AECOM

Civil Engineering and Development Department

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Landfill Gas Hazard Assessment Report

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	Name	Signature
Prepared & Checked:	Ben Hunter	
Reviewed & Approved:	David Paton	

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AECOM Asia Co. Ltd.
1501-1510, 15/F, Grand Central Plaza, Tower 1, 138 Shatin Rural Committee Road, Shatin, NT, Hong Kong
Tel: (852) 3922 9000 Fax: (852) 3922 9797 www.aecom.com

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1 INTRODUCTION

1.1 Background

1.1.1 Road improvement schemes were recommended in the Planning Study on Future Land Use at Anderson Road Quarry under Consultancy agreement No. CE4/2010(TP) to improve future traffic operations and cater for additional traffic demand from a population of 25,000 at the Development of Anderson Road Quarry site (ARQ Development).

1.1.2 On 18 July 2014, CEDD commissioned AECOM Asia Company Limited (AECOM) as the Consulting Engineer to undertake the assignment of Development of Anderson Road Quarry site, the scope of which includes off-site road improvement works.

1.1.3 The proposed road improvement schemes involve upgrade of several junctions including:

- Junction of (J/O) Lin Tak Road and Sau Mau Ping Road;
- J/O Clear Water Bay Road and Road L1 of the Development at Anderson Road (DAR); and
- A new merging lane at New Clear Water Bay Road near Shun Lee Tsuen Road.

1.1.4 An evaluation of potential risk posed by landfill gas (LFG) is required for any development proposed within 250m of the edge of a landfill, known as a Landfill Consultation Zone. There are three closed landfill sites in the vicinity of the ARQ Development including Ma Yau Tong West (MYTW), Ma Yau Tong Central (MYTC) and Jordan Valley (JV). Since the proposed works at J/O Lin Tak Road and Sau Mau Ping Road falls within the consultation zones of both the Ma Yau Tong West and Ma Yau Tong Central Landfills, and the proposed works at New Clear Water Bay Road near Shun Lee Tsuen Road falls within the consultation zone of the Jordan Valley Landfill (shown in **Figure 1.1**), a Qualitative Landfill Gas Hazard Assessment (QLFGHA) is required to assess risk resulting from potential landfill gas migration from the landfills.

1.2 Landfill gas characteristics and general hazards

1.2.1 The typical composition of LFG is about 60% methane and 40% carbon dioxide, although these percentages can vary widely depending on the site conditions. Also present are trace quantities of hydrogen sulphide, nitrogen and gaseous hydrocarbons such as hexane, octane and heptanes.

1.2.2 Methane is odorless and colorless, although in landfill gas it is typically associated with numerous highly odoriferous compounds which give some warning of its presence. However, the absence of odour should not be taken to mean that methane is absent. Methane is a flammable gas and will burn when mixed with air at concentrations between 5 and 15% (v/v). If a mixture of methane and air with a composition between these two values is ignited in a confined space, the resulting combustion may give rise to an explosion. Methane is also an asphyxiant.

1.2.3 Carbon dioxide, the other major component of landfill gas is an asphyxiating gas and causes adverse health effects at relatively low concentrations. The long-term Occupational Exposure Limit (OEL) is 0.5% (v/v). Like methane, it is odourless and colorless and its presence (or absence) can only be confirmed by using appropriately calibrated portable detectors.

1.2.4 Methane is lighter than air whereas carbon dioxide is heavier than air. Typical mixtures of landfill gas are likely to have a density close to or equal to that of air. However, site conditions may result in a ratio of methane to carbon dioxide which may make the gas mixture lighter or heavier than air. As a result, landfill gas may accumulate in either the base or top of any voids or confined spaces.

1.2.5 LFG migration can be a hazard because of the combustible and in some cases explosive nature of methane and the asphyxiant nature of carbon dioxide. LFG has the potential to cause fire, explosion or asphyxiation if it migrates into and accumulate in confined spaces such as building basements, underground car parks, lift shafts and maintenance chambers. For the same reasons, temporary structures such as site huts and any other unventilated enclosures erected during construction stage may also be exposed to LFG hazards. Underground services, such as sewer drains, storm drains and service ducts, may also be susceptible to the potential hazards as they may act as pathways for LFG. Geologic faults may also act as pathways for LFG.

2 ENVIRONMENTAL LEGISLATION AND GUIDELINES

2.1.1 EPD has issued two guidance notes regarding landfill gas hazard assessment, namely ProPECC PN 3/96 – Landfill Gas Hazard Assessment for Development Adjacent to Landfill and EPD/TR8/97 – Landfill Gas Hazard Assessment Guidance Note. These guidance notes set out the conditions under which a landfill gas hazard assessment should be carried out and provide guidance on undertaking landfill gas hazard assessment. The guidance notes state that assessment of landfill gas hazard is required for proposed development within the 250m Consultation Zone around a landfill.

2.1.2 It is a requirement that project proponents of developments adjacent to landfills undertake a landfill gas hazard assessment and submit the findings to EPD for vetting. As recommended in *ProPECC PN 3/96* (**Appendix A**), the project proponent and professionals responsible for the developments adjacent to landfills should:

(i) carry out a landfill gas hazard assessment to evaluate the degree of risk associated with the proposed development;

(ii) design suitable precautionary/protection measures to render the proposed development as safe as reasonably practicable;

(iii) ensure that the precautionary/protection measures will be implemented and constructed in accordance with the design; and

(iv) establish a maintenance and monitoring programme to ensure the continued performance of the implemented protection measures.

3 LANDFILL GAS HAZARD ASSESSMENT

3.1 Objectives of the Landfill Gas Hazard Assessment

3.1.1 This landfill gas hazard assessment aims to provide a qualitative risk assessment of hazard associated with potential landfill gas migration from Ma Yau Tong West Landfill, Ma Yau Tong Central Landfill and Jordan Valley Landfill to landfill gas sensitive elements of the off-site road improvement works associated with the ARQ Development.

3.1.2 The assessment covers the following:

3.1.3 Review of background information about each landfill that may have potential impacts on the proposed works.

3.1.4 Assessment of the degree of risks associated with the proposed works.

3.1.5 Formulation of any precautionary measures considered necessary (commensurate with the degree of risk) for the safe construction and operation of the proposed works.

3.2 Landfill Gas Hazard Assessment Criteria

3.2.1 The assessment of potential LFG hazards to the proposed works was carried out in accordance with the "Source-Pathway-Target" model presented in the EPD's Guidance Note. The source (landfill) may be classified as "Minor", "Medium" or "Major" depending on the characteristics of the landfill, age of the waste, control measures installed at the landfill, and monitoring data, etc.

3.2.2 The pathway may be classified as "Very short/ direct", "Moderately short/ direct" or "Long/ indirect" depending on path length, permeability of soils, spacing, tightness and direction of fissures/ joints, depth and thickness of the medium through which the gas can migrate, topography, and presence of any conduits, etc.

3.2.3 The targets may be classified as "Highly sensitive", "Medium sensitivity" or "Low sensitivity" depending on the nature and location of the development. The overall risk to a target can be one of the categories shown in **Table 3.1** depending on the combination of various categories of the source, pathway and target. Implications regarding each category of risk are summarized in **Table 3.2**.

Table 3.1 Classification of Risk Category

Source	Pathway	Target Sensitivity	Risk Category
Major	Very short / direct	High	Very High
		Medium	High
		Low	Medium
	Moderately short / direct	High	High
		Medium	Medium
		Low	Low
	Long / indirect	High	High
		Medium	Medium
		Low	Low
Medium	Very short / direct	High	High
		Medium	Medium
		Low	Low
	Moderately short / direct	High	High
		Medium	Medium
		Low	Low
	Long / indirect	High	Medium
		Medium	Low
		Low	Very Low
Minor	Very short / direct	High	High
		Medium	Medium
		Low	Low
	Moderately short / direct	High	Medium
		Medium	Low
		Low	Very Low
	Long / indirect	High	Medium
		Medium	Low
		Low	Very Low

Table 3.2 Summary of General Categorization of Risk

Level of Risk	Implication
Very high (undesirable)	The type of development being proposed is very undesirable and a less sensitive form of development should be considered. At the very least, extensive engineering measures, alarm systems and emergency plans are likely to be required.
High	Significant engineering measures will be required to protect the planned development.
Medium	Engineering measures will be required to protect the planned development.
Low	Some precautionary measures will be required to ensure that the planned development is safe.
Very low (insignificant)	The risk is so low that no precautionary measures are required.

3.3 Description of the Environment

Jordan Valley Landfill

Landfill Site Layout

3.3.1 Jordan Valley Landfill is located in Kwun Tong next to Tseung Kwan O Road and to the north of Hing Tin Estate. **Figure 1.1** shows the location of the landfill.

History of the Landfill

3.3.2 Jordan Valley Landfill was in operation between 1986 and 1990. The site was closed in 1990 and contains about 1.5 million tonnes of domestic and industrial waste. The total area of the landfill is about 11 ha.

3.3.3 No liner was installed before the deposition of waste. The landfill is underlain by a main spine drain which extends the full length of the landfill and is connected to secondary lateral drains. The leachate is processed at the Leachate Pre-treatment Works, leachate is also received and treated onsite from Ma Yau Tong West Landfill and Ma Yau Tong Central Landfill.

Restoration Works

3.3.4 Restoration works were carried out at the landfill between 1997 and 1998. Monitoring of landfill gas and leachate measurements at the periphery of the landfill site is ongoing. The monitoring will continue until the end of the landfill Aftercare Period, which is 20 years from the restoration works completion date.

Landfill Gas Management of Jordan Valley Landfill

3.3.5 The landfill gas management system consists of a LFG control and utilisation system. The system consists of extraction wells, associated piping, condensate removal, and LFG flare. The system is designed to thermally treat 500m^3/hr of LFG and is capable of generating 220kW of power.

3.3.6 Landfill gas monitoring data presented in **Table B.1**and **Table B.4** of **Appendix B** respectively indicate that no measurable concentrations of methane or carbon dioxide concentrations < 1.5% were detected at relevant LFG monitoring locations around the periphery of JVL. Based on this monitoring data, gas control at the source is considered to be adequate.

Leachate Management of Jordan Valley Landfill

3.3.7 JV landfill was originally designed/built without lining or a leachate collection system. A capping system was installed on the landfill to prevent infiltration of surface runoff into the landfill and a leachate extraction system was installed to the north of the landfill to control the level of leachate on the landfill slope. The leachate extraction / management system is integrated with the LFG management system. Collected leachate is treated onsite.

Ma Yau Tong West Landfill

Landfill Site Layout

3.3.8 Ma Yau Tong West Landfill is located in Kwun Tong next to Tseung Kwan O Road and to the north of Hing Tin Estate. **Figure 1.1** shows the location of the landfill.

History of the Landfill

3.3.9 Ma Yau Ting West Landfill was in operation between 1979 and 1981. The site was closed in 1981 and contains about 0.6 million tonnes of domestic and industrial waste. The total area of the landfill is about 6 ha.

3.3.10 No liner was installed before the deposition of waste. The landfill is underlain by a main spine drain which extends the full length of the landfill and is connected to secondary lateral drains. The leachate is collected in a leachate storage tank and tankered to the Leachate Pre-treatment Works at Jordan Valley Landfill for treatment.

Restoration Works

3.3.11 Restoration works at the landfill commenced in March 1997 and was completed in May 1998. Monitoring of landfill gas and leachate measurements at the periphery of the landfill site is currently ongoing. The monitoring will continue until the end of the landfill Aftercare Period, which is 20 years from the restoration works completion date.

Landfill Gas Management at Ma Yau Tong West Landfill

3.3.12 Landfill gas management consists of passive venting with a standby utility flare integrated into the LFG management system, as a contingency to provide active control of LFG if required.

3.3.13 Landfill gas monitoring data presented in **Table B.2** and **Table B.5** of **Appendix B** respectively indicate no measurable concentrations of methane or carbon dioxide levels greater than 1.5% were detected at any relevant LFG monitoring locations around MYTW Landfill, hence, it is considered gas control at the source is adequate.

Leachate Management at Ma Yau Tong West Landfill

3.3.14 MYTW Landfill was originally designed/built without a lining system or leachate collection system. A capping system constructed to prevent infiltration of surface runoff into the landfill. A leachate extraction system was installed to the to control the level of leachate on the landfill slope. The leachate extraction / management system is integrated with the LFG management system. The collected leachate is stored temporarily at the leachate storage tank to the west of the landfill. It is then tankered to the Leachate Pre-treatment Works at Jordan Valley Landfill for treatment.

Ma Yau Tong Central Landfill

Landfill Site Layout

3.3.15 Ma Yau Tong Central Landfill is located in Kwun Tong south of Tseung Kwan O Tunnel and to the East of Lin Tak Road. **Figure 1.1** shows the location of the landfill.

History of the Landfill

3.3.16 Ma Yau Ting Central Landfill was in operation between 1981 and 1986. The site was closed in 1986 and contains about 1.0 million tonnes of domestic and industrial waste. The total area of the landfill is about 11 ha.

3.3.17 No liner was installed before deposition of waste. The landfill is underlain by a main spine drain which extends the full length of the landfill and is connected to secondary lateral drains. Leachate is collected in a storage tank and tankered to the Leachate Pre-treatment Works at Jordan Valley Landfill for treatment.

Restoration Works

3.3.18 Restoration works at the landfill commenced in 1997 and were completed in 1998. Monitoring of landfill gas and leachate measurements at the periphery of the landfill site are currently ongoing. The monitoring will continue until the end of the landfill Aftercare Period, which is 20 years from the restoration works completion date.

Landfill Gas Management at Ma Yau Tong Central Landfill

3.3.19 The landfill gas management system consists of active LFG extraction wells and associated piping, blower and flare system, condensate management system, knock out, electrical control and monitoring of LFG both on and off-site. The LFG gas extraction system is integrated with the leachate management system.

3.3.20 LFG is collected from the landfill by active gas extraction and is transferred to the onsite gas management system where the LFG is flared. The system prevents LFG from migrating off-site.

3.3.21 The methane monitoring data is presented in Error! Reference source not found. of **Appendix B** and revealed that no measurable concentrations of methane were detected at any of the relevant LFG monitoring locations at MYTC Landfill.

3.3.22 Carbon dioxide monitoring data presented inError! Reference source not found. of **Appendix B** indicates that carbon dioxide levels were < 1.5% at all the relevant offsite monitoring locations MYTC Landfill. Hence, it is considered that there is adequate control of the gas at the source.

Leachate Management at Ma Yau Tong Central Landfill

3.3.23 MYTC Landfill is originally designed/built without a lining system or leachate collection system underneath. A capping system was installed to prevent infiltration of surface runoff into the landfill. A leachate extraction system was installed to the south of the landfill to control the level of leachate on the landfill slope. The leachate extraction / management system is integrated with the LFG management system. The collected leachate is stored temporarily at the gas / leachate compound at the north of the landfill. It is then tankered to the Leachate Pre-treatment Works at Jordan Valley Landfill for treatment.

3.4 Geological Assessment

Geology/Hydrogeology at Jordan Valley Landfill

3.4.1 According to Hong Kong Geological Topography Map (Series: HGM20, 1:20,000 Scale) – Sheet No. 11 (Hong Kong and Kowloon, Edition 1, 1986), the Site is mainly fine to medium grained granite, with minor intrusions of Quartzphyric rhyolite. The fine to medium grained granite is considered to have low permeability for significant gas migration.

3.4.2 There are three geological faults in the vicinity of JVL. One geological fault trends NW/SE through the centre of the landfill site. This crosses another geological fault trending NE-SW immediately to the south of the landfill. A third geological fault extends to the SE from this fault. The exact locations of the NW-SE faults are not certain and the degree to which the faults are fractured or infilled is also not known, however the NE-SW trending fault has been identified to be lead towards the Project site.

3.4.3 Recent groundwater monitoring data at JVL has been obtained to identify the local groundwater levels. Gauged groundwater levels from March 2013 to September 2014 are summarized in **Table B.7** and **Table B.8** of **Appendix B**. The location of the groundwater monitoring wells is shown in **Figure 3.1**. Groundwater levels ranged from 63.38mPD to 126.73mPD across the landfill. It is conservatively assumed that the unsaturated zone for potential landfill gas could range from ground level to 63.38mPD to 126.73mPD.

Geology/Hydrogeology at Ma Yau Tong West Landfill

3.4.4 According to Hong Kong Geological Topography Map (Series: HGM20, 1:20,000 Scale) – Sheet No. 11 (Hong Kong and Kowloon, Edition 1, 1986), the geology of the site comprises

colluvium and granite. The rock (fine to medium grained granite) is considered to have low permeability for significant gas migration.

3.4.5 There are no geological fault lines identified within the vicinity of the landfill.

3.4.6 Recent groundwater monitoring data at MYTW Landfill has been obtained to identify local groundwater levels. Groundwater monitoring data from March 2013 to September 2014 for are summarized in **Table B.9** and **Table B.10** of **Appendix B**. The location of the groundwater monitoring wells is shown in **Figure 11.4**. Groundwater levels ranged from 14.61mPD to 69.13mPD across the landfill. It is conservatively assumed that the unsaturated zone for potential landfill gas could range from ground level to 14.61mPD to 69.13mPD.

Geology/Hydrogeology at Ma Yau Tong Central Landfill

3.4.7 According to Hong Kong Geological Topography Map (Series: HGM20, 1:20,000 Scale) – Sheet No. 11 (Hong Kong and Kowloon, Edition 1, 1986), the Site is mainly underlain by fine grained granite to the west and fine ash to vitric tuff to the east. The rock stratum (fine to medium grained granite) in the direction of the proposed road improvement works is considered to have low permeability for significant gas migration.

3.4.8 There are no geological fault lines identified within the vicinity of the landfill.

3.4.9 Recent groundwater monitoring data at MYTC Landfill has been obtained to identify the groundwater level in the area. Monitoring data from March 2013 to September 2014 for groundwater levels are summarized in **Table B.11** and **Table B.12** of **Appendix B**. The location of the groundwater monitoring wells is shown in **Figure 3.2**. Groundwater levels ranged from 14.61mPD to 69.13mPD across the landfill. It is conservatively assumed that the unsaturated zone for potential landfill gas could range from ground level to 14.61mPD to 69.13mPD.

4 QUALITATIVE RISK ASSESSMENT

4.1 Assessment Methodology

4.1.1 The qualitative risk assessment is based on the methodology which is stipulated in EPD's Guidance Note and includes the following steps:

- Review of background information – collect and assess relevant background information about the landfill such as historical information, geological and hydrogeological data and results of any environmental monitoring.
- Evaluation of sources – nature and extent of the sources of landfill gas.
- Identification of targets – different elements of the proposed development which are sensitive to landfill gas impacts.
- Assessment of the risk to each target – qualitative assessment of risk based on the "source-pathway-target" analysis.
- Precautionary measures and recommendations – propose protection and precautionary measures based on the risk category.

4.2 Qualitative Source-Pathway-Target Analysis

Landfill Gas Source

Jordan Valley Landfill

4.2.1 Landfill gas generation is dependent upon a number of factors including temperature, pH, substrate availability, moisture content and oxygen level. At Jordan Valley Landfill sufficient LFG is produced for electricity generation which powers the onsite leachate treatment plant. Excess LFG produced is flared onsite to prevent horizontal migration[1].

4.2.2 A post-restoration monitoring programme commenced in 1998 under the restoration contract for JVL. The monitoring is conducted on a regular basis. LFG (including methane and carbon dioxide) and oxygen are monitored at selected monitoring wells installed within and outside the boundary of the landfill. The locations of these monitoring wells are shown on **Figure 3.1**. Available gas monitoring data provided by EPD from January 2013 to February 2015 are tabulated in **Table B.1** and **Table B.4** of **Appendix B.**

4.2.3 As shown in **Table B.1** of **Appendix B**, no detectable concentrations of methane have been measured in monitoring wells outside the landfill boundary in the direction of the proposed development. Background levels of carbon dioxide are unknown; however carbon dioxide levels in monitoring wells ranged from 0.0% to 1.3% at 13 locations. Taking into account the zero level of methane and presence of gas control measures such as vents and barriers to mitigate gas migration, the landfill gas source of JVL is be classified as **Medium**.

Ma Yau Tong West Landfill

4.2.4 Landfill gas generation is dependent upon a number of factors including temperature, pH, substrate availability, moisture content and oxygen level. At Ma Yau Tong West Landfill extremely low amounts of LFG are produced with low methane content. Due to the low methane content flaring is not required and the gas is vented to atmosphere to prevent horizontal migration[2].

4.2.5 A post-restoration monitoring programme commenced in 1998 under the restoration contract for MYTW Landfill. The monitoring is conducted on a regular basis. LFG (including carbon dioxide) and oxygen are monitored at selected monitoring wells installed within and outside the boundary of the landfill. The locations of these monitoring wells are shown on **Figure 3.3**. The available gas monitoring data provided by EPD from January 2013 to February 2015 are tabulated in **Table B.2** and **Table B.5** of **Appendix B.**

4.2.6 As shown in **Table B.2** of **Appendix B**, no methane has been detected in monitoring wells installed along the boundary of the landfill in the vicinity of the proposed development. Background levels of carbon dioxide are unknown; however carbon dioxide levels in monitoring wells ranged from 0.0% to 1.2% at 10 of the monitoring locations. Taking into account the zero level of methane and that gas control (such as vents and barriers) to prevent gas migration has been installed at the landfill, the landfill gas source of MYTW Landfill would be considered **Medium**.

Ma Yau Tong Central Landfill

[1] Legislative Council of the Hong Kong Special Administration Region of the Peoples Republic Of China (June 2003), *Note for public works subcommittee of finance committee, Supplementary information on 45DR – Restoration of Pillar Point Valley Landfill*

[2] Legislative Council of the Hong Kong Special Administration Region of the Peoples Republic Of China (June 2003), *Note for public works subcommittee of finance committee, Supplementary information on 45DR – Restoration of Pillar Point Valley Landfill*

4.2.7 Landfill gas generation is dependent upon a number of factors including temperature, pH, substrate availability, moisture content and oxygen level. Ma Yau Tong Central Landfill produces relatively low amounts of LFG. All LFG produced is flared onsite to prevent horizontal migration[3].

4.2.8 A post-restoration monitoring programme commenced in 1998 under the restoration contract for MYTC Landfill. The monitoring is conducted on a regular basis. LFG (including carbon dioxide) and oxygen are monitored at some monitoring wells installed within and outside the boundary of the landfill. The locations of these monitoring wells are shown on **Figure 3.2**. The available gas monitoring data provided by EPD from January 2013 to February 2015 are tabulated in **Table B.3** and **Table B.6** of **Appendix B.**

4.2.9 As shown in **Table B.3** of **Appendix B**, zero level of methane has been detected at the monitoring wells installed along the boundary of the landfill in the vicinity of the proposed development. The carbon dioxide levels varied from 0.0% to 1.4% (with unknown background level) at 13 of the monitoring wells. Taking into account the zero level of methane and that gas control (such as vents and barriers) to prevent gas migration that has been installed at the landfill, the landfill gas source of MYTC Landfill would be considered **Medium**.

4.3 Analysis of Pathways

Natural Pathways

4.3.1 For the natural pathways, the presence of natural cavities, pore paces and fractures is directly related to the prevailing local geography. The rock stratum beneath MYTW and MYTC landfills in the direction of the proposed road improvement works is considered to have low permeability for significant gas migration and there are no geological fault lines directly crossing or in proximity to the proposed road improvement works. However, the distance between proposed road improvement works boundary and MYTW and MYTC landfills will be less than 5m in places, therefore natural pathways are classified as **Very Short/Direct** for MYTW and MYTC Landfills.

4.3.2 There are three geological faults in the vicinity of the JVL as identified in **Section 3.4.2** one of which was identified to run in the direction of the road improvement works. The path length between the JVL landfill and the proposed road improvement works boundary is between 150 – 250m; however as the nature of the fault line (i.e. whether it is an open or infilled fault) is unknown, this natural pathway is conservatively classified as **Short/Direct**.

Man-made Pathways (Utilities)

4.3.3 Based on the available utility layout plans, no existing utilities or services directly link JVL, MYTC or MYTCW landfills to the proposed road improvement works. It is therefore considered that there are no man-made pathways between the landfill and the proposed works. In the case of MYTC and MYTW landfills the proposed development is within 5m of the landfill boundary in certain sections. Therefore the man-made pathways for MYTC and MYTW landfills are classified as **Very Short/Direct**. The man-made pathways for JVL are classified as **Long/Indirect**.

4.4 Analysis of Targets

4.4.1 In general, potential targets associated with a proposed development include:

- Excavations for foundations, utilities installation and drainage works during construction phase;

[3] Legislative Council of the Hong Kong Special Administration Region of the Peoples Republic Of China (June 2003), *Note for public works subcommittee of finance committee, Supplementary information on 45DR – Restoration of Pillar Point Valley Landfill*

- Slope cutting works during the construction phase;
- Piling works for noise barriers / enclosures and flyover during construction phase; and
- Manholes, inspection chambers or voids of services/utilities during operational phase.

4.4.2 Excavation for construction of foundation works, earth retaining structures, road works, utility installation etc. during construction phase involve excavation in an open air environment, however, as landfill gas maybe heavier than air, potential exists for landfill gas to accumulate in trenches or excavations. According to Section 3.18 of Landfill Gas Hazard Assessment Guidance Note, the level of risk for deep excavations is categorised as **Medium Sensitivity**.

4.4.3 Slope cutting works to facilitate the road improvement works during construction phase involve excavation in an open air environment. According to Section 3.18 of Landfill Gas Hazard Assessment Guidance Note, the level of risk for shallow excavations is categorised as **Low Sensitivity**

4.4.4 Piling works for proposed noise barriers / enclosures and flyover during construction phase involve piling in an open air environment. According to Section 3.18 of Landfill Gas Hazard Assessment Guidance Note, creation of a gas pathway could pose potential problems, therefore the target is categorised as **Low Sensitivity**

4.4.5 Some manholes, inspection chambers or voids of services/utilities will be present within the project site during the operational phase. Since access to these confined spaces will be restricted to authorized persons who have awareness of potential LFG hazard, these targets are also categorized as **Medium Sensitivity.**

4.5 Source-Pathway-Target Analysis

4.5.1 Based upon the sources, pathways and targets classified above, the qualitative landfill gas hazard assessment for the proposed development is presented in **Table 4.1** to **Table 4.3**.

Table 4.1 Qualitative Source-Pathway Target Analysis of proposed road improvement works in the proximity to Jordan Valley Landfill

Source	Pathway	Target Sensitivity	Risk
Jordan Valley Landfill was closed in 1990. The restoration programme includes LFG management to reduce potential safety and health risks. Gas monitoring is conducted on a regular basis. Methane, carbon dioxide and oxygen concentrations are monitored within monitoring wells installed within and outside the boundary of the landfill. No methane has been detected in monitoring wells installed along the boundary of the landfill in the vicinity of the proposed development. Carbon dioxide levels varied from 0.0% to <1.5% (unknown background level) in 14 of the monitoring wells. Taking into account the zero level of methane and presence of gas control measures such as vents and barriers to mitigate gas migration, JVL is considered a Medium source. (***Medium Source***)	**Natural Pathways** A fault line passes through the proposed road (improvement works) alignment and JVL, therefore natural pathways are classified as Direct/Short. (***Direct /Short***)	**Excavation for proposed works during construction phase** Excavation for construction of foundation works, earth retaining structures, road works, drainage, sewerage, water works, etc. during construction phase. (*Medium Sensitivity Target*)	Medium
		Slope works during construction phase Slope cutting to facilitate road works during construction phase. (*Low Sensitivity Target*)	Low
		Piling works during construction phase Piling works for proposed noise barriers / enclosures and flyover during construction phase. (*Low Sensitivity Target*)	Low
		Maintenance of services / utilities during operational phase Manholes or inspection chambers of services / utilities during operational phase. (*Medium Sensitivity Target*)	Medium
	Man-Made Pathways There are no utilities or services directly linking JVL and the proposed road improvement works. Man-made pathways are classified as Long/Indirect. (***Long/Indirect***)	**Excavation for proposed works during construction phase** Excavation for construction of foundation works, earth retaining structures, road works, drainage, sewerage, water works, etc. during construction phase. (*Medium Sensitivity Target*)	Low
		Slope works during construction phase Slope cutting to facilitate road works during construction phase. (*Low Sensitivity Target*)	Low
		Piling works during construction phase Piling works for proposed noise barriers / enclosures and flyover during construction phase. (*Low Sensitivity Target*)	Low
		Maintenance of services / utilities during operational phase Manholes or inspection chambers of services / utilities during operational phase. (*Medium Sensitivity Target*)	Low

Table 4.2 Qualitative Source-Pathway Target Analysis of proposed road improvement works in the proximity to Ma Yau Tong West Landfill

Source	Pathway	Target Sensitivity	Risk
Ma Yau Tong West Landfill was closed in 1981. The restoration programme includes LFG management to reduce potential safety and health risks. Gas monitoring is conducted on a regular basis. Methane, carbon dioxide and oxygen concentrations are monitored within monitoring wells installed within and outside the boundary of the landfill. No methane has been detected at the monitoring wells installed along the boundary of the landfill in the vicinity of the proposed development. Carbon dioxide levels varied from 0.0% to <1.5% (unknown background level) in 10 of the monitoring wells. Taking into account the zero level of methane and installation of gas control measures (such as vents and barriers) to prevent gas migration, MYTW landfill is considered a Medium source. (***Medium Source***)	**Natural Pathways** The proposed development is within 5m of the landfill boundary in certain sections. Therefore natural pathways for MYTW Landfill are classified as Very Short/Direct. (***Very Short/Direct***)	**Excavation for proposed works during construction phase** Excavation for construction of foundation works, earth retaining structures, road works, drainage, sewerage, water works, etc. during construction phase. (*Medium Sensitivity Target*)	Medium
		Slope works during construction phase Slope cutting to facilitate road works during construction phase. (*Low Sensitivity Target*)	Low
		Piling works during construction phase Piling works for proposed noise barriers / enclosures and flyover during construction phase. (*Low Sensitivity Target*)	Low
		Maintenance of services / utilities during operational phase Manholes or inspection chambers of services / utilities during operational phase. (*Medium Sensitivity Target*)	Medium
	Man-Made Pathways There are no utilities or services directly linking MYTC Landfill and the proposed road improvement works. The proposed development is within 5m of the landfill boundary in certain sections. Therefore man-made pathways for MYTCW Landfill are classified as Very Short/Direct. (***Very Short/Direct***)	**Excavation for proposed works during construction phase** Excavation for construction of foundation works, earth retaining structures, road works, drainage, sewerage, water works, etc. during construction phase. (*Medium Sensitivity Target*)	Medium
		Slope works during construction phase Slope cutting to facilitate road works during construction phase. (*LowSensitivity Target*)	Low
		Piling works during construction phase Piling works for proposed noise barriers / enclosures and flyover during construction phase. (*Low Sensitivity Target*)	Low
		Maintenance of services / utilities during operational phase Manholes or inspection chambers of services / utilities during operational phase. (*Medium Sensitivity Target*)	Medium

Table 4.3 Qualitative Source-Pathway Target Analysis of proposed road improvement works in the proximity to Ma Yau Tong Central Landfill

Source	Pathway	Target Sensitivity	Risk
Ma Yau Tong Central Landfill was closed in 1986. The restoration programme includes LFG management to reduce the potential safety and health risks. Gas monitoring is conducted on a regular basis. Methane, carbon dioxide and oxygen concentrations are monitored within monitoring wells installed within and outside the boundary of the landfill. No methane has been detected at the monitoring wells installed along the boundary of the landfill in the vicinity of the proposed development. The carbon dioxide levels varied from 0.0% to <1.5% (with unknown background level) at 11 of the monitoring wells. Taking into account the zero level of methane and that gas control (such as vents and barriers) to prevent gas migration has been installed at the landfill; MYTC landfill is considered a Medium source. (***Medium Source***)	**Natural Pathways** The proposed development is within 5m of the landfill boundary in certain sections. Therefore the natural pathways for MYTC Landfill is classified as Very Short/Direct. (***Very Short/Direct***))	**Excavation for proposed works during construction phase** Excavation for construction of foundation works, earth retaining structures, road works, drainage, sewerage, water works, etc. during construction phase. (*Medium Sensitivity Target*)	Medium
		Slope works during construction phase Slope cutting to facilitate road works during construction phase. (*Low Sensitivity Target*)	Low
		Piling works during construction phase Piling works for proposed noise barriers / enclosures and flyover during construction phase. (*Low Sensitivity Target*)	Low
		Maintenance of services / utilities during operational phase Manholes or inspection chambers of services / utilities during operational phase. (*Medium Sensitivity Target*)	Medium
	Man-Made Pathways There are no utilities or services directly linking between MYTC Landfill and the proposed road improvement works. The proposed development is within 5m of the landfill boundary in certain sections. Therefore the man-made pathways for MYTC Landfill are classified as Very Short/Direct. (***Very Short/Direct***)	**Excavation for proposed works during construction phase** Excavation for construction of foundation works, earth retaining structures, road works, drainage, sewerage, water works, etc. during construction phase. (*Medium Sensitivity Target*)	Medium
		Slope works during construction phase Slope cutting to facilitate road works during construction phase. (*Low Sensitivity Target*)	Low
		Piling works during construction phase Piling works for proposed noise barriers / enclosures and flyover during construction phase. (*Low Sensitivity Target*)	Low
		Maintenance of services / utilities during operational phase Manholes or inspection chambers of services / utilities during operational phase. (*Medium Sensitivity Target*)	Medium

4.6 Site Categorization

4.6.1 According to Landfill Gas Hazard Assessment Guidance Note (EPD/TR8/97), for the purpose of categorising a subject site, the category is based on the highest level of risk nominated for any of the potential impacts identified. For example, a subject site with four low risks and one medium risk will fall into the category of medium level of risk; and a site with four low risks, two medium risks, and one high risk will fall into the category of high level of risk. However, if four or more different impacts arise in a particular risk category, then the overall risk classification may be considered to be one category higher. For instance, a site with three low risks and four medium risks will fall into the category of high level of risk.

4.6.2 Referring to **Table 4.1** to **Table 4.3**, the overall hazard level for the proposed project associated with JVL, MYTW and MYTC Landfills is **Medium** for each of the three areas.

4.6.3 In accordance with the EPD's guidance note, some precautionary measures are required to protect a proposed area of medium or high level of risk. Some recommendations for protection measures for the proposed project (during the construction phase and operation phase) are provided and are presented in the following section.

4.6.4 The general implications and generic precautionary measures for mitigation of the perceived risks as recommended in the Guidance Note are summarized in **Table 4.4** . Details of the precautionary measures are provided in **Section 5**.

Table 4.4 Summary of the Implication and Generic Protection / Precautionary Measures

Category	Level of Risk	Implication	Generic Protection / Precautionary Measures
C	Medium	Engineering measures will be required to protect the proposed development.	Use of 'semi active' or enhanced passive gas controls eg wind driven cowls and other devices which assist in the ventilation of gas but do not rely on electrically powered fans. Detection systems in some situations.
D	Low	Some precautionary measures will be required to ensure that the planned development is safe.	Passive control of gas only such as provision of barriers to the movement of gas eg. membranes in floors or walls, or in trenches, coupled with high permeability vents such as no-fines gravel in trenches or voids/permeable layers below structures

5 RECOMMENDED PRECAUTIONARY MEASURES FOR CONSTRUCTION PHASE AND OPERATIONAL PHASE

5.1 General

5.1.1 An overall Medium level of risk is derived for the construction stage. General precautionary measures in terms of safety procedures and sensible housekeeping practices are recommended to minimize risk.

5.1.2 Contractors shall note the possible presence of landfill gas in the ground (even if it is unlikely) and shall take this into account in the design, construction of the proposed works.

5.1.3 A Safety Officer or an appropriately qualified person, trained in the use of gas detection equipment, landfill gas related hazards and the appropriate actions to take in the event of adverse circumstances, shall be present on site throughout the works, in particular, when works are undertaken below ground.

5.1.4 The contractor shall take cognizance of the presence of surface water and leachate management system and landfill gas management systems near the proposed works area. The contractor shall take all reasonable care to avoid any damage, loss, injury, interruption or impairment of the integrity of the landfill facilities within the works limits, storage area and across road area. The contractor shall also liaise and seek EPD and their landfill contractor – Hong Kong Landfill Restoration Group Limited (HKLRG) agreement on site arrangement before carrying out the proposed work.

5.2 Recommended Safety Measures during Construction

5.2.1 The contractor shall be aware of, and inform all workers accordingly, that methane and carbon dioxide is always likely to be present in the soil voids.

5.2.2 All personnel working on site and all visitors to the site be informed of the nearby landfill site and the possibility of landfill gas in the vicinity of the proposed works area. Safety warning notices shall be posted.

5.2.3 No worker shall be allowed to work alone at any time inside the trenches or joint bays or near to any excavation. At least one other worker shall be available to assist in a rescue in an emergency case.

5.2.4 Smoking and naked flames shall be strictly prohibited within the site or confined space if any. ‘No Smoking’ and ‘No Naked Flame’ notices shall be posted prominently at the site entrance and other conspicuous locations.

5.2.5 All electrical equipment, such as motors and extension cords, shall be intrinsically safe.

5.2.6 Adequate safely equipment shall be available at all times. This includes but is not limited to fire extinguishing equipment, breathing apparatus and personal protective equipment.

5.2.7 In the event of working inside a confined space is required, sufficient approved resuscitation equipment, breathing apparatus and safety torches shall be available. Persons involved in or supervising such work shall be trained and practiced for the use of such equipment. A permit-to-work system for entry into confined space shall be established by an approved qualified person and consistently enforced. All relevant Ordinances, Legislations, Guidelines and Codes of Practice pertaining to work in confined space must be strictly adhered to.

5.3 Landfill Gas Monitoring

5.3.1 The works area shall be monitored periodically during construction for the presence of methane, carbon dioxide and oxygen using gas detection equipment. The gas detection equipment shall be an intrinsically safe portable instrument, appropriately calibrated and capable of measuring the following gases in the ranges indicated below:

- Methane 0 – 100% LEL and 0 – 100% v/v;
- Carbon dioxide 0 – 100%; and
- Oxygen 0 – 21%.

5.3.2 During construction, monitoring of excavations shall be undertaken as follows:

For excavation deeper than 1 m, measurements shall be made:

- At the ground surface before excavation commences;
- Immediately before any worker enters an excavation;
- At the beginning of each working day for the entire period the excavation remains open; and
- Periodically through the working day whilst workers are in the excavation.

For excavation between 300 mm and 1 m deep, measurements shall be made:

- Directly after the excavation has been completed; and
- Periodically whilst the excavation remains open.

For excavation less than 300 mm, monitoring may be omitted at the discretion of the Safety Officer or other appropriate qualified person.

5.3.3 The monitoring frequency and area to be monitored shall be set down prior to commencement of ground works either by the Safety Officer or by an appropriately qualified person.

5.3.4 Monitoring should be undertaken by the Safety Officer or by an appropriately qualified person. The monitoring results shall be recorded and kept on site and shall be readily available at all times for inspection by the relevant authority.

Actions in the Event of Gas Being Detected During the Construction Phase

5.3.5 Depending upon the results of measurements, actions will vary. Actions shall be set down by the Safety Officer or other appropriately qualified person prior to commencement of occupancy of the proposed works area. As a minimum these shall encompass those actions specified in **Table 5.1**.

Table 5.1 Actions in the Event of Gas Being Detected During Construction Phase

Parameter	Measurement	Action
Oxygen (O_2)	< 19%	Ventilate to restore O_2 to >19%
	< 18%	• Stop works • Evacuate personnel / prohibit entry • Increase ventilation to restore O_2 to > 19%
Methane (CH_4)	> 10% LEL	• Post 'No Smoking' signs • Prohibit hot works • Ventilate to restore $CH_4$to < 10% LEL
	> 20% LEL	• Stop works • Evacuate personnel / prohibit entry • Increase ventilation to restore CH_4 to < 10% LEL
Carbon Dioxide (CO_2)	> 0.5%	• Ventilate to restore CO_2 to < 0.5%
	> 1.5%	• Stop works • Evacuate personnel / prohibit entry • Increase ventilation to restore $CO_2$to < 0.5%

Notes: Sources: Landfill Gas Hazard Assessment Guidance Note
LEL: Lower Explosive Limit

5.4 Safety Measures during Operation

5.4.1 Precautionary measures as listed below are recommended for implementation during operational phase:

5.4.2 As this project is primarily a road and drainage improvement scheme with no involvement of any building structure, the main precautionary measures during the operational phase relate to inspection or maintenance of buried utilities / services within the 250m LFG Consultation Zone.

5.4.3 The presence of landfill gas should be assumed at all times by maintenance workers. All maintenance workers inspecting any manhole should be fully trained in the issue of landfill gas hazard. Any manhole which is large enough to permit to access to personnel should be subject to safe entry procedures; work in confined spaces is controlled by the Factories and Industrial Undertakings (Confined Spaces) Regulations of the Factories and Industrial Undertakings Ordinance. Following the Code of Practice on Safety and Health at Work in Confined Spaces (Labour Department, Hong Kong) maintains compliance with the above regulations. A strictly regulated "work permit procedure" should be implemented and the relevant safety procedures must be rigidly followed. Adequate communication with maintenance staff should be maintained with respect to landfill gas hazard;

5.4.4 Utility companies should undertake a landfill gas surveillance exercise at the utility manholes/inspection chambers. The surveillance exercise shall be:

(i) Undertaken using an intrinsically safe portable instrument, appropriately calibrated and capable of measuring the following gases in the ranges indicated:

- Methane 0 – 100% LEL and 0 – 100% v/v;
- Carbon dioxide 0 – 100%; and
- Oxygen 0 – 21%.

(ii) Undertaken for the duration of the site occupancy, or until such time that EPD agree that surveillance is no longer required;

Actions in the Event of Gas Being Detected During the Operational Phase

5.4.5 Depending on the results of the measurements, actions required will vary and should be set down by appropriately qualified person. As a minimum these shall encompass those actions specified in **Table 5.2**.

Table 5.2 Actions in the Event of Gas Being Detected During Operational Phase

Parameter	Measurement	Action
Oxygen (O_2)	< 19%	Ventilate to restore O_2 to >19%
	< 18%	• Stop works • Evacuate personnel / prohibit entry • Increase ventilation to restore O_2 to > 19%
Methane (CH_4)	> 10% LEL	• Post 'No Smoking' signs • Prohibit hot works • Ventilate to restore $CH_4$to < 10% LEL
	> 20% LEL	• Stop works • Evacuate personnel / prohibit entry • Increase ventilation to restore CH_4 to < 10% LEL
Carbon Dioxide (CO_2)	> 0.5%	• Ventilate to restore CO_2 to < 0.5%
	> 1.5%	• Stop works • Evacuate personnel / prohibit entry • Increase ventilation to restore $CO_2$to < 0.5%

6 CONCLUSION

6.1.1 The proposed road improvement works at Shun Lee Tsuen Road fall within the 250 m Consultation Zone of the closed Jordan Valley Landfill. The proposed road improvement works at Lin Tak Road Widening/Lin Tak Road Flyover falls within the 250m Consultation Zone of the closed Ma Yau Tong Central and Ma Yau Tong West Landfills. A Landfill Gas Hazard Assessment has been conducted to qualitatively assess potential risk associated with Landfill gas and hazard to the proposed works.

6.1.2 The Source-Pathway-Target analysis of Jordan Valley Landfill and the proposed works indicated a medium source with a very short & direct pathway towards medium to low sensitivity targets resulting in an overall risk category of medium during the construction and operation stages.

6.1.3 The Source-Pathway-Target analysis of Ma Yau Tong West Landfill and the proposed works indicated a medium source with a very short & direct pathway towards medium to low sensitivity targets resulting in an overall risk category of medium during the construction and operation stages.

6.1.4 The Source-Pathway-Target analysis of Ma Yau Tong Central Landfill and the proposed works indicated a medium source with a very short & direct pathway towards medium to low sensitivity targets resulting in an overall risk category of medium during the construction and operation stages.

6.1.5 Mitigation measures in terms of general precautionary measures, safety procedures and sensible housekeeping practices are recommended to minimize the perceived risks.

7 REFERENCES

(i) Black & Veatch (2007) Cable Route for Cutting 2 Existing 132kV Cable Circuits in and out of Junk Bay Road Substation: Landfill Gas Hazard Assessment Report.

(ii) Environmental Protection Department (1996) ProPECC PN 3/96 – Landfill Gas Hazard Assessment for Developments adjacent to Landfills.

(iii) Environmental Protection Department (1996) Landfill Gas Hazard Assessment Guidance Note (EPD/TR8/97).

(iv) ERM (2004) Junk Bay Road Substation: Qualitative Landfill Gas Hazard Assessment.

(v) Hong Kong Geological Survey map, Sheet 11, Series HGM20 Edition 1- 1986 (scale 1:20,000) (published by Geotechnical Control Office in 1986)

(vi) Legislative Council of the Hong Kong Special Administration Region of the Peoples Republic of China (June 2003), Note for public works subcommittee of finance committee, Supplementary information on 45DR – Restoration of Pillar Point Valley Landfill

(vii) PBA Ltd. (2007) Design and Construction of No-dig Works at Junk Bay Road Substation on NKIL No. 5471: Landfill Gas Hazard Assessment Report.

FIGURES

ISO A1 594mm x 841mm

Approved:

Checked:

Designer:

Project Management Initials:

840800 E

842000 E

821600 N

820400 N

820200 N

CLOSED JORDAN VALLEY LANDFILL

CLOSED MA YAU TONG WEST LANDFILL

CLOSED MA YAU TONG CENTRAL LANDFILL

NEW CLEAR WATER BAY ROAD

CLEAR WATER BAY ROAD

ANDERSON ROAD

SAU MAU PING ROAD

TSEUNG KWAN O ROAD

TSEUNG KWAN O TUNNEL

LIN TAK ROAD

KWUN TONG ROAD

KWUN TONG BYPASS

PO LAM ROAD

WAI YIP STREET

JORDAN VALLEY

KOWLOON BAY

NGAU TAU KOK

CROCODILE HILL

KWUN TONG

SAU MAU PING

TAI SHAN

SAM LONG

TAI NGAU WU

TSUI LAM

NG KWAI SHAN

LAM TIN

Kwun Tong Typhoon Shelter

LEGEND:

- ROAD IMPROVEMENT WORKS (SHUN LEE TSUEN ROAD)
- ROAD IMPROVEMENT WORKS (CLEAR WATER BAY ROAD)
- ROAD IMPROVEMENT WORKS (LIN TAK ROAD WIDENING/ LIN TAK ROAD FLYOVER)
- 250M CONSULTATION ZONE BOUNDARY
- CLOSED LANDFILL
- CONSULTATION ZONE

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PROJECT
項目

DEVELOPMENT OF ANDERSON ROAD QUARRY SITE - INVESTIGATION, DESIGN AND CONSTRUCTION

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業主

土木工程拓展署
Civil Engineering and Development Department

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STATUS
階段

SCALE 比例
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DIMENSION UNIT 尺寸單位
METRES

KEY PLAN
索引圖

PROJECT NO. 項目編號
60328348

CONTRACT NO. 合約編號
CE 10/2014 (CE)

SHEET TITLE
圖紙名稱

LOCATIONS OF PREVIOUS LANDFILLS AND PROPOSED SITE BOUNDARY

SHEET NUMBER
圖紙編號

60328348/LGHAR/FIGURE 1.1

Plot File by: ZHILZ 2015/6/9
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ISO A1 594mm x 841mm

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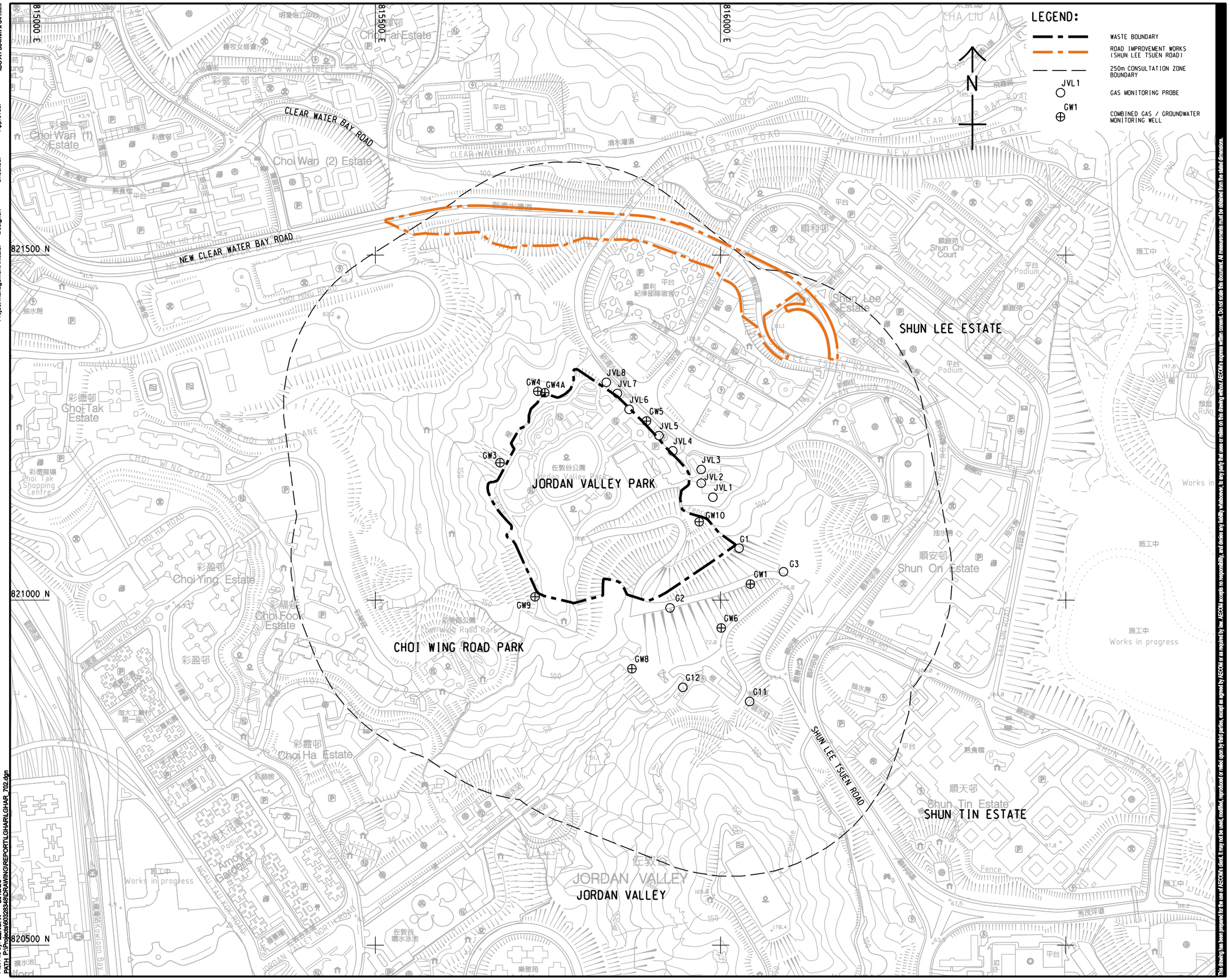
Checked:

Designer:

Project Management Initials:



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AECOM

PROJECT
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DEVELOPMENT OF ANDERSON ROAD QUARRY SITE - INVESTIGATION, DESIGN AND CONSTRUCTION

CLIENT
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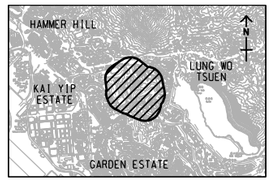

PROJECT NO. 項目編號
60328348

CONTRACT NO. 合約編號
CE 10/2014 (CE)

SHEET TITLE 圖紙名稱
LOCATION OF GAS AND GROUNDWATER MONITORING WELLS OF PREVIOUS JORDAN VALLEY LANDFILL

SHEET NUMBER 圖紙編號
60328348/LGHAR/FIGURE 3.1

ISO A1 594mm x 841mm

Approved:

Checked:

Designer:

Project Management Initials:

842500 E

843000 E

843500 E

820000 N

819500 N

819000 N

N

LEGEND:

- WASTE BOUNDARY
- ROAD IMPROVEMENT WORKS (LIN TAK ROAD WIDENING/ LIN TAK ROAD FLYOVER)
- CONSALTATION ZONE BOUONDARY
- G5 — GAS MONITORING PROBE
- GW1 — COMBINED GAS / GROUNDWATER MONITORING WELL

PO TAT ESTATE

SAU MAU PING SOUTH ESTATE

TSEUNG KWAN O TUNNEL

HING TIN ESTATE

TSEUNG KWAN O ROAD

LIN TAK ROAD

ST. EDWARD'S CATHOLIC PRIMARY SCHOOL

LAM TIN ESTATE

LAM TIN PARK

PREVIOUS MA YAU TONG CENTRAL LANDFILL

NG KWAI SHAN

CHUI LING ROAD

GW1 GW3 GW4 GW5 GW6 GW7 GW8 GW9 GW10 GW11

G1 G2 G5

GP2 GP3

AECOM

PROJECT 項目

DEVELOPMENT OF ANDERSON ROAD QUARRY SITE - INVESTIGATION, DESIGN AND CONSTRUCTION

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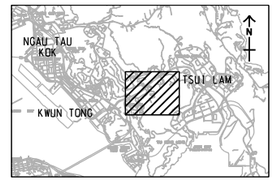

PROJECT NO. 項目編號 60328348

CONTRACT NO. 合約編號 CE 10/2014 (CE)

SHEET TITLE 圖紙名稱

LOCATION OF GAS AND GROUNDWATER MONITORING WELLS OF PREVIOUS MA YAU TONG CENTRAL LANDFILL

SHEET NUMBER 圖紙編號

60328348/LGHAR/FIGURE 3.2

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ISO A1 594mm x 841mm

Approved:

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Designer:

Project Management Initials:

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842500 E

843000 E

820000 N

819500 N

819000 N

LEGEND:

WASTE BOUNDARY

ROAD IMPROVEMENT WORKS (LIN TAK ROAD WIDENING/ LIN TAK ROAD FLYOVER)

CONSALTATION ZONE BOUONDARY

GW1 COMBINED GAS/GROUNDWATER MONITORING WELL

G5 GAS MONITORING PROBE

N

PO TAT ESTATE

SAU MAU PING SOUTH ESTATE

PREVIOUS MA YAU TONG WEST LANDFILL

HING TIN ESTATE

LAM TIN ESTATE

LAM TIN PARK

NG KWAI SHAN

ST. EDWARD'S CATHOLIC PRIMARY SCHOOL

TSEUNG KWAN O ROAD

LIN TAK ROAD

TSEUNG KWAN O TUNNEL

GW1 GW2 GW3 GW4 GW5 GW6 GW7

G1 G4 G5

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狀態

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DIMENSION UNIT 尺寸單位
METRES

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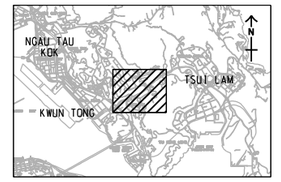

PROJECT NO. 項目編號
60328348

CONTRACT NO. 合約編號
CE 10/2014 (CE)

SHEET TITLE 圖紙名稱

LOCATION OF GAS AND GROUNDWATER MONITORING WELLS OF PREVIOUS MA YAU TONG WEST LANDFILL

SHEET NUMBER 圖紙編號

60328348/LGHAR/FIGURE 3.3

Appendix A
Practice Note for Professional Persons: Landfill Gas Hazard Assessment for Developments adjacent to Landfills (ProPECC PN 3/96)

ENVIRONMENTAL PROTECTION DEPARTMENT
PRACTICE NOTE FOR PROFESSIONAL PERSONS

Landfill Gas Hazard Assessment for Developments adjacent to Landfills

Introduction

Landfill gas is a generic term used to describe the mixture of gaseous product generated as a result of the waste decomposition in landfills. It is both flammable and asphyxiating, and, as a consequence, it has the potential to cause fire, explosion or asphyxiation. In view of the very nature of landfill gas, it might pose potential hazards to developments adjacent to these landfills. It is prudent, therefore, that special attention be given in respect of the developments adjacent to landfills to ensure that their intended uses are safe. Further information on landfill gas in terms of its characteristics, its generation and movement as well as its hazards are presented in **Appendix I**.

2. The potential hazards of landfill gas and the need for protection measures for developments adjacent to landfills in the Territory have been outlined in section 6.5 of Chapter 9 of the Hong Kong Planning Standards and Guidelines (HKPSG). In line with the advice in the HKPSG, the Environmental Protection Department (EPD) has been requiring, by administrative means, project proponents of relevant developments to carry out a landfill gas hazard assessment and to submit a report on the findings to the EPD for vetting. This requirement is usually incorporated through the landuse planning process, either as conditions of planning permissions, or as special conditions in relevant land-title documents. Based on the experience gained to date, this Practice Note is intended to provide project proponents with specific guidelines for developments adjacent to landfills in the Territory.

3. The objectives of this Practice Note are :

(i) to set out the conditions under which a landfill gas hazard assessment may be required;

(ii) to provide some general guidelines on how a proper landfill gas hazard assessment should be conducted; and

(iii) to outline some typical protection measures that are commonly adopted for protection of developments adjacent to landfills.

For the purposes of assessing the degree of risk associated with developments adjacent to landfills, the landfill gas hazard assessment outlined in this Practice Note will only focus on the safety hazards such as fire and explosion. The potential health hazards associated with landfill gas are beyond the scope of this Practice Note.

Consultation Zone

4. It has been a common approach in many countries to designate a zone around a landfill, within which if development is proposed, the relevant authorities will need to be consulted. This is to ensure that the potential hazards associated with landfill gas are properly considered for developments adjacent to landfills. For similar purpose, a Consultation Zone around each of the landfills in the Territory has been established. There are in total 16 landfills in the Territory and their locations are shown in the appended plan. The Consultation Zone represents the area of land surrounding the landfill boundary as defined by a line running parallel to and 250 m away from the edge of the waste if this can be identified or, if not, the recognized landfill site boundary. Detailed plans delineating such a Consultation Zone for each of the landfills are kept by the EPD and are available for inspection. The extent of the Consultation Zone was established by making reference to international practices and taking into account the local conditions in Hong Kong.

5. It is advisable that the professional persons, who are involved in any development or re-development projects falling in whole or in part within the Consultation Zones, should give attention to the procedures, requirements and guidelines set out below so that the potential hazards associated with landfill gas for the proposed development can be minimized or avoided at an early stage. In this context, the term "development" has the same meaning as that in the Town Planning Ordinance, i.e. "carrying out building, engineering, mining or other operations in, on, over or under land, or making a material change in the use of land or buildings".

Role of the Professional Person

6. If a proposed development is identified to be within a Consultation Zone, the project proponent or professional person responsible for the development is generally required to carry out a landfill gas hazard assessment and submit the report to the EPD for vetting. It should be emphasized, however, that this requirement is not to be applied indiscriminately with no exception. In situations where certain types of developments are

evidenced to have a very low sensitivity to landfill gas impacts, the requirement for the hazard assessment in these instances might be waived even though the proposed developments fall within the Consultation Zones. On the other hand, in some particular exceptional circumstances, a landfill gas hazard assessment might be required despite the proposed developments are located outside the Consultation Zones. These mainly refer to situations where the physical setting between a landfill and the proposed site is identified to have distinct geological features (e.g. fault lines and lineaments) or predominant artificial buried structures (e.g. utility tunnels and conduits) and that these will act as the preferential pathways for gas migration. Such exceptional circumstances might warrant a landfill gas hazard assessment to be carried out to ensure the safety of the proposed development. If the need for a landfill gas hazard assessment is in doubt, advice can be sought from the EPD.

7. When the need for a landfill gas hazard assessment is confirmed, the project proponents and professional persons responsible for the proposed developments or re-developments should :

(i) carry out a landfill gas hazard assessment to evaluate the degree of risk associated with the proposed development;

(ii) design suitable precautionary/protection measures to render the proposed development as safe as reasonably practicable;

(iii) ensure that the precautionary/protection measures will be implemented and constructed in accordance with the design; and

(iv) establish a maintenance and monitoring programme for ensuring the continued performance of the implemented protection measures.

For planning purposes, the proposed buildings and structures should generally be sited at least 10 m away from the edge of the waste in a landfill.

8. The landfill gas hazard assessment should be carried out and completed for submission to the EPD for vetting at the early planning stage of the project. The early completion of the assessment study will ensure that the identified protection measures be considered and incorporated into the overall design process for the proposed development.

Landfill Gas Hazard Assessment

9. In general, a landfill gas hazard assessment entails two main components

comprising a qualitative risk assessment and the design of precautionary/protection measures. Specifically, a proper assessment should include, but is not limited to, the following steps:

(i) review of background information pertaining to the landfill(s) that might have potential impacts on the proposed development (e.g. landfill site history, waste type and age, geological and hydrogeological data and environmental monitoring data);

(ii) evaluation of the nature and extent of the sources, including the likely concentrations and/ or amounts of hazardous emissions which might have the potential for impacts on the proposed development;

(iii) identification of the possible pathways through the ground, underground cavities, utilities and ground water, and the nature of these pathways through which the hazardous emissions must traverse if they were to reach the proposed development;

(iv) identification of the potential targets associated with the proposed development which are sensitive to the impacts of the hazardous emissions (e.g. building basements, underground car parks, unventilated excavations and any other confined spaces);

(v) assessment of the degree of risk which the hazardous emissions may pose to the sensitive targets for each possible source-pathway-target combination, using a qualitative technique;

(vi) formulation of suitable precautionary measures for the safe construction of the proposed development and suitable protection measures for its safe intended use; and

(vii) identification of monitoring requirement for assessing the adequacy and performance of the implemented protection measures.

10. As assessing the degree of risk and designing the appropriate protection measures require special expertise, it is advised that experienced professional persons who have the sound knowledge and experience in this particular field should be engaged for the above-discussed hazard assessment study.

Landfill Gas Protection Measures

11. A wide range of protection measures is available for protection of developments against landfill gas hazards. However, they can be broadly classified as either passive control systems or active control systems. These may include, but are not limited to, the following :

Passive Control Systems :

- passive trench vents or well vents in the ground;
- physical barriers in the ground;
- passive ventilation (vents) systems beneath the building floor; and
- physical barriers beneath or inside the building floor.

Active Control Systems :

- active trench vents or well vents in the ground; and
- active ventilation (vents) systems beneath the building floor.

12. The selection of an appropriate protection measure is site-specific, and is dependent on the degree of risk identified for the proposed development. In some cases, it may be necessary to adopt a combination of protection measures under either or both of the passive and active control systems. A brief description of these protection measures is presented in **Appendix II**.

13. Landfill gas hazards that may arise during the construction phase should not be overlooked. To ensure safe construction of the development, precautionary measures should be clearly laid down and adhered to with respect to, for example, welding and flame-cutting, trenching and excavation as well as creation of confined spaces at, near to or below ground. Periodic monitoring should also be carried out at all works areas, particularly in all excavations and confined spaces created on site.

Advice from the Environmental Protection Department

14. The Environmental Protection Department is presently preparing a Guidance

Note which will provide more detailed guidelines for carrying out the qualitative risk assessment and designing the appropriate protection measures against landfill gas hazards for developments adjacent to landfills. In parallel, the EPD is also developing an electronic database which shall contain information including environmental monitoring data for landfill gas, leachate and groundwater for each of the landfills in the Territory. To facilitate the project proponents in carrying out the landfill gas hazard assessment, access to the Guidance Note as well as the database will be made available to the project proponents when they are completed. Enquiries for further information and specific advice on landfill gas hazard issues can be addressed to: Facilities Development Group, Environmental Protection Department (Attention Mr. Andy King, Telephone No. 2835 1177, Faxline No. 2591 6662).

(Robert J.S. Law)
Director of Environmental Protection

Environmental Protection Department
28/F Southorn Centre
130 Hennessy Road
Wan Chai

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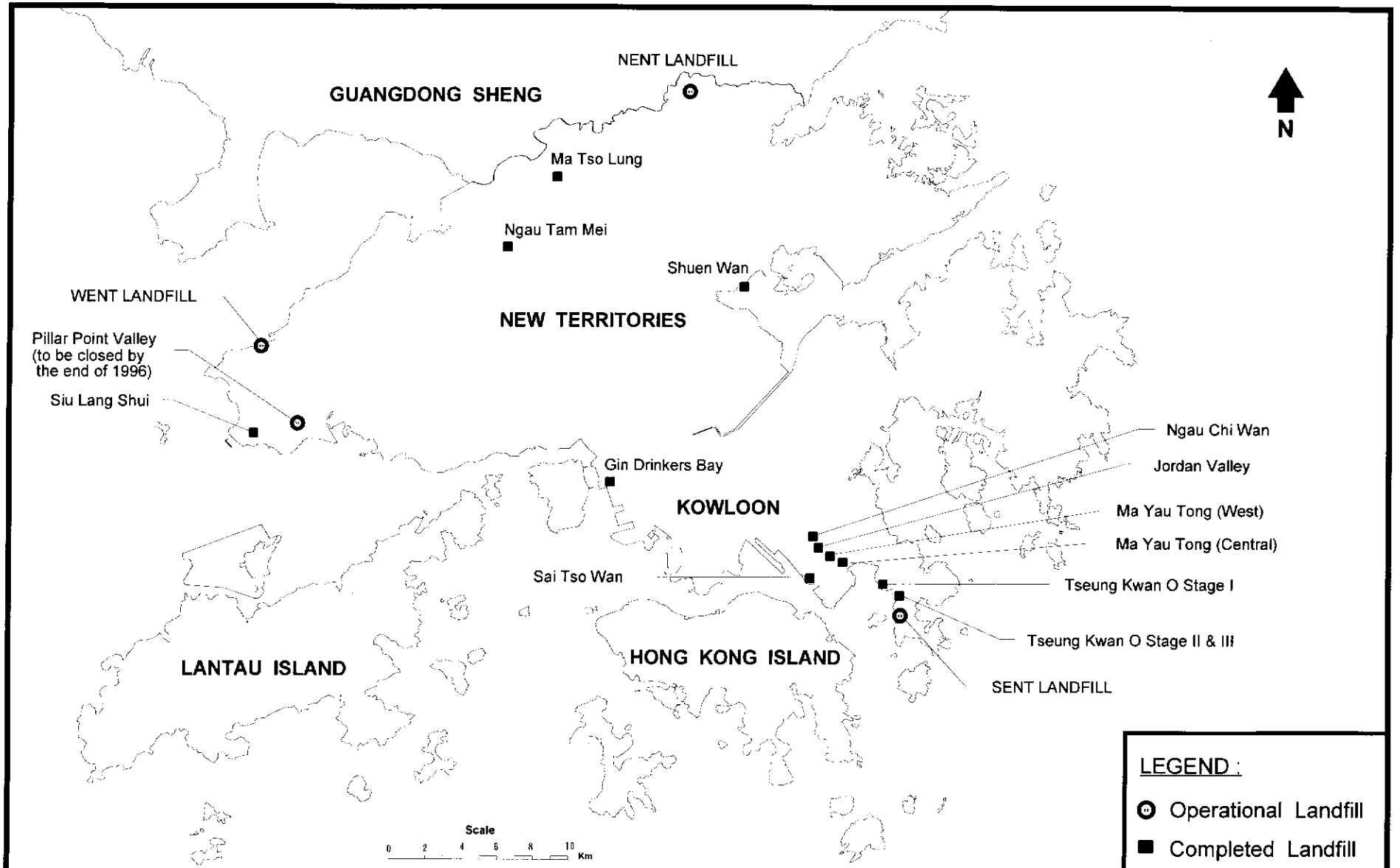

Location of Landfills

Environmental Protection Department

Background Information on Landfill Gas

(I) Landfill Gas Characteristics

Landfill gas is a generic term used to describe the mixture of gaseous by-product generated as a result of the waste decomposition. It consists principally of methane (about 60%) and carbon dioxide (about 35 %) as well as other low levels of compounds, including nitrogen, sulphides and organics. The actual composition of landfill gas varies, depending on the make-up of waste and the various stages of decomposition of waste.

Methane, which is colourless and odourless, is the constituent of most concern. It is highly flammable and can be explosive when all three of the following conditions are met :

(a) its concentration in air is between 5 to 15 % by volume (the Lower Explosive Limit (LEL) and Upper Explosive Limit (UEL), respectively) ;

(b) the gases are in a confined or semi-confined space; and

(c) a source of ignition is present.

Carbon dioxide is colourless, odourless and noncombustible. It is a constituent also of concern because, in the absence of oxygen, it can asphyxiate humans and animals.

(II) Landfill Gas Generation and Movement

Landfill gas is generated as a result of the biological decomposition of organic materials in landfills. In the initial stage of decomposition, waste begins to break down under the aerobic (in the presence of oxygen) condition, producing mainly carbon dioxide and water. As the oxygen is used up within the filled area, the process proceeds to anaerobic (absence of free oxygen) decomposition, where both methane and carbon dioxide are produced. Methane production from landfilled wastes normally reaches a maximum rate at about two years after placement and may continue at this rate for many years. This depends on such factors as waste composition, age, density, temperature and depth; the site operations practice; the position of the water/leachate level as well as local climate.

Landfill gas moves through the subsurface by convection and / or by diffusion. In general, convection is the predominant transport mechanism in dry, coarse-grained soil.

Whereas, in dry, fine-grained soil, diffusion is the likely governing mechanism. However, both convection and diffusion mechanisms will cease to operate when the migrating pathway through which landfill gas tends to move becomes fully saturated. It should be noted, however, that landfill gas may dissolve in and move along with groundwater and may subsequently be released from it.

(III) Landfill Gas Potential Hazards

Landfill gas generated at a landfill site has a tendency to migrate off site, potentially affecting the nearby buildings and structures. Landfill gas has the potential to cause explosion, fire or asphyxiation if it migrates into and accumulates in the confined spaces such as building basements, underground car parks, lift shafts, pumping stations and maintenance chambers. For the same reasons, temporary structures such as site huts and any other unventilated enclosures erected during construction are also exposed to landfill gas hazards. Underground services might also be susceptible to the potential hazards associated with landfill gas as they commonly form the preferential pathways for landfill gas. These include sewer drains, storm drains and service ducts.

Appendix II

Typical Landfill Gas Protection Measures

(I) The landfill gas protection measures should be designed to meet the following objectives :

(a) to prevent landfill gas from entering all buildings, services, ducts and confined air spaces;

(b) to ensure the development is safe for its intended purpose throughout the remaining gas producing lifetime of the landfill; and

(c) to be simple, robust and easy to maintain.

(II) There are a number of protection measures commonly adopted for protection of developments adjacent to landfills. These include both passive and active control systems :

Passive Control Systems :

(a) Passive Trench Vents or Well Vents in the Ground

Passive trench vents or well vents are control measures that provide an engineered escape route for landfill gas, and they are usually installed across the potential migration pathway at the site boundary. Trench vents usually consist of a granular backfilled trench with vertical vent pipes installed along the trench. Well vents are the special case of trench vents, and they are typically perforated piping installed vertically into pre-drilled boreholes with the top of the pipe extending above ground for venting.

(b) Physical Barriers in the Ground

Physical barriers basically comprise low-permeability barriers, which may be constructed of earth, soil bentonite, cement bentonite or geosynthetics, to impede the flow of gas. To ensure effective control of landfill gas, barriers are required to extend below the water table or keyed into a low-permeability zone. These systems are commonly constructed across the potential migration pathway to intercept and prevent migrating gas from entering the development.

(c) Passive Ventilation Systems beneath the Building Floor

Passive ventilation systems simply rely on natural air movements through the clear voids created below the structural slabs of buildings for venting of sub-slab gases. Alternatively, vents are installed within a gravel bedding placed beneath the buildings. These vents typically are connected to risers that ventilate sub-slab gases above the roof of buildings.

(d) Physical Barriers beneath or inside the Building Floor

These physical barriers typically consist of the low-permeability geomembranes incorporated into the building floor slabs to impede sub-slab gases from entering the buildings. Geomembranes such as high density polyethylene (HDPE) are commonly used in these applications because they have good resistance to chemical attack, good strength characteristics, and low gas permeabilities.

Active Control Systems :

(a) Active Trench Vents or Well Vents in the Ground

In these active systems, the trench vents or well vents are manifolded together such that either a negative pressure barrier or a positive pressure barrier can be created by applying a vacuum to the vents or by injecting air to the vents, respectively. Active vents either in the form of a continuous trench or a series of discrete wells are installed across the potential migration pathway at the site boundary to prevent migrating gas from entering the development.

(b) Active Ventilation Systems beneath the Building Floor

These active ventilation systems typically consist of vents placed in a gravel bedding directly beneath buildings. These vents commonly are connected to a blower or blowers which either apply a vacuum to extract sub-slab gases and then ventilate them through a riser or risers above the roof of the building, or inject air beneath the slab to provide a positive pressure barrier to impede sub-slab gases from entering the building.

Appendix B
Landfill Gas and Groundwater Monitoring Data

Table B.1 Methane Monitoring Data from Jordan Valley Landfill

Well/Probe		Jan '13	Feb '13	Mar '13	Apr '13	May '13	Jun '13	Jul '13	Aug '13	Sep '13	Oct '13	Nov '13	Dec '13	Jan '14	Feb '14	Mar '14	Apr '14	May '14	Jun '14	Jul '14	Aug '14	Sep '14	Oct '14	Nov '14	Dec '14	Jan '15	Feb '15
G1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G2		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G3	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G11	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G12	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW4		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW4A		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW8		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW9		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW10		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table B.2 Methane Monitoring Data from Ma Yau Tong West Landfill

Well/Probe		Jan '13	Feb '13	Mar '13	Apr '13	May '13	Jun '13	Jul '13	Aug '13	Sep '13	Oct '13	Nov '13	Dec '13	Jan '14	Feb '14	Mar '14	Apr '14	May '14	Jun '14	Jul '14	Aug '14	Sep '14	Oct '14	Nov '14	Dec '14	Jan '15	Feb '15
G1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G4	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G5	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW2		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW4		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW7		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table B.3 Methane Monitoring Data from Ma Yau Tong Central Landfill

Well/Probe		Jan '13	Feb '13	Mar '13	Apr '13	May '13	Jun '13	Jul '13	Aug '13	Sep '13	Oct '13	Nov '13	Dec '13	Jan '14	Feb '14	Mar '14	Apr '14	May '14	Jun '14	Jul '14	Aug '14	Sep '14	Oct '14	Nov '14	Dec '14	Jan '15	Feb '15
G1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G2	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP2		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GP3		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW4		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW7		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW8		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW9		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW10		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GW11		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table B.4 Carbon Dioxide Monitoring Data from Jordan Valley Landfill

Well/ Probe		Jan '13	Feb '13	Mar '13	Apr '13	May '13	Jun '13	Jul '13	Aug '13	Sep '13	Oct '13	Nov '13	Dec '13	Jan '14	Feb '14	Mar '14	Apr '14	May '14	Jun '14	Jul '14	Aug '14	Sep '14	Oct '14	Nov '14	Dec '14	Jan '15	Feb '15	Min	Max	Average	Range
G1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.1	0.1	0.1	0.2	0.0	0.2	0.0	0.0	0.0	0.2	0.3	0.2	0.1	0.1	0.0	0.3	0.1	0.0-0.3
G2		0.2	0.0	0.2	0.4	0.5	0.2	0.2	0.3	0.0	0.2	0.2	0.2	0.2	0.3	0.4	0.2	0.2	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.5	0.2	0.0-0.5
G3	**A**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.1	0.1	0.0	0.2	0.0	0.3	0.0	0.0-0.3
	B	0.4	0.4	0.8	0.7	0.5	0.4	0.3	0.4	0.4	0.4	0.2	0.4	0.5	0.6	0.5	0.5	0.7	0.3	0.7	0.8	0.3	0.0	0.0	0.0	0.3	0.7	0.0	0.8	0.4	0.0-0.8
	C	0.2	0.0	0.4	0.2	0.4	0.0	0.4	0.5	0.2	0.3	0.3	0.1	0.2	0.2	0.2	0.3	0.2	0.0	0.0	0.2	0.2	0.3	0.2	0.3	0.0	0.0	0.0	0.5	0.2	0.0-0.5
G11	**A**	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0-0.2
	B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0-0.3
G12	**A**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0-0.2
	B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0-0.2
GW1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.0-0.3
GW3		0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	0.0-0.4
GW4		0.6	0.2	0.0	0.0	0.0	0.7	0.0	0.8	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.2	0.0	0.0	0.0	0.4	0.0	0.0	0.8	0.2	0.0-0.8
GW4A		0.4	0.4	0.0	0.2	0.3	0.8	0.4	0.7	0.0	0.7	0.0	0.6	0.6	0.7	0.7	0.7	0.7	0.7	1.3	0.0	0.0	0.3	0.2	0.3	0.1	0.4	0.0	1.3	0.4	0.0-1.3
GW5		0.3	0.7	0.6	0.4	0.5	0.6	0.7	0.0	0.7	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.4	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.7	0.0	0.0	0.7	0.3	0.0-0.7
GW6		0.6	1.0	0.8	0.8	0.9	1.0	1.0	1.0	1.0	0.6	0.1	0.7	0.5	0.4	0.5	0.5	0.8	0.3	0.7	0.7	0.7	0.4	0.3	0.2	0.8	0.6	0.1	1.0	0.7	0.1-1.0
GW8		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.3	0.0	0.0	0.0	0.3	0.0	0.0-0.3
GW9		0.0	0.0	0.2	0.2	0.1	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.6	0.6	0.6	0.7	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.2	0.0-0.7
GW10		0.2	0.0	0.1	0.4	0.5	1.2	0.2	0.2	0.8	0.4	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.8	0.2	0.0	0.0	0.0	0.0	0.7	0.2	0.0	1.2	0.3	0.0-1.2

Table B.5 Carbon Dioxide Monitoring Data from Ma Yau Tong West Landfill

Well /Probe		Jan '13	Feb '13	Mar '13	Apr '13	May '13	Jun '13	Jul '13	Aug '13	Sep '13	Oct '13	Nov '13	Dec '13	Jan '14	Feb '14	Mar '14	Apr '14	May '14	Jun '14	Jul '14	Aug '14	Sep '14	Oct '14	Nov '14	Dec '14	Jan '15	Feb '15	Min	Max	Average	Range
G1		0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.0	0.6	0.1	0.0-0.6
G4	**A**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0
	B	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0-0.2
	C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0-0.1
G5	**A**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0-0.0
	B	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0-0.2
	C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0-0.1
GW1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0-0.2
GW2		0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.4	0.2	0.3	0.7	0.2	0.0	0.0	0.2	0.3	0.0	0.3	0.0	0.7	0.2	0.0-0.7
GW3		0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	0.5	0.4	0.5	0.2	0.0	0.7	0.1	0.0-0.7
GW4		0.0	0.1	0.0	0.2	0.4	0.0	0.0	0.2	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	0.0-0.4
GW5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.6	0.5	0.4	0.8	0.0	0.8	0.1	0.0-0.8
GW6		0.2	0.8	1.1	0.4	0.3	0.7	0.4	0.7	0.7	0.8	0.7	0.4	0.8	0.7	0.7	0.8	0.0	0.7	0.7	0.7	1.2	1.1	0.9	0.8	0.6	0.4	0.0	1.2	0.7	0.0-1.2
GW7		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.1	0.0-0.7

Table B.6 Carbon Dioxide Monitoring Data from Ma Yau Tong Central Landfill

Well/Probe		Jan '13	Feb '13	Mar '13	Apr '13	May '13	Jun '13	Jul '13	Aug '13	Sep '13	Oct '13	Nov '13	Dec '13	Jan '14	Feb '14	Mar '14	Apr '14	May '14	Jun '14	Jul '14	Aug '14	Sep '14	Oct '14	Nov '14	Dec '14	Jan '15	Feb '15	Min	Max	Average	Range
G1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.2	0.3	0.2	0.4	0.0	0.0	0.4	0.1	0.0-0.4
G2	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0-0.1
	B	0.9	0.2	0.2	0.5	0.8	0.7	0.0	0.7	0.8	0.4	0.1	0.5	0.3	0.4	0.7	0.4	0.6	0.8	0.7	0.7	0.7	0.4	0.3	0.2	0.1	0.6	0.0	0.9	0.5	0.0-0.9
	C	0.2	0.5	0.4	0.0	0.2	0.2	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.3	0.1	0.0	0.5	0.1	0.0-0.5
GP2		0.2	0.4	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.4	0.1	0.0-0.4
GP3		0.4	0.0	0.4	0.0	0.2	0.2	0.0	0.2	0.4	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.4	0.7	0.1	0.1	0.4	0.5	0.4	0.3	0.2	0.0	0.7	0.2	0.0-0.7
GW1		0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0-0.3
GW4		0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.3	0.2	0.0	0.0	0.7	0.1	0.0-0.7
GW5		0.0	0.0	0.0	0.4	0.0	0.3	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	0.1	0.0-0.4
GW6		0.8	0.8	0.7	0.7	0.7	1.4	0.3	0.8	0.7	0.6	0.0	0.7	0.7	0.8	0.7	0.7	0.7	0.8	0.7	0.7	1.0	0.7	0.6	0.5	0.4	0.8	0.0	1.4	0.7	0.0-1.4
GW7		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0-0.2
GW8		0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0-0.3
GW9		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	0.0-0.4
GW10		0.4	0.3	0.4	0.6	0.4	0.8	0.8	0.5	0.4	0.4	0.0	0.4	0.5	0.7	0.5	0.4	0.3	0.3	0.4	0.4	0.0	0.3	0.2	0.1	0.2	0.2	0.0	0.8	0.4	0.0-0.8
GW11		0.7	0.7	0.0	0.4	0.6	1.0	0.0	0.8	0.0	0.2	0.2	0.7	0.2	0.0	0.4	0.7	0.4	0.7	0.5	0.3	0.7	0.2	0.3	0.2	0.2	0.7	0.0	1.0	0.4	0.0-1.0

Table B.7 Groundwater Level Monitoring Results at Jordan Valley Landfill (Depth in meters)

Well	Well Head Level (mPD)	Mar '13	Sep '13	Mar '14	Sep '14	Average	Min	Max
GW1	78.79	10.30	10.00	12.14	12.11	**11.14**	**10.00**	**12.14**
GW3	125.07	3.74	5.74	5.00	5.00	**4.87**	**3.74**	**5.74**
GW4	131.50	5.62	5.56	5.46	4.77	**5.35**	**4.77**	**5.62**
GW4A	127.27	7.11	8.00	7.88	7.89	**7.72**	**7.11**	**8.00**
GW5	125.53	8.20	8.10	8.13	8.00	**8.11**	**8.00**	**8.20**
GW6	73.77	5.55	4.87	5.88	5.94	**5.56**	**4.87**	**5.94**
GW8	66.73	2.30	3.70	3.68	3.77	**3.36**	**2.30**	**3.77**
GW9	122.10	3.70	4.82	10.67	10.64	**7.46**	**3.70**	**10.67**
GW10	107.37	15.68	13.00	12.88	12.77	**13.58**	**12.77**	**15.68**

Table B.8 Groundwater Level Monitoring Results at Jordan Valley Landfill (Depth in mPD)

Well	Well Head Level (mPD)	Mar '13	Sep '13	Mar '14	Sep '14	Average	Min	Max
GW1	78.79	68.49	68.79	66.65	66.68	**67.65**	**66.65**	**68.79**
GW3	125.07	121.33	119.33	120.07	120.07	**120.20**	**119.33**	**121.33**
GW4	131.50	125.88	125.94	126.04	126.73	**126.15**	**125.88**	**126.73**
GW4A	127.27	120.16	119.27	119.39	119.38	**119.55**	**119.27**	**120.16**
GW5	125.53	117.33	117.43	117.40	117.53	**117.42**	**117.33**	**117.53**
GW6	73.77	68.22	68.90	67.89	67.83	**68.21**	**67.83**	**68.90**
GW8	66.73	64.49	63.03	63.05	62.96	**63.38**	**62.96**	**64.49**
GW9	122.10	118.40	117.28	111.43	111.46	**114.64**	**111.43**	**118.40**
GW10	107.37	91.89	94.37	94.49	94.60	**93.84**	**91.89**	**94.60**

Table B.9 Groundwater Level Monitoring Results at Ma Yau Tong West (Depth in meters)

Well	Well Head Level (mPD)	Mar '13	Sep '13	Mar '14	Sep '14	Average	Min	Max
GW1	71.50	2.37	N/A	N/A	N/A	**2.37**	**2.37**	**2.37**
GW2	62.63	4.90	4.62	3.96	4.63	**4.53**	**3.96**	**4.90**
GW3	25.88	4.80	N/A	4.00	N/A	**4.40**	**4.00**	**4.80**
GW4	52.69	4.37	3.00	3.74	3.71	**3.71**	**3.00**	**4.37**
GW5	52.02	11.30	7.94	7.43	7.39	**8.52**	**7.39**	**11.30**
GW6	32.26	17.65	14.30	14.28	14.23	**15.12**	**14.23**	**17.65**
GW7	52.56	11.80	7.88	8.66	8.64	**9.25**	**7.88**	**11.80**

Table B.10 Groundwater Level Monitoring Results at Ma Yau Tong West Landfill (Depth in mPD)

Well	Well Head Level (mPD)	Mar '13	Sep '13	Mar '14	Sep '14	Average	Min	Max
GW1	71.50	69.13	N/A	N/A	N/A	**69.13**	**69.13**	**69.13**
GW2	62.63	57.73	58.01	58.67	58.00	**58.10**	**57.73**	**58.67**
GW3	25.88	21.08	N/A	21.88	N/A	**21.48**	**21.08**	**21.88**
GW4	52.69	48.32	49.69	48.95	48.98	**48.99**	**48.32**	**49.69**
GW5	52.02	40.72	44.08	44.59	44.63	**43.51**	**40.72**	**44.63**
GW6	32.26	14.61	17.96	17.98	18.03	**17.15**	**14.61**	**18.03**
GW7	52.56	40.76	44.68	43.90	43.92	**43.32**	**40.76**	**44.68**

Table B.11 Groundwater Level Monitoring Results at Ma Yau Tong Central (Depth in meters)

Well	Well Head Level (mPD)	Mar '13	Sep '13	Mar '14	Sep '14	Average	Min	Max
GW1	193.70	8.00	7.84	7.90	6.47	**7.55**	**6.47**	**8.00**
GW4	116.71	13.24	13.30	13.30	13.60	**13.36**	**13.24**	**13.60**
GW6	164.60	16.02	14.67	14.62	15.76	**15.27**	**14.62**	**16.02**
GW7	186.80	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GW8	127.50	16.84	15.40	11.78	10.63	**13.66**	**10.63**	**16.84**
GW9	87.40	16.58	15.54	15.56	10.12	**14.45**	**10.12**	**16.58**
GW10	130.87	17.37	9.62	9.70	8.54	**11.31**	**8.54**	**17.37**
GW11	175.05	17.60	7.37	7.42	9.37	**10.44**	**7.37**	**17.60**

Table B.12 Groundwater Level Monitoring Results at Ma Yau Tong Central Landfill (Depth in mPD)

Well	Well Head Level (mPD)	Mar '13	Sep '13	Mar '14	Sep '14	Average	Min	Max
GW1	193.70	185.70	185.86	185.80	187.23	**186.15**	**185.70**	**187.23**
GW4	116.71	103.47	103.41	103.41	103.11	**103.35**	**103.11**	**103.47**
GW6	164.60	148.58	149.93	149.98	148.84	**149.33**	**148.58**	**149.98**
GW7	186.80	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GW8	127.50	110.66	112.10	115.72	116.87	**113.84**	**110.66**	**116.87**
GW9	87.40	70.82	71.86	71.84	77.28	**72.95**	**70.82**	**77.28**
GW10	130.87	113.50	121.25	121.17	122.33	**119.56**	**113.50**	**122.33**
GW11	175.05	157.45	167.68	167.63	165.68	**164.61**	**157.45**	**167.68**