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# INTEGRATED WASTE SERVICES, NORTHERN BALEFILL, DUBLIN

# Multiple Waste Treatment Facility, EIS Amendment

**Submitted to:**
Integrated Waste Services
Planning SA

REPORT

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# Table of Contents



**TABLES**

**APPENDICES**

**FIGURES**

# 1.0 INTRODUCTION

This EIS Amendment was prepared as an addendum to support the current Integrated Waste Services Pty Ltd (IWS) development application, lodged with the Development Assessment Commission (DAC), to amend the IWS Northern Balefill Development Authorisation to construct a Multi-Purpose Waste Treatment Facility (MWTF). The MWTF will be constructed at the IWS Northern Balefill site (the 'site'), Port Wakefield Road, Dublin, South Australia. The location of the site is shown on Figure 1. The MWTF will receive and treat listed waste, refer section 1.1 and 2.

This report (this document) forms part of the overall MWTF development application and provides a summary overview of the following:

- proposed handling and treatment processes for soil remediation
- the proposed contamination trigger levels for incoming material
- environmental impact review and risk assessment

The operations proposed as part of the MWTF development are considered to be equivalent to those current site activities covered by the previous site Environmental Impact Statement (1996), and related Amendments, to operate the Northern Balefill Landfill and Low Level Contaminated Waste (LLCW) and Liquid Treatment Plant Residues facility.

It is proposed to undertake the MWTF development in two Stages.

- Stage 1 will comprise a storage and laydown area, that is a concrete pad that will form the foundation of the planned MWTF (a future facility specifically designed to treat listed waste). It is intended the storage and laydown area will be used for interim storage of soil, prior to development of Stage 2. No walls, service areas or other infrastructure associated with the final MWTF will be constructed as part of the works associated with this.
- Stage 2 includes development of the overall MWTF treatment facility and support infrastructure.

It is planned that Stage 2 will commence development within 12 months of the Stage 1 facility commencing receipt of listed waste.

## 1.1 Proposed Development

The proposed development occurs within the existing IWS Northern Balefill site and will principally consist of a storage and treatment shed over a sealed concrete pad and other operational and staff facilities. The proposed development will be located approximately 700 metres from Port Wakefield Road and outside the existing 520m buffer zone created around the nearest dwellings on the adjacent properties (refer Figure 4). The proposed trigger contaminant levels for material to be received by the MWTF are provided in Table 1.

MWTF development features are outlined in the main MWTF Development Application. The MWTF will be developed to incorporate the following key features:

- concrete and bunded soil storage and laydown areas
- sealed soil treatment and remediation facilities

- unidirectional drive through facility with vehicle rejection area
- clean stormwater harvesting infrastructure for utilisation in processing and revegetation
- stormwater management systems to divert flows around the facility while minimising erosion and systems to store water from contaminated storage and treatment facilities
- utilisation of existing site facilities, including the weigh bridge & wheel wash, and
- revegetated perimeter buffer zones & retention of existing revegetation where possible.

## 1.2 Summary of Expected Site Conditions

The site environmental conditions are not considered to have changed substantially since the original site EIS and associated amendments. The potential for negative environmental impacts associated with Stage 1 and 2 is low due to proposed design and operation of the facility.

The receipt and transport of material will be managed in accordance with current site procedures for receipt of low level contaminated waste materials, including inspection of loads, review of waste tracking certification and material chemical analysis, site security and load covering.

Transport activities associated with MWTF operation will be consistent with current site use. Upgrade of internal access routes is proposed as part of overall works. This does not vary from previous EIS conditions.

The treatment of listed waste will be a controlled activity within enclosed and concrete bunded facilities. There is no offsite movement of material expected as part of proposed operations. The treatment of listed waste is expected to produce low level contaminated waste suitable for onsite disposal or reusable material options. There are no byproducts of significance expected to be produced during facility operation.

The proposed treatment options are outlined in section 2. An environmental impact review and risk assessment is provided in section 3.

**Table 1: MWTF Trigger Concentrations**

| | Intermediate Landfill Cover | Low Level Contaminated Waste Cell | | Proposed Multi-Purpose Waste Treatment Facility – TRIGGER CONCENTRATION | | Comment |
|---|---|---|---|---|---|---|
| | Max Concentration (mg/kg) | Max Concentration (mg/kg) | Max Leachability (mg/L) | Max Conc without a mutually agreed pre-treatment trial (mg/kg) | Max leachability without a mutually agreed pre-treatment trial (mg/L) | |
| **METALS/METALLOIDS** | | | | | | |
| Arsenic | 200 | 750 | 5 | 5,000 | 50 | Likely Treatment - Chemical Fixation to reduce leachability to below LLCW leachability criteria - for disposal in to LLCW cell. (Concentrations of metals remain unchanged, but are less mobile due to fixation) |
| Barium | | - | 100 | | 1000 | |
| Beryllium | 40 | 150 | 1 | 1,000 | 10 | |
| Cadmium | 30 | 60 | 0.5 | 1,000 | 5 | |
| Chromium (VI) | 200 | 750 | 5 | 5,000 | 50 | |
| Chromium (III) | 120,000 | 300,000 | 20 | 500,000 | 200 | |
| Cobalt | 170 | 1,000 | - | 5,000 | TBA | |
| Copper | 2,000 | 7,500 | 10 | 25,000 | 100 | |
| Lead | 1,200 | 5,000 | 5 | 15,000 | 50 | |
| Manganese | 6,000 | 10,000 | 50 | 75,000 | 500 | |
| Methyl Mercury | 20 | 75 | - | 500 | TBA | |
| Mercury | 30 | 110 | 0.1 | 750 | 1 | |
| Nickel | 600 | 3,000 | 2 | 30,000 | 20 | |
| Silver | - | - | 5 | | 50 | |

| | Intermediate Landfill Cover | Low Level Contaminated Waste Cell | | Proposed Multi-Purpose Waste Treatment Facility – TRIGGER CONCENTRATION | | Comment |
|---|---|---|---|---|---|---|
| | Max Concentration (mg/kg) | Max Concentration (mg/kg) | Max Leachability (mg/L) | Max Conc without a mutually agreed pre-treatment trial (mg/kg) | Max leachability without a mutually agreed pre-treatment trial (mg/L) | |
| Zinc | 14,000 | 50,000 | 250 | 350,000 | 2500 | |
| **VOLATILE COMPOUNDS** | | | | | | |
| Benzene | 5 | 15 | 1 | 150 | 10 | Likely Treatment - Bioremediation of volatile organics to concentrations suitable for reuse off site, or disposal on site |
| Ethylbenzene | 100 | 1,000 | 30 | 10,000 | 300 | |
| Toluene | 50 | 500 | 14.4 | 5,000 | 144 | |
| Xylene (total) | 180 | 1,800 | 50 | 18,000 | 500 | |
| Total Petroleum Hydrocarbons (TPH) (C6-C9) | 100 | 1,000 | - | 10,000 | - | |
| TPH >C9 | 1,000 | 10,000 | - | 100,000 | - | |
| **SEMI-VOLATILE COMPOUNDS** | | | | | | |
| TPH >C28 | - | - | - | 50,000 | - | Treatment dependent upon composition of compounds, but would likely require either a mixture of bioremediation and stabilisation, or a more sophisticated treatment such as soil washing). Treatment Trials required prior to accepting waste. Treatment trial could be conducted at facility with up to 5m$^3$ of waste. |
| Aldrin + Dieldrin (total) | 2 | 50 | 0.1 | 500 | 1 | |
| Chlordane | 2 | 50 | 0.6 | 500 | 6 | |
| DDT | 2 | 50 | 0.3 | 500 | 3 | |
| Heptachlor | 2 | 50 | 0.3 | 500 | 3 | |
| Phenolic compounds (Total) | 17,000 | 50,000 | 14.4 | 100,000 | 144 | |

| | Intermediate Landfill Cover | Low Level Contaminated Waste Cell | | Proposed Multi-Purpose Waste Treatment Facility – TRIGGER CONCENTRATION | | Comment |
|---|---|---|---|---|---|---|
| | Max Concentration (mg/kg) | Max Concentration (mg/kg) | Max Leachability (mg/L) | Max Conc without a mutually agreed pre-treatment trial (mg/kg) | Max leachability without a mutually agreed pre-treatment trial (mg/L) | |
| Polychlorinated Biphenyls | 2 | 50 | - | 500 | TBA | |
| Benzo(a)pyrene | 2 | 5 | 0.001 | 50 | 0.01 | |
| Polycyclic Aromatic Hydrocarbons (PAH) (total) | 40 | 200 | - | 2000 | TBA | |
| **OTHER** | | | | | | |
| Cyanides (total) | 1,000 | 3,500 | 10 | 12,500 | 100 | Likely Treatment - dependent upon composition of compounds, but would likely require either bioremediation and stabilisation |

**Notes:**

1. The Pre-Treatment Trial would need to be conducted by a suitably qualified and experienced environmental professional to the satisfaction of the licensee. This is likely to include EPA liaison.
2. The Pre-Treatment Trial could be conducted at the source site, or at the IWS site (nominally maximum of 5 $m^3$ of soil)
3. Material needing a Pre-Treatment Trial would also require a Management Plan, including environmental management during transportation, and health and safety during treatment, and disposal.
4. "TBA" - Acceptance, treatment and disposal criteria will need to be developed in consultation with the EPA for chemicals not listed in the LLCW/LTPR facility schedule
5. The disposal of treated waste with concentrations above the Low Level Contaminated Waste (LLCW) total concentration criteria in the LLCW cell will be dictated by the leachate concentrations only.
6. Leachability as measured using leach test method AS4439
7. Material with concentrations of chemical above these triggers, or concentrations of chemicals not listed on this table, can be accepted provided a pre-trial is conducted by a suitably qualified and experienced environmental professional to the satisfaction of IWS, in consultation its environmental consultants and the EPA.

## 2.0 REMEDIATION OUTLINE

A number of remediation technologies will be proposed to treat contaminated wastes such as soil, non liquid industrial residues and process waste, sludge and sediment. It is expected the majority of listed waste received will be contaminated soil or sludges.

Upon receiving listed waste, the remediation technology that is best suited to the contaminants present will be chosen. The proposed remediation processes are established technologies. It is proposed that technologies 1 and 2 would be the treatment options for initiation of the development, refer Table 2.

Table 2 summarises the types of waste that can be treated by each remediation process and the applicability to contaminants in the waste. Table 3 summarises the materials that can be treated by the different remediation options and the materials required to undertake remediation. Sections 2.2 – 2.4 discuss each remediation technology.

**Table 2: Remediation Technologies**

| No. | Remediation Technology | Waste Types | Applicability to Contaminants | Section Reference |
|---|---|---|---|---|
| 1 | Contaminant Stabilisation | Soil and sludges | Reduces toxicity and mobility of inorganic contaminants (such as heavy metals), and some organics and mixed organic/inorganic wastes. | 2.2 |
| 2 | Bioremediation | Soil and sludges | Accelerates degradation of organic contaminants (such as petroleum hydrocarbons) and other biodegradable contaminants into stable, non-toxic by products. | 2.3 |
| **Future Options** | | | | |
| 3 | Low Temperature, Indirect Thermal Desorption | Soil, sediments or sludges | Effectively removes organic contaminants with boiling points of up to approximately 300ºC including petroleum, pesticides, chlorinated organic compounds, semi-volatile and volatile organic compounds. Polychlorinated biphenyls (PCBs) and dioxins can also be removed at slightly higher temperatures (between 400 and 510 ºC). | 2.4.1 |
| 4 | Chemical Hydrocarbon Treatment | Soil and sludges | Accelerates decomposition of a wide range of hydrocarbon contaminants including heavy hydrocarbons (such as lubricating oils, bunker and diesel fuels) lighter fractions (such as petrol), monocyclic aromatic hydrocarbons (such as BTEX), jet fuel, and polycyclic aromatic hydrocarbons (PAHs). | 2.4.2 |
| 5 | In Vessel Composting | Soils, industrial sludges | Accelerates organic degradation of organic contaminants (such as petroleum hydrocarbons) into stable, non-toxic by products. | 2.4.3 |

| No. | Remediation Technology | Waste Types | Applicability to Contaminants | Section Reference |
|---|---|---|---|---|
| 6 | Solvent Extraction System | Soil, sediments, fly ash and sludges | Effectively removes organic contaminants including chlorinated organic compounds, semi-volatile and volatile organic compounds – pesticides, PAHs, dioxins and furans, PCBs, 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane (DDT) and petroleum products. Organically bound metals can be extracted with the target pollutants. | 2.4.4 |

## 2.1 Materials

The proposed facility will have the capacity to treat contaminated wastes including soil, non liquid industrial residues and process waste, sludge and sediment, however, it is expected that primarily contaminated soil will be received and treated. Contaminants which the facility can treat include:

- inorganics, such as heavy metals
- total petroleum hydrocarbons (TPH), including petroleum, semi-volatile and volatile organic compounds
- acid sulphate soils
- monocyclic aromatic hydrocarbons, such as BTEX
- the *future technologies* outlined in table 2 would be suitable to treat the following materials:
  - persistent organic pollutants, such as pesticides and dioxins
  - polychlorinated biphenyls (PCBs), and
  - polycyclic aromatic hydrocarbons (PAHs).

The remediation technologies will utilise a variety of materials, both biological and chemical, to treat the contaminants of interest and remediate the waste to an appropriate level. Upon receiving contaminated waste, the remediation technology that is best suited to the contaminants will be selected.

**Table 3: Materials Used in Remediation Processes**

| Remediation Technology | Process Materials |
|---|---|
| Contaminant Stabilisation | Sulphur cement, silicate cement, phosphates and proprietary fixation reagents |
| Bioremediation | Nutrients, water, green organics, inorganic fertilizers (e.g. super phosphate and urea), biosolids (as an inoculum), biosurfactants (microbial and plant derived), vegetable oils, complex sugars (e.g. cyclodextrins) and carbohydrates |
| Low Temperature, Indirect Thermal Desorption | Water, natural gas, propane or fuel oil (to power process equipment) and aerosol filters |
| Chemical Hydrocarbon Treatment | A chemical solution containing surfactants, sequestrants, hyper wetting agents and autotrophic bacteria (all natural ingredients) |
| In Vessel Composting | Water and thermophiles and micro-organisms whose enzymes are active at high temperatures |
| Solvent Extraction System | A proprietary solvent (with 3 day biological half life) and some use of a biological culture in a nutrient supplement |

## 2.2 Contaminant Stabilisation

Prior to treatment and costing, initial bench top trials are conducted to determine the most effective methods of stabilisation. Based upon the outcome of these trials, advice can be given on the most cost effective approach to achieving the objectives of the remediation. Both physical and chemical stabilisation/fixation can be enhanced with the use of the treatment unit. Up to 100 tonnes per hour can be homogeneously mixed with fixating chemicals.

Contaminant stabilisation is the process by which soil is treated to reduce the leachability, bioavailability and toxicity of inorganic contaminants, effectively locking the contaminants in the soil matrix. By stabilising the contaminants, leachability criteria can be met allowing offsite disposal or onsite, managed reuse.

Stabilisation can occur through physical or chemical fixation. Physical fixation or stabilisation is often achieved with the use of binders such as cement, lime, gypsum or ash. Chemical fixation is achieved with the use of proprietary products that absorb and immobilise, or reduce, the mobility of the contaminants.

Chemical testing of the stabilised product would be undertaken in order to determine the suitability for re-use or disposal.

### *2.2.1.1 Physical Stabilisation (Solidification)*

Mixing waste with sulphur cement, silicate cement or phosphates results in solidification of the material. The treated waste can then be managed on-site or disposed of to a licensed off-site facility. Waste characteristics such as void volume, soil pore size and permeability will influence the effectiveness of this treatment method.

#### 2.2.1.2 Chemical Stabilisation

Contaminants are chemically absorbed and immobilised or reduced in toxicity by proprietary processes. This process involves the addition of proprietary reagents to the soil in order to produce an insoluble complex within the soil matrix. It also minimises the leachability of heavy metals from within the soil matrix. Contaminated soil is pre-screened to remove debris that can adversely affect the process. Pre-treatment may be required to improve the performance of the process and the product to meet specific conditions.

Contaminated soil is then loaded into a hopper and conveyed to the reaction vessel where proprietary fixation reagents are added and blended with the soil. Treated soil exits on a conveyor and is stockpiled and analysed to verify compliance with site specific targets. Pending successful remediation results, waste is released from holding to be disposed off-site or reused on-site in accordance with existing license conditions.

## 2.3 Bioremediation

The bioremediation process will primarily be used to treat hydrocarbons and other biodegradable contaminants. Bioremediation involves two main types of processes:

- Biopiling, and
- Co-composting.

Biopiling involves mixing the listed waste with nutrients and water, and ensuring adequate oxygen is available either passively or through an aeration system to generate an environment that is conducive to the proliferation of micro-organisms that degrade the contaminants of concern.

Co-composting is similar to biopiling in that the listed waste is mixed with nutrients and water, but the nutrients can be in the form of green organic material that can present a wider diversity of micro-organisms and therefore a wider metabolic capability to degrade contaminants. Co-composting can also assist in elevating temperatures within the windrow up to 70$^{o}$C to 80$^{o}$C that can have a physical affect on contaminants (e.g. solubility) and assist in the degradation process.

Chemical testing of the treated product would be undertaken in order to determine the suitability for re-use or disposal.

Bioremediation processes normally require the listed waste to initially be screened and subsequently mechanically mixed with the required amendments before being placed into windrows on the concrete pad. Mixing occurs within the shed. Amendments may include:

- green organics
- inorganic fertilizers (e.g. super phosphate and urea)
- biosolids (as an inoculum)
- biosurfactants (microbial and plant derived surfactants)
- vegetable oils
- complex sugars (e.g. cyclodextrins), and
- carbohydrates.

In most cases a forced vacuum aeration system will be established on the concrete lined pad in a bed of woodchips before the mixed material is placed on top. Windrow dimensions will generally be 5m at the base, 2.5m high and of a practical length, determined by the volume of material and size limitation of the

concrete pad. Windrow forming will be undertaken using a front end loader or excavator. All windrows will be covered for dust suppression and to maintain windrow integrity.

Monitoring during treatment will involve a number of parameters, including:

- contaminant sampling and testing
- temperature monitoring
- moisture monitoring, and
- off-gas monitoring for oxygen, carbon dioxide and methane.

The process involves indirect heating of soil, condensation, water treatment and residue disposal. The outer layers of a triple skinned, concentric, cylindrical chamber are heated such that the soil in the internal Rotary Dryer reaches the design temperature. Soil, prepared by feed screening plates and conveyors, is fed into the dryer. The moisture in the soil boils and natural organics vaporise.

Soil exits the dryer through a double tipping valve arrangement to maintain air/vapour seal and is conditioned with water before re-use. Steam generated during soil conditioning/rehydration is passed through a dust filter before being vented to the atmosphere. The dust collected is directed back to the conditioning system.

Vapour is extracted from the dryer and directed to the closed air pollution control system. The vapour contains contaminants and steam, which are condensed for destruction and reuse respectively; as well as particulates that are aerosol filtered and collected for disposal. This is achieved by cooling the gases and directing them through a vapour phase carbon polishing system and particulate/aerosol filter. Water used to cool the vapour is treated through a process of coagulation, separation and filtration to remove condensed oil and solids that may be present. These solids are collected for offsite disposal.

## 2.4 Soil-Swapping

Another benefit of the site the availability of potential backfill soil to replace contaminated soil removed from sites, where necessary. This can be back-loaded onto the washed-down truck as it departs the site, reducing transportation (costs and environmental impact). This *Soil-Swap* facility will result in sites being remediated faster and more efficiently.

## 2.5 Possible Future Remediation Processes

The facility has been designed to enable the incorporation of other existing proven treatment technologies for contaminated wastes that are not suitable for contaminant stabilisation or bioremediation. These technologies are currently used by Veolia worldwide and include the following.

### 2.5.1 Low Temperature, Indirect Thermal Desorption

Indirect Thermal Desorption (ITD) is a physical separation process whereby soil is heated in the absence of flame and organic contaminants are volatilised. The contamination is concentrated, thus reducing the quantity of material requiring disposal. As the Indirect Thermal Desorption Unit is a closed system, off gas can be treated by condensation, collection or combustion. The soil retains its physical properties allowing for reuse after treatment.

In contrast to Direct Thermal Desorption, treatment occurs without combustion in an inert atmosphere (less than five percent oxygen). This obviates the potential for contaminant creation through incomplete combustion during treatment.

### 2.5.2 Chemical Hydrocarbon Treatment

Chemical hydrocarbon treatment utilises a chemical formulation that is specifically designed to degrade hydrocarbons in a variety of media. It is a non-toxic, bio-degradable, pathogenic free and readily utilised liquid. The formulation is highly concentrated to allow rapid and economical remediation. It is a non-toxic, bio-degradable, pathogenic free and readily utilised liquid. It contains surfactants, sequestrants, hyper wetting agents and autotrophic bacteria. The chemical treatment works on three levels:

Cation exchange: By introducing a cation charged substrate, the cation exchange between the hydrocarbons and the soil matrix is displaced, leaving the hydrocarbons detached and accessible for destruction.

Chemical bond separation: The now available hydrocarbon chains are broken down by substitution. The bonds between the carbon-carbon and carbon-hydrogen atoms continue to break down until either the formulation is exhausted or water and carbon dioxide molecules are formed.

Micelle formation: Hydrocarbons remaining in the soil after this reaction are prevented from re-adsorbing to the soil matrix via the creation of micelles, which are dissolvable clusters of molecules. The hydrocarbon chains are trapped in the micelles, preventing the hydrocarbons from re-contacting the soil particles. Should reapplication of the formulation occur, the previously trapped hydrocarbons will still be available for chemical bond separation.

The formation of micelles also increases the efficiency of bacterial degradation and acts as a biocatalyst. Although multiple applications of the formulation can reduce the hydrocarbon chains to carbon dioxide and water, it can often be more economical to remediate low concentrations through bioremediation. Listed waste may be pre-processed, if required, to maximise the surface area for contact with the formulation.

The chemical formulation is applied and mixed mechanically until homogenous distribution is achieved. The material is stockpiled, protected from the elements and left to activate. Typically, the soil will be turned on a scheduled basis to promote homogenous distribution, aeration and continued contaminant reduction.

The formulation breaks the hydrocarbon chains until, if desired, carbon and water molecules are formed. Bacterial culture can be applied to 'polish' the remediation process (bio augmentation) by removing low concentration residuals. Once target concentrations have been achieved, the soil or sludge can be re-used or transported off-site for disposal.

### 2.5.3 In Vessel Composting

In Vessel Composting is an enhanced bioremediation technique whereby temperature, oxygen and moisture content are controlled to accelerate organic degradation in a contained area.

Wastes are mixed using a variety of methods depending on physical characteristics. Front end loaders or multi auger shear units may aid in this mixing. The material is blended with ingredients that optimise aerobic degradation of target contaminants or parameters. Ingredients may be added to increase porosity, carbon to nitrogen ratio or moisture content.

Once blended, the material enters the composting vessel. This vessel is computer controlled to ensure that optimum temperature and oxygen levels are maintained. For the breakdown of contaminants such as PAHs, thermophiles or micro-organisms whose enzymes are active at high temperatures, have been found to be most effective.

The activity of indigenous micro-organisms is accelerated under these conditions resulting in the breakdown of organic contaminants in a controlled environment where off-gas, if produced, can be extracted and treated. The process also pasteurises the material and results in the destruction of weed seeds and potentially harmful soil flora. The composted material removed from the vessel is further matured prior to re-use.

### 2.5.4 Solvent Extraction System

Solvent Extraction is a physical separation process that uses a non toxic proprietary solvent to extract persistent organic chemicals from soil. As the contamination is concentrated, it significantly reduces the quantity of material requiring disposal. The Solvent Extraction System operates at ambient temperatures in a closed system without material discharge to air or water. The treated soil retains its physical properties allowing reuse after treatment. The system provides for maximum solvent recycling.

Batches of contaminated soil are placed in the extraction bins and solvent, transferred from the solvent storage tank with a spark proof, pneumatic pumping system, is allowed to permeate the soil without mixing. The contaminants are dissolved in the extract solution.

The number of extraction cycles and resident time required depend on contaminant concentration, target concentration and soil characteristics. Treatment times can vary from several hours to days or months.

The extract solution is drained from the extraction bins and transferred to the sedimentation/extract solution storage tank. Suspended solids settle or are flocculated and removed. The solution is pumped through a micro-filtration unit to remove fines and transferred to the solvent recovery system.

The organic contaminants are separated from the solvent through chemical regeneration in a proprietary solvent purification station. The contaminant concentrate is destroyed off-site and the clean solvent is recycled through the extraction bins until the target concentrations in soil are achieved.

Clean residual solvent in the soil can be recovered through a Vapour Recovery System. As the condensed solvent can be re-used, vapour extraction allows for maximum solvent recycling to occur. The solvent vapour is drawn through the condenser and liquid filter. Removal of residual solvent, although harmless and biodegradable, reduces the risk of increasing the leachability of any contaminant remaining. The biological half-life of the solvent is three days thus any low level residual solvent will degrade quickly. As the extraction process may remove natural organic and some inorganic biological nutrients (i.e. nitrates and phosphates), a biological culture in a nutrient supplement can be added.

# 3.0 ENVIRONMENTAL IMPACT REVIEW

The proposed MWTF will be operated in accordance with the EPA approved Landfill Environmental Management Plan (refer section 3.1). A revised LEMP was submitted with the MWTF Development Application and will be submitted for EPA approval.

MWTF operation is within the scope of the current management program of the LEMP, that is balefill and Low Level Contaminated Waste Disposal cells.

The potential environmental impacts associated with operation of the MWTF are consistent with those assessed and detailed in the previous site Environmental Impact Statement (EIS). The MWTF is located within the existing balefill operation site and environmental site conditions will be similar to those assessed in the EIS.

MWTF specific odour modelling was undertaken as part of Development Application assessment, due to the potential for odour associated with received listed waste. The findings of odour modelling are discussed in the MWTF Development Application and results are provided in Appendix 1 and Table 7. No other environmental impact studies were undertaken for the proposed MWTF, and general conditions are considered consistent with the environmental impact assessment undertaken as part of the overall Northern Balefill site Environmental Impact Statement (EIS) (1996) and as amended July 2003.

Table 7 provides a summary of the potential environmental impacts associated with the MWTF and a qualitative risk assessment. Table 8 provides a summary of expected MWTF activities and an outline of the design aspects and a risk assessment of potential impacts associated with these activities. The risk assessment matrix used for the review is provided in section 3.2.

## 3.1 Landfill Environmental Management Plan

The EPA approved LEMP includes the following key site management aspects:

- Environmental Management System
- Groundwater and Leachate Management Plan
- Soil Erosion Management Plan
- Surface Water and Drainage Management Plan
- Landfill Gas Management Plan
- Air Quality and Management Plan
- Vegetation Management and Revegetation Plan
- Pest Plant and Animal Management Plan
- Aboriginal Heritage Management Plan
- Facilities Management Plan
- Fire Risk Management Plan
- Financial Assurance
- Closure and Post Closure Management Plan
- Low Level Contaminated Waste (LLCW) & Liquid Treatment Plant Residue (LTPR) Cells

- Hazardous Substances Management Plan.

The revised LEMP, refer Development Application, will be submitted to the EPA for approval and include MWTF aspects. The main MWTF related changes relate to odour management and monitoring.

## 3.2 Qualitative Risk Assessment

A qualitative risk assessment was undertaken based on assessment of likelihood and consequence of potential environmental impacts and activities associated with MWTF operation. Table 4 describes the likelihood criteria, Table 5 consequence and Table 6 the overall risk matrix.

**Table 4: Description of Likelihood**

| Level | Description | Likelihood Criteria (either/or) |
|---|---|---|
| A | Almost Certain | ■ The event will occur<br>■ The likelihood is unknown<br>■ The event is of a continuous nature |
| B | Likely | ■ The event is expected to occur during operation lifetime |
| C | Possible | ■ Not likely to occur during operation lifetime but may occur in such an operation |
| D | Unlikely | ■ May occur |
| E | Rare | ■ Has almost never occurred but conceivably could |

**Table 5: Description of Consequence**

| Level | Description | Consequence Criteria (either/or) |
|---|---|---|
| 5 | Insignificant | ■ Possible impacts but without noticeable or notifiable consequences |
| 4 | Minor | ■ Some limited consequences but no significant long term changes<br>■ May be simply rehabilitated<br>■ Not of concern to wider community |
| 3 | Moderate | ■ Significant changes<br>■ Maybe rehabilitate with difficulty |
| 2 | Major | ■ Substantial and significant changes<br>■ Will attract public concern |
| 1 | Catastrophic | ■ Extreme permanent changes to environment (not able to be |

| Level | Description | Consequence Criteria (either/or) |
|---|---|---|
| | | practically or significantly rehabilitated or alleviated)<br>■ Major public outrage<br>■ Consequences are unknown |

**Table 6: Qualitative Risk Matrix**

| | | | Likelihood of Consequence | | | | |
|---|---|---|---|---|---|---|---|
| | | | E | D | C | B | A |
| | | | Rare | Unlikely | Possible | Likely | Almost Certain |
| Severity of Consequence | 5 | Insignificant | **Low 5E** | **Low 5D** | **Low 5C** | **Moderate 5B** | **High 5A** |
| | 4 | Minor | **Low 4E** | **Low 4D** | **Moderate 4C** | **High 4B** | **High 4A** |
| | 3 | Moderate | **Moderate 3E** | **Moderate 3D** | **High 3C** | **High 3B** | **Extreme 3A** |
| | 2 | Major | **High 2E** | **High 2D** | **Extreme 2C** | **Extreme 2B** | **Extreme 2A** |
| | 1 | Catastrophic | **High 1E** | **Extreme 1D** | **Extreme 1C** | **Extreme 1B** | **Extreme 1A** |

**Table 7: MWTF Environmental Impact Risk Assessment**

| No. | Environmental Aspect | Comment / MWTF Detail | Management | Risk Assessment | | |
|---|---|---|---|---|---|---|
| | | | | Likelihood | Consequence | Risk |
| 1. | Air Emissions | ■ General air emissions including greenhouse gas associated with vehicle movement and operation. There will be an insignificant impact to overall regional air quality associated with vehicle and equipment.<br>■ Potential for dust from construction, and uncovered material, refer item 9 and 10.<br>■ No dust is expected from MWTF operation.<br>■ Refer item 2 for odour | ■ There are no additional measures proposed for MWTF.<br>■ Air quality will be managed in accordance with the site LEMP.<br>■ Dust suppression measures during construction will include watering, as required.<br>■ A greenhouse gas inventory will be maintained for the MWTF. | Unlikely | Insignificant | Low |
| 2. | Odour | ■ There is potential for odour due to the nature of listed wastes and onsite storage.<br>■ Worst case scenario odour dispersion modelling was undertaken in accordance with EPA Guideline (373/07): Modelling predicted maximum ground level concentrations of 1.9 odour units at the nearest sensitive receptor (below EPA criteria of 10 odour units).<br>■ MWTF will operate under negative pressure fitted with rapid closing doors to maximise capture of potential odours.<br>■ MWTF exhaust system will be connected to a biofiltration unit to treat and reduce potential | ■ Odour dispersion modelling will be undertaken within 12 months of commencing operations to confirm the MWTF facility meets EPA odour criterion of 10 odour units (3 minute average, 99.9%),<br>■ A copy of the odour dispersion modelling report will be provided to the EPA for their information. | Possible | Insignificant | Low |

| No. | Environmental Aspect | Comment / MWTF Detail | Management | Risk Assessment | | |
|---|---|---|---|---|---|---|
| | | | | Likelihood | Consequence | Risk |
| | | odour emissions. Design will be finalised in detailed facility design phase. | | | | |
| 3. | Noise | ■ There is potential for additional noise to be created associated with vehicle and equipment operation. Operating hours will be in accordance with current EPA Licence.<br>■ The facility is within the existing site noise buffer zone to surrounding neighbours.<br>■ Existing site environmental mounding and vegetated screening will assist in noise control.<br>■ The volume of vehicle traffic and MWTF design will not significantly increase overall site noise levels | ■ Stage 2 works will include extension of mounded vegetation screens to provide additional visual screening from the direction of Port Wakefield Road and the northern property boundary. This will further contribute to noise management.<br>■ Noise management will be undertaken in accordance with existing site LEMP.<br>■ Night time operations are not proposed. | Possible | Insignificant | Low |
| 4. | Visual Amenity | ■ Vegetated mounds will be present around three sides of the proposed facility.<br>■ The MWTF is not expected to contribute significantly to change in visual amenity due to existing operations and structures and screening mounds.<br>■ The site is located in remote low density area, with neighbours at least 400m from the MWTF. | ■ MWTF works will include extension of existing mounded vegetation screens to provide additional visual screening from the direction of Port Wakefield Road and the northern property boundary.<br>■ Visual amenity will be managed in accordance with existing site LEMP | Possible | Insignificant | Low |

| No. | Environmental Aspect | Comment / MWTF Detail | Management | Risk Assessment | | |
|---|---|---|---|---|---|---|
| | | | | Likelihood | Consequence | Risk |
| 5. | Stormwater | ■ Stormwater transport pollutants if listed waste is exposed to potential water runoff.<br>■ Stormwater runoff from roofing will be captured for onsite reuse in revegetation activities.<br>■ Stormwater management systems will divert flows around the facility.<br>■ All listed waste will be stored in roofed facility or covered with low permeability material (such as Bentofix) on raised concrete foundations.<br>■ Any water or liquid produced through remediation or due to material moisture content will be captured in concrete sumps for treatment and/or licensed disposal, as required. | ■ Stormwater will be managed in accordance with existing site LEMP | Possible | Minor | Moderate |
| 6. | Groundwater | ■ The MWTF will be constructed on concrete foundations within an enclosed structure. No listed waste will be stored outside the MWTF.<br>■ Groundwater at the site is highly saline with no beneficial users.<br>■ Groundwater monitoring is undertaken as part of current site management. | ■ No additional groundwater management measures are proposed as part of the MWTF. Groundwater will be managed in accordance with the LEMP. | Rare | Insignificant | Low |

| No. | Environmental Aspect | Comment / MWTF Detail | Management | Risk Assessment | | |
|---|---|---|---|---|---|---|
| | | | | Likelihood | Consequence | Risk |
| | | ■ There are no adverse groundwater impacts expected as part of MTWF operation. | | | | |
| 7. | Terrestrial Ecology | ■ The site was highly disturbed with minimal ecological values prior to commencement of operations as a landfill. Site conditions have not altered since this time.<br>■ The MWTF site has no existing remnant native vegetation and is located within the approved landfill operations site.<br>■ There are no significant flora or fauna aspects relating to the site.<br>■ No direct impacts are expected as part of MWTF operations. | ■ Management will be undertaken in accordance with the site LEMP. | Rare | Insignificant | Low |
| 8. | Offsite movement of contaminated material | ■ There is potential for movement of contaminated material offsite or within the site associated with uncovered transport to site, wheel drag or surface water runoff from uncovered material. Material may pose health or environmental risk to humans or environmental receptors.<br>■ The site currently operates wheelwash and load covering requirements for receipt of low level contaminated material. This will prevent offsite movement. | ■ An additional wheelwash facility will be constructed for the MWTF. All collected material will be treated as listed waste in the MWTF.<br>■ All MWTF material being transported to site will be covered by contractors and vehicle operators.<br>■ Movement, transport and handling of material will be managed in accordance with the site LEMP. | Rare | Moderate | Moderate |

| No. | Environmental Aspect | Comment / MWTF Detail | Management | Risk Assessment | | |
|---|---|---|---|---|---|---|
| | | | | Likelihood | Consequence | Risk |
| | | ■ All received listed waste will be stored within the MWTF under roofing and/or covered with low permeability material, such as Bentofix. | ■ All listed waste received onsite will be stored under cover to protect from potential water infiltration. | | | |

**Table 8: MWTF Operational Activity Risk Assessment**

| No. | Operational Aspect | Comment / MWTF Detail | Management | Risk Assessment | | |
|---|---|---|---|---|---|---|
| | | | | Likelihood | Consequence | Risk |
| 9. | Material Transport | ■ Potential for offsite movement of listed waste associated with transport of uncovered loads to site.<br>■ The site currently operates LLCW disposal activities.<br>■ Refer item 8 (offsite movement of contaminated material) and item 13 (traffic) | ■ Refer item 8 | Rare | Moderate | Moderate |
| 10. | Material Receipt and Handling | ■ Potential for exposure of staff to harmful chemicals within listed waste.<br>■ Potential for spillage of material outside MWTF boundaries.<br>■ No manual handling of material will be occur.<br>■ The site currently operates LLCW disposal including receipt and handling of materials chemical analysis and certificates.<br>■ All vehicle unload points and MWTF will be upon bunded concrete base minimising potential for loss to ground. | ■ Material receipt and handling will be undertaken in accordance with the site LEMP.<br>■ No material will be accepted to site without contaminated waste details including chemical analysis.<br>■ Detailed health and safety plan will be developed for the MWTF.<br>■ All deposit and handling of material will occur within sealed operational areas only. | Unlikely | Minor | Low |
| 11. | Chemical Storage and | ■ Some chemicals may be required as part of listed waste treatment, refer section 2. There is potential for soil and water impacts | ■ The volume of chemicals stored will be minimised by ordering chemicals | Rare | Minor | Low |

| No. | Operational Aspect | Comment / MWTF Detail | Management | Risk Assessment | | |
|---|---|---|---|---|---|---|
| | | | | Likelihood | Consequence | Risk |
| | Handling | associated with spillage.<br>■ Chemicals utilised in the treatment process will be stored in a concrete bunded chemical storage area within the MWTF.<br>■ Major volumes of chemicals will not be stored onsite.<br>■ Chemicals are not currently used as part of balefill or LLCW operations, excepting minor volumes of hydrocarbon and vehicle maintenance fluids.<br>■ MWTF chemical use / storage is not likely to cause environmental impacts. | for specific batch requirements only.<br>■ Chemical storage and handling will managed in accordance with the site LEMP.<br>■ An up to date chemical inventory will be maintained onsite, including MSDS. | | | |
| 12. | Waste Management | ■ Waste can pose a risk to soil and water contamination, pests and vermin or health.<br>■ Unused chemicals from remediation will likely be in minor volumes only and will be disposed of offsite according to manufacture and regulator requirements.<br>■ Remediated soil will result in either LLCW or reusable materials.<br>■ LLCW remediated material will be disposed of onsite in accordance with current site | ■ Disposal of LLCW will be undertaken in accordance with the existing EPA approved site LEMP.<br>■ Where possible, unused remediation chemicals will be returned to the manufacturer/supplier.<br>■ No chemicals will be disposed of onsite, unless suitable within the limitations of the existing balefill or LLCW.<br>■ Waste inventory will be maintained | Unlikely | Insignificant | Low |

| No. | Operational Aspect | Comment / MWTF Detail | Management | Risk Assessment | | |
|---|---|---|---|---|---|---|
| | | | | Likelihood | Consequence | Risk |
| | | management practices.<br>■ Remediated soil that is tested and shown to be suitable for reuse will be reused onsite or used as *clean fill* (as per EPA requirements) offsite.<br>■ General non-putrescible and putrescible waste will be in minor volumes and managed in accordance with current site practices. | including type, volumes, disposal details, dates etc.<br>■ Minor non-putrescible and putrescible waste will be managed in accordance with current site practices | | | |
| 13. | Traffic | ■ It expected on average up to 20 - 40 vehicles per week or 3-6 per day may enter the site for MWTF, or approximately 6-12 two-way vehicle movements per day. Traffic movements reported in the EIS were estimated at 7,300 two-way movements per year along Port Wakefield Road. Additional vehicle movements expected as a result of the MWTF form less than 0.1 % of those reported in the EIS and can be described as negligible. | ■ The MWTF will have insignificant traffic impacts.<br>■ Existing site speed limits will apply<br>■ Some internal road upgrade will be undertaken and designed as per Australian Standards<br>■ Overall all site vehicle movement and traffic management will be reviewed as part of MWTF operation design. | | | |
| 14. | Emergency | ■ Maybe potential for fire associated with some listed wastes and chemical.<br>■ No major chemical volumes will be stored onsite.<br>■ Fire control aspects will be included in detailed | ■ Refer item 11 and 12<br>■ Emergency management will be undertaken in accordance with existing site procedures and the EPA approved LEMP. | Unlikely | Minor | Low |

| No. | Operational Aspect | Comment / MWTF Detail | Management | Risk Assessment | | |
|---|---|---|---|---|---|---|
| | | | | Likelihood | Consequence | Risk |
| | | design of MWTF.<br>■ The potential emergency events are considered to be similar to those existing onsite due to balefill and LLCW disposal operations.<br>■ All listed waste will be stored and treated within bunded, covered and lined facility. | ■ Fire control and watering systems will be incorporated in MWTF design basis.<br>■ Incidents will be reported and managed in accordance with existing site procedures and EPA reporting requirements. | | | |

# 4.0 CONCLUSION

Development will comprise two stages, an initial material receiving and storage laydown area (Stage 1) and a proposed MWTF (Stage 2). It is planned that Stage 2 will commence development within 12 months of the Stage 1 facility commencing receipt of listed waste.

The staged approach would enable IWS to accept material for future processing at the MWTF in the short term, while the development of the MWTF is undertaken. This will enable a more efficient transition to soil treatment in the future.

The receipt and storage of such material is considered low risk due to:

- proposed facility design and controls (refer Development Application)
- existing site management procedures (refer amended LEMP, Development Application), and
- complimentary LLCW disposal options on the site.

The proposal is able to integrate into the existing IWS Northern Balefill site, utilising much of the existing infrastructure and the landfill environmental management programme. The potential environmental impacts are similar to those associated with current operations and site conditions are consistent with previous EIS findings. Odour potential was evaluated specifically for the MWTF to redress material specific risk.

The MWTF will enable IWS to offer a suite of waste management services at a single consolidated location within the existing IWS Northern Balefill site. This minimises the requirement for additional transport of materials requiring disposal as LLCW.

This development encompasses key objectives of South Australia's Waste Strategy 2005-2010; development of the MWTF will foster sustainable behaviour by providing a mechanism by which listed waste can be treated and reused resulting in better managed treatment of wastes in South Australia. The use of effective systems means that the material that is disposed of to landfill following treatment to remove, stabilise or neutralise contaminants, will present a significantly reduced environmental and human health risk.

# 5.0 REFERENCES

IWS (current) Northern Balefill EPA License

IWS (2006) Northern Balefill Landfill Environmental Management Plan (LEMP)

IWS (2008) Multi-purpose Waste Treatment Facility Development Application, submitted to Planning SA 2008.

P&M Borrelli & Sons Pty Ltd (1996) Mallala Solid Waste Landfill Environmental Impact Statement, February 1996.

AMB/AGK:RDwyer/amb

# FIGURES


# INTERGRATED WASTE SERVICES

## GENERAL SITE LOCATION MAP

Legend

- Town Location
- Road
- Site Location

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Image sourced from Google 20.11.2007
Cadastral Data sourced from DEH

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ADELAIDE SA 5000 AUSTRALIA

PH (08) 8213 2100
FAX (08) 8213 2101

0 3,750 7,500
Scale in metres

SCALE 1:170,000

N

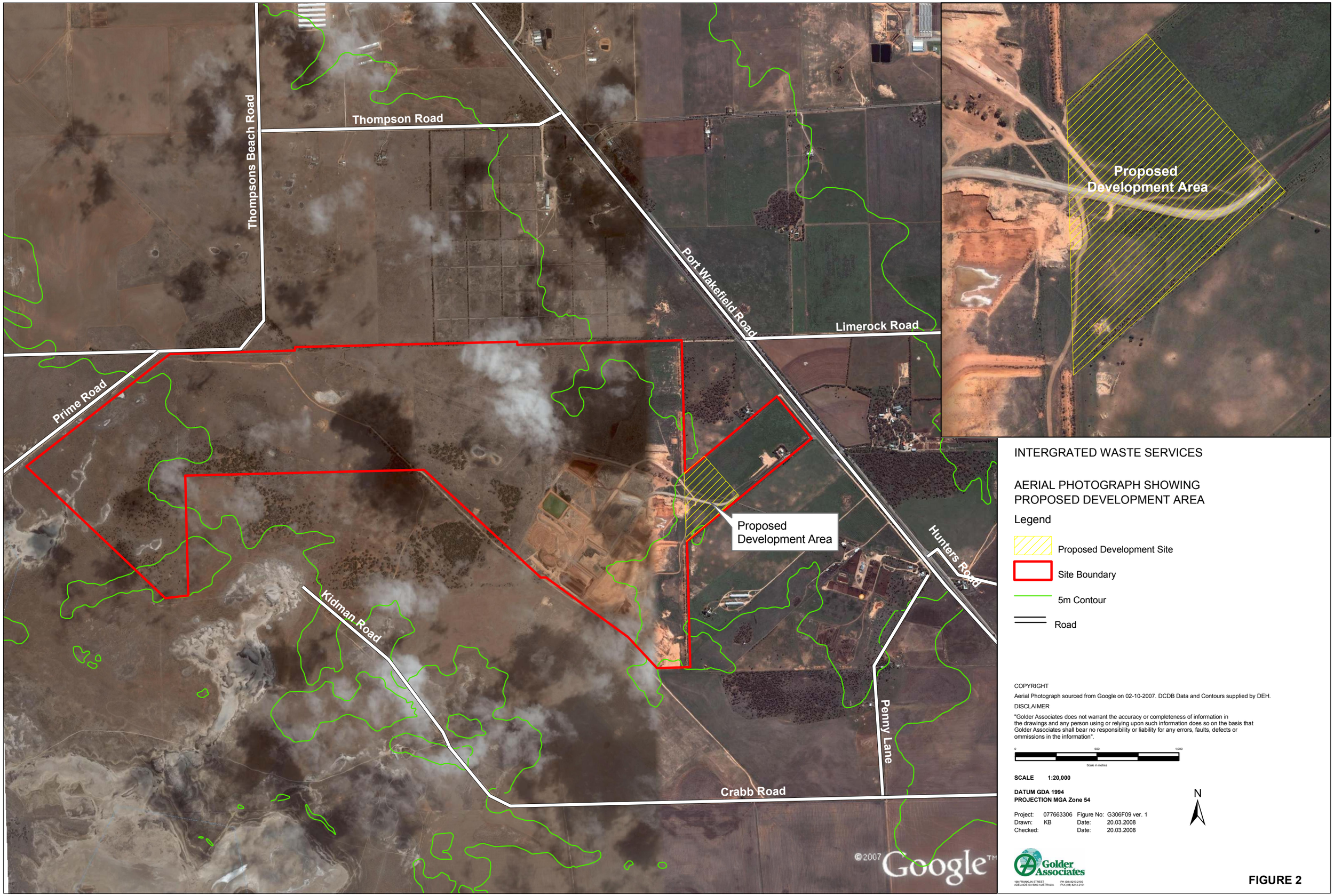
DATUM GDA 1994
PROJECTION MGA Zone 54

| | | | |
|---|---|---|---|
| Project: | 077663306 | Figure No: | G306F15 ver. 1 |
| Drawn: | KB | Date: | 19.03.2008 |
| Checked: | | Date: | 19.03.2008 |

**FIGURE 1**



J:\2007\Env\077663306 - IWS Green Star\GIS\PROJECT\077663306 G306F15 ver. 1Figure 1. Site Plan.mxd




INTERGRATED WASTE SERVICES

AERIAL PHOTOGRAPH SHOWING
PROPOSED DEVELOPMENT AREA

Legend

- Proposed Development Site
- Site Boundary
- 5m Contour
- Road



0 500 1,000
Scale in metres

**SCALE** 1:20,000

**DATUM GDA 1994**
**PROJECTION MGA Zone 54**

Project: 077663306 Figure No: G306F09 ver. 1
Drawn: KB Date: 20.03.2008
Checked: Date: 20.03.2008

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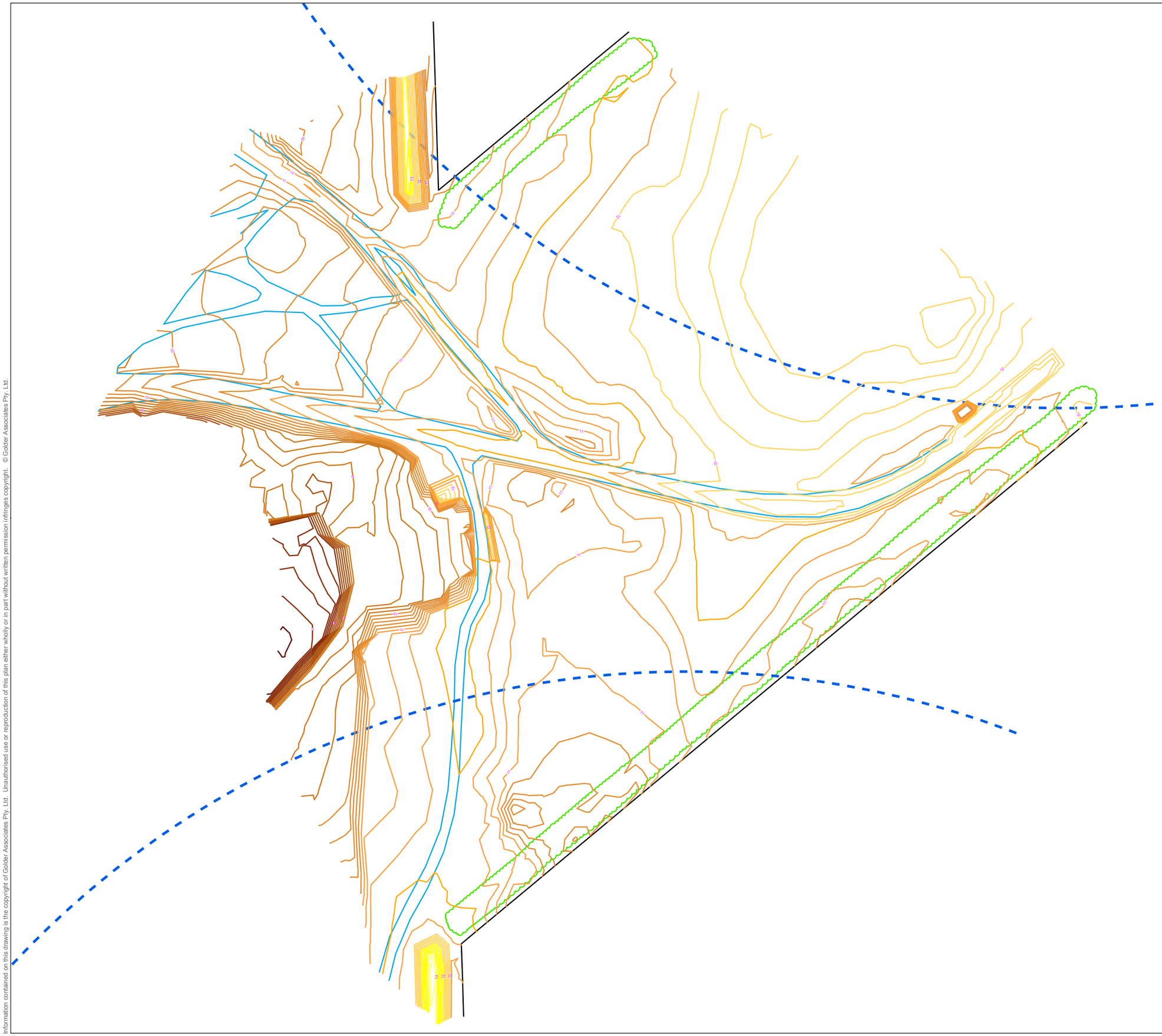
**FIGURE 2**

J:\2007\Env\077663306 - IWS Approval\GIS\PROJECT\GIS\Project\077663306 G306F09 ver. 1 Development Area and Site Plan.mxd



INTERGRATED WASTE SERVICES

PROPOSED DEVELOPMENT
AREA SURVEY

Legend

CONTOUR - ELEVATION (m)

- 0
- 6.8
- 7 - 7.8
- 8 - 8.8
- 9 - 9.8
- 10 - 10.8
- 11 - 11.8
- 12 - 12.8
- 13 - 13.8
- 14 - 14.4
- 520m BUFFER
- FENCE
- TRACK
- TREE



0 50 100

Scale in metres

SCALE 1:2,000

N

**DATUM GDA 1994**
**PROJECT MGA Zone 54**

Project: 077663306 Figure No: G306F12 ver. 1
Drawn: KB Date: 19.03.2008
Checked: Date: 19.03.2008

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**FIGURE 3**



J:\2007\Env\077663306 - IWS Green Star\GIS\PROJECT\077663306 G306F12 ver. 1 Cad Layout.mxd


INTERGRATED WASTE SERVICES

MULTIPURPOSE WASTE TREATMENT FACILITY SITE LAYOUT

Legend

- Building
- Storage and Laydown Area for Treatment Storage
- Wheel Wash
- Boundary
- Buffer Zone (520m)
- Cell Boundary



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0 50 100

Scale in metres

SCALE 1:1,250

N

**DATUM GDA 1994**
**PROJECTION MGA Zone 54**

Project: 077663306 Figure No: G306F16 VER. 3
Drawn: KB Date: 19.03.2008
Checked: Date: 19.03.2008

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**FIGURE 4**



J:\2007\Env\077663306 - IWS Green Star\GIS\PROJECT\077663306 G306F16 VER. 3 Proposed Site Layout - all buildings.mxd

CATCHMENT FLOWING TOWARDS LANDSCAPED MOUNDS

DRAINAGE CHANNEL TO JOIN PROPOSED INTERNAL SURFACE WATER DRAIN

FUTURE ENERGY GENERATOR

POSSIBLE FUTURE MRRF SITE

STORAGE & LAYDOWN AREA FOR TREATMENT FACILITY

MULTI-PURPOSE WASTE TREATMENT FACILITY

UPGRADED WHEEL WASH

POSSIBLE FUTURE RESOURCE RECOVERY FACILITY

DRAINS TO PIPE THROUGH ACCESS ROAD

EXISTING SEDIMENTATION / EVAPORATION POND

CATCHMENT CONTRIBUTING TO THE EASTERN PART OF ORIGINAL BORROW PIT STORAGE IS AN ONSITE CATCHMENT

LANDSCAPED MOUND IS EFFECTIVELY ON CATCHMENT DIVIDE

DRAINAGE CHANNEL TO EXISTING EVAPORATION POND

# INTERGRATED WASTE SERVICES

# SURFACE WATER DRAINAGE FOR WASTE TREATMENT FACILITY

## Legend

- Landscaped Mound Toe Drain
- 520m Buffer
- Track
- Drain
- Internal Surface Water Drain
- Surface Water Drainage Direction
- Proposed Vegetated Screen
- Existing Mounded Vegetated Screen
- Existing Vegetated Screen
- Building
- Future Energy Generator
- Possible Future Resource Recovery Facility
- Possible Future MRRF Site
- Rainwater Tank
- Storage and Laydown Area for Treatment Storage
- Upgraded Wheel Wash
- Boundary
- Cell Boundary

Elevation (m)

- 13.554 - 14.412
- 12.696 - 13.554
- 11.838 - 12.696
- 10.979 - 11.838
- 10.121 - 10.979
- 9.263 - 10.121
- 8.405 - 9.263
- 7.547 - 8.405
- 6.688 - 7.547



0 50 100

Scale in metres

SCALE 1:2,750

N

**DATUM GDA 1994**
**PROJECTION MGA Zone 54**

Project: 077663306 Figure No: G306F13 ver. 2
Drawn: KB Date: 19.03.2008
Checked: Date: 19.03.2008

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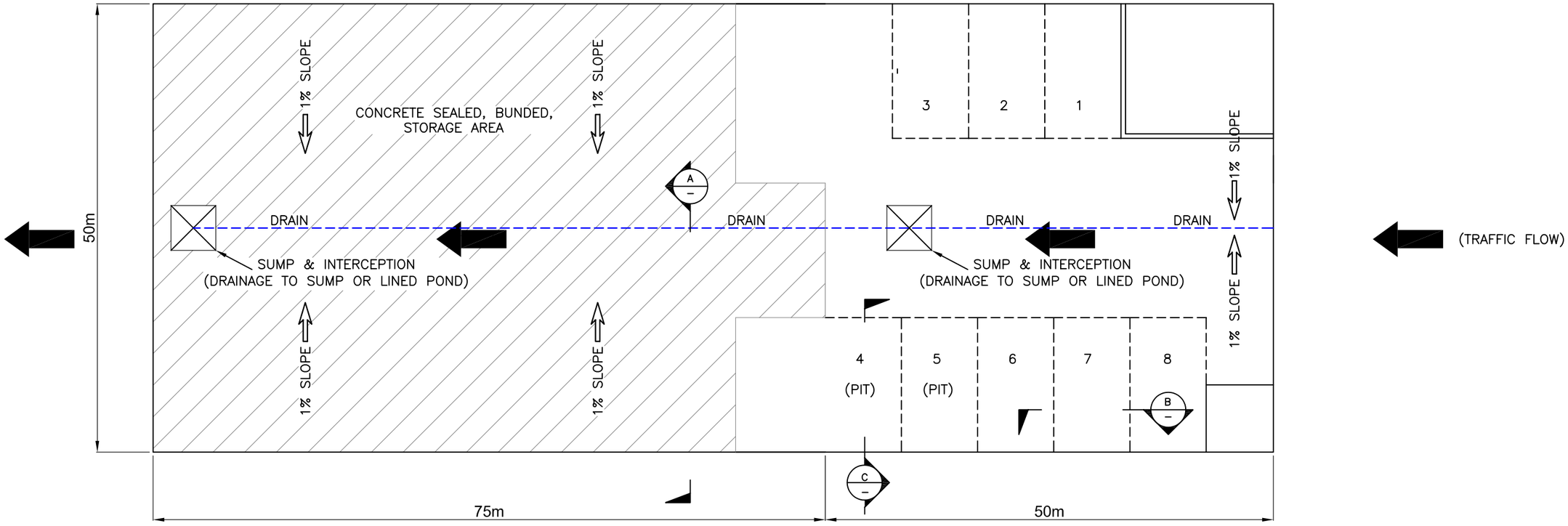
**FIGURE 5**



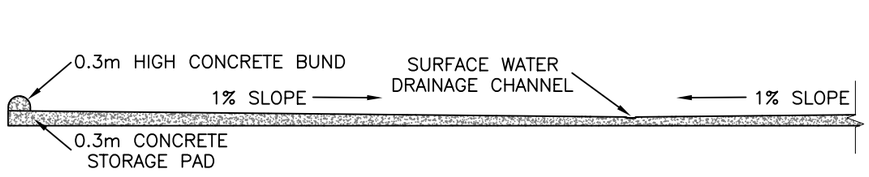
J:\2007\Env\077663306 - IWS Green Star\GIS\PROJECT\077663306 G306F13 ver. 2 Figure 5 Surface Water Drainage.mxd

LEGEND

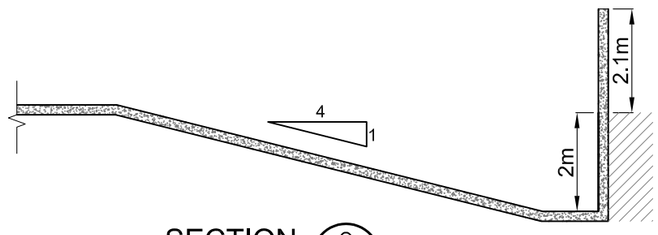
–FUTURE PERMANENT MATERIAL RECEIVING AND STORAGE LAYDOWN AREA



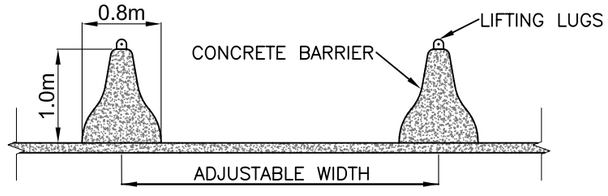

PLAN VIEW




SECTION A
NTS




SECTION C
NTS




SECTION B
NTS

BASE PLAN AND SCALE SOURCED FROM SKETCHES AND SITE OBSERVATIONS

0 10 20 30 40 50m
Scale in metres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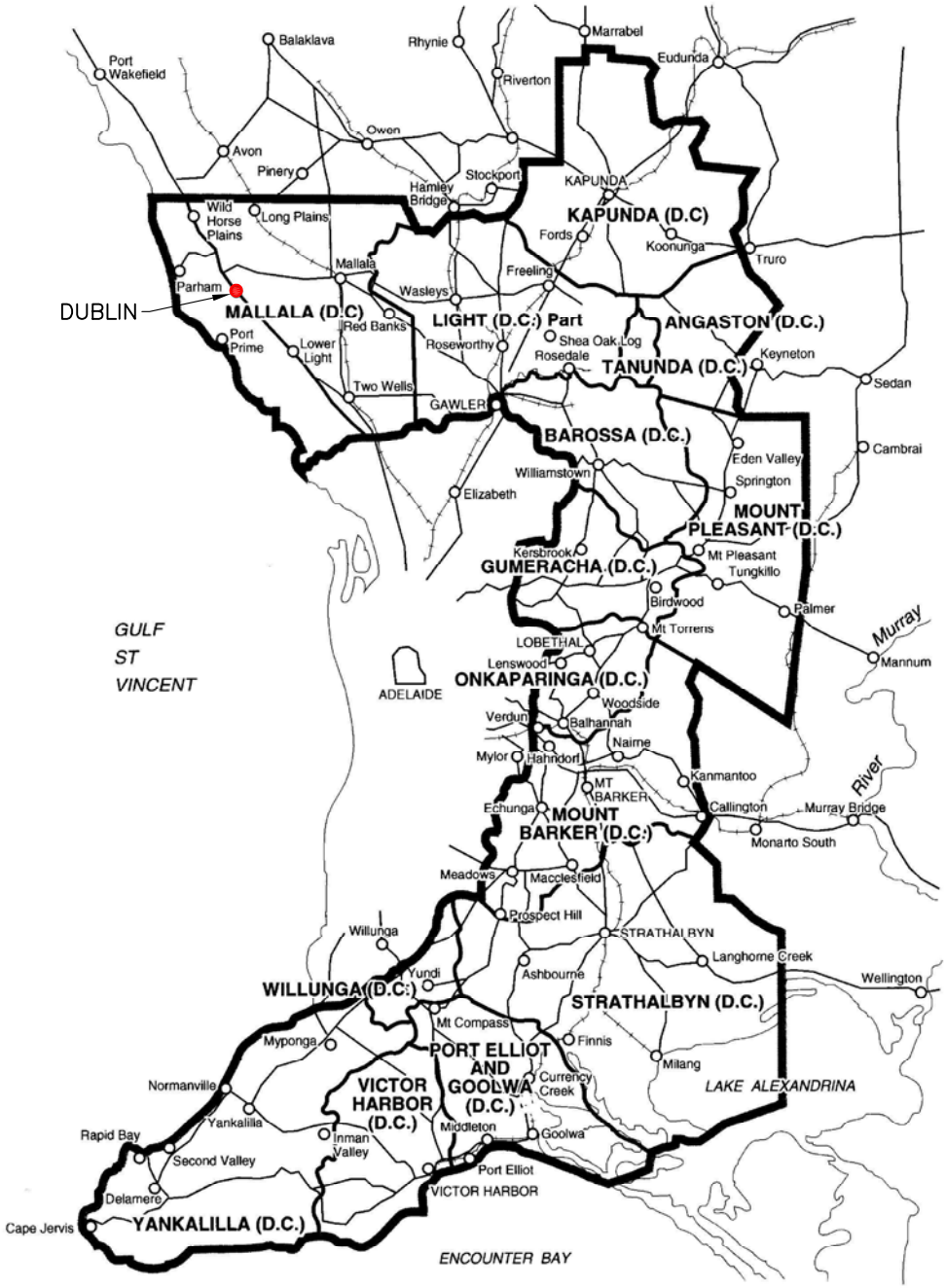
| | | | |
|---|---|---|---|
| CLIENT: INTEGRATED WASTE SERVICES | | PROJECT: MULTI-PURPOSE WASTE TREATMENT FACILITY | |
| DRAWN: DJH | 20-03-2008 | TITLE: TREATMENT FACILITY CONCEPT DESIGN ( Not for Construction ) | |
| CHECKED: | 20-03-2008 | | |
| SCALE: 1:500 | A3 | PROJECT No: 077663306 | FIGURE No: FIGURE 6 REV. 3 |

xref:-
cadfile:- J:\2007\ENV\077663306 IWS\DRAWINGS\3306 FIG. 6 REV. 3




LEGEND

Development Plan Boundary

Boundary of Outer Metropolitan

BASE PLAN AND SCALE SOURCED FROM DISTRICT COUNCIL OF MALLALA DRAWING NO: FIGURE OM/1 DATED 18 JANUARY 2007.

0 10 20 30 40km

Scale in kilometres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| | | | |
|---|---|---|---|
| CLIENT: INTEGRATED WASTE SERVICES | | PROJECT: MULTI-PURPOSE WASTE TREATMENT FACILITY | |
| DRAWN: DJH 18-03-2008 | | TITLE: OUTER METROPOLITAN DEVELOPMENT ZONE (FIG. OM/1 Consolidated - 18 January 2007) | |
| CHECKED: 18-03-2008 | | | |
| SCALE: AS SHOWN | A4 | PROJECT No: 077663306 | FIGURE No.: FIGURE 7 REV. 1 |




xref:- J:\2007\ENV\077663306 IWS GREEN STAR\DRAWINGS\REFERENCE DRAWINGS\FIG. 7 OUTER METRO_DEVEL_ZONE
cadfile:- J:\2007\ENV\077663306 IWS GREEN STAR\DRAWINGS\FIG. 7 REV. 1

# APPENDIX A

## Odour Modelling Assessment

A·W·N Pty. Ltd. ACN 083 198 001 ABN 74 083 198 001
Consulting Environmental Engineers/Scientists – Pollution Monitoring and Control

# Integrated Waste Services Pty Ltd
# Dublin, South Australia

# Plume Dispersion Modelling Assessment

April 2008

**Report No: I19 (Revision 1: 02/05/2008)**
**Report Date of Issue: 28/04/2008**

# Document Control

A•W•N (Air Water Noise) Consultants ABN 74 083 198 001
(NATA Laboratory Accreditation No. 1910)

3 & 4/18 Thomas Street, Ferntree Gully, Victoria 3156
Telephone: (03) 9758-7299 Facsimile: (03) 9752-2694 Email: awn@awn.com.au


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| | |
|---|---|
| **Project** | Integrated Waste Services Pty. Ltd., Dublin, South Australia: Plume Dispersion Modelling Assessment |
| **Project No.** | Report No. I19 (Revision 1: 01/05/2008) |
| **Prepared by** | A.W.N. (Air Water Noise) Consultants, 3 & 4/18 Thomas Street, Ferntree Gully, 3156 |
| **Project Manager** | Ms. Jacinda Shen |
| **Prepared for** | Golder Associates Pty. Ltd.,<br>199 Franklin St.,<br>Adelaide SA 5000.<br>Attn: Mr Adam Kilsby |

## Approval for Issue

| Revision | Author | Reviewed By | Name: Title | Signature | Date |
|---|---|---|---|---|---|
| Original | Jacinda Shen | | Frank Fleer, Managing Director | | 02/05/2008 |

## Revision History

| Revision | Date Issued | Reason/Comments |
|---|---|---|
| Original | 28/04/2008 | Initial issue. |
| Revision 1 | 02/05/2008 | Minor revision to pages 1.1 & 3.1. |

## Distribution

| Revision | Copy No. | Location |
|---|---|---|
| Original | 1 | Integrated Waste Services Pty. Ltd. |
| Original | 2 | A.W.N. (Air Water Noise) Consultants: Project file |

# Table of Contents

# 1.0 Introduction

A.W.N. (Air Water Noise) Consultants was commissioned by Golder Associates Pty. Ltd. to conduct a plume dispersion modelling assessment of odour emissions from the proposed Green Star Multi-Purpose Waste Treatment Facility located in Dublin, South Australia. The facility will be constructed at the Integrated Waste Services (IWS) Northern Balefill site, Port Wakefield Road, Dublin, South Australia.

By necessity the modelling assessment contains a number of assumptions concerning biofilter design, soil surface areas and windrow arrangement. If, on the completion of detailed design, these parameters vary significantly from those contained within this report, the plume dispersion modelling assessment should be revised.

The following report outlines the modelling approach and predicted impacts.

# 2.0 Abbreviations

- GLC – Ground level concentration:
  As determined by application of the AUSPLUME gaussian plume dispersion model.
- IWS – Integrated Waste Services
- SAEPA – Environment Protection Authority of South Australia

# 3.0 Emissions to Air

The proposed IWS facility will consist of a receipt/storage building, treatment platform and associated site amenities. A diagram of the proposed facility is presented in Figure 1.

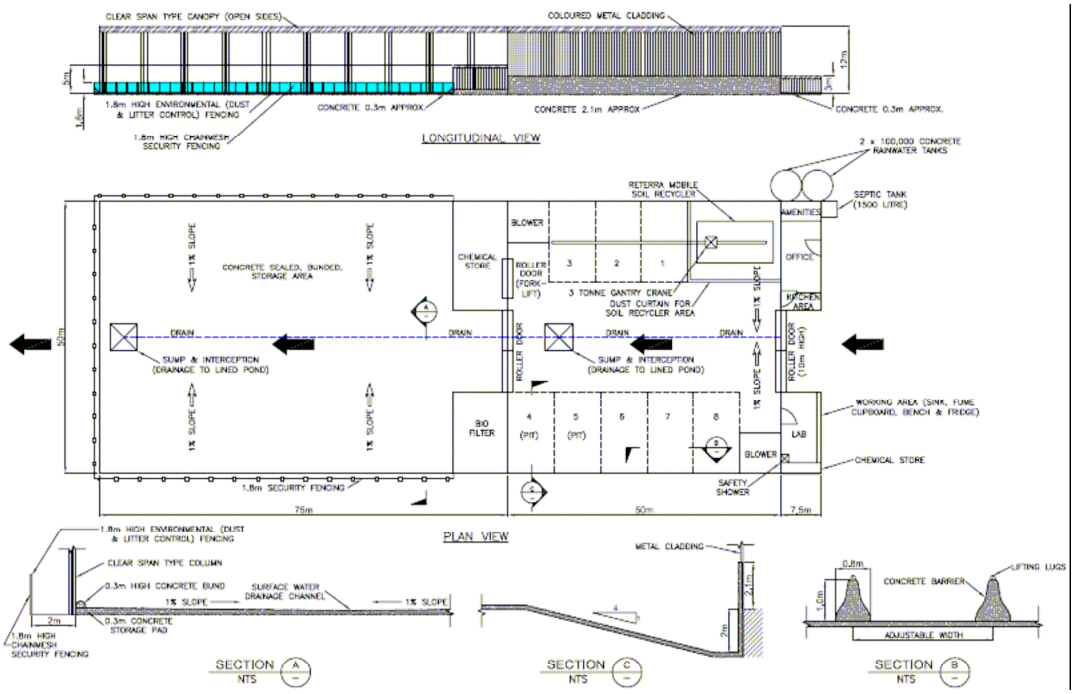



Figure 1 Proposed Multi-Purpose Waste Treatment Facility: Site Layout

Operations at the proposed facility will consist of soil delivery, treatment, storage and despatch. Contaminated soil will be delivered in trucks entering the facility through the eastern roller door. Once inside the receipt/storage building soil will be transferred to the treatment bays where the applied treatment will be tailored to the waste type. Treatments that may be utilised include contaminant stabilisation or bioremediation. Delivery trucks exit the building via the western roller door, travelling through the treatment pad area before leaving the site. The treatment pad is an impervious slab used for storage and treatment of soil.

Emissions to air from the receipt/storage building will be controlled by a biofilter located at the western end of the building. The treatment pad will be covered by the roof extension of the receipt/storage building, although the sides will be open. Tarpaulins, HDPE or other geosynthetics may also be used to cover stored soil on the treatment pad.

Odour emissions will therefore consist of biofilter exhaust, treatment pad emissions and fugitive emissions from the receipt/storage building.

Odour emission rates from the proposed site have been estimated using odour flux rates measured at a gas works remediation site in Victoria. Odour flux sampling was conducted at two locations on two soil remediation stockpiles of different ages.

Odour flux results for this sampling event were as follows:

| Sampling Location | ou.m$^3$/m$^2$/min |
|---|---|
| Stockpile (48 hours old) front | 53 |
| Stockpile (48 hours old) back | 7.6 |
| Stockpile (2 weeks old) front | 12 |
| Stockpile (2 weeks old) back | 31 |

**NOTES**:
Odour flux sampling was conducted in accordance with Australian/New Zealand Standard "Methods for Sampling and Analysis of Stationary Source Emissions: Method No. 4: Area Source Sampling – Direct Measurement Techniques", AS/NZ 4323.4 (draft).
Odour analysis was conducted in accordance with Australian Standard "Stationary Source Emissions – Determination of Odour Concentration by Dynamic Olfactometry," AS4323.3.

The odour emission estimation methodologies for the three identified IWS sources are detailed in Section 3.1 – 3.3. It should be noted that gas works soil remediation odour flux results were used as the basis for estimating emissions from the proposed plant as it is generally accepted that contaminated gas works soil is highly odorous and represents a worst case odour flux scenario for soil remediation.

## 3.1 Biofilter exhaust

As the proposed facility has not yet been constructed and operating processes are dependent on the type of waste deliveries received, the quantification of odour emissions required a number of assumptions. These were as follows:

- The biofilter cross sectional area will be 146 m$^2$;
- The biofilter will be enclosed and fitted with an exhaust stack of 13 m height and 0.8 m diameter;
- The biofilter will operate at a minimum face velocity of 3 m/min;
- The biofilter will operate at a minimum odour removal efficiency of 85%;
- The soil surface area inside the receipt/storage building will not be greater than 6,000 m$^2$;
- The receipt/storage building exhaust ventilation system will capture 50% of odorous emissions for treatment by the biofilter.

In order to represent a worst case scenario it was also assumed that the odour flux rate of emission from soil inside the building is equal to the highest measured result at the Victorian gas works remediation facility.

Based on all the listed assumptions, the odour emission rate from the biofilter exhaust is estimated to be 24,000 ou.m$^3$/min.

## 3.2 Treatment Pad Emissions

Treatment pad operations will be heavily dependent on the type of soils delivered and the type of treatments required. For the purpose of estimating emissions, it was assumed that the pad would be covered with two large windrows on either side of the main thoroughfare from the eastern roller door. A nominal windrow height of 2 m was also assumed.

Odour flux rates from the windrows will be dependent on the age of material in the piles. For the purpose of estimating emissions it was assumed that the northern windrow is 48 hours old and the southern windrow is 2 weeks old. The maximum measured odour emission rates for each of the stockpiles at the Victorian gas works site was used for each source.

In summary, odour emission rates for the proposed site are as follows:

| Treatment pad | ou.$m^3$/$m^2$/min |
|---|---|
| Northern windrow | 53 |
| Southern windrow | 31 |

## 3.3 Fugitive Emissions

Fugitive emissions from the receipt/storage building were estimated in the same manner as the biofilter exhaust emissions. Hence the assumptions regarding the magnitude of product surface area inside the building, the use of the maximum measured odour flux rate and a capture efficiency of 50% are also applicable to this source.

Additionally, it was assumed that fugitive emissions would be released from the eastern roller door. This assumes that there is no building roof ridge vent.

Based on these assumptions the odour emission rate for fugitive emissions from the proposed facility is 160,000 ou.$m^3$/min.

# 4.0 Plume Dispersion Modelling

The AUSPLUME model is a regulatory model approved by the Environment Protection Authority of South Australia (SAEPA) for use in assessing the dispersal of industrial source emissions to air.

The Environment Protection Act 1993, and the associated regulatory guidelines, require that the prediction of maximum concentrations for an individual source be undertaken using either a currently approved version of AUSPLUME, or an alternative model where AUSPLUME is considered not suitable.

AUSPLUME was considered appropriate for this assessment as the site is approximately 7 km east of the coast, consequently coastal meteorological effects are not likely to significantly impact on the site. Similarly, the proposed facility is located in simple terrain, with odour emission sources impacting on the environment immediately surrounding the site rather than long range transport scenarios.

AUSPLUME version 6.0 was the model used in this assessment.

Assumptions made in the application of the model included the following:

- Roughness height of 0.1 m was assumed;
- Plume buoyancy effects were considered;
- Pasquill-Gifford formulae were adjusted for roughness height;
- Building wake effects were assessed using the Prime building wake algorithm;
- Terrain effects were considered negligible.

## 4.1 Meteorological Data

The model requires the following hourly meteorological data for a one year period:

- Atmospheric stability (Pasquill class);
- Mixing depth;
- Wind speed;
- Wind direction;
- Temperature;

SAEPA Guidelines: "Air Quality Impact Assessment Using Design Ground Level Pollutant Concentrations (DGLC's)" require the meteorological data to be representative of meteorological conditions within the vicinity of the site, and to be approved by the Authority.

The 2000 meteorological file for Edinburgh Airfield was utilised in this assessment. The file was developed and approved by SAEPA. It should be noted that this file is 95% complete.

An analysis of the predominant wind direction at the proposed site was conducted by creating a frequency distribution of wind speed and wind direction for the Edinburgh Airfield 2000 meteorological file. A wind rose was then generated from the frequency distribution indicating that the predominant wind direction was north-east, with approximately 4% of observations in this sector recording a wind speed between 5.7 and 8.8 m/s.

Other significant wind directions include the north-north east, east-north east, south west and west-south west. There were fewer observations in the north west sector.

The wind rose for Edinburgh Airfield is presented in Figure 2.

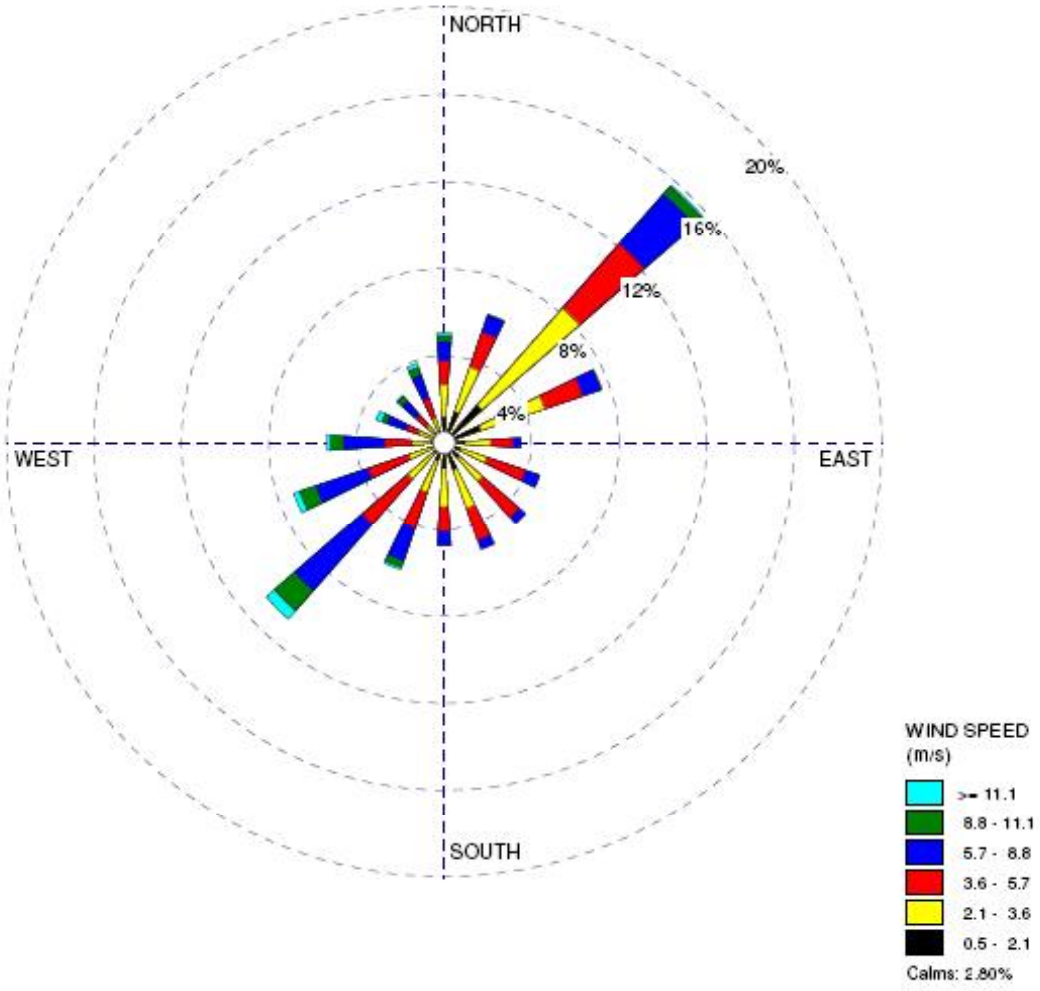



Figure 2 Wind Rose for Edinburgh Airfield 2000 Meteorological File

## 4.2 Model Input Data

Modelling of odorous emission from the proposed facility required the emission sources to be categorised as either point, area or volume sources. Model input data for each of these groups is detailed in the following sections.

### 4.2.1 Point Sources

Point sources are sources that emit pollutants from a single location, usually with a degree of elevation and a mechanical mechanism for creating plume rise.

The biofilter exhaust was included in the plume dispersion modelling assessment as a point source.

Model input data required for the biofilter exhaust stack includes the following:

- Source co-ordinates;
- Exhaust gas velocity;
- Exhaust gas temperature;
- Source diameter;
- Discharge height above ground level;
- Dimensions of influencing buildings;
- Odour emission rate

The model input data used in this assessment is presented in Table 1.

**Table 1 Model Input Data: Point Source**

| PARAMETER | BIOFILTER EXHAUST |
|---|---|
| **LOCATION:** | |
| ID | PS 1 |
| X, Y (m) | 260,117, 6,179,731 |
| $H_s$ (m) | 13 |
| D (m) | 0.8 |
| V (m/s) | 15 |
| $T_s$(°C) | 17 |
| **BUILDING WAKE ALGORITHM:** | |
| $H_b$ (m) | BPIP |
| $W_b$ (m) | BPIP |
| **ODOUR EMISSION RATE: (ou.m$^3$/min)** | 24,000 |

**NOTES:**

| | |
|---|---|
| x, y | UMT co-ordinates. |
| $H_b$ | Height of nearest influencing building. |
| $W_b$ | Width of nearest influencing building. |
| $H_s$ | Stack height (above ground level). |
| D | Stack internal exit diameter. |
| $T_s$ | Exhaust gas temperature (derived from the Bureau of Meteorology 2007 annual average for Edinburgh) |
| V | Exhaust gas velocity. |

### 4.2.2 Area Sources

Area sources are sources that emit pollutants at or near ground level over a large area without plume rise. Examples of area sources are wastewater treatment plants, feed lots and stockpiles.

The AUSPLUME regulatory mode for area sources requires the following model input data:

- Area source shape;
- Source co-ordinates;
- Estimate of initial vertical spread;
- Area source height;
- Odour emission rate.

The two large theoretical windrows located on the treatment pad were modelled as area sources in the modelling assessment.

The model input data for these sources is presented in Table 2.

**Table 2 Model Input Data: Area Source**

| Parameter | Northern Windrow | Southern Windrow |
|---|---|---|
| ID | AS 1 | AS 2 |
| Area source shape: | Polygon | Polygon |
| X, Y (m) | 260,117, 6,179,759 | 260,113, 6,179,739 |
| L (m) | 63 | 63 |
| VS (m) | 2 | 2 |
| H (m) | 2 | 2 |
| Odour Emission Rate ou.$m^3/m^2$/min | 53 | 31 |

**Notes**:

| | | |
|---|---|---|
| X,Y | = | UMT co-ordinate, south east corner |
| VS | = | Initial vertical spread |
| H | = | Height of the source above ground level |
| L | = | Area source length (east/west direction) |

### 4.2.3 Volume Sources

Volume sources are bulky, diffuse sources that emit or release pollutants over large areas in three dimensions. Examples of volume sources are fugitive emissions from buildings, structures and large stockpiles.

The model input data required for volume sources includes:

- Source coordinates;
- Effective emission height;
- Horizontal spread;
- Vertical spread;
- Odour emission rate.

Fugitive odorous emissions from the receipt/storage building at the proposed site were modelled as a volume source.

The horizontal and vertical spreads and effective emission height were determined using the conventions for volume sources. These are as follows:

- Vertical spread = Building height / 2 (m)
- Horizontal spread = Building width / 4 (m)
- Effective emission height = Building height / 2 (m)

Model input data for fugitive emissions from the receipt/storage building are contained in Table 3.

**Table 3 Model Input Data: Volume Source**

| Source ID | V1 |
|---|---|
| Location (X, Y) metres | 260,174, 6,179,738 |
| Effective emission height (m) | 6 |
| Horizontal spread (m) | 13 |
| Vertical spread (m) | 3 |
| Odour emission rate (ou.$m^3$/min) | 160,000 |

## 4.3 Building Downwash

Building downwash occurs when aerodynamic turbulence, induced by buildings, causes a pollutant emitted from an elevated source to be mixed rapidly toward the ground, resulting in higher ground level concentrations.

To evaluate the occurrence of building downwash, the position and dimensions of each structure relative to each point source must be identified for each of the possible directions of wind flow.

Buildings that are within an area of 5L from the point source, where L is the lesser of the building height or projected building width, should be considered for downwash effects.

AUSPLUME V6 provides the Prime algorithm which was used to determine building downwash effects. Influencing building dimensions were calculated from the site plan.

## 4.4 Background Concentration

Background concentrations are used in AUSPLUME to estimate the contribution of other sources in the area in addition to those being modelled. No additional sources of odour were considered in this modelling assessment.

## 4.5 Model Receptors

A Cartesian receptor grid of 50 m spacing between UMT co-ordinates 259,117 and 261,117 in the easterly domain and UMT co-ordinates 6,178,731 and 6,180,831 in the northerly domain was used in this assessment.

The origin of the receptor grid was located at UMT co-ordinates 260,116, 6,179,731(x,y).

Discrete receptors representing the residential buildings in the area were also used in the modelling assessment.

Input data for the discrete receptors is presented in Table 4. Figure 3 represents a graphical summary of discrete receptor locations.

**Table 4 Model Input Data: Discrete Receptor Locations**

| Location | UMT Co-ordinates | | Height Above Ground Level (m) |
|---|---|---|---|
| | X (m) | Y (m) | |
| Discrete receptor 1 | 260,563 | 6,179,992 | 0 |
| Discrete receptor 2 | 260,930 | 6,179,444 | 0 |
| Discrete receptor 3 | 260,281 | 6,179,127 | 0 |
| Discrete receptor 4 | 260,374 | 6,180,237 | 0 |

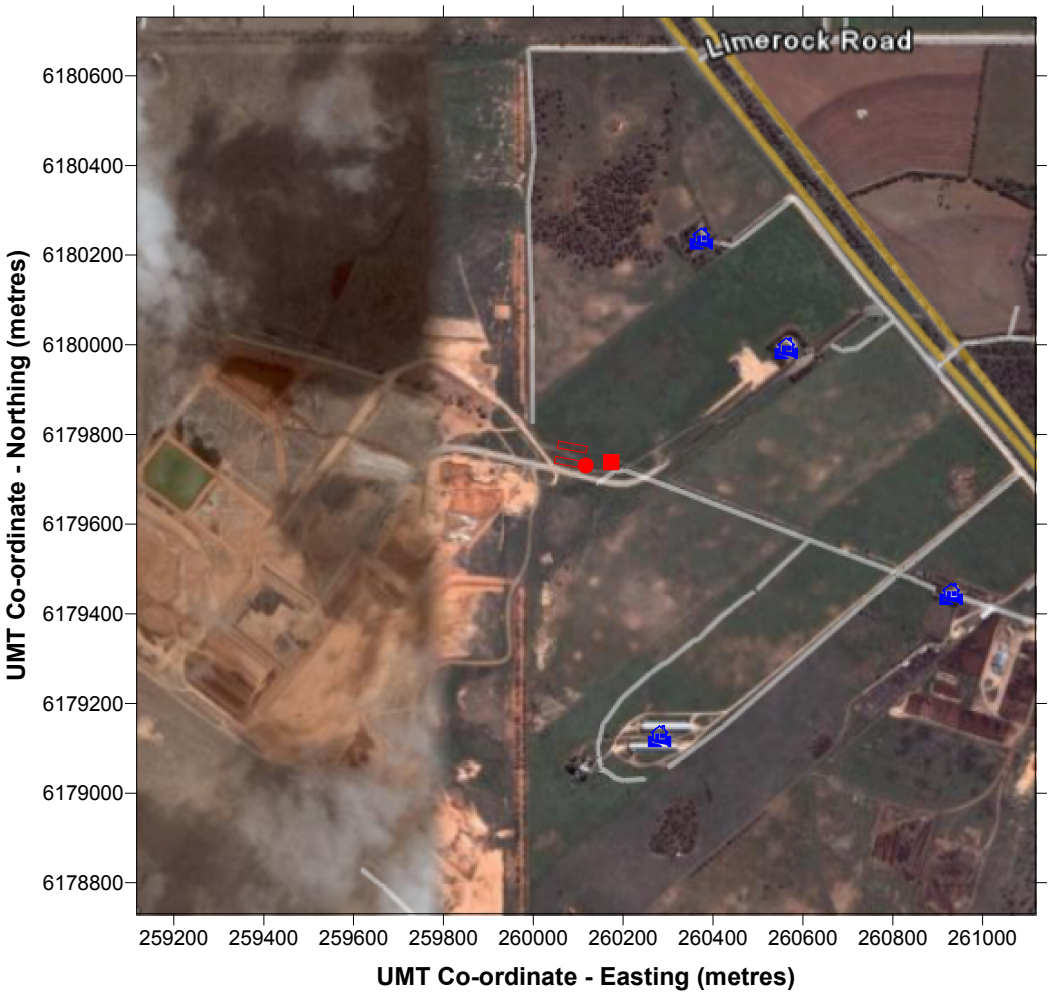
## 4.6 Model Output Data

The AUSPLUME model predicts the one hour average concentration at each receptor specified, for each hour of the year's meteorological data. The highest ground level concentration is established for each hour and is referred to as the peak hourly concentration.

The maximum predicted ground level concentration is defined as the 99.9$^{th}$ percentile or the 8$^{th}$ highest of the peak hourly concentrations.

## 4.7 Modelling Assessment Results

The maximum predicted GLCs for odour are displayed in Table 5. Also displayed is the odour criterion as specified by SAEPA in the document: “EPA Guidelines: Odour Assessment using Odour Source Modelling”, April 2007. The odour criterion is based on the population density of the surrounding area. The stated criterion is based on a density of less than 12 people located in single residences in different directions from the site. The criterion is applicable at the residences and hence the displayed maximum predicted GLC has been calculated for the sensitive receptors only, not for all points on the receptor grid. The receptor grid results have been used to generate an isopleth plot of the highest ground level concentrations. This plot is displayed in Figure 4. Model output files are contained in Appendix 1.



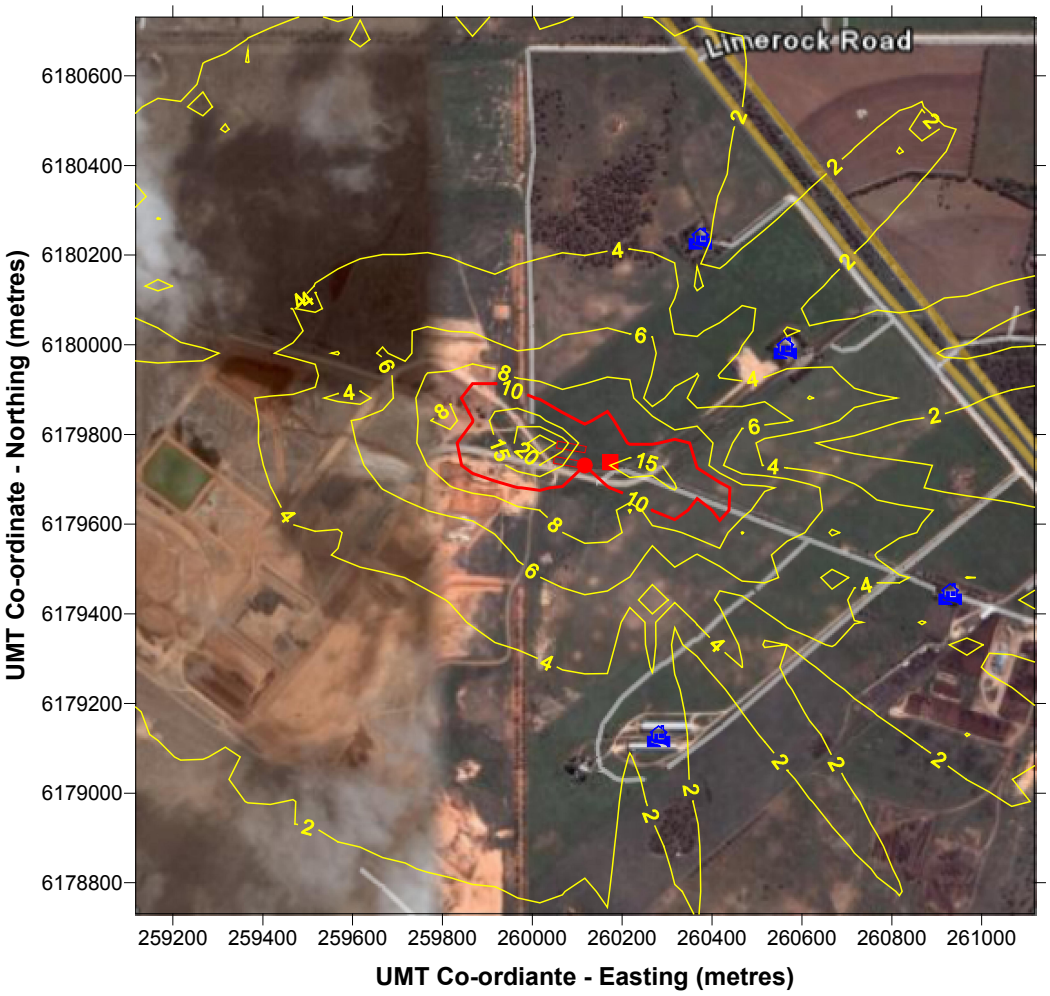

**Key**

| Symbol | Description |
|---|---|
| —— | Area source boundary |
| ● | Point source |
| ■ | Volume source |
| | Discrete receptor |

Figure 3 Discrete Receptor Locations

**Table 5 Maximum Predicted GLC**

| Atmospheric Contaminant | Averaging Period | Maximum Predicted GLC (ou) | Location (x, y) | Odour criteria (ou) 99.9$^{TH}$ percentile |
|---|---|---|---|---|
| Odour | 3 minute | 1.9 | 260,563, 6,179,992 | 10 |




**Key**

| Symbol | Description |
|---|---|
| | Rank 1 concentration isopleth (ou) |
| | Odour criterion (ou) |
| | Area source boundary |
| | Point source |
| | Volume source |
| | Discrete receptor |

Figure 4 Highest Ground Level Odour Concentration Isopleth Plot (3 Minute Averaging Period)

# 5.0 Discussion

The modelling assessment results indicate that the maximum predicted ground level concentration for odour complies with the odour criterion at the discrete receptors. Examination of the isopleth plot illustrates that the isopleth representing the odour criterion forms an oval shaped ring, 100 – 200 m from the four sources at the proposed facility.

The modelling results should represent a worst case evaluation. The worst case aspects of the model are as follows:

- Biofilter exhaust and fugitive emission calculations were based on all soil inside the receipt/storage building having an odour flux rate equal to the highest measured at the Victorian gas works remediation site. In reality, soil inside the building will be of varying ages with a range of odour flux rates;
- Biofilter exhaust and fugitive emission calculations assumed that all storage bays inside the building were full;
- Treatment pad emission calculations assumed that the entire north side of the pad was covered with soil with a flux rate equal to the highest measured result from the Victorian gas works remediation site;
- Treatment pad emission calculations assumed that the entire south side of the pad was covered with soil with a flux rate equal to the highest measured result from 2 week old soil at the Victorian gas works remediation site;
- Treatment pad emission calculations did not make any allowance for the reduction of odourous emissions due to the soil being covered;
- The model was based on 24 hours per day/7days per week operation, with a resulting continuous odour emission scenario.

# Appendix 1

1

Odour_21042008

| | |
|---|---|
| Concentration or deposition | Concentration |
| Emission rate units | OUV/min |
| Concentration units | Odour_Units |
| Units conversion factor | 1.67E-02 |
| Constant background concentration | 0.00E+00 |
| Terrain effects | None |
| Smooth stability class changes? | No |
| Other stability class adjustments ("urban modes") | None |
| Ignore building wake effects? | No |
| Decay coefficient (unless overridden by met. file) | 0.000 |
| Anemometer height | 10 m |
| Roughness height at the wind vane site | 0.300 m |
| Use the convective PDF algorithm? | No |

DISPERSION CURVES

| | |
|---|---|
| Horizontal dispersion curves for sources <100m high | Pasquill-Gifford |
| Vertical dispersion curves for sources <100m high | Pasquill-Gifford |
| Horizontal dispersion curves for sources >100m high | Briggs Rural |
| Vertical dispersion curves for sources >100m high | Briggs Rural |
| Enhance horizontal plume spreads for buoyancy? | Yes |
| Enhance vertical plume spreads for buoyancy? | Yes |
| Adjust horizontal P-G formulae for roughness height? | Yes |
| Adjust vertical P-G formulae for roughness height? | Yes |
| Roughness height | 0.100m |
| Adjustment for wind directional shear | None |

PLUME RISE OPTIONS

| | |
|---|---|
| Gradual plume rise? | Yes |
| Stack-tip downwash included? | Yes |
| Building downwash algorithm: | PRIME method. |
| Entrainment coeff. for neutral & stable lapse rates | 0.60,0.60 |
| Partial penetration of elevated inversions? | No |
| Disregard temp. gradients in the hourly met. file? | No |

and in the absence of boundary-layer potential temperature gradients given by the hourly met. file, a value from the following table (in K/m) is used:

| Wind Speed Category | Stability Class A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Rural" values (unless overridden by met. file)

AVERAGING TIME: 3 minutes.

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1

Odour_21042008

SOURCE CHARACTERISTICS

STACK SOURCE: P1

| X(m) | Y(m) | Ground Elev. | Stack Height | Diameter | Temperature | Speed |
|---|---|---|---|---|---|---|
| 260117 | 6179731 | 0m | 13m | 0.80m | 17C | 15.0m/s |

Effective building dimensions (in metres)

| Flow direction | 10° | 20° | 30° | 40° | 50° | 60° | 70° | 80° | 90° | 100° | 110° | 120° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effective building width | 58 | 64 | 69 | 73 | 75 | 74 | 72 | 66 | 59 | 50 | 57 | 64 |
| Effective building height | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Along-flow building length | 50 | 56 | 64 | 70 | 73 | 75 | 74 | 70 | 65 | 58 | 63 | 70 |
| Along-flow distance from stack | -8 | -4 | -3 | -2 | 0 | 1 | 2 | 3 | 4 | 5 | -1 | -9 |
| Across-flow distance from stack | -34 | -31 | -26 | -21 | -15 | -9 | -2 | 5 | 11 | 18 | 24 | 29 |

| Flow direction | 130° | 140° | 150° | 160° | 170° | 180° | 190° | 200° | 210° | 220° | 230° | 240° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effective building width | 70 | 73 | 74 | 73 | 70 | 65 | 58 | 63 | 69 | 73 | 75 | 74 |
| Effective building height | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Along-flow building length | 73 | 75 | 75 | 71 | 67 | 59 | 51 | 56 | 64 | 70 | 73 | 74 |
| Along-flow distance from stack | -16 | -23 | -29 | -34 | -38 | -41 | -43 | -52 | -61 | -68 | -73 | -75 |
| Across-flow distance from stack | 33 | 36 | 38 | 39 | 39 | 37 | 34 | 30 | 26 | 21 | 15 | 9 |

| Flow direction | 250° | 260° | 270° | 280° | 290° | 300° | 310° | 320° | 330° | 340° | 350° | 360° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effective building width | 72 | 66 | 59 | 50 | 56 | 64 | 70 | 73 | 74 | 74 | 70 | 65 |
| Effective building height | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Along-flow building length | 74 | 70 | 65 | 58 | 63 | 70 | 73 | 75 | 74 | 71 | 66 | 59 |
| Along-flow distance from stack | -76 | -74 | -69 | -63 | -62 | -61 | -57 | -53 | -46 | -38 | -29 | -19 |
| Across-flow distance from stack | 2 | -5 | -11 | -17 | -25 | -29 | -33 | -36 | -38 | -39 | -39 | -37 |

(Constant) emission rate = 2.40E+04 OUV/min
No gravitational settling or scavenging.

INTEGRATED POLYGON AREA SOURCE: A1

| X0(m) | Y0(m) | Ground El | No. Vertices | Ver. spread | Height |
|---|---|---|---|---|---|
| 260054 | 6179770 | 0m | 4 | 2m | 2m |

Integrated Polygon Area Source Vertice Locations (in metres)

| No. | X | Y | No. | X | Y |
|---|---|---|---|---|---|
| 1 | 260054 | 6179770 | 2 | 260056 | 6179785 |
| 3 | 260120 | 6179773 | 4 | 260117 | 6179759 |

(Constant) emission rate = 5.30E+01 OUV/min per square metre
No gravitational settling or scavenging.

INTEGRATED POLYGON AREA SOURCE: A2

| X0(m) | Y0(m) | Ground El | No. Vertices | Ver. spread | Height |
|---|---|---|---|---|---|
| 260047 | 6179736 | 0m | 4 | 2m | 2m |

Integrated Polygon Area Source Vertice Locations (in metres)

| No. | X | Y | No. | X | Y |
|---|---|---|---|---|---|
| 1 | 260047 | 6179736 | 2 | 260050 | 6179751 |
| 3 | 260113 | 6179739 | 4 | 260110 | 6179725 |

(Constant) emission rate = 3.10E+01 OUV/min per square metre
No gravitational settling or scavenging.

VOLUME SOURCE: V1

| X(m) | Y(m) | Ground Elevation | Height | Hor. spread | Vert. spread |
|---|---|---|---|---|---|
| 260174 | 6179738 | 0m | 6m | 13m | 3m |

(Constant) emission rate = 1.60E+05 OUV/min
No gravitational settling or scavenging.

1

Odour_21042008

RECEPTOR LOCATIONS

The Cartesian receptor grid has the following x-values (or eastings):
259117.m 259167.m 259217.m 259267.m 259317.m 259367.m 259417.m
259467.m 259517.m 259567.m 259617.m 259667.m 259717.m 259767.m
259817.m 259867.m 259917.m 259967.m 260017.m 260067.m 260117.m
260167.m 260217.m 260267.m 260317.m 260367.m 260417.m 260467.m
260517.m 260567.m 260617.m 260667.m 260717.m 260767.m 260817.m
260867.m 260917.m 260967.m 261017.m 261067.m 261117.m

and these y-values (or northings):
6178731.m 6178781.m 6178831.m 6178881.m 6178931.m 6178981.m 6179031.m
6179081.m 6179131.m 6179181.m 6179231.m 6179281.m 6179331.m 6179381.m
6179431.m 6179481.m 6179531.m 6179581.m 6179631.m 6179681.m 6179731.m
6179781.m 6179831.m 6179881.m 6179931.m 6179981.m 6180031.m 6180081.m
6180131.m 6180181.m 6180231.m 6180281.m 6180331.m 6180381.m 6180431.m
6180481.m 6180531.m 6180581.m 6180631.m 6180681.m 6180731.m

DISCRETE RECEPTOR LOCATIONS (in metres)

| No. | X | Y | ELEVN | HEIGHT | No. | X | Y | ELEVN | HEIGHT |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 260563 | 6179992 | 0.0 | 0.0 | 3 | 260281 | 6179127 | 0.0 | 0.0 |
| 2 | 260930 | 6179444 | 0.0 | 0.0 | 4 | 260374 | 6180237 | 0.0 | 0.0 |

---

METEOROLOGICAL DATA : Location :Edinburgh Airfield :Surface Roughness 0.3 m

---

1 Peak values for the 100 worst cases (in Odour_Units)
Averaging time = 3 minutes

| Rank | Value | Time Recorded hour,date | Coordinates (* denotes polar) | | |
|---|---|---|---|---|---|
| 1 | 2.98E+01 | 23,25/10/00 | (260017, | 6179781, | 0.0) |
| 2 | 2.95E+01 | 21,13/04/00 | (260017, | 6179781, | 0.0) |
| 3 | 2.93E+01 | 03,08/01/00 | (260017, | 6179781, | 0.0) |
| 4 | 2.93E+01 | 03,25/04/00 | (260017, | 6179781, | 0.0) |
| 5 | 2.86E+01 | 02,09/01/00 | (260017, | 6179781, | 0.0) |
| 6 | 2.86E+01 | 01,08/02/00 | (260017, | 6179781, | 0.0) |
| 7 | 2.51E+01 | 21,21/09/00 | (260017, | 6179781, | 0.0) |
| 8 | 2.51E+01 | 06,29/03/00 | (260017, | 6179781, | 0.0) |
| 9 | 2.29E+01 | 20,11/06/00 | (260067, | 6179781, | 0.0) |
| 10 | 2.29E+01 | 03,28/07/00 | (260067, | 6179781, | 0.0) |
| 11 | 2.27E+01 | 01,02/05/00 | (260017, | 6179781, | 0.0) |
| 12 | 2.27E+01 | 22,30/05/00 | (260017, | 6179781, | 0.0) |
| 13 | 2.24E+01 | 01,11/06/00 | (260067, | 6179781, | 0.0) |
| 14 | 2.20E+01 | 03,24/08/00 | (260067, | 6179781, | 0.0) |
| 15 | 2.18E+01 | 21,10/08/00 | (260017, | 6179781, | 0.0) |
| 16 | 2.18E+01 | 06,01/07/00 | (260017, | 6179781, | 0.0) |
| 17 | 2.13E+01 | 19,30/06/00 | (260067, | 6179781, | 0.0) |
| 18 | 2.06E+01 | 01,13/08/00 | (260067, | 6179781, | 0.0) |
| 19 | 2.06E+01 | 19,28/07/00 | (260017, | 6179781, | 0.0) |
| 20 | 2.06E+01 | 22,10/08/00 | (260017, | 6179781, | 0.0) |
| 21 | 1.99E+01 | 20,17/04/00 | (260017, | 6179781, | 0.0) |
| 22 | 1.99E+01 | 18,22/05/00 | (260017, | 6179781, | 0.0) |
| 23 | 1.99E+01 | 20,01/05/00 | (260017, | 6179781, | 0.0) |
| 24 | 1.99E+01 | 21,06/05/00 | (260017, | 6179781, | 0.0) |
| 25 | 1.98E+01 | 03,17/03/00 | (260067, | 6179781, | 0.0) |
| 26 | 1.98E+01 | 22,25/09/00 | (260067, | 6179781, | 0.0) |
| 27 | 1.97E+01 | 23,14/04/00 | (260017, | 6179731, | 0.0) |
| 28 | 1.97E+01 | 18,15/05/00 | (260017, | 6179731, | 0.0) |
| 29 | 1.97E+01 | 19,16/07/00 | (260067, | 6179781, | 0.0) |
| 30 | 1.97E+01 | 06,25/08/00 | (260067, | 6179781, | 0.0) |
| 31 | 1.97E+01 | 04,18/06/00 | (260067, | 6179781, | 0.0) |
| 32 | 1.97E+01 | 05,25/10/00 | (259967, | 6179831, | 0.0) |
| 33 | 1.97E+01 | 19,22/05/00 | (259967, | 6179831, | 0.0) |
| 34 | 1.95E+01 | 04,09/02/00 | (260017, | 6179731, | 0.0) |
| 35 | 1.94E+01 | 07,11/06/00 | (260067, | 6179781, | 0.0) |

| | | | | |
|---|---|---|---|---|
| 36 | 1.94E+01 | 01,31/05/00 | (259967, 6179831, | 0.0) |
| 37 | 1.91E+01 | 20,13/08/00 | (260017, 6179781, | 0.0) |
| 38 | 1.87E+01 | 24,13/04/00 | (260017, 6179731, | 0.0) |
| 39 | 1.86E+01 | 03,12/02/00 | (260017, 6179731, | 0.0) |
| 40 | 1.86E+01 | 23,31/05/00 | (260017, 6179731, | 0.0) |
| 41 | 1.86E+01 | 04,07/04/00 | (260017, 6179731, | 0.0) |
| 42 | 1.84E+01 | 04,15/03/00 | (260017, 6179731, | 0.0) |
| 43 | 1.79E+01 | 19,15/04/00 | (260217, 6179731, | 0.0) |
| 44 | 1.74E+01 | 18,12/09/00 | (260217, 6179731, | 0.0) |
| 45 | 1.73E+01 | 03,06/02/00 | (260017, 6179731, | 0.0) |
| 46 | 1.73E+01 | 03,13/12/00 | (260017, 6179731, | 0.0) |
| 47 | 1.73E+01 | 02,14/06/00 | (260017, 6179781, | 0.0) |
| 48 | 1.64E+01 | 23,04/03/00 | (260017, 6179831, | 0.0) |
| 49 | 1.64E+01 | 20,08/05/00 | (260017, 6179831, | 0.0) |
| 50 | 1.62E+01 | 19,27/03/00 | (260017, 6179831, | 0.0) |
| 51 | 1.61E+01 | 01,26/03/00 | (260017, 6179731, | 0.0) |
| 52 | 1.59E+01 | 23,30/01/00 | (260017, 6179731, | 0.0) |
| 53 | 1.58E+01 | 02,16/03/00 | (260017, 6179831, | 0.0) |
| 54 | 1.57E+01 | 19,08/05/00 | (260017, 6179831, | 0.0) |
| 55 | 1.57E+01 | 17,21/05/00 | (260017, 6179831, | 0.0) |
| 56 | 1.54E+01 | 03,02/06/00 | (260017, 6179781, | 0.0) |
| 57 | 1.53E+01 | 01,01/06/00 | (260067, 6179781, | 0.0) |
| 58 | 1.53E+01 | 07,01/07/00 | (260067, 6179781, | 0.0) |
| 59 | 1.53E+01 | 04,24/11/00 | (260317, 6179681, | 0.0) |
| 60 | 1.53E+01 | 05,05/03/00 | (260017, 6179831, | 0.0) |
| 61 | 1.51E+01 | 04,13/06/00 | (260067, 6179731, | 0.0) |
| 62 | 1.50E+01 | 19,01/08/00 | (260017, 6179731, | 0.0) |
| 63 | 1.49E+01 | 20,15/05/00 | (260017, 6179831, | 0.0) |
| 64 | 1.47E+01 | 02,21/04/00 | (260017, 6179731, | 0.0) |
| 65 | 1.46E+01 | 03,30/11/00 | (260017, 6179831, | 0.0) |
| 66 | 1.46E+01 | 18,17/05/00 | (260167, 6179731, | 0.0) |
| 67 | 1.46E+01 | 24,25/04/00 | (260317, 6179681, | 0.0) |
| 68 | 1.43E+01 | 03,14/01/00 | (260267, 6179731, | 0.0) |
| 69 | 1.41E+01 | 04,23/06/00 | (260067, 6179731, | 0.0) |
| 70 | 1.41E+01 | 01,11/03/00 | (260167, 6179781, | 0.0) |
| 71 | 1.41E+01 | 24,06/05/00 | (260017, 6179731, | 0.0) |
| 72 | 1.39E+01 | 06,26/02/00 | (260017, 6179831, | 0.0) |
| 73 | 1.36E+01 | 23,26/09/00 | (260017, 6179781, | 0.0) |
| 74 | 1.34E+01 | 05,04/12/00 | (260017, 6179731, | 0.0) |
| 75 | 1.33E+01 | 23,18/03/00 | (260017, 6179831, | 0.0) |
| 76 | 1.33E+01 | 02,25/11/00 | (260017, 6179831, | 0.0) |
| 77 | 1.33E+01 | 06,03/03/00 | (260017, 6179831, | 0.0) |
| 78 | 1.32E+01 | 24,28/11/00 | (260017, 6179831, | 0.0) |
| 79 | 1.32E+01 | 07,07/05/00 | (260017, 6179831, | 0.0) |
| 80 | 1.32E+01 | 07,20/04/00 | (260017, 6179831, | 0.0) |
| 81 | 1.32E+01 | 24,17/12/00 | (260017, 6179831, | 0.0) |
| 82 | 1.32E+01 | 21,30/01/00 | (260017, 6179831, | 0.0) |
| 83 | 1.32E+01 | 05,26/09/00 | (260017, 6179831, | 0.0) |
| 84 | 1.32E+01 | 22,05/04/00 | (260017, 6179831, | 0.0) |
| 85 | 1.25E+01 | 04,13/12/00 | (260217, 6179681, | 0.0) |
| 86 | 1.24E+01 | 21,31/03/00 | (260217, 6179681, | 0.0) |
| 87 | 1.22E+01 | 22,18/12/00 | (260017, 6179731, | 0.0) |
| 88 | 1.22E+01 | 23,30/05/00 | (260017, 6179731, | 0.0) |
| 89 | 1.21E+01 | 10,27/02/00 | (260067, 6179781, | 0.0) |
| 90 | 1.21E+01 | 23,10/06/00 | (260017, 6179831, | 0.0) |
| 91 | 1.20E+01 | 21,08/02/00 | (260017, 6179831, | 0.0) |
| 92 | 1.18E+01 | 23,12/06/00 | (260017, 6179731, | 0.0) |
| 93 | 1.17E+01 | 06,30/05/00 | (260017, 6179731, | 0.0) |
| 94 | 1.16E+01 | 01,08/12/00 | (260017, 6179731, | 0.0) |
| 95 | 1.16E+01 | 21,18/09/00 | (260017, 6179731, | 0.0) |
| 96 | 1.16E+01 | 22,07/12/00 | (260217, 6179731, | 0.0) |
| 97 | 1.15E+01 | 02,05/06/00 | (260017, 6179781, | 0.0) |
| 98 | 1.14E+01 | 19,11/06/00 | (260067, 6179781, | 0.0) |
| 99 | 1.14E+01 | 01,02/06/00 | (260017, 6179831, | 0.0) |
| 100 | 1.14E+01 | 19,16/06/00 | (260017, 6179831, | 0.0) |

Odour_21042008 - no gridded receptors

| | |
|---|---|
| Concentration or deposition | Concentration |
| Emission rate units | OUV/min |
| Concentration units | Odour_Units |
| Units conversion factor | 1.67E-02 |
| Constant background concentration | 0.00E+00 |
| Terrain effects | None |
| Smooth stability class changes? | No |
| Other stability class adjustments ("urban modes") | None |
| Ignore building wake effects? | No |
| Decay coefficient (unless overridden by met. file) | 0.000 |
| Anemometer height | 10 m |
| Roughness height at the wind vane site | 0.300 m |
| Use the convective PDF algorithm? | No |

DISPERSION CURVES

| | |
|---|---|
| Horizontal dispersion curves for sources <100m high | Pasquill-Gifford |
| Vertical dispersion curves for sources <100m high | Pasquill-Gifford |
| Horizontal dispersion curves for sources >100m high | Briggs Rural |
| Vertical dispersion curves for sources >100m high | Briggs Rural |
| Enhance horizontal plume spreads for buoyancy? | Yes |
| Enhance vertical plume spreads for buoyancy? | Yes |
| Adjust horizontal P-G formulae for roughness height? | Yes |
| Adjust vertical P-G formulae for roughness height? | Yes |
| Roughness height | 0.100m |
| Adjustment for wind directional shear | None |

PLUME RISE OPTIONS

| | |
|---|---|
| Gradual plume rise? | Yes |
| Stack-tip downwash included? | Yes |
| Building downwash algorithm: | PRIME method. |
| Entrainment coeff. for neutral & stable lapse rates | 0.60,0.60 |
| Partial penetration of elevated inversions? | No |
| Disregard temp. gradients in the hourly met. file? | No |

and in the absence of boundary-layer potential temperature gradients given by the hourly met. file, a value from the following table (in K/m) is used:

| Wind Speed Category | Stability Class A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 4 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 5 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |
| 6 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.035 |

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Rural" values (unless overridden by met. file)

AVERAGING TIME: 3 minutes.

1

Odour_21042008 - no gridded receptors

SOURCE CHARACTERISTICS

STACK SOURCE: P1

| X(m) | Y(m) | Ground Elev. | Stack Height | Diameter | Temperature | Speed |
|---|---|---|---|---|---|---|
| 260117 | 6179731 | 0m | 13m | 0.80m | 17C | 15.0m/s |

Effective building dimensions (in metres)

| Flow direction | 10° | 20° | 30° | 40° | 50° | 60° | 70° | 80° | 90° | 100° | 110° | 120° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Effective building width | 58 | 64 | 69 | 73 | 75 | 74 | 72 | 66 | 59 | 50 | 57 |
| 64 | | | | | | | | | | | |
| Effective building height | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 12 | | | | | | | | | | | |
| Along-flow building length | 50 | 56 | 64 | 70 | 73 | 75 | 74 | 70 | 65 | 58 | 63 |
| 70 | | | | | | | | | | | |
| Along-flow distance from stack | -9 | -4 | -3 | -2 | -1 | 1 | 2 | 3 | 4 | 5 | -1 |
| -9 | | | | | | | | | | | |
| Across-flow distance from stack | -34 | -31 | -26 | -21 | -15 | -9 | -3 | 4 | 11 | 17 | 24 |
| 29 | | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow direction | 130° | 140° | 150° | 160° | 170° | 180° | 190° | 200° | 210° | 220° | 230° |
| 240° | | | | | | | | | | | |
| Effective building width | 70 | 73 | 74 | 73 | 70 | 65 | 58 | 63 | 69 | 73 | 75 |
| 74 | | | | | | | | | | | |
| Effective building height | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 12 | | | | | | | | | | | |
| Along-flow building length | 73 | 75 | 75 | 71 | 67 | 59 | 51 | 56 | 64 | 70 | 73 |
| 74 | | | | | | | | | | | |
| Along-flow distance from stack | -15 | -22 | -28 | -33 | -38 | -40 | -42 | -52 | -61 | -68 | -73 |
| -75 | | | | | | | | | | | |
| Across-flow distance from stack | 33 | 36 | 38 | 39 | 39 | 37 | 34 | 31 | 26 | 21 | 16 |
| 9 | | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow direction | 250° | 260° | 270° | 280° | 290° | 300° | 310° | 320° | 330° | 340° | 350° |
| 360° | | | | | | | | | | | |
| Effective building width | 72 | 66 | 59 | 50 | 56 | 64 | 70 | 73 | 74 | 74 | 70 |
| 65 | | | | | | | | | | | |
| Effective building height | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 12 | | | | | | | | | | | |
| Along-flow building length | 74 | 70 | 65 | 58 | 63 | 70 | 73 | 75 | 74 | 71 | 66 |
| 59 | | | | | | | | | | | |
| Along-flow distance from stack | -76 | -74 | -69 | -63 | -62 | -61 | -58 | -53 | -46 | -38 | -29 |
| -19 | | | | | | | | | | | |
| Across-flow distance from stack | 3 | -4 | -11 | -17 | -24 | -29 | -33 | -36 | -38 | -39 | -38 |
| -37 | | | | | | | | | | | |

(Constant) emission rate = 2.40E+04 OUV/min
No gravitational settling or scavenging.

INTEGRATED POLYGON AREA SOURCE: A1

| X0(m) | Y0(m) | Ground El | No. Vertices | Ver. spread | Height |
|---|---|---|---|---|---|
| 260054 | 6179770 | 0m | 4 | 2m | 2m |

Integrated Polygon Area Source Vertice Locations (in metres)

| No. | X | Y | No. | X | Y |
|---|---|---|---|---|---|
| 1 | 260054 | 6179770 | 2 | 260056 | 6179785 |
| 3 | 260120 | 6179773 | 4 | 260117 | 6179759 |

(Constant) emission rate = 5.30E+01 OUV/min per square metre
No gravitational settling or scavenging.

INTEGRATED POLYGON AREA SOURCE: A2

| X0(m) | Y0(m) | Ground El | No. Vertices | Ver. spread | Height |
|---|---|---|---|---|---|
| 260047 | 6179736 | 0m | 4 | 2m | 2m |

Integrated Polygon Area Source Vertice Locations (in metres)

| No. | X | Y | No. | X | Y |
|---|---|---|---|---|---|
| 1 | 260047 | 6179736 | 2 | 260050 | 6179751 |
| 3 | 260113 | 6179739 | 4 | 260110 | 6179725 |

(Constant) emission rate = 3.10E+01 OUV/min per square metre
No gravitational settling or scavenging.

VOLUME SOURCE: V1

| X(m) | Y(m) | Ground Elevation | Height | Hor. spread | Vert. spread |
|---|---|---|---|---|---|
| 260174 | 6179738 | 0m | 6m | 13m | 3m |

(Constant) emission rate = 1.60E+05 OUV/min
No gravitational settling or scavenging.

1

RECEPTOR LOCATIONS

DISCRETE RECEPTOR LOCATIONS (in metres)

| No. | X | Y | ELEVN | HEIGHT | No. | X | Y | ELEVN | HEIGHT |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 260563 | 6179992 | 0.0 | 0.0 | 3 | 260281 | 6179127 | 0.0 | 0.0 |
| 2 | 260930 | 6179444 | 0.0 | 0.0 | 4 | 260374 | 6180237 | 0.0 | 0.0 |

METEOROLOGICAL DATA : Location :Edinburgh Airfield :Surface Roughness 0.3 m

1 Peak values for the 100 worst cases (in Odour_Units)
Averaging time = 3 minutes

| Rank | Value | Time Recorded hour,date | Coordinates (* denotes polar) |
|---|---|---|---|
| 1 | 3.52E+00 | 18,12/09/00 | (260930, 6179444, 0.0) |
| 2 | 3.30E+00 | 04,24/11/00 | (260930, 6179444, 0.0) |
| 3 | 3.00E+00 | 01,26/04/00 | (260281, 6179127, 0.0) |
| 4 | 2.78E+00 | 24,25/04/00 | (260930, 6179444, 0.0) |
| 5 | 2.67E+00 | 21,19/08/00 | (260563, 6179992, 0.0) |
| 6 | 2.65E+00 | 20,18/09/00 | (260374, 6180237, 0.0) |
| 7 | 2.08E+00 | 03,23/02/00 | (260563, 6179992, 0.0) |
| 8 | 1.90E+00 | 03,07/04/00 | (260563, 6179992, 0.0) |
| 9 | 1.76E+00 | 03,03/03/00 | (260930, 6179444, 0.0) |
| 10 | 1.75E+00 | 24,16/12/00 | (260374, 6180237, 0.0) |
| 11 | 1.56E+00 | 02,30/01/00 | (260281, 6179127, 0.0) |
| 12 | 1.55E+00 | 03,26/02/00 | (260374, 6180237, 0.0) |
| 13 | 1.44E+00 | 21,02/04/00 | (260281, 6179127, 0.0) |
| 14 | 1.40E+00 | 18,07/06/00 | (260281, 6179127, 0.0) |
| 15 | 1.40E+00 | 01,17/09/00 | (260563, 6179992, 0.0) |
| 16 | 1.34E+00 | 23,07/08/00 | (260563, 6179992, 0.0) |
| 17 | 1.32E+00 | 24,22/12/00 | (260374, 6180237, 0.0) |
| 18 | 1.28E+00 | 03,26/03/00 | (260281, 6179127, 0.0) |
| 19 | 1.28E+00 | 22,16/12/00 | (260563, 6179992, 0.0) |
| 20 | 1.20E+00 | 06,29/01/00 | (260374, 6180237, 0.0) |
| 21 | 1.20E+00 | 19,15/05/00 | (260374, 6180237, 0.0) |
| 22 | 1.20E+00 | 21,19/09/00 | (260374, 6180237, 0.0) |
| 23 | 1.20E+00 | 24,27/10/00 | (260374, 6180237, 0.0) |
| 24 | 1.18E+00 | 18,18/05/00 | (260563, 6179992, 0.0) |
| 25 | 1.16E+00 | 01,10/11/00 | (260374, 6180237, 0.0) |
| 26 | 1.09E+00 | 20,19/04/00 | (260374, 6180237, 0.0) |
| 27 | 1.08E+00 | 23,31/10/00 | (260563, 6179992, 0.0) |
| 28 | 1.08E+00 | 19,19/09/00 | (260563, 6179992, 0.0) |
| 29 | 1.06E+00 | 02,13/12/00 | (260374, 6180237, 0.0) |
| 30 | 1.06E+00 | 19,06/10/00 | (260563, 6179992, 0.0) |
| 31 | 1.06E+00 | 17,22/05/00 | (260563, 6179992, 0.0) |
| 32 | 1.05E+00 | 04,24/02/00 | (260563, 6179992, 0.0) |
| 33 | 1.05E+00 | 04,29/01/00 | (260374, 6180237, 0.0) |
| 34 | 1.05E+00 | 19,07/05/00 | (260374, 6180237, 0.0) |
| 35 | 1.04E+00 | 18,19/04/00 | (260563, 6179992, 0.0) |
| 36 | 9.99E-01 | 23,28/11/00 | (260374, 6180237, 0.0) |
| 37 | 9.88E-01 | 17,17/05/00 | (260281, 6179127, 0.0) |
| 38 | 9.55E-01 | 19,07/06/00 | (260563, 6179992, 0.0) |
| 39 | 9.10E-01 | 23,07/12/00 | (260374, 6180237, 0.0) |
| 40 | 8.88E-01 | 05,12/02/00 | (260281, 6179127, 0.0) |
| 41 | 8.84E-01 | 19,21/09/00 | (260374, 6180237, 0.0) |
| 42 | 8.60E-01 | 24,16/09/00 | (260563, 6179992, 0.0) |
| 43 | 8.51E-01 | 02,25/03/00 | (260563, 6179992, 0.0) |
| 44 | 8.40E-01 | 22,06/04/00 | (260374, 6180237, 0.0) |
| 45 | 8.40E-01 | 03,30/05/00 | (260374, 6180237, 0.0) |
| 46 | 8.16E-01 | 05,09/12/00 | (260930, 6179444, 0.0) |
| 47 | 8.13E-01 | 20,15/04/00 | (260281, 6179127, 0.0) |
| 48 | 8.02E-01 | 19,29/06/00 | (260563, 6179992, 0.0) |
| 49 | 7.97E-01 | 22,07/12/00 | (260930, 6179444, 0.0) |
| 50 | 7.87E-01 | 20,19/12/00 | (260374, 6180237, 0.0) |
| 51 | 7.82E-01 | 01,11/11/00 | (260563, 6179992, 0.0) |
| 52 | 7.48E-01 | 19,16/10/00 | (260374, 6180237, 0.0) |
| 53 | 7.24E-01 | 17,27/03/00 | (260374, 6180237, 0.0) |
| 54 | 7.22E-01 | 05,10/06/00 | (260374, 6180237, 0.0) |

| | | | | |
|---|---|---|---|---|
| 55 | 7.18E-01 | 02,11/01/00 | (260930, 6179444, | 0.0) |
| 56 | 7.11E-01 | 02,25/08/00 | (260374, 6180237, | 0.0) |
| 57 | 7.00E-01 | 03,06/08/00 | (260281, 6179127, | 0.0) |
| 58 | 6.94E-01 | 20,31/01/00 | (260374, 6180237, | 0.0) |
| 59 | 6.94E-01 | 19,22/09/00 | (260374, 6180237, | 0.0) |
| 60 | 6.94E-01 | 01,05/11/00 | (260374, 6180237, | 0.0) |
| 61 | 6.88E-01 | 18,29/08/00 | (260563, 6179992, | 0.0) |
| 62 | 6.80E-01 | 19,04/12/00 | (260374, 6180237, | 0.0) |
| 63 | 6.80E-01 | 22,27/10/00 | (260374, 6180237, | 0.0) |
| 64 | 6.73E-01 | 17,16/06/00 | (260374, 6180237, | 0.0) |
| 65 | 6.69E-01 | 01,12/11/00 | (260374, 6180237, | 0.0) |
| 66 | 6.53E-01 | 22,26/06/00 | (260281, 6179127, | 0.0) |
| 67 | 6.50E-01 | 21,15/08/00 | (260374, 6180237, | 0.0) |
| 68 | 6.43E-01 | 05,20/05/00 | (260930, 6179444, | 0.0) |
| 69 | 6.35E-01 | 16,14/06/00 | (260281, 6179127, | 0.0) |
| 70 | 6.34E-01 | 20,08/10/00 | (260374, 6180237, | 0.0) |
| 71 | 6.33E-01 | 20,15/10/00 | (260374, 6180237, | 0.0) |
| 72 | 6.30E-01 | 22,09/06/00 | (260374, 6180237, | 0.0) |
| 73 | 6.30E-01 | 20,26/07/00 | (260374, 6180237, | 0.0) |
| 74 | 6.26E-01 | 21,16/03/00 | (260563, 6179992, | 0.0) |
| 75 | 6.21E-01 | 02,24/02/00 | (260374, 6180237, | 0.0) |
| 76 | 6.17E-01 | 02,02/01/00 | (260281, 6179127, | 0.0) |
| 77 | 6.05E-01 | 04,22/12/00 | (260281, 6179127, | 0.0) |
| 78 | 6.05E-01 | 19,24/05/00 | (260281, 6179127, | 0.0) |
| 79 | 6.05E-01 | 24,19/03/00 | (260374, 6180237, | 0.0) |
| 80 | 6.05E-01 | 06,23/02/00 | (260374, 6180237, | 0.0) |
| 81 | 6.05E-01 | 03,09/01/00 | (260374, 6180237, | 0.0) |
| 82 | 6.05E-01 | 01,04/02/00 | (260374, 6180237, | 0.0) |
| 83 | 6.05E-01 | 05,08/04/00 | (260281, 6179127, | 0.0) |
| 84 | 6.05E-01 | 01,20/10/00 | (260374, 6180237, | 0.0) |
| 85 | 6.05E-01 | 20,30/05/00 | (260374, 6180237, | 0.0) |
| 86 | 5.88E-01 | 07,04/06/00 | (260374, 6180237, | 0.0) |
| 87 | 5.76E-01 | 21,30/05/00 | (260374, 6180237, | 0.0) |
| 88 | 5.71E-01 | 05,08/01/00 | (260281, 6179127, | 0.0) |
| 89 | 5.68E-01 | 20,30/06/00 | (260374, 6180237, | 0.0) |
| 90 | 5.65E-01 | 18,30/06/00 | (260563, 6179992, | 0.0) |
| 91 | 5.58E-01 | 05,25/05/00 | (260281, 6179127, | 0.0) |
| 92 | 5.58E-01 | 06,12/09/00 | (260281, 6179127, | 0.0) |
| 93 | 5.58E-01 | 06,15/08/00 | (260563, 6179992, | 0.0) |
| 94 | 5.48E-01 | 22,06/06/00 | (260374, 6180237, | 0.0) |
| 95 | 5.35E-01 | 23,21/11/00 | (260374, 6180237, | 0.0) |
| 96 | 5.35E-01 | 04,30/05/00 | (260374, 6180237, | 0.0) |
| 97 | 5.35E-01 | 04,26/11/00 | (260281, 6179127, | 0.0) |
| 98 | 5.30E-01 | 03,08/06/00 | (260281, 6179127, | 0.0) |
| 99 | 5.23E-01 | 04,28/07/00 | (260281, 6179127, | 0.0) |
| 100 | 5.22E-01 | 21,09/08/00 | (260930, 6179444, | 0.0) |

At Golder Associates we strive to be the most respected global group of companies specialising in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organisational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.


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