Appendix O
Landfill Gas Risk Assessment

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WSN Environmental Solutions

Jacks Gully AWT Facility

Landfill Gas Risk Assessment

Final report

March 2006

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

WSN Environmental Solutions (WSN) currently operates the Jacks Gully Waste and Recycling Centre (WRC), which is located in the Macarthur region, within the Camden Local Government Area.

The Jacks Gully WRC is approximately 55 km south west of Sydney and 5 km east of Camden, and is situated off Richardson Road, 50 metres from the intersection with Springs Road. Access to the site is via a private road, off Richardson Road.

WSN is proposing to construct an Alternative Waste Technology (AWT) facility on the Jacks Gully WRC site. Landfilling of putrescible waste on the site will cease when the AWT facility becomes operational.

The proposed AWT facility would involve the following:

- Processing of approximately 90,000 tonnes per annum of municipal solid waste;
- Composting of 30,000 tonnes per annum of green waste and biosolids; and
- Generation of biogas and electricity.

GHD was engaged by WSN to identify and evaluate the potential risks to operation of the AWT facility from landfill gas.

The proposed AWT facility will be located on an engineered platform adjacent to the existing Jacks Gully landfill, and there is a potential risk of lateral migration of landfill gas from the landfill onto the AWT site, particularly in future when the current gully area is progressively filled.

This report provides:

- A brief description of the proposed Jacks Gully AWT facility;
- An outline of the existing Jacks Gully WRC, with a particular focus on landfill gas;
- Identification and evaluation of the potential risks to the AWT facility from the adjacent landfill; and
- Conclusions and recommendations.

2. Background

2.1 Jacks Gully WRC

WSN has been operating the Jacks Gully WRC since 1974. Currently the facility comprises the following:

- Gatehouse with weighbridge;
- Small vehicles receival facility;
- Recycling operations; and
- Landfilling operation.

Figure 2.1 shows the current layout of the facility, with the proposed AWT facility in the southern part of the site.

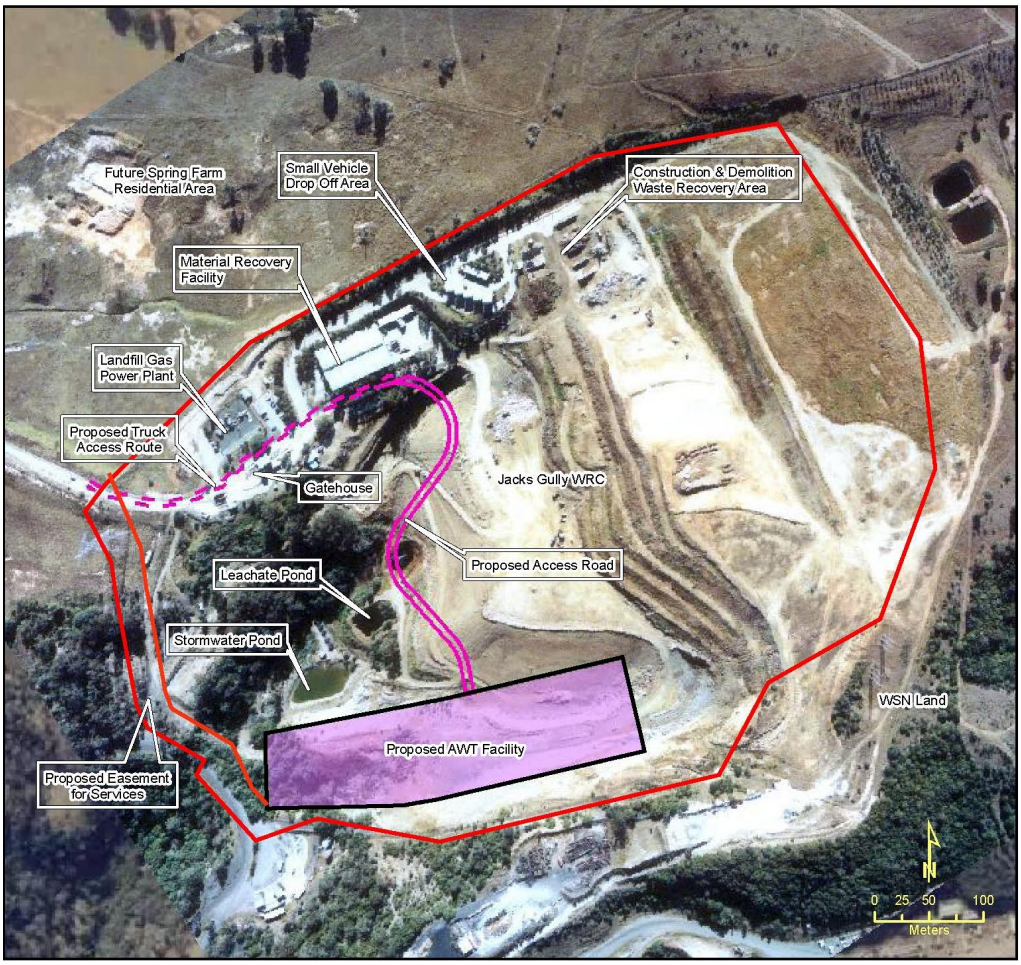


Figure 2.1: Layout of Jacks Gully WMC site

2.2 Existing Conditions

Jacks Gully WRC currently accepts approximately 450,000 tonnes/year of waste, which includes approximately 210,000 tonnes/year of putrescible waste and 150,000 tonnes/yr of VENM. This is all landfilled on site. In addition approximately 40,000 tonnes/yr of dry waste is landfilled on site.

It is anticipated that the landfill will cease accepting further domestic waste in 2007. After this time only non-putrescible waste will be landfilled at the site for an estimated 15 years. Only an estimated 30,000 tonnes of residuals from the AWT facility and dry wastes will then be landfilled on site annually.

Upon completion the landfill will be capped and landscaped to an agreed profile. The final profile of the landfill site will eventually blend into the new topography created by the engineered platform of the AWT facility.

Landfill gas, consisting mainly of methane and carbon dioxide with traces of volatile organic compounds, is currently being generated from the anaerobic biodegradation of organic waste within the landfill. Currently the Jacks Gully landfill is generating sufficient landfill gas to run a 1 MW generator and a second 1 MW generator is soon to be installed by Energy Developments Limited (EDL), which has a 25 yr contract to operate the landfill gas systems on the site.

Although there is the potential for landfill gas migration, WSN currently utilises worlds best practice techniques for landfill technical design and landfill gas collection and processing. This ensures that all available landfill gas generated from landfill is being effectively managed.

WSN has been actively collecting and managing landfill gas from the Jacks Gully landfill for the past few years . Several of the existing odour/gas management initiatives include:-

- Effective gas monitoring program (routine surface and sub surface gas monitoring);
- Gas Accumulation Monitoring within adjacent buildings;
- Odour Monitoring program – on and off-site odour patrols;
- A long term contract (25 years) with (EDL) to operate and maintain gas management system. EDL is also responsible for installation of new gas infrastructure in accordance with site filling plans;
- Active gas extraction and collection system - series of vertical gas wells at depth of 20 metres within landfill areas (typically 50 metre spacing);
- Gas processing system – one (1) power generation module is used to process all landfill gas collected from site. A gas flare is also installed on site to deal with excess landfill gas and also acts as contingency in event of power station problems. (This ensures virtually no downtime on the active gas collection system).

Engineering measures at the Jacks Gully landfill also include:

- Lining of the landfill with a 900 mm layer of low permeability compacted clay ($K< 10^{-9}$ m/s) – which prevents / minimises potential subsurface landfill gas migration;
- Daily and intermediate covering of landfilled waste – which helps to minimise atmospheric emissions of landfill gas and control / minimise rainfall infiltration into the landfilled waste (thus minimising / controlling landfill gas generation);

- A low permeability final capping layer that is progressively constructed – to minimise emissions of landfill gas to the atmosphere emissions and control / minimise rainfall infiltration into the landfilled waste (thus minimising / controlling landfill gas generation); and
- Progressive installation of the active gas extraction system.

2.3 Jacks Gully AWT Facility

The proposed Jack's Gully AWT facility will comprise an ArrowBio Plant for processing MSW, using ArrowBio technology (from Israel) and a Garden Organics Plant, using tunnel-composting technology. Both plants will be located on a large earth platform constructed within the gully, adjacent to the landfill. The platform will be constructed from compacted soil and other engineering materials such as coal washery reject materials.

The main components of the ArrowBio Plant will include the following:

- A receival Hall (MSW drop off, large items removed, loaded onto conveyor for small items removal)
- MSW processing building, which houses the ArrowBio processing equipment. Waste is immersed into a water stream to permit separation of various fractions. Air from the building, which is kept at a slight negative pressure is vented to a biofilter;
- Anaerobic digestion plant; and
- Gas power plant.

2.3.1 ArrowBio Plant

Material separation processes in the ArrowBio Plant will result in the following streams of recovered materials:

- plastics for recycling/reprocessing (offsite);
- metals for recycling; and
- organics for further processing.

Residuals will be disposed of to the Jacks Gully landfill.

The organic fraction is subject to further processing involving the anaerobic digestion within a water stream, recovery of gases (biogas) for fuel source (electricity production) and dewatering / processing of stabilised sludge for eventual use as soil conditioner. Ancillary works to the organics processing include wastewater treatment, and electricity generation.

2.3.2 Garden Organics Plant

The Garden Organics Plant includes delivery, pre-treatment, sorting, shredding, biosolids receival, mixing, intensive composting and product storage areas. The main components of the Garden Organics plant are as follows:

- Green waste delivery in 3 bays;
- Conveyor / decompactor to transfer green waste to the tunnels (during this process, contaminants are removed, and the waste is shredded before being combined with biosolids);

- Biosolids delivery / pre-treatment. Biosolids are received by truck which deposits the material into an enclosed pit from where the biosolids can be mixed with the green waste; and
- The green waste mixture is then transferred to the composting tunnels where it is aerated and kept under optimum conditions before transfer to the product storage area; and
- Air is continually recycled within the tunnels with excess odorous air vented via a biofilter.

The composted product will be stored in the southern end of the building before collection and transport offsite by enclosed vehicles.

Figure 2.2 shows a conceptual layout of the AWT facility. The eventual profile of the landfill is in the foreground, shown in brown (active landfill area) and in green (revegetated areas). To the right (west) is the green waste processing facility, with the MSW processing facility located in the centre of the platform. The anaerobic digestion plant is located to the left of the plan (east).

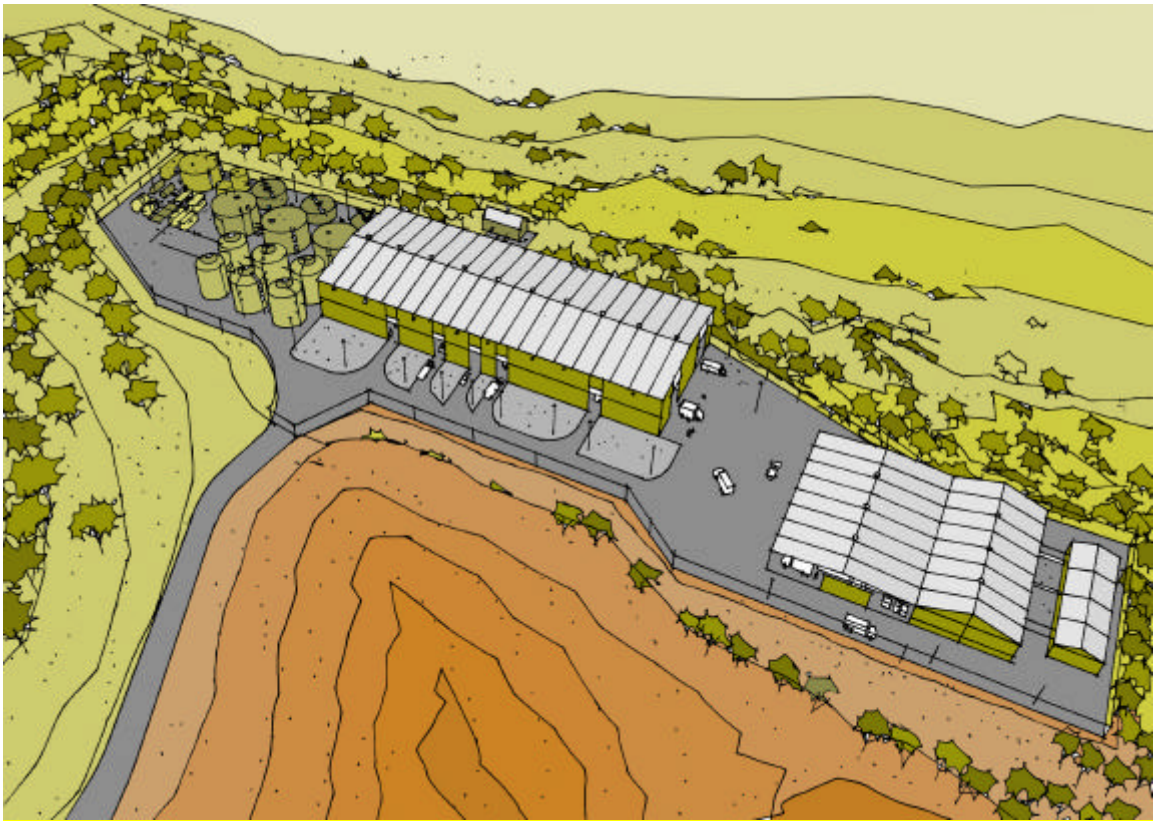


Figure 2.2: Conceptual Layout of the AWT Facility

3. Identification and Evaluation of Risks

3.1 General

An assessment of the risks presented by landfill gas to the proposed Jack Gully AWT facility has been undertaken following the process outlined in the Australian Standard AS4360:2004 Risk Management, HB436: 2004 Risk Management Guidelines, and HB203:2006 Environmental Risk Management Principles and Process. The process, issues, results and recommended risk management measures are described in the following sections.

3.2 Process

Figure 3.1 (from AS 4360) describes the risk management process used for this evaluation. The steps in the process encompass:

- Establishing the context;
- Identifying the risks;
- Analysing the risks;
- Evaluating the risks; and
- Treating / managing the risks.

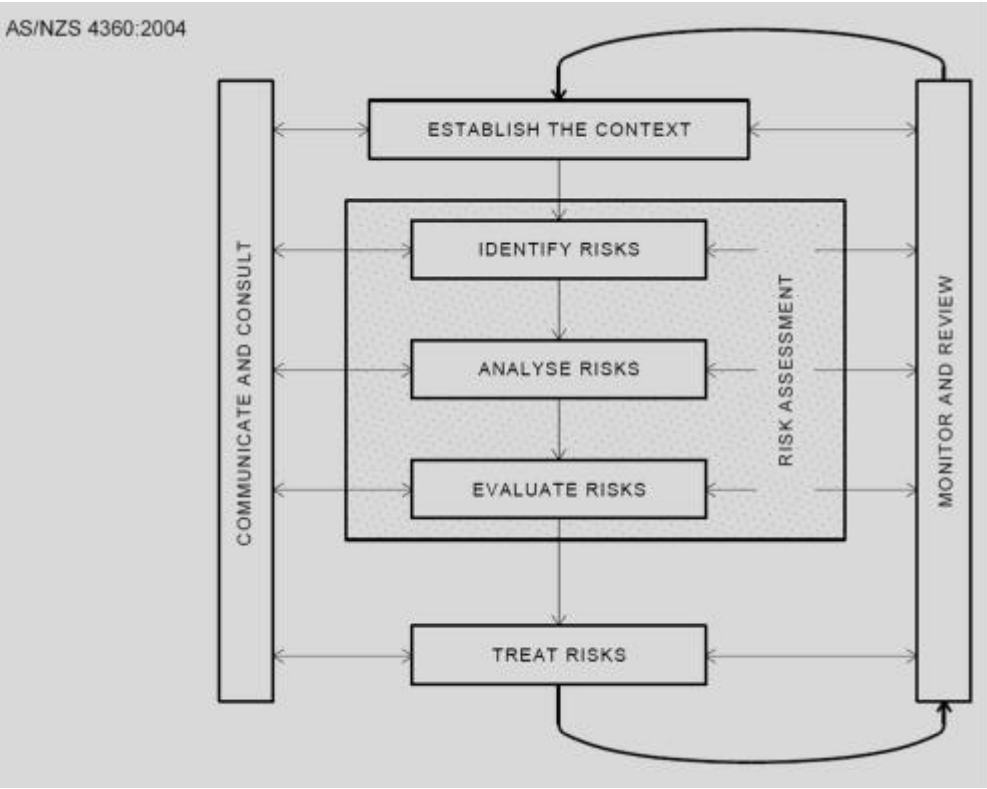


Figure 3.1: Risk Management Process (from AS4360)

In analysing the risks guidance on assessing the severity of consequences and likelihood of an incident occurring was obtained from HB436:2004 (including Tables 6.2, 6.3, 6.4, .6.5) and HB203: 2006 (including Tables 4A & 4B).

A qualitative evaluation of the overall risk was undertaken considering both the consequences and likelihood of an incident occurring using a matrix as per Table 3-1 (from HB203: 2006).

Table 3-1 Risk Evaluation Matrix (from HB203: 2006)

Likelihood	Consequence				
	Catastrophic	Major	Moderate	Minor	Insignificant
Almost certain	E	E	E	H	H
Likely	E	E	H	H	M
Possible	E	E	H	M	L
Unlikely	E	H	M	L	L
Rare	H	H	M	L	L

Legend:

E = extreme risk; immediate action required

H = high risk: senior management attention needed

M = moderate risk; management responsibility must be specified

L = low risk; manage by routine procedures

3.3 Issues

The primary hazards (to human health) presented by landfill gas are ignition / explosion / fire and asphyxiation. Landfill gas typically comprises 40 – 60% methane, which is flammable when in air at concentrations between 5% and 15 % (v/v). Landfill gas also typically contains 40 – 50% carbon dioxide and little or no oxygen. Consequently, should landfill gas accumulate within an enclosed structure, displacing the atmospheric air, the atmosphere within the enclosed structure can present a hazard in regard to asphyxiation.

Landfill gas can travel long distances, through soils and rock fractures, and could potentially enter the strata beneath the AWT facility, once waste materials are landfilled alongside the platform.

In undertaking the identification and evaluation of risks presented by landfill gas the following issues have been considered:

- Landfill gas will continue to be generated after landfilling of putrescible waste ceases at the Jacks Gully WRC;
- Although much of the non-putrescible waste that will be placed adjacent to the platform after 2007 will have low gas generation potential, it has the potential to permit gas migration from the previously landfilled putrescible wastes;

- The proposed AWT facility will be located on a raised earth platform immediately adjacent to the landfill, and landfilled waste currently only adjoins the north-eastern portion of the platform. Therefore while the hazard presented by landfilled waste will be initially quite low, as the height of waste rises alongside the platform, the risk of lateral migration will increase;
- The current clay landfill lining system has been installed and tested in accordance with EPA guidelines.

  However there is potential that on its own may not prevent lateral, subsurface migration of landfill gas, and its performance at preventing migration cannot be effectively monitored;
- While there is an active landfill gas extraction system at Jacks Gully WRC, the timing and location of wells adjacent to the AWT site is not certain, however it is anticipated that within the next six months 6-7 wells will be installed through the current filling area.
- The likely permeability of the raised earth platform is not known but landfill gas is effective at penetrating many engineering materials;
- There will be a number of potential ignition sources (activities, equipment, services) at the AWT site during construction and operation;
- There is a potential for accumulation of landfill gas within structures / facilities during construction and operation of the AWT facility;
- Prior to capping of the landfilled waste, the risk of lateral subsurface gas migration is likely to be lower (than after capping) depending on the characteristics of the daily and intermediate cover layers, but this is difficult to quantify; and
- Building foundations / floors may not be effective at preventing movement of landfill gas into the buildings on the site, and a method which keeps the hazard at a safe distance is likely to be most effective.

3.4 Results

3.4.1 Risks during construction

However there is currently very little landfilled material alongside the platform, except at its eastern end. This is where the risk would be greatest at present. The results of the risk identification and evaluation process are presented in Table 3-2.

3.4.2 Risks during operation

The potential risks posed by landfill gas during operation of the AWT facility are similar to those that will exist during construction, although they would occur over a longer time period. During operation of the facility, non-putrescible material such as residuals from the AWT facility will be placed into the landfill adjacent to the platform.

This will gradually increase the level of risk associated with landfill gas migration, as it will provide a more direct pathway from putrescible waste that has been placed into the landfill previously, and the platform. The results of the risk identification and evaluation process are presented in Table 3-3.

Table 3-2 Identification and Evaluation of Risks during Construction

Potential Hazardous Event / Risk	Existing Mitigation, Monitoring and Management Measures	Likely Consequences	Likelihood of Impact	Level of Risk	Recommended Additional Measures / Controls	Contingency Measures
Lateral migration of landfill gas to the AWT site during construction and emission / accumulation of the landfill gas within a void or structure eg. excavation, pit, pipe, access chamber, or building, leading to: ◗ Ignition / explosion / fire ◗ Asphyxiation	Landfill lined with 900 mm layer of low permeability compacted clay. Progressive capping and revegetation of the landfilled waste. Active extraction and recovery of landfill gas for generating energy, encompassing progressive installation of gas extraction wells. Regular landfill gas monitoring.	The consequences of lateral gas migration from the landfill to the AWT site during construction could range from **Insignificant to Major** due to the close proximity of the AWT site to the landfill, the potential for ignition of the landfill gas by construction activities, and the potential harm to construction personnel should gas accumulation occur (possibly leading to asphyxiation or an explosion).	The likelihood of lateral gas migration from the landfill to the AWT site is considered to be **Rare to Unlikely** due to the landfill lining system, the active gas management measures, and the regular gas monitoring.	The overall level of risk presented by lateral gas migration during construction of the AWT will range from **Low to High** (refer Table 3-1). This indicates that senior management attention is required, but probably to the extent of ensuring that adequate precautions are taken, in the unlikely event that current measures fail.	Classification of the construction site hazard (according to as AS 2430) and design and construction of the AWT facility accordingly. Preparation of a site specific health and safety plan for the facility construction Education / training of all construction personnel. Regular landfill gas emissions and accumulation monitoring. Restricted smoking at the AWT site Control over construction activities / equipment that present a potential ignition source. Controls over personnel entering confined / enclosed spaces. See Section 3.5 for details.	Installation of active gas extraction wells within the landfilled waste along the boundary of the AWT and the landfill during construction of the AWT (if monitoring indicates lateral migration is occurring). Installation of active gas extraction wells between the AWT facility and the landfill.

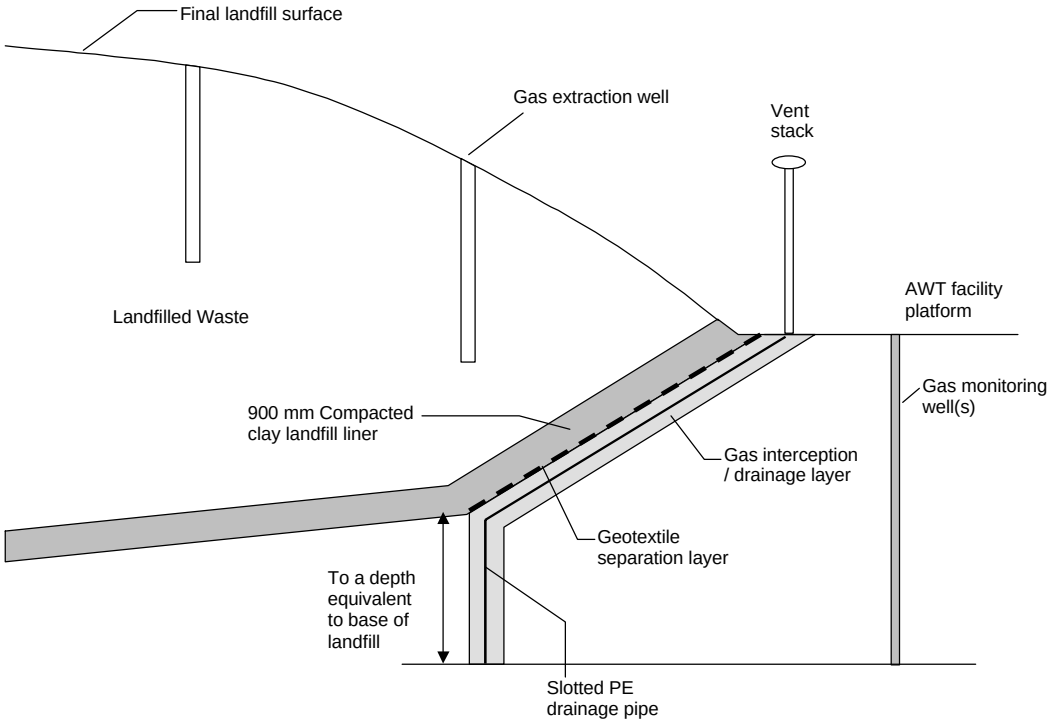
Table 3-3 Identification and Evaluation of Risks during Operation

Potential Hazardous Event / Risk	Existing Mitigation, Monitoring and Management Measures	Likely Consequences	Likelihood of Impact	Level of Risk	Recommended Additional Measures / Controls	Contingency Measures
Lateral migration of landfill gas to the AWT site during operation and emission / accumulation of landfill gas within a void or structure eg. pit, pipe, access chamber, or building, leading to: ◗ Ignition / explosion / fire ◗ Asphyxiation	Landfill lined with 900 mm layer of low permeability compacted clay. Active extraction and recovery of landfill gas for generating energy, encompassing progressive installation of gas extraction wells. Regular landfill gas monitoring.	The consequences of lateral gas migration from the landfill to the AWT site during operation could range from **Insignificant to Major** due to the close proximity of the AWT site to the landfill, the potential for ignition of the landfill gas by operational activities and the potential harm to AWT personnel should gas accumulation occur (possibly leading to asphyxiation or an explosion).	The likelihood of lateral gas migration from the landfill to the AWT site is considered to be **Rare to Unlikely** due to the landfill lining system, the active gas management measures, the passive gas interception and drainage system, the risk management measures and the regular gas monitoring.	The overall level of risk presented by lateral gas migration during operation of the AWT facility will range from **Low to High** (refer Table 3-1). This indicates that senior management attention is required, but probably to the extent of ensuring that adequate precautions are taken, in the unlikely event that current measures fail.	Classification of the AWT facility hazard (according to as AS 2430) and design and operation of the AWT facility accordingly. Preparation of a site specific health and safety plan for the facility operation. Education / training of all AWT personnel. Installation of a passive gas interception and drainage system between the landfill and the AWT. Installation of additional landfill gas monitoring wells (between the AWT and the landfill) and inclusion in the monitoring program. Regular landfill gas emissions and accumulation monitoring at the AWT site. Restricted smoking at the AWT site Control over activities / equipment that present a potential ignition source. Controls over personnel entering confined / enclosed spaces. See Section 3.5 for details.	Increased monitoring (frequency of monitoring). Active extraction of gas from the passive gas interception and drainage system.

3.5 Recommended Additional Risk Management Measures

Since the potential consequences of gas accumulation are quite severe (death or injury) it is recommended that additional control measures be implemented to minimise and manage the risks. These measures recognise the importance and effectiveness of the landfill gas management systems that currently exist on site, but are designed to provide an additional level of hazard reduction as a contingency measure.

- Design, construction and operation of the AWT facility considering the results of the site hazard assessment / classification;
- Preparation and implementation of a site specific health and safety plan that considers the risk presented by landfill gas and the results of the site hazard assessment / classification. Management and monitoring measures may include the following:
  - Education / training of all site workers and visitors to the site;
  - No smoking on the site, except at well ventilated designated smoking areas;
  - Regular landfill gas monitoring encompassing:
    - Subsurface gas concentrations – in all available monitoring wells (at least quarterly then monthly if levels are greater than 1.25% v/v);
    - Surface emissions – prior to and during work each day;
    - Gas accumulation monitoring in all excavations and subsurface structures - prior to and during work each day;
  - Frequency of montoring to be linked to preformace of landfill extraction system and monitoring results from surface and subsurface monitoring at the landfill.
  - Gas testing prior to use of equipment or undertaking activities that present a potential ignition source;
  - Power to the construction site shall be designed considering the risks presented by landfill and in accordance with the results of the site assessment / classification; and
  - No entering of confined / enclosed spaces except in accordance with confined spaces regulations.
- Installation of subsurface landfill gas monitoring wells, located between the landfill and the AWT facility, which are monitored at least quarterly.
- A passive gas interception and drainage system could be installed between the landfill and AWT site progressively as the adjacent area is landfilled. The interception and drainage system should comprise a layer of suitable aggregate placed under the landfill liner (against the AWT facility earth platform), and a network of slotted polyethylene pipe placed within the layer of aggregate, which vents freely to atmosphere, as per Figure 3-1;
- Alternatively, or in addition to the above-mentioned passive system, additional gas collection wells could be located near the platform.



TYPICAL SECTION

Figure 3-1 Cross-section of possible landfill gas collection system

4. Conclusions and Recommendations

The location of the proposed AWT facility in close proximity to the existing Jacks Gully landfilling operation means that there is a potential risk that the development could be adversely affected by the lateral migration of landfill gas.

The existing Jacks Gully WRC landfilling operation has a range of landfill gas management measures including:

- A low permeability landfill lining system that acts to prevent / minimise the landfill gas migration and emissions;
- An active gas extraction system that is being progressively installed; and
- Regular landfill gas monitoring.

GHD's assessment of the risks presented by landfill gas to the proposed Jack Gully AWT facility follows the process outlined in AS4360:2004 Risk Management, HB436:2004 Risk Management Guidelines, and HB203:2004 Environmental Risk Management Principles and Process.

The assessment considered landfill gas generation at the site, the existing landfill gas management and monitoring measures, and the issues that could affect the generation, migration and impact of landfill gas on the AWT facility.

The results of the risk assessment indicate that the overall risk of landfill gas during the construction and operation of the AWT facility will range from Low to High.

It is therefore recommended that WSN Environmental Solution implement additional measures to minimise and manage the specific risks to the proposed AWT facility including:

- Design, construction and operation of the AWT facility considering the results of the hazard assessment and classification;
- Assessment and classification of the hazards presented by landfill gas during construction and operation of the AWT facility in accordance with AS2430 Classification of Hazardous Areas;
- Installation of subsurface landfill gas monitoring wells between the AWT facility and the landfill;
- Possible installation of a passive gas interception and drainage system between the AWT facility and the landfill, and/or additional landfill gas collection wells near the platform;
- Regular monitoring of landfill gas migration and emissions at the AWT facility site; and
- Preparation and implementation of a site specific health and safety plan for the construction and operation of the AWT facility, which includes implementation of controls over activities / equipment that present a risk of ignition of landfill gas and regular monitoring for landfill gas.

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