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Woodlawn Bioreactor

Odour and Dust Impact Assessment

Woodlawn Expansion Project

Report Number 30-2464-R2

22 February 2011

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EXECUTIVE SUMMARY

Introduction

Veolia Environmental Services (Australia) Pty Ltd (Veolia) operates a Bioreactor facility located within the 6,000 hectare (ha) Woodlawn Eco-Precinct, in the Southern Highlands of NSW (the Project Site). Prior to becoming a waste management facility, Woodlawn operated as a base metals mine site during the 1970s to 1990s. The Woodlawn Bioreactor is now located within a 25 million cubic metre void, which was created during the mining operations.

The Woodlawn Bioreactor was originally approved in 2000 to receive up to 500,000 tonnes per annum (tpa) of putrescible waste by rail from Sydney. In 2010, this development consent was modified to include up to 50,000 tpa of putrescible waste by road from the surrounding region.

Veolia is currently seeking approval to receive and process 1.13 million tonnes of waste per year at the Woodlawn Bioreactor and 1.18 million tonnes of waste per year at the Crisps Creek Intermodal Facility.

This revised Odour and Dust Impact Assessment comprises consideration of comments received following the public exhibition of the Environmental Assessment (EA) and remodelling of the dust and odour impacts based on the additional input requirements requested in DECCW's response to the EA.

The issues raised by the Department of Environment, Climate Change and Water (DECCW) regarding dust and odour are addressed in this report, as have comments received by the local community regarding recent odour experiences.

Predicted impacts of the Woodlawn Expansion Project have been compared to NSW Department of Environment, Climate Change and Water (DECCW) criteria. These criteria are designed to minimise both health (particulate matter) and nuisance (odour and dust) impacts from the Project.

Odour

Additional odour monitoring was undertaken in January 2011 in wet weather conditions, which based on operational and community experience is likely to represent worst case conditions. This new odour emission rate data was used to remodel the potential impacts of the current operations as well as the proposed tonnage increase under worst case conditions.

The report also provides a summary of the range of waste management and odour control measures which have been trialled since the commencement of operations. These measures include, but are not limited to, the trialling of a range of alternate waste cover systems and the management of leachate in temporary storage ponds.

Veolia has been made aware that odour has been detected from time to time by residents along Taylors Creek Road and in Tarago village. This feedback has been used in assessing the performance of site operations and waste management measures.

Veolia will continue to work with the local community to further improve waste management measures at the facility and relating operational updates as a function of the Woodlawn Community Liaison Committee.

Further analysis of potential odour impacts in the local community includes consideration of Tarago Village as a potentially sensitive receptor, as well as discussion regarding likely maximum odour concentrations, in addition to the 99th percentile of 1 second averages, which is the odour criterion required to be assessed by DECCW.

EXECUTIVE SUMMARY

An odour criterion of 6 odour units (OU) has been adopted for this Project, based on accepted NSW DECCW methodologies. This means that 6 OU should not be exceeded on more than 3.6 days per year. Since the theoretical odour detection limit (that is where no odour impact is experienced) is 1 OU, this criterion is not intended to achieve 'no odour'.

The results of the odour modelling predicted that the 99th percentile 1-second average ground-level odour concentrations at the surrounding sensitive receptor locations ranged from 0.5 OU to 3.4 OU and therefore the predicted odour concentrations were below the Project specific odour performance goal of 6 OU.

The results of the additional maximum odour concentrations predicted that not only would 6OU performance goal be met by the 99th percentile assessment, but the maximum odour concentrations for all non Project related receptors would not exceed this goal.

Dust

Particulate matter emissions associated with the proposed Woodlawn Expansion Project are not predicted to result in exceedances of the adopted criteria for the Project.

Dust deposition levels are significantly below the adopted background level and are predicted to result in incremental increases of less than 0.2 g/m^2/month at all receptors.

PM_{10} concentrations are predicted to be less than 7.5 µg/m^3 as a 24-hour maximum and 0.7 µg/m^3 as an annual average at all receptors, excluding background concentrations.

Total suspended particulate concentrations are predicted to be less than 0.1 µg/m^3 as an annual average at all modelled receptors, excluding background concentrations

When the predicted incremental PM_{10} and TSP impacts are aggregated with worst-case background concentrations, the total impacts do not exceed any ambient air quality standards.

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1 INTRODUCTION

Veolia Environmental Services (Australia) Pty Ltd (Veolia) operates a Bioreactor facility located within the 6,000 hectare (ha) site at the Woodlawn Eco-Precinct, in the Southern Highlands of NSW (the Project Site). Prior to becoming a waste management facility, Woodlawn operated as a base metals mine site during the 1970s to 1990s. The Woodlawn Bioreactor is now located within a 25 million cubic metre void, which was created during the mining operations.

The Woodlawn Bioreactor was originally approved in 2000 to receive up to 500,000 tonnes per annum (tpa) of putrescible waste by rail from Sydney. In 2010, this development consent was modified to include up to 50,000 tpa of putrescible waste by road from the surrounding region.

Veolia is currently seeking approval to receive and process 1.13 million tonnes of waste per year at the Woodlawn Bioreactor and 1.18 million tonnes of waste per year at the Crisps Creek Intermodal Facility.

This report is provided as an update to the original submitted Air Quality and Odour assessment report, dated November 2010. Comments on the original report were received during community consultation and from the NSW DECCW. These comments have been addressed within this report. A brief summary of the comments received, and the relevant sections within this report where the updates performed can be found, are provided in Box 1 below.

Box 1

Issue	Summary of Comment	Action Taken to Address Comment	Relevant Report Section
1	Discharges to air associated with Landfill Gas Engines (LGEs) not assessed	Particulate matter has been modelled from the LGEs, and monitored emissions of VOCs, Nitrogen Oxides and Carbon Monoxide have been compared to the relevant POEO regulations	**Section 5.5**
2, 5	Certain elements identified within the particulate matter and odour emissions inventory were omitted from the modelling assessment	These elements have been included in updated dispersion modelling assessment (dozer in the particulate emissions and volume sources in the odour emissions modelling assessments)	**Section 6.1** **Section 6.2**
4, 6	Specific Odour Emission Rates were not able to be verified by DECCW	A full outline of the calculation method for odour emission rates used within this assessment have been provided as an Appendix. All sampling reports, assumptions and raw data have been provided as requested by DECCW.	**Section 5.2** **Appendix E**
3	It was unclear how the effect of wet weather on odour emission rates was dealt with in the modelling assessment	Veolia engaged SLR Consulting to perform an updated odour monitoring campaign at the Woodlawn site, with 42 odour samples being taken. These samples were taken during wet weather conditions and were observed to result in significantly higher odour emissions that those taken previously during dry weather. The updated modelling assessment presented here utilises these worst case odour emission rates	**Section 5.2** **Section 6.1** **Appendix E**

Further to the information provided in Box 1, extra information relating to the odour impact assessment has been provided within this report. An additional sensitive receptor has been included within Tarago Village itself, reflecting the ongoing observations of odour reported by residents. Predicted odour concentrations in the base case and during the expansion scenarios have been subject to further and more detailed analysis, providing information of the likely maximum odour concentrations and frequency of exceedance of the odour detection threshold. This information is outlined in **Section 6.1.1** and has been provided to allow increased understanding of the likely impacts of the expansion, over and above what was provided in the previous report.

1.1 Process Overview

1.1.1 Bioreactor

Waste material is currently transported in sealed containers via rail to the Crisps Creek Intermodal Facility, approximately 8 km to the southeast of the Woodlawn Bioreactor, then by road to the Bioreactor Site (refer **Section 1.1.2**). These containers are designed to reduce odour and dust impacts from the transport element of the project. Once at the site, trucks and containers are driven into the mine void, where waste is unloaded and spread by a dozer and compactor. Upon subsequent degradation, landfill gas containing methane (CH_4) is produced which is collected, transferred to the onsite generators and combusted to produce power.

Quantities of organic rich waters or leachate are produced during the waste degradation process, and this leachate is recirculated within the waste to further encourage biological activity and optimise bioreactor performance. However, during the initial phases of the project it has been necessary, on occasion, to store and treat excess volumes of leachate outside the void. Leachate is pumped directly out of the void and temporarily stored in ponds located in the Evaporation Dam area (ED3) (refer **Table 1** and **Figure 1**) prior to undergoing treatment to remove odorous components after which the treated leachate is also stored in the ED3 area to be evaporated.

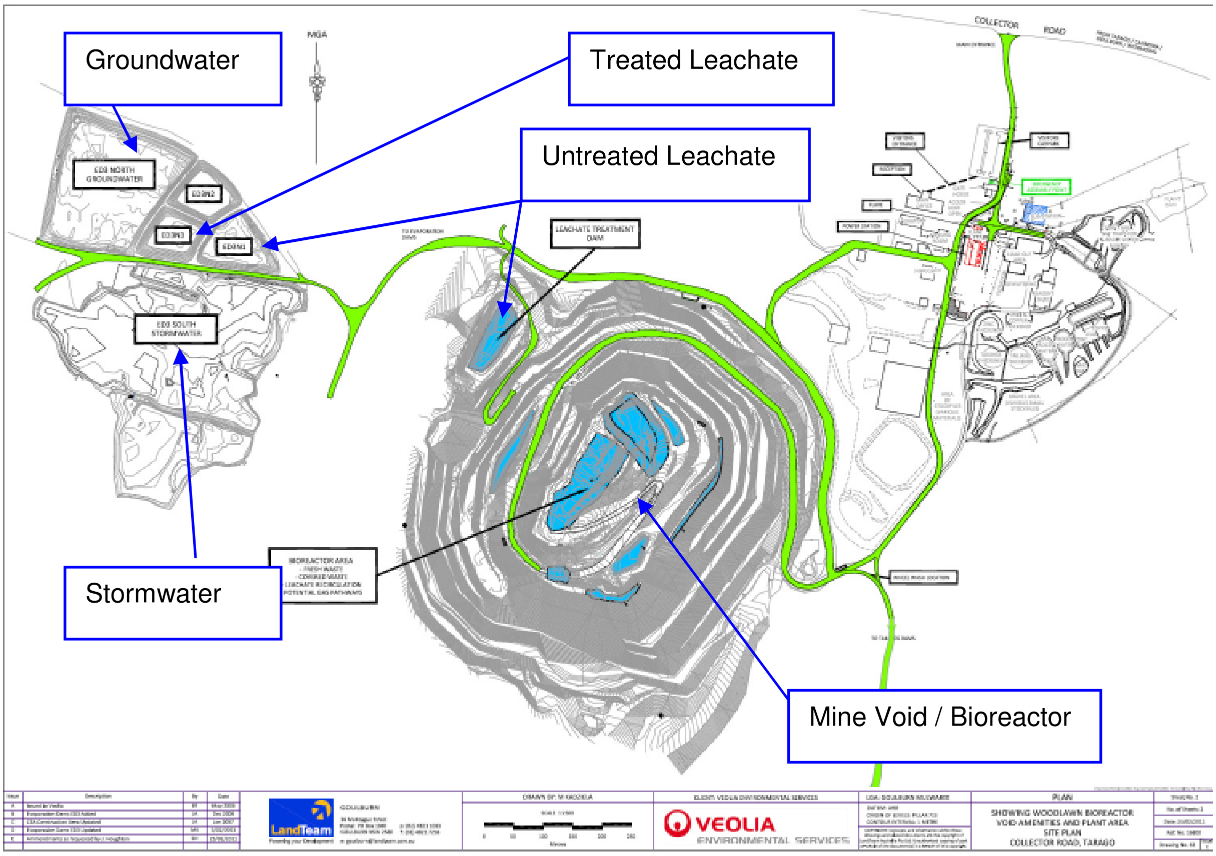
Table 1 Description of Liquid Storage

Pond/Dam	Contents	Area (ha)	Location
Leachate Dam	Untreated Leachate	0.4	Immediate East of Main Void
ED3N-1	Untreated Leachate	0.7	Refer **Figure 1**
ED3N-3	Treated Leachate	1.4	
Evaporation Dam ED3 North	Groundwater	3.6	
Evaporation Dam ED3 South	Stormwater	6.7	

ED3N-2 and ED3N-3 (with a combined area of 1.3 ha) have been used previously to store leachate, however as the waste volumes increase so does the ability to absorb leachate within the waste. As the hydraulic gradient reduces, thus the need to extract leachate from the void and storing in ED3 also is reduced. Veolia has implemented other operational solutions regarding leachate treatment and water management to reduce potential impacts from these sources including reducing the amount of stored leachate, improved treatment process and increasing evaporation capability. For the purposes of this report and in the interests of conservatism within the impact assessment, these ponds have been assumed to contain treated leachate.

Waste is stored in the Mine Void (refer **Figure 1**) with the daily tipping face currently occupying an area of approximately 0.64 ha. A 0.03 ha area of waste experiencing leachate recirculation has been assumed and covered waste has been assumed to be present in the remaining area of approximately 6.03 ha. It is noted that Veolia was granted approval to trial alternate daily cover materials on the fresh waste by the NSW Department of Environment Climate Change & Water (DECCW).

Figure 1 Layout of Woodlawn Bioreactor and Liquid Storage / Management System



Source: Veolia Woodlawn, 2011

Trucks delivering waste are driven from the Crisps Creek Intermodal Facility along sealed local roads, before arriving at the Woodlawn site. The main haul road on site is sealed up to the edge of the void, and is unsealed within the void. The majority of the secondary roads on site are unsealed. A water cart is used on site to control dust and protect the unsealed road surfaces.

1.1.2 Crisps Creek Intermodal Facility

The Crisps Creek Intermodal Facility (IMF) is located approximately 8 km to the southeast of the Woodlawn Bioreactor. Material is transported from the IMF to the Woodlawn Bioreactor by road.

Transport of waste to the IMF and subsequently to the Woodlawn Bioreactor occurs in sealed containers. This results in negligible odour emissions resulting from operations occurring at the IMF and during transport to Woodlawn.

In the case of dust, roads at the IMF are all sealed and therefore, assuming all roads are free of material, emissions of particulate will be limited to brake and tyre wear and diesel particulate matter contained in vehicle exhaust emissions. It is considered that emissions of particulate from these sources will be negligible when compared to emissions from surrounding sources such as agricultural areas, or vehicles using the main road itself.

It is not considered that emissions of odour or dust from the IMF would form a material consideration in determining the impacts of the Project, and that a quantitative assessment of odour or dust from the IMF would not provide any meaningful information and is therefore not warranted. Given the above, the impacts of odour or dust from the IMF have not been considered further within this study.

1.1.3 Alternative Waste Treatment Facility

Approval was granted to Veolia in November 2007 to construct and operate an Alternative Waste Technology (AWT) facility at the Woodlawn site incorporating the "Woodlawn Alternative Sorting and Processing" (WASP) facility and the "Composted Organics and Greenwaste" (WOCOG) facility, this would ultimately be used to produce compost for mine rehabilitation. Although the AWT has not been constructed yet, this assessment assumes that any current and future operations at the site include the AWT facility. Certain elements of the facility have the potential to generate dust and odour and these have been assessed quantitatively within this report.

Details of the AWT design have been referenced from the approval documents as submitted by Heggies in November 2006 (Report 30-1392R2R8 dated 2 November 2006). Details of waste throughputs have been referenced from the Preliminary Environmental Assessment, Woodlawn Bioreactor – Waste Expansion Project, January 2010.

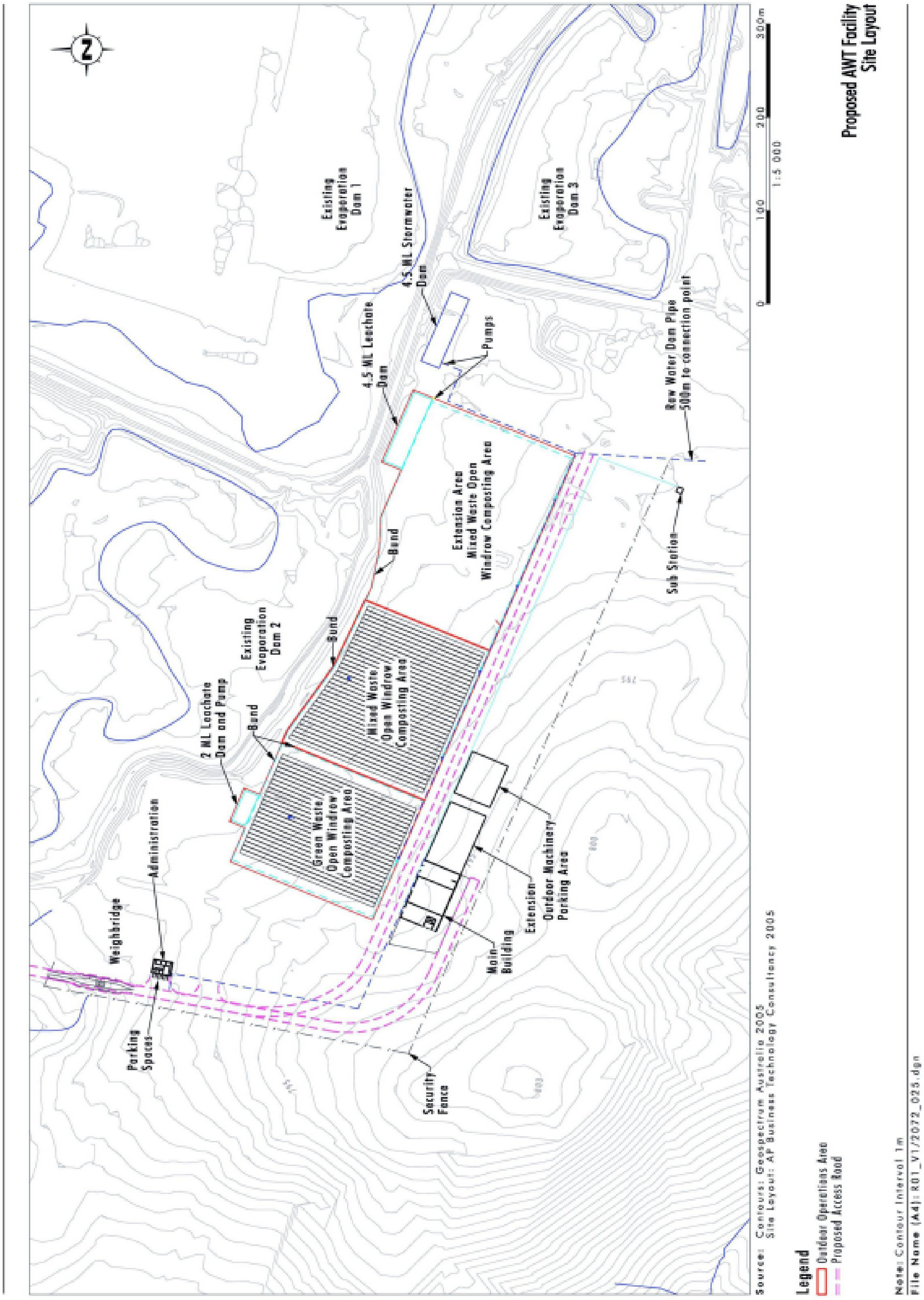
The AWT facility will be comprised of a range of processing and recycling technology which is modular in nature allowing for extension as required dependant on volumes received to the site. The waste processing building will have an initial total floor area of 0.27 ha with the potential to expand to 0.54 ha in total building size to accommodate for future growth.

The proposed processing capacity for the WASP will be 240,000 tpa. The WOCOG will have a processing capacity of 40,000 tpa.

The WASP and WOCOG facilities will each have open windrow composting areas comprising 6.4 ha and 2.24 ha respectively. Two leachate dams will control surface water run-off and leachate generated at the AWT facility.

The AWT facility is illustrated in **Figure 2**.

Figure 2 Proposed AWT Facility Layout



Source: Umwelt (Australia) Pty Limited (2006)

1.1.4 Hours of Operation

The proposed hours of operation at the approved AWT and Bioreactor are between 6.00 am to 10.00 pm six days per week with the exception of truck operations at the IMF, which would be between 7.00 am and 10.00 pm.

Current operating hours at the Woodlawn Bioreactor are from 6.00 am to 7.00 pm and 6.00 am to 6.00 pm at the Crisps Creek IMF, Mondays to Saturdays with the exception of truck operations at the IMF, which are be between 7.00 am and 6.00 pm. The approved hours of operation for the approved AWT are 6.00 am to 10.00 pm.

1.1.5 Waste Management Strategies

A range of waste management and odour control measures have been trialled since the commencement of operations at the Project site. These measures have been initiated based on understanding of the major odour generating activities or as a response to community complaints.

The history of odour management at the Project Site is complex. Veolia has been made aware that odour has been detected from time to time by residents along Taylors Creek Road and within Tarago Village. This feedback has been used in assessing the performance of site operations and waste management measures. The range of odour issues experienced at the Project site, the resulting management strategies and future proposed strategies are presented in **Table 2**.

Table 2 Summary of Odour Management Issues at Woodlawn Bioreactor

Odour Source	Issue	Measures Implemented	Future Strategies
Liquid Waste			
Groundwater (ED3 North) Stormwater (ED3 South)	Extraction system contaminated with leachate in late 2005 & early 2006	– Isolated contamination in 2005 – Segregated ED3 to control different liquids in 2006 – Evaporated contaminated liquid by 2007	Continue to manage stormwater and groundwater separately. Regular monitoring to ensure that the extraction system does not become odorous due to any contamination.
Leachate Untreated (ED3N-1 & Leachate Pond) Treated (ED3N-3)	Storage & treatment of leachate outside void from mid 2007	– Collaboration with University of Queensland to develop a method of treatment to eliminate odour from stored leachate from 2007 to 2010 – No leachate extraction from void since end of 2009 – Successful leachate treatment and removal of solids in 2010 – Odour monitoring confirmed negligible odour from this source in 2011	Capacity for leachate to be stored within the waste mass will continue to increase due to the volume of waste in the void. Continue to manage leachate primarily within the void, through re-injection in to the waste mass and treatment as required.

Odour Source	Issue	Measures Implemented	Future Strategies
Leachate recirculation – within void	Leachate spraying within the void as a means of reducing leachate volume from 2006	– Refinement of leachate recirculation practices to reduce odour emissions from site. – Method of reinjection through trenches located around the perimeter of the waste enabling leachate to be recirculated through the fresh waste under the intermediate soil cover since early 2010	Continue the practice of leachate re-injection as the preferred means of leachate recirculation to reduce odour emissions.
Solid Waste			
Waste area – within void	Waste area within the void becoming increasingly odorous during wet weather conditions	– Management practices to reduce the potential for these odours including working with the minimum practical tipping face – Ongoing trials of alternative daily cover materials and methods	Best practice material and methods for waste cover will continue to be investigated for their applicability at Woodlawn.
Other Sources			
Potential gas pathways – within void	Gas leakage from a previously active gas extraction system in late 2010.	– Gas well was located and capped to stop this gas leakage in 2010 – Monitoring potential gas pathways as a new odour source in 2011 – New gas wells drilled in areas identified as potential gas pathways for connection into the existing gas extraction system	Continued expansion of the gas extraction infrastructure in areas identified as having potential gas pathways such as around the edge of the void, resulting in increased gas collection for energy production and reducing fugitive odorous emissions.

Veolia will continue to work with the local community to further improve waste management measures at the facility and relating operational updates as a function of the Woodlawn Community Liaison Committee. The community are invaluable in providing feedback to the operational staff at Woodlawn, although to date there has been no formal structure in how observations of odour have been provided. It is recommended that a more structured method for recording odour observations is trialled with local residents.

It is proposed that an odour diary is provided to interested residents, with provisions for inclusion of details such as date, time, location at which the odour was detected, the duration of the event, continuity of odour during the event and an odour character and intensity descriptor. Using these consistent fields and descriptors, odour events can be identified, cross referenced with on-site meteorological data and operational activities to identify the likely source of odour, identify any patterns in odour observations from the community and act on the information provided by the community to work towards further odour management practices. An example of the proposed odour diary is included as **Appendix F**.

The modelling results presented in **Section 6** of this report seek to represent off-site odour and dust impacts associated with a likely worst case operational scenario for a current base case scenario and the 1.13 Mtpa waste expansion scenario.

1.2 Study Overview

This report seeks to quantify the odour and dust/particulate impact at a range of identified sensitive land uses that may potentially be impacted by changes due to the proposed Woodlawn Expansion Project.

To quantify any increase in generated odour, a 'base case' has been modelled, against which the increased waste processing scenario can be assessed. In the case of dust, a cumulative assessment of proposed operations and background concentrations of particulate have been modelled representing the Project operations.

It is assumed that processing of larger quantities of waste will result in increased odour being generated, mainly from the fresh tip face, rather than from leachate storage. The modelling undertaken as part of this assessment has assumed that all liquid storage areas are at capacity and the fresh tip face is currently 80 m by 80 m (projected to increase to approximately 100 m by 200 m (2 ha) under the increased waste processing scenario). It is considered that these assumptions represent a worst case scenario as leachate storage areas are not likely to be at capacity. It is also considered to be unlikely that Veolia would operate such a large tip-face.

As previously discussed, operation of an AWT facility has been granted approval for the Project Site but has not yet been constructed at the current time. However, potential emissions from the AWT have been quantitatively assessed within this report to allow the determination of the potential cumulative odour and dust impact from all approved and proposed odour and dust sources at the Woodlawn Bioreactor Site and Crisps Creek Intermodal Facility

In order to quantify potential odorous emissions from the Project, SLR Consulting utilised a combination of site specific odour emission rate data and data derived from similar facilities (for the AWT) to conduct a Level 3 odour impact assessment in accordance with the NSW Department of Environment, Climate Change and Water (DECCW) 2006 document *Technical Framework: Assessment and Management of Odour from Stationary Sources in New South Wales* (DECCW, 2006a), hereafter referred to as the Odour Framework. This assessment involved the modelling of local meteorology and the dispersion of odorous emissions from the Project Site to predict the level of impact that may be experienced in the surrounding environment.

To quantify emissions of dust and particulate matter from the Project, SLR Consulting utilised emission factors as defined in the Australian Department of Environment "Emission Estimation Technique Manual for Mining version 2.3 (National Pollutant Inventory, 2001) and relevant United States Environmental Protection Agency (USEPA) AP-42 emission factors.

1.3 Sensitive Receptors

The nearest potentially affected residences are summarised in **Table 3**.

Table 3 Potentially Affected Residences

Property ID	Property Name	Distance to Project Site (m)	Easting (m)	Northing (m)	Elevation (m AHD)
1	"Woodlawn Farm"	1,600	734518	6118363	796
2	"Cowley Hills"	2,000	736673	6117689	794
3	"Pylara"	4,000	737493	6114373	742
4	"Torokina"	3,700	731287	6114653	720
5	Tarago Village	5,800	741148	6115437	699

The properties of "Woodlawn", "Cowley Hills" and "Pylara" are all Veolia-owned residences and as such, could be considered to be 'Project-related' residences. However, in the interests of minimising odour and dust impacts on the surrounding area, the odour and dust impact from both current and project operations have been assessed at *all* surrounding residences, project-related or not.

Due to the significant distances between the Project Site and the identified sensitive receptors, results for the receptors noted in **Table 2** can be considered to represent the odour and dust impacts across a wider area than at the individual receptor points themselves (e.g. at neighbouring properties within 100 m to 200 m). Examination of the individual pollutant contour plots provided in **Section 6** can be examined to obtain more refined information on the spatial distributions of predicted pollutant impacts if required.

1.4 Site Topography

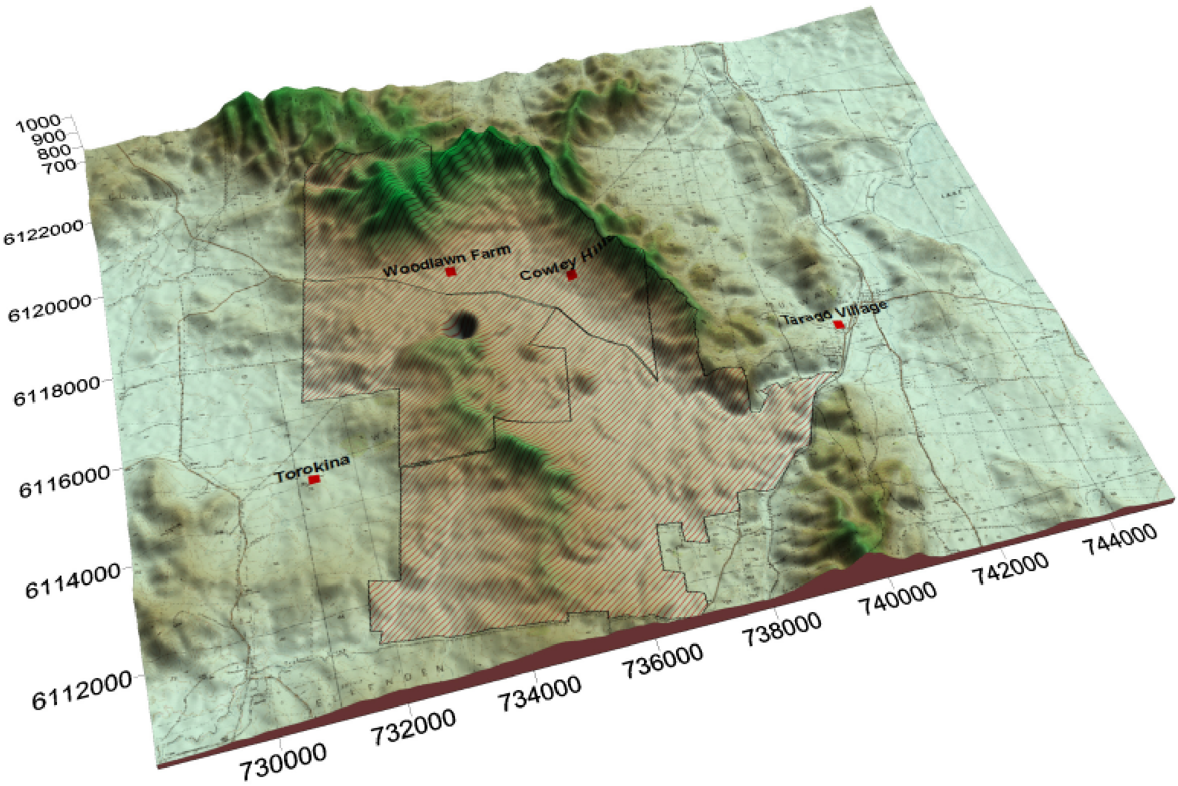
The project site and surrounding residences are located in undulating terrain. To the northeast of the site the topography rises to a high point of 1000 metres (m) AHD falling away to a height of 690 m AHD to the southwest. To the southeast of the approved AWT facility and directly south of the mine void, a topographic ridge extends to a height of 880 m AHD. Beyond this, the land falls away to a height of 740 m AHD.

The residences to the east of the facility ("*Woodlawn Farm*" and "*Cowley Hills*") are on a similar elevation to the approved AWT with no significant topographical features in-between. To the northwest and west of the approved AWT, the land falls away to a height of 700 m AHD.

Local atmospheric dispersion could be influenced by night-time katabatic drainage flows from elevated terrain or channelling effects in valleys or gullies around the site.

A three dimensional representation of the area is given in **Figure 3**, with a vertical exaggeration of four applied to emphasise terrain features.

Figure 3 3-Dimensional Regional Topography Surrounding Project Site (Vertical Exaggeration 4)



NOTE: Topography shown with vertical exaggeration of 4. Project Boundary indicated by hatched area.

2 IMPACT ASSESSMENT CRITERIA

2.1 Odour

Impacts from odorous air contaminants are often nuisance-related rather than health-related. Odour performance goals guide decisions on odour management, but are generally not intended to achieve “no odour”.

The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the *odour threshold* and defines one odour unit per cubic metre (OU/m^3). An odour goal of less than 1 OU/m^3 would theoretically result in no odour impact being experienced. The terms OU/m^3 references odour concentration. Although the NSW DECCW goals are referenced as an odour concentration, the nomenclature is for the $/m^3$ to be dropped from the odour goal. Hence, a criteria of 2 OU/m^3 is equivalent to 2 OU.

In practice, the character of a particular odour can only be judged by the receiver’s reaction to it, and preferably only compared to another odour under similar social and regional conditions. Based on the literature available, the level at which an odour is perceived to be a nuisance can range from 2 OU/m^3 to 10 OU/m^3 depending on a combination of the following factors:

- *Odour Quality*: whether an odour results from a pure compound or from a mixture of compounds. Pure compounds tend to have a higher threshold (lower offensiveness) than a mixture of compounds.
- *Population sensitivity:* any given population contains individuals with a range of sensitivities to odour. The larger a population, the greater the number of sensitive individuals it may contain.
- *Background level:* whether a given odour source, because of its location, is likely to contribute to a cumulative odour impact. In areas with more closely-located sources it may be necessary to apply a lower threshold to prevent offensive odour.
- *Public expectation:* whether a given community is tolerant of a particular type of odour and does not find it offensive, even at relatively high concentrations. For example, background agricultural odours may not be considered offensive until a higher threshold is reached than for odours from a landfill facility.
- *Source characteristics:* whether the odour is emitted from a stack (point source) or from an area (diffuse source). Generally, the components of point source emissions can be identified and treated more easily than diffuse sources. Emissions from point sources can be more easily controlled using control equipment. Point sources tend to be located in urban areas, while diffuse sources are more often located in rural locations.
- *Health Effects:* whether a particular odour is likely to be associated with adverse health effects. In general, odours from agricultural activities are less likely to present a health risk than emissions from industrial facilities.

Experience gained through odour assessments from proposed and existing facilities in NSW indicates that an odour performance goal of 7 OU/m^3 is likely to represent the level below which “offensive” odours should not occur (for an individual with a ‘standard sensitivity’ to odours). The NSW DECCW recommends within the Odour Framework that, as design goal, no individual be exposed to ambient odour levels of greater than 7 OU/m^3. This is expressed as the 99th percentile value, as a nose response time average (approximately one second).

Odour performance goals need to be designed to take into account the range in sensitivities to odours within the community, and provide additional protection for individuals with a heightened response to odours, using a statistical approach which depends on the size of the affected population. As the affected population size increases, the number of sensitive individuals is also likely to increase, which suggests that more stringent goals are necessary in these situations. In addition, the potential for cumulative odour impacts in relatively sparsely populated areas can be more easily defined and assessed than in highly populated urban areas. It is often not possible or practical to determine and assess the cumulative odour impacts of all odour sources that may impact on a receptor in an urban environment. Therefore, the proposed odour performance goals allow for population density, cumulative impacts, and anticipated odour levels during adverse meteorological conditions and community expectations of amenity.

Where a number of the factors above simultaneously contribute to making an odour “offensive”, an odour goal of 2 OU/m^3 at the nearest residence (existing or any likely future residences) is appropriate, which generally occurs for affected populations equal or above 2000 people.

The equation used by the NSW DECCW to determine the appropriate impact assessment criteria for complex mixtures of odorous air pollutants, as specified in the Approved Methods, is expressed as follows:

$$\text{Impact assessment criterion (OU)} = (\log_{10}(\text{population})-4.5)/-0.6$$

A summary of the impact assessment criteria given for various population densities, as drawn from the Approved Methods, is given in **Table 4**

Table 4 NSW DECCW Impact Assessment Criteria for Complex Mixtures of Odorous Air Pollutants (nose-response-time average, 99th percentile)

Population of Affected Community	Impact Assessment Criteria for Complex Mixtures of Odours (OU)
Urban area (≥ 2000)	2.0
~300	3.0
~125	4.0
~30	5.0
~10	6.0
Single residence (≤ 2)	7.0

Source: The Approved Methods (DECCW, 2005)

The Approved Methods states that the impact assessment criteria for complex mixtures of odorous air pollutants must be applied at the nearest existing or likely future off-site sensitive receptor(s).

The incremental impact (predicted impact due to the pollutant source alone) must be reported in units consistent with the impact assessment criteria (OU), as peak concentrations (i.e. approximately 1 second average) and as the:

- 100th percentile of dispersion model predictions for Level 1 impact assessments, or
- 99th percentile of dispersion model predictions for Level 2 impact assessments.

Given the low number of sensitive receptor locations in the immediate vicinity of the Woodlawn site (four, Section 1.3) it is expected that an odour impact assessment criteria of 6 OU (expressed as the 99th percentile for a nose response average, i.e. 1-second average) would appropriately assess the odour performance of the Woodlawn Bioreactor.

2.2 Particulate Matter

The term *"particulate matter"* refers to a category of airborne particles typically less than 50 microns (µm) in diameter and ranging down to 0.1 µm in size.

Total particulate matter, often called *total suspended particulate* (TSP) comprises the sum of the particle size fractions.

Particles less than 10 microns (µm) and 2.5 µm in diameter are referred to in this report as PM_{10} and $PM_{2.5}$ particles respectively.

2.2.1 Particulate Matter as PM_{10}

PM_{10} is considered to be an important pollutant in terms of potential impact to human health due to its ability to penetrate into the respiratory system.

The DECCW PM_{10} assessment goals as expressed in the Approved Methods are:

- a 24-hour maximum of 50 micrograms per cubic metre (µg/m^3);
- a 24-hour maximum of 150 µg/m^3 (Project and other sources); and
- an annual average of 30 µg/m^3 (Project and other sources).

The 24-hour PM_{10} reporting standard of 50 µg/m^3 is numerically identical to the "*Ambient Air Quality National Environment Protection Measure"* (NEPM) (National Environmental Protection Council, 1998) reporting standard except that the NEPM reporting standard allows for five exceedances per year.

2.2.2 Particulate Matter as TSP

The annual goal for particulate matter (as TSP) is given as 90 µg/m^3 (relating to a cumulative measure of Project and other sources), as recommended by the National Health and Medical Research Council (NHMRC) at their 92nd session in October 1981. This goal has also been adopted in the Approved Methods.

2.2.3 Particulate Matter as Nuisance Dust

The preceding sections are concerned with the health impacts of particulate matter. Nuisance impacts need also to be considered, mainly in relation to dust. In NSW, accepted practice regarding the nuisance impact of dust is that dust-related nuisance can be expected to impact on residential areas when annual average dust deposition rate exceeds 4 g/m^2/month.

Table 5 presents the DECCW impact assessment goals for dust deposition, showing the allowable increase in dust deposition rate over the ambient (background) level which would be acceptable so that dust nuisance could be avoided.

Table 5 DECCW Goals for Allowable Dust Deposition

Averaging Period	Maximum Increase in Deposited Dust Level	Maximum Total Deposited Dust Level
Annual	2g/m^2/month	4g/m^2/month

Source: Approved Methods, DECCW 2005.

3 EXISTING AIR QUALITY ENVIRONMENT

3.1 Background Odour Environment

The Woodlawn Bioreactor is the only source of similar odorous emissions in the local region. It is not considered likely that cumulative impacts between emissions from this and any other site in the surrounding region would occur.

Odour is currently generated by activities taking place at the Woodlawn Bioreactor, with the same activities occurring as part of this proposed increase in waste processing. Only odour generating activities occurring as part of the waste processing and management process have been assessed within this report.

3.2 Background Particulate Matter Environment

3.2.1 Background Dust Deposition

Background dust deposition monitoring has been conducted at the Woodlawn site at a number of locations since 2002 (i.e. before the bioreactor was operational). To determine the likely background dust levels under current operations of the Woodlawn Facility, dust deposition monitoring data from January 2007 to January 2010 is used in this assessment.

Background dust deposition monitoring conducted at three representative locations between January 2007 and January 2010 is presented in **Table 6**.

Dust deposition gauge DG18 “Chinnery” was decommissioned in March 2007 on DECCW advice due to consistently low readings. Annual average total insoluble solids at this location were of the order of 2.2 g/m^2/month between August 2004 and February 2007.

Table 6 Background Dust Deposition, Woodlawn

Date	Insoluble Matter (g/m^2/month)		
	DG22 “*East Void*”	DG24 “*West Void*”	DG28 “*Pylara*”
Jan-07	1.2	2.4	1.5
Feb-07	1.9	1.9	0.9
Mar-07	1.6	1.5	1.1
Apr-07	1.4	0.5	0.7
May-07	5.5	1.1	1.6
Jun-07	1.6	0.7	1.6
Jul-07	2	0.7	0.3
Aug-07	1.4	0.7	0.7
Sep-07	2.6	0.8	1.2
Oct-07	0.9	0.9	2.6
Nov-07	0.7	1	1.8
Dec-07	3.6	2.1	1.6
Jan-08	1.3	2	1.9
Feb-08	0.6	0.5	0.7
Mar-08	1.1	1.1	1.1
Apr-08	1.8	1.6	1.5
May-08	0.9	0.5	0.5
Jun-08	3.5	1.3	1.4

Date	Insoluble Matter (g/m^2/month)		
	DG22 "*East Void*"	DG24 "*West Void*"	DG28 "*Pylara*"
Jul-08	1.7	0.4	0.8
Aug-08	5	1.2	0.3
Sep-08	11.6	12.5	7.3
Oct-08	2.1	1.1	2.8
Nov-08	3.9	2.6	6.2
Dec-08	4.4	3.8	1.6
Jan-09	7.4	7.8	14.3
Feb-09	2.1	1.9	2.5
Mar-09	2.4	2.5	4.1
Apr-09	3.8	3.4	1.7
May-09	2.8	2.4	1
Jun-09	2	1.6	2
Jul-09	0.8	1.3	2.2
Aug-09	4.3	2.9	1
Sep-09	25.8	26.8	19.6
Oct-09	2.3	2.3	0.9
Nov-09	4.6	5.5	2.5
Dec-09	2.8	2.7	2.2
Jan-10	5	10.2	1.4
Average	**3.5**	**3.1**	**2.6**

A conservatively high estimate of the background dust deposition rate (insoluble solids) in the vicinity of the Woodlawn facility for assessment purposes is assumed to be of the order of 3.5 g/m^2/month expressed as an annual average. This is the maximum of all the average deposition rates obtained from the three monitoring sites and contains a dust storm event which contributes to the high readings. However, it is considered to be appropriately conservative.

3.2.2 Background Particulate Matter

Background monitoring of PM_{10} has been conducted on a regular basis at the "*Pylara*" site since August 2004. Sampling was conducted using a High Volume Air Sampler (HVAS) in accordance with the NSW DECCW's "*Approved methods for the sampling and analysis of air pollutants in New South Wales*" 2005, specifically, AM-18 (AS 3580.9.6-1990 "*Particulate Matter* - PM_{10} - *high volume sampler with size-selective inlet*"). Sampling was conducted to coincide with the NSW DECCW standard one-day-in-six run cycle.

The results of the PM_{10} monitoring conducted at "*Pylara*" from 16 August 2004 to 18 November 2007 are given in **Table 7**. Data has only been collected up to 18 November 2007 as this site was decommissioned on the advice of NSW DECCW following a number of consistently low readings.

Table 7 PM_{10} Monitoring Results – "Pylara"

Date	PM_{10} (µg/m^3)	Date	PM_{10} (µg/m^3)	Date	PM_{10} (µg/m^3)
18/11/07	<1	16/07/05	<1	29/01/05	2
03/11/07	<1	10/07/05	<1	23/01/05	<1

Date	PM_{10} (µg/m^3)	Date	PM_{10} (µg/m^3)	Date	PM_{10} (µg/m^3)
26/10/07	<1	04/07/05	<1	17/01/05	11
18/10/07	<1	28/06/05	<1	11/01/05	4
12/10/07	<1	22/06/05	<1	05/01/05	5
02/10/07	<1	16/06/05	<1	30/12/04	1
24/09/07	<1	10/06/05	13	24/12/04	5
16/09/07	<1	04/06/05	23	18/12/04	7
13/02/06	<1	29/05/05	3	12/12/04	<1
07/02/06	<1	23/05/05	4	06/12/04	11
01/02/06	4	17/05/05	<1	01/12/04	39
23/01/06	4	11/05/05	16	25/11/04	<1
17/01/06	11	05/05/05	11	19/11/04	1
11/01/05	<1	29/04/05	<1	13/11/04	1
03/01/06	1	23/04/05	25	07/11/04	<1
19/12/05	1	17/04/05	2	01/11/04	5
13/12/05	1	11/04/05	5	26/10/04	3
26/09/05	<1	05/04/05	<1	20/10/04	5
20/09/05	<1	30/03/05	No Results	14/10/04	12
14/09/05	<1	24/03/05	No Results	08/10/04	5
08/09/05	<1	24/03/05	No Results	02/10/04	<1
02/09/05	<1	18/03/05	No Results	27/09/04	36
27/08/05	<1	12/03/05	No Results	21/09/04	8
21/08/05	<1	06/03/05	No Results	15/09/04	13
15/08/05	3	28/02/05	5	09/09/04	19
09/08/05	<1	22/02/05	<1	03/09/04	2
03/08/05	<1	16/02/05	7	28/08/04	10
28/07/05	<1	10/02/05	2	22/08/04	14
22/07/05	2	04/02/05	4	16/08/04	3
				Average	**9**

The above results indicate that PM_{10} monitoring conducted at the "*Pylara*" site near Woodlawn yielded 24-hour average PM_{10} concentrations below the NSW (DECCW) goal of 50 µg/m^3 expressed as a 24-hour average. The maximum 24-hour average was 39 µg/m^3 recorded on 1 December 2004. The results provide an indication of the background concentration of PM_{10} in the area surrounding the Woodlawn Site.

Examination of the NEPM Ambient Air Quality Report for NSW and the ACT for 2004 identifies that high PM_{10} and $PM_{2.5}$ concentrations were recorded at Monash (ACT) and within Sydney between 30 November 2004 and 1 December 2004. The NEPM report for the ACT identifies that ongoing drought conditions within this month resulted in exceedances of the NEPM Standard for PM_{10}. This is supported by the NSW NEPM report which identifies exceedances at Wagga Wagga on 30 November 2004 which were also attributed to "the continuing drought conditions experienced across NSW". Exceedances in the Sydney area were partially attributed to bushfire conditions.

It is clear that the unusually high PM_{10} concentration readings at the Woodlawn 'Pylara' monitoring station on 1 December 2004 were due to regional particulate events and driven by the continuing drought conditions. Using this PM_{10} concentration as a background concentration for assessment purposes would be highly conservative and does not reflect the usual distribution of particulate concentrations over the three year period of monitoring. Further analysis of the collected PM_{10} data shows the following statistics (assuming all <1 µg/m^3 readings are at the limit of detection of 1 µg/m^3):

- Mean: 5 µg/m^3
- Standard deviation: ±7.4 µg/m^3
- 75th Percentile: 5 µg/m^3
- 90th Percentile: 13 µg/m^3
- 99th Percentile 36.6 µg/m^3
- Maximum: 39 µg/m^3

Comparison of the above statistics indicates that the recorded data predominantly shows low recorded 24-hour PM_{10} concentrations, e.g. the 90th percentile of the recorded data is 13 µg/m^3. This demonstrates that values in excess of 13 µg/m^3 are recorded on only 10% of the duration of the monitoring exercise.

Further statistical analysis of the collated 24-hour PM_{10} monitoring data reports a skew value of +2.8 and a kurtosis of +8.8.

Skew is a statistical function that reports how evenly a population is distributed around the mean of that population. A positive skew represents a population that "tails off" towards the upper extents, and a negative skew represents a distribution tailing off towards the lower extents. Skew is dimensionless. The reported skew value of +2.8 value of indicates that the recorded data is typically low, but dominated by a small number of higher readings (i.e. representative of PM_{10} episodes, with much lower "standard" conditions).

Similarly, kurtosis is a statistical function that describes how flat or peaked a population is compared to a normal distribution. A positive value represents a distribution that is more peaked, and a negative value represents a distribution that is flatter than a normal distribution. The reported kurtosis value of +8.8 describes a distribution dominated by higher readings (i.e. representative of PM_{10} episodes).

These statistical functions support the assumption that the site typically experiences low 24-hour PM_{10} concentrations, with sporadic higher readings, which are typical of short-duration PM_{10} episodes.

Section 5.2 of the NSW DECCW document "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" states that for Level 2 assessments, ambient monitoring data for at least one year of continuous measurements should be used in dispersion modelling.

However, in the absence of continuous hourly PM_{10} readings for a full year, the 99th percentile PM_{10} concentration recorded at Woodlawn between 16 August 2004 and November 2007 (36.6 µg/m^3) has been taken as the background concentration of PM_{10} at Woodlawn.

This is considered highly conservative given the average PM_{10} concentration at the *"Pylara"* monitoring site is of the order of 9 µg/m^3 (excluding those results which are below the laboratory limit of detection) and recent results at the site have indicated PM_{10} concentrations below the laboratory limit of detection.

It is noted that the PM_{10} fraction is typically 50% of the total suspended particulate (TSP) concentration in the ambient air of regions where road traffic is not the dominant particulate source, such as rural environments (US EPA, 2001). In the absence of monitoring data for TSP, the annual average TSP concentration for the region may therefore be derived by multiplying the annual average PM_{10} concentration by a factor of two.

To predict a conservatively high background concentration of annual TSP, the annual average PM_{10} records at Woodlawn for the period August 2004 to September 2005 (9 µg/m^3) were multiplied by two to derive the annual average TSP concentration. This corresponds to a mean 24-hour background TSP concentration of 18 µg/m^3, which may be approximated to an annual mean value.

3.3 Background Air Quality Environment for Assessment Purposes

Based on the data and discussion in **Section 3.1** and **Section 3.2** the site specific background air quality levels adopted for the assessment of the Project are presented in **Table 8**.

Table 8 Background Air Quality Environment for Assessment Purposes

Air Quality Parameter	Averaging Period	Assumed Background Level
TSP	Annual	18 µg/m^3
PM_{10}	24-Hour	36.6 µg/m^3
	Annual	9 µg/m^3
Dust	Annual	3.5 g/m^2/month
Odour	Nose-Response Time (1s)	Negligible

4 CLIMATE AND DISPERSION METEOROLOGY

4.1 Local Meteorology

An assessment of wind conditions at the Woodlawn site has been undertaken using on-site weather data from 2005 and 2008. Wind speed and direction were recorded at two Wind Power prospecting weather stations during 2005, known as Woodlawn 13 Mast, at heights of 30 m and 45 m, and Collex Mast, at heights of 40 m and 65 m. In addition, a Veolia (formerly Collex) operated weather station recorded wind speed and direction at 10 m at the Woodlawn Bioreactor. This station changed location in 2008 and data for 14 February 2008 to 14 February 2009 (hereafter, '2008 data') has been obtained to compare to that from 2005.

A summary of the annual wind behaviour for 2005 and 2008 at each location is presented as wind roses in **Appendix A**. The wind roses indicate very little variation in wind direction with wind speeds increasing with height during 2005. 2008 data shows the dominant wind directions as observed within the 2005 dataset. It is therefore considered that the use of 2005 data is appropriate for use within this assessment. Additionally, the greater availability of meteorological observations at varying locations and heights during 2005 allows greater confidence to be placed in any generated meteorological dataset to be used in dispersion modelling of odour and particulate.

A meteorological input file was generated for incorporation into the atmospheric dispersion model using 2005 site specific monitoring data.

4.2 Modelling Approach

Gaussian plume dispersion models such as Ausplume assume that the meteorological conditions are uniform spatially over the entire modelling domain for any given hour. While this may be valid for some applications, in complex topographical situations illustrated in **Figure 3**, the meteorological conditions may be complex and be more accurately simulated using a wind field and puff model.

The Project Site is situated amongst significant topography, particularly to the north, east and southeast, where separate ridgelines dominate the region. It can be assumed that this topography will influence regional meteorology, particularly the generation of night-time katabatic drainage flows into the valley and the channelling of larger scale synoptic flows by regional terrain.

This phenomenon is displayed in the CALMET wind field presented in **Figure 4**, where channelling and intensifying of regional winds can be viewed through the surrounding valley.

In view of the foregoing, the topography of the area has been considered in the atmospheric dispersion model.

The current assessment utilises the CALPUFF (Version 6.1) modelling system. The CALPUFF modelling system comprises of three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard routinely available meteorological and geophysical databases.

In the simplest terms, CALMET is a meteorological model that develops ***hourly*** wind and other meteorological fields on a three-dimensional gridded modelling domain. Associated two dimensional fields such as mixing height, surface characteristics, and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly varying wind field thus reflects the influences of local topography and land uses.

An example of the spatially varying surface flows generated by the CALMET meteorological model is presented in **Figure 4**.

Figure 4 Example of Spatially Varying Surface Flows Generated by CALMET for the Project Site

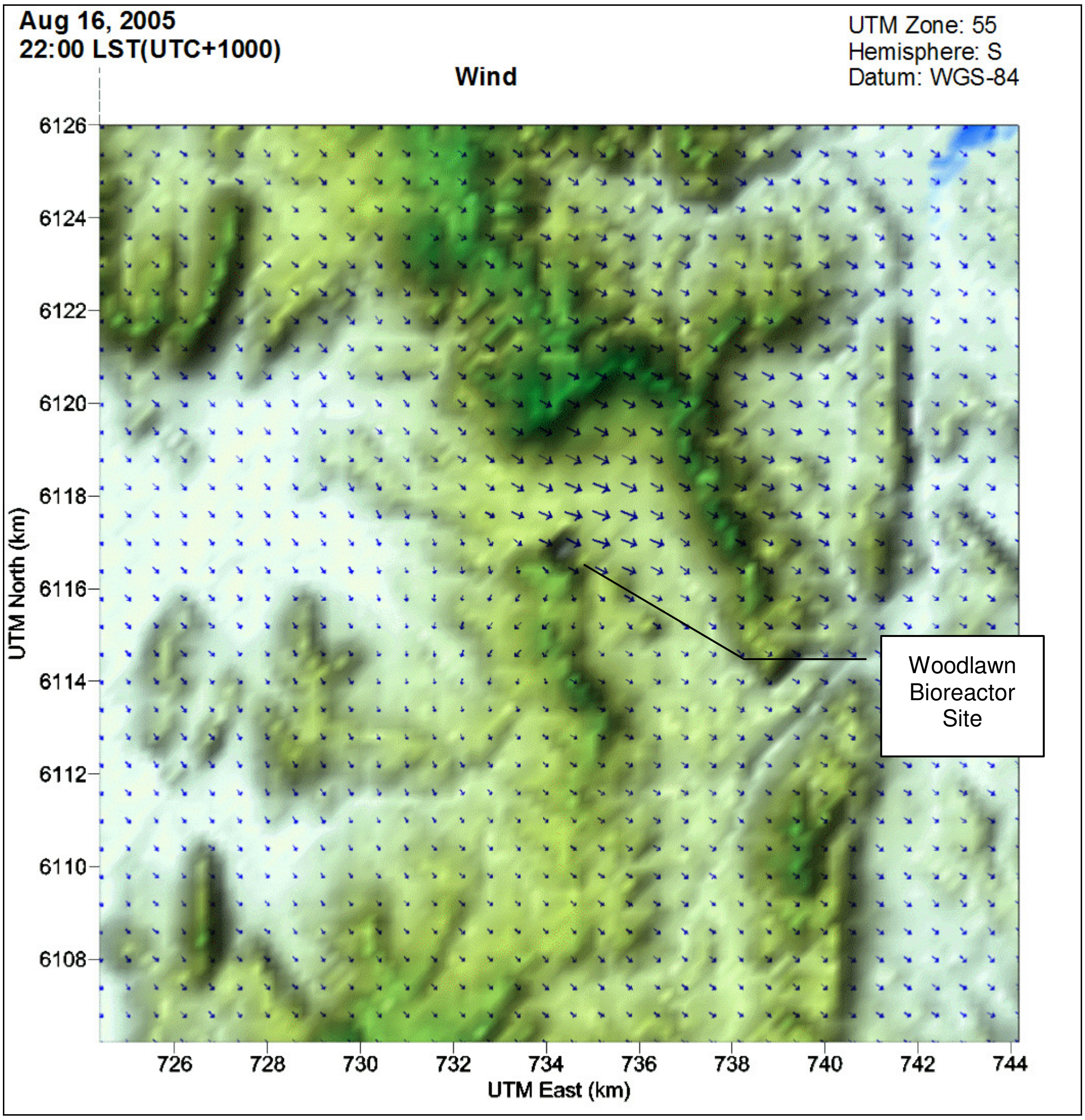


Figure 4 shows a wind field simulated by the CALMET model for one hour of stable night-time conditions during winter.

The CALPUFF model makes use of wind fields generated by the CALMET model, and is discussed further in **Section 4.3**.

The Air Pollution Model (TAPM) meteorological model Version 3 was used to generate upper air observations, which were subsequently used as input for the CALMET meteorological model.

TAPM software, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which may be used to predict three-dimensional meteorological data and air pollution concentrations, with no local data inputs required.

The model predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations.

Additionally, the TAPM model may assimilate actual local wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values. This function of accounting for actual meteorological observations within the region of interest is referred to as “data assimilation”.

Thus, direct measurements for 2005 of hourly average wind speed, wind direction and temperature, obtained at 10 m, 30 m, 40 m, 45 m and 65 m at the Woodlawn weather stations, and TAPM generated upper air data have been used in creating a meteorological input file for modelling purposes.

The prevailing wind directions and average wind speeds for each Woodlawn weather station are summarised in **Table 9**.

Table 9 Summary of Annual Wind Behaviour at Woodlawn, 2005

	Woodlawn Bioreactor	Woodlawn13 Mast		Collex Mast	
Observation Height	**10 m**	**30 m**	**45 m**	**40 m**	**65 m**
Frequency of Calms (%)	3.1	0.4	0.3	0.1	0.1
Average Wind Speed (m/s)	3.2	7.6	7.9	9.0	8.7
Dominant Wind Direction	WNW and W	WNW	WNW	WNW	WNW

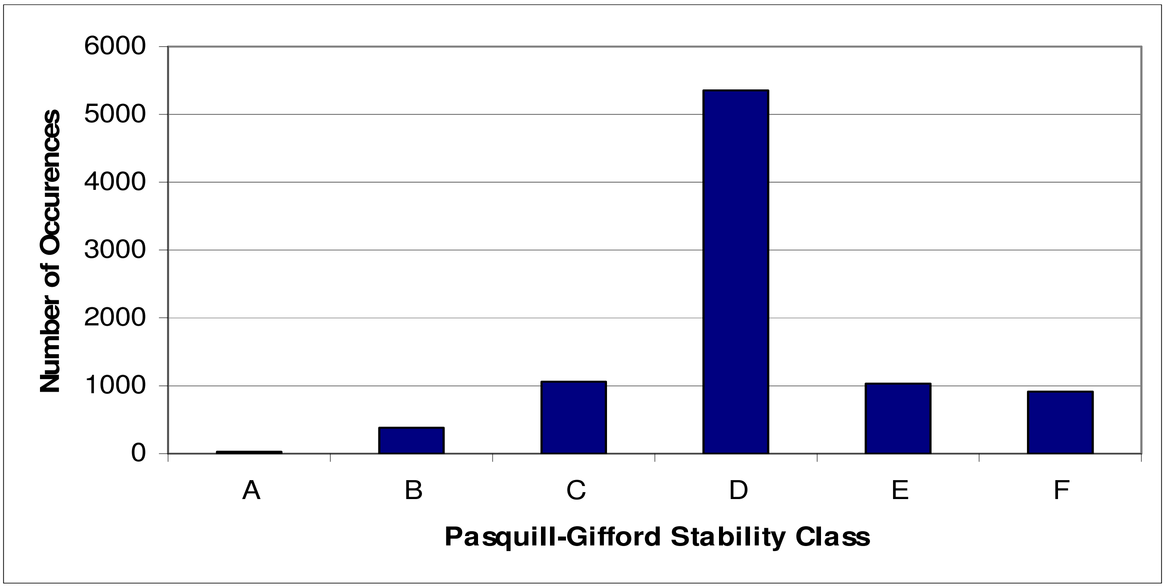
It is noted that typically the change in wind velocity with height (velocity profile) will be positive (i.e. wind speed increases with height). It is noted that the wind speeds recorded at the Collex Mast show a marginally lower average wind speed at 65 m than at 40 m. This anomaly may be explained due to the influence of the adjacent complex terrain on the velocity profile.

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford-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.

Stability Class “A” represents highly unstable conditions that are typically found during summer, categorised by strong winds and convective conditions. Conversely, Stability Class “F” relates to highly stable conditions, typically associated with night-time clear skies, light winds and the presence of a temperature inversion. Classes “B” through to “E” represent conditions intermediate to these extremes.

The frequency of occurrence of each Stability Class for the year 2005, as predicted by the CALMET model, is presented in **Figure 5**. The results indicate a high frequency of conditions typical to Stability Class “D” throughout the year at the Project Site. This is indicative of neutral conditions, which will neither enhance nor impede atmospheric dispersion.

Figure 5 Annual Stability Class Distribution for the Woodlawn Site.



Appendix B illustrates the seasonal variation in atmospheric stability class at the Woodlawn Site. This data indicates that Stability Class "D" dominates in all seasons.

4.3 Meteorological Model Configuration

Table 10 details the parameters used in the meteorological modelling to drive the CALPUFF model.

Table 10 Meteorological Parameters used for this Study

TAPM (v 3.0)	
Number of grids (spacing)	5 (30 km, 10 km, 3 km, 1 km, 300 m)
Number of grids point	20 x 20 x 20
Year of analysis	2005
Centre of analysis	Woodlawn Bioreactor, Woodlawn (35°4' S, 149°34' E)
Data assimilation	Meteorological data assimilation using wind data from 5 onsite monitoring locations
CALMET (v 6.1)	
Meteorological grid domain	20 km x 20 km
Meteorological grid resolution	0.2 km
Surface meteorological stations	Woodlawn Weather Station (10 m) Woodlawn 13 Mast (30 m) Collex Mast (40 m)
Upper air meteorological stations	Data extracted from TAPM for Collex Mast weather station

In summary, meteorological data collected during 2005 at three locations at the Woodlawn site was used in the odour impact assessment. Data from 2008/2009 was also obtained from a meteorological monitoring station at the site to identify whether the data from 2005 was representative of the longer term wind environment. Data provided in **Appendix A** demonstrates that the 2005 data is indeed representative with westerly winds dominating across the year (25%). Easterly and north-easterly winds are important components of the wind environment at the site with observed frequencies of approximately 15% and 8% respectively. These components of the wind are more dominant in the summer months with frequencies of approximately 20% and 15% respectively.

Observed meteorological data from three locations for a full calendar year (2005) has been included within the CALMET model. The CALMET model has been used to derive a **spatially** (3-dimensional) and **hourly** varying meteorological input file which has taken into account the topography and land use between the Project site and all surrounding sensitive receptors.

5 DISPERSION MODELLING CONFIGURATION

CALPUFF is a transport and dispersion model that advects "puffs" of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so it typically uses the fields generated by CALMET, discussed in **Section 4**. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentration or hourly deposition fluxes evaluated at selected receptor locations. CALPOST is then used to process these files, producing tabulations that summarise results of the simulation (Scire et al, 2006).

Air pollutant concentrations were simulated for a regular Cartesian receptor grid covering a nested 5 km by 5 km computational domain, set within the CALMET modelling domain and centred on the Woodlawn Bioreactor, with a grid resolution of 200 m. Concentrations were also predicted at the sensitive receptors identified in **Table 3**.

5.1 Modelling Scenarios

5.1.1 Base Case Odour Scenario

The modelling scenario developed for the 'base case' assessment has been formulated to reflect current worst case operations as follows. For information on the emissions rates quoted for each source and justification for their adoption, refer to **Section 5.2**.

- All liquid storage areas have been assumed to be at full capacity.

  Emission rates used reflect the worst case rates calculated from all monitoring to date for the following sources:
  - Stormwater - 0.5 OU.m^3/m^2/s
  - Groundwater - 0.7 OU.m^3/m^2/s
  - Leachate - 8.8 OU.m^3/m^2/s
  - Treated Leachate - 0.2 OU.m^3/m^2/s (maximum odour emission rate from the most recent monitoring in January 2011)
- A (0.64 ha) area has been assumed to be active for fresh waste tipping – 7.3 OU.m^3/m^2/s
- Four trenches each 20m by 4m in size (0.03 ha in total) have been assumed to be present within the void, containing recirculated leachate – 2.5 OU.m^3/m^2/s.
- A large (6.03 ha) area of waste cover has been assumed – 0.2 OU.m^3/m^2/s.
- Emissions of gas through a potential pathway around the edge of the covered waste (assumed to be 2.5cm wide by the circumference of the void (0.0022ha)) have been modelled – 23.9 OU.m^3/m^2/s
- Operation of the AWT (yet to be constructed) – see **Section 5.2.3**.

Maximum calculated emission rates from all previous odour monitoring campaigns have been adopted, with the exception of treated leachate. In previous modelling assessments, the mean calculated odour emission rates have been used.

Emission source configurations were based on the layout provided by Veolia (2009) and illustrated in **Figure 1**. The number and surface area of the odorous sources included in each modelling scenario, based on the process layout, are identified in **Table 1**.

For the AWT, a likely layout has been adopted from a previous Heggies (SLR Consulting) report (10-5410 R2 20070612). Further information is provided in **Section 5.2**.

All odour sources have been modelled as individual area / volume sources within CALPUFF.

5.1.2 Expansion Project Odour Scenario

The proposed Woodlawn Expansion Project (1.13 million tpa) has been assumed to affect the odour sources as follows. For information on the emissions rates quoted for each source and justification for their adoption, refer to **Section 5.2**.

- All liquid storage areas have been assumed to be at full capacity with emission rates adopted as described for the base case scenario**.**
- A large (2 ha) area has been assumed to be active for fresh waste tipping.
- Ten trenches each 20m by 4m in size (0.08 ha in total) have been assumed to be present within the void, containing leachate recirculated within the void.
- A large (40.9 ha) area of waste cover has been assumed with emission rates as adopted for the base case scenario – all waste operations are assumed to occur at the top of the void.
- Emissions of gas through a potential pathway around the edge of the covered waste have been assumed to have ceased due to the installation of appropriate gas extraction infrastructure around the edge of the void. Refer to **Section 5.2.5** for details of the installed gas infrastructure.

It is also noted that this scenario reflects waste operations at the top of the void and represents a worst case scenario in terms of odour source areas.

All other assumptions adopted for the ‘base case’ scenario remain unchanged as part of the Woodlawn Expansion Project scenario, including the operation of the AWT within the modelling scenario.

Due to the nature of the operations at the Project Site, increased quantities of waste received do not result in a linear *pro-rata* increase in odour generation. Therefore, emissions of odour have been assumed to be worst case in terms of liquid storage, waste tipping and AWT operation (refer **Section 5.2**) and in terms of the odour emission rates used.

5.1.3 Waste Expansion Project Particulate Scenario

The modelling scenario for the Project reflects particulate matter emissions resulting from operation of the AWT and transport of material along unsealed roads to the mine void. Wind erosion of the cover material and windrows etc at the AWT has also been included. It is considered that this represents a worst case scenario in terms of particulate matter emissions, as for the Project odour scenario, all activities are assumed to occur on the void surface.

No base case scenario has been developed for particulate matter.

5.2 Odour Emission Rates

5.2.1 Odour Definitions

Odour concentration is measured in terms of odour units (OU). One OU is the concentration of odour-containing air that can just be detected by 50% of members of an odour panel (persons chosen as representative of the average population sensitivity to odour). This process is defined within Australian Standard AS4323.3 (2001) *Stationary Source Emissions – Part 3: Determination of Odour Concentration by Dynamic Olfactometry.*

An Odour Emission Rate (OER) is the product of the odour concentration (OU/m^3) and the volumetric flow rate (m^3/s or m^3/min), and is often annotated as OU.m^3/s, or OU.m^3/min. Alternatively, an odour emission rate can be thought of as the volume of clean air that would be required to dilute the concentration of odorous gas emitted per unit time down to 1 OU.

The Specific Odour Emission Rate (SOER) may be defined as the quantity of odour emitted per unit time from a unit surface area. The quantity of odour emitted is not determined directly by olfactometry, but is calculated from the concentration of odour (as measured by olfactometry) which is then multiplied by the volume of air passing through the measurement system per unit time. SOERs are often annotated as OU.m^3/m^2/s, or OU.m^3/m^2/min.

5.2.2 Site Specific Monitoring

Odour emission rates have been derived through site specific odour monitoring. SLR Consulting has conducted a number of odour monitoring campaigns of the leachate and waste storage areas and at the Project Site between 2007 and 2011 with the most recent monitoring campaign being conducted in January 2011.

A summary of all odour monitoring undertaken at the Woodlawn site between April 2007 and January 2011 is included as **Appendix E** to this report. These data have been used in the calculation of odour emission rates for each source at the Woodlawn site, with maximum odour emission rates used in modelling (except for the treated leachate, as discussed above). A full discussion of the odour monitoring methodology and full calculations of all odour emission rates are presented in **Appendix E**.

The following section provides justification for the use of the emissions rates which are not the maxima monitored.

Justification for Selected Emission Rates

Treated Leachate

Procedures used to treat leachate produced within the void have been substantially refined over time at Woodlawn. Previously, processes were experimental and in some cases the desired reduction in odour was not achieved which resulted in significantly higher emission rates, captured through monitoring campaigns to be between 3.6 OU.m^3/m^2/s and 7.4 OU.m^3/m^2/s (2007 and 2009). As the treatment process developed it was determined that while the liquid was successfully treated for odour the solids that were left suspended in the liquid quickly became odorous due to high BOD/COD. The use of flocculants was able to drop out the suspended solids thus removing the final source of odour from the treated liquid. The success of this updated treatment processes has been shown through the most recent monitoring campaign (January 2011) to result in significantly reduced odour emission rates (0.2 OU.m^3/m^2/s). These practices are expected to continue to result in reduced emission rates and have been used for the base case, and expansion modelling scenarios.

Leachate Recirculation

Previous practices of leachate spraying within the void do not now occur, with the updated practice of leachate recirculation undertaken. The practice of leachate recirculation has been refined to reduce odour emissions from site and as a result recirculation of leachate is now achieved through a method of reinjection through trenches located around the perimeter of the waste. This allows the leachate to be recirculated through the fresh waste under the intermediate soil cover. The use of the emission rate for leachate recirculation (from January 2011 monitoring campaign [2.5 OU.m^3/m^2/s]) has been adopted for this source for the base case, and expansion modelling scenarios.

Gas emissions

Emissions of odour from this source is a result of a changing phase in gas production and is being addressed through the installation of appropriate gas extraction infrastructure (for further information, refer to **Section 5.2.5**). It is not considered that emissions from this source will be apparent following the installation of this infrastructure and have therefore not been modelled as part of the expansion scenario. Emissions for the base case scenario however have been derived using the emission rate monitored during the January 2011 monitoring campaign (23.9 $OU.m^3/m^2/s$). However, depending on the atmospheric pressure, emissions of gas will vary as a function of mean sea level pressure.

The odour monitoring of this source occurred on 12 January 2011 at approximately 10.00 am. Review of the climate statistics for BoM Goulburn Airport AWS (approximately 40 km north of Woodlawn) indicates that the mean sea level atmospheric pressure during the hour 10.00am to 11.00am on 12 January 2011 was 1012.3 hPa. Further review of the data for Goulburn Airport AWS indicates that between December 2009 and December 2010, the minimum mean sea level atmospheric pressure recorded was 997.0 hPa. Maximum gas emission potential can therefore be calculated based on these data, first correcting to standard pressure (pressure at time of measurement/1013.0 hPa) then correcting for minimum potential pressure (997 hPa/minimum pressure). The resulting maximum potential emission rate of 24.3 $OU.m^3/m^2/s$ has been applied to all hours of the year and the resulting concentrations predicted at each receptor can therefore be viewed as conservatively high.

5.2.3 Derived Emissions Data

Odour emission rates used in the modelling assessment for the AWT were based on a literature review of available odour assessments of AWT operations within NSW including Jacks Gully, Lucas Heights, Buttonderry, Bells Ridge, Eastern Creek and Blaxland Waste Management Facilities and the Camden Soil Mix Composting and Recycling Facility. Presented in **Table 11** are the sources and emission rates adopted for this assessment. Next to each source is the name of the source as used in the CALPUFF modelling input file (**Appendix D**).

Table 11 AWT Odour Sources and Properties

Source	**OER ($OU.m^3/m^2/s$)**	**Source Dimensions**	
VOLUME SOURCES		Horizontal Spread	Vertical Spread
WASP – MSW Storage / Sorting / Processing (SRC_1)	5.65	20	2
WOCOG – Greenwaste Storage / Sorting / Processing (SRC_2)	2.37	10	3.5
AREA SOURCES	**SOER ($OU.m^3/m^2/s$)**	**Area (m^2)**	
AWT Recyclables Storage (WR2)	5.65	~ 48	
AWT Rejects Storage (WR2)	5.65	~ 48	
AWT Organics Storage (WR2)	5.65	~ 60	
AWT Fresh Waste in Windrow (WR2)	5.65	~ 4,000	
AWT Freshly Turned Waste in Windrow (WR4)	4.915	~ 4,000	
AWT Composted Material in Windrow (WR3, WR5_2)	0.11	~ 40,000	
AWT Final Product Storage (WR4_2)	0.83	~ 9,000	

5.2.4 Adopted Odour Emission Rates

A total of seventeen odour sources have been selected for modelling with eight related to the Liquid Storage and Bioreactor sources and nine relating to the unbuilt AWT facility. The emission rates adopted for modelling are presented in **Table 12** for the Bioreactor sources and **Table 11** for the AWT sources.

Within this assessment, all liquid storage areas have been assumed to be at maximum capacity and occupy the areas noted in **Table 1**.

As discussed in **Section 1.1**, waste is stored in the Mine Void (refer **Figure 1**) with fresh waste occupying an area of approximately 0.64 ha [2 ha], leachate recirculation areas occupying an area of approximately 0.03 ha [0.08 ha] and covered waste occupying an area of approximately 6.04 ha [40.8 ha] respectively [numbers represent the expansion project]. The emission rates are as presented in **Table 12.**

Table 12 Emission Rates Adopted for Modelling

Source	Contents	Emission Rate Adopted (refer Appendix E)	Notes
ED3-North	Groundwater	0.7 $OU.m^3/m^2/s$	Maximum of all campaigns (November 2009)
ED3-South	Stormwater	0.5 $OU.m^3/m^2/s$	Maximum of all campaigns (June 2007)
ED3N-2 / ED3N-3	Treated Leachate	0.2 $OU.m^3/m^2/s$	Maximum of January 2011 campaign
ED3N-1/ Leachate Dam	Untreated Leachate	8.8 $OU.m^3/m^2/s$	Maximum of all campaigns (November 2009)
Mine Void 1	Fresh Waste	7.3 $OU.m^3/m^2/s$	Maximum of all campaigns (January 2011) Wet Fresh Waste emission rate adopted
Mine Void 2	Leachate Recirculation	2.5 $OU.m^3/m^2/s$	Maximum of all campaigns (January 2011)
Mine Void 3	Covered Waste	0.2 $OU.m^3/m^2/s$	Maximum of all campaigns (January 2011)
Mine Void 4	Gas Emissions	23.9 $OU.m^3/m^2/s$	Maximum of all campaigns (January 2011) refer **Section 5.2.5**

5.2.5 Uncaptured Gas Emissions

The operation of a bioreactor is designed to maximise the production of high quality methane which is captured and combusted for energy production. Gas capture wells are designed to optimise the capture of methane and, simply put, less gas captured results in less energy produced. While maximising the capture of gas for energy production is a core principle of the bioreactor, there is also a financial incentive for Veolia to produce more energy from the waste received at Woodlawn.

There are several phases to gas production in a bioreactor. Initially, fresh waste is brought to site which due to its unsaturated nature produces low quality gas (approximately 30% to 40% methane content) which is unsuitable for combustion within the gas engines on its own. This gas is mixed with higher quality gas, making it suitable for combustion, thereby controlling emissions of greenhouse gas and also controlling odour. The gas production within the bioreactor increases once leachate is recirculated into the waste and increases further as the waste continues to degrade. As gas is produced, the pressure increases, forcing it through pathways in the waste which are then intercepted by gas extraction infrastructure. This gas is highly valuable, as the methane content is significantly higher than that produced within fresh waste, and is ideal for combustion in gas engines to produce electricity. The infrastructure to collect this gas is designed to capture as high percentage of gas as possible with the ultimate aim being to capture all of the gas which is produced.

At Woodlawn in late 2010, waste in the saturated zone at the base of the void started to reach the mature stage of gas production. This was reflected in the discovery of gas escaping from a previously decommissioned section of the gas extraction infrastructure which coincided with odour issues experienced on site and an uncharacteristically high number of complaints for the operations at the time of the exhibition of the Environmental Assessment. Immediate action was taken to resolve this issue, and the gas well head was capped. This resulted in an immediate decrease in the number of complaints received, providing a level of confirmation that this action had resolved the issue.

The experience led to further consideration of escaping gas as being a large contributor to off site odour issues. During the odour monitoring campaign in January 2011, potential gas pathways were identified at the edge of the waste mass and were sampled for odour emissions, the results of which are discussed in **Appendix E**. The monitoring has helped to confirm that waste at the base of the void is under sufficient pressure to allow gas migration, with some of the migration occurring towards the edge of the void. Gas infrastructure is now being installed in these areas around the edge of the waste mass to maximise gas capture and reduce quantities of gas emissions to the ambient environment.

It is considered by operational personnel at Woodlawn that this represents a new stage of gas production, and additional gas infrastructure at the edges of the void will now become a part of the ongoing gas infrastructure program. The installation of this infrastructure will act to minimise the quantity of gas migrating through the void without being captured. The ultimate aim of the bioreactor operation is to capture as much gas as possible for energy production.

Within the base case scenario, fugitive gas emissions have been modelled to assess their impact on the sensitive receptors in **Table 3**. The maximum odour emission rate from this source has been used as input to the dispersion modelling exercise, with an appropriate peak-to-mean ratio applied (refer **Section 5.2.6**).

Emissions of gas through this pathway have been assumed to be removed in the expansion scenario modelling assessment as a result of continual void inspection, drilling of gas infrastructure and connection to the network of gas extraction infrastructure.

5.2.6 Odour Peak-to-Mean Ratios

The NSW DECCW document "*Technical Notes - Assessment and Management of Odour from Stationary Sources in New South Wales"*, (DECCW, 2006b – the Odour Notes) states that Peak-to-Mean ratios should be incorporated when conducting atmospheric dispersion modelling of odour.

It is commonly recognised that dispersion models such as CALPUFF need to be supplemented to accurately simulate atmospheric dispersion of odours. This is because the instantaneous perception of odours by the human nose typically occurs over a time scale of approximately one second but dispersion model predictions are typically valid for time scales equivalent to ten minutes to one hour averaging periods.

To estimate the effects of plume meandering and concentration fluctuations perceived by the human nose, it is possible to multiply dispersion model predictions by a correction factor called a "peak-to-mean ratio".

The peak to mean ratio (P/M60) is defined as the ratio of peak 1-second average concentrations to mean 1-hour average concentrations.

To estimate peak concentrations, this assessment has used data presented in Table 10.1 of the Odour Notes. Specifically, to establish a conservatively high estimate of peak odour concentrations, the following peak to mean ratio (P/M60) has been adopted, corresponding to near-field receptors for area sources:

- A Peak-to-Mean Ratio (P/M60) of 2.5 has been applied to the emission rate during periods where atmospheric stability class is between A and D.
- A Peak-to-Mean Ratio (P/M60) of 2.3 has been applied to the emission rate during periods where atmospheric stability class are E or F.

5.3 Particulate Matter Emission Rates

A review has been carried out of the potential for particulate generation during the operation of the Woodlawn Expansion Project (including the movement of waste on-site and the proposed 24 MW landfill gas combustion facility) as well as the AWT facility. The activities identified include:

- Mixed waste trucks/containers travelling to the void from the main road
- Wind erosion from covered waste
- Mixed waste trucks unloading to WASP bunker
- Green waste unloading to WOCOG bunker
- Loading Reject Storage Bins
- Loading Recyclables Storage Bins
- Loading Organic Material Storage Bins
- Organic Material Transfer from waste processing building to windrows
- Wind erosion from windrows
- Final Product Screening and Storage
- Combustion of landfill gas in 24 x 1 MW JE Genbacher Gas Engines

Table 13 presents the emission factors for the key atmospheric pollutants used in the dispersion modelling carried out for this assessment. These estimate the emissions expected under normal operating conditions. The ratio of the PM_{10} fraction of the total particulate emission ranges from 75% (e.g. screening) down to 25% (e.g. operation of dozers).

The proportion of the PM_{10} fraction for each activity was derived primarily from the Commonwealth Department of Environment and Heritage (DEH) (2001) document, "*Emission Estimation Technique Manual for Mining, Version 2.3*".

Table 13 Particulate Emission Factors for Air Quality Dispersion Modelling

Activity	Total Particulate Emission Factor [1]	PM_{10} Emission Factor	Emission Factor Units
Waste Truck Unloading	0.00004	0.00002	kg/t
Screening	0.08	0.06	kg/t
Wind Erosion	0.40	0.20	kg/ha/hr

Handling/Transferring/Conveying	0.005	0.002	kg/t
Dozer	0.117	0.015	kg/t
Loading Storage Bins	0.0004	0.0002	kg/t

Note 1: Total Particulate emission factor is used to derive the rate of dust deposition

In general, emission factors equations have been used as contained in Table 1 of "*Emission Estimation Technique Manual for Mining, Version 2.3*", (National Pollutant Inventory, 2001).

Emissions resulting from heavy vehicles travelling on unpaved roads have been derived using the USEPA AP42 emission factors (Wheel Generated Dust from Unpaved Roads (2003)) as outlined in **Equation 1.**

$$EF = k \times \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W}{3}\right)^{0.45} \times \left(\frac{281.9}{1000}\right) \times \left(\frac{365-p}{365}\right) \quad \text{(kg/VKT)}$$ **Equation 1**

where
k = 4.9 (TSP)
k = 1.5 (PM_{10})
s = silt content (%), W = vehicle gross mass (tonnes)
p = number of days in year with rainfall greater than 0.25mm

VKT = Vehicle Kilometre Travelled

Emissions from the combustion of landfill gas have been derived using the NPI Emission Estimation Technique for Combustion Engines Version 3 June 2008 (National Pollutant Inventory, 2008). Emission factors for PM_{10} are provided for uncontrolled landfill gas fired turbines either as kg/kWh, or kg/m^3. Emissions (g/s) based on both gas combustion (12,750 m^3/hr) and kWh capacity (24,000 kWh) have been calculated to be 0.67 g/s and 0.65 g/s, respectively. In the interests of conservatism, the higher emission rate has been used, and divided between all 24 proposed units. Stack parameters (exit velocity, temperature etc have been sourced from monitoring reports for the existing engines). Details are provided within the emissions inventory provided as **Appendix C**.

5.4 Particulate Emission Inventory

The following assumptions have been made in deriving the emission inventory for the modelling exercise.

General

- To represent a worst case scenario, the haul road is assumed to originate at the main road and travel into the pit - a distance of approximately 2.6 km.
- It has been assumed that Level 1 watering controls (< 2 l/m^2/hr) are applied to the road and a 50% control factor has been applied accordingly.
- The silt content of the roads is assumed to be 5%.
- The moisture content of Mixed Waste is taken to be 32%.
- The moisture content of Green Waste is taken to be 30%.
- The moisture content of Organic Waste is taken to be 30%.
- Average 10 m height wind speeds on site is taken to be 3 m/s (based on on-site meteorological measurements).

- Operations occurring within the shed are assumed not to generate fugitive particulate emissions. Given the high moisture content of MSW, particulate emissions are unlikely to be significant. All equipment with the potential for dust generation will be fitted with fabric filters or housed within the AWT facility.
- The particulate emission factors used for unloading of waste (MSW and green waste) to the WASP and WOCOG bunkers and the unloading of organic material onto windrows were derived from the *"Emission Estimation Technique Manual for Mining Version 2.3"*. The factors correspond to unloading trucks (rear dumping).
- The particulate emission factors for the loading of materials into the rejects bins, recyclables bins and organic waste storage area were derived from Table 1 of *"Emission Estimation Technique Manual for Mining Version 2.3*". The factors correspond to trucks dumping overburden.
- The particulate emission factors for the transferring organic waste from the waste processing building to the windrow area were derived from Table 1 of *"Emission Estimation Technique Manual for Mining Version 2.3*". The factors correspond to Handling, Transferring and Conveying (High Moisture Content Ores).
- The particulate emission factors for the unloading organic waste onto windrows were derived from Table 1 of *"Emission Estimation Technique Manual for Mining Version 2.3*". The factors correspond to unloading trucks (rear dumping).
- The particulate emission factors for wind erosion from covered waste, windrows and final product storage were derived from Table 1 of *"Emission Estimation Technique Manual for Mining Version 2.3*". The factors correspond to Wind Erosion.
- The particulate emission factors for the turning of windrows were derived from Table 1 of *"Emission Estimation Technique Manual for Mining Version 2.3*". The factors correspond to dozers working on material other than coal.
- The particulate emission factors for final product screening / de-stoning were derived from Table 1 of *"Emission Estimation Technique Manual for Mining Version 2.3*". The factors correspond to screening.
- The background PM_{10} used in dispersion modelling was derived from PM_{10} concentrations recorded at the Woodlawn monitoring station at Pylara (refer **Section 3.2.2**).
- For both Scenarios, the entire Windrow Composting area is assumed to be at full capacity at all times.
- An optional alternative fuel processing module is assumed to be in operation. Particulate emissions from the alternative fuel processing module are assumed to be insignificant as the unit will be housed within the WASP building and fitted with a fabric filter. However storage and loading of the alternative fuel for transport off-site has the potential to generate particulate emissions. Accordingly, the emission factors for the alternative fuel loading was derived from Table 1 of "*Emission Estimation Technique Manual for Mining Version 2.3*". The factors correspond to Handling, Transferring and Conveying (Low Moisture Content Ores).
- The WASP throughput is assumed to 240,000 tpa.
- The WOCOG throughput is assumed to be 40,000 tpa.
- The modelling assessment assumes the facility is in operation for 312 days per annum.
- To provide a worst-case conservative impact assessment, a silt content of 3% for the mixed waste and green waste material has been assumed for the site and used within emission factor equations.

A particulate emissions inventory is provided in **Appendix C**.

5.5 Other Pollutant Emissions

As previously described, the proposed expansion will require up to 24 Landfill Gas Engines, for which emissions of particulate matter have been quantitatively assessed within this report. These engines also have the capacity to emit quantities of nitrogen oxides (NO_X), carbon monoxide (CO) and volatile organic compounds (VOCs). A quantitative modelling assessment has not been performed for these pollutants however, an assessment of how these emissions compare with requirements stipulated in the Protection of the Environment Operations (Clean Air) Regulations 2010 (the POEO regulations) has been undertaken.

Mandatory annual monitoring is undertaken at the existing three landfill gas engines. The maximum monitored emissions for VOCs, CO and NO_X for all three engines, along with the relevant emission limits, taken from the POEO regulations are presented in **Table 14**.

Table 14 Emission Limits applicable to Landfill Gas Engines (POEO, 2010)

Air Impurity	100 Percentile Concentration Limit	Maximum from Existing Engines
Volatile Organic Compounds (VOCs) as n-propane	40 mg/m^3 VOCs or 125 mg/m^3 CO	4.2 mg/m^3 (VOCs) 1073 mg/m^3 (CO)
Nitrogen Dioxide (NO_2) or Nitric Oxide (NO) or both, as NO_2 equivalent	450 mg/m^3	449 mg/m^3

Clause 38 (2) of the POEO regulations states that the requirement for a standard of concentration for volatile organic compounds or carbon monoxide is deemed to be met if either of those standards is achieved. Therefore, even though the standard of concentration for carbon monoxide is exceeded, the standard of concentration of VOCs is met and therefore, all emissions from the landfill gas engines are in compliance with the POEO regulations.

6 AIR QUALITY IMPACT ASSESSMENT

6.1 Odour Impact Assessment

Table 15 presents the 99th percentile 1 second average odour concentrations at the surrounding sensitive receptor locations, as predicted by CALPUFF under worst case conditions, for current ('base case') and proposed (Waste Expansion Scenario) operations at the Project Site using the emission rates discussed in **Section 5.2**. It can be seen that concentrations are predicted to range between 0.5 OU and 2.9 OU at all receptors for the base case (current) scenario, increasing to between 0.7 OU and 3.5 OU for the Project scenario.

The corresponding isopleth plots of these dispersion modelling results are presented in **Figure 6** and **Figure 7**.

Table 15 Predicted 99th Percentile 1 Second Average Odour Concentration

Receptor ID	Predicted Odour Concentration (OU/m^3) – Base Case	Predicted Odour Concentration (OU/m^3) – Woodlawn Expansion Project
Receptor 1: "Woodlawn Farm"	2.9	3.4
Receptor 2: "Cowley Hills"	1.5	2.0
Receptor 3: "Pylara"	0.6	1.2
Receptor 4: "Torokina"	0.7	1.1
Receptor 5: Tarago Village	0.5	0.7

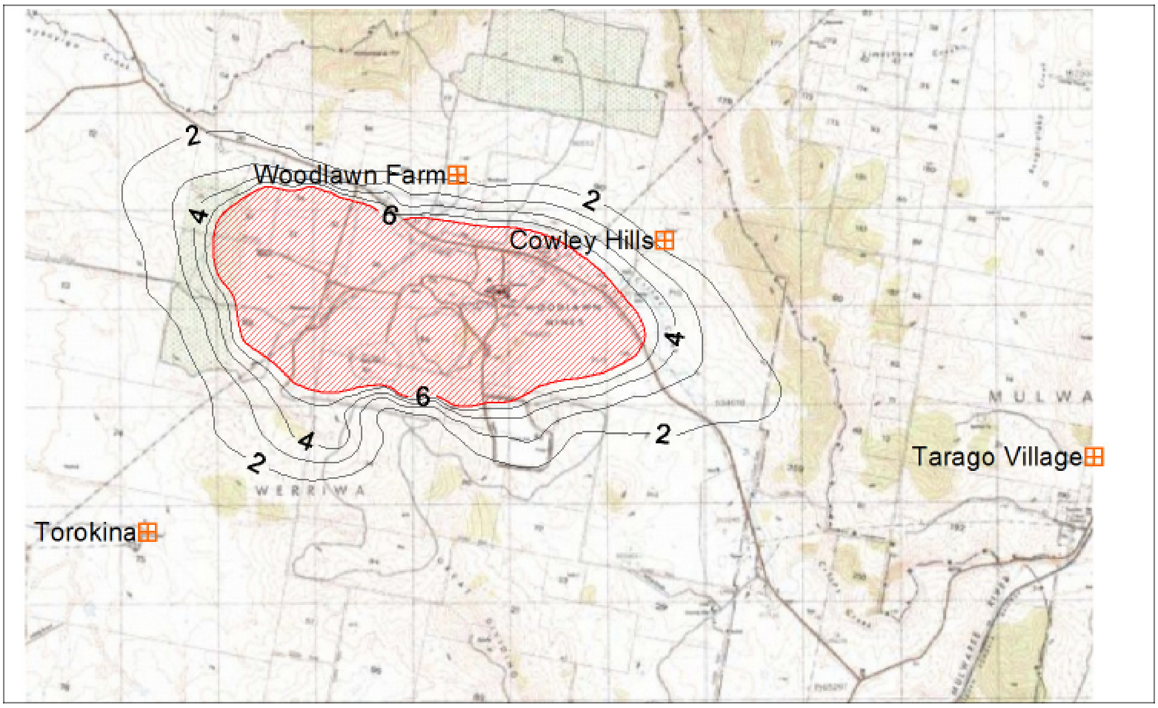
It is noted that the results presented in **Table 15**, **Figure 6** and **Figure 7** relate to the 99th percentile odour concentration, the 88th highest concentration of the 8,760 hours (1 year) which have been modelled. These results indicate that under worst case operating conditions, odour concentrations will satisfy the Project odour criterion of 6 OU at all surrounding residences in both scenarios modelled, reflecting current and proposed operating conditions under the Woodlawn Expansion Project.

Although these predictions indicate that the NSW DECCW criterion is not exceeded, they do not purport to show that *no odour* will be experienced at the receptors assessed within this report. As previously discussed in **Section 2.1** the odour criteria is designed to take into account the likelihood of sensitive individuals being present within a population, based on the population size. Additionally, the criterion is not designed to achieve *no odour.*

The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the *odour threshold* and defines one odour unit per cubic metre (OU/m^3). An odour goal of less than 1 OU/m^3 would theoretically result in no odour impact being experienced.

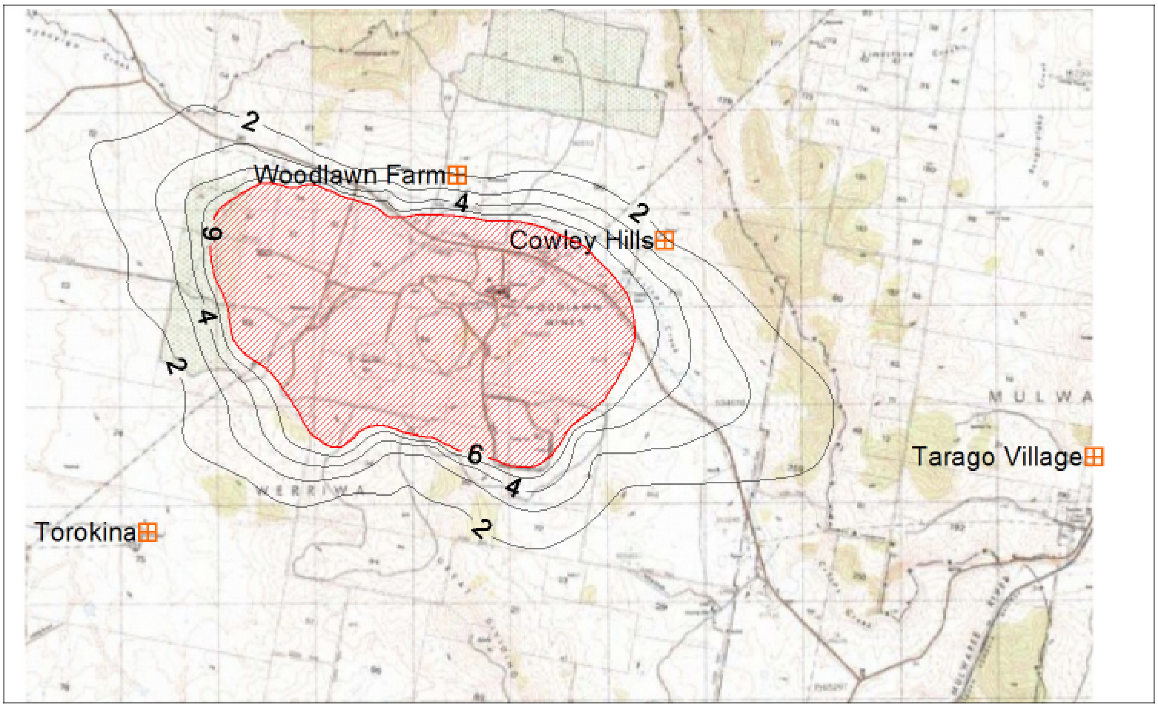
To provide further discussion on the apparent disparity between the experience of individuals surrounding the Project site and the monitoring results provided in **Table 15**, **Section 6.1.1** examines the frequency distribution of all odour concentrations predicted at each receptor, for all hours of the year, rather than just comparison of the 99th percentile odour concentrations, as required by the NSW DECCW.

Figure 6 99th Percentile 1 Second Average Odour Concentration – Woodlawn Bioreactor – Base Case



2005 Meteorology, Emission Rates adopted from **Section 5.2**; Adopted Criterion – 6 OU

Figure 7 99th Percentile 1 Second Average Odour Concentration – Woodlawn Bioreactor – Woodlawn Expansion Project and AWT Facility



2005 Meteorology, Emission Rates adopted from **Section 5.2**; Adopted Criterion – 6 OU

6.1.1 Frequency Distribution of Odour Concentrations

The top ten odour concentrations modelled over the course of the year (8,760 hours) at each receptor identified in **Table 3** have been extracted for both the base case and expansion scenario and are presented in **Table 16** and **Table 17**, respectively.

Table 16 Maximum to Tenth Highest Predicted Odour Concentrations – Base Case

Receptor ID	Predicted Odour Concentration (OU/m^3) – Base Case									
	Max	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Receptor 1: “Woodlawn Farm”	15.4	15.1	13.7	13.1	11.6	10.9	10.6	10.4	10.3	10.1
Receptor 2: “Cowley Hills”	5.3	4.4	4.1	4.0	3.9	3.9	3.6	3.6	3.6	3.5
Receptor 3: “Pylara”	4.7	2.9	2.8	2.4	2.2	2.0	1.9	1.9	1.7	1.7
Receptor 4: “Torokina”	5.1	3.7	3.4	3.1	2.8	2.7	2.7	2.7	2.6	2.5
Receptor 5: Tarago Village	1.6	1.3	1.2	1.0	1.0	1.0	0.9	0.9	0.9	0.8

Table 17 Maximum to Tenth Highest Predicted Odour Concentrations – Woodlawn Expansion Project

Receptor ID	Predicted Odour Concentration (OU/m^3) – Woodlawn Expansion Project									
	Max	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Receptor 1: “Woodlawn Farm”	16.6	15.4	15.1	14.1	13.1	11.6	11.4	10.9	10.7	10.6
Receptor 2: “Cowley Hills”	7.3	6.6	5.9	5.6	5.6	5.4	5.4	5.1	4.9	4.6
Receptor 3: “Pylara”	7.9	6.9	3.8	3.8	3.4	3.4	3.2	3.1	3.1	2.9
Receptor 4: “Torokina”	5.1	3.5	3.4	3.3	3.2	3.1	2.8	2.7	2.7	2.7
Receptor 5: Tarago Village	2.3	2.0	1.8	1.7	1.7	1.5	1.3	1.3	1.3	1.2

Results for Torokina and Tarago Village are also presented graphically in **Figure 8** and **Figure 9**, respectively.

Through this assessment, it is demonstrated that although the NSW DECCW odour impact assessment criterion of 6 OU is met at each receptor for both the base case and expansion scenarios, odour is predicted to reach concentrations in excess of the odour threshold (1 OU) on several occasions with the maximum odour concentration predicted to reach 16.6 OU at Woodlawn Farm, during the expansion scenario.

Figure 8 Highest Predicted Odour Concentrations – Base Case and Expansion Scenarios – Torokina

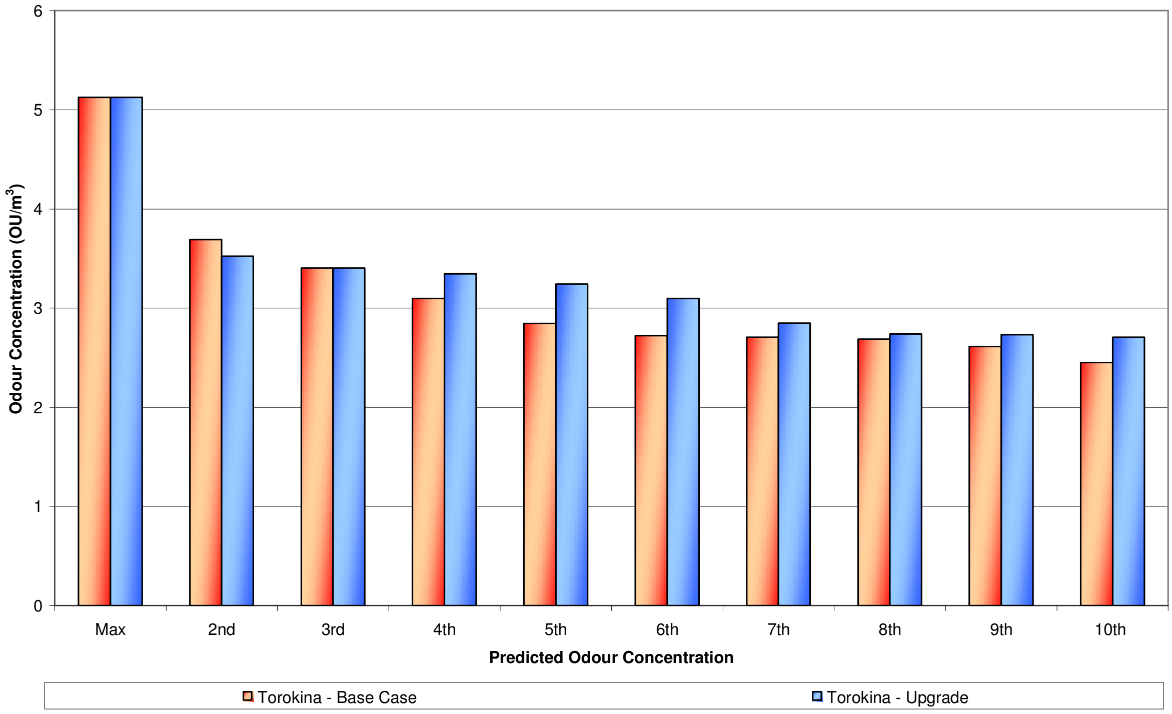
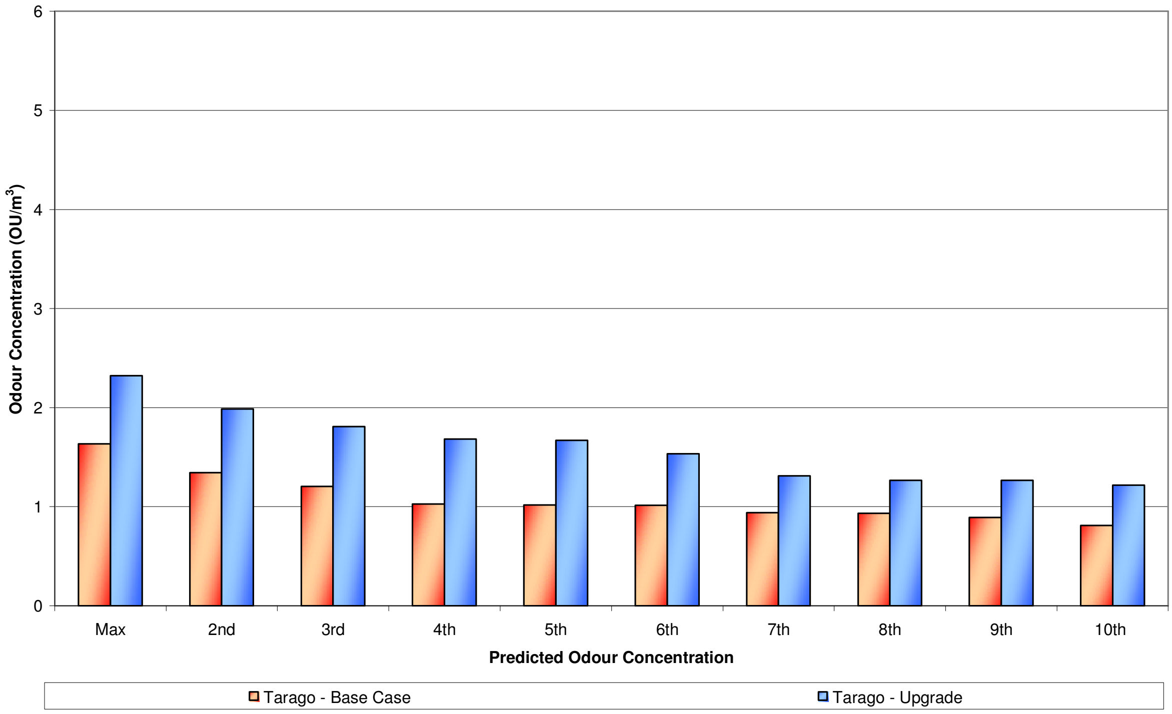


Figure 9 Highest Predicted Odour Concentrations – Base Case and Expansion Scenarios – Tarago Village



A further assessment of the worst case scenario data indicates that exceedances of the theoretical odour threshold of 1 OU are predicted to occur, and are predicted to increase as a result of the expansion (refer **Table 18**). This confirms that emissions of odour from the Woodlawn Site will be noticeable at all receptors on occasion however, model predictions of odour for both the base case and expansion scenario are below NSW DECCW criterion, which defines acceptable levels of odour.

Table 18 Model Predictions >1 OU – Base Case and Expansion Scenarios

Receptor ID	Number of Hours in excess of 1 OU Predicted Odour Concentration - Base Case	Number of Hours in excess of 1 OU Predicted Odour Concentration – Woodlawn Expansion Scenario
Receptor 1: “Woodlawn Farm”	229	263
Receptor 2: “Cowley Hills”	173	241
Receptor 3: “Pylara”	42	117
Receptor 4: “Torokina”	56	99
Receptor 5: Tarago Village	6	25

It is demonstrated in **Table 18** that the odour detection threshold is currently predicted to be exceeded approximately 6 times within Tarago, increasing to 25 times following the proposed expansion. In reality, this means that odour will be noticeable, but not strong on up to 25 occasions over a year following the expansion. Again, it is noted that this is not an exceedance of the Project criterion, but an occurrence that would theoretically result in odour detection.

6.1.2 Comparison with Previously Submitted Assessment Reports

It is noted that the previous submitted assessment report showed differing predictions of odour for both the base case and the expansion scenario to those which are presented within this report. It is shown that generally, odour predictions have increased slightly for the base case scenario, with predictions decreasing during the expansion scenario at Woodlawn Farm, but are shown to increase from 1.1 OU to 1.3 OU at Torokina.

The changes in the predicted odour concentrations are a result of the changes in the emission rates used within the modelling assessment and the spatial distributions of the corresponding emission sources. For example, the fresh waste emission rate of 0.7 $OU.m^3/m^2/s$ was applied over a 2 ha area for the previous expansion scenario.

For the current expansion scenario the emission rate applied is 7.3 $OU.m^3/m^2/s$ over 2 ha, resulting in an increase in odour emissions of 132,000 OU/s from the most recent modelled base case. However, this emission increase is offset by the reduction in predicted odour emissions from the treated leachate ponds. As previously discussed, the emission rate obtained during the most recent monitoring campaign is deemed to better reflect current practices of leachate treatment which result in improved odour management and control. The use of this emission factor of 0.2 $OU.m^3/m^2/s$ over a 1.4 ha area as compared to the previously used emission rate of 3.6 $OU.m^3.m^2/s$ results in an emission reduction of approximately 60,500 OU/s.

A comparison between the previously submitted expansion scenario versus the currently presented expansion scenario shows that the differences in odour emissions from each source has resulted in an increase to the total OU emitted from the site in the currently submitted scenario, attributable to the increased emissions from covered waste, fresh waste, untreated leachate, stormwater and groundwater. However, the predicted 99^{th} percentile odour concentration is shown to increase at Torokina only, with predicted odour concentrations remaining the same at Pylara and Cowley Hills and decreasing from 4.1 OU to 3.5 OU at Woodlawn Farm. This change is due to the spatial distribution of the emissions changes.

6.2 Particulate Matter / Dust Impact Assessment

6.2.1 Particulate Matter as PM_{10}

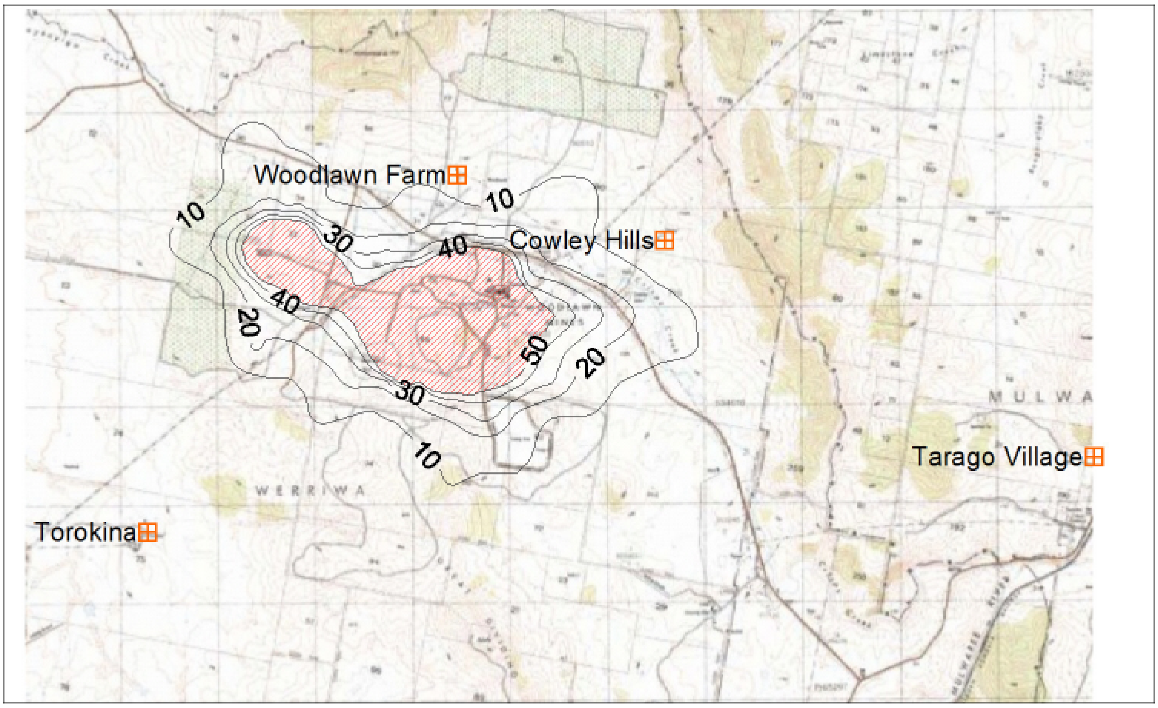
Table 19 shows the results of the CALPUFF predictions for the 24-hour average PM_{10} concentrations. The results show the maximum 24-hour average PM_{10} concentrations predicted at the nearest receptor locations surrounding Woodlawn site over a one year time frame.

A contour plot of the maximum 24-hour average PM_{10} concentrations is presented in **Figure 10**. The contour plots do not represent the dispersion pattern at any particular instant in time, but show the predicted maximum 24-hour average PM_{10} concentrations that occurred at each location. They therefore represent the concentrations that can possibly be reached under the conditions modelled.

Table 19 Background and Predicted 24-Hour Average PM_{10} Concentrations

	Maximum 24-Hour PM_{10} Concentrations (µg/m^3)			
Residence	**Background**	**Increment**	**Background + Increment**	**Project Goal**
Scenario 1				
1. "Woodlawn Farm"	36.6	7.3	43.9	50
2. "Cowley Hills"	36.6	5.4	42.0	50
3. "Pylara"	36.6	2.3	38.9	50
4. "Torokina"	36.6	2.2	38.8	50
5: Tarago Village	36.6	1.2	37.8	50

Figure 10 Predicted Maximum 24-hour Incremental PM_{10} Concentration (µg/m^3) – Woodlawn Bioreactor – Woodlawn Expansion Project and AWT Facility



2005 Meteorology, Emission Rates adopted from **Section 5.2**; Adopted Criterion – 50 µg/m^3

The results presented in **Table 19** and **Figure 10** shows that at all receptor locations, the maximum 24-hour average concentration of PM_{10} (background plus increment) associated with the proposed Project is predicted to be below the project goal of 50 µg/m^3 (24-hour average).

The contribution of the Project to total 24 hour PM_{10} concentrations is predicted to be low, with a maximum incremental 24-hour PM_{10} concentrations of 7.3 µg/m^3 predicted at "Woodlawn Farm". Even assuming a high background PM_{10} concentration of 36.6 µg/m^3 (the 99.9th percentile of three years of monitoring data), the total predicted PM_{10} concentration as a result of the Project is predicted to comply with the project goal.

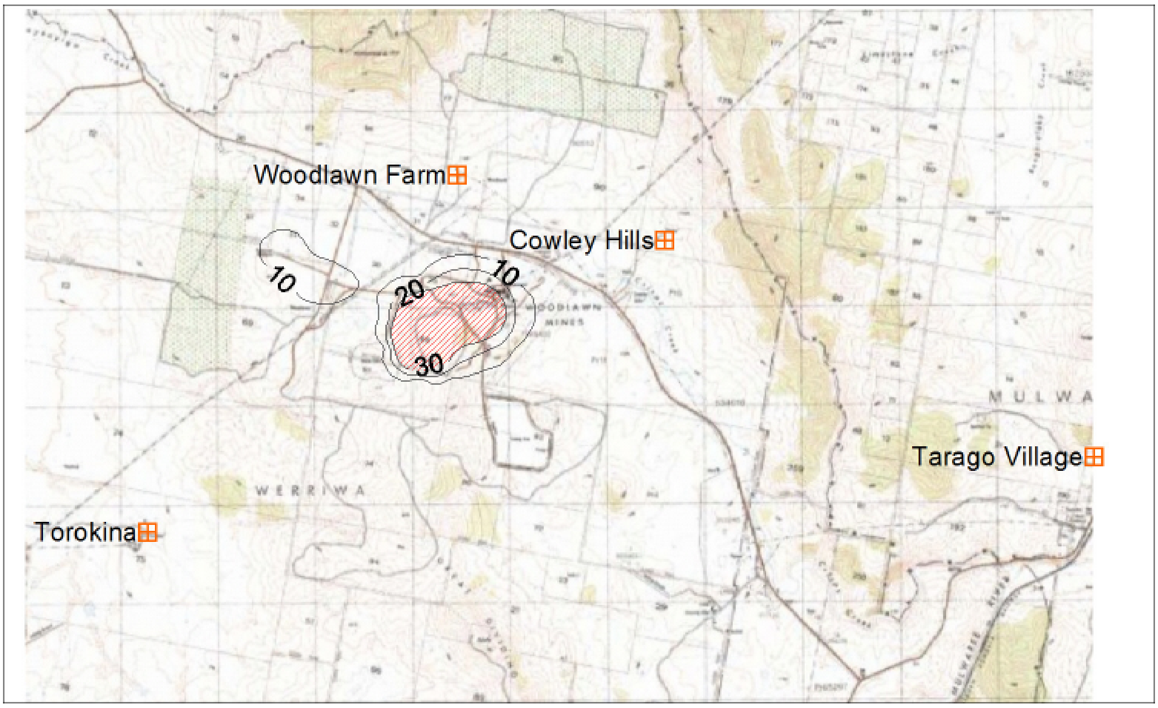
Table 20 shows the results of the CALPUFF predictions for annual average PM_{10}. The results show the predicted annual average PM_{10} concentration at the nearest receptor locations surrounding the Woodlawn Site over a one-year time frame.

A contour plot of the annual average PM_{10} concentrations is presented in **Figure 11**.

Table 20 Background and Predicted Annual Average PM_{10} Concentrations

	Maximum Annual Average PM_{10} Concentrations (µg/m^3)			
Residence	**Background**	**Increment**	**Background + Increment**	**Project Goal**
Scenario 1				
1. "Woodlawn Farm"	9	0.7	9.7	30
2. "Cowley Hills"	9	0.5	9.5	30
3. "Pylara"	9	0.2	9.2	30
4. "Torokina"	9	0.2	9.2	30
5: Tarago Village	9	0.1	9.1	30

Figure 11 Predicted Annual Average PM_{10} Incremental Concentration (µg/m^3) – Woodlawn Bioreactor – Woodlawn Expansion Project and AWT Facility



The results presented in **Table 20** and **Figure 11** indicate that at each receptor location, the maximum annual average concentration of PM_{10} (background plus increment) associated with the Project is predicted to be significantly below the project goal of 30 µg/m^3. The contribution of the Project to the total annual average PM_{10} concentrations is predicted to be insignificant with a maximum incremental annual average PM_{10} concentration of 0.7 µg/m^3 predicted at "Woodlawn Farm".

6.2.2 Particulate Matter as TSP

Table 21 shows the results of the CALPUFF predictions for annual average TSP. The results show the average concentrations predicted at the nearest receptor locations over a one year time frame. Background levels of TSP are assumed to be 18 µg/m^3 (refer **Section 3.3**).

Table 21 Background and Predicted Incremental Total Suspended Particulate

	Annual Average TSP Concentration (µg/m³)			
Residence	**Background**	**Increment**	**Background + Increment**	**Project Goal**
Scenario 1				
1. “Woodlawn Farm”	18	<0.1	<18.1	90
2. “Cowley Hills”	18	<0.1	<18.1	90
3. “Pylara”	18	<0.1	<18.1	90
4. “Torokina”	18	<0.1	<18.1	90
5: Tarago Village	18	<0.1	<18.1	90

The results presented in **Table 22** show that increases in the annual average TSP concentration associated with the Woodlawn Expansion Project and the AWT Facility are predicted to be insignificant in comparison with current average background levels. Annual average TSP concentrations are predicted to comply with the project goal of 90 µg/m^3.

No contour plot has been provided of the incremental increase in annual average TSP concentrations due to the low concentrations predicted.

6.2.3 Particulate Matter as Dust Deposition

Table 22 shows the results of the modelling predictions for dust deposition. The results show the average deposition rates predicted at the nearest receptor locations over a one year time frame. Background levels of dust deposition at these locations ranged from 1.5 g/m^2/month to 3.5 g/m^2/month. For assessment purposes, background levels have been conservatively assumed to be in the order of 3.5 g/m^2/month (refer **Section 3.2.1**).

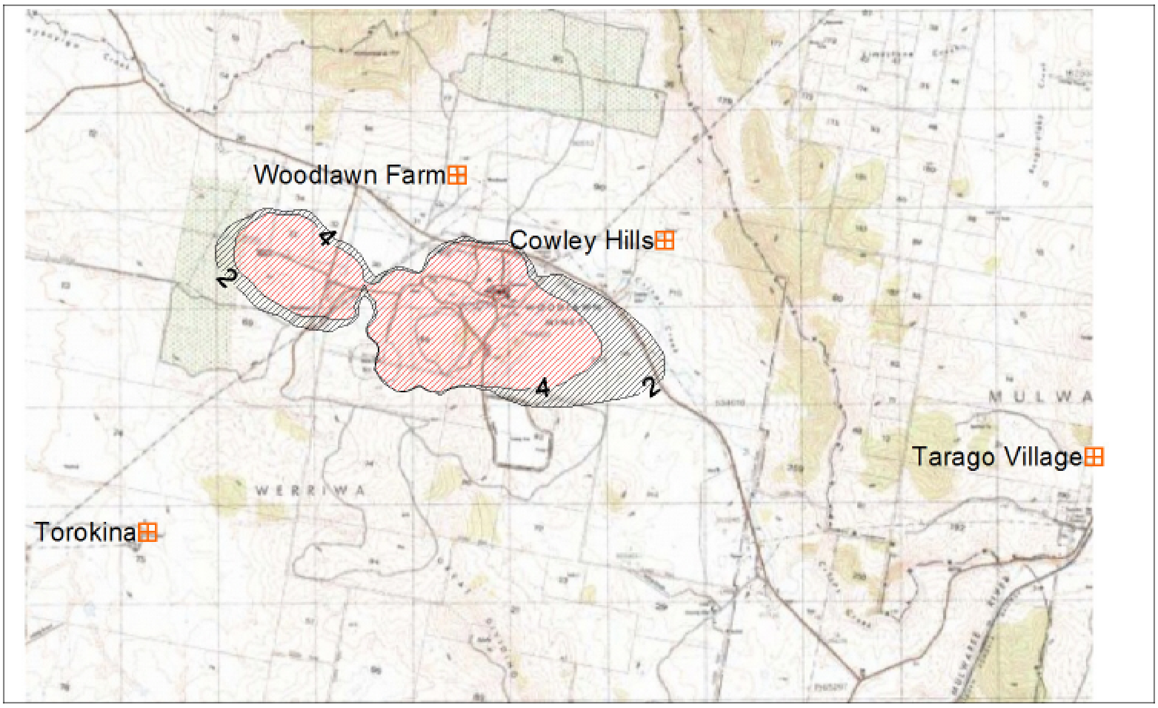
A contour plot of the modelled dust deposition values obtained around the Woodlawn Site is presented in Error! Reference source not found.**Figure 12**

Table 22 Background and Predicted Incremental Dust Deposition

	Annual Average Dust Deposition (g/m²/month)			
Residence	**Background**	**Increment**	**Background + Increment**	**Project Goal**
Scenario 1				
1. “Woodlawn Farm”	3.5	0.2	3.7	4.0
2. “Cowley Hills”	3.5	0.2	3.7	4.0
3. “Pylara”	3.5	0.1	3.6	4.0
4. “Torokina”	3.5	0.1	3.6	4.0
5: Tarago Village	3.5	0.2	3.7	4.0

The results presented in **Table 22** and **Figure 12** show that increases in the annual average monthly dust deposition associated with the Woodlawn Expansion Project and the AWT Facility are predicted to be insignificant in comparison with current average background dust deposition levels. Annual average monthly dust deposition levels are predicted to comply with the project goal of 4 g/m^2/month even assuming worst case existing background dust levels.

Figure 12 Predicted Annual Average Incremental Dust Deposition (g/m^2/month) – Woodlawn Bioreactor – Woodlawn Expansion Project and AWT Facility



2005 Meteorology, Emission Rates adopted from **Section 5.2**; Adopted Criterion – 2 g/m^2/month

7 CONCLUSIONS

SLR Consulting Australia Pty Ltd (SLR Consulting) has been commissioned by Veolia Environmental Services (Australia) Pty Ltd to undertake an odour and dust impact assessment of the Woodlawn Bioreactor facility near Tarago, in the Southern Highlands of NSW. Veolia seek to increase the quantity of waste received at the facility to 1.13 million tonnes per annum and 1.18 million tonnes of waste per year at the Crisps Creek Intermodal Facility.

All odour sources at the Woodlawn Bioreactor and Crisps Creek Intermodal Facility have been identified and odour emission rates, based on site specific monitoring, have been applied. Atmospheric dispersion modelling of odour has indicated that at all surrounding residences, odour is predicted to be at concentrations less than 3.4 OU as a 99th percentile, 1 second average. The Project specific odour performance goal was assumed to be 6 OU. Comparison with a ‘base case’ scenario designed to reflect current operating conditions at the Woodlawn site has shown an increase in odour impact at surrounding receptors resulting from the increase in surface area of waste, although the increase does not cause an exceedance of the relevant criterion.

A worst case scenario has been modelled, with all liquid storage areas modelled at capacity and with an active waste tipping area of 2 ha with emission rates associated with wet fresh waste, shown in **Appendix E** to be more odorous than dry fresh waste. In reality, leachate (treated and untreated), groundwater and stormwater storage areas are unlikely to be at levels approaching capacity as leachate is used on the waste to encourage degradation of fresh waste. Excessive storage should not be required and an active waste tipping face of the modelled size should not be required in reality.

Based upon the results of this modelling assessment, it is not considered that the proposed Project will lead to an exceedance of the odour performance goal.

Cumulative particulate matter emissions associated with the proposed Woodlawn Expansion Project and the approved AWT Facility are not predicted to result in exceedances of the adopted criteria for the Project. Dust deposition levels are significantly below the adopted background level and are predicted to result in incremental increases of less than 0.2 g/m^2/month at all receptors. PM_{10} concentrations are predicted to be less than 8 µg/m^3 as a 24-hour maximum and 0.7 µg/m^3 as an annual average at all receptors. Total suspended particulate concentrations are predicted to be less than 0.1 µg/m^3 as an annual average at all modelled receptors.

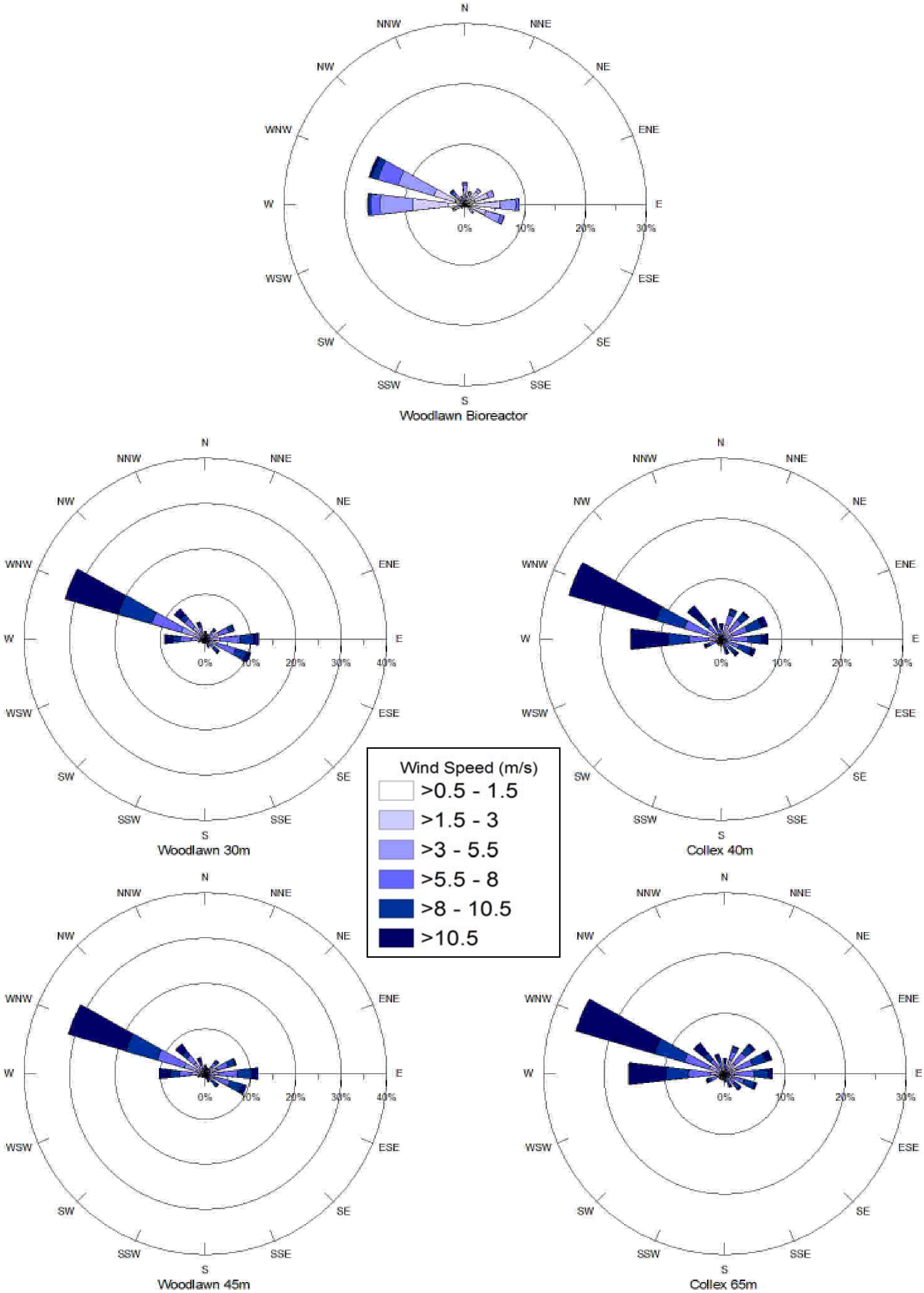
8 CLOSURE

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR Consulting) with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Veolia Environmental Services (Australia) Pty Ltd. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR Consulting.

SLR Consulting disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

Annual and Seasonal Wind Roses for the Project Site - 2005



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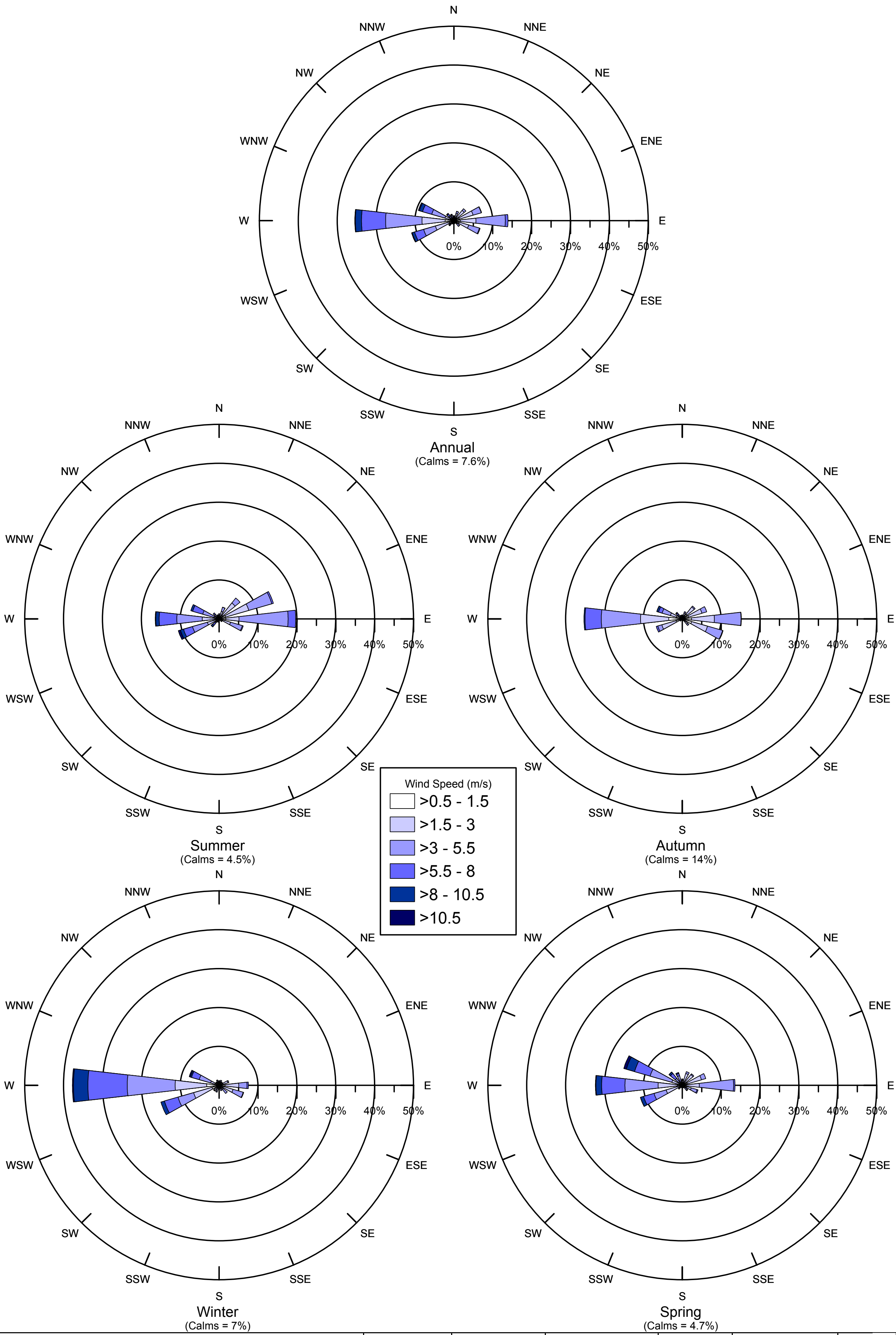
Designed by	Checked by	Approved by - date	Filename	Dated
RK	DR	DR – 09/06/06	30-1546	09/06/06

Appendix A: Annual Windroses for Woodlawn Weather Stations- 2005



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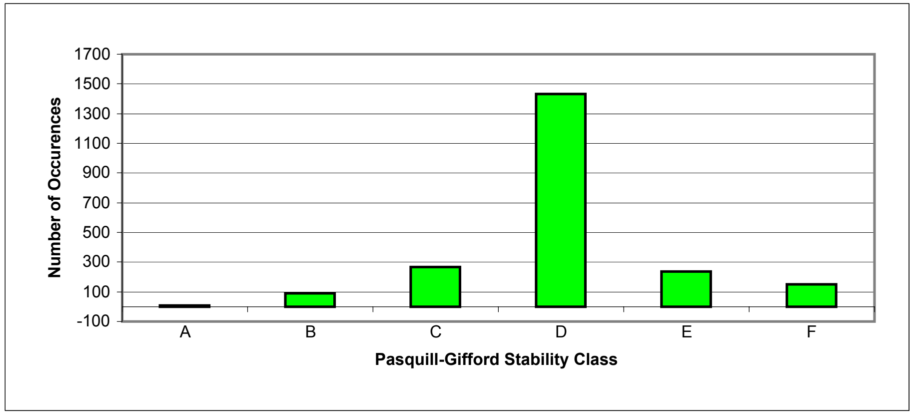
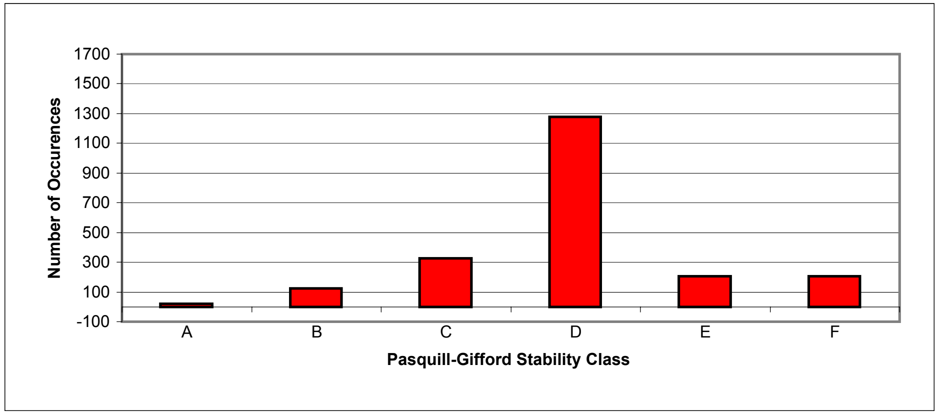
Designed by	Checked by	Approved by - date	Filename	Dated
MD	SF	MD	10-5410	18/12/09

Appendix A: Woodlawn Seasonal Windroses
March 2008 – March 2009

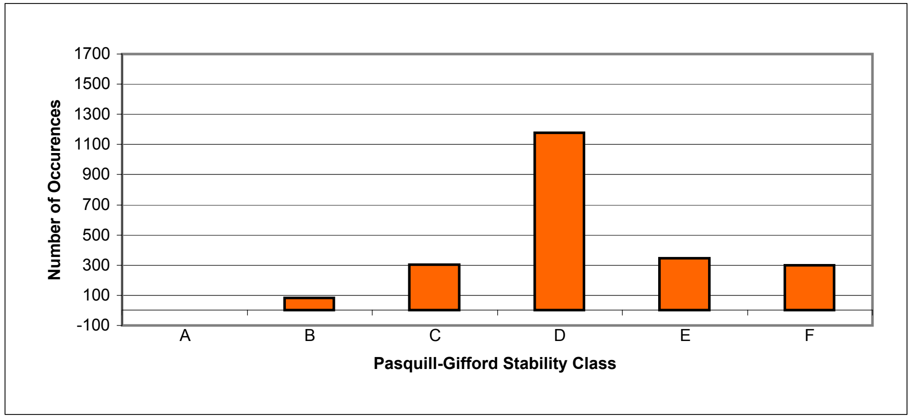
Seasonal Atmospheric Stability Class Distribution for the Project Site - 2005



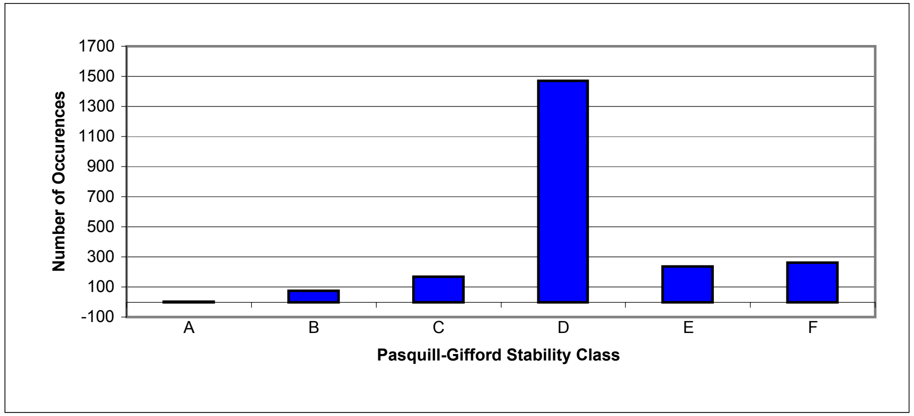
Spring



Summer



Autumn



Winter

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Designed by	Checked by	Approved by - date	Filename	Dated
SF	DR	31/08/2006		31/08/2006

Seasonal Stability Class Frequency Distribution for Woodlawn Site - 2005

Appendix C - Particulate Emissions Inventory

Woodlawn Waste Expansion Project - Particulate Sources	**TSP Emission Factor**	**PM_{10} Emission Factor**	**Emission Factor Units**	**Throughput (tonnes per hour)**	**Number of Hectares of stockpile**	**Average number of kilometres per hour**	**Working days available**	**Working hours per day**	**TSP Emission Rate (mg/s)**	**PM_{10} Emission Rate (mg/s)**	**TSP Emission Flux ($mg/s/m^2$)**	**PM_{10} Emission Flux ($mg/s/m^2$)**
WASP and WOCOG Windrows												
MSW Trucks unloading to bunker (uload1)	0.00004	0.00002	kg/t	37	N/A	N/A	250	13	0.4	0.2	N/A	N/A
MSW Trucks unloading to bunker (uload1a)	0.00004	0.00002	kg/t	44	N/A	N/A	312	16	0.4	0.2	N/A	N/A
Loading Reject Storage Bins (Load1)	0.0004	0.0002	kg/t	3	N/A	N/A	312	16	0.3	0.1	N/A	N/A
Loading Recycling Storage Bins (Load2)	0.0004	0.0002	kg/t	2	N/A	N/A	312	16	0.2	0.1	N/A	N/A
Loading Organic Material Storage Bins (Load3)	0.0004	0.0002	kg/t	24	N/A	N/A	312	16	2.7	1.1	N/A	N/A
Organic Material Tranfer - WASP to OW (HTC1)	0.005	0.002	kg/t	24	N/A	N/A	312	16	33.3	13.3	N/A	N/A
Unloading Organic Material onto Windrow (uload2)	0.000040	0.000019	kg/t	24	N/A	N/A	312	16	0.3	0.1	N/A	N/A
Fluffer Unloading (HTC3)	0.060	0.0300	kg/t	14	N/A	N/A	N/A	N/A	233.3	116.7	N/A	N/A
WOCOG												
Green Waste Trucks unloading to bunker (uload3)	0.00004	0.00002	kg/t	12	N/A	N/A	312	16	0.1	0.1	N/A	N/A
Green Waste Transfer to OW (HTC2)	0.005000	0.002000	kg/t	12	N/A	N/A	312	16	16.7	6.7	N/A	N/A
Unloading Green Waste Material onto Windrow (uload4)	0.000040	0.000019	kg/t	12	N/A	N/A	312	16	0.1	0.1	N/A	N/A
Final Product Screening (MS1)	0.080	0.0600	kg/t	12	N/A	N/A	312	16	266.7	200.0	N/A	N/A
Wind sifter/destoner (sift)	0.080	0.0600	kg/t	12	N/A	N/A	312	16	266.7	200.0	N/A	N/A
Dozer (Doz)	0.117	0.015	kg/hr	N/A	N/A	N/A	312	16	32.4	4.2	N/A	N/A
Wind Erosion												
Open Waste Wind Erosion	0.400	0.2000	kg/ha/hr	N/A	15	N/A	365	24	N/A	N/A	0.011	0.006
WASP and WOCOG Windrows	0.400	0.2000	kg/ha/hr	N/A	6	N/A	365	24	N/A	N/A	0.011	0.006
Haul Road Wind Erosion per source (19)	2.654	0.682	kg/VKT	N/A	N/A	15.6	312	16	302.7	77.8	N/A	N/A

Point Sources

	TSP Emission Factor	**PM10 Emission Factor**	**Emission Factor Units**	**m3/sec**	**Emission Factor Units**	**g/s**	**Temperature (K)**	**Velocity (m/s)**
24 x 1MW GE Jenbacher Engines	N/A	0.00019	kg/m3	3.5	m3/hr	0.7	410	46.3
	N/A	0.000098	kg/kWh	24	Mw	0.7		

Note: Sources provided in parentheses indicate source ID in CALPUFF INPUT file
Note: Both emission factors for PM10 from landfill gas fired engines provided to demonstrate no variation depending on measure used
Note: No TSP emission factor provided in the NPI for landfill gas fired engines.

Appendix D - CALPUFF Input File

```
Woodlawn Part 3a
1.2Mtpa
Feb 10
---------------- Run title (3 lines) ------------------------------------------

                    CALPUFF MODEL CONTROL FILE
                    --------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names

--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input    ! METDAT = C:\CALPUFF\30-1546\WOODLA~1\CALMET.DAT !
    or
ISCMET.DAT    input    * ISCDAT = *
    or
PLMMET.DAT    input    * PLMDAT = *
    or
PROFILE.DAT   input    ! PRFDAT = PROFILE.DAT !
SURFACE.DAT   input    * SFCDAT = *
RESTARTB.DAT  input    * RSTARTB = *
--------------------------------------------------------------------------------
CALPUFF.LST   output   ! PUFLST = CALPUFF.LST !
CONC.DAT      output   ! CONDAT = CONC.DAT !
DFLX.DAT      output   ! DFDAT = DFLX.DAT !
WFLX.DAT      output   ! WFDAT = WFLX.DAT !

VISB.DAT      output   ! VISDAT = VISB.DAT !
RHO2D.DAT     output   * RHODAT = *
RESTARTE.DAT  output   * RSTARTE = *
--------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT = *
VOLEMARB.DAT  input    * VOLDAT = *
BAEMARB.DAT   input    * ARDAT = *
LNEMARB.DAT   input    * LNDAT = *
--------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    * OZDAT = *
VD.DAT        input    * VDDAT = *
CHEM.DAT      input    * CHEMDAT = *
H2O2.DAT      input    * H2O2DAT = *
HILL.DAT      input    * HILDAT = *
HILLRCT.DAT   input    * RCTDAT = *
COASTLN.DAT   input    * CSTDAT = *
FLUXBDY.DAT   input    * BDYDAT = *
BCON.DAT      input    * BCNDAT = *
DEBUG.DAT     output   * DEBUG = *
MASSFLX.DAT   output   * FLXDAT = *
MASSBAL.DAT   output   * BALDAT = *
FOG.DAT       output   * FOGDAT = *
--------------------------------------------------------------------------------
All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = F !
         F = UPPER CASE
NOTE: (1) file/path names can be up to 70 characters in length


Provision for multiple input files
----------------------------------

     Number of CALMET.DAT files for run (NMETDAT)
                                        Default: 1       ! NMETDAT = 1 !
```

```
     Number of PTEMARB.DAT files for run (NPTDAT)
                                Default: 0       ! NPTDAT =  0  !

     Number of BAEMARB.DAT files for run (NARDAT)
                                Default: 0       ! NARDAT =  0  !

     Number of VOLEMARB.DAT files for run (NVOLDAT)
                                Default: 0       ! NVOLDAT =  0  !

!END!

-------------
Subgroup (0a)
-------------

  The following CALMET.DAT filenames are processed in sequence if NMETDAT>1

Default Name  Type          File Name
------------  ----          ---------
 none         input    * METDAT=     *   *END*



--------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

    Option to run all periods found
    in the met. file     (METRUN)   Default: 0       ! METRUN = 1 !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in met. file

     Starting date:   Year (IBYR) -- No default       ! IBYR = 2005 !
     (used only if   Month (IBMO) -- No default       ! IBMO = 1 !
      METRUN = 0)      Day (IBDY) -- No default       ! IBDY = 1 !
                      Hour (IBHR) -- No default       ! IBHR = 0 !

     Base time zone        (XBTZ) -- No default       ! XBTZ = -10 !
        PST = 8., MST = 7.
        CST = 6., EST = 5.

     Length of run (hours) (IRLG) -- No default       ! IRLG = 8760 !

     Number of chemical species (NSPEC)
                                Default: 5       ! NSPEC = 1 !

     Number of chemical species
     to be emitted  (NSE)       Default: 3       ! NSE = 1 !

     Flag to stop run after
     SETUP phase (ITEST)        Default: 2       ! ITEST = 2 !
     (Used to allow checking
     of the model inputs, files, etc.)
           ITEST = 1 - STOPS program after SETUP phase
           ITEST = 2 - Continues with execution of program
                       after SETUP

     Restart Configuration:

        Control flag (MRESTART)      Default: 0       ! MRESTART = 0 !

           0 = Do not read or write a restart file
           1 = Read a restart file at the beginning of
               the run
           2 = Write a restart file during run
           3 = Read a restart file at beginning of run
```

```
               and write a restart file during run

        Number of periods in Restart
        output cycle (NRESPD)        Default: 0       ! NRESPD = 0 !

           0 = File written only at last period
          >0 = File updated every NRESPD periods

     Meteorological Data Format (METFM)
                                     Default: 1       ! METFM = 1 !

           METFM = 1 - CALMET binary file (CALMET.MET)
           METFM = 2 - ISC ASCII file (ISCMET.MET)
           METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
           METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
                       surface parameters file (SURFACE.DAT)
           METFM = 5 - AERMET tower file (PROFILE.DAT) and
                       surface parameters file (SURFACE.DAT)

     Meteorological Profile Data Format (MPRFFM)
            (used only for METFM = 1, 2, 3)
                                     Default: 1       ! MPRFFM = 1 !

           MPRFFM = 1 - CTDM plus tower file (PROFILE.DAT)
           MPRFFM = 2 - AERMET tower file (PROFILE.DAT)

     PG sigma-y is adjusted by the factor (AVET/PGTIME)**0.2
     Averaging Time (minutes) (AVET)
                                     Default: 60.0    ! AVET = 60 !
     PG Averaging Time (minutes) (PGTIME)
                                     Default: 60.0    ! PGTIME = 60 !


!END!


-------------------------------------------------------------------------------

INPUT GROUP: 2 -- Technical options
--------------


     Vertical distribution used in the
     near field (MGAUSS)                   Default: 1     ! MGAUSS = 1 !
        0 = uniform
        1 = Gaussian

     Terrain adjustment method
     (MCTADJ)                              Default: 3     ! MCTADJ = 3 !
        0 = no adjustment
        1 = ISC-type of terrain adjustment
        2 = simple, CALPUFF-type of terrain
            adjustment
        3 = partial plume path adjustment

     Subgrid-scale complex terrain
     flag (MCTSG)                          Default: 0     ! MCTSG = 0 !
        0 = not modeled
        1 = modeled

     Near-field puffs modeled as
     elongated slugs? (MSLUG)              Default: 0     ! MSLUG = 0 !
        0 = no
        1 = yes (slug model used)

     Transitional plume rise modeled?
     (MTRANS)                              Default: 1     ! MTRANS = 1 !
        0 = no  (i.e., final rise only)
        1 = yes (i.e., transitional rise computed)
```

```
Stack tip downwash? (MTIP)           Default: 1     ! MTIP = 1 !
   0 = no  (i.e., no stack tip downwash)
   1 = yes (i.e., use stack tip downwash)

Method used to simulate building
downwash? (MBDW)                     Default: 1     ! MBDW = 1 !
   1 = ISC method
   2 = PRIME method

Vertical wind shear modeled above
stack top? (MSHEAR)                  Default: 0     ! MSHEAR = 0 !
   0 = no  (i.e., vertical wind shear not modeled)
   1 = yes (i.e., vertical wind shear modeled)

Puff splitting allowed? (MSPLIT)     Default: 0     ! MSPLIT = 0 !
   0 = no (i.e., puffs not split)
   1 = yes (i.e., puffs are split)

Chemical mechanism flag (MCHEM)      Default: 1     ! MCHEM = 0 !
   0 = chemical transformation not
       modeled
   1 = transformation rates computed
       internally (MESOPUFF II scheme)
   2 = user-specified transformation
       rates used
   3 = transformation rates computed
       internally (RIVAD/ARM3 scheme)
   4 = secondary organic aerosol formation
       computed (MESOPUFF II scheme for OH)

Aqueous phase transformation flag (MAQCHEM)
(Used only if MCHEM = 1, or 3)       Default: 0     ! MAQCHEM = 0 !
   0 = aqueous phase transformation
       not modeled
   1 = transformation rates adjusted
       for aqueous phase reactions

Wet removal modeled ? (MWET)         Default: 1     ! MWET = 0 !
   0 = no
   1 = yes

Dry deposition modeled ? (MDRY)      Default: 1     ! MDRY = 1 !
   0 = no
   1 = yes
   (dry deposition method specified
    for each species in Input Group 3)


Gravitational settling (plume tilt)
modeled ? (MTILT)                    Default: 0     ! MTILT = 0 !
   0 = no
   1 = yes
   (puff center falls at the gravitational
    settling velocity for 1 particle species)

Restrictions:
    - MDRY  = 1
    - NSPEC = 1  (must be particle species as well)
    - sg    = 0  GEOMETRIC STANDARD DEVIATION in Group 8 is
                 set to zero for a single particle diameter

Method used to compute dispersion
coefficients (MDISP)                 Default: 3     ! MDISP = 3 !

   1 = dispersion coefficients computed from measured values
       of turbulence, sigma v, sigma w
   2 = dispersion coefficients from internally calculated
       sigma v, sigma w using micrometeorological variables
```

```
        (u*, w*, L, etc.)
     3 = PG dispersion coefficients for RURAL areas (computed using
         the ISCST multi-segment approximation) and MP coefficients in
         urban areas
     4 = same as 3 except PG coefficients computed using
         the MESOPUFF II eqns.
     5 = CTDM sigmas used for stable and neutral conditions.
         For unstable conditions, sigmas are computed as in
         MDISP = 3, described above.  MDISP = 5 assumes that
         measured values are read

Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
(Used only if MDISP = 1 or 5)          Default: 3     ! MTURBVW = 3 !
     1 = use sigma-v or sigma-theta measurements
         from PROFILE.DAT to compute sigma-y
         (valid for METFM = 1, 2, 3, 4, 5)
     2 = use sigma-w measurements
         from PROFILE.DAT to compute sigma-z
         (valid for METFM = 1, 2, 3, 4, 5)
     3 = use both sigma-(v/theta) and sigma-w
         from PROFILE.DAT to compute sigma-y and sigma-z
         (valid for METFM = 1, 2, 3, 4, 5)
     4 = use sigma-theta measurements
         from PLMMET.DAT to compute sigma-y
         (valid only if METFM = 3)

Back-up method used to compute dispersion
when measured turbulence data are
missing (MDISP2)                       Default: 3     ! MDISP2 = 3 !
(used only if MDISP = 1 or 5)
     2 = dispersion coefficients from internally calculated
         sigma v, sigma w using micrometeorological variables
         (u*, w*, L, etc.)
     3 = PG dispersion coefficients for RURAL areas (computed using
         the ISCST multi-segment approximation) and MP coefficients in
         urban areas
     4 = same as 3 except PG coefficients computed using
         the MESOPUFF II eqns.

[DIAGNOSTIC FEATURE]
Method used for Lagrangian timescale for Sigma-y
(used only if MDISP=1,2 or MDISP2=1,2)
(MTAULY)                               Default: 0     ! MTAULY = 0 !
     0 = Draxler default 617.284 (s)
     1 = Computed as Lag. Length / (.75 q) -- after SCIPUFF
    10 <Direct user input (s)             -- e.g., 306.9


[DIAGNOSTIC FEATURE]
Method used for Advective-Decay timescale for Turbulence
(used only if MDISP=2 or MDISP2=2)
(MTAUADV)                              Default: 0     ! MTAUADV = 0 !
     0 = No turbulence advection
     1 = Computed (OPTION NOT IMPLEMENTED)
    10 <Direct user input (s)   -- e.g., 300


Method used to compute turbulence sigma-v &
sigma-w using micrometeorological variables
(Used only if MDISP = 2 or MDISP2 = 2)
(MCTURB)                               Default: 1     ! MCTURB = 1 !
     1 = Standard CALPUFF subroutines
     2 = AERMOD subroutines

PG sigma-y,z adj. for roughness?      Default: 0     ! MROUGH = 0 !
(MROUGH)
     0 = no
     1 = yes
```

```
Partial plume penetration of          Default: 1     ! MPARTL = 1 !
elevated inversion?
(MPARTL)
   0 = no
   1 = yes

Strength of temperature inversion     Default: 0     ! MTINV = 0 !
provided in PROFILE.DAT extended records?
(MTINV)
   0 = no (computed from measured/default gradients)
   1 = yes

PDF used for dispersion under convective conditions?
                                      Default: 0     ! MPDF = 0 !
(MPDF)
   0 = no
   1 = yes

Sub-Grid TIBL module used for shore line?
                                      Default: 0     ! MSGTIBL = 0 !
(MSGTIBL)
   0 = no
   1 = yes

Boundary conditions (concentration) modeled?
                                      Default: 0     ! MBCON = 0 !
(MBCON)
   0 = no
   1 = yes, using formatted BCON.DAT file
   2 = yes, using unformatted CONC.DAT file

Note:  MBCON > 0 requires that the last species modeled
       be 'BCON'.  Mass is placed in species BCON when
       generating boundary condition puffs so that clean
       air entering the modeling domain can be simulated
       in the same way as polluted air.  Specify zero
       emission of species BCON for all regular sources.

Individual source contributions saved?
                                      Default: 0     ! MSOURCE = 0 !
(MSOURCE)
   0 = no
   1 = yes


Analyses of fogging and icing impacts due to emissions from
arrays of mechanically-forced cooling towers can be performed
using CALPUFF in conjunction with a cooling tower emissions
processor (CTEMISS) and its associated postprocessors.  Hourly
emissions of water vapor and temperature from each cooling tower
cell are computed for the current cell configuration and ambient
conditions by CTEMISS. CALPUFF models the dispersion of these
emissions and provides cloud information in a specialized format
for further analysis. Output to FOG.DAT is provided in either
'plume mode' or 'receptor mode' format.

Configure for FOG Model output?
                                      Default: 0     ! MFOG = 0 !
(MFOG)
   0 = no
   1 = yes  - report results in PLUME Mode format
   2 = yes  - report results in RECEPTOR Mode format


Test options specified to see if
they conform to regulatory
values? (MREG)                        Default: 1     ! MREG = 0 !

   0 = NO checks are made
```

```
        1 = Technical options must conform to USEPA
            Long Range Transport (LRT) guidance
                        METFM    1 or 2
                        AVET     60. (min)
                        PGTIME   60. (min)
                        MGAUSS   1
                        MCTADJ   3
                        MTRANS   1
                        MTIP     1
                        MCHEM    1 or 3 (if modeling SOx, NOx)
                        MWET     1
                        MDRY     1
                        MDISP    2 or 3
                        MPDF     0 if MDISP=3
                                 1 if MDISP=2
                        MROUGH   0
                        MPARTL   1
                        SYTDEP   550. (m)
                        MHFTSZ   0
                        SVMIN    0.5 (m/s)


!END!


--------------------------------------------------------------------------------

INPUT GROUP: 3a, 3b -- Species list
-------------------

------------
Subgroup (3a)
------------

  The following species are modeled:

! CSPEC =         ODOR !            !END!


                                                         Dry                 OUTPUT GROUP
    SPECIES          MODELED          EMITTED       DEPOSITED                   NUMBER
     NAME         (0=NO, 1=YES)    (0=NO, 1=YES)    (0=NO,                    (0=NONE,
   (Limit: 12                                        1=COMPUTED-GAS           1=1st CGRUP,
    Characters                                       2=COMPUTED-PARTICLE      2=2nd CGRUP,
    in length)                                       3=USER-SPECIFIED)        3= etc.)

!          ODOR  =          1,               1,           1,                  0   !


!END!

  Note:  The last species in (3a) must be 'BCON' when using the
         boundary condition option (MBCON > 0).  Species BCON should
         typically be modeled as inert (no chem transformation or
         removal).


-------------
Subgroup (3b)
-------------
  The following names are used for Species-Groups in which results
  for certain species are combined (added) prior to output.  The
  CGRUP name will be used as the species name in output files.
  Use this feature to model specific particle-size distributions
  by treating each size-range as a separate species.
  Order must be consistent with 3(a) above.
```

```
-------------------------------------------------------------------------------


INPUT GROUP: 4 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = UTM !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST = 0 !
     (FNORTH)                   Default=0.0     ! FNORTH = 0 !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN = 55 !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = S !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 = 0N !
     (RLON0)                    No Default      ! RLON0 = 0E !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 = 30N !
     (XLAT2)                    No Default      ! XLAT2 = 60N !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E


     Datum-region
     ------------
```

```
     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its output
     consistent with local mapping products.  The list of Datum-Regions with
     official transformation parameters is provided by the National Imagery and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)
     ------------------------------------------------------------------------------
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                    Default: WGS-84     ! DATUM = WGS-84 !


METEOROLOGICAL Grid:

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX = 100 !
            No. Y grid cells (NY)      No default     ! NY = 100 !
         No. vertical layers (NZ)      No default     ! NZ = 8 !

           Grid spacing (DGRIDKM)      No default     ! DGRIDKM = 0.2 !
                                       Units: km

                Cell face heights
                    (ZFACE(nz+1))      No defaults
                                       Units: m
   ! ZFACE =  0.0, 20.0, 40.0, 80.0, 160.0, 320.0, 700.0, 1300.0, 1700.0 !

            Reference Coordinates
           of SOUTHWEST corner of
                 grid cell(1, 1):

            X coordinate (XORIGKM)     No default     ! XORIGKM = 724.2770 !
            Y coordinate (YORIGKM)     No default     ! YORIGKM = 6106.1070 !
                                      Units: km


COMPUTATIONAL Grid:

     The computational grid is identical to or a subset of the MET. grid.
     The lower left (LL) corner of the computational grid is at grid point
     (IBCOMP, JBCOMP) of the MET. grid.  The upper right (UR) corner of the
     computational grid is at grid point (IECOMP, JECOMP) of the MET. grid.
     The grid spacing of the computational grid is the same as the MET. grid.

        X index of LL corner (IBCOMP)      No default     ! IBCOMP = 1 !
                  (1 <= IBCOMP <= NX)

        Y index of LL corner (JBCOMP)      No default     ! JBCOMP = 1 !
                  (1 <= JBCOMP <= NY)


        X index of UR corner (IECOMP)      No default     ! IECOMP = 100 !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP = 100 !
                  (1 <= JECOMP <= NY)
```

```
SAMPLING Grid (GRIDDED RECEPTORS):

     The lower left (LL) corner of the sampling grid is at grid point
     (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
     sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
     The sampling grid must be identical to or a subset of the computational
     grid.  It may be a nested grid inside the computational grid.
     The grid spacing of the sampling grid is DGRIDKM/MESHDN.

        Logical flag indicating if gridded
        receptors are used (LSAMP)         Default: T     ! LSAMP = T !
        (T=yes, F=no)

        X index of LL corner (IBSAMP)      No default     ! IBSAMP = 1 !
         (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)      No default     ! JBSAMP = 1 !
         (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)      No default     ! IESAMP = 2 !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP = 2 !
         (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                      Default: 1     ! MESHDN = 2 !
        (MESHDN is an integer >= 1)

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 5 -- Output Options
--------------
                                             *                          *
     FILE                       DEFAULT VALUE            VALUE THIS RUN
     ----                       -------------            --------------

   Concentrations (ICON)              1                  ! ICON = 1 !
   Dry Fluxes (IDRY)                  1                  ! IDRY = 1 !
   Wet Fluxes (IWET)                  1                  ! IWET = 0 !
   2D Temperature (IT2D)              0                  ! IT2D = 0 !
   2D Density (IRHO)                  0                  ! IRHO = 0 !
   Relative Humidity (IVIS)           1                  ! IVIS = 0 !
    (relative humidity file is
     required for visibility
     analysis)
   Use data compression option in output file?
   (LCOMPRS)                           Default: T        ! LCOMPRS = F !

   *
    0 = Do not create file, 1 = create file


    QA PLOT FILE OUTPUT OPTION:

       Create a standard series of output files (e.g.
       locations of sources, receptors, grids ...)
       suitable for plotting?
       (IQAPLOT)                       Default: 1        ! IQAPLOT = 1 !
         0 = no
         1 = yes
```

```
    DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

       Mass flux across specified boundaries
       for selected species reported hourly?
       (IMFLX)                         Default: 0         ! IMFLX = 0 !
         0 = no
         1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
                  are specified in Input Group 0)

       Mass balance for each species
       reported hourly?
       (IMBAL)                         Default: 0         ! IMBAL = 0 !
         0 = no
         1 = yes (MASSBAL.DAT filename is
              specified in Input Group 0)


    LINE PRINTER OUTPUT OPTIONS:

       Print concentrations (ICPRT)    Default: 0         ! ICPRT = 0 !
       Print dry fluxes (IDPRT)        Default: 0         ! IDPRT = 0 !
       Print wet fluxes (IWPRT)        Default: 0         ! IWPRT = 0 !
       (0 = Do not print, 1 = Print)

       Concentration print interval
       (ICFRQ) in hours                Default: 1         ! ICFRQ = 1 !
       Dry flux print interval
       (IDFRQ) in hours                Default: 1         ! IDFRQ = 1 !
       Wet flux print interval
       (IWFRQ) in hours                Default: 1         ! IWFRQ = 1 !

       Units for Line Printer Output
       (IPRTU)                         Default: 1         ! IPRTU = 5 !
                       for            for
                  Concentration    Deposition
           1 =       g/m**3         g/m**2/s
           2 =      mg/m**3        mg/m**2/s
           3 =      ug/m**3        ug/m**2/s
           4 =      ng/m**3        ng/m**2/s
           5 =     Odour Units

       Messages tracking progress of run
       written to the screen ?
       (IMESG)                         Default: 2         ! IMESG = 2 !
         0 = no
         1 = yes (advection step, puff ID)
         2 = yes (YYYYJJJHH, # old puffs, # emitted puffs)


     SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

                ---- CONCENTRATIONS ----   ------ DRY FLUXES ------   ------ WET FLUXES ------   --
   SPECIES
   /GROUP       PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?   SAV
   -------      ------------------------   ------------------------   ------------------------   ---
!         ODOR =     1,          1,           0,           1,           0,           0,           0


  Note:  Species BCON (for MBCON > 0) does not need to be saved on disk.


     OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

       Logical for debug output
       (LDEBUG)                                 Default: F     ! LDEBUG = F !

       First puff to track
       (IPFDEB)                                 Default: 1     ! IPFDEB = 1 !
```

```
       Number of puffs to track
       (NPFDEB)                                 Default: 1     ! NPFDEB = 1 !

       Met. period to start output
       (NN1)                                    Default: 1     ! NN1 = 1 !

       Met. period to end output
       (NN2)                                    Default: 10    ! NN2 = 10 !

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs
-------------------------

---------------
Subgroup (6a)
---------------
       Number of terrain features (NHILL)       Default: 0     ! NHILL = 0 !

       Number of special complex terrain
       receptors  (NCTREC)                      Default: 0     ! NCTREC = 0 !

       Terrain and CTSG Receptor data for
       CTSG hills input in CTDM format ?
       (MHILL)                                  No Default     ! MHILL = 2 !
       1 = Hill and Receptor data created
           by CTDM processors & read from
           HILL.DAT and HILLRCT.DAT files
       2 = Hill data created by OPTHILL &
           input below in Subgroup (6b);
           Receptor data in Subgroup (6c)

       Factor to convert horizontal dimensions  Default: 1.0   ! XHILL2M = 1.0 !
       to meters (MHILL=1)

       Factor to convert vertical dimensions    Default: 1.0   ! ZHILL2M = 1.0 !
       to meters (MHILL=1)

       X-origin of CTDM system relative to      No Default     ! XCTDMKM = 0.0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

       Y-origin of CTDM system relative to      No Default     ! YCTDMKM = 0.0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

! END !

---------------
Subgroup (6b)
---------------

                          1 **
     HILL information


HILL           XC        YC       THETAH  ZGRID  RELIEF    EXPO 1    EXPO 2   SCALE 1    SCALE 2    A
 NO.          (km)      (km)      (deg.)   (m)     (m)      (m)       (m)       (m)        (m)
----          ----      ----      ------  -----  ------    ------    ------   -------    -------    -


---------------
Subgroup (6c)
---------------

    COMPLEX TERRAIN RECEPTOR INFORMATION
```

```
                    XRCT         YRCT        ZRCT          XHH
                    (km)         (km)         (m)
                   ------        -----      ------         ----


-------------------
1
     Description of Complex Terrain Variables:
          XC, YC  = Coordinates of center of hill
          THETAH  = Orientation of major axis of hill (clockwise from
                    North)
          ZGRID   = Height of the  0  of the grid above mean sea
                    level
          RELIEF  = Height of the crest of the hill above the grid elevation
          EXPO 1  = Hill-shape exponent for the major axis
          EXPO 2  = Hill-shape exponent for the major axis
          SCALE 1 = Horizontal length scale along the major axis
          SCALE 2 = Horizontal length scale along the minor axis
          AMAX    = Maximum allowed axis length for the major axis
          BMAX    = Maximum allowed axis length for the major axis

          XRCT, YRCT = Coordinates of the complex terrain receptors
          ZRCT    = Height of the ground (MSL) at the complex terrain
                    Receptor
          XHH     = Hill number associated with each complex terrain receptor
                    (NOTE: MUST BE ENTERED AS A REAL NUMBER)

   **
     NOTE: DATA for each hill and CTSG receptor are treated as a separate
           input subgroup and therefore must end with an input group terminator.

-------------------------------------------------------------------------------


INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases
--------------

      SPECIES     DIFFUSIVITY      ALPHA STAR      REACTIVITY    MESOPHYLL RESISTANCE     HENRY'S LAW
       NAME        (cm**2/s)                                            (s/cm)                (dimens
      -------     -----------      ----------      ----------    --------------------     -----------
!         ODOR =     0.1509,            1,             8,                  0,                   0.04 !


!END!


-------------------------------------------------------------------------------


INPUT GROUP: 8 -- Size parameters for dry deposition of particles
--------------

     For SINGLE SPECIES, the mean and standard deviation are used to
     compute a deposition velocity for NINT (see group 9) size-ranges,
     and these are then averaged to obtain a mean deposition velocity.

     For GROUPED SPECIES, the size distribution should be explicitly
     specified (by the 'species' in the group), and the standard deviation
     for each should be entered as 0.  The model will then use the
     deposition velocity for the stated mean diameter.

      SPECIES      GEOMETRIC MASS MEAN        GEOMETRIC STANDARD
       NAME             DIAMETER                   DEVIATION
                        (microns)                  (microns)
      -------      -------------------        ------------------
* DRYPART = *
!END!
```

```
-------------------------------------------------------------------------------


INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
--------------

     Reference cuticle resistance (s/cm)
     (RCUTR)                          Default: 30    ! RCUTR = 30 !
     Reference ground resistance  (s/cm)
     (RGR)                            Default: 10    ! RGR = 10 !
     Reference pollutant reactivity
     (REACTR)                         Default: 8     ! REACTR = 8 !

     Number of particle-size intervals used to
     evaluate effective particle deposition velocity
     (NINT)                           Default: 9     ! NINT = 9 !

     Vegetation state in unirrigated areas
     (IVEG)                           Default: 1     ! IVEG = 1 !
        IVEG=1 for active and unstressed vegetation
        IVEG=2 for active and stressed vegetation
        IVEG=3 for inactive vegetation

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 10 -- Wet Deposition Parameters
---------------


                      Scavenging Coefficient -- Units: (sec)**(-1)

       Pollutant      Liquid Precip.       Frozen Precip.
       ---------      --------------       --------------
* WETDEPOS = *
!END!


-------------------------------------------------------------------------------


INPUT GROUP: 11 -- Chemistry Parameters
---------------

     Ozone data input option (MOZ)     Default: 1            ! MOZ = 1 !
     (Used only if MCHEM = 1, 3, or 4)
        0 = use a monthly background ozone value
        1 = read hourly ozone concentrations from
            the OZONE.DAT data file

     Monthly ozone concentrations
     (Used only if MCHEM = 1, 3, or 4 and
      MOZ = 0 or MOZ = 1 and all hourly O3 data missing)
     (BCKO3) in ppb                   Default: 12*80.
     ! BCKO3 = 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00 !

     Monthly ammonia concentrations
     (Used only if MCHEM = 1, or 3)
     (BCKNH3) in ppb                  Default: 12*10.
     ! BCKNH3 = 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00 !

     Nighttime SO2 loss rate (RNITE1)
     in percent/hour                  Default: 0.2          ! RNITE1 = 0.2 !

     Nighttime NOx loss rate (RNITE2)
     in percent/hour                  Default: 2.0          ! RNITE2 = 2 !
```

```
    Nighttime HNO3 formation rate (RNITE3)
    in percent/hour                   Default: 2.0          ! RNITE3 = 2 !

    H2O2 data input option (MH2O2)    Default: 1            ! MH2O2 = 1 !
    (Used only if MAQCHEM = 1)
       0 = use a monthly background H2O2 value
       1 = read hourly H2O2 concentrations from
           the H2O2.DAT data file

    Monthly H2O2 concentrations
    (Used only if MQACHEM = 1 and
     MH2O2 = 0 or MH2O2 = 1 and all hourly H2O2 data missing)
    (BCKH2O2) in ppb                  Default: 12*1.
    ! BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !


--- Data for SECONDARY ORGANIC AEROSOL (SOA) Option
    (used only if MCHEM = 4)

    The SOA module uses monthly values of:
         Fine particulate concentration in ug/m^3 (BCKPMF)
         Organic fraction of fine particulate     (OFRAC)
         VOC / NOX ratio (after reaction)         (VCNX)
    to characterize the air mass when computing
    the formation of SOA from VOC emissions.
    Typical values for several distinct air mass types are:

       Month    1    2    3    4    5    6    7    8    9   10   11   12
               Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

    Clean Continental
       BCKPMF   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.
       OFRAC  .15  .15  .20  .20  .20  .20  .20  .20  .20  .20  .20  .15
       VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

    Clean Marine (surface)
       BCKPMF  .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5
       OFRAC  .25  .25  .30  .30  .30  .30  .30  .30  .30  .30  .30  .25
       VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

    Urban - low biogenic (controls present)
       BCKPMF  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.
       OFRAC  .20  .20  .25  .25  .25  .25  .25  .25  .20  .20  .20  .20
       VCNX     4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.

    Urban - high biogenic (controls present)
       BCKPMF  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.
       OFRAC  .25  .25  .30  .30  .30  .55  .55  .55  .35  .35  .35  .25
       VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

    Regional Plume
       BCKPMF  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.
       OFRAC  .20  .20  .25  .35  .25  .40  .40  .40  .30  .30  .30  .20
       VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

    Urban - no controls present
       BCKPMF 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
       OFRAC  .30  .30  .35  .35  .35  .55  .55  .55  .35  .35  .35  .30
       VCNX     2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.

    Default: Clean Continental
    ! BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
    ! OFRAC = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15 !
    ! VCNX = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00 !


!END!
```

```
-------------------------------------------------------------------------------


INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters
---------------

     Horizontal size of puff (m) beyond which
     time-dependent dispersion equations (Heffter)
     are used to determine sigma-y and
     sigma-z (SYTDEP)                           Default: 550.   ! SYTDEP = 550 !

     Switch for using Heffter equation for sigma z
     as above (0 = Not use Heffter; 1 = use Heffter
     (MHFTSZ)                                   Default: 0      ! MHFTSZ = 0 !

     Stability class used to determine plume
     growth rates for puffs above the boundary
     layer (JSUP)                               Default: 5      ! JSUP = 5 !

     Vertical dispersion constant for stable
     conditions (k1 in Eqn. 2.7-3)  (CONK1)     Default: 0.01   ! CONK1 = 0.01 !

     Vertical dispersion constant for neutral/
     unstable conditions (k2 in Eqn. 2.7-4)
     (CONK2)                                    Default: 0.1    ! CONK2 = 0.1 !

     Factor for determining Transition-point from
     Schulman-Scire to Huber-Snyder Building Downwash
     scheme (SS used for Hs <Hb + TBD * HL)
     (TBD)                                      Default: 0.5    ! TBD = 0.5 !
        TBD <0   ==> always use Huber-Snyder
        TBD = 1.5 ==> always use Schulman-Scire
        TBD = 0.5 ==> ISC Transition-point

     Range of land use categories for which
     urban dispersion is assumed
     (IURB1, IURB2)                             Default: 10     ! IURB1 = 10 !
                                                         19     ! IURB2 = 19 !

     Site characterization parameters for single-point Met data files ---------
     (needed for METFM = 2,3,4,5)

        Land use category for modeling domain
        (ILANDUIN)                              Default: 20     ! ILANDUIN = 20 !

        Roughness length (m) for modeling domain
        (Z0IN)                                  Default: 0.25   ! Z0IN = .25 !

        Leaf area index for modeling domain
        (XLAIIN)                                Default: 3.0    ! XLAIIN = 3.0 !

        Elevation above sea level (m)
        (ELEVIN)                                Default: 0.0    ! ELEVIN = .0 !

        Latitude (degrees) for met location
        (XLATIN)                                Default: -999.  ! XLATIN = -999.0 !

        Longitude (degrees) for met location
        (XLONIN)                                Default: -999.  ! XLONIN = -999.0 !

     Specialized information for interpreting single-point Met data files -----

        Anemometer height (m) (Used only if METFM = 2,3)
        (ANEMHT)                                Default: 10.    ! ANEMHT = 10.0 !

        Form of lateral turbulance data in PROFILE.DAT file
        (Used only if METFM = 4,5 or MTURBVW = 1 or 3)
        (ISIGMAV)                               Default: 1      ! ISIGMAV = 1 !
```

```
        0 = read sigma-theta
        1 = read sigma-v

    Choice of mixing heights (Used only if METFM = 4)
    (IMIXCTDM)                              Default: 0      ! IMIXCTDM = 0 !
        0 = read PREDICTED mixing heights
        1 = read OBSERVED mixing heights

 Maximum length of a slug (met. grid units)
 (XMXLEN)                                   Default: 1.0    ! XMXLEN = 1 !

 Maximum travel distance of a puff/slug (in
 grid units) during one sampling step
 (XSAMLEN)                                  Default: 1.0    ! XSAMLEN = 1 !

 Maximum Number of slugs/puffs release from
 one source during one time step
 (MXNEW)                                    Default: 99     ! MXNEW = 99 !

 Maximum Number of sampling steps for
 one puff/slug during one time step
 (MXSAM)                                    Default: 99     ! MXSAM = 99 !

 Number of iterations used when computing
 the transport wind for a sampling step
 that includes gradual rise (for CALMET
 and PROFILE winds)
 (NCOUNT)                                   Default: 2      ! NCOUNT = 2 !

 Minimum sigma y for a new puff/slug (m)
 (SYMIN)                                    Default: 1.0    ! SYMIN = 1 !

 Minimum sigma z for a new puff/slug (m)
 (SZMIN)                                    Default: 1.0    ! SZMIN = 1 !

 Default minimum turbulence velocities sigma-v and sigma-w
 for each stability class over land and over water (m/s)
 (SVMIN(12) and SWMIN(12))

                ----------  LAND  ----------       ---------  WATER  ----------
    Stab Class :  A    B    C    D    E    F         A    B    C    D    E    F
                ---  ---  ---  ---  ---  ---       ---  ---  ---  ---  ---  ---
 Default SVMIN : .50, .50, .50, .50, .50, .50,      .37, .37, .37, .37, .37, .37
 Default SWMIN : .20, .12, .08, .06, .03, .016,     .20, .12, .08, .06, .03, .016

       ! SVMIN = 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.37, 0.37, 0.37, 0.37, 0.37, 0.37 !
       ! SWMIN = 0.2, 0.12, 0.08, 0.06, 0.03, 0.016, 0.2, 0.12, 0.08, 0.06, 0.03, 0.016 !

 Divergence criterion for dw/dz across puff
 used to initiate adjustment for horizontal
 convergence (1/s)
 Partial adjustment starts at CDIV(1), and
 full adjustment is reached at CDIV(2)
 (CDIV(2))                                  Default: 0.0,0.0  ! CDIV = 0, 0 !

 Minimum wind speed (m/s) allowed for
 non-calm conditions. Also used as minimum
 speed returned when using power-law
 extrapolation toward surface
 (WSCALM)                                   Default: 0.5    ! WSCALM = 0.5 !

 Maximum mixing height (m)
 (XMAXZI)                                   Default: 3000.  ! XMAXZI = 3000 !

 Minimum mixing height (m)
 (XMINZI)                                   Default: 50.    ! XMINZI = 50 !

 Default wind speed classes --
 5 upper bounds (m/s) are entered;
```

```
the 6th class has no upper limit
(WSCAT(5))                      Default   :
                                ISC RURAL : 1.54, 3.09, 5.14, 8.23, 10.8 (10.8+)

                         Wind Speed Class :  1     2     3     4     5
                                            ---   ---   ---   ---   ---
                                  ! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.8 !

Default wind speed profile power-law
exponents for stabilities 1-6
(PLX0(6))                       Default   : ISC RURAL values
                                ISC RURAL : .07, .07, .10, .15, .35, .55
                                ISC URBAN : .15, .15, .20, .25, .30, .30

                          Stability Class :  A     B     C     D     E     F
                                            ---   ---   ---   ---   ---   ---
                                   ! PLX0 = 0.07, 0.07, 0.1, 0.15, 0.35, 0.55 !

Default potential temperature gradient
for stable classes E, F (degK/m)
(PTG0(2))                       Default: 0.020, 0.035
                                   ! PTG0 = 0.02, 0.035 !

Default plume path coefficients for
each stability class (used when option
for partial plume height terrain adjustment
is selected -- MCTADJ=3)
(PPC(6))                  Stability Class :  A     B     C     D     E     F
                             Default  PPC : .50,  .50,  .50,  .50,  .35,  .35
                                            ---   ---   ---   ---   ---   ---
                                    ! PPC = 0.5, 0.5, 0.5, 0.5, 0.35, 0.35 !

Slug-to-puff transition criterion factor
equal to sigma-y/length of slug
(SL2PF)                               Default: 10.       ! SL2PF = 10 !

Puff-splitting control variables ------------------------

  VERTICAL SPLIT
  --------------

  Number of puffs that result every time a puff
  is split - nsplit=2 means that 1 puff splits
  into 2
  (NSPLIT)                            Default:   3       ! NSPLIT = 3 !

  Time(s) of a day when split puffs are eligible to
  be split once again; this is typically set once
  per day, around sunset before nocturnal shear develops.
  24 values: 0 is midnight (00:00) and 23 is 11 PM (23:00)
  0=do not re-split    1=eligible for re-split
  (IRESPLIT(24))                      Default:  Hour 17 = 1
  ! IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

  Split is allowed only if last hour's mixing
  height (m) exceeds a minimum value
  (ZISPLIT)                           Default: 100.      ! ZISPLIT = 100 !

  Split is allowed only if ratio of last hour's
  mixing ht to the maximum mixing ht experienced
  by the puff is less than a maximum value (this
  postpones a split until a nocturnal layer develops)
  (ROLDMAX)                           Default: 0.25      ! ROLDMAX = 0.25 !


  HORIZONTAL SPLIT
  ----------------

  Number of puffs that result every time a puff
```

```
       is split - nsplith=5 means that 1 puff splits
       into 5
       (NSPLITH)                          Default:   5        ! NSPLITH = 5 !

       Minimum sigma-y (Grid Cells Units) of puff
       before it may be split
       (SYSPLITH)                         Default:  1.0       ! SYSPLITH = 1 !

       Minimum puff elongation rate (SYSPLITH/hr) due to
       wind shear, before it may be split
       (SHSPLITH)                         Default:  2.        ! SHSPLITH = 2 !

       Minimum concentration (g/m^3) of each
       species in puff before it may be split
       Enter array of NSPEC values; if a single value is
       entered, it will be used for ALL species
       (CNSPLITH)                         Default:  1.0E-07   ! CNSPLITH = 1E-7 !

     Integration control variables ------------------------

       Fractional convergence criterion for numerical SLUG
       sampling integration
       (EPSSLUG)                          Default:   1.0e-04  ! EPSSLUG = 0.0001 !

       Fractional convergence criterion for numerical AREA
       source integration
       (EPSAREA)                          Default:   1.0e-06  ! EPSAREA = 1E-6 !

       Trajectory step-length (m) used for numerical rise
       integration
       (DSRISE)                           Default:   1.0      ! DSRISE = 1 !

       Boundary Condition (BC) Puff control variables ------------------------

       Minimum height (m) to which BC puffs are mixed as they are emitted
       (MBCON=2 ONLY).  Actual height is reset to the current mixing height
       at the release point if greater than this minimum.
       (HTMINBC)                          Default:   500.     * HTMINBC = *

       Search radius (km) about a receptor for sampling nearest BC puff.
       BC puffs are typically emitted with a spacing of one grid cell
       length, so the search radius should be greater than DGRIDKM.
       (RSAMPBC)                          Default:   10.      * RSAMPBC = *

       Near-Surface depletion adjustment to concentration profile used when
       sampling BC puffs?
       (MDEPBC)                           Default:   1        * MDEPBC = *
          0 = Concentration is NOT adjusted for depletion
          1 = Adjust Concentration for depletion

!END!


-------------------------------------------------------------------------------


INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters
--------------------------------

---------------
Subgroup (13a)
---------------

     Number of point sources with
     parameters provided below      (NPT1)  No default  ! NPT1 = 0 !

     Units used for point source
     emissions below                (IPTU)  Default: 1  ! IPTU = 1 !
           1 =        g/s
```

```
        2 =       kg/hr
        3 =       lb/hr
        4 =     tons/yr
        5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
        6 =     Odour Unit * m**3/min
        7 =     metric tons/yr

    Number of source-species
    combinations with variable
    emissions scaling factors
    provided below in (13d)        (NSPT1) Default: 0  ! NSPT1 = 0 !

    Number of point sources with
    variable emission parameters
    provided in external file      (NPT2)  No default  ! NPT2 = 0 !

    (If NPT2 > 0, these point
    source emissions are read from
    the file: PTEMARB.DAT)

!END!

---------------
Subgroup (13b)
---------------
                                         a
         POINT SOURCE: CONSTANT DATA
         -----------------------------
                                                                               b           c
  Source       X          Y       Stack    Base     Stack    Exit  Exit    Bldg.  Emission
   No.     Coordinate Coordinate Height Elevation Diameter  Vel.  Temp.   Dwash   Rates
              (km)       (km)       (m)      (m)       (m)  (m/s) (deg. K)
  ------   ---------- ---------- ------  ------   -------- ----- -------- ----- --------

--------

   a
    Data for each source are treated as a separate input subgroup
    and therefore must end with an input group terminator.

    SRCNAM  is a 12-character name for a source
            (No default)
    X       is an array holding the source data listed by the column headings
            (No default)
    SIGYZI  is an array holding the initial sigma-y and sigma-z (m)
            (Default: 0.,0.)
    ZPLTFM  is the platform height (m) for sources influenced by an isolated
            structure that has a significant open area between the surface
            and the bulk of the structure, such as an offshore oil platform.
            The Base Elevation is that of the surface (ground or ocean),
            and the Stack Height is the release height above the Base (not
            above the platform).  Building heights entered in Subgroup 13c
            must be those of the buildings on the platform, measured from
            the platform deck.  ZPLTFM is used only with MBDW=1 (ISC
            downwash method) for sources with building downwash.
            (Default: 0.0)
    FMFAC   is a vertical momentum flux factor (0. or 1.0) used to represent
            the effect of rain-caps or other physical configurations that
            reduce momentum rise associated with the actual exit velocity.
            (Default: 1.0  -- full momentum used)

   b
    0. = No building downwash modeled
    1. = Downwash modeled for buildings resting on the surface
    2. = Downwash modeled for buildings raised above the surface (ZPLTFM > 0.)
    NOTE: must be entered as a REAL number (i.e., with decimal point)

   c
    An emission rate must be entered for every pollutant modeled.
```

```
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IPTU
     (e.g. 1 for g/s).

---------------
Subgroup (13c)
---------------

           BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH
           -------------------------------------------------------
Source                                                                a
 No.       Effective building height, width, length and X/Y offset (in meters)
           every 10 degrees.  LENGTH, XBADJ, and YBADJ are only needed for
           MBDW=2 (PRIME downwash option)
------     --------------------------------------------------------------------



--------

    a
     Building height, width, length, and X/Y offset from the source are treated
     as a separate input subgroup for each source and therefore must end with
     an input group terminator.  The X/Y offset is the position, relative to the
     stack, of the center of the upwind face of the projected building, with the
     x-axis pointing along the flow direction.


---------------
Subgroup (13d)
---------------
                                                 a
          POINT SOURCE: VARIABLE EMISSIONS DATA
          ---------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 13b.  Factors entered multiply the rates in 13b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------


INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
--------------------------------
```

```
---------------
Subgroup (14a)
---------------

     Number of polygon area sources with
     parameters specified below (NAR1)       No default  ! NAR1 = 15 !

     Units used for area source
     emissions below            (IARU)       Default: 1  ! IARU = 5 !
           1 =        g/m**2/s
           2 =       kg/m**2/hr
           3 =       lb/m**2/hr
           4 =     tons/m**2/yr
           5 =     Odour Unit * m/s  (vol. flux/m**2 of odour compound)
           6 =     Odour Unit * m/min
           7 =     metric tons/m**2/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (14d)        (NSAR1) Default: 0  ! NSAR1 = 9 !

     Number of buoyant polygon area sources
     with variable location and emission
     parameters (NAR2)                      No default  ! NAR2 = 0 !
     (If NAR2 > 0, ALL parameter data for
     these sources are read from the file: BAEMARB.DAT)

!END!

---------------
Subgroup (14b)
---------------
                                     a
          AREA SOURCE: CONSTANT DATA
          ----------------------------
                                                           b
Source          Effect.    Base      Initial    Emission
 No.            Height   Elevation   Sigma z     Rates
                  (m)       (m)        (m)
-------         ------    ------     --------   ---------


   1 ! SRCNAM = LDAM !
   1 ! X =         0.0,   797.19,         0.1,     8.8 !
!END!
   2 ! SRCNAM = GW !
   2 ! X =         0.0,   791.39,         0.1,     0.7 !
!END!
   3 ! SRCNAM = TL1 !
   3 ! X =         0.0,   791.56,         0.1,     0.2 !
!END!
   4 ! SRCNAM = UTL !
   4 ! X =         0.0,   791.55,         0.1,     8.8 !
!END!
   5 ! SRCNAM = SW !
   5 ! X =         0.0,   792.37,         0.1,     0.5 !
!END!
   6 ! SRCNAM = COVW !
   6 ! X =         0.0,   731.67,         0.1,     0.2 !
!END!
   7 ! SRCNAM = FW !
   7 ! X =         0.0,   753.02,         0.1,     7.3 !
!END!
   8 ! SRCNAM = WR3 !
   8 ! X =         0.0,   793.74,         2.0,   0.253 !
!END!
   9 ! SRCNAM = WR2 !
   9 ! X =         0.0,   792.15,         2.0,    13.0 !
```

```
!END!
  10 ! SRCNAM = WR4 !
  10 ! X =         0.0,   791.81,         2.0,    11.3 !
!END!
  11 ! SRCNAM = WR4_2 !
  11 ! X =         0.0,   796.36,         2.0,    11.3 !
!END!
  12 ! SRCNAM = WR5 !
  12 ! X =         0.0,   796.38,         2.0,    5.45 !
!END!
  13 ! SRCNAM = WR5_2 !
  13 ! X =         0.0,   796.74,         2.0,   0.253 !
!END!
  14 ! SRCNAM = LEACHINJ !
  14 ! X =         0.0,   697.05,         0.1,     2.5 !
!END!
  15 ! SRCNAM = CRACK !
  15 ! X =         0.0,   705.26,         0.1,    26.7 !
!END!

--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IARU
     (e.g. 1 for g/m**2/s).

---------------
Subgroup (14c)
---------------

           COORDINATES (km) FOR EACH VERTEX(4) OF EACH POLYGON
           --------------------------------------------------------
Source                                                                 a
 No.       Ordered list of X followed by list of Y, grouped by source
------     ------------------------------------------------------------

   1 ! SRCNAM = LDAM !
   1 ! XVERT = 734.010,734.076,734.094,734.039 !
   1 ! YVERT = 6116.993,6117.097,6117.078,6116.973 !
!END!
   2 ! SRCNAM = GW !
   2 ! XVERT = 733.365,733.309,733.462,733.562,733.366 !
   2 ! YVERT = 6117.434,6117.231,6117.200,6117.351,6117.438 !
!END!
   3 ! SRCNAM = TL1 !
   3 ! XVERT = 733.469,733.568,733.617,733.635,733.556 !
   3 ! YVERT = 6117.197,6117.350,6117.318,6117.270,6117.182 !
!END!
   4 ! SRCNAM = UTL !
   4 ! XVERT = 733.571,733.698,733.640,733.572 !
   4 ! YVERT = 6117.176,6117.156,6117.265,6117.180 !
!END!
   5 ! SRCNAM = SW !
   5 ! XVERT = 733.460,733.750,733.571,733.334,733.288 !
   5 ! YVERT = 6117.177,6117.129,6116.910,6117.029,6117.096 !
!END!
   6 ! SRCNAM = COVW !
   6 ! XVERT = 734.260,734.420,734.469,734.599,734.526 !
   6 ! YVERT = 6116.961,6117.148,6117.146,6117.056,6116.832 !
!END!
   7 ! SRCNAM = FW !
   7 ! XVERT = 734.406,734.365,734.465,734.526 !
   7 ! YVERT = 6116.890,6116.847,6116.805,6116.833 !
!END!
   8 ! SRCNAM = WR3 !
```

```
   8 ! XVERT = 733.042,733.095,732.815,732.762 !
   8 ! YVERT = 6117.319,6117.438,6117.563,6117.444 !
!END!
   9 ! SRCNAM = WR2 !
   9 ! XVERT = 733.073,733.126,733.095,733.042 !
   9 ! YVERT = 6117.305,6117.424,6117.438,6117.319 !
!END!
  10 ! SRCNAM = WR4 !
  10 ! XVERT = 733.103,733.156,733.126,733.073 !
  10 ! YVERT = 6117.292,6117.410,6117.424,6117.305 !
!END!
  11 ! SRCNAM = WR4_2 !
  11 ! XVERT = 732.726,732.779,732.767,732.713 !
  11 ! YVERT = 6117.460,6117.579,6117.585,6117.466 !
!END!
  12 ! SRCNAM = WR5 !
  12 ! XVERT = 732.713,732.767,732.753,732.700 !
  12 ! YVERT = 6117.466,6117.585,6117.591,6117.472 !
!END!
  13 ! SRCNAM = WR5_2 !
  13 ! XVERT = 732.700,732.753,732.688,732.635 !
  13 ! YVERT = 6117.472,6117.591,6117.620,6117.501 !
!END!
  14 ! SRCNAM = LEACHINJ !
  14 ! XVERT = 734.401,734.405,734.365,734.360 !
  14 ! YVERT = 6116.892,6116.890,6116.847,6116.850 !
!END!
  15 ! SRCNAM = CRACK !
  15 ! XVERT = 734.396,734.400,734.397,734.393 !
  15 ! YVERT = 6116.894,6116.893,6116.889,6116.891 !
!END!

--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------
Subgroup (14d)
---------------
                                              a
          AREA SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 14b.  Factors entered multiply the rates in 14b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                               Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)


   1 ! SRCNAM = LDAM !
   1 ! IVARY = 4 !    (6 speed classes for each stability)
```

```
   1 ! ODOR = 2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.3,2.3,2.3,2.3,2.3,2.3,
          2.3,2.3,2.3,2.3,2.3,2.3      !
!END!
   2 ! SRCNAM = GW !
   2 ! IVARY = 4 !    (6 speed classes for each stability)
   2 ! ODOR = 2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.3,2.3,2.3,2.3,2.3,2.3,
          2.3,2.3,2.3,2.3,2.3,2.3      !
!END!
   3 ! SRCNAM = TL1 !
   3 ! IVARY = 4 !    (6 speed classes for each stability)
   3 ! ODOR = 2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.3,2.3,2.3,2.3,2.3,2.3,
          2.3,2.3,2.3,2.3,2.3,2.3      !
!END!
   4 ! SRCNAM = UTL !
   4 ! IVARY = 4 !    (6 speed classes for each stability)
   4 ! ODOR = 2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.3,2.3,2.3,2.3,2.3,2.3,
          1,2.3,2.3,2.3,2.3,2.3      !
!END!
   5 ! SRCNAM = SW !
   5 ! IVARY = 4 !    (6 speed classes for each stability)
   5 ! ODOR = 2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.3,2.3,2.3,2.3,2.3,2.3,
          2.3,2.3,2.3,2.3,2.3,2.3      !
!END!
   6 ! SRCNAM = COVW !
   6 ! IVARY = 4 !    (6 speed classes for each stability)
   6 ! ODOR = 2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.3,2.3,2.3,2.3,2.3,2.3,
          2.3,2.3,2.3,2.3,2.3,2.3      !
!END!
   7 ! SRCNAM = FW !
   7 ! IVARY = 4 !    (6 speed classes for each stability)
   7 ! ODOR = 2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.3,2.3,2.3,2.3,2.3,2.3,
          2.3,2.3,2.3,2.3,2.3,2.3      !
!END!
  14 ! SRCNAM = LEACHINJ !
  14 ! IVARY = 4 !    (6 speed classes for each stability)
  14 ! ODOR = 2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.5,2.5,2.5,2.5,2.5,2.5,
          2.3,2.3,2.3,2.3,2.3,2.3,
          2.3,2.3,2.3,2.3,2.3,2.3      !
```

```
!END!
  15 ! SRCNAM = CRACK !
  15 ! IVARY = 4 !    (6 speed classes for each stability)
  15 ! ODOR = 2.5,2.5,2.5,2.5,2.5,2.5,
         2.5,2.5,2.5,2.5,2.5,2.5,
         2.5,2.5,2.5,2.5,2.5,2.5,
         2.5,2.5,2.5,2.5,2.5,2.5,
         2.3,2.3,2.3,2.3,2.3,2.3,
         2.3,2.3,2.3,2.3,2.3,2.3      !
!END!

--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


--------------------------------------------------------------------------------

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters
---------------------------

---------------
Subgroup (15a)
---------------

     Number of buoyant line sources
     with variable location and emission
     parameters (NLN2)                              No default  ! NLN2 = 0 !

     (If NLN2 > 0, ALL parameter data for
      these sources are read from the file: LNEMARB.DAT)

     Number of buoyant line sources (NLINES)        No default   ! NLINES = 0 !

     Units used for line source
     emissions below                (ILNU)          Default: 1   ! ILNU = 1 !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (15c)        (NSLN1) Default: 0  ! NSLN1 = 0 !

     Maximum number of segments used to model
     each line (MXNSEG)                             Default: 7   ! MXNSEG = 7 !

     The following variables are required only if NLINES > 0.  They are
     used in the buoyant line source plume rise calculations.

        Number of distances at which                Default: 6   ! NLRISE = 6 !
        transitional rise is computed

        Average building length (XL)                No default   * XL = *
                                                    (in meters)

        Average building height (HBL)               No default   * HBL = *
                                                    (in meters)

        Average building width (WBL)                No default   * WBL = *
                                                    (in meters)

        Average line source width (WML)             No default   * WML = *
```

```
                                                       (in meters)

          Average separation between buildings (DXL)  No default   * DXL = *
                                                       (in meters)

          Average buoyancy parameter (FPRIMEL)        No default   * FPRIMEL = *
                                                       (in m**4/s**3)

!END!
```

Subgroup (15b)

```
            BUOYANT LINE SOURCE: CONSTANT DATA
            ----------------------------------
                                                                                           a
Source     Beg. X      Beg. Y      End. X    End. Y     Release    Base        Emission
 No.     Coordinate  Coordinate  Coordinate Coordinate  Height    Elevation      Rates
            (km)        (km)        (km)      (km)        (m)        (m)
------   ----------  ----------  ---------  ----------  -------   ---------    ---------

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by ILNTU
     (e.g. 1 for g/s).
```

Subgroup (15c)

```
                                                        a
            BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA
            ---------------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 15b.  Factors entered multiply the rates in 15b.
     Skip sources here that have constant emissions.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.
```

```
-------------------------------------------------------------------------------


INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters
---------------------------

---------------
Subgroup (16a)
---------------

     Number of volume sources with
     parameters provided in 16b,c (NVL1)     No default  ! NVL1 = 2 !

     Units used for volume source
     emissions below in 16b       (IVLU)     Default: 1  ! IVLU = 5 !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (16c)      (NSVL1)    Default: 0  ! NSVL1 = 0 !

     Number of volume sources with
     variable location and emission
     parameters                   (NVL2)     No default  ! NVL2 = 0 !

     (If NVL2 > 0, ALL parameter data for
      these sources are read from the VOLEMARB.DAT file(s) )

!END!

---------------
Subgroup (16b)
---------------
                                        a
           VOLUME SOURCE: CONSTANT DATA
           ------------------------------
                                                                            b
         X            Y         Effect.    Base     Initial    Initial    Emission
     Coordinate   Coordinate    Height   Elevation   Sigma y    Sigma z     Rates
        (km)        (km)         (m)       (m)        (m)        (m)
     ----------   ----------    ------    ------    --------   --------   --------

   1 ! SRCNAM = SRC_1 !
   1 ! X =  732.860, 6117.505,     0.0,   794.75,       20.0,       2.0,    5.65 !
!END!
   2 ! SRCNAM = SRC_2 !
   2 ! X =  732.976, 6117.433,     0.0,   793.45,       10.0,       2.0,    2.37 !
!END!

--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IVLU
     (e.g. 1 for g/s).

---------------
Subgroup (16c)
```

```
---------------
                                                  a
          VOLUME SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 16b.  Factors entered multiply the rates in 16b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use VOLEMARB.DAT and NVL2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information
-----------------------

---------------
Subgroup (17a)
---------------

     Number of non-gridded receptors (NREC)  No default  ! NREC = 380 !

!END!

---------------
Subgroup (17b)
---------------
                                                a
           NON-GRIDDED (DISCRETE) RECEPTOR DATA
           ------------------------------------

                   X            Y          Ground        Height   b
Receptor       Coordinate   Coordinate    Elevation   Above Ground
  No.            (km)         (km)          (m)           (m)
--------       ----------   ----------    ---------   ------------


    1 ! X =       734.581,     6118.143,       783.5,          0.0 !   !END!
    2 ! X =       736.674,     6117.689,       780.7,          0.0 !   !END!
    3 ! X =       737.492,     6114.373,       744.5,          0.0 !   !END!
    4 ! X =       731.286,     6114.654,       726.2,          0.0 !   !END!
    5 ! X =       741.148,     6115.437,       699.9,          0.0 !   !END!
    6 ! X =       729.783,     6113.136,       761.4,          0.0 !   !END!
    7 ! X =       729.783,     6113.636,       736.0,          0.0 !   !END!
    8 ! X =       729.783,     6114.136,       744.5,          0.0 !   !END!
    9 ! X =       729.783,     6114.636,       750.2,          0.0 !   !END!
```

```
10 ! X =       729.783,     6115.136,       705.8,            0.0 !   !END!
11 ! X =       729.783,     6115.636,       697.3,            0.0 !   !END!
12 ! X =       729.783,     6116.136,       693.3,            0.0 !   !END!
13 ! X =       729.783,     6116.636,       694.2,            0.0 !   !END!
14 ! X =       729.783,     6117.136,       693.1,            0.0 !   !END!
15 ! X =       729.783,     6117.636,       692.5,            0.0 !   !END!
16 ! X =       729.783,     6118.136,       698.8,            0.0 !   !END!
17 ! X =       729.783,     6118.636,       720.6,            0.0 !   !END!
18 ! X =       729.783,     6119.136,       715.8,            0.0 !   !END!
19 ! X =       729.783,     6119.636,       700.0,            0.0 !   !END!
20 ! X =       729.783,     6120.136,       701.2,            0.0 !   !END!
21 ! X =       730.283,     6113.136,       745.6,            0.0 !   !END!
22 ! X =       730.283,     6113.636,       731.5,            0.0 !   !END!
23 ! X =       730.283,     6114.136,       723.5,            0.0 !   !END!
24 ! X =       730.283,     6114.636,       717.4,            0.0 !   !END!
25 ! X =       730.283,     6115.136,       704.9,            0.0 !   !END!
26 ! X =       730.283,     6115.636,       697.9,            0.0 !   !END!
27 ! X =       730.283,     6116.136,       697.2,            0.0 !   !END!
28 ! X =       730.283,     6116.636,       698.1,            0.0 !   !END!
29 ! X =       730.283,     6117.136,       698.3,            0.0 !   !END!
30 ! X =       730.283,     6117.636,       701.5,            0.0 !   !END!
31 ! X =       730.283,     6118.136,       720.4,            0.0 !   !END!
32 ! X =       730.283,     6118.636,       729.5,            0.0 !   !END!
33 ! X =       730.283,     6119.136,       717.2,            0.0 !   !END!
34 ! X =       730.283,     6119.636,       707.8,            0.0 !   !END!
35 ! X =       730.283,     6120.136,       708.1,            0.0 !   !END!
36 ! X =       730.783,     6113.136,       749.4,            0.0 !   !END!
37 ! X =       730.783,     6113.636,       733.0,            0.0 !   !END!
38 ! X =       730.783,     6114.136,       721.2,            0.0 !   !END!
39 ! X =       730.783,     6114.636,       712.4,            0.0 !   !END!
40 ! X =       730.783,     6115.136,       706.3,            0.0 !   !END!
41 ! X =       730.783,     6115.636,       702.4,            0.0 !   !END!
42 ! X =       730.783,     6116.136,       706.1,            0.0 !   !END!
43 ! X =       730.783,     6116.636,       703.5,            0.0 !   !END!
44 ! X =       730.783,     6117.136,       705.2,            0.0 !   !END!
45 ! X =       730.783,     6117.636,       710.0,            0.0 !   !END!
46 ! X =       730.783,     6118.136,       741.1,            0.0 !   !END!
47 ! X =       730.783,     6118.636,       730.3,            0.0 !   !END!
48 ! X =       730.783,     6119.136,       716.3,            0.0 !   !END!
49 ! X =       730.783,     6119.636,       720.3,            0.0 !   !END!
50 ! X =       730.783,     6120.136,       717.0,            0.0 !   !END!
51 ! X =       731.283,     6113.136,       753.7,            0.0 !   !END!
52 ! X =       731.283,     6113.636,       744.8,            0.0 !   !END!
53 ! X =       731.283,     6114.136,       733.2,            0.0 !   !END!
54 ! X =       731.283,     6114.636,       726.7,            0.0 !   !END!
55 ! X =       731.283,     6115.136,       713.6,            0.0 !   !END!
56 ! X =       731.283,     6115.636,       717.1,            0.0 !   !END!
57 ! X =       731.283,     6116.136,       716.5,            0.0 !   !END!
58 ! X =       731.283,     6116.636,       711.3,            0.0 !   !END!
59 ! X =       731.283,     6117.136,       719.1,            0.0 !   !END!
60 ! X =       731.283,     6117.636,       726.5,            0.0 !   !END!
61 ! X =       731.283,     6118.136,       738.8,            0.0 !   !END!
62 ! X =       731.283,     6118.636,       733.0,            0.0 !   !END!
63 ! X =       731.283,     6119.136,       739.5,            0.0 !   !END!
64 ! X =       731.283,     6119.636,       728.8,            0.0 !   !END!
65 ! X =       731.283,     6120.136,       731.4,            0.0 !   !END!
66 ! X =       731.783,     6113.136,       751.2,            0.0 !   !END!
67 ! X =       731.783,     6113.636,       742.3,            0.0 !   !END!
68 ! X =       731.783,     6114.136,       729.2,            0.0 !   !END!
69 ! X =       731.783,     6114.636,       726.1,            0.0 !   !END!
70 ! X =       731.783,     6115.136,       727.8,            0.0 !   !END!
71 ! X =       731.783,     6115.636,       737.5,            0.0 !   !END!
72 ! X =       731.783,     6116.136,       731.9,            0.0 !   !END!
73 ! X =       731.783,     6116.636,       742.3,            0.0 !   !END!
74 ! X =       731.783,     6117.136,       739.7,            0.0 !   !END!
75 ! X =       731.783,     6117.636,       756.0,            0.0 !   !END!
76 ! X =       731.783,     6118.136,       758.4,            0.0 !   !END!
77 ! X =       731.783,     6118.636,       762.8,            0.0 !   !END!
78 ! X =       731.783,     6119.136,       749.0,            0.0 !   !END!
```

```
 79 ! X =       731.783,     6119.636,        749.6,            0.0 !   !END!
 80 ! X =       731.783,     6120.136,        766.8,            0.0 !   !END!
 81 ! X =       732.283,     6113.136,        765.0,            0.0 !   !END!
 82 ! X =       732.283,     6113.636,        748.9,            0.0 !   !END!
 83 ! X =       732.283,     6114.136,        735.7,            0.0 !   !END!
 84 ! X =       732.283,     6114.636,        737.9,            0.0 !   !END!
 85 ! X =       732.283,     6115.136,        759.8,            0.0 !   !END!
 86 ! X =       732.283,     6115.636,        770.3,            0.0 !   !END!
 87 ! X =       732.283,     6116.136,        748.6,            0.0 !   !END!
 88 ! X =       732.283,     6116.636,        774.8,            0.0 !   !END!
 89 ! X =       732.283,     6117.136,        771.2,            0.0 !   !END!
 90 ! X =       732.283,     6117.636,        783.1,            0.0 !   !END!
 91 ! X =       732.283,     6118.136,        774.4,            0.0 !   !END!
 92 ! X =       732.283,     6118.636,        775.5,            0.0 !   !END!
 93 ! X =       732.283,     6119.136,        770.0,            0.0 !   !END!
 94 ! X =       732.283,     6119.636,        781.6,            0.0 !   !END!
 95 ! X =       732.283,     6120.136,        812.4,            0.0 !   !END!
 96 ! X =       732.783,     6113.136,        785.6,            0.0 !   !END!
 97 ! X =       732.783,     6113.636,        763.5,            0.0 !   !END!
 98 ! X =       732.783,     6114.136,        771.5,            0.0 !   !END!
 99 ! X =       732.783,     6114.636,        780.9,            0.0 !   !END!
100 ! X =       732.783,     6115.136,        787.8,            0.0 !   !END!
101 ! X =       732.783,     6115.636,        776.4,            0.0 !   !END!
102 ! X =       732.783,     6116.136,        763.0,            0.0 !   !END!
103 ! X =       732.783,     6116.636,        784.3,            0.0 !   !END!
104 ! X =       732.783,     6117.136,        791.2,            0.0 !   !END!
105 ! X =       732.783,     6117.636,        795.5,            0.0 !   !END!
106 ! X =       732.783,     6118.136,        785.3,            0.0 !   !END!
107 ! X =       732.783,     6118.636,        786.5,            0.0 !   !END!
108 ! X =       732.783,     6119.136,        805.1,            0.0 !   !END!
109 ! X =       732.783,     6119.636,        817.0,            0.0 !   !END!
110 ! X =       732.783,     6120.136,        859.4,            0.0 !   !END!
111 ! X =       733.283,     6113.136,        780.0,            0.0 !   !END!
112 ! X =       733.283,     6113.636,        793.6,            0.0 !   !END!
113 ! X =       733.283,     6114.136,        795.0,            0.0 !   !END!
114 ! X =       733.283,     6114.636,        810.2,            0.0 !   !END!
115 ! X =       733.283,     6115.136,        812.7,            0.0 !   !END!
116 ! X =       733.283,     6115.636,        790.2,            0.0 !   !END!
117 ! X =       733.283,     6116.136,        808.2,            0.0 !   !END!
118 ! X =       733.283,     6116.636,        805.5,            0.0 !   !END!
119 ! X =       733.283,     6117.136,        792.1,            0.0 !   !END!
120 ! X =       733.283,     6117.636,        787.2,            0.0 !   !END!
121 ! X =       733.283,     6118.136,        790.6,            0.0 !   !END!
122 ! X =       733.283,     6118.636,        802.1,            0.0 !   !END!
123 ! X =       733.283,     6119.136,        861.8,            0.0 !   !END!
124 ! X =       733.283,     6119.636,        890.3,            0.0 !   !END!
125 ! X =       733.283,     6120.136,        913.6,            0.0 !   !END!
126 ! X =       733.783,     6113.136,        785.0,            0.0 !   !END!
127 ! X =       733.783,     6113.636,        797.2,            0.0 !   !END!
128 ! X =       733.783,     6114.136,        818.4,            0.0 !   !END!
129 ! X =       733.783,     6114.636,        848.9,            0.0 !   !END!
130 ! X =       733.783,     6115.136,        851.4,            0.0 !   !END!
131 ! X =       733.783,     6115.636,        824.2,            0.0 !   !END!
132 ! X =       733.783,     6116.136,        849.7,            0.0 !   !END!
133 ! X =       733.783,     6116.636,        838.9,            0.0 !   !END!
134 ! X =       733.783,     6117.136,        793.8,            0.0 !   !END!
135 ! X =       733.783,     6117.636,        784.1,            0.0 !   !END!
136 ! X =       733.783,     6118.136,        788.1,            0.0 !   !END!
137 ! X =       733.783,     6118.636,        807.1,            0.0 !   !END!
138 ! X =       733.783,     6119.136,        870.1,            0.0 !   !END!
139 ! X =       733.783,     6119.636,        990.3,            0.0 !   !END!
140 ! X =       733.783,     6120.136,        985.5,            0.0 !   !END!
141 ! X =       734.283,     6113.136,        807.8,            0.0 !   !END!
142 ! X =       734.283,     6113.636,        830.8,            0.0 !   !END!
143 ! X =       734.283,     6114.136,        852.8,            0.0 !   !END!
144 ! X =       734.283,     6114.636,        859.8,            0.0 !   !END!
145 ! X =       734.283,     6115.136,        835.2,            0.0 !   !END!
146 ! X =       734.283,     6115.636,        836.2,            0.0 !   !END!
147 ! X =       734.283,     6116.136,        860.7,            0.0 !   !END!
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148 ! X =       734.283,     6116.636,       786.6,           0.0 !   !END!
149 ! X =       734.283,     6117.136,       776.3,           0.0 !   !END!
150 ! X =       734.283,     6117.636,       788.5,           0.0 !   !END!
151 ! X =       734.283,     6118.136,       786.4,           0.0 !   !END!
152 ! X =       734.283,     6118.636,       805.5,           0.0 !   !END!
153 ! X =       734.283,     6119.136,       864.4,           0.0 !   !END!
154 ! X =       734.283,     6119.636,       935.9,           0.0 !   !END!
155 ! X =       734.283,     6120.136,       969.3,           0.0 !   !END!
156 ! X =       734.783,     6113.136,       836.3,           0.0 !   !END!
157 ! X =       734.783,     6113.636,       904.7,           0.0 !   !END!
158 ! X =       734.783,     6114.136,       839.9,           0.0 !   !END!
159 ! X =       734.783,     6114.636,       803.8,           0.0 !   !END!
160 ! X =       734.783,     6115.136,       801.2,           0.0 !   !END!
161 ! X =       734.783,     6115.636,       822.4,           0.0 !   !END!
162 ! X =       734.783,     6116.136,       812.1,           0.0 !   !END!
163 ! X =       734.783,     6116.636,       810.5,           0.0 !   !END!
164 ! X =       734.783,     6117.136,       789.5,           0.0 !   !END!
165 ! X =       734.783,     6117.636,       781.3,           0.0 !   !END!
166 ! X =       734.783,     6118.136,       781.2,           0.0 !   !END!
167 ! X =       734.783,     6118.636,       796.1,           0.0 !   !END!
168 ! X =       734.783,     6119.136,       840.8,           0.0 !   !END!
169 ! X =       734.783,     6119.636,       866.8,           0.0 !   !END!
170 ! X =       734.783,     6120.136,       952.1,           0.0 !   !END!
171 ! X =       735.283,     6113.136,       866.1,           0.0 !   !END!
172 ! X =       735.283,     6113.636,       826.5,           0.0 !   !END!
173 ! X =       735.283,     6114.136,       798.8,           0.0 !   !END!
174 ! X =       735.283,     6114.636,       779.2,           0.0 !   !END!
175 ! X =       735.283,     6115.136,       785.0,           0.0 !   !END!
176 ! X =       735.283,     6115.636,       794.5,           0.0 !   !END!
177 ! X =       735.283,     6116.136,       798.6,           0.0 !   !END!
178 ! X =       735.283,     6116.636,       780.7,           0.0 !   !END!
179 ! X =       735.283,     6117.136,       776.5,           0.0 !   !END!
180 ! X =       735.283,     6117.636,       774.0,           0.0 !   !END!
181 ! X =       735.283,     6118.136,       778.0,           0.0 !   !END!
182 ! X =       735.283,     6118.636,       788.2,           0.0 !   !END!
183 ! X =       735.283,     6119.136,       819.7,           0.0 !   !END!
184 ! X =       735.283,     6119.636,       849.3,           0.0 !   !END!
185 ! X =       735.283,     6120.136,       905.3,           0.0 !   !END!
186 ! X =       735.783,     6113.136,       793.9,           0.0 !   !END!
187 ! X =       735.783,     6113.636,       792.7,           0.0 !   !END!
188 ! X =       735.783,     6114.136,       776.9,           0.0 !   !END!
189 ! X =       735.783,     6114.636,       764.5,           0.0 !   !END!
190 ! X =       735.783,     6115.136,       781.7,           0.0 !   !END!
191 ! X =       735.783,     6115.636,       779.3,           0.0 !   !END!
192 ! X =       735.783,     6116.136,       778.3,           0.0 !   !END!
193 ! X =       735.783,     6116.636,       771.5,           0.0 !   !END!
194 ! X =       735.783,     6117.136,       764.5,           0.0 !   !END!
195 ! X =       735.783,     6117.636,       766.0,           0.0 !   !END!
196 ! X =       735.783,     6118.136,       772.7,           0.0 !   !END!
197 ! X =       735.783,     6118.636,       789.6,           0.0 !   !END!
198 ! X =       735.783,     6119.136,       814.7,           0.0 !   !END!
199 ! X =       735.783,     6119.636,       844.8,           0.0 !   !END!
200 ! X =       735.783,     6120.136,       876.8,           0.0 !   !END!
201 ! X =       736.283,     6113.136,       768.9,           0.0 !   !END!
202 ! X =       736.283,     6113.636,       762.2,           0.0 !   !END!
203 ! X =       736.283,     6114.136,       767.7,           0.0 !   !END!
204 ! X =       736.283,     6114.636,       757.1,           0.0 !   !END!
205 ! X =       736.283,     6115.136,       786.6,           0.0 !   !END!
206 ! X =       736.283,     6115.636,       765.6,           0.0 !   !END!
207 ! X =       736.283,     6116.136,       758.4,           0.0 !   !END!
208 ! X =       736.283,     6116.636,       759.7,           0.0 !   !END!
209 ! X =       736.283,     6117.136,       759.4,           0.0 !   !END!
210 ! X =       736.283,     6117.636,       764.4,           0.0 !   !END!
211 ! X =       736.283,     6118.136,       779.4,           0.0 !   !END!
212 ! X =       736.283,     6118.636,       796.1,           0.0 !   !END!
213 ! X =       736.283,     6119.136,       824.1,           0.0 !   !END!
214 ! X =       736.283,     6119.636,       847.9,           0.0 !   !END!
215 ! X =       736.283,     6120.136,       909.2,           0.0 !   !END!
216 ! X =       736.783,     6113.136,       767.7,           0.0 !   !END!
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217 ! X =       736.783,     6113.636,       757.0,           0.0 !   !END!
218 ! X =       736.783,     6114.136,       751.7,           0.0 !   !END!
219 ! X =       736.783,     6114.636,       748.6,           0.0 !   !END!
220 ! X =       736.783,     6115.136,       755.8,           0.0 !   !END!
221 ! X =       736.783,     6115.636,       758.5,           0.0 !   !END!
222 ! X =       736.783,     6116.136,       749.1,           0.0 !   !END!
223 ! X =       736.783,     6116.636,       752.0,           0.0 !   !END!
224 ! X =       736.783,     6117.136,       761.1,           0.0 !   !END!
225 ! X =       736.783,     6117.636,       780.0,           0.0 !   !END!
226 ! X =       736.783,     6118.136,       808.2,           0.0 !   !END!
227 ! X =       736.783,     6118.636,       843.6,           0.0 !   !END!
228 ! X =       736.783,     6119.136,       881.1,           0.0 !   !END!
229 ! X =       736.783,     6119.636,       911.8,           0.0 !   !END!
230 ! X =       736.783,     6120.136,       941.9,           0.0 !   !END!
231 ! X =       737.283,     6113.136,       762.8,           0.0 !   !END!
232 ! X =       737.283,     6113.636,       752.3,           0.0 !   !END!
233 ! X =       737.283,     6114.136,       748.3,           0.0 !   !END!
234 ! X =       737.283,     6114.636,       744.8,           0.0 !   !END!
235 ! X =       737.283,     6115.136,       752.6,           0.0 !   !END!
236 ! X =       737.283,     6115.636,       750.7,           0.0 !   !END!
237 ! X =       737.283,     6116.136,       752.2,           0.0 !   !END!
238 ! X =       737.283,     6116.636,       776.3,           0.0 !   !END!
239 ! X =       737.283,     6117.136,       809.8,           0.0 !   !END!
240 ! X =       737.283,     6117.636,       849.9,           0.0 !   !END!
241 ! X =       737.283,     6118.136,       872.9,           0.0 !   !END!
242 ! X =       737.283,     6118.636,       902.8,           0.0 !   !END!
243 ! X =       737.283,     6119.136,       855.9,           0.0 !   !END!
244 ! X =       737.283,     6119.636,       885.2,           0.0 !   !END!
245 ! X =       737.283,     6120.136,       907.5,           0.0 !   !END!
246 ! X =       737.783,     6113.136,       757.5,           0.0 !   !END!
247 ! X =       737.783,     6113.636,       746.9,           0.0 !   !END!
248 ! X =       737.783,     6114.136,       739.1,           0.0 !   !END!
249 ! X =       737.783,     6114.636,       740.0,           0.0 !   !END!
250 ! X =       737.783,     6115.136,       757.1,           0.0 !   !END!
251 ! X =       737.783,     6115.636,       778.5,           0.0 !   !END!
252 ! X =       737.783,     6116.136,       781.3,           0.0 !   !END!
253 ! X =       737.783,     6116.636,       823.1,           0.0 !   !END!
254 ! X =       737.783,     6117.136,       899.7,           0.0 !   !END!
255 ! X =       737.783,     6117.636,       919.5,           0.0 !   !END!
256 ! X =       737.783,     6118.136,       862.9,           0.0 !   !END!
257 ! X =       737.783,     6118.636,       868.0,           0.0 !   !END!
258 ! X =       737.783,     6119.136,       801.6,           0.0 !   !END!
259 ! X =       737.783,     6119.636,       801.0,           0.0 !   !END!
260 ! X =       737.783,     6120.136,       800.3,           0.0 !   !END!
261 ! X =       738.283,     6113.136,       748.6,           0.0 !   !END!
262 ! X =       738.283,     6113.636,       743.3,           0.0 !   !END!
263 ! X =       738.283,     6114.136,       739.0,           0.0 !   !END!
264 ! X =       738.283,     6114.636,       781.4,           0.0 !   !END!
265 ! X =       738.283,     6115.136,       812.3,           0.0 !   !END!
266 ! X =       738.283,     6115.636,       849.0,           0.0 !   !END!
267 ! X =       738.283,     6116.136,       849.2,           0.0 !   !END!
268 ! X =       738.283,     6116.636,       868.6,           0.0 !   !END!
269 ! X =       738.283,     6117.136,       856.3,           0.0 !   !END!
270 ! X =       738.283,     6117.636,       837.4,           0.0 !   !END!
271 ! X =       738.283,     6118.136,       809.4,           0.0 !   !END!
272 ! X =       738.283,     6118.636,       803.3,           0.0 !   !END!
273 ! X =       738.283,     6119.136,       768.4,           0.0 !   !END!
274 ! X =       738.283,     6119.636,       762.0,           0.0 !   !END!
275 ! X =       738.283,     6120.136,       758.9,           0.0 !   !END!
276 ! X =       738.783,     6113.136,       745.6,           0.0 !   !END!
277 ! X =       738.783,     6113.636,       738.1,           0.0 !   !END!
278 ! X =       738.783,     6114.136,       788.2,           0.0 !   !END!
279 ! X =       738.783,     6114.636,       811.4,           0.0 !   !END!
280 ! X =       738.783,     6115.136,       800.3,           0.0 !   !END!
281 ! X =       738.783,     6115.636,       825.4,           0.0 !   !END!
282 ! X =       738.783,     6116.136,       809.7,           0.0 !   !END!
283 ! X =       738.783,     6116.636,       794.2,           0.0 !   !END!
284 ! X =       738.783,     6117.136,       791.4,           0.0 !   !END!
285 ! X =       738.783,     6117.636,       797.5,           0.0 !   !END!
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286 ! X =       738.783,     6118.136,       774.4,            0.0 !   !END!
287 ! X =       738.783,     6118.636,       757.6,            0.0 !   !END!
288 ! X =       738.783,     6119.136,       750.9,            0.0 !   !END!
289 ! X =       738.783,     6119.636,       739.2,            0.0 !   !END!
290 ! X =       738.783,     6120.136,       742.8,            0.0 !   !END!
291 ! X =       739.283,     6113.136,       730.2,            0.0 !   !END!
292 ! X =       739.283,     6113.636,       742.2,            0.0 !   !END!
293 ! X =       739.283,     6114.136,       727.0,            0.0 !   !END!
294 ! X =       739.283,     6114.636,       771.4,            0.0 !   !END!
295 ! X =       739.283,     6115.136,       783.2,            0.0 !   !END!
296 ! X =       739.283,     6115.636,       803.6,            0.0 !   !END!
297 ! X =       739.283,     6116.136,       769.2,            0.0 !   !END!
298 ! X =       739.283,     6116.636,       779.9,            0.0 !   !END!
299 ! X =       739.283,     6117.136,       777.2,            0.0 !   !END!
300 ! X =       739.283,     6117.636,       751.7,            0.0 !   !END!
301 ! X =       739.283,     6118.136,       745.9,            0.0 !   !END!
302 ! X =       739.283,     6118.636,       755.5,            0.0 !   !END!
303 ! X =       739.283,     6119.136,       732.9,            0.0 !   !END!
304 ! X =       739.283,     6119.636,       726.1,            0.0 !   !END!
305 ! X =       739.283,     6120.136,       728.1,            0.0 !   !END!
306 ! X =       739.783,     6113.136,       726.2,            0.0 !   !END!
307 ! X =       739.783,     6113.636,       721.4,            0.0 !   !END!
308 ! X =       739.783,     6114.136,       732.9,            0.0 !   !END!
309 ! X =       739.783,     6114.636,       724.8,            0.0 !   !END!
310 ! X =       739.783,     6115.136,       750.0,            0.0 !   !END!
311 ! X =       739.783,     6115.636,       756.7,            0.0 !   !END!
312 ! X =       739.783,     6116.136,       747.6,            0.0 !   !END!
313 ! X =       739.783,     6116.636,       754.9,            0.0 !   !END!
314 ! X =       739.783,     6117.136,       739.0,            0.0 !   !END!
315 ! X =       739.783,     6117.636,       741.4,            0.0 !   !END!
316 ! X =       739.783,     6118.136,       734.4,            0.0 !   !END!
317 ! X =       739.783,     6118.636,       736.3,            0.0 !   !END!
318 ! X =       739.783,     6119.136,       725.1,            0.0 !   !END!
319 ! X =       739.783,     6119.636,       719.3,            0.0 !   !END!
320 ! X =       739.783,     6120.136,       713.8,            0.0 !   !END!
321 ! X =       740.283,     6113.136,       769.6,            0.0 !   !END!
322 ! X =       740.283,     6113.636,       747.1,            0.0 !   !END!
323 ! X =       740.283,     6114.136,       704.3,            0.0 !   !END!
324 ! X =       740.283,     6114.636,       727.0,            0.0 !   !END!
325 ! X =       740.283,     6115.136,       741.8,            0.0 !   !END!
326 ! X =       740.283,     6115.636,       729.5,            0.0 !   !END!
327 ! X =       740.283,     6116.136,       725.6,            0.0 !   !END!
328 ! X =       740.283,     6116.636,       724.0,            0.0 !   !END!
329 ! X =       740.283,     6117.136,       736.4,            0.0 !   !END!
330 ! X =       740.283,     6117.636,       736.1,            0.0 !   !END!
331 ! X =       740.283,     6118.136,       722.2,            0.0 !   !END!
332 ! X =       740.283,     6118.636,       716.6,            0.0 !   !END!
333 ! X =       740.283,     6119.136,       715.7,            0.0 !   !END!
334 ! X =       740.283,     6119.636,       712.0,            0.0 !   !END!
335 ! X =       740.283,     6120.136,       710.4,            0.0 !   !END!
336 ! X =       740.783,     6113.136,       763.0,            0.0 !   !END!
337 ! X =       740.783,     6113.636,       754.4,            0.0 !   !END!
338 ! X =       740.783,     6114.136,       702.9,            0.0 !   !END!
339 ! X =       740.783,     6114.636,       710.5,            0.0 !   !END!
340 ! X =       740.783,     6115.136,       718.2,            0.0 !   !END!
341 ! X =       740.783,     6115.636,       711.2,            0.0 !   !END!
342 ! X =       740.783,     6116.136,       739.2,            0.0 !   !END!
343 ! X =       740.783,     6116.636,       752.4,            0.0 !   !END!
344 ! X =       740.783,     6117.136,       768.1,            0.0 !   !END!
345 ! X =       740.783,     6117.636,       762.6,            0.0 !   !END!
346 ! X =       740.783,     6118.136,       737.9,            0.0 !   !END!
347 ! X =       740.783,     6118.636,       720.0,            0.0 !   !END!
348 ! X =       740.783,     6119.136,       723.0,            0.0 !   !END!
349 ! X =       740.783,     6119.636,       716.0,            0.0 !   !END!
350 ! X =       740.783,     6120.136,       720.1,            0.0 !   !END!
351 ! X =       741.283,     6113.136,       729.1,            0.0 !   !END!
352 ! X =       741.283,     6113.636,       712.9,            0.0 !   !END!
353 ! X =       741.283,     6114.136,       696.0,            0.0 !   !END!
354 ! X =       741.283,     6114.636,       689.6,            0.0 !   !END!
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  355 ! X =       741.283,     6115.136,       693.0,           0.0 !   !END!
  356 ! X =       741.283,     6115.636,       698.9,           0.0 !   !END!
  357 ! X =       741.283,     6116.136,       739.7,           0.0 !   !END!
  358 ! X =       741.283,     6116.636,       772.5,           0.0 !   !END!
  359 ! X =       741.283,     6117.136,       766.2,           0.0 !   !END!
  360 ! X =       741.283,     6117.636,       738.6,           0.0 !   !END!
  361 ! X =       741.283,     6118.136,       732.3,           0.0 !   !END!
  362 ! X =       741.283,     6118.636,       735.7,           0.0 !   !END!
  363 ! X =       741.283,     6119.136,       747.2,           0.0 !   !END!
  364 ! X =       741.283,     6119.636,       752.2,           0.0 !   !END!
  365 ! X =       741.283,     6120.136,       743.4,           0.0 !   !END!
  366 ! X =       741.783,     6113.136,       696.9,           0.0 !   !END!
  367 ! X =       741.783,     6113.636,       696.5,           0.0 !   !END!
  368 ! X =       741.783,     6114.136,       689.1,           0.0 !   !END!
  369 ! X =       741.783,     6114.636,       688.4,           0.0 !   !END!
  370 ! X =       741.783,     6115.136,       686.1,           0.0 !   !END!
  371 ! X =       741.783,     6115.636,       685.6,           0.0 !   !END!
  372 ! X =       741.783,     6116.136,       694.7,           0.0 !   !END!
  373 ! X =       741.783,     6116.636,       714.9,           0.0 !   !END!
  374 ! X =       741.783,     6117.136,       699.8,           0.0 !   !END!
  375 ! X =       741.783,     6117.636,       691.8,           0.0 !   !END!
  376 ! X =       741.783,     6118.136,       687.9,           0.0 !   !END!
  377 ! X =       741.783,     6118.636,       708.3,           0.0 !   !END!
  378 ! X =       741.783,     6119.136,       710.3,           0.0 !   !END!
  379 ! X =       741.783,     6119.636,       693.5,           0.0 !   !END!
  380 ! X =       741.783,     6120.136,       687.6,           0.0 !   !END!

-------------
    a
     Data for each receptor are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     Receptor height above ground is optional.  If no value is entered,
     the receptor is placed on the ground.
```

Appendix E

Consolidated Odour Monitoring Report Woodlawn 2007-2011

Woodlawn Bioreactor

Consolidated Odour Monitoring Report

April 2007 - January 2011

Report Number 30-2464-R4

16 February 2011

Veolia Environmental Services (Australia) Pty Ltd
Cnr Unwin & Shirley Sts
Rosehill NSW 2142

Version: Revision 0

Woodlawn Bioreactor

Consolidated Odour Monitoring Report

April 2007 - January 2011

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DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
30-2464-R4	Revision 0	16 February 2011	Martin Doyle	Kirsten Lawrence	Martin Doyle

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APPENDICES

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR Consulting, formerly Heggies Pty Ltd) has been commissioned by Veolia Environmental Services (Australia) Pty Ltd (Veolia) to undertake odour monitoring of a range of odour sources at the 6,000 hectare Woodlawn Bioreactor site near Tarago in the Southern Highlands of NSW (the Project Site).

SLR Consulting has been working with Veolia at the Project Site, monitoring a range of odour sources since April 2007 with four distinct odour monitoring campaigns undertaken between April 2007 and January 2011. The monitoring undertaken during each campaign is summarised in **Table 1**. It is noted that some of these monitoring campaigns were associated with dispersion modelling assessments, although this report addresses odour monitoring only.

Table 1 Odour Monitoring at Woodlawn April 2007 to January 2011

Date of Sampling	Odour Sources Sampled
April 2007	Leachate – 2 samples
June 2007	Leachate – 2 samples Groundwater – 1 sample Stormwater – 1 sample
November 2009	Leachate – 2 samples Treated Leachate – 2 samples Groundwater – 2 samples Stormwater – 2 samples Fresh Uncovered Waste – 1 sample Aged Uncovered Waste – 1 sample
January 2011	Leachate – 3 samples Treated Leachate – 3 samples Groundwater – 3 samples Stormwater – 3 samples Wet Covered Waste – 3 samples Dry Covered Waste – 3 samples Wet Fresh Waste – 3 samples Leachate Recirculation – 3 samples Potential Gas Pathways – 3 samples
Purge of the flux hood occurs for each source with a residence time of 4 times the chamber volume	

This report provides a consolidated summary of all the odour monitoring undertaken between April 2007 and January 2011. It outlines the sampling methodologies used, summarises the odour monitoring results obtained, including calculation of specific odour emission rates (SOER) for each source and analyses the variation in odour emissions from each source. It is intended initially as an internal discussion document to inform Veolia on how to progress the Odour Impact Assessment for the Woodlawn Waste Expansion Project.

2 METHODOLOGY

2.1 Odour Sampling

All odour samples were taken using an Isolation Flux Hood (IFH) and carried out according to the method described in the US EPA technical report "*EPA/60068-86/008 – Measurement of Gaseous Emission Rates from Land Surfaces using an Emission Isolation Flux Chamber – User's Guide*", and Australian/New Zealand (AS/NZ) Standard (4323.4:2009) *"Stationary source emissions Method 4: Area source sampling – Flux chamber technique"*.

Wind is a major factor in the release of odour from area sources, and in conveying any potential odour from the source to other areas. The use of the IFH ensures a consistent sampling environment as air is blown over a known area and in a controlled environment so that odours are released into the air stream in a repeatable and predictable manner.

The sampling of liquid area sources using the IFH requires the hood to be floated over the odorous surface. The IFH is made to float by placing it within an inflated inner tube. Once a seal is formed between the IFH and the liquid surface, industrial grade, odour-free nitrogen is forced into the hood. The nitrogen is swept across the surface of the area, encouraging odour release. The same procedure is followed for land surfaces, although odour free sand is used around the exterior of the hood base creating a seal.

2.1.1 Flux Hood Purging

Both the USEPA and Australian Standard require that prior to sampling of odour, nitrogen is pumped into the hood for a period of four residence times of the hood volume (30 litres). Sampling in April 2007 and June 2007 used a sweep gas flow rate of nitrogen of 10 litres per minute (l/min) (purge time 12 minutes), sampling in November 2009 used a sweep gas flow rate of 7 l/min (purge time of 17 minutes) and the most recent sampling campaign used a sweep gas flow rate of 5 l/min (purge time of 24 minutes). Although both the USEPA and Australian Standard identify that a sweep gas flow rate of 5 l/min and purge time of 24 minutes be used, the calculation of the specific odour emission rate (SOER) includes parameters for sweep gas flow rate, which means that although the odour concentrations from each source may differ, the SOER should remain the same, all other parameters being equal.

During odour sampling, the nitrogen flow rate was maintained at the purge rate whilst samples were taken as required within USEPA and Australian Standard documentation.

2.1.2 Sampling Rate

A maximum sampling rate is stipulated in both the USEPA and Australian Standard which is less than half of the purge rate with each sample to be taken within 30 minutes. Sampling rates during all monitoring campaigns were half that of the purge rate.

The odorous sample is drawn through a Teflon tube, into a single use, odour-free Nalophan sample bag secured inside a drum kept under vacuum using a pump. The balance of the gas flow is vented to atmosphere.

2.2 Odour Analysis

All odour samples were labelled and delivered to a Sydney laboratory for testing. The laboratory used for sampling campaigns in April 2007, June 2007 and November 2009 was The Odour Unit, with odour samples analysed at Stephenson Environmental Management for the January 2011 campaign. Both laboratories are NATA accredited for Australian Standard AS/NZS 4323.3:2001 "*Determination of Odour Concentration by Dynamic Olfactometry*". As required by the Australian Standard, all samples were analysed within 30 hours of sampling. The odour concentration measurements were performed using dynamic olfactometry according to AS/NZS 4323.3:2001.

2.3 Specific Odour Emission Rate Calculations

Results of the odour analysis for each sample were provided by the laboratory, expressed as Odour Units (OU) contained within each odour sampling bag. From this information, and knowledge of the sweep gas flow rate and surface area of the IFH, a specific odour emission rate (SOER) for each sample and for each source can be calculated.

An SOER is an expression of odour flux, expressed as odour released per unit time over a given area, and is expressed as:

SOER ($OU.m^3/m^2/s$) = OC x Q/A

Where:
OC= odour concentration of compound from air in the chamber (OU)
Q = sweep gas flow rate into chamber (m^3/s)
A = sample source total surface (m^2)

Table 2 Values of Q and A used in SOER calculations

Date of Sampling	A (m^2)	Q (m^3/s)
April 2007	0.49	0.010
June 2007	0.49	0.010
November 2009	0.405	0.007
January 2011	0.405	0.005

3 ODOUR MONITORING RESULTS

3.1 Odour Monitoring Results for All Campaigns

Results of the odour monitoring are presented in **Table 3** for solid waste sources, **Table 4** for liquid waste sources and **Table 5** for ‘other’ sources.

Laboratory certificates for all samples are provided in **Appendix A**.

Table 3 Odour Monitoring Results Woodlawn Bioreactor – Solid Waste Sources

Source	Sample ID	Monitoring Date	Odour Concentration (OU)	Gas Sweep Flow Rate (l/min)	Area (m^2) (A)	m^3/s (Q)	SOER ($OU.m^3/m^2/s$)
Solid Waste							
Dry Covered Waste	DCW1	11-1-11 1135hrs	249	5	0.13	8.3E-05	0.2
Dry Covered Waste	DCW2	11-1-11 1150hrs	140	5	0.13	8.3E-05	0.1
Dry Covered Waste	DCW3	11-1-11 1200hrs	114	5	0.13	8.3E-05	0.1
Wet Covered Waste	WCW1	11-1-11 1215hrs	71	5	0.13	8.3E-05	0.0
Wet Covered Waste	WCW2	11-1-11 1225hrs	247	5	0.13	8.3E-05	0.2
Wet Covered Waste	WCW3	11-1-11 1300hrs	155	5	0.13	8.3E-05	0.1
Dry Fresh Waste	New Waste	26-11-2009 1000hrs	1,120	7	0.13	1.2E-04	1.0
Wet Fresh Waste	WFW1	12-1-11 0900hrs	6,761	5	0.13	8.3E-05	4.4
Wet Fresh Waste	WFW2	12-1-11 0945hrs	11,220	5	0.13	8.3E-05	7.3
Wet Fresh Waste	WFW3	12-1-11 0955hrs	6,310	5	0.13	8.3E-05	4.1
Dry Old Waste	Old Waste	26-11-2009 0930 hrs	512	7	0.13	1.2E-04	0.5
Leachate Recirculation	LR1	12-1-11 1050hrs	2,723	5	0.13	8.3E-05	1.8
Leachate Recirculation	LR2	12-1-11 1100hrs	3,802	5	0.13	8.3E-05	2.5
Leachate Recirculation	LR3	12-1-11 1115hrs	2,512	5	0.13	8.3E-05	1.6

Table 4 Odour Monitoring Results Woodlawn Bioreactor – Liquid Waste Sources

Source	Sample ID	Monitoring Date	Odour Concentration (OU)	Gas Sweep Flow Rate (l/min)	Area (m^2) (A)	m^3/s (Q)	SOER ($OU.m^3/m^2/s$)
Liquid Waste							
Leachate	LP1	10-1-11 1315hrs	3,404	5	0.13	8.3E-05	2.2
Leachate	LP2	10-1-11 1315hrs	10,351	5	0.13	8.3E-05	6.7
Leachate	LP3	10-1-11 1315hrs	3,192	5	0.13	8.3E-05	2.1
Leachate	Untreated Leachate 1	25-11-2009 1400hrs	9,740	7	0.13	1.2E-04	8.8
Leachate	Untreated Leachate 2	25-11-2009 1430hrs	6,320	7	0.13	1.2E-04	5.7
Leachate	Leachate Sample 1	11-04-2007 1245hrs	6,320	10	0.19	1.7E-04	5.6
Leachate	Leachate Sample 2	11-04-2007 1205hrs	5,790	10	0.19	1.7E-04	5.1
Leachate	ED3 North Trial Pond	04-06-2007 1325hrs	5,050	10	0.19	1.7E-04	4.5
Treated Leachate	TL1	10-1-11 1515hrs	291	5	0.13	8.3E-05	0.2
Treated Leachate	TL2	10-1-11 1530hrs	231	5	0.19	8.3E-05	0.1
Treated Leachate	TL3	10-1-11 1540hrs	233	5	0.19	8.3E-05	0.1
Treated Leachate	Treated Leachate 1	25-11-2009 1540hrs	8,190	7	0.13	1.2E-04	7.4
Treated Leachate	Treated Leachate 2	25-11-2009 1600hrs	5,310	7	0.13	1.2E-04	4.8
Treated Leachate	Leachate Dam	04-06-2007 1600hrs	4,100	10	0.19	1.7E-04	3.6
Groundwater	Evap 1	25-11-2009 1300hrs	724	7	0.13	1.2E-04	0.7
Groundwater	Evap 2	25-11-2009 1320hrs	332	7	0.13	1.2E-04	0.3
Groundwater	GW1	10-1-11 1530hrs	195	5	0.13	8.3E-05	0.1
Groundwater	GW2	10-1-11 1600hrs	250	5	0.13	8.3E-05	0.2
Groundwater	GW3	10-1-11 1615hrs	230	5	0.13	8.3E-05	0.1
Groundwater	ED3 North	04-06-2007 1510hrs	104	10	0.19	1.7E-04	0.1
Stormwater	SW1	11-1-11 0840hrs	29	5	0.13	8.3E-05	0.0
Stormwater	SW2	11-1-11 0910hrs	20	5	0.13	8.3E-05	0.0
Stormwater	SW3	11-1-11 0920hrs	27	5	0.13	8.3E-05	0.0

Source	Sample ID	Monitoring Date	Odour Concentration (OU)	Gas Sweep Flow Rate (l/min)	Area (m^2) (A)	m^3/s (Q)	SOER ($OU.m^3/m^2/s$)
Liquid Waste							
Stormwater	Stormwater 1	25-11-2009 1150hrs	223	7	0.13	1.2E-04	0.2
Stormwater	Stormwater 2	25-11-2009 1210hrs	56	7	0.13	1.2E-04	0.1
Stormwater	ED3 South	04-06-2007 1430hrs	512	10	0.19	1.7E-04	0.5

Table 5 Odour Monitoring Results Woodlawn Bioreactor – 'Other' Waste Sources

Source	Sample ID	Monitoring Date	Odour Concentration (OU)	Gas Sweep Flow Rate (l/min)	Area (m^2) (A)	m^3/s (Q)	SOER ($OU.m^3/m^2/s$)
Other Sources							
Potential Gas Pathway	GC1	12-1-11 1015hrs	23,150	5	0.13	8.3E-05	15.0
Potential Gas Pathway	GC2	12-1-11 1025hrs	11,637	5	0.13	8.3E-05	7.5
Potential Gas Pathway	GC3	12-1-11 1035hrs	36,926	5	0.13	8.3E-05	23.9

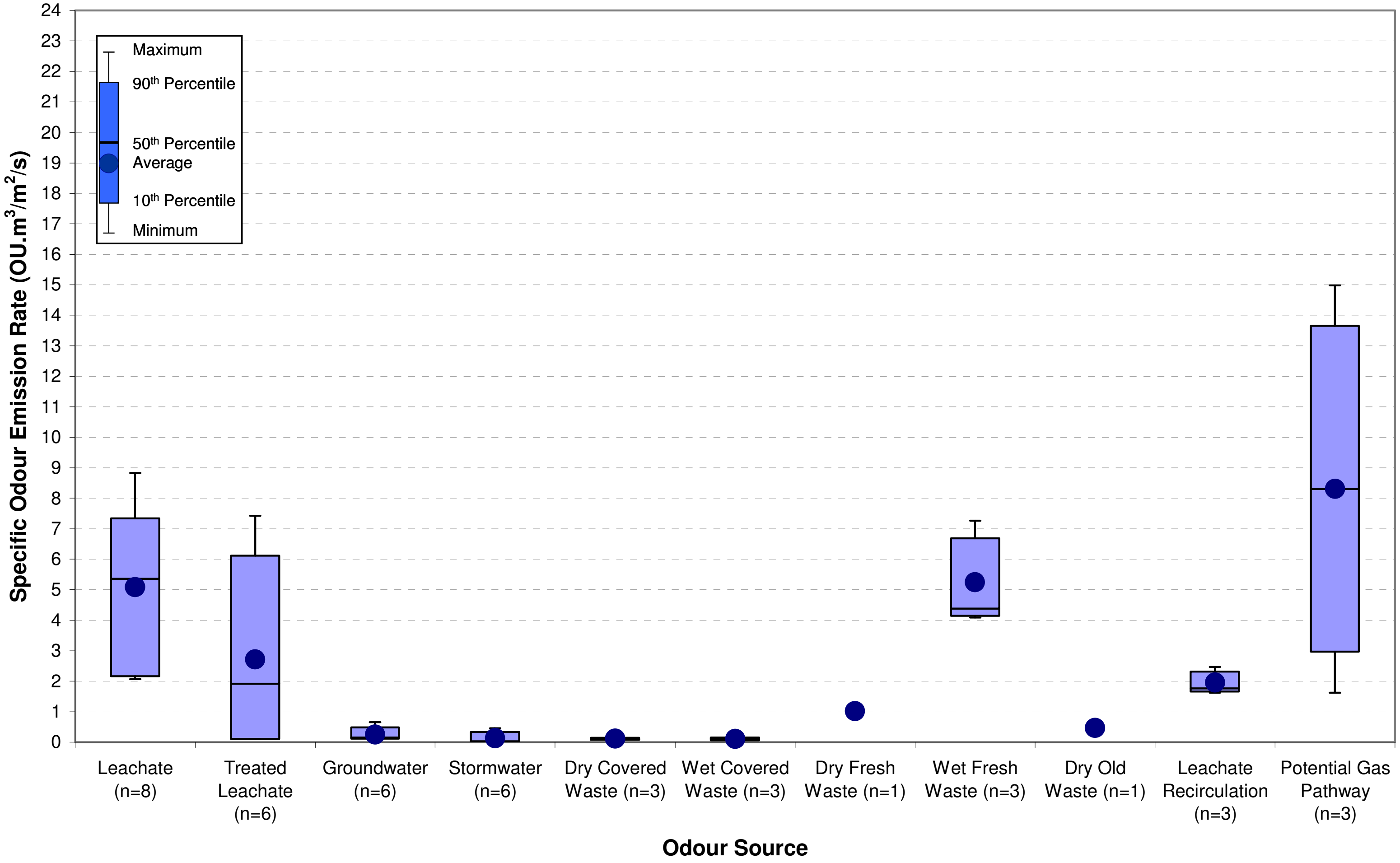
Presented in **Table 6** and **Figure 1** are the calculated average and maximum specific odour emission rates by odour source over all monitoring campaigns (2007 to 2011). It is demonstrated that the highest odour emissions per unit area are generated from the potential gas pathways within the void, with maximum and average calculated SOER's almost three times higher than those from leachate. It is noted that the number of samples taken from each source differ, and therefore the level of confidence afforded to each result necessarily fluctuates. Continued monitoring of each source will reduce this uncertainty over time.

Table 6 Calculated Average and Maximum Specific Odour Emission Rates by Source (all monitoring campaigns)

Odour Source	Source Average Emission Rate (all campaigns)	Source Maximum Emission Rate (all campaigns)
Potential Gas Pathway (n=3)	15.5	23.9
Leachate (n=8)	5.1	8.8
Treated Leachate (n=6)	2.7	7.4
Wet Fresh Waste (n=3)	5.2	7.3
Leachate Recirculation (n=3)	1.9	2.5
Dry Fresh Waste (n=1)	1.0	1.0
Groundwater (n=6)	0.2	0.7
Dry Old Waste (n=1)	0.5	0.5
Stormwater (n=6)	0.1	0.5
Dry Covered Waste (n=3)	0.1	0.2
Wet Covered Waste (n=3)	0.1	0.2

Sorted by maximum emission rate
n = number of samples taken

Figure 1 Calculated Specific Odour Emission Rates by Source (all monitoring campaigns)



3.2 Odour Monitoring Results Variation over Time

Table 7 presents the average and maximum calculated SOER's for each source by monitoring campaign, to allow an assessment to be made of the changes in odour emissions over time. Some of these sources have been monitored on only one occasion, and therefore this assessment cannot be made. This is the case for all solid waste types and data for the potential gas pathway presented in **Table 7**.

Table 7 Calculated Average and Maximum Specific Odour Emission Rates by Source and Monitoring Campaign

Odour Source	Source Average Emission Rate	Source Maximum Emission Rate
Solid Waste		
Dry Covered Waste JAN 11 (n=3)	0.1	0.2
Wet Covered Waste JAN 11 (n=3)	0.1	0.2
Dry Fresh Waste NOV 09 (n=1)	1.0	1.0
Wet Fresh Waste JAN 11 (n=3)	5.2	7.3
Dry Old Waste NOV 09 (n=1)	0.5	0.5
Leachate Recirculation JAN 11 (n=3)	1.9	2.5
Liquid Waste		
Leachate APR 07 (n=2)	5.4	5.6
Leachate JUN 07 (n=1)	4.5	4.5
Leachate NOV 09 (n=2)	7.3	8.8
Leachate JAN 11 (n=3)	3.7	6.7
Treated Leachate JUN 07 (n=1)	3.6	3.6
Treated Leachate NOV 09 (n=2)	6.1	7.4
Treated Leachate JAN 11 (n=3)	0.1	0.2
Groundwater JUN 07 (n=1)	0.1	0.1
Groundwater NOV 09 (n=2)	0.5	0.7
Groundwater JAN 11 (n=3)	0.1	0.2
Stormwater JUN 07 (n=1)	0.1	0.1
Stormwater NOV 09 (n=2)	0.1	0.2
Stormwater JAN 11 (n=3)	0.0	0.0
Other Sources		
Potential Gas Pathway JAN 11 (n=3)	15.5	23.9

Sorted by maximum emission rate
n = number of samples taken

Figure 2 presents the variation in calculated SOER's for leachate, monitored in all four monitoring campaigns between April 2007 and January 2011. Variability in odour emissions will always exist (due to a combination of the selection of sample location and ambient weather conditions [e.g. wind stirring up of lake sediments for example]) although with an increasing number of samples taken, the general odour emission characteristics (mean and maximum) of a source can be identified. Eight odour samples from leachate have been obtained over the four campaigns, with maximum emission rates varying between 4.5 OU.m^3/m^2/s and 8.8 OU.m^3/m^2/s. No temporal variation in emissions can be identified within the results for this or any source at the present time.

Figure 2 Calculated Average and Maximum Specific Odour Emission Rates for Leachate

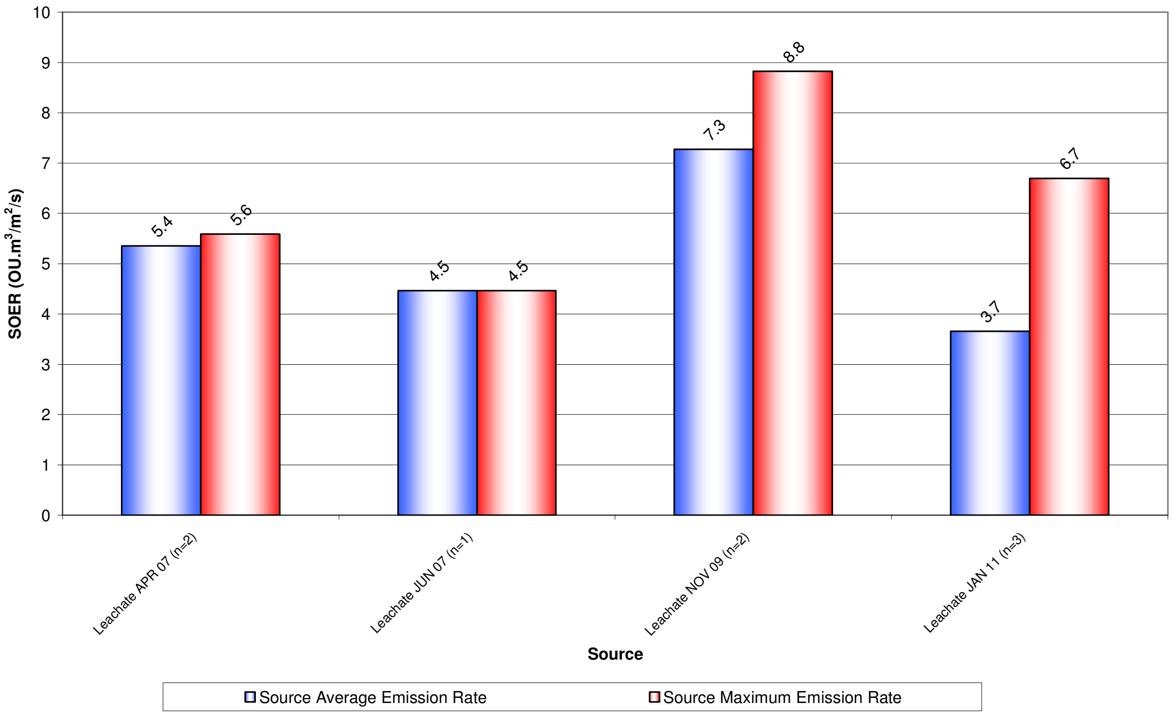


Figure 3 presents the variation in calculated SOER's for the treated leachate, monitored in three monitoring campaigns between June 2007 and January 2011. Six odour samples from treated leachate have been obtained over the three campaigns with maximum emission rates varying between 0.2 $OU.m^3/m^2/s$ and 7.4 $OU.m^3/m^2/s$.

Procedures used to treat leachate produced within the void have been substantially refined over time at Woodlawn. Previously, processes were experimental and in some cases the desired reduction in odour was not achieved which resulted in significantly higher emission rates, captured through monitoring campaigns to be between 3.6 $OU.m^3/m^2/s$ and 7.4 $OU.m^3/m^2/s$ (2007 and 2009). As the treatment process developed it was determined that while the liquid was successfully treated for odour the solids that were left suspended in the liquid quickly became odorous due to high BOD/COD. The use of flocculants was able to drop out the suspended solids thus removing the final source of odour from the treated liquid. The success of this updated treatment processes has been shown through the most recent monitoring campaign (January 2011) to result in significantly reduced odour emission rates (0.2 $OU.m^3/m^2/s$). These practices are expected to continue to result in reduced emission rates.

Figure 3 Calculated Average and Maximum Specific Odour Emission Rates for Treated Leachate

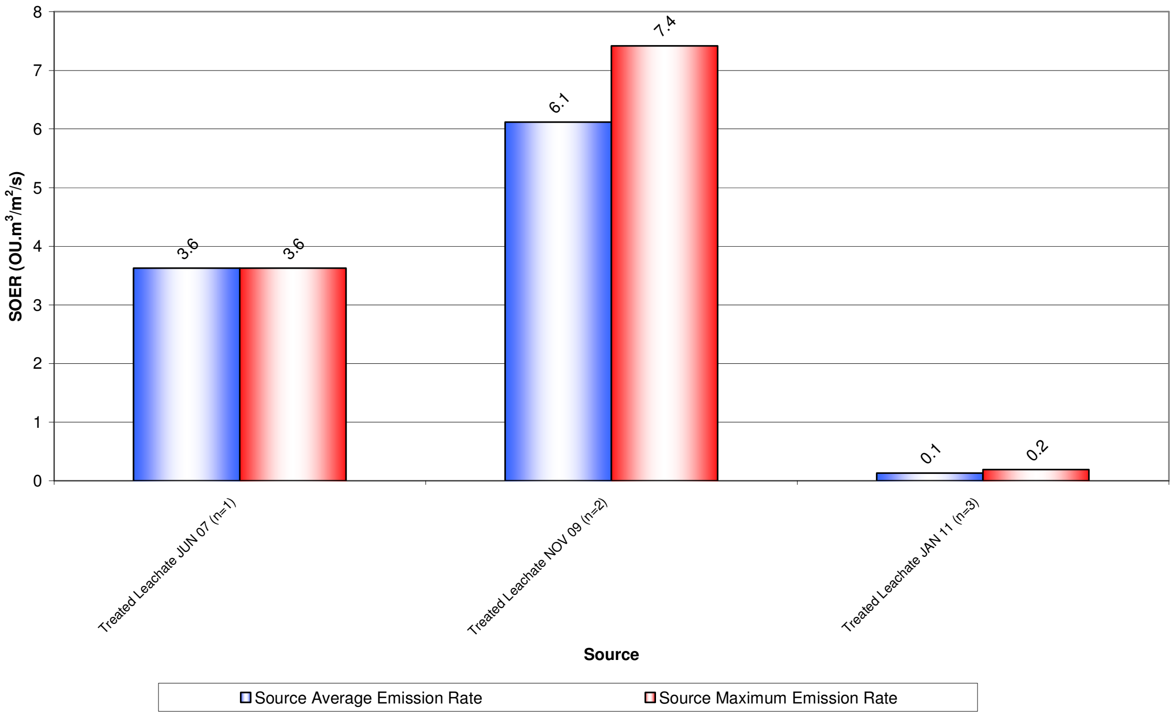


Figure 4 presents the variation in calculated SOER's for groundwater, monitored in three monitoring campaigns between June 2007 and January 2011. Six odour samples from groundwater have been obtained over the three campaigns with maximum emission rates varying between 0.1 $OU.m^3/m^2/s$ and 0.7 $OU.m^3/m^2/s$.

Figure 4 Calculated Average and Maximum Specific Odour Emission Rates for Groundwater

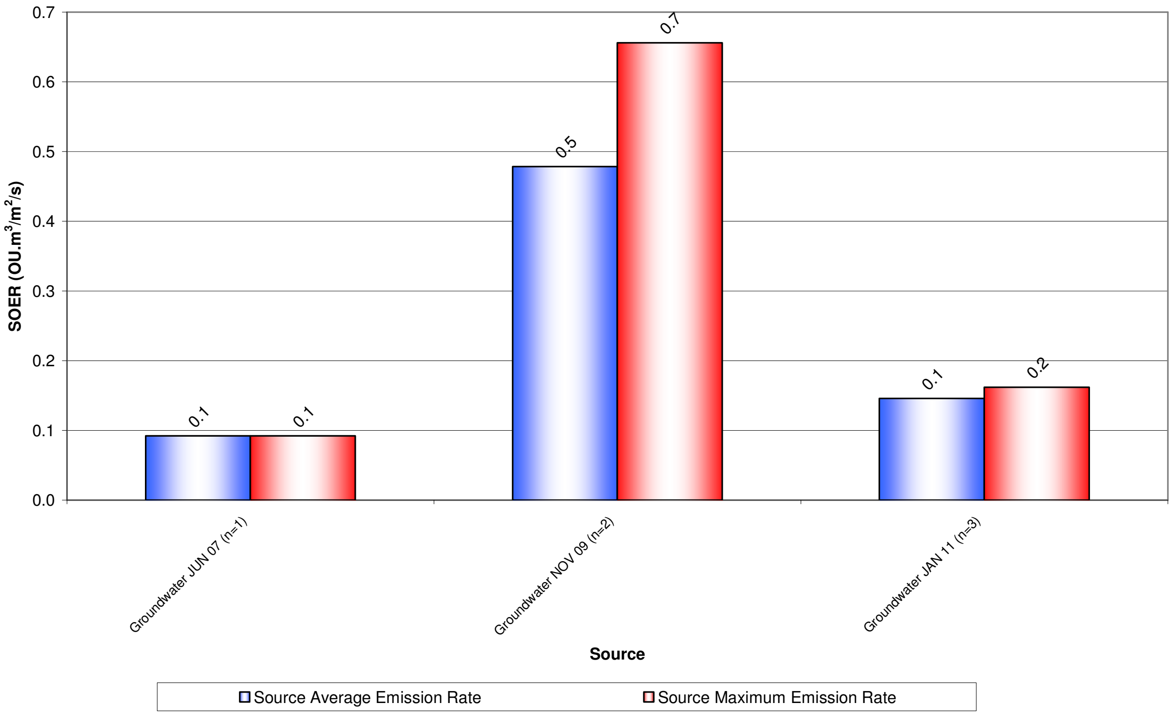
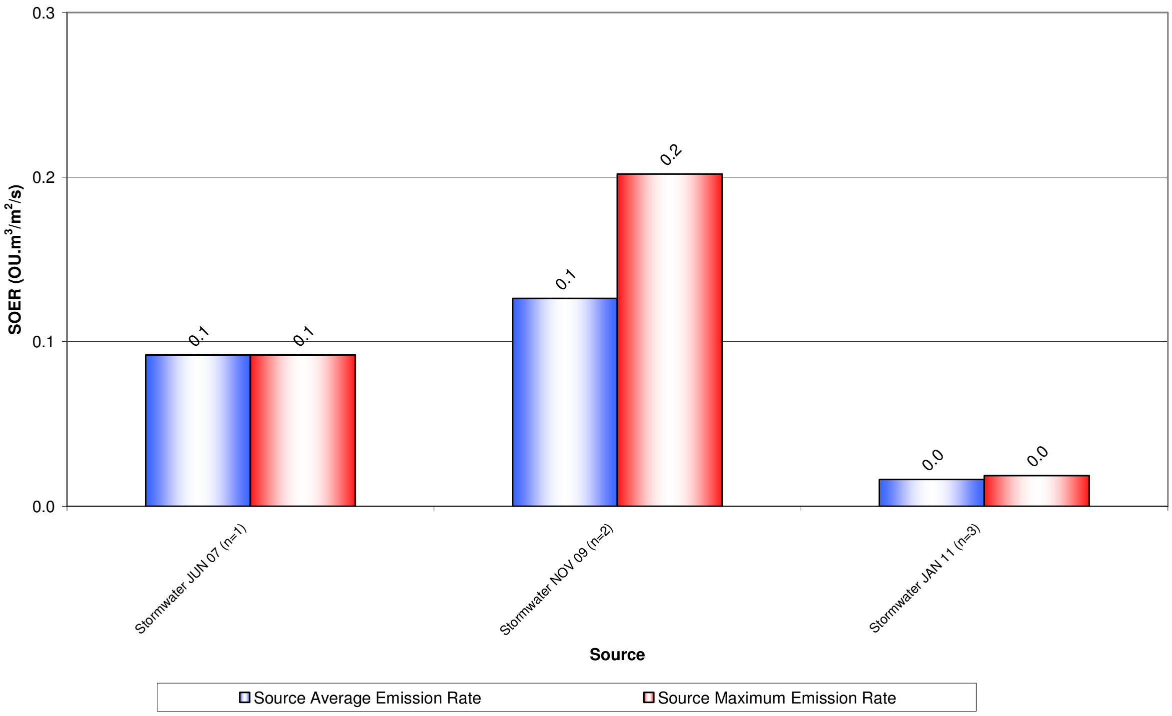


Figure 5 presents the variation in calculated SOER's for stormwater in three monitoring campaigns between June 2007 and January 2011. Six odour samples from stormwater have been obtained over the three campaigns with maximum emission rates varying between 0.0 $OU.m^3/m^2/s$ and 0.2 $OU.m^3/m^2/s$.

Figure 5 Calculated Average and Maximum Specific Odour Emission Rates for Stormwater



4 CONCLUSION

SLR Consulting has been commissioned by Veolia to undertake a review and consolidation of odour monitoring data from the Woodlawn Bioreactor site, in the Southern Highlands, NSW. This report examines odour monitoring data from April 2007 to January 2011 and aims to inform on the importance of odour sources at the site.

The results have indicated that the top four odour sources, in terms of specific odour emission rate ($OU.m^3/m^2/s$) are the potential gas pathway around the landfill edge, leachate, treated leachate and wet fresh waste.

Emissions totals from the Woodlawn site will not only be affected by the emission rates calculated within this report, but also by the surface area of each emission source. It is important therefore that accurate quantification of emission source areas are used to calculate site emissions in any dispersion modelling assessment undertaken. Over, or under-prediction of source areas (especially the potential gas pathway around the edge of the landfill, leachate, treated leachate and wet fresh waste) will have considerable impacts on off-site predictions.

5 CLOSURE

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of Veolia Environmental Services (Australia) Pty Ltd. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR Consulting.

SLR Consulting disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

Example Odour Diary

Event	Date	Time of Day	Location	Event Duration	Continuity of Odour	Character and Strength of Odour
1						
2						
3						
….						

Odour Character Descriptors

1	Fragrant	21	Like blood, raw meat
2	Perfumy	22	Rubbish
3	Sweet	23	Compost
4	Fruity	24	Silage
5	Bakery (fresh bread)	25	Sickening
6	Coffee-like	26	Musty, earthy, mouldy
7	Spicy	27	Sharp, pungent, acid
8	Meaty (cooked, good)	28	Metallic
9	Sea/marine	29	Tar-like
10	Herbal, green, cut grass	30	Oily, fatty
11	Bark-like, birch bark	31	Like gasoline, solvent
12	Woody, resinous	32	Fishy
13	Medicinal	33	Putrid, foul, decayed
14	Burnt, smoky	34	Paint-like
15	Soapy	35	Rancid
16	Garlic, onion	36	Sulphidic
17	Cooked vegetables	37	Dead animal
18	Chemical	38	Faecal (like manure)
19	Etherish, anaesthetic	39	Sewer odour
20	Sour, acrid, vinegar		

Odour Intensity Scale

Odour intensity	Intensity level
Extremely strong	A
Very strong	B
Strong	C
Distinct	D
Weak	E
Very weak	F
Not perceptive	G