by each activity. Haul road distances and routes, landfill areas, activity operating hours, truck movements and other details have been provided by Maunsell in order to estimate the dust emissions for the operations.

Table 6 – Dust emission estimates

Activity	TSP (kg/y)		
	Staging 0-10 years	**Staging 10-20 years**	**Staging 40-50 years**
Excavation			
Removing topsoil	1004	1004	-
Excavators in pit	3462	2935	-
Hauling material to stockpile	9233	7826	-
Dumping material at stockpile	371	314	-
Dozers shaping tipping face	23429	23429	-
Landfilling			
Dozers working in landfill (4h/d)	19600	19600	19600
Hauling waste on sealed road	121	121	121
Hauling waste on unsealed road	400	400	56
Dumping waste	3	2.8	3
Scraping and transporting cover material	118	118	128
Shaping covered area	23429	23429	23429
Wind erosion from exposed landfill excavation areas	3044	2840	2876
Wind erosion from stockpiles	1135	1135	1135

5.3 Odour emissions

Odour emission rates from area sources, such as landfills, are difficult to measure for a variety of reasons. Firstly the source is often heterogeneous. For example in the case of landfill sites, there will be different odour emission rates from different sections of the landfill. Secondly, unlike stack emissions, area emission rates are dependent upon atmospheric conditions including wind speed, degree of turbulence, temperature, etc. This adds another level of complexity to odour assessments.

A detailed odour measurement study was carried out by **Zib and Associates** (**2002**) for Eastern Creek Landfill (Stage 2) in western Sydney. Measurements were made on the major sources from the site, including the open face, 1-day cover, intermediate cover, restored surface and leachate pond. The leachate pond odour emission rate at Eastern Creek Landfill was 0.17 $ou.m^3/s/m^2$. A higher leachate pond odour emission rate of 0.28 $ou.m^3/s/m^2$ has been recorded by Holmes Air Sciences at another landfill in Sydney with a similar total leachate pond surface area to the proposed Armidale Landfill leachate pond. The results from this other odour testing are not currently in the public domain, however they represent the most conservative odour emission rate for this source and have therefore been used in this assessment.

Table 7 provides the quantitative information on odour emissions for the dispersion modelling. Three stages of operation have been modelled. These scenarios are described in more detail in **Section 6.1**. Odour emissions in the dispersion model have been multiplied by the recommended peak to mean ratios for different source types (see **Appendix A**) to predict odour levels for nose-response times. Peak to mean factors for the near field have been applied for the purposes of this assessment. For area sources, these factors have numerical values of 2.5 for unstable and neutral atmospheric conditions and 2.3 for stable conditions.

Table 7 – Estimated near field odour emissions for the proposed Armidale Landfill

Staging	Source	Area (m^2)	Odour emission rate ($ou.m^3/s/m^2$)	Peak odour emission rate (Neutral) P/M = 2.5 ($ou.m^3/s/m^2$)	Peak odour emission rate (Stable) P/M = 2.3 ($ou.m^3/s/m^2$)	Total emissions (ou.m3/s) neutral	Total emissions (ou.m3/s) stable
0-10 years	Leachate pond	2970	0.28	0.7	0.644	2079	1913
	Active tipping face	32	7.06	17.65	16.24	565	520
	1-day cover	15516	0.35	0.875	0.805	13576	12490
10-20 years	Leachate pond	2970	0.28	0.7	0.644	2079	1913
	Active tipping face	32	7.06	17.65	16.24	565	520
	1-day cover	15191	0.35	0.875	0.805	13292	12229
	Intermediate	34694	0.1	0.25	0.23	8674	7980
40-50 years	Leachate pond	2970	0.28	0.7	0.644	2079	1913
	Active tipping face	32	7.06	17.65	16.24	565	520
	1-day cover	15998	0.35	0.875	0.805	13998	12879
	Intermediate	50958	0.1	0.25	0.23	3811	3506
	Final capping	103403	0.05	0.125	0.115	8929	8214

6 APPROACH TO ASSESSMENT

6.1 Dust

The model used to predict dust impacts was the US EPA ISCST3 model (the ISC model). The model is fully described in the user manual and the accompanying technical description (**US EPA, 1995**).

It has been apparent for a number of years that the ISC model has a tendency to overestimate the 24-hour PM_{10} concentrations, while still predicting the longer term average concentrations reasonably accurately. In recent years the DEC have permitted the use of a calibration factor to correct for the tendency of ISC to over-predict 24-hour average PM_{10} concentrations. In most instances, the DEC has required that a site-specific calibration factor be developed from local model and monitoring results.

One of the earliest calibration studies was undertaken as part of the EIS for the Warkworth mine in the Hunter Valley (**Holmes Air Sciences, 2002**). The calibration was done by comparing the predicted maximum 24-hour average PM_{10} concentrations at the several mine operated monitors. The maximum measured PM_{10} concentrations were then determined by inspection of the monitoring data. From these investigations the average extent of over-prediction was found to be a factor of 2.6; that is, unadjusted model predictions appeared to over predict 24-hour PM_{10} concentrations by 260%. This factor was used to adjust the model predictions for the Warkworth EIS downwards to obtain a calibrated prediction of the worst-case 24-hour PM_{10} concentrations for all scenarios that were assessed.

Other studies undertaken at other locations have derived different calibration factors, both larger and smaller than 2.6. Further studies to develop a more scientifically robust methodology for dealing with the over-prediction of short-term concentrations by the ISC model are to be conducted as part of the approval conditions for the Mt Owen Mine.

Comparisons between ISC and AUSPLUME, an advanced Gaussian dispersion model based on ISC, (see **Holmes Air Sciences, 2003** for example) have suggested that a correction factor is appropriate for short term (that is, 24-hour average) ISC predictions. Although the comparison between AUSPLUME and ISC shows varying difference, AUSPLUME has consistently predicted almost 50% lower than uncorrected ISC predictions. Thus, AUSPLUME may have some advantages over ISC in that it more accurately predicts 24-hour average concentrations of PM_{10}, which are known to be consistently overestimated by ISC.

Results from a simplified model comparison of AUSPLUME and ISC showed that 1-hour average PM_{10} concentrations downwind of a source and along the plume centreline were between 2.8 and 3.5 times higher using ISC than for AUSPLUME (see Appendix C of **Holmes Air Sciences, 2006**). The difference between the models depends on the meteorological conditions. Different results from the two models were largely explained by the way in which each model has interpreted the plume dispersion curves.

These studies, and the recently completed calibration study undertaken as part of the Mt Owen Mine's conditions of approval, have lead to a better understanding of the reasons for the over-prediction. It appears that a substantial fraction of effect is due to the fact that the dispersion curves used in the ISC model have not been adjusted for differences in averaging times and the effects of the aerodynamic roughness. For most model runs for a particular site these will be different from the conditions where the original dispersion curves were developed.

To overcome this difficultly the ISC model has been modified to create a model that will be referred to as ISCMOD. ISCMOD is identical to ISC except that the horizontal plume spreading dispersion curves have been modified to adopt the recommendations of the American Meteorological Society's (AMS) expert panel on dispersion curves (**Hanna, 1977**) and the suggestions made by **Arya (1999)**. The suggested changes were recommended because, as the AMS panel notes, the original horizontal dispersion curves relate to an averaging time of three minutes and they recommend that these be adjusted to the one hour curves required by ISC. The change involves increasing the horizontal plume widths by a factor of 1.82 $(60 \text{ minutes} / 3 \text{ minute})^{0.2}$.

The ISCMOD model was used to predict 24-hour average PM_{10} and annual average dust deposition, TSP, and PM_{10} concentrations from the operation of the proposed Armidale landfill. These concentrations were determined at discrete receivers spread over the area shown in **Figure 2**. Receivers were chosen to be finely spaced in areas near the dust sources and at nearby residences.

Estimates of emissions for each source were developed on an hourly time step taking into account the activities that would take place at that location. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of activity and the wind speed. It is important to do this to ensure that long-term average emission rates are not combined with worst-case dispersion conditions which are associated with light winds. Light winds at a mine site would correspond with periods of low dust generation because wind erosion and other wind dependent emissions rates will be low. Light winds also correspond with periods of poor dispersion. If these measures are not taken then the model has the potential to significantly overstate impacts.

6.2 Odour

Odour impacts were assessed for the three stages used in the dust modelling. Potential odour impacts of the proposed facility on the surrounding receivers have been assessed using AUSPLUME v6.0.

The AUSPLUME model has been used to predict the 1-hour average odour levels, expressed in odour units, at a grid of receivers 5 x 5 km centred on the project site and at discrete receiver points located at nearby receivers. For the purpose of presenting the results, the 99th percentile and maximum predicted 1-hour odour level at each receiver has been retained by the model and contour plots have been prepared showing the distribution of these levels. The contour plots do not represent the dispersion pattern at any particular instant in time, but show the 99th and 100th percentile odour levels that occurred at each location. The 100th percentile levels are used to show odour levels which can possibly be reached under the modelled conditions. The 99th percentile levels relate to the DEC odour goals.

7 ASSESSMENT OF IMPACTS

7.1 Dust impacts

This section provides an interpretation of the predicted dust concentration contours and dust deposition levels for three stages in the life of the landfill operation. For each stage four isopleth diagrams have been produced showing the following:

- The predicted maximum 24-hour average PM_{10} concentrations;
- The predicted annual average PM_{10} concentrations;
- The predicted annual average TSP concentrations;
- The predicted annual average dust deposition.

The isopleths do not include dust contributions from sources other than the proposed landfill. These plots are shown for the three stages of operation in **Figure 6** to **Figure 17**. The predicted dust concentrations and deposition levels at all residential receivers were within the DEC criteria. Note that these predictions do not take account of background levels, as required by the DEC. However, the model predictions are very low and it was concluded that the proposed activities would be unlikely to cause exceedances of the DEC air quality criteria.

The highest dust impacts during each stage are concentrated around the section of the landfill where the dust generating activity will be occurring. For example, during Stage 0-10 Years the highest impacts are at the southern end of the proposed site, as most of the dust generating activity occurs in Cell 1 during this stage. The highest predicted concentrations at residential receivers for each stage are shown in **Table 8**.

Table 8 – Predicted dust concentrations								
Stage	Dust prediction	Receiver (see **Figure 8**)						Relevant air quality goal
		1	2	3	4	5	6	
0-10 years	Maximum 24-hour PM_{10}	3.71	8.91	1.27	0.70	0.79	1.61	50
	Annual PM_{10}	0.25	0.60	0.10	0.03	0.04	0.03	30
	Annual TSP	0.36	0.98	0.13	0.05	0.05	0.03	90
	Annual dust deposition	0.08	0.10	0.03	0.01	0.01	0.00	4
10-20 years	Maximum 24-hour PM_{10}	4.28	6.21	1.37	0.79	0.90	1.66	50
	Annual PM_{10}	0.32	0.39	0.11	0.04	0.04	0.03	30
	Annual TSP	0.47	0.62	0.15	0.05	0.06	0.04	90
	Annual dust deposition	0.10	0.06	0.03	0.01	0.01	0.00	4
40-50 years	Maximum 24-hour PM_{10}	2.85	1.55	0.85	0.69	0.70	1.37	50
	Annual PM_{10}	0.30	0.09	0.08	0.03	0.03	0.03	30
	Annual TSP	0.43	0.14	0.11	0.04	0.05	0.03	90
	Annual dust deposition	0.09	0.01	0.02	0.01	0.01	0.00	4

7.2 Odour impacts

The dispersion model results for odour levels at off-site receivers are presented in **Table 9** and odour contours are shown in **Figure 18** to **Figure 23**. The figures include plots of predicted maximum odour levels (corrected for nose response times) and odour levels at the 99^{th} percentile to compare with the DEC odour goals.

Table 9 – Predicted 99^{th} percentile odour concentrations						
Stage	Receiver (see **Figure 8**)					
	1	2	3	4	5	6
0-10 years	0.15	1.48	0.16	0.04	0.04	0.02
10-20 years	0.27	2.09	0.26	0.06	0.06	0.03
40-50 years	0.63	1.08	0.38	0.09	0.09	0.04

The DEC goal for a single rural receiver is 7 ou at the 99^{th} percentile. The odour levels at the 99^{th} percentile are well within the 7 ou odour goal for all three stages. It is therefore concluded that the off-site odour impacts from the landfill will be at acceptable levels.

8 CONCLUSIONS

This report has assessed the air quality impacts associated with the proposed Armidale landfill. Dust and odour impacts have been addressed and dispersion modelling has been used to predict off-site dust and odour levels due to landfill operations. The dispersion modelling took account of the local meteorology and terrain information and used emission estimates to predict off-site air quality impacts.

The conclusions of the assessment can be summarised as follows:

- Dust impacts due to the landfill operations are predicted to be low and are unlikely to cause exceedances of the DEC criteria;
- Odour impacts due to the landfill operations are predicted to be at acceptable levels.

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