Veolia Environmental Services (Australia) Pty Limited

Woodlawn Bioreactor Expansion Project

Independent Odour Audit

September 2012

FINAL REPORT

THE ODOUR UNIT PTY LTD

ABN 5309 116 5061
ACN 091 165 061

Australian Technology Park
Locomotive Workshop
Suite 16012, 2 Locomotive St
EVELEIGH, NSW 2015
www.odourunit.com.au

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Report Prepared By: T. Schulz & M. Assal	**Approved By:** T. Schulz	
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EXECUTIVE SUMMARY

Introduction

In June 2012, Veolia Environmental Services (Australia) Pty Ltd (VES) engaged The Odour Unit Pty Ltd (TOU) to carry out an Independent Odour Audit of the Woodlawn Bioreactor Facility located at Collector Road, Tarago, NSW.

This Audit was undertaken by TOU, with the endorsement of the Director-General of the Department of Planning.

Background

The Audit is a requirement condition for the Woodlawn Waste Expansion Project which received approval on 16 March 2012.

The Audit consisted of:

- *Preliminary investigation:* An initial site visit carried out by TOU Managing Director Terry Schulz on 8 June 2012;
- *Fieldwork:* Collection of odour samples from key sources (as per *Condition 7 (e)*), recording of relevant field observations and measurements, and discussions with VES Woodlawn staff in regards to the operations of the Bioreactor. All samples were collected and tested according to AS/NZS 4323.3:2001. TOU's NATA accredited laboratory was used for all testing;
- *Reviewing:* a comprehensive review of all relevant assessments carried out since the Woodlawn Waste Expansion Project approval was granted and other relevant reports pertaining to this Audit; and
- *Reporting:* a comprehensive summary of all aspects of the Audit, complying with the Audit objectives.

Audit Scope

The specific scope of works for this Audit is detailed in *Condition 7 of Schedule 4 in* the *Specific Environmental Conditions - Landfill site* and enforced by *Section 75J* of the *Environmental Planning and Assessment Act 1979* as part of the project approval for the Woodlawn Waste Expansion Project.

The objectives of the Audit were to review previous air quality and odour studies carried out at the Woodlawn site and confirm that the findings in those studies were realistic and appropriate for current and future operations.

All key sources were measured in this Audit with the following exceptions:

- *Consideration of wet weather conditions:* No rainfall was experienced during sampling. As a result, this Audit was unable to collect representative odour samples under wet weather conditions but considered the effects of wet weather in terms of the need to handle increased levels of leachate under wet weather conditions; and
- *Leachate recirculation:* This Audit was unable to observe and thus collect representative samples for this scenario. Since the EA, VES has developed a leachate recirculation system that involves direct injection of leachate into the waste which eliminates the need for spraying over the surface. Therefore, no suitable access points for the collection of odour samples from this source are available.

Audit Findings

The quantitative findings of this Audit have been summarised in **Table 9.1**, and discussed below. Because previous assessments have tended to focus mainly on the Specific Odour Emission Rates (SOER) from individual emission sources, a direct comparison is made with the results of this Audit with previous data for SOER. **Table 9.1** also shows the overall Odour Emission Rate (OER) for each source, based on the exposed surface area of each source. The resultant odour emission inventory for the site enables the individual source emissions to be considered in context. It is recommended that future audits and assessments use this Odour Emission Inventory approach.

Table 9.1 – Measurable Odour Emissions Rates for the Woodlawn Facility site

Sample Location	Area (m^2)^^	Audit		EA	
		Mean SOER ($ou.m^3/m^2/s$)	Mean OER ($ou.m^3/s$)	Mean SOER ($ou.m^3/m^2/s$)	Mean OER ($ou.m^3/s$)
ED3N-1	7,000	394	2,760,000	8.80	61,600
Active Tipping Face^	40,000^^^	8.36	334,000	7.30	292,000
Storage Pond 7	1,200	85	102,000	n/m	n/m
ED3N-2 & 3	13,000	0.29	3,800	7.40	96,200
ED3N-4	16,000	0.41	6,600	0.70	11,200
Leachate Aeration Dam^^^^	2,000	0.46	920	3.6	7,200^^^^^

^ excludes potential gas pathways within Bioreactor and other fugitive emission sources
^^ areas used by this Audit may vary to that used in the EA
^^^as per AAQMP estimate
^^^^excludes emissions from the aeration/stripping action which is likely to be more odorous
^^^^^represents mean result for different batches of leachate between 2007 to 2011

The principal findings of this Audit may be summarised as follows:

- ED3N-1 is currently the largest odour emission contributor, yielding a SOER result 40 times greater than that predicted in the EA. This finding is considered to be as a result of higher than normal volumes of leachate generated in the preceding months;

- The SOER results obtained in this Audit for ED3N-2, ED3N-3 and ED3N-4 are lower than that found in the EA, and suggests that leachate quality is satisfactory, once it reaches these dams;

- Based on the sampling and testing within the Bioreactor for those odour emission sources able to be quantified, this Audit has found that the odour emissions from the freshly-tipped and 1 week old waste material are similar to the predicted SOER values used in the EA. It is not known how these emissions compare with the fugitive odour emissions that are unable to be accurately quantified;

- This Audit's on-site observation that fugitive odour releases are occurring as a result of short-circuiting of landfill gas around the perimeter of the waste mass, suggests that previous estimates of this release have underestimated the true odour emission rate. Previous sampling and modeling of this source, used as the basis for the estimates used in the EA, assigned an 2.5 cm perimeter 'gap' for this source. It is likely that a more realistic width for this gap would be up to two metres. This source is considered to be potentially more significant than the freshly tipped and 1 week old waste material. Accurate quantification of this emission is difficult;

- While the gas collection system appears to be effective in capturing landfill gas generated by the Bioreactor, the potential still exists for improved fugitive gas emission capture from the aforementioned 'wall effects' and other potential gas pathways, which could be resulting in off-site odour impacts. This Audit has attempted to quantify the extent of these fugitive gas emissions by calculating the odour emission rate from gas leakage, based on 80% and 70% gas capture efficiencies, the measured gas odour concentration of 9,300,000 odour units, and minimal odour concentration reduction in the gas as it passes through the upper layers of the waste. The resultant odour emission rates were calculated to be 752,000 ou.m^3/s and 1,290,000 ou.m^3/s for 80% and 70% gas capture efficiencies respectively. These very high emission rates are not compatible with the relatively low odour ambient odour levels within the Bioreactor and this Audit finds that either substantial odour reduction is occurring before the gas exists the waste layer, or the gas capture efficiencies are greater than the 70-80% estimates supplied by VES. Notwithstanding this finding, this Audit supports ongoing efforts by VES to improve gas capture, provided ongoing documenting of gas capture is maintained. Variation in fugitive gas emissions could have the potential to be highly significant to odour emissions at the site;

- This Audit has found that previous studies have failed to identify the odour emissions from the operation of the Evaporator Units used in ED3N-3 and ED3N-4, and that these emissions have the potential to contribute significantly to odour emissions if good effluent quality in these dams is not maintained. The Audit supports the current practice of selective operation of the Evaporator Units, based on prevailing wind and weather conditions;

- A review of production data and complaints records relevant to this Audit demonstrates that all record-keeping duties by VES in this respect are currently being adequately maintained;

- No samples were collected from the Crisps Creek Intermodal Facility as the waste transportation process is enclosed, virtually eliminating any potential odour emission sources from this facility (given the daily inspection practices of the containers are sustained to identify any faulty containers). Based on the practices undertaken at this site and the experience of the Audit team with container handling at the Clyde Terminal in Sydney, this Audit has found that the transportation of waste from the Facility to the Bioreactor is most unlikely to be a significant odour emission source;

- This Audit has examined compliance or otherwise with *Condition 7(f)* from two perspectives, namely odour complaint record analysis and compliance with the modelling-based, project-specific odour performance goal of 6 ou. A review of the complaints records for the site indicates that adverse odour impacts have been occurring since 2005, suggesting, on face value, that *Condition 7 (f)* has not always being met. Unfortunately the complaint data does not assist in identifying the nature or likely source of the problematic odours. This Audit finds that VES has been actively undertaking measures to minimise odour emissions from the Bioreactor Facility, including participation in a community consultation process designed to provide the necessary odour impact feedback. This feedback is important given the widely different odour characters from the Bioreactor emissions and Leachate Dam emissions;

- The odour dispersion modelling results determined in the revised EA by SLR Consulting showed concentrations of less than 3.4 ou as a 99th percentile, 1 second nose response time average; thus complying with the project specific odour performance goal of 6 ou. This Audit did not have access to the site-specific odour dispersion model used in the EA assessment and did not carry out modelling, using the odour emission rates determined in the Audit. It is therefore unable to determine whether compliance with the 6 ou criterion is being achieved, based on the approach used in odour dispersion modelling, whereby the modelled emission rates prevail over an entire year. Clearly there is evidence that the Audit's odour emission data for the leachate management system and ED3N-1 in particular, may represent higher transient emissions and not represent what VES consider normal operating conditions. VES's intention to upgrade the leachate management system should and must reduce the odour emissions from ED3N-1 if compliance with the EA modelling criterion is to be repeated in the future;

- At the time this audit was undertaken and based on the odour emissions identified during sampling for this audit, it is possible the 6 ou criterion goal may not have been met. Subsequent audits should incorporate repeat sampling and testing of the site emissions, following the planned leachate system upgrade, and involve a re-run of the existing dispersion model, to quantitatively check compliance. Based on this Audit's findings, compliance is likely to be achieved if the emissions from ED3N-1 are returned to the values used in the EA modelling; and

- This Audit finds that VES has been actively undertaking measures to minimise odour emissions from the Bioreactor Facility, including participation in a community consultation process designed to provide clear communication in relation to the site operations and any odour impact feedback.

This Audit has found that the current odour controls are effective in mitigating odour emissions. These include:

- Improvement of the Landfill Gas Extraction system;
- Treatment of extracted leachate prior to storage in ED3N system;
- Leachate recirculation methods using direct injection of leachate in the sub-surface layers of waste in the Bioreactor;
- Improvement of evaporation capabilities via the installation of automated Evaporator Units operating under favorable meteorological conditions;
- Water cart to control dust and sealed roads, which is an ongoing practice to minimise dust generation and suppress potential odours dispersed in this manner;
- Using the minimal active tipping as practically possible during operations; and
- Transportation of waste in sealed containers until unloading at the Bioreactor

Notwithstanding these measures, this Audit has found that the following improvements are possible and achievable as a means of further mitigating odour emissions from the Woodlawn site:

- *Treatment of excess leachate:* Better management of excess leachate storage in ED3N-1 is necessary in the interim via a more continuous in-situ leachate treatment system, until the site's need for storage into this dam is proven to be reduced or eliminated (as predicted in the EA). As a priority, however, VES should focus on the removal of untreated excess leachate currently in ED3N-1 and follow by adequately managing leachate within the Bioreactor or any excess leachate treated directly through the leachate treatment system prior to storage in ED3N-1. If VES are unable to manage leachate treatment without the need for storage of excess leachate in ED3N-1, then additional management measures will need to be adopted; and

- *Continued on-going improvement in Landfill Gas Extraction:* This Audit supports VES's plan to continuously increase the efficiency of gas capture capabilities including around the perimeter of the Bioreactor. A review of production data and advice from VES has shown that Landfill Gas Capture has increased by 88% over the past 12 months. This is a highly positive result.

Audit Recommendations

This Audit has examined options for reducing odour emissions from the Woodlawn site and makes the following non-exhaustive recommendations:

Mandatory recommendations

In general, review and improvement of leachate treatment at the site.

Three options are:

1. Maintaining the existing batch leachate treatment system but prioritising the removal of untreated excess leachate in ED3N-1 and adequately managing leachate within the Bioreactor or any excess leachate treated directly through the treatment system prior to storage in ED3N-1. If storage of untreated leachate is required in ED3N-1 for an extended period, the covering of ED3N-1 will need to be considered;

2. Continue to develop the current batch treatment system into a continuous treatment system; and

3. Continue to implement the current improvements to the Landfill Gas Extraction System including from perimeter area of the Bioreactor as outlined in the Infrastructure Plan to minimise potential odour from fugitive gas emissions from the Bioreactor.

Non-mandatory recommendations

Other odour mitigation measures recommended for consideration include:

- *Biofiltration Trial:* filling areas of the Bioreactor perimeter identified as potential emission sources with suitable organic-based media for biofiltration of landfill gas short-circuiting due to 'wall effects' and monitor the effects;

- *Operation of the Evaporator Units:* It is recommended that VES reviews the operation of the Evaporator Units in light of the findings of this Audit regarding the potential of this process to emit odours in significant quantities. The review should re-examine appropriate weather conditions for their use and the significance of the quality of the effluent in generating odours during evaporation activity; and

- *Review gas and leachate quality in different areas of the Bioreactor:* It is recommended that VES reviews gas and leachate quality to identify areas of higher potential odour sources that can be targeted with future gas collection infrastructure and leachate management strategies.

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APPENDICES

APPENDIX A: ODOUR CONCENTRATION RESULT SHEETS

APPENDIX B: ODOUR EMISSIONS CALCULATION SHEETS

APPENDIX C: CONDITION 7 (C) ATTACHMENTS

APPENDIX D: LIQUID ODOUR MEASUREMENT METHODOLOGY

1 INTRODUCTION

In June 2012, Veolia Environmental Services (Australia) Pty Ltd (VES) engaged The Odour Unit Pty Ltd (TOU) to carry out an Independent Odour Audit of the Woodlawn Bioreactor Facility located at Collector Road, Tarago, NSW. The specific scope of works for this Audit is detailed in *Condition 7* of *Schedule 4* in the *Specific Environmental Conditions - Landfill site* and enforced by *Section 75J* of the *Environmental Planning and Assessment Act 1979* as part of the project approval for the Woodlawn Waste Expansion Project.

1.1 WOODLAWN WASTE EXPANSION PROJECT SUMMARY

In March 2010, VES issued an application to the Department of Planning & Infrastructure (DPI) seeking approval to increase the maximum throughput rate of the Woodlawn Bioreactor from 500,000 to 1.13 million tonnes per annum (tpa). Simultaneously, VES was also seeking to increase the maximum throughput rate of the nearby Crisps Creek Intermodal Facility (IMF) to 1.18 million tpa.

The proposal also entailed:

- Installing additional lighting at the Bioreactor site;
- Extending the approved hours of operation at the Bioreactor and the IMF site;
- Increasing the number of truck movements transporting waste to the Bioreactor from the IMF; and
- Increasing the amount of waste transported to the site by road from regional councils from 50,000 to 130,000 tpa.

VES received approval for the Woodlawn Waste Expansion Project on 16 March 2012.

1.2 OBJECTIVES

In accordance with the project approval requirements of *Condition 7* of *Schedule 4* in the *Specific Environmental Conditions - Landfill sites* (DA 10_0012), VES is required to carry out an Independent Odour Audit 3 months from the date of project approval and annually thereafter, unless otherwise agreed by the Director-General. The Independent Odour Audit must:

a. *Consult with OEH and the Department;*
b. *Audit the effectiveness of the odour controls on-site in regard to protecting receivers against offensive odour;*
c. *Review the proponents' production data (that are relevant to the odour Audit) and complaint records;*
d. *Review the relevant odour sections of the Air Quality and Greenhouse Gas Management Plan for the project and assess the effectiveness of odour control;*
e. *Measure all key odour sources on-site including:*
    i. *consideration of wet weather conditions providing all raw data used in this analysis;*
    ii. *consideration of (but not limited to) all liquid storage area, active tipping faces, waste cover area, aged waste areas and recirculation of leachate onto waste in the Void;*
    iii. *a comparison of the results of these measurements against the predictions in the EA*
f. *Determine whether the project is complying with the requirements in this approval to protect receivers against offensive odour*
g. *Outline all reasonable and feasible measures (including cost/benefit analysis, if required) that may be required to improve odour control at the site and; and*
h. *Recommend and prioritise (mandatory and non-mandatory) recommendations for their implementations*

This is the first Independent Odour Audit commissioned since the Woodlawn Waste Expansion project approval was granted.

1.3 COMPLIANCE WITH AUDIT OBJECTIVES

This Audit has been undertaken by TOU and endorsed by the Director-General of the Department of Planning.

This Audit consisted of:

- **Preliminary investigation**: An initial site visit carried out by TOU Managing Director Terry Schulz on 8 June 2012;
- **Fieldwork:** Collection of odour samples from key sources (as per *Condition 7 (e)),* recording of relevant field observations and measurements, and discussions with VES Woodlawn staff in regards to the operations of the Bioreactor;
- **Reviewing:** a comprehensive review of all relevant assessments carried out since the Woodlawn Waste Expansion Project approval was granted and other relevant reports pertaining to this Audit; and
- **Reporting:** a comprehensive summary of all aspects of the Audit, complying with the Audit objectives mentioned in **Section 1.2**

This report summarises the Independent Odour Audit carried out by TOU at the VES Woodlawn site.

2 THE SITE

2.1 WOODLAWN BIOREACTOR FACILITY

The Woodlawn Bioreactor Facility (Woodlawn) is located 250 km south of Sydney, within the 6,000 hectare (ha) Woodlawn Eco-Precinct, in the Southern Tablelands near Goulburn in New South Wales. An aerial view of the Woodlawn Facility is shown in **Photo 2.1.**

Prior to waste operations, Woodlawn operated as a base metals open-cut mine site during the 1970s and 1990s, processing copper, lead and zinc. Since September 2004, the mine void has been operated as an in-situ Bioreactor. Putrescible waste from the Sydney metropolitan area was historically received solely via rail from the Clyde Transfer Terminal. Since approval of the Woodlawn Waste Expansion Project, initial truckloads of waste from local regional areas have been accepted.

Waste contained within the Bioreactor undergoes anaerobic decomposition, which is supplemented by leachate recirculation, resulting in the production of landfill gas (also referred to as landfill gas). The landfill gas, predominately rich in methane (CH_4) and carbon dioxide (CO_2), is continuously extracted from the Bioreactor and directly consumed via purpose built landfill gas-fired engines that form the site's power plant. At the time of this Audit, four landfill gas-fired engines were operational with each capable of generating up to 1.065 Megawatt hours (MWh) of 'green' electricity. All electricity generated is exported to the main grid. This process is described in more detail in the proceeding section.

Aside from generating 'green' electricity from waste at Woodlawn, VES is also undertaking mine rehabilitation works and has established innovative wind farm, aquaculture and horticulture projects within the Eco-Precinct. These undertakings are not relevant to the Audit and thus have been excluded.

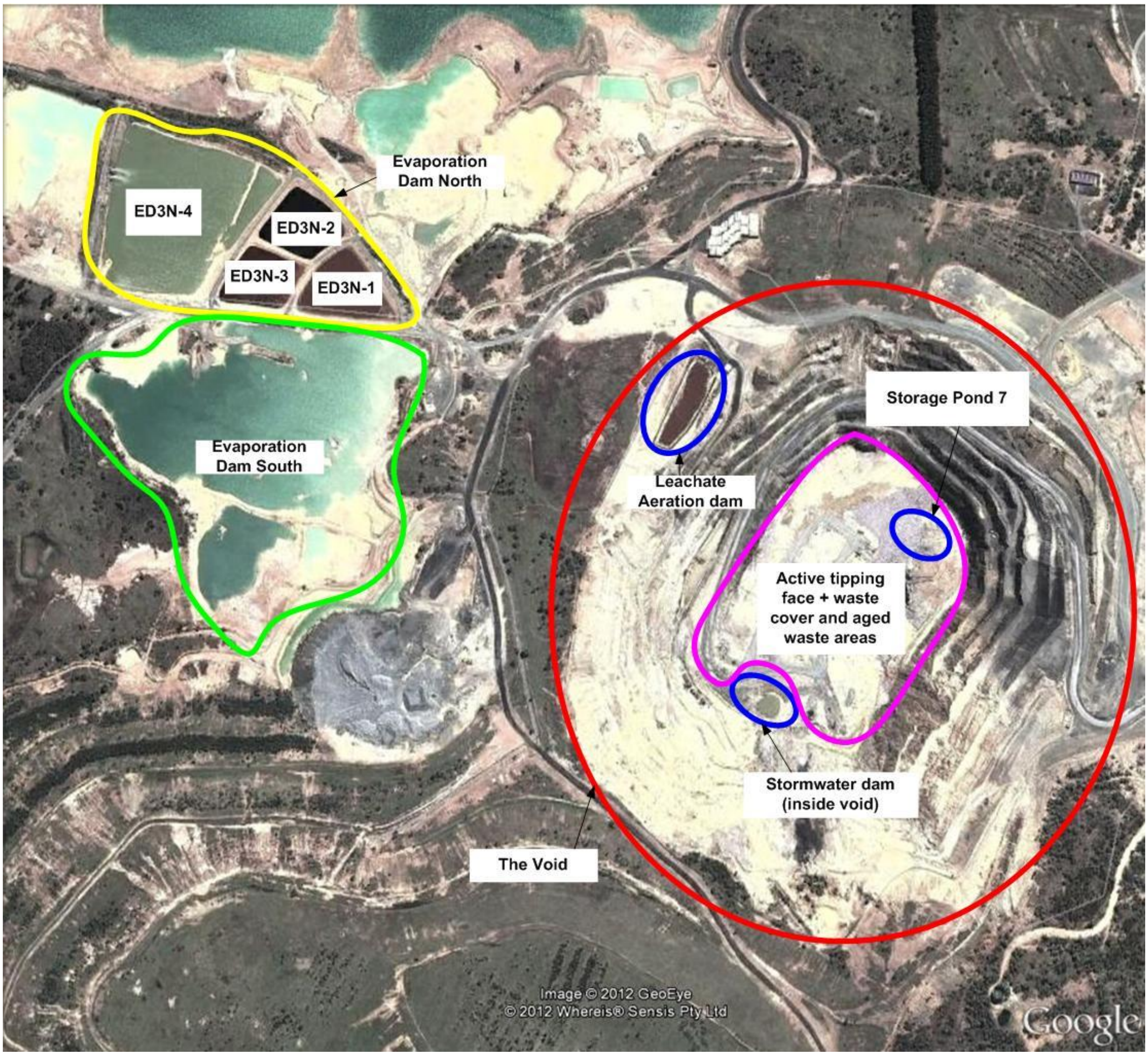


Photo 2.1 – An aerial view of the Woodlawn Site, Southern Tablelands, NSW

2.2 PROCESS OVERVIEW

Woodlawn has approval to operate between 0600hrs to 1900hrs on Mondays to Saturdays, with no activities on Sundays, Good Friday or Christmas Day.

The operational processes at Woodlawn can be categorised under two primary management systems, namely:

1. The Bioreactor Waste Management System; and

2. The Leachate Management System

These management systems are described in concise detail in the following section. Further details in regards to these systems are contained in the Environmental Assessment (EA) Woodlawn Expansion Report (August 2010).

2.2.1 Bioreactor Waste Management

At first glance, the Bioreactor layout appears to be a simple landfilling operation, consisting of:

- An active tipping face;
- Waste cover area;
- Aged waste area;
- A mobile tipping platform;
- A leachate recirculation system; and
- A gas extraction system.

On closer inspection, however, it is clear that there are complex operating procedures for the Bioreactor that result in a dynamic site layout that is able to vary with time and operational demands (such as the requirement of covering areas of waste, setup of a gas extraction system at a specified location and the need for a leachate recirculation system). Operations at the time of the Audit, which shows a larger than normal tipping face, is shown in **Photo 2.2.**

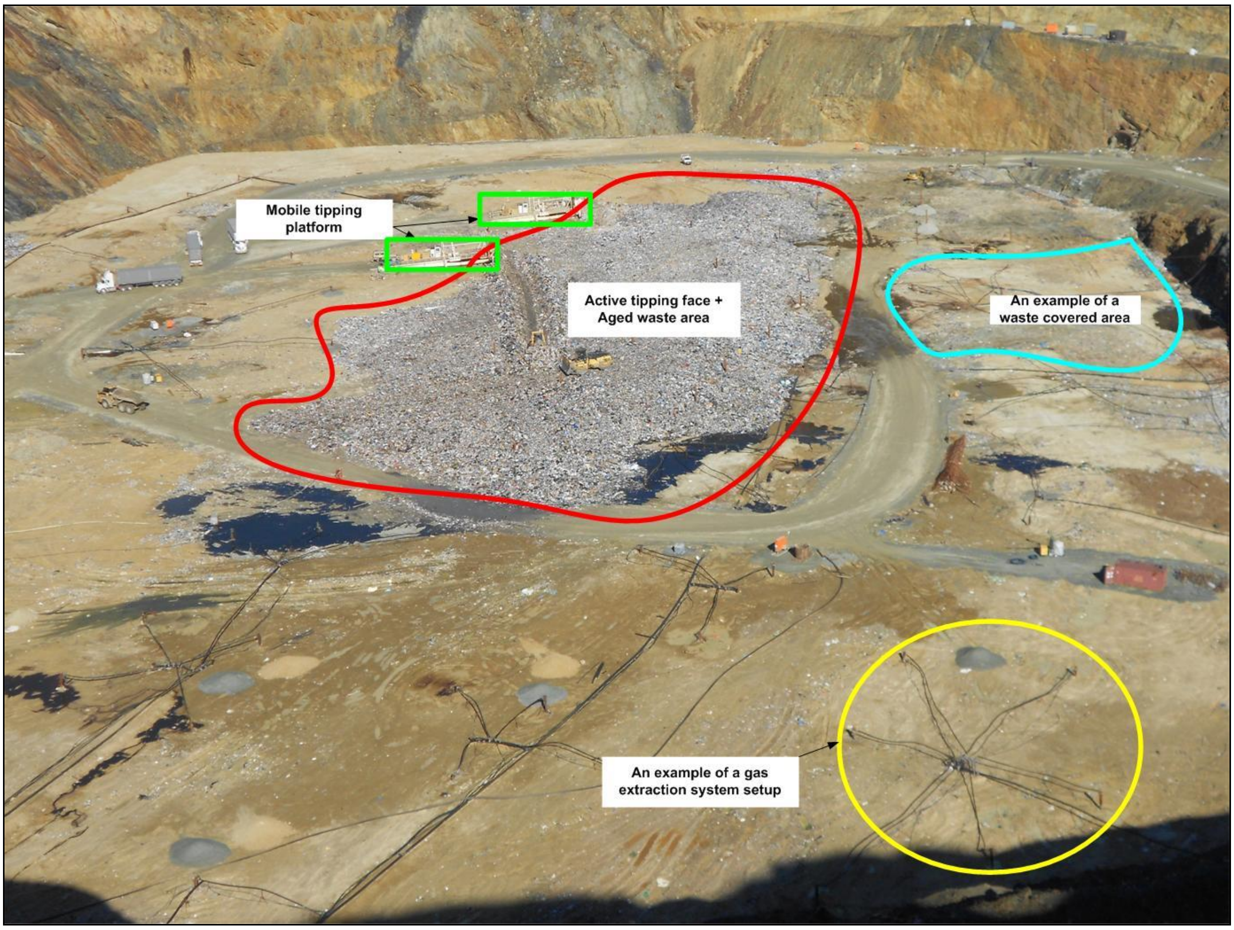


Photo 2.2 – Operations at time of Audit on 20 June 2012

The current procedure for operating the Bioreactor involves the receival of putrescible waste, transported to Woodlawn by rail from Sydney after being containerised at VES Transfer Terminal situated in Clyde, NSW. The Clyde Transfer Terminal is a state-of-the-art waste transport intermodal link, where waste is received at the terminal, compacted into sealed containers, loaded onto rail and transported to the Crisps Creek Intermodal Facility, approximately 8 km to the southeast of the Woodlawn Bioreactor. Waste is also received by road from local regional areas.

Waste received by rail to the Intermodal Facility is transported via trucks in sealed containers to the Bioreactor, where waste is unloaded via a mobile tipping platform and subsequently transported by a dozer to the compactor on the active tipping face. The tipping face is the active gas infrastructure construction area and waste is placed strategically around drainage material and gas extraction infrastructure. The active tipping face is then progressively covered. As informed by VES, covering of the active tipping face is an ongoing operational process, although the area of exposed waste on a daily basis will vary depending on positioning in the Bioreactor, gas infrastructure and weather conditions.

It is understood that the tipping process is supplemented by hydrogen sulphide (H_2S) emission control which involve in-situ addition of metal oxide (haematite and magnetite) to the waste as placed. Once a waste area is covered, leachate recirculation is promoted to optimise degradation rates. This promotes landfill gas generation which is continuously extracted by the landfill gas infrastructure within the waste.

2.2.2 Leachate Management System

The Leachate Management System (LMS) has been described in *Chapter 8* of the *Environmental Assessment Woodlawn Expansion Project*. The key features of the system are as follows:

- **Evaporation Dam 3 North (ED3N):** this pond system covers an area of 3.6 hectares and is divided into four lagoons:
    - *ED3N – 1:* contains excess untreated leachate directly from areas within the Bioreactor and may contain high sulphate concentrations. This liquid is stored until treated in the Leachate Aeration Dam. At top water level (TWL), the surface area is 0.7 ha;
    - *ED3N – 2:* receives treated leachate from the Leachate Aeration Dam. At TWL, the area is approximately 0.65 ha;
    - *ED3N – 3:* receives treated leachate from the Leachate Aeration Dam. On-site evaporators are used to promote evaporation. At TWL, the area is approximately 0.65 ha; and
    - *ED3N – 4:* receives treated leachate from ED3N–2 and ED3N-3. The lagoon can also contain a mix of acid mine drainage and low level

organics (leachate) which are treated by evaporation. At TWL the area is 1.6 ha. Evaporators are used to promote evaporation.

The mechanical evaporation systems are Turbomist Evaporation Pump Units, each capable of spraying 350 L/min into the air. These units are operated only under favourable wind directions (i.e. when wind direction favours air movement back over the dam) and when ambient relative humidity (RH) levels are less than 75%. Information provided by VES indicates that approximately 20% to 30% of the pumped water is evaporated, depending upon ambient temperature and RH conditions. ED3N-3 is equipped with two evaporators and ED3N-4 has four units.

- **Evaporation Dam 3 South:** contains stormwater runoff which is contaminated with acid mine drainage. At TWL the area is 6.7 ha.
- **Leachate Aeration Dam:** receives leachate directly from the Bioreactor or from storage in ED3N-1. It is located within the upper levels, northwest of the Bioreactor and operates as a batch cycle, treating a maximum of 12 ML per treatment cycle. Current leachate treatment involves four surface aerators treating the leachate for a period of 2-3 months (depending on the quality of leachate). Regular water testing is carried out to monitor the treatment process and determine when treatment is complete. At TWL, the area is approximately 0.2 ha. Upon completion of a treatment cycle the treated leachate is flocculated and subsequently pumped to ED3N-2 for subsequent evaporation. Excess sludge remaining from treatment is returned to waste in the Bioreactor as an organic rich supplement for waste degradation and gas productivity.
- **Storage Pond 7 (inside Bioreactor)**: was designed to intercept rainfall run-off but at the time of the Audit the stormwater runoff was redirected and this pond was used for temporary storage of excess leachate. It is either pumped out of the Bioreactor to ED3N-1 or recirculated back into the waste. The total area, based on this Audit's measurements, at TWL is approximately 0.12 ha.

A process flow diagram of the leachate management system setup during this Audit is illustrated in **Photo 2.3.** It is condition of the site's Environmental Protection License

(EPL) that no leachate (treated or untreated) is allowed to be directly discharged from site. The only means of volume reduction is through mechanical and/or natural evaporation processes.

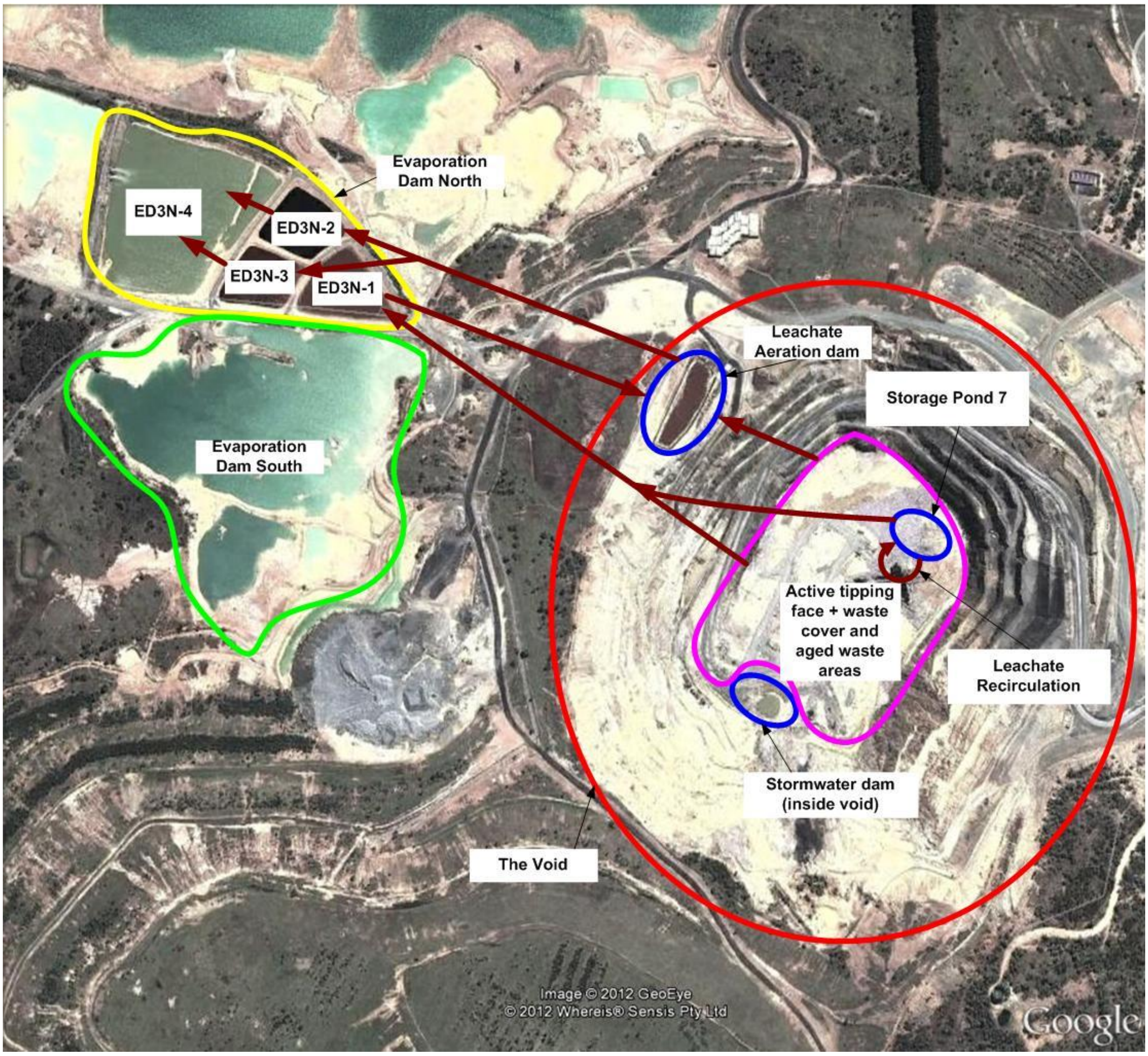


Photo 2.3– Schematic flow diagram of the leachate management system at the Woodlawn site

According to *Chapter 8* of the EA for the Woodlawn Expansion Project (August 2010), the leachate (and any wastewater) generated on-site is sourced from (in order of highest contribution of Total Inflow):

- indirect rainfall (sides of the pit) (63%);

- groundwater inflow (21%);
- rainfall (direct onto waste) (13%);
- recirculated leachate (2%); and
- added water (water brought into Bioreactor, including water used to extinguish any landfill fires) (1%).

3 SAMPLING PROGRAM

As per *Condition 7 (e)* of *Schedule 4* in the *Specific Environmental Conditions - Landfill site,* this Audit measured all key sources at the Woodlawn Bioreactor Facility, with two exceptions (see further below for details). An initial site visit, prior to the undertaking of fieldwork, was carried out by TOU Managing Director Terry Schulz to become familiar with the layout and operations at the Woodlawn Bioreactor Facility. This visit enabled the scoping of an updated emissions inventory of the site (in addition to that already submitted in the EA). The scope of work focused on the main odour emission sources at the site, and was based on historical odour emissions data and the observations and experience of Mr Schulz.

A subsequent visit by TOU was the carried out to perform all aspects of the fieldwork required for this Audit. It involved a total collection of twenty five samples, namely, twenty three odour samples and two leachate samples. The leachate samples were collected for subsequent odour concentration measurement using TOU's in-house NATA-accredited odour testing facility, and included the Liquid Odour Concentration Method (see **Section 4.3 & Appendix D** for details). This method is able to quantify the odour emissions caused by the natural or forced evaporation of odorous liquids.

The sampling program has been summarised in **Table 3.1.** As shown**,** there are several key sampling locations at the Woodlawn Bioreactor Facility. This includes:

- The Bioreactor;
- ED3N System; and
- The Landfill Gas System.

Table 3.1 – Woodlawn Bioreactor Facility Sampling Program: 19 June – 21 June 2012			
Location	**Date**	**Source Type**	**No. of samples collected**
The Bioreactor			
Active Tipping Face	20 June 2012	Area source	2
Waste Cover Area	20 June 2012	Area source + Point source	6
Aged Waste Area	20 June 2012	Area source	2
Storage Pond 7	20 June 2012	Area source	2
Leachate Aeration Dam	21 June 2012	Area source	2
ED3N Pond System			
ED3N - 1	21 June 2012	Area source (3) + Liquid odour measurement (1)	4
ED3N - 2	21 June 2012	Area source	2
ED3N - 3	21 June 2012	Area source	2
ED3N - 4	21 June 2012	Area source (1) + Liquid odour measurement (1)	2
Landfill Gas System			
Gas engine inlet (i.e. landfill gas)	21 June 2012	Point source	1
TOTAL			**25**

The sampling program includes all key sources requested in *Condition 7 (e) of Schedule 4 in the Specific Environmental Conditions - Landfill site* with the following exceptions:

- *Consideration of wet weather conditions:* No rainfall was experienced during sampling. As a result, this Audit was unable to collect representative odour samples under wet weather conditions but considered the effects of wet weather in terms of the need to handle increased levels of leachate under wet weather conditions; and
- *Leachate recirculation:* This Audit was unable to observe and thus collect representative samples for this scenario. Since the EA, VES has developed a leachate recirculation system that involves direct injection of leachate into the waste which eliminates the need for spraying over the surface. Therefore, no suitable access points for the collection of odour samples from this source are available.

No samples were collected from the Crisps Creek Intermodal Facility as the waste transportation process is enclosed. As will be discussed in **Section 7.1.1.5**, it is not considered to be a significant odour emission source.

4 SAMPLING METHODOLOGIES

4.1 POINT SOURCE SAMPLING

4.1.1 Landfill Gas System

The method used for collecting samples from the Landfill Gas Inlet involved drawing the sample air through a Teflon™ sampling tube into a single use, Nalophan sample bag. The air sample was drawn into the sample bag using the positive pressure on the discharge side of the extraction fan driving the Landfill Gas Extraction System.

4.1.2 Potential gas pathways from Bioreactor: Gas leakage

During the course of undertaking the fieldwork, it was noticed by the Audit that gas bubbles were evident in some small pools of water on the surface of the Bioreactor (likely to be mainly from rainfall as the site had experienced significant wet weather intervals the week prior to sampling). These pools existed randomly across the Bioreactor surface. A sample from this source was taken using two different techniques:

1. Point source surface outflow:
    - A hood was placed on the bubbling location;
    - Once placed, the hood was sealed using surrounding material and time given to purge the air inside the hood. The lid of the hood has a vent pipe which allowed airflow through the hood and establish continuous air changes inside the hood; and
    - After a brief lapse of time, a bag was placed on the vent pipe opening, forming a seal, and sample collected at the rate of gas emission from the enclosed surface.
2. Area Source Sampling Method - Isolation Flux Method (see **Section 4.2**)

While the latter sampling technique is standard for area source samples, the first sampling technique involved the collection of gas by utilising the pressure of the gas emerging from the surface of the pool of water, at the rate which the gas was permeating out of the waste surface enclosed by the hood. This provided the Audit with a preliminary means of determining the quantity of leaking landfill gas. A 30L Nalophan sample bag was filled in 15 min, equating to a gas diffusion rate of 2 L/min from the waste surface. At the covered area of 0.407 m^2, this was equivalent to a specific gas emission rate of 4.91 $L/m^2/min$. Although unable to be measured, it is likely that the gas emission rate was occurring across wider areas of the waste surface than were able to be observed in ponded surface water areas.

4.2 AREA SOURCE SAMPLING METHOD

The objective of the area source sampling programme was to collect representative samples at various locations at the Woodlawn Bioreactor Facility and included both solid and liquid area sources. This was undertaken using an isolation flux hood (IFH). All sampling using the IFH is carried out according to the method described in the US EPA technical report '*EPA/600/8-86/008*'. This method is also defined in Australian Standard AS/NZS4323.4. TOU's IFH adheres to the design specifications, materials of construction and supporting equipment that the US EPA report '*EPA/600/8-86/008*' defines. **Table 4.1** summarises the design specifications of the IFH.

Once the IFH apparatus is set up for sample collection, dry nitrogen is then introduced into the hood at a sweep rate of 5 litres per minute.

Table 4.1 - IFH Design Specifications	
Diameter (m)	0.406
Surface Area (m^2)	0.13
Volume (L)	30*

*When the skirt of the hood is immersed into the water or solid surface by the specified 25 millimetres.

Area source samples are opened to the atmosphere resulting in wind being a major factor in the release of odourous pollutants from the surface and conveying the pollutant from the source to areas beyond the boundary of the Woodlawn Bioreactor Facility. The IFH system is designed to simulate the mass transfer of odorous pollutants into the atmosphere, resulting in a controlled and consistent sampling environment. This is achieved by the flux of dry nitrogen sweep gas into the IFH, as it is positioned on the solid or liquid surface. On a liquid surface this is achieved by floating the IFH within an inflated tyre inner tube. The nitrogen gas then transports the odour from the surface in a similar manner to the wind, albeit at a very low sweep velocity. This odorous air is then sampled, for later odour testing.

As the IFH has a constant 5 litres per minute inflow of nitrogen gas to it, the sampling chamber remains under very slight positive pressure (less than 2 Pa) and produces a net outflow through the vent on top of the IFH, therefore eliminating any chance of contamination with external air from the atmosphere. The IFH's volume of 30 litres and the 5 litres per minute nitrogen sweep rate results in a gas residence time of 6 minutes. The standard method prescribes a minimum of four (4) air changes in order to achieve optimum purging and equilibrium in the hood, and hence a total of 24 minutes is allowed before sampling commences. The sample is then collected at a flow rate of approximately 2 litres per minute over a 5–10 minute period to obtain a 10–20 litre sample for analysis.

The method followed by TOU is depicted in the schematic of the sampling equipment shown in **Figure 4.1 & 4.2**. The IFH is manufactured from acrylic resin to ensure it does not contribute to the odour sample. All other surfaces in contact with the sample are made from Teflon ® or stainless steel.

The use of the IFH method enables a Specific Odour Emission Rate (SOER) to be calculated (ou.$m^3/m^2/s$). A SOER is a measure of odour released from a representative area unit. The SOER is multiplied by the area of the source to obtain an Odour Emission Rate (OER) (ou.m^3/s), or the total odour released from each source. This calculation has been illustrated in **Equations 4.1 & 4.2** below.

All area source samples collected in this Audit were collected in the above manner.

$SOER\ (ou.m^3m^{-2}s^{-1}) = OC * \frac{Q}{A}$	**Equation 4.1**
$OER\ (ou.m^3s^{-1}) = SOER * area\ of\ source\ unit\ (m^2)$	**Equation 4.2**

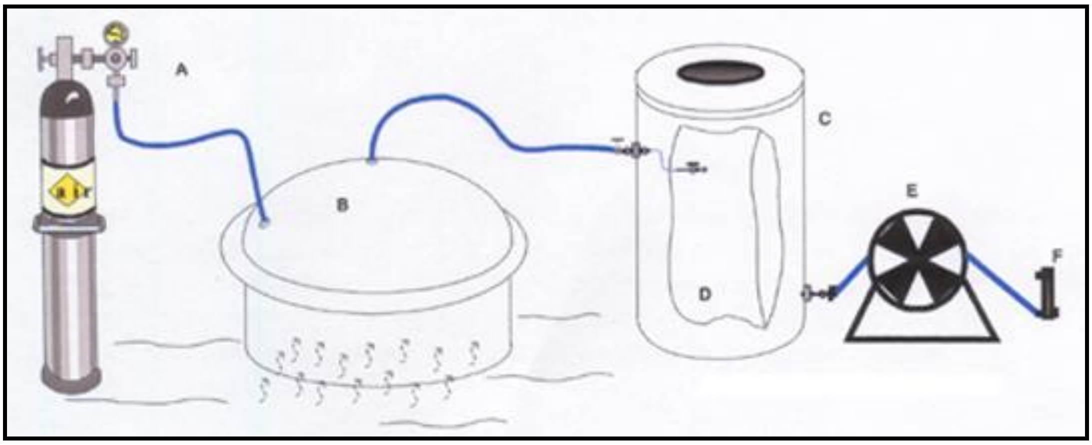
where

QC = odour concentration of compound from air in the chamber (ou)

Q = sweep gas volumetric flow rate into chamber (m^3/s)

A = sample source total surface area (m^2)

Figure 4.1 - Schematic Drawing of Sampling with the Isolation Flux Hood (IFH)

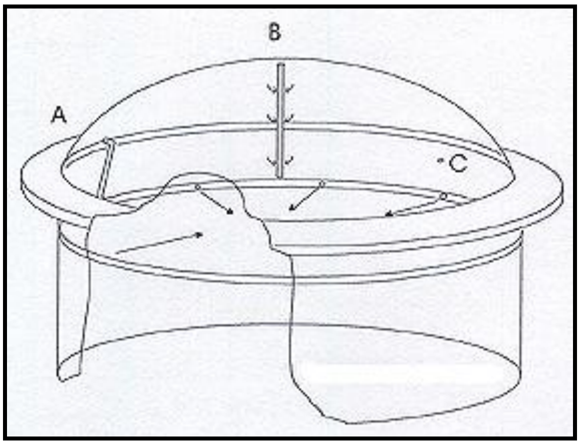


Source: Odotech - Odoflux Isolation Flux Hood Manual

Key

A	Cylinder of medical air, nitrogen or any neutral gas.
B	Isolation Flux Hood (detailed diagram shown in **Figure 4.2**)
C	Lung chamber (sampling drum)
D	Nalophan sampling bag
E	Sampling pump
F	Air flow meter

Figure 4.2 - Schematic of the Isolation Flux Hood



Source: Odotech - Odoflux Isolation Flux Hood Manual

Key

A Inlet gas from gas cylinder.

B Outlet to sample bag.

C Additional gas outlet points for other sampling, or temperature and moisture monitoring.

4.3 LIQUID ODOUR METHOD

4.3.1 Overview

The Liquid Odour Method was developed by TOU, with funding for the final development and validation of the method provided by the Alumina Industry Air Emissions Forum (AIAEF). While the method was originally developed in response to a perceived need within the alumina refining industry for measurement of the odour release potential from process liquors, it is universally applicable to aqueous solutions containing odorous substances. In simple terms, it measures the odour released when an odorous liquid evaporates. It is directly relevant to the mechanical evaporation system in use at Woodlawn to dispose of treated leachate (and any wastewater) (see **Appendix D** for details on methodology).

As an example of how the Liquid Odour Measurement results can be used, a mechanical evaporation rate of 2 L/s and an evaporation potential of 13 ou/mL would result in an odour emission rate of 26,000 ou.m^3/s.

5 ODOUR CONCENTRATION MEASUREMENT METHOD

TOU's odour laboratory operates to the Australian Standard for odour measurement '*Determination of odour concentration by dynamic olfactometry'* (AS/NZS 4323.3:2001) which prescribes a method for sample analysis that provides quality assurance/quality control and ensures a high degree of confidence in the accuracy, repeatability and reproducibility of results.

The concentration of the gaseous odour samples were measured using a technique known as dynamic olfactometry. Dynamic olfactometry involves the repeated presentation of both a diluted gaseous odour sample and an odour-free air stream to a panel of qualified assessors through two adjacent ports on the olfactometer (known as the Odormat™). TOU utilises four (4) to six (6) trained assessors (or panellists) for sample analysis, with the results from four qualified panellists being the minimum allowed under the Australian Standard AS/NZS 4323.3:2001. For this Audit, four panelists were used.

The method for odour concentration analysis involves the odorous gas sample initially being diluted to the point where it cannot be detected by any member of the panel. The assessor's step- up to the olfactometer in turn, takes a sniff from each port, then choose which port contains the odour and enter their response. At each stage of the testing process, the concentration of the odourous gas is systematically increased (doubled) and re-presented to the panellist's. A round is completed when all assessors have correctly detected the presence of the odour with certainty. The odour is presented to the panel for three rounds and results taken from the latter two rounds, as stated in AS/NZS 4323.3:2001.

The results obtained give an odour measurement measured in terms of odour units (ou). One (1) ou is the concentration of odorous air that can 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 AS/NZS 4323.3:2001. The odour units can be subsequently multiplied by an emission rate or volumetric flow to obtain an Odour Emission Rate (ou.m^3/s) or a SOER (ou. m^3/m^2/s) for area source samples collected using the IFH method (see **Section 4.2**).

5.1 ODOUR MEASUREMENT ACCURACY

The repeatability and odour measurement accuracy of the Odormat™ is determined by its deviation from statistically reference values specified in AS/NZS4323.3:2001. This includes calculation of instrumental repeatability (r), where r must be less than 0.477 to comply with the standard criterion for repeatability. It's accuracy (A) is also tested against the 95th percentile confidence interval, where A must be less than 0.217 to comply with the accuracy criterion as mentioned in the Standard.

The Odormat™ V02 was last calibrated in August 2011 and complied with all requirements set out in the AS/NZS4323.3:2001 (see **Appendix A** – Result sheets: *Repeatability and Accuracy*). The calibration gas used was 50 ppm n-butanol in nitrogen (N_2) gas.

6 RESULTS

e. Measure all key odour sources on-site including:

i. consideration of wet weather conditions providing all raw data used in this analysis;

ii. consideration of (but not limited to) all liquid storage area, active tipping faces, waste cover area, aged waste areas and recirculation of leachate onto waste in the Void;

iii. a comparison of the results of these measurements against the predictions in the EA.

The laboratory results sheets have been appended as **Appendix A.**

As per *Condition 7 (e),* **Table 6.1** summarises the odour emissions inventory of the Woodlawn Bioreactor Facility during the sampling visit and compares the results obtained by the Audit to that submitted in the Environment Assessment Submissions Report *Woodlawn Expansion Project August 2010.*

Table 6.2 summarises in-situ chemical testing results obtained using Gastec ® Detector Tubes.

Table 6.3 summarises liquid odour measurement results.

Table 7.1 in **Section 7** summarises odour emission rates from sampling sources amenable to quantitative measurement. The sources are ranked in descending order. This table does not include potential gas pathways and other fugitive emission sources from the waste surface, due to the difficulty in assigning an appropriate emission area for these sources in order to calculate an odour emission rate (ou.m^3/s) derived from the SOER (ou.m^3/m^2/s) and the area (m^2).

Table 6.1 – The Audit vs. EA Woodlawn Expansion Project Odour Emissions Testing Results

Sample Location	Audit				EA	
	Sample Number	**Odour Concentration (ou)**	**SOER ($ou.m^3/m^2/s$)**	**Odour Character**	**SOER Range ($ou.m^3/m^2/s$)**	**SOER Model Input ($ou.m^3/m^2/s$)**
The Bioreactor						
Active tipping area						
Southwest corner (disturbed)	TOUSC12226	17,900	11.1	garbage, fermented fruit		
Southwest corner within Bioreactor (disturbed)	TOUSC12227	35,700	22.2	garbage, fermented fruit	1.0 – 7.3*	
Fresh Waste 1 day old (Disturbed - Southwest within Bioreactor)	TOUSC12229	11,600	6.91	rotten meat, garbage		7.3 (wet fresh waste emission adopted)
Aged Waste (1 week old)	TOUSC12231	304	0.17	Wet, mild	0.5	
Aged Waste (1 week old)	TOUSC12232	2,230	1.42	garbage		
Waste cover area						
Potential gas pathways within Bioreactor (Evident gas leak – 3 ppm H_2S)	TOUSC12228	8,190	5.20	rotten meat, garbage	7.5 – 23.9	
Potential gas pathways within Bioreactor (Bubbling gas - 30L in 15 min via hood)	TOUSC12233	185,000	n/a	fermented fruit, pineapple, garbage	n/a	
Potential gas pathways within Bioreactor (Bubbling gas)	TOUSC12234	185,000	115	fermented fruit, pineapple, garbage		
Potential gas pathways within Bioreactor (Wall effects - west within Bioreactor edge)	TOUSC12235	4,470	2.94	garbage, fermented fruit	7.5 – 23.9	23.9
Potential gas pathways within Bioreactor (Wall effects - northwest within Bioreactor edge)	TOUSC12236	2,440	1.61	garbage		
Covered area - South within Bioreactor	TOUSC12230	431	0.25	musty, slight garbage	0.1 - 0.2**	0.2

*includes dry and wet waste

Table 6.1 continued – The Audit vs. EA Woodlawn Expansion Project Odour Emissions Testing Results						
	The Audit				EA	
Sample Location	Sample Number	Odour Concentration (ou)	SOER ($ou.m^3/m^2/s$)	Odour character	SOER Range ($ou.m^3/m^2/s$)	SOER Model Input ($ou.m^3/m^2/s$)
The Bioreactor continued						
Catchment Pond (stormwater + leachate)						
Storage Pond 7	TOUSC12237	131,000	85.0	rotten egg	2.1 – 8.8	8.8
Leachate Recirculation						
Leachate Recirculation	n/m				1.6 – 2.5	2.5
Evaporation Dam 3 North (ED3N) Pond System						
ED3N-4 (Evaporation Dam - Eastern middle)	TOUSC12238	664	0.410	Musty	0.1 – 0.7	0.7***
ED3N-3 (Treated leachate from ED3N-2 Western middle)	TOUSC12239	559	0.346	burnt, musty	0.1 - 7.4	0.2****
ED3N-3 (Treated leachate from ED3N-2: Northern end)	TOUSC12240	609	0.400	burnt, musty		
ED3N-2 (Treated leachate from Leachate Aeration Dam: Western end)	TOUSC12241	362	0.226	musty, plastic		
ED3N-2 (Treated leachate from Leachate Aeration Dam: Northern end)	TOUSC12242	304	0.190	burnt, musty		
ED3N-1 (Untreated Leachate & acid mine drainage: Southern middle - 1)	TOUSC12243	902,000	564	rotten egg	2.1 – 8.8	8.8
ED3N-1 (Untreated Leachate & acid mine drainage: Western middle)	TOUSC12244	293,000	183	rotten egg		
ED3N-1 (Southern middle - 2)	TOUSC12245	696,000	435	rotten egg		
Evaporation Dam 3 South (ED3S) Pond System						
ED3S (Stormwater)	n/m				0.0 - 0.5	0.5

**Includes dry and wet covered waste
*** Includes groundwater and fully treated leachate
****Partial/fully treated leachate

Table 6.1 continued – The Audit vs. EA Woodlawn Expansion Project Odour Emissions Testing Results						
	The Audit				**EA**	
Sample Location	**Sample Number**	**Odour Concentration (ou)**	**SOER ($ou.m^3/m^2/s$)**	**Odour character**	**SOER Range ($ou.m^3/m^2/s$)**	**SOER Model Input ($ou.m^3/m^2/s$)**
Leachate Aeration Dam (Inside Bioreactor)						
Surface sample - 1	TOUSC12247	724	0.459	meat, ammonia	0.1 - 7.4*****	3.6
Surface sample– 2	TOUSC12248	724	0.459	meat, livestock	0.1 - 7.4*****	3.6
Landfill Gas Extraction System						
Landfill gas inlet	TOUSC12246	9,310,000	n/a	rotten egg	n/m	

*****Includes partially/fully treated leachate (dependent on the treatment stage of the process at the time samples were collected)

Table 6.2 – Gastec ® Detector Tubes			
Sample Location	**H_2S Test 1**	**H_2S Test 2**	**NH_3 Test 1**
ED3N-1 (Southern middle near liquid surface)	180 ppm	180 ppm	>30 ppm

Table 6.3 – Liquid Odour Method Testing Results and Derived Odour Emission Rates

Sample Location	TOU Sample Number	Odour Concentration (ou)	Calculated Liquid Odour Potential (ou/mL)	Natural Evaporation rate (L/s) ******		Natural Evaporation Odour Emission Rate (ou.m^3/s)		Mechanical Evaporation Rate (L/min)		Mechanical Evaporation Odour Emission Rate (ou.m^3/s) ******		Audit Mean Odour Emission Rate (ou.m^3/s)	Odour Character
				Jan 2012	Jun 2012	Jan 2012	Jun 2012	Jan 2012	Jun 2012	Jan 2012	Jun 2012		
ED3N-4 (Southern middle)	TOUSC 12305	215	13.01	0.868	0.196	11,370	2,570	130	70	91,100	60,700	6,600	Cheesy, vinegar
ED3N-1 (Eastern middle)	TOUSC 12306	3,160	191.3	0.381	0.086	72,650	16,400	Nil		No evaporators		2,760,000	Sour, ammonia, faecal

****** The natural evaporation rate is based on the mean January /June value for the site i.e. 145 / 32 mm/month respectively
******* Mechanical evaporation rate is based on 30% / 20% evaporation efficiency by the 4 evaporators in ED3N-4 in January/June respectively, and all Evaporator Units running.

6.1 COMMENTS ON THE SAMPLING AND TESTING RESULTS

The following sections comment on the sampling and testing results presented in **Tables 6.1-6.3**.

6.1.1 Bioreactor samples

- The SOER results for the Active Tipping Area within the Bioreactor are generally consistent with previous results and the values used in EA dispersion modelling;
- The two disturbed waste samples (TOUSC12226 and 12227) were from areas identified by site staff as potentially odour sources;
- The Waste Cover samples (TOUSC12228 and 12233-36) were collected from areas identified by site staff as potentially odour sources;
- The single sample (TOUSC12230) collected on the covered area of the waste surface was judged to be representative of the bulk of the covered area; and
- The waste covered gas leakage surface emissions samples (observed via the water pools) were later shown not to be solely landfill gas. While it is was assumed all emissions were landfill gas, it was identified during the Audit that some samples were found to be an ester such as ethyl butyrate (see **Section 7.1.1.2** for further details).

6.1.2 Leachate Samples

- The Storage Pond 7 sample was collected from the 'middle' section of the pond;
- As previously mentioned, the leachate recirculation system has been improved since sampling undertaken for the EA and is now operating as a direct injection system that does not have suitable access points for sampling;
- All samples from the ED3N system were collected at different locations, from the bank of the dams (i.e. no replicates);
- The mean SOER result for Dams ED3N-2, ED3N-3 and ED3N-4 (mean 0.31 ou.m^3/m^2/s) is higher than the EA modelling value by 57%. This is likely due to

the different quality of leachate during this Audit than during the undertaking of the EA (as advised by VES). The possibility of differing water quality in the Pond was not considered in the EA;

- The mean SOER result for Dam ED3N-1 (mean 394 ou.$m^3/m^2/s$) is 45 times greater than the EA modelling value (8.8 ou.$m^3/m^2/s$), reflecting the highly odorous condition of this dam at the time of sampling and suggesting that the Pond contents at the time of the EA investigation may have been of better quality; and
- Dam ED3S was not found to emit any odour at the time of this Audit and was not sampled.

6.1.3 Leachate Aeration Dam

- The results for the Leachate Aeration Dam represent the odours emanating from the surface of the liquor. It was not possible to determine the odours released from the stripping action of the aerators. It is understood that during sampling, the leachate in this dam was approaching the end of the treatment batch cycle; and
- It is possible that odour emissions may be greater at the commencement of a batch cycle until sufficient oxygen is introduced to commence treatment.

6.1.4 Landfill gas Sample

- The landfill gas sample was collected from the gas supply pipe to the gas engines; and
- The odour concentration in the landfill gas (9,300,000 ou) is consistent with previous landfill gas testing by TOU and was the highest recorded odour concentration for landfill gas tested by TOU.

6.1.5 Liquid Odour Measurement

- The Liquid Odour Measurement results represent the odour that would be released if the sample were evaporated, either by natural or mechanical means;
- The natural evaporation rates shown are based on the mean rate for January and June 2012 at the site;
- Under natural evaporation conditions the results shown are a small fraction of the more substantial odour emission rate arising from the wind-driven mass transfer of odorants from the surface of the liquid to the gas/air phase (i.e. as determined by the SOER method); and
- Under mechanical evaporation conditions, when the Evaporator Units are operating, the resultant odour emission rate is greater than that determined by the SOER method.

6.1.6 Gastec Detector Tube Results

- These results are for samples drawn at the liquid surface at each of the two sampling locations on ED3N-1.

7 DISCUSSION

7.1 DISCUSSION OF AUDIT FINDINGS

The following discussion examines the results of the Audit against each of the conditions of consent.

7.1.1 Condition 7 (B & D)

Audit the effectiveness of the odour controls on-site in regard to protecting receivers against offensive odour

Review the relevant odour sections of the Air Quality and Greenhouse Gas Management Plan for the project and assess the effectiveness of odour control

Based on the EA for the Woodlawn Expansion Project and Ambient Air Quality Monitoring Plan (AAQMP), complemented by this Audit's on-site experience and consultations with VES Woodlawn personnel, it is clear that there is a range of odour controls implemented at the Woodlawn Bioreactor Facility designed to mitigate off-site impacts arising from its waste management operations. These include:

- **Leachate Recirculation Methods:** As previously mentioned in **Section 3**, since the EA, VES has developed a leachate recirculation system that involves direct injection of leachate into the waste as opposed to previously utilised methods such as surface spraying over the surface. The direction injection based leachate recirculation system involves the extraction of leachate from lower waste levels and reinjection into the top layer of waste beneath the surface, enabling absorption of leachate directly into the waste, which promotes the decomposition of waste and enhances the production of landfill gas. This Audit indicated that VES' adoption of this recirculation technique is more effective at minimising odours than previously utilised techniques; and

- An inherent effect of the recirculation process is the reduction in storage requirements for untreated leachate, thereby reducing the magnitude of potential odour impacts from ED3N-1 (currently the main storage of excess untreated leachate). VES maximises the recirculation potential of the waste and leachate is only removed from the Bioreactor when it becomes an issue to operations at the waste surface. The current impact from the storage of excess untreated leachate in ED3N-1 is discussed later in this section.

- **Reducing leachate storage volume in ED3N-1**: As described above, leachate recirculation reduces the volume of excess leachate required to be stored in ED3N-1.

- **Treatment of excess leachate**: The current treatment process involves treating leachate from ED3N-1 by aeration. This batch-based treatment process results in the reduction of odorous compounds. Based on odour sampling results in this Audit for treated leachate in ED3N-2, ED3N3 and ED3N-4, the current leachate treatment process undertaken by VES is effective at significantly reducing odours in the leachate.

- **Landfill Gas Extraction**: As advised by VES, gas capture volumes over the past 12 months have increased by 88%. This Audit finds that increasing gas capture is one of the most effective odour mitigating measures, while generation or flaring processes of landfill gas are active. All landfill gas generated by the Bioreactor is processed through the landfill gas engines and/or flared. In the event of power station failure, the site has the ability to manage collected landfill gas completely through the flare system.

- **Improve evaporation capability**: VES has implemented automated operation of onsite evaporators based on favourable wind direction and ambient relative humidity.

- **Water cart to control dust;** Use of the water cart is an ongoing operational activity, which is effective at minimising dust generation; and

- VES has also advised that the haul road within the mine void was sealed in September 2011 to assist with operations and to minimize potential dust emissions.

- **Using the minimal active tipping face as practically possible:** VES has advised that it operates to minimise the active tipping face as a site key performance indicator for the following reasons:

    1. To reduce surface area of potential odour source;
    2. Minimise temporary decommissioning of gas extraction infrastructure;
    3. Minimise fuel usage, particularly in dozer and compactor; and
    4. To meet EPA benchmark techniques.

- **Transportation of waste in sealed containers until unloading at the Bioreactor**: All containers are inspected, maintained and cleaned as part of site operations. Any faulty containers identified are taken out of service and decontaminated for maintenance. This Audit considers that this is a satisfactory practice to reduce potential odour sources from waste containers.

While it is difficult to directly quantify the effectiveness of some of these odour control measures in protecting sensitive receptors from adverse odour impacts, this Audit has drawn on experience from the site staff at the Woodlawn site, previous odour assessment studies and recent odour testing results from this Audit to make a judgement on the effectiveness of odour control measures, and where possible, provide a quantitative basis for this judgement.

7.1.1.1 Leachate extraction and reducing leachate storage capacity in ED3N

An intrinsic component of the leachate extraction system is the ED3N storage pond system, which stores both untreated and treated leachate. The treatment of the leachate is an effective form of odour control to reduce odorous compounds in the liquid prior to flocculation and removal as treated leachate for evaporation (by natural and/or mechanically means).

Prior to this Audit, the predicted and actual performance of this treatment process from an odour emission perspective was characterised by very low SOER values (all less than or equal to 0.5 ou.m^3/m^2/s). This included all four ponds (ED3N-1, ED3N-2, ED3N-3, and ED3N-4). The overall finding from previous assessments was that this pond system was not a major source of problematical odours. This was based on estimates of odour emission rates, dispersion modelling and later confirmation that the emission rates used in the modelling were realistic. In general terms, this Audit's independent odour testing on ED3N-4, ED3N-3 and ED3N-2, all of which store partially to fully-treated leachate, confirm this previous determination, finding similar SOER values to that previously used and/or measured. The key to this finding appears to be the fact that the liquor in these three ponds is treated. In this respect, it can be concluded that the leachate treatment process, prior to storage in ED3N-4, ED3N-3 and ED3N-2, is effective in reducing odour emissions. This result was not the case for ED3N-1, as it is understood that its contents during this Audit was of different quality to that during previous testing and investigations. The findings from this will be discussed further below.

Notwithstanding the merits of the current leachate treatment system, a key limitation, however, is the ability to refine the process to be suitable to treat the changing chemical composition of the leachate. This Audit was advised by VES that this constraint had resulted in reduced treatment capacity over the past 12 months and required VES to utilise available storage capacity in ED3N-1. The product of this resulted in a build-up of large volumes of untreated leachate over this period. The batch-based leachate treatment process can process a maximum of 12 ML at any given time and requires 2-3 months to complete each batch cycle. At this capacity, 48 ML per year is capable of being processed. VES has advised the Audit that it believes this will be sufficient to manage excess leachate based on the current site water balance.

While it is acknowledged that the state of ED3N-1 during this Audit was due to the build-up of excess leachate caused by the limited treatment capacity and earlier weather conditions, this Audit must review the conditions that were prevailing at the time of the Audit. As a result, a clear finding of this Audit is that ED3N-1 was found to be a major odour source likely to cause adverse odour impacts beyond the site boundary. This is due to the contents of ED3N-1 which stores organic-rich leachate mixed with acid mine drainage and thus has the potential for the generation and release of odorous compounds from the liquid phase to the gas phase by evaporation and mass transfer. The potential for ED3N-1 to be odorous in the future is evident from the Audit and emphasises that better management of excess leachate by VES will be required to avoid a reoccurrence of the need to store large amounts of untreated leachate in ED3N-1. This Audit was advised by VES that ED3N-1 will continue to only be used as a storage dam for excess leachate for contingency purposes (as was the case over the past 12 months leading up to this Audit), and that these volumes are expected to be minimal in the future.

In the context of the revised EA (i.e. Woodlawn Expansion Project Submissions Report March 2011), the worst case emission scenario mentioned for ED3N-1 was exceeded by a factor of 60 (upper limit) during this Audit, that is, a SOER of 564 ou.m^3/m^2/s vs. 8.8 ou.m^3/m^2/s. This result appears to be due to significant levels of H_2S, and to a lesser extent Ammonia (NH_3)), flashing off from the pond surface at the time this Audit was undertaking sampling, and is certain to be related to the quality of the leachate in the pond at the time. This finding was further verified by an olfactory assessment by the Audit's consultants whilst on-site, during which a 'rotten egg' odour (a typical odour characteristic of H_2S) was detected. In addition, in-situ chemical testing via Gastec ® Detector Tubes showed that H_2S concentrations at the water surface under the IFH sampling hood on pond ED3N-1 were found at potentially dangerous levels (180 ppm). At the average measured SOER from this Audit for pond ED3N-1 (393 ou.m^3/m^2/s), and given that the pond has a surface area of 0.7 Ha (7,000 m^2), the overall odour emission rate (OER) from this pond at the time of the Audit was 2,760,000 ou.m^3/s. This OER dominates all other odour emissions from the site as previously shown in **Section 6 - Table 6.3**.

Operationally, it is understood that ED3N-1 is maintained in an alkaline state, despite containing high sulphate levels. This flow of sulphate rich liquor presents a threat of acidification of the contents of ED3N-1, thereby decreasing the solubility of H_2S in solution and resulting in a greater quantity of H_2S partitioning to the gas phase (i.e. being flashed off at the water surface). To avoid further adverse odour impacts from this pond, it is vitally important that it be kept in an alkaline state and be regularly monitored. It understood that current monitoring operates in quarterly cycles and is required as part of the site's licence conditions for leachate monitoring. Advice from VES is that the pond was alkaline at the time of the Audit and is due to the mixing with leachate. The consequences of the pond operating under acidic conditions would be a SOER substantially higher than the already large values measured during this Audit.

It is clear from the above findings for ED3N-1, and regardless of the accuracy of projections in the EA of reductions in leachate volumes as the facility throughput increases (discussed further below), that a better, less-odorous means of operating ED3N-1 is required. VES has indicated it is currently working with Veolia Water to improve the current leachate treatment system, and that once those improvements are finalised in the coming months from this Audit, the intention is to treat the leachate currently stored (approximately 20ML) in ED3N-1, prior to implementing an ongoing continuous leachate treatment system, treating leachate directly from the Bioreactor. This should have the effect of significantly reducing the dependence on storage of untreated leachate in ED3N-1 in the future. Once these improvements are implemented, it is almost certain that this will assist in mitigating the current odour emission levels from ED3N-1. Further details on these mitigation measures have been discussed in **Section 8**.

The leachate treatment concept currently practiced at Woodlawn was developed by the University of Queensland (UQ) and assessed by URS in *Chapter 8 of the EA* for the *Woodlawn Expansion Project*. This report concluded that *"..under an increased maximum waste input rate of 1.13 million tpa, over a 10 year period would result in a reduction in the leachate rise because of a greater volume of unsaturated storage becoming available within the waste mass".* VES should apply caution in regards to this prediction and ensure that leachate management for the Bioreactor is optimised in order to reduce storage in ED3N-1 (given the very high SOER's), especially in wetter seasons. It is not clear from the EA how this will be achieved, however, it is based on the fact that fresh waste is able to adsorb leachate to reach optimum moisture levels for Bioreactor processes. As such, leachate recirculation is and will continue to be an important odour mitigation strategy and its optimisation will assist in minimising excess leachate storage volumes in ED3N-1. Put simply, the accuracy of the 10-year projection of minimal excess leachate production requires closer examination and, even if found to be realistic, will not remove the need for an interim leachate management plan involving minimizing excess untreated leachate storage in the ED3N-1 system.

A review of the AAQMP demonstrated that leachate management was missing as an odour mitigation strategy and should be included, based on the very high SOER potential generated by untreated leachate. It's odour monitoring assumptions have also excluded the storage of untreated leachate as an odour source. In light of this finding, a review of the AAQMP may be required.

7.1.1.2 Landfill Gas Extraction System

The Bioreactor's fundamental operation at Woodlawn is based on the waste decay process and the collection and use of the resultant landfill gas for renewable energy generation. An undesired product of this process is the generation of high levels of reduced sulphur compounds (primarily in the form of H_2S) which tend to have very low odour thresholds (for example H_2S is approximately 0.5 ppb) and thus has a high odour impact potential. Other odorous compounds found in landfills include the Volatile Fatty Acids (VFAs). As such, effective extraction of landfill gas will mitigate fugitive gas emissions from the Bioreactor, and will have the mutual effect of abating potential odour impacts from this source.

VES has indicated to the Audit that it has undertaken internal calculations for actual gas capture efficiency, which at the time of this Audit was between 70% and 80%. This Audit understands that VES objectives are to continually increase these gas capture performance efficiencies. This commitment should be effective in abating fugitive gas emissions from the Bioreactor.

Notwithstanding the above, it can be seen that, while the Bioreactor appears to have a relatively effective gas collection system, the potential still exists for fugitive gas emissions to emanate, which could lead to adverse off-site odour impacts. Based on the landfill gas odour concentration determined in this Audit, and using gas generation data provided by VES for the period of January 2009 to June 2012, this Audit has calculated that the total emission rate from leakage would be 752,000 $ou.m^3/s$ and

1,290,000 ou.m^3/s for 80% and 70% gas capture efficiencies respectively (see **Appendix B** for assumptions and calculations used to derive these results). This indicates that while operating with an effective gas collection system, any fugitive emissions of pure landfill gas (notably along the perimeter and other potential gas pathways present in the Bioreactor) would still be a highly significant contributor to odour emissions from the site.

In examining the above odour emission rate scenarios for gas leakage, the Audit team considered the relatively low ambient odour levels at the waste surface. Odour emission rates at the levels calculated would almost certainly result in far higher ambient odour levels in the Bioreactor than those experienced during the Audit, particularly during near-calm early morning conditions, not to mention correspondingly high levels of CH_4 and CO_2 . It is speculated that either the gas is not being emitted at the calculated rates or the gas is undergoing chemical transformation en route to the surface. This latter hypothesis was also raised by GHD in the *Gas Testing Report* of June 2007, in which the low surface methane levels were explained by the possible biological oxidation of the CH_4 in the aerobic upper layers of the Bioreactor. Under such conditions, it is reasonable to expect that the highly biodegradable odorous compounds in the gas (volatile organic acids and sulphides) would also be removed. If confirmed, this effect would be a highly significant finding, from a potential odour impact perspective, and decrease the emphasis on accurately measuring the gas emissions from the Bioreactor. It would also explain the relatively low levels of odour experienced during this Audit at the waste surface and immediately downwind of the Bioreactor.

In support of this hypothesis, the Audit's sampling field team noted that leaking gas emissions at the surface were evident at the waste surface (gas bubbles emanating from water pools). While this bubbling had been identified in previous odour assessments, a sample of this gas suggested that it was not predominantly landfill gas. A clear 'pineapple/fruity' odour characteristic was present, as opposed to the more typical landfill odour ('rotten eggs' or VFAs). Based on the TOU's experience in the odour industry, it was considered that the dominant odorant compound in this gas was most likely ethyl butyrate, formed by the esterification process (i.e. reaction between alcohol and acid). The alcohol likely forms through the fermentation process of putrescible waste (promoted by sugars in food wastes) forming alcohol. The butyric acid is a known breakdown product in the anaerobic waste decomposition process. It is likely that this applies to less mature decomposed waste and is an intermediate process which occurs before the methanogenic reaction process is fully completed. This 'non-landfill gas' emission has not been previously identified in any other study conducted to date at the Woodlawn Bioreactor Facility, despite being found in this Audit to be emitted at a high SOER of 115 ou.m^3/m^2/s and correspondingly high odour concentration of 185,000 ou. Notwithstanding these findings, and given that this 'pineapple/fruity' odour appears to have not been detected outside of the waste surface samples, this Audit finds that its presence is significant in that it supports the GHD and this Audit's hypothesis that biological oxidation of the landfill gas is occurring on fugitive landfill gas emissions.

Another finding from inspection of the modelling projections in the EA is that a base case odour scenario was selected which assumed that landfill gas short-circuits around the edges of the covered waste (assumed to be 2.5 cm wide by the circumference of the Bioreactor (0.0022 ha)) at a calculated SOER of 23.9 ou.m^3/m^2/s. The validity of using this emission area width is questionable, given that it is not possible to sample, using a conventional IFH odour sampling hood, such a narrow area, and considering this Audit's on-site observation that short-circuiting of landfill gas is occurring around the perimeter of the waste, at a distance from the walls greater than the 2.5 cm gap modeled. It is clearly evident from this Audit that these 'wall effects' are very dynamic in nature and depend on the effectiveness of covering, the compaction of the waste and the effectiveness of the gas collection system. Whilst an opinion only, this Audit considers that the potential gas pathways in the Bioreactor could be much greater in size than that assumed in the EA and emitting odour at a much greater OER. The challenge in managing this does become more difficult as the active Bioreactor area and perimeter grows with an expanded waste throughput to the facility. As previously mentioned, VES is continually improving and expanding its gas collection system in order to abate fugitive gas emissions. Gas collection results provided to the Audit shows that gas captured for energy generation and flaring has increased by 88% in the past 12 months leading up to this Audit. The Audit has been advised that VES has also developed a 3 year plan for expanding the gas collection infrastructure to increase gas capture which includes perimeter gas capture systems. This Audit endorses this plan to maximise gas collection and minimise fugitive emissions.

Further to the above, it is understood that the H_2S emanating from the waste surface is partially controlled in-situ through the addition of metal oxide (haematite and magnetite) to the waste as placed. While it is impossible to measure the effectiveness of this strategy, this Audit's on-site field measurement found low levels of H_2S (3 ppm) suggesting that the strategy is working and/or the biological oxidation process of the landfill gas emissions is taking place. As a precaution, it is recommended that this strategy is continued.

According to a recent Stephenson Stack Emission Survey on Generators No. 1, 2, 3 & 4 carried out in June 2012, all combusted gas emissions from all four generators comply with the EPL Limits for NO_x, SO_3/H_2SO_4 and H_2S. Although no data are available for odour levels in the engine exhausts the internal combustion process is usually very effective in destroying odour, to the extent that these exhausts are considered to be an effective odour mitigation measure and highly unlikely to be emitting problematical odour emissions. This could be confirmed if odour testing was included in the next scheduled stack testing of these exhausts.

7.1.1.3 Water cart to control dust

Water carting is a well-established method and seen across many waste facility across Australia in abating dispersion of dust, if carried out regularly. According to the SLR Consulting Odour Assessment 2010, water is used on site to control dust and protect the unsealed road surfaces. This Audit did witness this on site and endorses the continued practice as a means of controlling dust. Although dust control is a relatively minor odour mitigation practice it is known that odours do attach to particulates and this form of transportation and dispersion is common.

Since the EA, VES has advised that the haul road within the mine void was sealed to increase the efficiency of operations and to minimise potential dust emissions. This now means that all access roads between the Intermodal Facility and the Bioreactor are sealed up to the waste surface.

7.1.1.4 Using the minimal active tipping face as practically possible

For odour impact assessments at landfills in general it is usual for the focus to be on those odour sources that are obvious and relatively easy to quantify. This includes the tip face and material that has yet to be covered. There is generally real difficulty in quantifying diffuse odour emissions from capped and covered areas, and this typically narrows the focus even further on the easily quantifiable sources. This appears to be the case with the Woodlawn Bioreactor Facility and is typified by the previously-mentioned problems in determining the emission rates and impacts from fugitive landfill gas releases.

Based on the sampling and testing within the Bioreactor for those odour emission sources able to be quantified, this Audit found that odour emissions from the freshly-tipped and 1 week old waste material are similar to the predicted SOER values used in the EA. It is not known how these emissions compare with the fugitive odour emissions that are unable to be quantified. Interestingly, this material has been considered by previous studies to be greater than other emission sources identified at the site. Unfortunately, the inability to quantify all Bioreactor odour source emissions lessens the accuracy of dispersion modeling-based odour impact assessments for the site. For this reason, this Audit endorses the pragmatic odour mitigation strategy developed by VES for the site to minimise the exposed active tipping area within the Bioreactor.

A review of the odour dispersion modelling carried out in the EA by SLR Consulting Odour Assessment (2011), assumed that as a worst case scenario the active tipping face would be 2 ha. In comparison, the AAQMP assumes an active area of 4 ha as the worst case scenario (namely in the latter stages of the Bioreactor when the active face would be close to the final surface elevations). Additionally, a waste cover in the EA used a waste covered area of 6.03 ha, while the AAQMP assumes 12 ha. The difference in area values was clarified by VES to be due to an increased tonnage input which would require an increase to the tipping area. As such, this Audit has used a 4 ha active tipping face area as the worst case scenario.

The SOER values determined during this Audit for fresh to 1 week old waste varied from 0.17 to 6.91 ou.$m^3/m^2/s$. This compares well with the value used in the EA modeling (7.1 ou.$m^3/m^2/s$). The SOER values for disturbed fresh material (11.1 and 22.2 ou.$m^3/m^2/s$) were greater than the values modeled but were collected in a known problem location where higher levels of H_2S had been detected. On the basis of these results, the predicted SOER values used in the EA are considered appropriate, for the current and future operations.

7.1.1.5 Transportation of waste in sealed containers until unloading at the Bioreactor

In regards to the transportation of waste to the Bioreactor from the Crisps Creek Intermodal Facility, the AAQMP states that there are several key features to this including:

- Transportation of waste in sealed containers until unloading at the Bioreactor;
- Containers will be maintained as required at the Bioreactor site, prior to returning to the intermodal facility;
- Daily inspection of containers at Crisps Creek Intermodal Facility prior to unloading of train to identify any faulty containers requiring maintenance;
- All containers entering and leaving the Bioreactor site will be sealed; and
- The wheel wash to clean trucks before leaving site;

This Audit has found that the above measures are very effective in eliminating odour impact from the waste transport operations for Woodlawn site. The effectiveness of sealing the waste in containers for transportation has been proven to virtually eliminate all odours, through TOU's regular odour Audits at the VES Clyde Transfer Terminal (the current primary source of waste for the Woodlawn Bioreactor) independent of this Audit. As such, due to the complete containment of waste within the containers whilst at Crisps Creek IMF, any potential odour emission sources would be virtually eliminated (given the daily inspection practices of the containers are sustained to identify any faulty containers).This Audit determined that there was no need to sample this facility as it is most unlikely to result in any significant odour emissions leading to adverse odour impacts beyond the site boundary.

All other measures are considered to be good industry practices and appear to be successful in mitigating fugitive odour impacts from the transportation of waste through sensitive locations.

7.1.2 Condition 7 (C)

Review the proponents' production data (that are relevant to the odour Audit) and complaint records

The production data viewed that are relevant to the Audit included:

- Waste throughput to the Bioreactor;
- On-site evaporation data; and
- Landfill gas consumption in the generators and flare system.

This Audit obtained production data, complaint records and evaporation data from VES for the Woodlawn Bioreactor Facility. These are presented in **Appendix C**.

It appears that all record-keeping duties in this regard are being adequately maintained. Complaints records show that the necessary fields required by the *EPL Condition M4 Recording of pollution complaints* are being logged by VES.

7.1.3 Condition 7 (F)

Determine whether the project is complying with the requirements in this approval to protect receivers against offensive odour

This Audit has examined compliance or otherwise with *Condition 7(f)* from two perspectives, namely odour complaint record analysis and compliance with the modelling-based, project-specific odour performance goal of 6 ou.

A review of the complaints records for the site indicates that adverse odour impacts have been occurring since 2005, suggesting, on face value, that *Condition 7 (f)* has not always being met. Unfortunately the complaint data does not assist in identifying the nature or likely source of the problematic odours. This Audit finds that VES has been actively undertaking measures to minimise odour emissions from the Bioreactor Facility, including participation in a community consultation process designed to provide the necessary odour impact feedback. This feedback is important given the widely different odour characters from the Bioreactor emissions and Leachate Dam emissions.

The odour dispersion modelling results determined in the revised EA by SLR Consulting showed concentrations of less than 3.4 ou as a 99th percentile, 1 second nose response time average; thus complying with the project specific odour performance goal of 6 ou.

This Audit did not have access to the site-specific odour dispersion model used in the EA assessment and did not carry out modelling, using the odour emission rates determined in the Audit. It is therefore unable to determine whether compliance with the 6 ou criterion is being achieved, based on the approach used in odour dispersion modelling, whereby the modelled emission rates prevail over an entire year. Clearly there is evidence that the Audit's odour emission data for the leachate management system and ED3N-1 in particular, may represent higher transient emissions and not represent what VES consider normal operating conditions. VES's intention to upgrade the leachate management system should and must reduce the odour emissions from ED3N-1 if compliance with the EA modelling criterion is to be repeated in the future. At the time this audit was undertaken and based on the odour emissions identified during sampling for this audit, it is possible the 6 ou criterion goal may not have been met Subsequent Audits should incorporate repeat sampling and testing of the site emissions, following the planned leachate system upgrade, and involve a re-run of the existing dispersion model, to quantitatively check compliance. Based on this Audit's findings, compliance is likely to be achieved if the emissions from ED3N-1 are returned to the values used in the EA modelling

7.2 ODOUR EMISSIONS INVENTORY DISCUSSION

Interestingly, all previous odour assessments for the Woodlawn Bioreactor Facility have failed to clearly document estimates for OER for the individual and combined odour sources at the site or tabulate a site-wide odour emission inventory, instead focusing on SOER data as a way of comparing sources and assessing potential impacts. Clearly the dispersion modelling has needed to determine individual source and total site OERs in projecting downwind impacts, but these are not documented. While this approach does not detract from the odour dispersion modeling process and its projections of odour beyond the site boundaries, this Audit recommends that the overall odour emissions inventory for the site should be examined in future audits to place into context the emissions from any single source.

It is the finding of this Audit that the methods undertaken to identify and prioritise odour emission sources has identified the significance of key sources that were not clearly identified in the past.

Table 7.1 details the odour emission inventory for the site as determined by the testing carried out in this Audit, and compares these results with predictions of emissions contained in the EA. There are odour emissions not listed in the inventory, emanating mostly from sources where quantitative measurement or even estimates are difficult. These include the fugitive odour releases from the Bioreactor, previously described as potential gas pathways, arising from gas leakages from the covered areas and around the walls of the Bioreactor. Despite these omissions it is considered that the incomplete inventory has real value and is discussed below.

Table 7.1 – Measurable Odour Emissions Rates for the Woodlawn Facility site

Sample Location	Area (m^2)^^	Audit		EA	
		Mean SOER ($ou.m^3/m^2/s$)	Mean OER ($ou.m^3/s$)	Mean SOER ($ou.m^3/m^2/s$)	Mean OER ($ou.m^3/s$)
ED3N-1	7,000	394	2,760,000	8.80	61,600
Active Tipping Face^	40,000^^^	8.36	334,000	7.30	292,000
Storage Pond 7	1,200	85	102,000	n/m	n/m
ED3N-2 & 3	13,000	0.29	3,800	7.40	96,200
ED3N-4	16,000	0.41	6,600	0.70	11,200
Leachate Aeration Dam^^^^	2,000	0.46	920	3.6	7,200^^^^^

^ excludes potential gas pathways within Bioreactor and other fugitive emission sources
^^ areas used by this Audit may vary to that used in the EA
^^^as per AAQMP estimate
^^^^excludes emissions from the aeration/stripping action which is likely to be more odorous
^^^^^represents mean result for different batches of leachate between 2007 to 2011

From a comparative viewpoint, the SOER results in **Table 7.1** show close agreement between the Audit results and the EA value for the Active Tip Face emissions, and to a lesser extent, ED3N-2 & ED3N-3. This result is particularly significant for ED3N-4 because its contents are mechanically evaporated, under suitable wind and weather conditions. The low Audit result for ED3N-3, along with that for ED3N-2, is even more significant since this dam is also equipped with evaporator units. The emissions from the evaporators are further discussed below.

The most obvious finding from the odour emission inventory analysis is that the measured emissions from dam ED3N-1 exceed the predicted emissions by a factor of more than forty, and constitute the major site emission, dominating the combined emissions from all other sources at the site. This demonstrates the potential for ED3N-1 to contain highly odorous leachate batches. Put simply, and without the benefit of odour dispersion modelling, if the emissions from ED3N-1 prevailed for extended periods of time, they would easily account for the bulk of adverse odour impacts experienced in the surrounding areas. It is understood that the storage of large amounts of excess leachate in ED3N-1 is due to changes in leachate management by

VES over the past 12 months leading up to this Audit. It is not known whether the condition of the ED3N dam system, as occurring during this Audit was representative of ’normal’ conditions under which the facility operates, or is a transient result of two years of higher than average rainfall. While the EA has indicated that within ten years of increasing the waste processing capacity of the facility the quantity of excess leachate will be minimal, this Audit has focused on the current and near-future leachate quantities. Notwithstanding these considerations, VES has indicated to the audit team that it is aware of the problem and is currently investigating alternate means of managing and treating the leachate with Veolia Water (refer to **Section 7.1.1.1** for further details).

When the above finding regarding ED3N-1 are combined with the relatively high SOER and OER Audit values for Storage Pond 7, the data strongly suggest that the management of leachate in the Bioreactor, up to the point where it is treated in the Leachate Aeration Dam, needs to be reviewed as a priority matter in order to reduce these odour emissions to acceptable levels. . This Audit therefore supports the above investigations by VES. As previously mentioned, this Audit does understand that ED3N-1 is only used as a storage pond for excess leachate for contingency purposes and VES believe that future volumes are expected to be minimal. However, as previously mentioned, in the interim VES has indicated that, once the improvements to the treatment system are finalised in the coming months, the intention is to treat the leachate currently stored in ED3N-1 (approximately 20ML), prior to implementing an ongoing continuous leachate treatment system directly from the Bioreactor. Advice from VES confirms that it is not possible to completely prevent the mixing of Bioreactor leachate with acid mine drainage as a means of reducing sulphate and hydrogen sulphide levels in this combined leachate stream. This is unfortunate since the elevated levels of hydrogen sulphide (180 ppm) immediately above the surface of ED3N-1, together with the olfactory assessments by the Audit team, indicate that this is likely to be the dominant odorant in the system.

In terms of the significance of the fugitive odour emissions from the Woodlawn site, and the Bioreactor in particular, this Audit produced quantitative emission data for the gas emissions known to be occurring around the edges of the waste in the Bioreactor (wall effects) that differ from the olfactory observations by the Audit team. Given the shape of the mine void and the sloping walls, VES have advised that it is difficult to extend the gas collection well system to fully capture landfill gas short-circuiting in the gap between the waste and the walls, however, have recently refined the design of perimeter collection systems and has installed a pilot system along the western perimeter of the Bioreactor which will be monitored to determine the effectiveness of gas capture in this area. The SOER data collected by the team, using a 400 mm diameter sampling hood adjacent to the walls, indicated much lower SOER values than previously tested, and subsequently used in the EA modelling. Curiously, that modelling applied the SOER results to an emission area equivalent to a 25 mm wide strip around the perimeter of the Bioreactor, despite the sampling hood being the same 400 mm diameter as that used in this Audit. It was the Audit team's judgement that the Audit testing results failed to account for the bulk of the obvious fugitive gas releases that occur in particular sections of the perimeter of the Bioreactor. As a result, it is considered that the EA modelling is likely to have under-estimated the odour emission rate from this source. It is also likely that the SOER values contained in **Table 6.1** (samples TOUSC12235 and 12236) also understate the magnitude of this source. The implications of this effect is that this Audit considers that the 'wall effects' emissions within the Bioreactor are significant to warrant ongoing odour mitigation efforts.

7.3 OPERATION OF THE MECHANICAL EVAPORATOR UNITS

The derived results from the Liquid Odour Measurement (LOM) testing, as contained in **Table 6.3**, compare the conventionally-determined OER for ED3N-4, using the SOER and dam area values, with the OER determined by considering the odour released when the evaporation units are in operation and odorous liquid is evaporated into the atmosphere. The LOM method is not widely used outside TOU but offers a means of quantifying an odour emission rate that previously was not considered in odour impact assessment studies as was the case with the EA assessment. It could also be used as a potential odour management tool whereby the contents of either dam could be tested, before operation of the evaporator units, to check odour release potential of the operation.

It can be seen that the odour emissions from the operation of the evaporator units depend upon the number of units in operation, and the efficiency of the units, which in turn depends on ambient temperature and relative humidity. It can also be seen that the evaporation OER for ED3N-4 is greater than the SOER-derived value by a factor of 9 in June 2012 (from 6,570 ou.m^3/s to 60,700 ou.m^3/s) and by a factor of 17 in January 2012 (from 6,570 ou.m^3/s to 113,100 ou.m^3/s). Although not measured, the emissions from the operation of the evaporator units on ED3N-3 are also expected to be of the same magnitude (in terms of odour emissions per unit) as those for ED3N-4, given their similar SOER values.

It is acknowledged that VES operates the evaporators under wind and weather conditions only when the potential for downwind odour impacts is low. This Audit endorses this continued practice.

8 PRELIMINARY MITIGATION OPTIONS

Condition 7 (G & H)

Outline all reasonable and feasible measures (including cost/benefit analysis, if required) that may be required to improve odour control at the site and; and

Recommend and prioritise (mandatory and non-mandatory) recommendations for their implementations

In general terms this Audit has found that the odour emissions from the leachate management system and from ED3N-1 in particular, dominate the emissions from the site as a whole and need to reduced, in order to minimise future impacts in the surrounding areas. Opportunities have also been identified for reducing odour emissions from the Bioreactor. Possible odour mitigation options for these areas are discussed below. These options are not definitive and other management and technological options may be available.

8.1 MANDATORY MITIGATION MEASURES

8.1.1 Leachate Treatment

The existing leachate management system has been modified over the years to accommodate changing leachate volumes and conditions. At the time of the Audit, VES advised TOU that excess untreated leachate was stored in ED3N-1 due to improvements to the leachate treatment system with Veolia Water.

At the present time the system operates as a batch-treatment system, where leachate is pumped from the Bioreactor into ED3N-1 for storage until it is treated in the Leachate Aeration Dam. The leachate in ED3N-1 is maintained in a mildly alkaline condition, to minimise the release of hydrogen sulphide, but no other deliberate treatment occurs in that dam, other than natural evaporation and some natural aerobic and possibly anoxic breakdown of the organics. The untreated leachate stored in ED3N-1 should be treated in the current leachate treatment systems as a priority while improvements are implemented. The Leachate Aeration Dam is understood to operate on an approximate 2-month cycle, where it is loaded with leachate from ED3N-1 and aerobic treatment occurs until the liquor is deemed to be stable enough to be transferred to ED3N-2, 3 and 4. Based on the SOER results from this Audit the process is very effective in reducing odour emissions from ED3N-2, 3 and 4, to levels lower than predicted in the EA. Periodically, the sludge from the Leachate Aeration Dam is removed and disposed of into the Bioreactor and covered with fresh waste and cover material. The batch process is then repeated. At a treatment process level, the existing batch mode of operating the Leachate Aeration Dam is clearly resulting in good treatment and acceptable odour emissions in ED3N-2, 3 and 4, but relies upon the storage of untreated leachate in ED3N-1 for the duration of the batch cycle, and the consequent odour emissions from that dam. In addition, the treatment process in the Leachate Aeration Dam must deal with the high initial organic loadings at the commencement of the cycle – a situation not conducive to optimal balancing of organic loadings and biomass activity.

TOU recommends that VES improve management of leachate treatment to eliminate the requirement to store excess leachate within ED3N-1. This can be achieved by implementing the improvements currently been undertaken in conjunction with Veolia Water to the current leachate treatment system. Once those improvements are finalised in the coming months from this Audit, the intention is to treat the leachate currently stored (approximately 20ML) in ED3N-1, prior to implementing an ongoing continuous leachate treatment system, treating leachate directly from the Bioreactor. This should have the effect of significantly reducing the dependence on storage of untreated leachate in ED3N-1. It is understood that VES has a similar view and is currently investigating similar treatment options. If VES are unable to manage leachate treatment without the need for storage of excess leachate in ED3N-1, then additional management measures will need to be adopted. This could include development of a continuous leachate treatment system or maintaining its contents under highly alkaline conditions or implementing other technologies that would achieve to eliminate the need to store leachate in ED3N-1.

8.1.2 Fully Aerobic Treatment

VES in conjunction with Veolia Water are currently redesigning the current batch leachate treatment process to a fully aerobic treatment system. The new design will be a continuous system where leachate will be pumped directly from the bioreactor through the leachate treatment pond and the treated leachate will be extracted at the opposite end of the dam. This liquid will then pass through a flocculation process and then a clarification tank and the liquid will go directly to the evaporation ponds in ED3N. It is intended this will eliminate the need for storage in the ED3N-1 pond.

The disadvantage of fully-aerobic treatment options would be an increase in power consumption at the Woodlawn site.

8.2 NON-MANDATORY MITIGATION OPTIONS

8.2.1 Odour Mitigation from the Bioreactor

8.2.1.1 Biofiltration

Consideration should be given to the use of simple biofiltration as a means of mitigating the effects of fugitive landfill gas/odour releases around the perimeter of the Bioreactor. This process uses aerobic processes, similar to those found in aerobic wastewater treatment processes, to oxidize odorous compounds present in a gas stream.

While biofilters are not commonly used for this particular application, the presence of the ester-like compounds in the observed gas emissions in the Bioreactor indicates that biological oxidation of the landfill gas odours is already occurring, and biofiltration could be trialed around the perimeter. In its simplest form the biofilter would consist of a compost-based biofilter medium positioned at known emission locations around the perimeter, to a depth of 0.5 – 1.0m and a width of 3-5m. This medium would need to be kept moist by the application of stormwater or aerobic treated effluent. It could be reused around the site until exhausted.

8.2.1.2 Improved Landfill Gas Capture

This Audit has been advised that in 2011, VES reassessed the existing gas collection systems and redeveloped a new strategy to enable more efficient gas collection. This strategy was initiated in 2011 and was formalised in an Infrastructure Plan which was finalised in June 2012. A review of VES generation and flaring data indicates that landfill gas capture volumes at the site have increased by over 88% as a result of the redevelopment of the gas collection systems. This Audit recommends that VES continue the implementation of the gas systems detailed in the Infrastructure Plan, including proposed perimeter gas collection infrastructure systems. The gas capture efficiency is continuously monitored and recorded and the surface of the Bioreactor monitored to determine effectiveness of capture within specific gas capture areas of the Bioreactor.

8.2.2 Operation of the Evaporator Units

This Audit concurs with the current operating regime for the Evaporator Units on ED3N-3 and ED3N- 4 in which the units are operated only in favourable wind and weather conditions. The quantification by this Audit of the odour emissions from these units will enable VES to appreciate the relative significance of these emissions, in the context of other site emissions, and potentially better manage their individual and combined operation.

It is recommended that VES reviews the operation of the Evaporator Units in light of the findings of this Audit regarding the potential of this process to emit odours in significant quantities. The review should re-examine appropriate weather conditions for their use and the significance of the quality of the effluent in generating odours during evaporation activity.

9 AUDIT SUMMARY AND CONCLUSIONS

- The Audit involved a preliminary investigation, detailed odour sampling at the Woodlawn site and reviewing of previous studies and reporting.

- All key odour emission sources amenable to direct quantification were measured in this Audit.

- The quantitative findings of this Audit are summarised in **Table 9.1.**

Table 9.1 – Measurable Odour Emissions Rates for the Woodlawn Facility site

Sample Location	Area (m^2)^^	Audit		EA	
		Mean SOER ($ou.m^3/m^2/s$)	Mean OER ($ou.m^3/s$)	Mean SOER ($ou.m^3/m^2/s$)	Mean OER ($ou.m^3/s$)
ED3N-1	7,000	394	2,760,000	8.80	61,600
Active Tipping Face^	40,000^^^	8.36	334,000	7.30	292,000
Storage Pond 7	1,200	85	102,000	n/m	n/m
ED3N-2 & 3	13,000	0.29	3,800	7.40	96,200
ED3N-4	16,000	0.41	6,600	0.70	11,200
Leachate Aeration Dam^^^^	2,000	0.46	920	3.6	7,200^^^^^

^ excludes potential gas pathways within Bioreactor and other fugitive emission sources

^^ areas used by this Audit may vary to that used in the EA

^^^as per AAQMP estimate

^^^^excludes emissions from the aeration/stripping action which is likely to be more odourous

^^^^^represents mean result for different batches of leachate between 2007 to 2011

- As shown in the above table, ED3N-1 is currently the largest odour emission contributor, yielding a SOER result 40 times greater than that predicted in the EA. This finding is considered to be as a result of higher than normal volumes of leachate generated in the preceding months.

- The SOER results obtained in this Audit for ED3N-2, ED3N-3 and ED3N-4 are lower than that found in the EA, and suggests that leachate quality is satisfactory, once it reaches these dams.

- Based on the sampling and testing within the Bioreactor for those odour emission sources able to be quantified, this Audit has found that the odour emissions from the freshly-tipped and 1 week old waste material are similar to the predicted SOER values used in the EA. It is not known how these emissions compare with the fugitive odour emissions that are unable to be accurately quantified.

- This Audit has attempted to quantify the extent of these fugitive gas emissions by calculating the odour emission rate from gas leakage, based on 80% and 70% gas capture efficiencies, the measured gas odour concentration of 9,300,000 odour units, and minimal odour concentration reduction in the gas as it passes through the upper layers of the waste. The resultant odour emission rates were calculated to be 752,000 ou.m^3/s and 1,290,000 ou.m^3/s for 80% and 70% gas capture efficiencies respectively. These very high emission rates are not compatible with the relatively low odour ambient odour levels within the Bioreactor and this Audit finds that either substantial odour reduction is occurring before the gas exists the waste layer, or the gas capture efficiencies are greater than the 70-80% estimates supplied by VES.

- A review of VES' Ambient Air Quality and Monitoring Plan (May 2007) and site visit during this Audit, resulted in the identification of several odour controls currently used at the Woodlawn Bioreactor Facility. This Audit sought to measure their effectiveness in a qualitative manner, where possible.

- This Audit has found that the current odour controls are effective in mitigating odour emissions. These include:

    - Improvement of the Landfill Gas Extraction system;
    - Treatment of extracted leachate prior to storage in ED3N system;

- Leachate recirculation methods using direct injection of leachate in the sub-surface layers of waste in the Bioreactor;
- Improvement of evaporation capabilities via the installation of automated Evaporator Units operating under favorable meteorological conditions;
- Water cart to control dust and sealed roads, which is an ongoing practice to minimise dust generation and suppress potential odours dispersed in this manner;
- Using the minimal active tipping as practically possible during operations; and
- Transportation of waste in sealed containers until unloading at the Bioreactor.

- Notwithstanding these measures, this Audit has found that the following improvements are possible and achievable as a means of further mitigating odour emissions from the Woodlawn site:

  - *Treatment of excess leachate:* Better management of excess leachate storage in ED3N-1 is necessary in the interim via a more continuous in-situ leachate treatment system, until the site's need for storage into this dam is proven to be reduced or eliminated. As a priority, VES should focus on the removal of untreated excess leachate currently in ED3N-1 and follow by adequately managing leachate within the Bioreactor or any excess leachate treated directly through the leachate treatment system prior to storage in ED3N-1. If VES are unable to manage leachate treatment without the need for storage of excess leachate in ED3N-1, then additional management measures will need to be adopted; and

  - *Continued on-going improvement in Landfill Gas Extraction:* This Audit supports VES's plan to continuously increase the efficiency of gas capture capabilities including around the perimeter of the Bioreactor. A review of production data and advice from VES has shown that Landfill Gas Capture has increased by 88% over the past 12 months. This is a highly positive result. It is recommended that improvements to the landfill gas extraction system are continued to be implemented as outlined in the Infrastructure Plan to minimise potential odour from fugitive has emissions from the Bioreactor.

- A review of production data and complaints records relevant to this Audit demonstrates that all record-keeping duties by VES in this respect are currently being adequately maintained.

- No samples were collected from the Crisps Creek Intermodal Facility as the waste transportation process is enclosed, virtually eliminating any potential odour emission sources from this facility (given the daily inspection practices of the containers are sustained to identify any faulty containers). This Audit has determined that it is most unlikely to be a significant odour emission source.

- This Audit has examined compliance or otherwise with *Condition 7(f)* from two perspectives, namely odour complaint record analysis and compliance with the modelling-based, project-specific odour performance goal of 6 ou.

    - A review of the complaints records for the site indicates that adverse odour impacts have been occurring since 2005, suggesting, on face value, that *Condition 7 (f)* has not always being met. Unfortunately the complaint data does not assist in identifying the nature or likely source of the problematic odours;
    - The odour dispersion modelling results determined in the revised EA by SLR Consulting showed concentrations of less than 3.4 ou as a 99th percentile, 1 second nose response time average; thus complying with the project specific odour performance goal of 6 ou. This Audit did not have access to the site-specific odour dispersion model used in the EA assessment and did not carry out modelling, using the odour emission rates determined in the Audit. It is therefore unable to determine whether compliance with the 6 ou criterion is being achieved, based on the approach used in odour dispersion modelling, whereby the modelled emission rates prevail over an entire year. Clearly there is evidence that the Audit's odour emission data for the leachate management system

and ED3N-1 in particular, may represent higher transient emissions and not represent what VES consider normal operating conditions. VES's intention to upgrade the leachate management system should and must reduce the odour emissions from ED3N-1 if compliance with the EA modelling criterion is to be repeated in the future;

- At the time this audit was undertaken and based on the odour emissions identified during sampling for this audit, it is possible the 6 ou criterion goal may not have been met. Subsequent audits should incorporate repeat sampling and testing of the site emissions, following the planned leachate system upgrade, and involve a re-run of the existing dispersion model, to quantitatively check compliance. Based on this Audit's findings, compliance is likely to be achieved if the emissions from ED3N-1 are returned to the values used in the EA modelling.

- This Audit finds that VES has been actively undertaking measures to minimise odour emissions from the Bioreactor Facility, including participation in a community consultation process designed to provide clear communication in relation to the site operations and any odour impact feedback. This feedback is important given the widely different odour characters from the Bioreactor emissions and Leachate Dam emissions.

- This Audit has examined options for reducing odour emissions from the Woodlawn site and makes the following non-exhaustive recommendations:

<u>Mandatory recommendations</u>

- In general, review and improvement of leachate treatment at the site.

- Three options are:

    1. Maintaining the existing batch leachate treatment system but prioritising the removal of untreated excess leachate in ED3N-1 and adequately managing leachate within the Bioreactor or any excess leachate treated

directly through the treatment system prior to storage in ED3N-1. If storage of untreated leachate is required in ED3N-1 for an extended period, the covering of ED3N-1 will need to be considered;

2. Continue to develop the current batch leachate treatment system into a continuous leachate treatment system; and

3. Continue to implement the current Gas Infrastructure Plan to increase gas capture, including from the perimeter areas.

<u>Non-mandatory recommendations</u>

- Other odour mitigation measures recommended for consideration include:

    - *Biofiltration Trial:* filling areas of the Bioreactor perimeter identified as potential emission sources with suitable organic-based media for biofiltration of landfill gas short-circuiting due to ‘wall effects’ and monitor the effects;

    - *Operation of the Evaporator Units:* It is recommended that VES reviews the operation of the Evaporator Units in light of the findings of this Audit regarding the potential of this process to emit odours in significant quantities. The review should re-examine appropriate weather conditions for their use and the significance of the quality of the effluent in generating odours during evaporation activity; and

    - *Review gas and leachate quality in different areas of the Bioreactor:* It is recommended that VES reviews gas and leachate quality to identify areas of higher potential odour sources that can be targeted with future gas collection infrastructure and leachate management strategies.

REFERENCES

1. NSW Government Department of Planning & Infrastructure, Development Assessments, Major Assessments, *Woodlawn Waste Facility: Woodlawn Expansion Project,* July 2012

2. Stephenson Environmental Management Australia, *Woodlawn Landfill Stack Emission Survey – Generator Nos. 1,2,3 &4,* July 2012

3. Golder Associates, *Independent Environmental Audit Woodlawn Waste Management Facility,* April 2012

4. Submissions Report Woodlawn Expansion Project, *Appendix C – SLR Global Environmental Solution: Woodlawn Bioreactor Odour and Dust Impact Assessment Woodlawn Expansion Project,* March 2011

5. Environmental Assessment Woodlawn Expansion Project Volume 2 – Appendices, *Appendix D – Air Quality and Odour Assessment,* March 2011

6. Environmental Assessment Woodlawn Expansion Project Volume 2 – Appendices, *Appendix F – Greenhouse Gas Assessment,* March 2011

7. Environmental Assessment Woodlawn Expansion Project Volume 1 – Main Report, *Chapter 6 – Environmental Management,* August 2010

8. Environmental Assessment Woodlawn Expansion Project Volume 1 – Main Report, *Chapter 9 – Air Quality and Odour Assessment,* August 2010

9. Environmental Assessment Woodlawn Expansion Project Volume 1 – Main Report, *Chapter 10 – Greenhouse Gas Assessment,* August 2010

10. Veolia Environmental Services Pty Ltd, *Woodlawn Bioreactor Ambient Air Quality Monitoring Plan,* May 2007

REPORT SIGNATURE PAGE

The Odour Unit Pty Ltd (NSW)

P: (02) 9209 4420

F: (02) 9209 4421

E: info@odourunit.com.au

ABN: 53 091 165 061

Terry Schulz
Managing Director

Michael Assal
Engineer

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Appendix A: Odour Concentration Result Sheets

THE ODOUR UNIT

Aust. Technology Park
Locomotive Workshop
Suite 16012
2 Locomotive Street
Eveleigh NSW 2015

Phone: +61 2 9209 4420
Facsimile: +61 2 9209 4421
Email: info@odourunit.com.au
Internet: www.odourunit.com.au
ABN: 53 091 165 061

NATA
Accreditation Number: 14974

Odour Concentration Measurement Results

The measurement was commissioned by:

Organisation	Veolia Environmental Services	Telephone	(02) 9841 2932
Contact	Stephen Bernhart	Facsimile	(02) 9842 2992
Sampling Site	Woodlawn	Email	Stephen.Bernhart@veolia.com.au
Sampling Method	IFH	Sampling Team	TOU (JS + MA)

Order details:

Order requested by	Stephen Bernhart	Order accepted by	MA
Date of order	1/06/2012	TOU Project #	N1806L.03
Order number	4502181100	Project Manager	MA
Signed by	Stephen Bernhart	Testing operator	AS

Investigated Item	Odour concentration in odour units 'ou', determined by sensory odour concentration measurements, of an odour sample supplied in a sampling bag.
Identification	The odour sample bags were labelled individually. Each label recorded the testing laboratory, sample number, sampling location (or Identification), sampling date and time, dilution ratio (if dilution was used) and whether further chemical analysis was required.
Method	The odour concentration measurements were performed using dynamic olfactometry according to the Australian Standard 'Determination of Odour Concentration by Dynamic Olfactometry AS/NZS4323.3:2001. The odour perception characteristics of the panel within the presentation series for the samples were analogous to that for butanol calibration. Any deviation from the Australian standard is recorded in the 'Comments' section of this report.
Measuring Range	The measuring range of the olfactometer is $2^2 \leq \chi \leq 2^{18}$ ou. If the measuring range was insufficient the odour samples will have been pre-diluted. The machine is not calibrated beyond dilution setting 2^{17}. This is specifically mentioned with the results.
Environment	The measurements were performed in an air- and odour-conditioned room. The room temperature is maintained between 22^{o}C and 25^{o}C.
Measuring Dates	The date of each measurement is specified with the results.
Instrument Used	The olfactometer used during this testing session was: ODORMAT SERIES V02
Instrumental Precision	The precision of this instrument (expressed as repeatability) for a sensory calibration must be $r \leq 0.477$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V02: r = 0.3158 (June – November 2011) Compliance – Yes
Instrumental Accuracy	The accuracy of this instrument for a sensory calibration must be $A \leq 0.217$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V02: A = 0.2165 (June – November 2011) Compliance – Yes
Lower Detection Limit (LDL)	The LDL for the olfactometer has been determined to be 16 ou (4 times the lowest dilution setting)
Traceability	The measurements have been performed using standards for which the traceability to the national standard has been demonstrated. The assessors are individually selected to comply with fixed criteria and are monitored in time to keep within the limits of the standard. The results from the assessors are traceable to primary standards of n-butanol in nitrogen.

Date: Wednesday, 27 June 2012

Panel Roster Number: SYD20120621_040

J. Schulz
NSW Laboratory Coordinator

A. Schulz
Authorised Signatory

Odour Sample Measurement Results
Panel Roster Number: SYD20120621_040

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Nominal Sample Dilution	Actual Sample Dilution (Adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (ou)	Sample Odour Concentration (Final, allowing for dilution) (ou)	Specific Odour Emission Rate ($ou.m^3/m^2/s$)
Active tipping area - Southwest corner (disturbed)	SC12226	20/06/2012 1000hrs	21/06/2012 1021hrs	4	8	-	-	17,900	17,900	11.1
Active tipping area - Southwest corner within Void (disturbed)	SC12227	20/06/2012 1010hrs	21/06/2012 1047hrs	4	8	-	-	35,700	35,700	22.2
Potential gas pathways within Void (Evidence of gas leak – 3ppm H_2S)	SC12228	20/06/2012 1040hrs	21/06/2012 1119hrs	4	8	-	-	8,190	8,190	5.20
Fresh waste 1 day old (disturbed – southwest within Void)	SC12229	20/06/2012 1100hrs	21/06/2012 1150hrs	4	8	-	-	11,600	11,600	6.91
Covered area – South within Void	SC12230	20/06/2012 1145hrs	21/06/2012 1258hrs	4	8	-	-	431	431	0.25
Aged Waste (1 week old)	SC12231	20/06/2012 1215hrs	21/06/2012 1322hrs	4	8	-	-	304	304	0.17

Note: The following are not covered by the NATA Accreditation issued to The Odour Unit Pty Ltd:

1. The collection of Isolation Flux Hood (IFH) samples and the calculation of the Specific Odour Emission Rate (SOER).
2. Final results that have been modified by the dilution factors where parties other than The Odour Unit Pty Ltd. have performed the dilution of samples.

Odour Sample Measurement Results
Panel Roster Number: SYD20120621_040

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Nominal Sample Dilution	Actual Sample Dilution (Adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (ou)	Sample Odour Concentration (Final, allowing for dilution) (ou)	Specific Odour Emission Rate (ou.m^3/m^2/s)
Aged waste (1 week old)	SC12232	20/06/2012 1220hrs	21/06/2012 1359hrs	4	8	-	-	2,230	2,230	1.42
Potential gas pathways within Void (Bubbling gas via hood)	SC12233	20/06/2012 1300hrs	21/06/2012 1418hrs	4	8	-	-	185,000	185,000	n/a
Potential gas pathways within Void (Bubbling gas)	SC12234	20/06/2012 1310hrs	21/06/2012 1502hrs	4	8	-	-	185,000	185,000	115
Potential gas pathways within Void (Wall effects – west within Void edge)	SC12235	20/06/2012 1415hrs	21/06/2012 1548hrs	4	8	-	-	4,470	4,470	2.94
Storage Pond 7	SC12237	20/06/2012 1500hrs	21/06/2012 1642hrs	4	8	-	-	131,000	131,000	85.0
Potential gas pathways within Void (Wall effects – northwest within Void edge)	SC12236	20/06/2012 1510hrs	21/06/2012 1617hrs	4	8	-	-	2,440	2,440	1.61

Note: The following are not covered by the NATA Accreditation issued to The Odour Unit Pty Ltd:

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Odour Panel Calibration Results

Reference Odorant	Reference Odorant Panel Roster Number	Concentration of Reference gas (ppb)	Panel Target Range for n-butanol (ppb)	Measured Concentration (ou)	Measured Panel Threshold (ppb)	Does this panel calibration measurement comply with AS/NZS4323.3:2001 (Yes / No)
n-butanol	SYD20120621_040	49,900	$20 \leq \chi \leq 80$	861	58	Yes

Comments None.

Disclaimer Parties, other than TOU, responsible for collecting odour samples hereby certify that they have voluntarily furnished these odour samples, appropriately collected and labelled, to The Odour Unit Pty Ltd for the purpose of odour testing. The collection of odour samples by parties other than The Odour Unit Pty Ltd relinquishes The Odour Unit Pty Ltd from all responsibility for the sample collection and any effects or actions that the results from the test(s) may have.

Note This report shall not be reproduced, except in full, without written approval of The Odour Unit Pty Ltd. Any attachments to this Report are not covered by the NATA Accreditation issued to The Odour Unit Pty Ltd.

END OF DOCUMENT

THE ODOUR UNIT

Aust. Technology Park
Locomotive Workshop
Suite 16012
2 Locomotive Street
Eveleigh NSW 2015

Phone: +61 2 9209 4420
Facsimile: +61 2 9209 4421
Email: info@odourunit.com.au
Internet: www.odourunit.com.au
ABN: 53 091 165 061

NATA

Accreditation Number: 14974

Odour Concentration Measurement Results

The measurement was commissioned by:

Organisation	Veolia Environmental Services	Telephone	(02) 9841 2932
Contact	Stephen Bernhart	Facsimile	(02) 9842 2992
Sampling Site	Woodlawn	Email	Stephen.Bernhart@veolia.com.au
Sampling Method	IFH	Sampling Team	TOU (JS + MA)

Order details:

Order requested by	Stephen Bernhart	Order accepted by	MA
Date of order	1/06/2012	TOU Project #	N1806L.03
Order number	4502181100	Project Manager	MA
Signed by	Stephen Bernhart	Testing operator	AS

Investigated Item — Odour concentration in odour units 'ou', determined by sensory odour concentration measurements, of an odour sample supplied in a sampling bag.

Identification — The odour sample bags were labelled individually. Each label recorded the testing laboratory, sample number, sampling location (or Identification), sampling date and time, dilution ratio (if dilution was used) and whether further chemical analysis was required.

Method — The odour concentration measurements were performed using dynamic olfactometry according to the Australian Standard 'Determination of Odour Concentration by Dynamic Olfactometry AS/NZS4323.3:2001. The odour perception characteristics of the panel within the presentation series for the samples were analogous to that for butanol calibration. Any deviation from the Australian standard is recorded in the 'Comments' section of this report.

Measuring Range — The measuring range of the olfactometer is $2^2 \leq \chi \leq 2^{18}$ ou. If the measuring range was insufficient the odour samples will have been pre-diluted. The machine is not calibrated beyond dilution setting 2^{17}. This is specifically mentioned with the results.

Environment — The measurements were performed in an air- and odour-conditioned room. The room temperature is maintained between 22°C and 25°C.

Measuring Dates — The date of each measurement is specified with the results.

Instrument Used — The olfactometer used during this testing session was:
ODORMAT SERIES V02

Instrumental Precision — The precision of this instrument (expressed as repeatability) for a sensory calibration must be $r \leq 0.477$ in accordance with the Australian Standard AS/NZS4323.3:2001.
ODORMAT SERIES V02: $r = 0.3158$ (June – November 2011) Compliance – Yes

Instrumental Accuracy — The accuracy of this instrument for a sensory calibration must be $A \leq 0.217$ in accordance with the Australian Standard AS/NZS4323.3:2001.
ODORMAT SERIES V02: $A = 0.2165$ (June – November 2011) Compliance – Yes

Lower Detection Limit (LDL) — The LDL for the olfactometer has been determined to be 16 ou (4 times the lowest dilution setting)

Traceability — The measurements have been performed using standards for which the traceability to the national standard has been demonstrated. The assessors are individually selected to comply with fixed criteria and are monitored in time to keep within the limits of the standard. The results from the assessors are traceable to primary standards of n-butanol in nitrogen.

Date: Wednesday, 27 June 2012

Panel Roster Number: SYD20120622_041

J. Schulz
NSW Laboratory Coordinator

A. Schulz
Authorised Signatory

Odour Sample Measurement Results
Panel Roster Number: SYD20120622_041

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Nominal Sample Dilution	Actual Sample Dilution (Adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (ou)	Sample Odour Concentration (Final, allowing for dilution) (ou)	Specific Odour Emission Rate (ou.m^3/m^2/s)
ED3N-4 (Eastern middle)	SC12238	21/06/2012 0929hrs	22/06/2012 1017hrs	4	8	-	-	664	664	0.410
ED3N-3 (Treated leachate: Western middle)	SC12239	21/06/2012 0920hrs	22/06/2012 1046hrs	4	8	-	-	559	559	0.346
ED3N-3 (Treated leachate: Northern end)	SC12240	21/06/2012 0955hrs	22/06/2012 1114hrs	4	8	-	-	609	609	0.400
ED3N-2 (Treated leachate: Western end)	SC12241	21/06/2012 1010hrs	22/06/2012 1145hrs	4	8	-	-	362	362	0.226
ED3N-2 (Treated leachate: Northern end)	SC12242	21/06/2012 1050hrs	22/06/2012 1258hrs	4	8	-	-	304	304	0.190
ED3N-1 (Untreated leachate: Southern middle - 1)	SC12243	21/06/2012 1140hrs	22/06/2012 1348hrs	4	8	-	-	902,000	902,000	564

Note: The following are not covered by the NATA Accreditation issued to The Odour Unit Pty Ltd:
1. The collection of Isolation Flux Hood (IFH) samples and the calculation of the Specific Odour Emission Rate (SOER).
2. Final results that have been modified by the dilution factors where parties other than The Odour Unit Pty Ltd. have performed the dilution of samples.

Odour Sample Measurement Results
Panel Roster Number: SYD20120622_041

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Nominal Sample Dilution	Actual Sample Dilution (Adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (ou)	Sample Odour Concentration (Final, allowing for dilution) (ou)	Specific Odour Emission Rate ($ou.m^3/m^2/s$)
ED3N-1 (Untreated leachate: Western middle)	SC12244	21/06/2012 1148hrs	22/06/2012 1432hrs	4	8	-	-	293,000	292,000	183
ED3N-1 (Untreated leachate: Southern middle - 2)	SC12245	21/06/2012 1246hrs	22/06/2012 1507hrs	4	8	-	-	696,000	696,000	435
Leachate aeration dam (Surface sample 1)	SC12247	21/06/2012 1410hrs	22/06/2012 1659hrs	4	8	-	-	724	724	0.459
Leachate aeration dam (Surface sample 2)	SC12248	21/06/2012 1410hrs	22/06/2012 1723hrs	4	8	-	-	724	724	0.459
Landfill gas inlet	SC12246	21/06/2012 1500hrs	22/06/2012 1545hrs	4	8	-	-	9,310,000	9,310,000	n/a

Note: The following are not covered by the NATA Accreditation issued to The Odour Unit Pty Ltd:
1. The collection of Isolation Flux Hood (IFH) samples and the calculation of the Specific Odour Emission Rate (SOER).
2. Final results that have been modified by the dilution factors where parties other than The Odour Unit Pty Ltd. have performed the dilution of samples.

Odour Panel Calibration Results

Reference Odorant	Reference Odorant Panel Roster Number	Concentration of Reference gas (ppb)	Panel Target Range for n-butanol (ppb)	Measured Concentration (ou)	Measured Panel Threshold (ppb)	Does this panel calibration measurement comply with AS/NZS4323.3:2001 (Yes / No)
n-butanol	SYD20120622_041	49,900	$20 \le \chi \le 80$	1,024	49	Yes

Comments None.

Disclaimer Parties, other than TOU, responsible for collecting odour samples hereby certify that they have voluntarily furnished these odour samples, appropriately collected and labelled, to The Odour Unit Pty Ltd for the purpose of odour testing. The collection of odour samples by parties other than The Odour Unit Pty Ltd relinquishes The Odour Unit Pty Ltd from all responsibility for the sample collection and any effects or actions that the results from the test(s) may have.

Note This report shall not be reproduced, except in full, without written approval of The Odour Unit Pty Ltd. Any attachments to this Report are not covered by the NATA Accreditation issued to The Odour Unit Pty Ltd.

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Appendix B: Odour Emissions Calculation Sheets

The Odour Unit
Odour Emissions Calculation Sheet
Client: Veolia Environmental Services
Sampling Site: Woodlawn Bioreactor
Project Number: N1806L.03

Sample Location	TOU Sample Number	Odour Concentration (ou)	Nominal Air Temperature (^oC)	Measured Internal Flux Hood Odour Temperature (^oC)	Emission Factor Nominal Air Temperature	Emission Factor measured air temperature	Temperature Correction Factor	Enclosed surface area (m^2)	Flux chamber sweep air flow rate - Q (L/min)	Flux chamber sweep air flow rate - Q (m^3/min)	Odour Emission Rate at Source (Not corrected for temperature) (ou.m^3/m^2/min)	Odour Emission Rate at Source (Corrected for temperature) (ou.m^3/m^2/min)	Specific Odour Emission Rate (ou.m^3/m^2/s)	Odour character
Sample 1 – Active tipping face: Southwest corner (disturbed)	TOUSC12226	17,900	5.1	9.9	1.069	1.137	0.940	0.126	5	0.005	710.32	667.35	11.1	garbage, fermented fruit
Sample 2 - Active tipping face: Southwest corner within void (disturbed)	TOUSC12227	35,700	5.1	9.9	1.069	1.137	0.940	0.126	5	0.005	1416.67	1330.97	22.2	garbage, fermented fruit
Sample 3 – Waste cover area: Potential gas pathways within void (Evident gas leak – 3 ppm H2S)	TOUSC12228	8,190	7.8	11.0	1.107	1.154	0.959	0.126	5	0.005	325.00	311.76	5.20	rotten meat, garbage
Sample 4 – Active tipping face: Fresh Waste 1 day old (Disturbed - Southwest within void)	TOUSC12229	11,600	7.9	16.0	1.108	1.231	0.900	0.126	5	0.005	460.32	414.31	6.91	rotten meat, garbage
Sample 5 - Waste cover area: South within void	TOUSC12230	431	8.3	18.1	1.114	1.265	0.880	0.126	5	0.005	17.10	15.06	0.251	musty, slight garbage
Sample 6 – Aged Waste (1 week old)	TOUSC12231	304	9.0	20.9	1.124	1.312	0.857	0.126	5	0.005	12.06	10.33	0.172	Wet, mild
Sample 7 – Aged Waste (1 week old)	TOUSC12232	2,230	9.0	12.0	1.124	1.169	0.962	0.126	5	0.005	88.49	85.11	1.42	garbage
Sample 8 – Waste cover area: Potential gas pathways within void (Bubbling gas) (30L in 15 min via hood)	TOUSC12233	185,000												fermented fruit, pineapple, garbage
Sample 9 - Waste cover area: Potential gas pathways within void (Bubbling gas)	TOUSC12234	185,000	10.5	15.4	1.146	1.222	0.938	0.126	5	0.005	7341.27	6888.21	115	fermented fruit, pineapple, garbage
Sample 10 - Waste cover area: Potential gas pathways within void (Wall effects - west within void edge)	TOUSC12235	4,470	8.3	8.8	1.114	1.121	0.994	0.126	5	0.005	177.38	176.23	2.94	garbage, fermented fruit
Sample 11 – Northern Catchment Pond	TOUSC12237	131,000	8.3	9.8	1.114	1.136	0.981	0.126	5	0.005	5198.41	5098.03	85.0	rotten egg
Sample 12 - Waste cover area: Potential gas pathways within void (Wall effects - northwest within void edge)	TOUSC12236	2,440	7.9	8.0	1.108	1.110	0.999	0.126	5	0.005	96.83	96.70	1.61	garbage
Sample 13 - ED3N-4 (Evaporation Dam - Eastern middle)	TOUSC12238	664	9.5	14.7	1.131	1.211	0.935	0.126	5	0.005	26.35	24.63	0.410	musty
Sample 14 - ED3N-3 (Treated leachate from ED3N-2 Western middle)	TOUSC12239	559	9.5	14.7	1.131	1.211	0.935	0.126	5	0.005	22.18	20.73	0.346	burnt, musty
Sample 15 - ED3N-3 (Treated leachate from ED3N-2 Western middle: Northern end)	TOUSC12240	609	9.3	9.9	1.129	1.137	0.992	0.126	5	0.005	24.17	23.98	0.400	burnt, musty
Sample 16 - ED3N-2(Treated leachate from Leachate Aeration Dam: Western end)	TOUSC12241	362	9.5	13.8	1.131	1.196	0.946	0.126	5	0.005	14.37	13.58	0.226	musty, plastic
Sample 17 - ED3N-2(Treated leachate from Leachate Aeration Dam: Northern end)	TOUSC12242	304	9.5	13.8	1.131	1.196	0.946	0.126	5	0.005	12.06	11.41	0.190	burnt, musty
Sample 18 - ED3N-1(Untreated Leachate & acid mine drainage: Southern middle - 1)	TOUSC12243	902,000	9.7	14.0	1.134	1.200	0.946	0.126	5	0.005	35793.65	33847.68	564	rotten egg
Sample 19 - ED3N-1(Untreated Leachate & acid mine drainage: Western middle	TOUSC12244	293,000	9.7	14.0	1.134	1.200	0.946	0.126	5	0.005	11626.98	10994.87	183	rotten egg
Sample 20 - ED3N-1(Untreated Leachate & acid mine drainage: Southern middle - 2)	TOUSC12245	696,000	9.7	14.0	1.134	1.200	0.946	0.126	5	0.005	27619.05	26117.50	435	rotten egg
Sample 21 - Leachate Aeration Dam - 1 (Treated Leachate)	TOUSC 12246	724	11.3	14.5	1.158	1.207	0.959	0.126	5	0.005	28.73	27.56	0.459	meat, ammonia
Sample 22 - Leachate Aeration Dam - 2 (Treated Leachate)	TOUSC12247	724	11.3	14.5	1.158	1.207	0.959	0.126	5	0.005	28.73	27.56	0.459	meat, livestock
Sample 23 - Biogas Inlet	TOUSC12248	9,310,000												rotten egg

Liquid Odour Measurement - Calculation (25L N_2 with 413 μL sample)	TOU Sample Number	Odour Concentration (ou)	Volume of Liquid (mL)	Volume of dry N_2 (L)	Odour Concentration (ou/m^3)	Calculated Liquid Odour Concentration (ou/mL)	Evaporation Rate (m^3/hr)	Odour Emission Rate (ou.m^3/s)	Odour Character	IFH OER
Sample 24 - ED3N-4 (Southen middle)	TOUSC12305	215	0.41	25	215	13.01	2.06	7,447	Cheesy, vinegar	6,567
Sample 25 - ED3N-1 (Eastern middle)	TOUSC12306	3,160	0.41	25	3160	191.28	0.90	47,821	Sour, ammonia, dog manure	2,759,558

Location	Area (m^2)	TOU SOER ($ou.m^3/m^2/s$)	TOU OER ($ou.m^3/s$)	EA SOER ($ou.m^3/m^2/s$)	EA OER ($ou.m^3/s$)
ED3N-1	7,000	394	**2,759,558**	8.80	61,600
ED3N-2 & 3	13,000	0.29	**3,776**	7.40	96,200
ED3N-4	16,000	0.41	**6,567**	0.70	11,200
Storage Pond 7	1,200	85	**101,961**	n/m	n/m
Active Tipping Face	40,000	8.36	**334,409**	7.30	292,000
Leachate Aeration Dam	4,000	0.46	**1,840**	3.60	14,400

Landfill gas capture efficiency (%)	Landfill gas capture/month (m^3/month)	Biogas from Surface (m^3/month)	Biogas from Void Surface (m^3/s)	Biogas Odour Conc. (ou)	Biogas OER from surface ($ou.m^3/s$)
90	838,006	93,112	0.04	9,310,000	**334,441**
80	838,006	209,501	0.08	9,310,000	**752,492**
70	838,006	359,145	0.14	9,310,001	**1,289,986**

Date	Generation		
	LFG m^3	CH4 %	CH4 m^3
Jan-09	715,157	44.70	319675.35
Feb-09	705,714	44.10	311219.78
Mar-09	644,508	44.70	288094.91
Apr-09	582,979	46.90	273416.99
May-09	653,474	46.30	302558.65
Jun-09	550,016	46.30	254657.29
Jul-09	645,910	45.10	291305.24
Aug-09	601,124	46.00	276517.16
Sep-09	636,500	46.10	293426.40
Oct-09	618,982	46.03	284917.56
Nov-09	568,378	47.47	269808.92
Dec-09	602,923	49.40	297844.18
Jan-10	633,621	49.62	314402.97
Feb-10	545,990	51.20	279546.87
Mar-10	631,883	51.34	324408.85
Apr-10	638,644	51.08	326219.53
May-10	692,731	52.06	360635.63
Jun-10	715,273	53.53	382885.51
Jul-10	700,306	53.66	375783.96
Aug-10	816,358	52.44	428098.18
Sep-10	837,954	51.61	432468.26
Oct-10	895,459	51.29	459281.11
Nov-10	909,821	51.64	469831.56
Dec-10	869,479	52.94	460302.17
Jan-11	873,304	53.13	463986.34
Feb-11	701,912	54.86	385068.91
Mar-11	836,206	54.69	457321.06
Apr-11	755,608	55.15	416717.74
May-11	741,324	52.76	391122.77
Jun-11	757,946	51.34	389129.43
Jul-11	812,109	51.72	420022.64
Aug-11	793,649	51.50	408729.13
Sep-11	924,329	51.91	479819.05
Oct-11	827,463	52.07	430859.84
Nov-11	703,831	50.00	351915.31
Dec-11	1,076,307	50.00	538153.67
Jan-12	1,322,739	50.00	661369.44
Feb-12	1,037,395	50.00	518697.35
Mar-12	1,122,112	50.27	564085.55
Apr-12	1,256,023	55.81	700986.18
May-12	1,302,085	54.08	704167.47
Jun-12	1,292,738	56.69	732853.17
Mean	**798,816**	**51**	**406,960**

Date	Flared		
	LFG m^3	CH4 %	CH4 m^3
Jan-09	0.00		0.00
Feb-09	0.00		0.00
Mar-09	0.00		0.00
Apr-09	4924.909	50.52	2488.06
May-09	9623.061	49.89	4800.95
Jun-09	22676.49	49.92	11320.11
Jul-09	2412.217	47.44	1144.36
Aug-09	2143.331	49.14	1053.23
Sep-09	4305.724	48.06	2069.33
Oct-09	31559.81	49.10	15495.87
Nov-09	39822.49	50.52	20118.32
Dec-09	27337.06	50.84	13897.80
Jan-10	9180.336	49.72	4564.46
Feb-10	19394.24	51.04	9897.93
Mar-10	25809.04	51.98	13415.90
Apr-10	2840.304	51.71	1468.69
May-10	6580.667	52.06	3425.90
Jun-10	22780.42	53.53	12194.36
Jul-10	27900.83	53.66	14971.59
Aug-10	14084.77	52.44	7386.05
Sep-10	8211.22	51.61	4237.81
Oct-10	24145.96	51.29	12384.46
Nov-10	16912.88	51.64	8733.81
Dec-10	45360.46	52.94	24013.83
Jan-11	25621.81	53.13	13612.87
Feb-11	88958.78	54.86	48802.78
Mar-11	17665.17	54.69	9661.08
Apr-11	30122.4	55.15	16612.50
May-11	12478.24	52.76	6583.52
Jun-11	107437.1	51.34	55158.19
Jul-11	37047.42	51.72	19160.93
Aug-11	94955.55	51.50	48902.11
Sep-11	44161.39	51.91	22924.18
Oct-11	98815.87	52.07	51453.43
Nov-11	36884.16	50.00	18442.08
Dec-11	39115.45	50.00	19557.73
Jan-12	70689.59	50.00	35344.79
Feb-12	116814.8	50.00	58407.40
Mar-12	10204.83	50.27	5129.97
Apr-12	173967.2	55.81	97091.08
May-12	58160.42	54.08	31453.16
Jun-12	97302.03	56.69	55160.52
Mean	**39,190**	**52**	**20,578**

Appendix C: Condition 7 (c) Attachments

Woodlawn Waste Inputs 1 Jan 12 - 30 Jun 12

Date	Clyde	Regional
Jan-12	42,896.14	0.00
Feb-12	42,987.88	0.00
Mar-12	43,829.24	0.00
Apr-12	40,154.72	358.36
May-12	40,404.28	1,152.04
Jun-12	36,045.22	1,389.56
Total	**246,317.48**	**2,899.96**

Evaporation	2006								2006				2007					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	5.60	6.80	5.00	3.00	1.50	1.41
2	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	2.20	2.60	4.80	3.60	2.40	1.04
3	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	2.60	5.00	3.80	3.80	3.19	1.16
4	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	5.00	6.40	7.60	2.80	4.52	1.30
5	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	6.80	7.40	6.60	3.00	2.68	0.69
6	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	7.20	8.20	3.60	4.60	2.52	1.00
7	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	8.60	7.00	5.00	2.40	2.43	0.67
8	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	5.80	4.60	3.60	1.40	1.87	0.83
9	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	6.60	6.80	5.00	2.40	1.37	0.48
10	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	7.40	5.20	4.80	2.00	1.41	0.73
11	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	8.60	3.60	5.40	3.20	1.48	1.24
12	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	11.40	2.20	7.00	3.60	1.74	0.77
13	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	13.40	3.80	3.60	2.60	2.19	1.23
14	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	8.40	4.40	2.80	3.00	1.51	1.02
15	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	7.80	5.80	4.80	3.60	2.03	0.43
16	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	8.40	6.20	6.20	4.00	2.09	0.64
17	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	8.80	3.80	4.60	2.80	1.47	0.84
18	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	7.20	5.60	2.40	3.40	1.49	0.75
19	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	6.00	1.60	2.00	3.80	0.72	0.63
20	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	7.60	3.60	0.20	2.20	1.53	0.43
21	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	11.00	6.80	2.20	2.60	2.14	1.13
22	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	8.40	7.40	3.40	2.60	2.21	1.12
23	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	7.60	5.60	4.40	2.60	1.69	1.35
24	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	9.40	5.20	4.80	1.80	1.59	1.11
25	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	7.20	4.60	4.00	0.60	1.81	1.16
26	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	8.00	4.20	2.60	1.20	1.75	0.57
27	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	12.40	3.60	2.80	2.40	1.56	0.27
28	6.40	5.40	4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	10.60	3.00	2.80	1.40	2.20	0.42
29	8.20		4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	8.80		4.20	1.40	1.75	0.79
30	8.20		4.10	2.60	1.70	1.10	1.20	1.90	2.80	3.90	5.00	6.20	8.00		3.00	1.80	2.65	1.27
31	8.20		4.10		1.70		1.20	1.90		3.90		6.20	10.00		3.40		1.24	
Total Month	**203.8**	**151.2**	**127.1**	**78**	**52.7**	**33**	**37.2**	**58.9**	**84**	**120.9**	**150**	**192.2**	**246.8**	**141**	**126.4**	**79.6**	**60.68**	**26.47**
Accumulated Year	**204**	**355**	**482.1**	**560.1**	**612.8**	**645.8**	**683**	**741.9**	**825.9**	**946.8**	**1096.8**	**1289**	**246.8**	**387.8**	**514.2**	**593.8**	**654.48**	**681**

Evaporation data recorded from the Goulburn Tafe W

						2008												2009	
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1.21	1.13	4.17	4.49	2.73	2.82	7.058	4.079	4.42	3.876	2.082	1.889	2.563	2.158	1.339	3.822	8.25	5.487	6.915	7.353
0.82	1.27	2.87	5.04	4.66	2.286	7.126	2.908	4.566	3.485	1.918	0.485	1.146	0.953	2.667	4.838	2.408	7.579	8.11	6.754
1.21	2.29	3.26	5.41	4.31	5.675	7.446	4.000	4.257	5.316	1.977	0.828	1.139	1.469	2.828	6.486	3.711	6.729	6.339	6.712
1.75	0.94	2.94	8.39	1.49	4.147	2.006	4.788	4.536	2.663	2.314	0.46	1.32	1.967	1.616	6.588	3.963	6.955	5.254	5.055
1.18	1.59	2.46	5.05	3.30	4.956	7.4	1.496	4.274	3.13	2.225	0.771	0.847	1.659	1.006	1.318	5.035	5.046	6.369	4.618
0.72	1.67	1.44	5.48	2.40	1.109	6.6	1.512	4.457	3.239	2.423	0.76	1.387	1.263	1.288	2.328	3.928	5.442	8.86	6.982
1.06	1.65	1.87	5.68	4.5	4.2	6.883	4.498	5.111	2.656	2.177	1.026	1.22	1.656	1.162	3.205	6.31	7.507	8.46	7.344
1.02	1.71	1.38	3.90	2.097	3.395	6.251	3.381	3.829	2.231	2.323	1.351	1.312	1.147	2.65	3.387	3.199	6.765	8.21	8.81
0.70	2.11	1.61	3.89	2.106	4.31	6.6	2.689	4.053	1.712	2.209	0.5	1.227	1.663	2.508	4.196	3.801	6.172	3.146	8.3
0.90	2.39	2.04	3.91	2.929	6.974	5.175	2.861	4.623	1.81	2.056	1.211	0.51	1.35	3.038	4.017	5.71	6.895	4.802	2.73
1.19	3.15	2.55	4.12	4.648	3.645	6.945	4.415	4.768	2.685	2.026	0.588	0.875	0.664	2.896	4.264	5.541	3.662	4.78	1.038
1.44	3.09	1.69	4.89	5.543	1.426	7.747	4.853	4.954	3.052	1.296	0.865	1.079	1.452	3.56	3.963	5.464	1.874	4.981	4.292
1.09	2.27	2.29	3.87	5.421	5.00	5.179	3	4.862	2.614	1.532	1.672	1.215	1.511	4.341	4.769	6.244	0.951	4.415	1.801
1.02	1.69	3.53	4.15	6.033	4.40	7.447	1.161	4.992	2.11	1.757	1.089	1.621	1.801	5.149	4.463	6.274	4.303	6.69	3.05
0.86	1.02	4.08	4.78	6.794	5.362	1.344	3.54	4.861	2.854	1.874	1.572	2.064	1.693	2.177	1.793	6.243	3.726	9	2.4
1.06	1.08	3.46	6.31	6.455	5.385	6.369	5.299	5.892	2.901	1.997	1.141	1.281	1.726	4.05	3.63	6.192	5.567	9.69	2.225
1.04	1.87	3.82	7.67	5.901	0.933	4.194	5.042	4.894	2.611	1.468	0.794	1.247	1.834	2.663	4.097	4.685	6.225	7.435	3.11
1.34	0.82	2.25	4.52	6.297	4.659	4.4	4.186	4.841	1.902	1.245	1.042	1.28	2.186	2.098	4.755	5.378	3.919	6.079	2.313
1.30	0.95	3.21	4.95	5.31	4.40	2.054	4.73	5.056	2.09	1.432	1.056	1.051	1.361	3.326	4.845	3.55	4.689	6.418	3.187
1.52	0.78	4.30	5.30	6.444	2.116	1.72	4.48	2.672	1.27	1.881	0.842	1.652	2.009	4.809	5.672	2.603	5.48	7.43	5.529
1.49	0.94	1.92	5.45	6.425	1.79	3.779	5.237	4.843	1.596	1.602	0.297	1.258	2.209	5.661	4.572	3.418	4.656	7.28	3.265
1.15	1.14	3.13	7.20	6.425	5.306	2.357	2.445	1.335	2.494	1.74	1.192	1.394	2.44	4.423	3.561	5.702	5.765	7.637	4.303
0.78	0.88	3.23	6.92	0.573	2.921	4.681	5.397	1.763	1.229	1.673	1.271	1.551	1.138	4.422	3.28	2.389	6.683	5.991	3.535
1.51	1.16	3.62	4.15	1.268	4.309	5.547	6.058	3.212	2.211	1.193	1.118	1.17	1.594	2.527	3.602	2.16	3.337	6.481	4.391
1.60	1.70	4.87	1.97	2.786	4.859	6.208	5.649	1.777	1.685	1.456	1.126	1.146	2.284	2.461	4.178	5.332	1.37	7.481	6.763
1.99	2.03	4.68	1.29	5.691	5.20	4.636	4.078	0.872	1.569	1.499	1.623	1.547	2.553	3.68	5.96	4.286	6.181	4.449	5.653
1.86	2.98	3.07	2.36	4.37	6.216	6.022	5.26	2.734	3.338	1.253	1.242	1.2	2.669	4.221	5.949	3.299	7.006	6.364	5.124
1.30	3.73	3.92	4.32	6.6	3.844	6.413	3.85	3.058	2.642	1.484	1.607	0.866	2.212	5.675	8	5.683	4.365	4.688	4.802
1.73	4.86	5.73	4.75	5.35	6.515	5.972	0.894	2.139	1.338	1.37	1.198	1.235	1.744	6.15	5.297	3.178	5.461	6.868	
1.18	3.51	3.62	5.87	3.106	6.941	6.752		3.646	2.208	1.425	1.927	1.503	1.283	3.495	1.819	5.458	7.121	7.29	
1.56	3.98		5.56		7.736	6.868		3.861		1.726		1.703	2.13		5.019		6.405	7.182	
38.56	**60.372**	**92.97**	**151.606**	**131.946**	**132.835**	**169.179**	**111.786**	**121.158**	**74.517**	**54.633**	**32.543**	**40.609**	**53.778**	**97.886**	**133.673**	**139.394**	**163.323**	**205.09**	**131.44**
719.5	**779.88**	**872.8**	**1024.45**	**1156.4**	**1289.23**	**169**	**280.965**	**402.123**	**476.64**	**531.273**	**563.816**	**604.425**	**658.203**	**756.089**	**889.762**	**1029.16**	**1192.48**	**205**	**336.533**

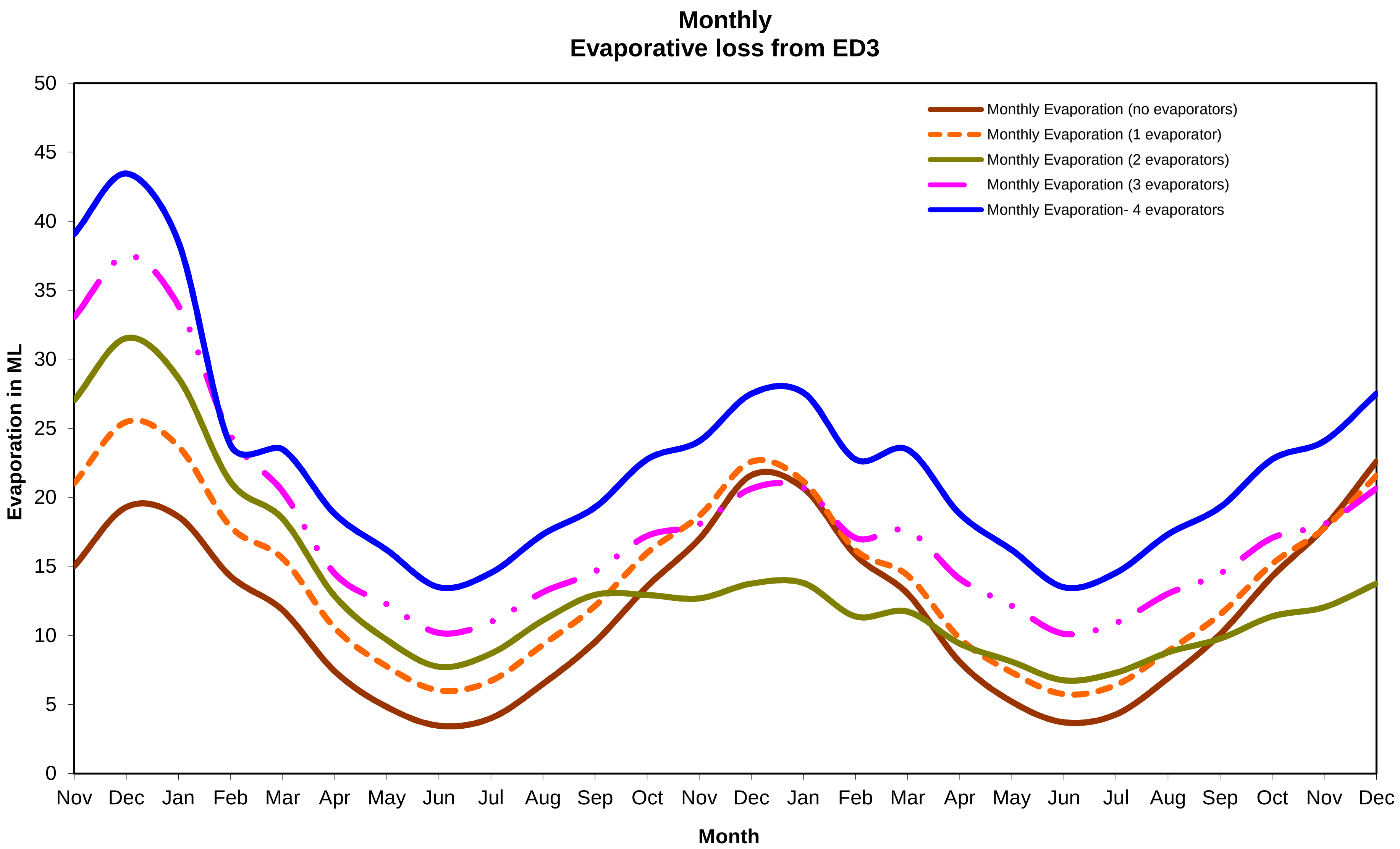
eather Station

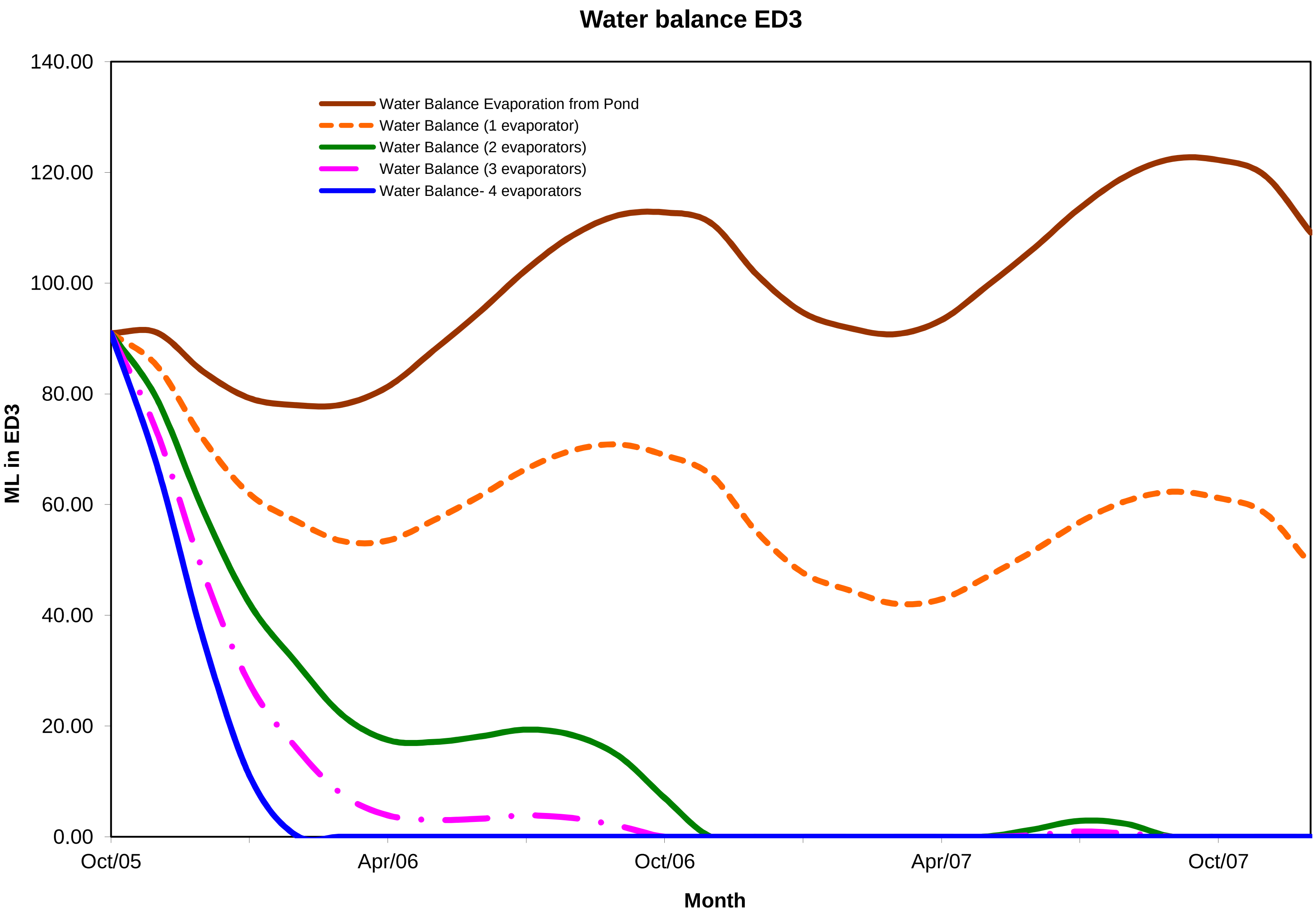
										2010					
Mar	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
6.917	2.423	1.755	1.077	1.847	1.551	1.984	4.057	4.662	2.028	3.998	5.099	3.148	2.332	1.695	0.878
4.472	1.71	2.372	0.801	1.384	1.814	2.912	6.426	5.645	5.513	6.6	6.074	1.88	3.354	1.916	1.125
3.878	1.453	1.88	0.787	1.089	1.202	2.841	1.895	5.112	5.577	4.735	5.207	2.762	2.975	2.831	1.087
3.498	3.908	2.072	0.56	1.165	2.058	1.365	0.766	7.929	7.173	4.158	3.146	3.891	2.655	1.683	0.855
5.725	2.928	2.129	0.701	1.104	1.529	2.454	1.152	5.29	6.583	4.044	3.664	4.055	2.152	2.958	0.907
4.923	3.621	1.981	1.211	1.493	1.623	3.174	2.186	1.641	6.23	5.176	2.508	1.321	3.063	1.433	1.303
4.612	2.546	2.117	1.313	0.921	1.996	3.339	2.677	2.032	6.638	7.148	2.434	3.007	1.81	2.05	1.055
4.945	2.97	2.058	0.786	1.202	2.192	1.115	1.318	4.208	7.695	3.889	1.551	1.534	1.5	1.903	1.346
2.91	3.12	1.763	1.105	0.611	2.206	2.108	3.38	5.156	7.358	5.272	1.77	3.112	3.291	1.955	1.332
3.338	3.284	2.182	0.895	0.771	1.865	1.68	2.502	6.205	4.17	7.378	5.177	3.092	2.66	1.906	0.827
3.617	1.841	1.215	1.285	0.927	1.887	2.787	2.709	6.607	6.303	7.771	4.201	2.743	3.463	2.485	1.431
4.376	2.073	1.848	1.049	0.982	1.502	3.644	2.501	6.865	6.729	7.485	6.063	3.919	3.058	3.087	1.381
3.763	2.514	1.946	0.691	2.192	1.643	5.067	1.654	6.934	7.03	9.3	4.934	2.812	3.207	1.911	1.201
1.961	0.469	2.119	1.578	1.559	2.055	6.87	3.239	4.736	6.693	5.012	0.81	3.277	2.865	2.033	1.074
3.811	1.969	1.581	1.521	0.818	1.996	2.964	2.22	6.605	3.489	2.788	0.918	2.577	3.386	1.734	1.141
4.779	4.187	1.602	1.015	1.049	2.365	3.78	2.346	5.514	6.185	3.759	3.496	3.634	2.66	1.728	1.179
4.66	3.699	1.789	0.784	1.013	3.062	3.287	3.11	7.546	8	3.442	4.03	4.26	2.696	1.379	1.443
4.282	2.983	1.842	1.059	1.434	2.581	3.727	3.306	5.807	11.73	6.841	5.162	4.197	2.758	0.917	0.864
4.783	2.608	1.432	1.027	1.474	2.222	2.763	3.298	5.604	1.331	4.313	4.24	4.181	2.507	1.724	1.379
3.871	1.738	1.076	1.456	1.814	2.725	3.061	4.18	6.838	6.966	6.507	3.96	3.73	2.511	1.701	0.776
4.548	1.094	1.284	1.107	2.203	2.918	3.498	5.517	8	3.649	7.994	4.726	4.999	2.921	0.885	1.32
4.535	1.638	1.287	0.589	2.459	1.673	3.687	5.776	4.833	7.337	7.766	6.52	4.999	2.688	1.165	1.185
4.201	1.488	0.719	1.161	2.013	2.523	2.501	4.272	6.697	6.719	9.95	6.017	3.975	2.918	1.664	0.491
5.067	1.991	1.288	0.863	0.761	2.127	1.283	5.039	0.884	7.524	9.65	5.734	4.213	3.392	1.157	1.154
6.118	1.73	1.478	0.824	1.547	1.984	3.13	5.359	1.841	8.85	4.516	4.929	3.705	1.498	0.839	0.983
5.434	1.438	1.413	1.087	1.784	2.257	4.556	1.522	6.292	0.754	6.134	4.726	4.034	2.387	0.64	1.076
3.611	1.52	0.777	0.838	0.859	2.071	1.988	1.903	5.591	0.895	7.369	4.487	4.923	2.272	0.491	0.995
2.982	1.68	1.037	1.244	1.546	3.473	1.579	2.641	4.326	3.024	6.039	4.945	4.015	1.531	0.891	1.21
3.861	1.917	0.689	0.798	1.562	4.048	2.576	4.087	8.2	4.501	3.961	[redacted]	4.129	2.867	1.166	1.24
4.352	1.667	0.843	0.898	1.621	1.767	3.663	2.571	3.657	6.765	6.124	[redacted]	1.592	2.643	0.628	1.417
2.855	[redacted]	0.777	[redacted]	1.283	2.321	[redacted]	5.037	[redacted]	6.318	3.125	[redacted]	0.785	[redacted]	0.27	[redacted]
132.69	**68.21**	**48.35**	**30.11**	**42.49**	**67.24**	**89.38**	**98.65**	**161.26**	**179.76**	**182.24**	**116.53**	**104.50**	**80.02**	**48.83**	**33.66**
469.218	**537.425**	**585.776**	**615.886**	**658.373**	**725.609**	**814.992**	**913.638**	**1074.895**	**1254.652**	**182**	**298.77**	**403.27**	**483.29**	**532.12**	**565.77**

						2011							
Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**
1.268	1.296	2.57	3.375	4.13	1.186	7.051	7.012	2.274	1.106	1.672	0.987	1.048	1.254
1.044	1.432	3.342	2.595	1.913	1.338	7.866	9.26	4.678	3.107	1.878	1.056	0.911	2.284
0.452	1.033	0.811	2.4	2.259	3.215	3.502	5.421	3.477	3.304	0.655	1.016	1.027	1.942
1.215	1.468	1.109	1.091	4.22	2.258	0.963	3.908	5.296	3.294	1.914	1.53	1.616	3.34
1.111	1.031	0.862	2.602	1.355	3.228	2.593	2.614	5.187	3.215	2.064	0.861	1.293	3.226
1.077	1.714	1.645	4.097	1.948	4.476	5.333	6.545	3.419	1.963	2.11	1.51	1.004	3.188
0.573	1.737	1.99	3.927	2.165	3.351	3.727	1.692	3.268	1.802	1.676	1.527	0.864	1.604
1.348	1.679	2.243	3.864	4.228	5.486	3.458	4.228	4.416	2.223	2.087	1.093	1.247	1.912
1.326	1.577	2.275	3.793	4.414	4.11	4.247	3.948	4.142	3.183	2.375	0.862	1.228	0.946
0.814	1.94	1.779	2.713	3.68	1.728	2.307	3.324	3.978	3.395	1.6	1.092	1.16	1.769
0.855	0.94	2.288	2.238	3.89	4.773	2.736	4.659	1.385	1.308	2.051	1.078	1.079	1.23
0.7	0.917	1.423	2.36	5.513	5.854	1.677	2.874	1.6	2.148	1.193	1.34	1.41	0.462
1.493	0.976	1.389	3.446	5.371	5.957	4.233	2.073	3.28	1.747	1.684	0.956	1.458	1.427
0.631	2.024	1.307	1.812	6.154	5.745	3.408	1.502	4.49	1.923	1.434	0.744	0.815	1.582
1.03	1.39	0.437	3.58	3.953	4.113	3.981	4.138	0.749	2.724	1.743	0.804	1.333	1.771
1.381	1.588	1.027	1.264	1.957	6.395	5.885	3.005	2.157	2.568	1.959	0.557	1.19	1.495
1.225	1.2	3.789	2.281	4.89	3.684	6.391	1.15	2.357	2.236	1.344	0.813	0.589	1.994
1.302	1.883	2.998	3.349	4.525	5.331	7.255	3.479	1.534	2.029	1.467	1.074	1.178	0.561
1.433	1.683	2.743	3.847	6.084	3.731	5.497	2.893	0.69	2.608	1.735	1.222	0.831	0.867
0.826	1.684	2.645	3.02	2.109	3.686	4.004	3.746	1.547	2.338	1.71	1.208	0.475	0.819
1.377	1.882	2.91	3.964	5.642	2.636	4.759	4.729	1.814	1.341	1.56	1.517	1.369	0.957
1.379	1.539	3.202	4.17	6.288	5.074	6.263	4.947	0.758	2.355	1.738	0.914	0.853	1.532
1.336	2.092	2.737	4.903	5.996	5.285	4.855	4.657	3.055	2.246	1.803	0.864	0.721	1.235
1.201	1.533	2.271	3.476	4.515	6.343	6.291	4.763	2.44	2.209	0.854	1.412	1.208	1.695
1.573	1.865	3.718	2.227	5.96	2.143	5.118	4.651	2.026	2.329	1.129	1.207	0.621	2.437
1.431	1.816	2.922	2.794	5.9	5.442	6.436	4.057	3.047	1.251	1.797	1.25	0.674	3.024
1.326	1.186	4.061	4.945	4.33	3.951	7.204	5.033	2.824	1.474	1.694	1.653	1.431	3.163
1.452	1.803	3.858	4.318	5.672	3.478	6.509	2.284	2.365	1.764	1.191	1.369	1.506	2.636
0.515	2.243	3.876	3.221	1.734	5.219	5.086	[redacted]	3.328	1.206	1.303	0.969	2.089	2.91
0.838	2.186	3.174	4.233	1.189	6.065	5.724		2.678	1.313	1.275	0.918	2.003	2.894
0.86	1.966	[redacted]	4.17	[redacted]	6.422	6.781		3.709	[redacted]	0.946	[redacted]	2.083	1.518
34.39	**49.30**	**71.40**	**100.08**	**121.98**	**131.70**	**151.14**	**112.592**	**87.968**	**65.709**	**49.641**	**33.403**	**36.314**	**57.674**
600.17	**649.47**	**720.87**	**820.94**	**942.93**	**1074.63**	**151.14**	**263.732**	**351.7**	**417.409**	**467.05**	**500.453**	**536.767**	**594.441**

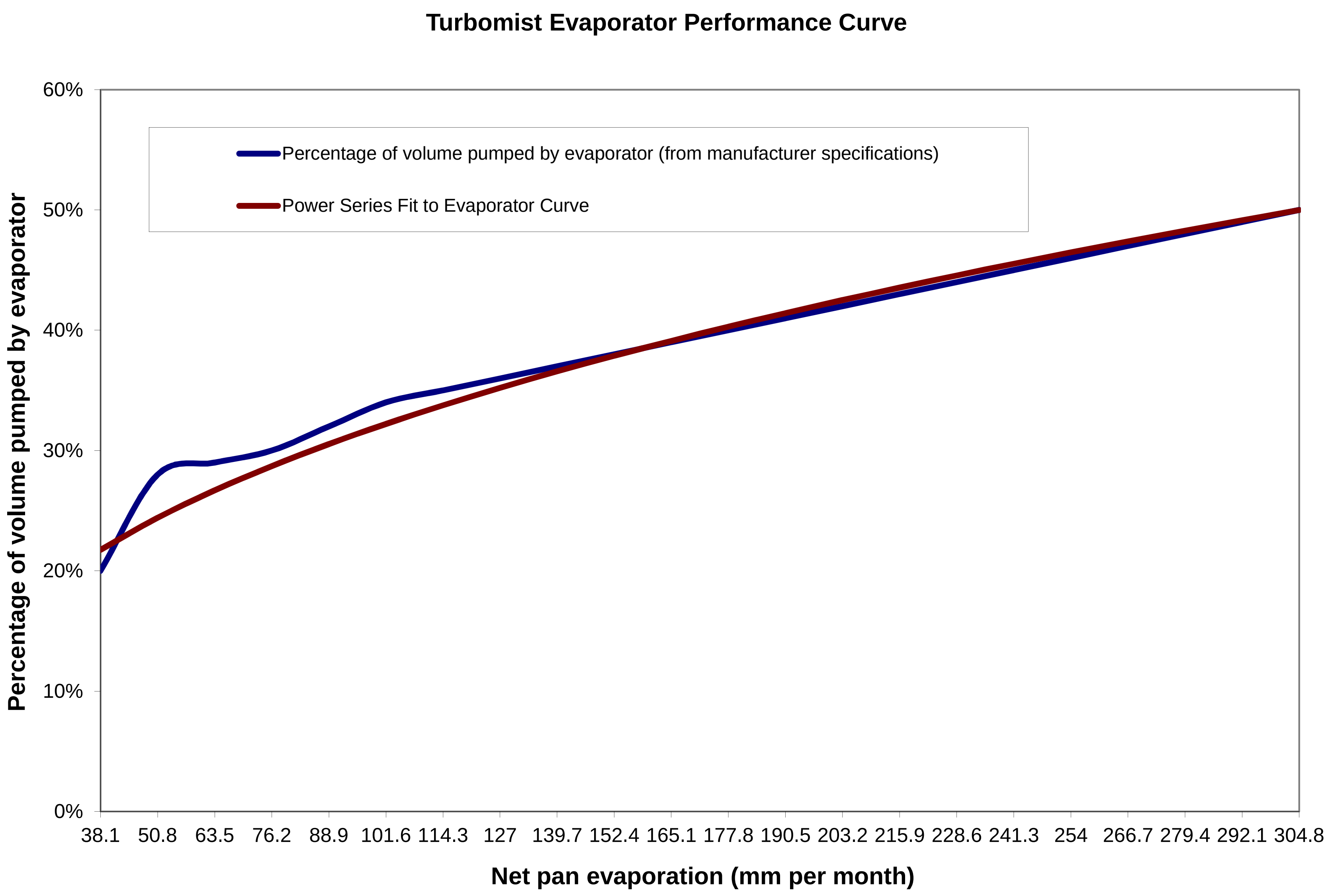
Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
				2012									
2.471	2.435	4.777	2.325	5.891	5.284	0.9	3.54	1.227	1.373	1.384			
2.241	1.588	4.316	4.913	6.209	2.501	1.154	2.845	2.177	0.793	0.822			
2.59	1.69	3.187	3.823	6.572	0.926	0.938	2.605	1.285	0.278	1.289			
3.132	3.258	2.896	5.667	7.179	1.351	0.919	3.164	2.134	0.594	1.277			
3.208	3.717	5.035	2.502	3.869	5.308	1.289	2.861	1.909	1.126				
2.879	2.781	6.021	4.276	5.369	6.111	4.487	2.241	1.845	0.44				
3.472	1.184	5.481	2.521	4.112	3.608	2.485	3.182	1.434	1.351				
2.624	1.667	4.105	4.129	6.458	1.226	1.009	3.775	1.077	1.279				
2.148	2.349	3.484	1.996	2.415	1.754	1.291	3.02	2.012	1.112				
1.354	2.354	4.679	5.002	6.068	2.106	3.155	2.901	2.752	1.18				
2.113	3.671	3.949	4.417	5.436	4.055	4.215	2.367	3.317	1.241				
1.992	2.976	4.623	3.436	3.858	2.691	3.676	2.476	2.556	0.629				
3.06	3.96	5.283	2.506	5.435	3.405	1.858	2.471	2.095	0.589				
2.947	3.783	4.932	2.187	6.049	3.371	3.285	2.797	1.384	1.253				
3.867	2.61	7.31	4.185	2.996	4.062	2.97	1.622	1.75	1.101				
3.495	3.47	6.555	5.44	2.083	4.704	4.013	2.658	1.504	1.735				
4.641	4.797	1.852	2.785	4.367	5.012	3.449	2.979	1.687	0.388				
4.808	4.456	4.183	5.786	5.552	3.774	2.386	1.349	1.343	1.027				
5.481	4.215	5.886	3.902	6.141	3.874	3.566	1.094	1.883	1.354				
5.343	4.925	7.084	1.302	6.487	4.644	2.513	2.241	1.763	1.264				
2.999	5.604	2.288	4.018	4.825	2.77	3.803	2.089	0.999	1.125				
3.491	5.794	4.966	2.69	4.856	4.255	4.005	1.749	1.613	1.895				
4.132	4.353	1.416	4.248	4.142	3.313	1.574	1.236	2.124	0.979				
5.552	5.458	2.959	5.868	3.036	4.821	3.37	2.224	2.66	1.068				
0.677	6.477	1.808	6.049	4.872	5.508	3.169	1.13	1.581	1.355				
1.441	0.997	0.889	6.216	2.176	5.785	2.475	0.934	1.061	1.264				
2.871	1.547	4.708	2.701	3.709	2.374	3.162	1.885	0.925	0.88				
3.301	2.761	4.889	4.081	2.485	2.673	1.564	1.73	1.416	0.587				
1.057	4.003	5.752	4.757	4.831	1.274	1.226	2.061	0.983	1.278				
1.649	2.008	5.654	6.255	5.77		3.304	1.868	1.428	1.283				
	4.498		3.977	2.548		3.262		1.146					
91.036	**105.386**	**130.967**	**123.96**	**145.796**	**102.54**	**80.472**	**69.094**	**53.07**	**31.821**	**4.772**	**0**	**0**	**0**
685.477	**790.863**	**921.83**	**1045.79**	**145.796**	**248.336**	**328.808**	**397.902**	**450.972**	**482.793**	**487.565**	**487.565**	**487.565**	**487.565**

Nov	Dec
0	0
487.565	487.565


Monthly
Evaporative loss from ED3
Evaporation in ML
50
45
40
35
30
25
20
15
10
5
0
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Monthly Evaporation (no evaporators)
Monthly Evaporation (1 evaporator)
Monthly Evaporation (2 evaporators)
Monthly Evaporation (3 evaporators)
Monthly Evaporation- 4 evaporators



Water balance ED3
Water Balance Evaporation from Pond
Water Balance (1 evaporator)
Water Balance (2 evaporators)
Water Balance (3 evaporators)
Water Balance- 4 evaporators
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
ML in ED3
Oct/05
Apr/06
Oct/06
Apr/07
Oct/07
Month



Turbomist Evaporator Performance Curve
60%
50%
40%
30%
20%
10%
0%
Percentage of volume pumped by evaporator
Percentage of volume pumped by evaporator (from manufacturer specifications)
Power Series Fit to Evaporator Curve
38.1
50.8
63.5
76.2
88.9
101.6
114.3
127
139.7
152.4
165.1
177.8
190.5
203.2
215.9
228.6
241.3
254
266.7
279.4
292.1
304.8
Net pan evaporation (mm per month)

	November	December	January	February	March	April	May	June	July	August	September	October	November
	30	31	31	28	31	30	31	30	31	31	30	31	30
	58.7	46.1	59.8	51.2	55.6	49.3	47.5	37.9	52.4	47.6	65.2	61.9	58.7
	5	6.2	6.3	5.5	4.1	2.6	1.6	1.1	1.2	1.9	2.8	3.8	5
Average Monthly Pan Evaporation (mm- total)	0.1725	0.22165	0.2232	0.1778	0.1488	0.093	0.0589	0.0405	0.04495	0.06975	0.099	0.13795	0.1725
Estimated monthly evaporation (M3) attributed to 1 evaporator (350 l/min)	6019	6875	6895	5686	5862	4701	4046	3371	3632	4330	4820	5687	6019
Estimated monthly evaporation (M3) attributed to 2 evaporators (350 l/min)	12037	13751	13789	11372	11725	9402	8093	6742	7264	8659	9640	11375	12037
Estimated monthly evaporation (M3) attributed to 3 evaporators (350 l/min)	18056	20626	20684	17058	17587	14103	12139	10113	10895	12989	14460	17062	18056
Estimated monthly evaporation (M3) attributed to 4 evaporator(s) (350 l/min)	24075	27502	27578	22744	23449	18804	16186	13484	14527	17318	19280	22750	24075
Estimated Evaporation (M3) attributed to surface evaporation (no evaporator)	15006.3	19291.2	18596.0	14286.3	11827.1	7397.5	4816.0	3457.6	4001.9	6488.1	9529.3	13544.4	16982.3
Estimated Evaporation (M3) attributed to surface evaporation (1 evaporator)	15006.3	18586.8	16798.5	12188.2	9715.6	5845.2	3705.0	2647.1	3070.1	4994.2	7313.1	10292.7	12643.1
Estimated Evaporation (M3) attributed to surface evaporation (2 evaporator)	15006.3	17777.3	14847.0	9755.6	6725.4	3443.3	1581.8	988.8	1414.3	2427.2	3296.7	1550.3	643.3
Estimated Evaporation (M3) attributed to surface evaporation (3 evaporator)	15006.3	16861.3	13193.4	7424.1	2837.6	382.6	121.3	65.6	78.0	143.4	178.4	144.2	0.0
Estimated Evaporation (M3) attributed to surface evaporation (4 evaporator(s))	15006.3	15950.5	10922.7	1049.4	25.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Evaporator evaporation as % of Surface Evaporation (1 evaporator)	40.1%	35.6%	37.1%	39.8%	49.6%	63.5%	84.0%	97.5%	90.8%	66.7%	50.6%	42.0%	35.4%
Evaporator evaporation as % of Surface Evaporation (2 evaporators)	80.2%	71.3%	74.2%	79.6%	99.1%	127.1%	168.0%	195.0%	181.5%	133.5%	101.2%	84.0%	70.9%
Evaporator evaporation as % of Surface Evaporation (3 evaporator(s))	120.3%	106.9%	111.2%	119.4%	148.7%	190.6%	252.1%	292.5%	272.3%	200.2%	151.7%	126.0%	106.3%
Evaporator evaporation as % of Surface Evaporation (4 evaporator(s))	160.4%	142.6%	148.3%	159.2%	198.3%	254.2%	336.1%	390.0%	363.0%	266.9%	202.3%	168.0%	141.8%
Evaporation from Pond	15006.33158	19291.2246	18595.96903	14286.305	11827.0785	7397.5361	4815.98473	3457.57676	4001.9273	6488.09051	9529.31306	13544.40844	16982.28
Incident Rainfall	10081.5	7243.5	8819.25	8027.25	6913.5	5626.5	6435	5395.5	6575.25	7656	8217	9050.25	10081.5
Water Pumped In	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000

	December	January	February	March	April	May	June	July	August	September	October	November	December
	31	31	28	31	30	31	30	31	31	30	31	30	31
	46.1	59.8	51.2	55.6	49.3	47.5	37.9	52.4	47.6	65.2	61.9	58.7	46.1
	6.2	6.3	5.5	4.1	2.6	1.6	1.1	1.2	1.9	2.8	3.8	5	6.2
Average Monthly Pan Evaporation (mm- total)	0.22165	0.2232	0.1778	0.1488	0.093	0.0589	0.0405	0.04495	0.06975	0.099	0.13795	0.1725	0.22165
Estimated monthly evaporation (M3) attributed to 1 evaporator (350 l/min)	6875	6895	5686	5862	4701	4046	3371	3632	4330	4820	5687	6019	6875
Estimated monthly evaporation (M3) attributed to 2 evaporators (350 l/min)	13751	13789	11372	11725	9402	8093	6742	7264	8659	9640	11375	12037	13751
Estimated monthly evaporation (M3) attributed to 3 evaporators (350 l/min)	20626	20684	17058	17587	14103	12139	10113	10895	12989	14460	17062	18056	20626
Estimated monthly evaporation (M3) attributed to 4 evaporator(s) (350 l/min)	27502	27578	22744	23449	18804	16186	13484	14527	17318	19280	22750	24075	27502
Estimated Evaporation (M3) attributed to surface evaporation (no evaporator)	21601.0	20657.1	15814.9	13016.6	8081.2	5197.2	3706.7	4272.1	6895.5	10083.4	14273.9	17829.0	22594.3
Estimated Evaporation (M3) attributed to surface evaporation (1 evaporator)	15705.6	14263.7	10500.7	8482.3	5096.7	3274.3	2374.8	2773.1	4542.8	6698.9	9492.6	11738.3	14684.1
Estimated Evaporation (M3) attributed to surface evaporation (2 evaporator)	0.0	0.0	0.0	0.0	0.0	0.0	1.5	32.2	107.1	123.3	0.0	0.0	0.0
Estimated Evaporation (M3) attributed to surface evaporation (3 evaporator)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	35.5	30.9	0.0	0.0	0.0
Estimated Evaporation (M3) attributed to surface evaporation (4 evaporator(s))	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Evaporator evaporation as % of Surface Evaporation (1 evaporator)	31.8%	33.4%	36.0%	45.0%	58.2%	77.9%	90.9%	85.0%	62.8%	47.8%	39.8%	33.8%	30.4%
Evaporator evaporation as % of Surface Evaporation (2 evaporators)	63.7%	66.8%	71.9%	90.1%	116.3%	155.7%	181.9%	170.0%	125.6%	95.6%	79.7%	67.5%	60.9%
Evaporator evaporation as % of Surface Evaporation (3 evaporator(s))	95.5%	100.1%	107.9%	135.1%	174.5%	233.6%	272.8%	255.0%	188.4%	143.4%	119.5%	101.3%	91.3%
Evaporator evaporation as % of Surface Evaporation (4 evaporator(s))	127.3%	133.5%	143.8%	180.1%	232.7%	311.4%	363.8%	340.0%	251.2%	191.2%	159.4%	135.0%	121.7%
Evaporation from Pond	21600.97867	20657.05538	15814.9363	13016.6113	8081.18995	5197.22556	3706.71156	4272.10208	6895.50571	10083.4006	14273.9441	17829.0205	22594.3205
Incident Rainfall	7243.5	8819.25	8027.25	6913.5	5626.5	6435	5395.5	6575.25	7656	8217	9050.25	10081.5	7243.5
Water Pumped In	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000

	Initial Volume stored in ED3													
Progressive Water Balance (no evaporators)	90976	91051	84003	79226	77967	78054	81283	87902	94840	102413	108581	112268	112774	110874
Progressive RL of dam	789.09	789.09	789.02	788.96	788.95	788.95	788.99	789.06	789.13	789.21	789.27	789.31	789.31	789.29
Progressive Water Balance (1 evaporator)	90976	85032	71813	61939	57093	53428	53509	57192	61569	66443	69775	70859	68929	65349
Progressive RL of dam	789.09	789.03	788.87	788.73	788.67	788.62	788.62	788.67	788.73	788.79	788.84	788.85	788.83	788.78
Progressive Water Balance (2 evaporators)	90976	79013	58919	42151	31618	22091	17471	17108	18114	19355	18358	14622	7005	0
Progressive RL of dam	789.09	788.96	788.70	788.46	788.26	788.07	787.81	787.75	787.93	788.02	787.98	787.28	785.83	784.50
Progressive Water Balance (3 evaporators)	90976	72995	47751	27693	16238	7727	3868	3042	3259	3861	3385	1963	0	0
Progressive RL of dam	789.09	788.88	788.55	788.18	787.58	785.97	785.23	785.08	785.12	785.23	785.14	784.87	784.50	784.50
Progressive Water Balance- 4 evaporators	90976	66976	35767	11085	320	0	0	0	0	0	0	0	0	0
Progressive RL of dam	789.09	788.80	788.34	786.60	784.56	784.50	784.50	784.50	784.50	784.50	784.50	784.50	784.50	784.50

Progressive Water Balance (no evaporators)	101516	94678	91891	90787	93333	99571	106259	113562	119323	122457	122233	119485	109135
Progressive RL of dam	789.20	789.13	789.10	789.09	789.11	789.18	789.25	789.32	789.38	789.41	789.41	789.38	789.27
Progressive Water Balance (1 evaporator)	55011	47672	44513	42082	42911	47025	51674	56845	60628	62327	61197	58521	49205
Progressive RL of dam	788.64	788.55	788.50	788.46	788.48	788.54	788.60	788.67	788.72	788.74	788.73	788.69	788.57
Progressive Water Balance (2 evaporators)	0	0	0	0	0	68	1346	2885	2339	0	0	0	0
Progressive RL of dam	784.50	784.50	784.50	784.50	784.50	784.51	784.76	785.05	784.94	784.50	784.50	784.50	784.50
Progressive Water Balance (3 evaporators)	0	0	0	0	0	0	282	955	587	0	0	0	0
Progressive RL of dam	784.50	784.50	784.50	784.50	784.50	784.50	784.55	784.68	784.61	784.50	784.50	784.50	784.50
Progressive Water Balance- 4 evaporators	0	0	0	0	0	0	0	0	0	0	0	0	0
Progressive RL of dam	784.50	784.50	784.50	784.50	784.50	784.50	784.50	784.50	784.50	784.50	784.50	784.50	784.50

	1/11/2005	1/12/2005	1/01/2006	1/02/2006	1/03/2006	1/04/2006	1/05/2006	1/06/2006	1/07/2006	1/08/2006	1/09/2006	1/10/2006	1/11/2006
Monthly Evaporation (no evaporators)	15.006	19.291	18.596	14.286	11.827	7.398	4.816	3.458	4.002	6.488	9.529	13.544	16.982
Monthly Evaporation (1 evaporator)	21.025	25.462	23.693	17.874	15.578	10.546	7.752	6.018	6.702	9.324	12.133	15.980	18.662
Monthly Evaporation (2 evaporators)	27.044	31.528	28.636	21.127	18.450	12.845	9.675	7.731	8.678	11.086	12.937	12.925	12.681
Monthly Evaporation (3 evaporators)	33.063	37.487	33.877	24.482	20.425	14.485	12.261	10.179	10.973	13.132	14.638	17.207	18.056
Monthly Evaporation- 4 evaporators	39.081	43.452	38.501	23.793	23.475	18.804	16.186	13.484	14.527	17.318	19.280	22.750	24.075

	1/12/2006	1/01/2007	1/02/2007	1/03/2007	1/04/2007	1/05/2007	1/06/2007	1/07/2007	1/08/2007	1/09/2007	1/10/2007	1/11/2007	1/12/2007
Monthly Evaporation (no evaporators)	21.601	20.657	15.815	13.017	8.081	5.197	3.707	4.272	6.896	10.083	14.274	17.829	22.594
Monthly Evaporation (1 evaporator)	22.581	21.158	16.187	14.345	9.798	7.321	5.746	6.405	8.872	11.519	15.180	17.757	21.560
Monthly Evaporation (2 evaporators)	13.751	13.789	11.372	11.725	9.402	8.093	6.744	7.296	8.766	9.763	11.375	12.037	13.751
Monthly Evaporation (3 evaporators)	20.626	20.684	17.058	17.587	14.103	12.139	10.113	10.902	13.024	14.491	17.062	18.056	20.626
Monthly Evaporation- 4 evaporators	27.502	27.578	22.744	23.449	18.804	16.186	13.484	14.527	17.318	19.280	22.750	24.075	27.502

Net pan evaporation (inches/month)	Percentage of volume pumped by evaporator	Net pan evaporation (inches/month)	Percentage of volume pumped by evaporator
1.5	20	7.0	40
2.0	28	7.5	41
2.5	29	8.0	42
3.0	30	8.5	43
3.5	32	9.0	44
4.0	34	9.5	45
4.5	35	10	46
5.0	36	10.5	47
5.5	37	11	48
6.0	38	11.5	49
6.5	39	12	50
7.0	40	12+	up to 85

Net pan evaporation	Percentage of volume pumped by evaporator (from manufacturer specifications)			
1.5	20%	38.1	21.8%	21.8%
2	28%	50.8	24.4%	24.4%
2.5	29%	63.5	26.7%	26.7%
3	30%	76.2	28.7%	28.7%
3.5	32%	88.9	30.5%	30.5%
4	34%	101.6	32.2%	32.2%
4.5	35%	114.3	33.8%	33.8%
5	36%	127	35.2%	35.2%
5.5	37%	139.7	36.6%	36.6%
6	38%	152.4	37.9%	37.9%
6.5	39%	165.1	39.1%	39.1%
7	40%	177.8	40.3%	40.3%
7.5	41%	190.5	41.4%	41.4%
8	42%	203.2	42.5%	42.5%
8.5	43%	215.9	43.5%	43.5%
9	44%	228.6	44.6%	44.6%
9.5	45%	241.3	45.5%	45.5%
10	46%	254	46.5%	46.5%
10.5	47%	266.7	47.4%	47.4%
11	48%	279.4	48.3%	48.3%
11.5	49%	292.1	49.1%	49.1%
12	50%	304.8	50.0%	50.0%
12+	up to 86			

Date	Generation		
	LFG m^3	CH4 %	CH4 m^3
Jan-09	715157.391	44.70	319675.35
Feb-09	705713.793	44.10	311219.78
Mar-09	644507.6315	44.70	288094.91
Apr-09	582978.6661	46.90	273416.99
May-09	653474.408	46.30	302558.65
Jun-09	550015.7408	46.30	254657.29
Jul-09	645909.6134	45.10	291305.24
Aug-09	601124.257	46.00	276517.16
Sep-09	636499.7727	46.10	293426.40
Oct-09	618982.3116	46.03	284917.56
Nov-09	568377.7557	47.47	269808.92
Dec-09	602923.4432	49.40	297844.18
Jan-10	633621.4634	49.62	314402.97
Feb-10	545989.9806	51.20	279546.87
Mar-10	631883.23	51.34	324408.85
Apr-10	638644.3417	51.08	326219.53
May-10	692730.749	52.06	360635.63
Jun-10	715272.7635	53.53	382885.51
Jul-10	700305.5498	53.66	375783.96
Aug-10	816358.0946	52.44	428098.18
Sep-10	837954.388	51.61	432468.26
Oct-10	895459.3647	51.29	459281.11
Nov-10	909820.991	51.64	469831.56
Dec-10	869478.9712	52.94	460302.17
Jan-11	873303.8568	53.13	463986.34
Feb-11	701911.9806	54.86	385068.91
Mar-11	836206.0057	54.69	457321.06
Apr-11	755607.8672	55.15	416717.74
May-11	741324.4398	52.76	391122.77
Jun-11	757945.904	51.34	389129.43
Jul-11	812108.7453	51.72	420022.64
Aug-11	793648.8024	51.50	408729.13
Sep-11	924328.7454	51.91	479819.05
Oct-11	827462.7231	52.07	430859.84
Nov-11	703830.625	50.00	351915.31
Dec-11	1076307.334	50.00	538153.67
Jan-12	1322738.884	50.00	661369.44
Feb-12	1037394.707	50.00	518697.35
Mar-12	1122111.703	50.27	564085.55
Apr-12	1256022.54	55.81	700986.18
May-12	1302084.81	54.08	704167.47
Jun-12	1292738	56.69	732853.17

Date	Flared		
	LFG m^3	CH4 %	CH4 m^3
Jan-09	0.00		0.00
Feb-09	0.00		0.00
Mar-09	0.00		0.00
Apr-09	4924.909	50.52	2488.06
May-09	9623.061	49.89	4800.95
Jun-09	22676.49	49.92	11320.11
Jul-09	2412.217	47.44	1144.36
Aug-09	2143.331	49.14	1053.23
Sep-09	4305.724	48.06	2069.33
Oct-09	31559.81	49.10	15495.87
Nov-09	39822.49	50.52	20118.32
Dec-09	27337.06	50.84	13897.80
Jan-10	9180.336	49.72	4564.46
Feb-10	19394.24	51.04	9897.93
Mar-10	25809.04	51.98	13415.90
Apr-10	2840.304	51.71	1468.69
May-10	6580.667	52.06	3425.90
Jun-10	22780.42	53.53	12194.36
Jul-10	27900.83	53.66	14971.59
Aug-10	14084.77	52.44	7386.05
Sep-10	8211.22	51.61	4237.81
Oct-10	24145.96	51.29	12384.46
Nov-10	16912.88	51.64	8733.81
Dec-10	45360.46	52.94	24013.83
Jan-11	25621.81	53.13	13612.87
Feb-11	88958.78	54.86	48802.78
Mar-11	17665.17	54.69	9661.08
Apr-11	30122.4	55.15	16612.50
May-11	12478.24	52.76	6583.52
Jun-11	107437.1	51.34	55158.19
Jul-11	37047.42	51.72	19160.93
Aug-11	94955.55	51.50	48902.11
Sep-11	44161.39	51.91	22924.18
Oct-11	98815.87	52.07	51453.43
Nov-11	36884.16	50.00	18442.08
Dec-11	39115.45	50.00	19557.73
Jan-12	70689.59	50.00	35344.79
Feb-12	116814.8	50.00	58407.40
Mar-12	10204.83	50.27	5129.97
Apr-12	173967.2	55.81	97091.08
May-12	58160.42	54.08	31453.16
Jun-12	97302.03	56.69	55160.52

Certificate of Analysis

Batch No:	**WOODLAWN_120564**	*Page*	Page 1 of 2
Final Report:	WOODLAWN_120564_LFTK8	*Laboratory*	Canberra Laboratory
		Address	PO Box 1834, Fyshwick, Canberra. ACT 2609.
Client:	**Woodlawn Bioreactor**	*Phone*	02 6202 5401
Contact:	**Tandy Hargrave**	*Fax*	02 6202 5452
Address:	PO Box 141 Goulburn NSW 2580	*Contact:*	Shane Reynolds Supervisor Chemistry shane.reynolds@alsglobal.com
Client Ref:	**Leachate Samples**	*Date Sampled:*	13-Jun-2012
		Date Samples Received:	13-Jun-2012
		Date Issued:	**20-Jun-2012**
		Date Testing Commenced:	13-Jun-2012
Client PO:	4502145753		

The sample(s) referred to in this report were analysed by the following method(s):

- NATA accreditation does not cover the performance of this service

Analysis	*Method*	*Laboratory*	*NATA No.*	*Analysis*	*Method*	*Laboratory*	*NATA No.*	*Analysis*	*Method*	*Laboratory*	*NATA No.*
Sulphate	35	CANBERRA	992	**BOD**	190	CANBERRA	992	**Chem Oxy Demand**	201	CANBERRA	992
Conductivity	65	CANBERRA	992	**T.Diss Solids**	260	CANBERRA	992	**pH**	210	CANBERRA	992
Ammonia (asN)	32	CANBERRA	992	**Nitrate (asN)**	150 152	CANBERRA	992	**Nitrite (asN)**	150	CANBERRA	992
T.Kjel.N (calc)		CANBERRA	992	**T.Oxid Nit(asN)**	150	CANBERRA	992	**Tot.Phosp (asP)**	220	CANBERRA	992
Total Nitrogen	114	CANBERRA	992	**Vol Fatty Acids**		ALS_MELB	992				

Temperature on receipt at Lab: 12.1

NATA Accredited Laboratory No. 992

Accredited for compliance with ISO/IEC 17025

WORLD RECOGNISED ACCREDITATION

Signatories

These results have been electronically signed by the authorised signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11

Name	*Title*	*Name*	*Title*
Chau Lethitran	**Nutrients**	**Geetha Ramasundera**	**Chemistry**
Shane Reynolds	**Supervisor Chemistry**	**Terry Obrien**	**Supervisor Nutrients**

Batch No: **WOODLAWN_120564**

Report Number: **WOODLAWN_120564_LFTK8**

Client: **Woodlawn Bioreactor**

Client Ref: **Leachate Samples**

			Sample No.	**892941**	**892942**
			Client Sample ID.	Leachate Dam	Lagoon 1
			Sample Point.	LEACHATE	LEACHATE
			Sample Date.	13-Jun-2012 12:00:00AM	13-Jun-2012 12:00:00AM
Analysis	**Analyte**	**LOR**	**Units**		
Ammonia (asN)	Ammonia	<0.1	mg/L N	1200	1700
BOD	BOD_Result	<2	mg/L	11000	7200
Chem Oxy Demand	COD	<1	mg/L	26000	12000
Conductivity	SpC	<2	uS/cm	33000	22000
Nitrate (asN)	Nitrate	<0.01	mg/L N	<0.1	<0.1
Nitrite (asN)	Nitrite	<0.01	mg/L N	<5.0	<5.0
pH	pH	<0.1	pH units	8.4	7.8
Sulphate	Sulphate	<0.4	mg/L SO4	5000	190
T.Diss Solids	TDS	<20	mg/L	38000	12000
T.Kjel.N (calc)	TKN_calc	N/A	mg/L N	2395.0	1895.0
T.Oxid Nit(asN)	Oxidised_N	<0.05	mg/L N	<5.0	<5.0
Tot.Phosp (asP)	Total_P	<0.01	mg/L P	24	8.8
Total Nitrogen	Total_N	<0.05	mg/L N	2400	1900
Vol Fatty Acids	Vol Fatty Acid	<10	mg/L	3100	6100

These samples were analysed as received into the Laboratory.
Tests marked # are not NATA accredited.
A blank space indicates no test performed. A 'P' indicates results are pending authorisation
Soil results expressed in mg/kg dry weight unless specified otherwise

LOR = Limit of reporting. When a reported LOR is higher than the standard LOR, this may due to high moisture content, insufficient sample or matrix interference.

The analytical procedures in this report (including house methods) are developed from internationally recognised procedures such as those published by USEPA, APHA and NEPM

Appendix D: Liquid Odour Measurement Methodology

Methodology

The Liquid Odour Method is comprised of the following components:

- Evaporation of a known amount of liquid in a known volume of dry nitrogen contained in a Nalophan odour sample bag;
- Determination of the odour concentration of the gaseous sample by Dynamic Dilution Olfactometry following AS/NZS 4323.3:2001; and
- Calculation of the odour concentration in the liquid from the gaseous odour concentration (ou/m^3) and the volume of liquid evaporated to produce the gaseous sample.

Procedure

Liquid Sample Storage

The liquid samples collected from the Woodlawn Bioreactor Facility were sourced from the untreated and treated leachate ponds (i.e. ED3N-1 and ED3N-4 respectively). These were refrigerated prior to testing. A liquid sample was extracted immediately from the refrigerated sample bottle and not allowed to warm to room temperature. This is the general procedure when carrying out the liquid odour measurement method for aqueous samples.

Liquid Sample Size

The volume of liquid is determined by the requirement to produce a gaseous sample with relative humidity of less than 100%. This equates to less than 2.3% v/v water at 20^{o} C, or for a 25 L sample, 413 μL of aqueous sample. The method development work carried out to date has shown that 413 μL of liquid sample in 25 L dry nitrogen will evaporate in approximately 30 mins. The nominal liquid sample size required for the Liquid Odour method can be specified as 340-413 μL, which provides a gaseous sample with 80-100% RH. For the liquids samples collected at the Woodlawn Bioreactor Facility, 413 μL of liquid sample was used in 25 L dry nitrogen.

Table D1 details a range of liquid volumes and approximate evaporation times observed from the method development work carried out to date.

Table D1 - Liquid sample volumes, evaporation and equilibration time		
Volume µL (% saturation)	**Approximate evaporation time (in 25 L dry nitrogen)**	**Recommended equilibration time (in 25 L dry nitrogen)**
280 µL (60%)	20-30 min	60 min
340 µL (80%)	30-40 min	60 min
413 µL (100%)	40-60 min	60 min

Sample Equilibration and Ageing

The development work to date has shown that condensate derived odour samples are not stable and degrade significantly over time. However, the degradation appears insignificant in the first 2-4 hours after preparation of the gaseous samples. Therefore, samples must be tested within that time period after preparation.

For samples prepared at 100% saturation or below, the equilibration time can be standardised to 1 hour.

Sample Preparation and Odour Testing Procedure

The gaseous sample for odour testing is prepared as follows:

- Dispense 25 L of dry nitrogen into a conditioned Nalophan bag
- Place a piece of clear packaging tape (approximately 100 mm long) onto the wall of the bag half way between the ends. Ensure that the a least a 1 cm^2 section of tape is completely adhered to the bag with no air bubbles trapped between the tape and bag that could allow a leak of gas to the edge of the tape
- Remove the liquid sample from cold storage
- Rinse the microlitre syringe (5 x) with the liquid sample
- Draw up the required volume of liquid sample (see **Liquid Sample Size** and **Table D1**) and record the exact volume in the syringe
- Inject the liquid through the tape and wall of the bag at the point where the tape has completely adhered to the bag. Tap the syringe to displace residual drop that adheres to the needle and withdraw the syringe from the bag.

- Place a second piece of packaging tape over the first piece such that the puncture hole is sealed. Ensure no air bubbles are trapped between the layers of tape such that a leak could occur.
- Vigorously shake the bag to disperse the liquid droplets inside the bag (to aid in the evaporation rate)
- Store the bag in the laboratory for the prescribed equilibration time (see **Sample Equilibration and Ageing** and **Table D1**) to allow all the liquid to evaporate
- At the completion of the equilibration time, carry out the measurement of odour concentration using AS/NZS 4323.3:2001.

Calculation of Liquid Odour Concentration

The odour concentration from a liquid (ou per mL) is calculated from the gaseous sample odour concentration, the volume of liquid used to prepare the gaseous sample and the volume of dry nitrogen:

$$\boxed{[odour]_{liquid} = \frac{\left(\dfrac{OU}{m^3} \times \dfrac{litres_{Nitrogen}}{1000}\right)}{mL_{liquid}}}$$

An example of the calculation is presented in **Table D2**.

Table D2 – Example calculation of liquid odour concentration		
Parameter	**Value**	**Unit**
Volume of liquid (ED3N-4 – Treated Leachate)	0.413	mL
Volume of dry N_2	25	L
Measured odour concentration	215	ou
Calculated liquid odour concentration	= (955 x 25/1000)/0.413 = 13.01	ou.m^3/mL

Calculation of Odour Emission Rates from Evaporation of Liquids

A primary driver for development of a liquid odour measurement is the requirement to predict odour emission rates from liquids area sources (such as storage ponds) as well as condensates. In particular, evaporation of condensates or other odorous refinery waters in cooling towers has been implicated as a significant contributor to refinery odour. With a measurement of the odour from liquids now available, the estimation of emission rates can be considered. An example is presented below for the treated leachate pond (ED3N-4) that returned a measured odour concentration of 13.01 ou.m^3/mL (see **Table D2**) with an evaporation rate of 0.868 L/sec (based on on-site evaporation data collected by VES over January 2012).

Odour concentration	= 13.01 ou.m^3/mL
Ambient pond evaporation rate	= 0.868 L/sec
Odour emission rate	= 13.01 ou.m^3/mL x 868 mL/sec
	= 11,370 ou.m^3/sec