Bromsberrow North Sandpit: Landfill Gas Risk Assessment

10 January 2024

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Prepared for

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Myers Road
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Report reference:

331201261R6, January 2024

Report status:

Final

CONFIDENTIAL

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Revision record:

Issue	Date	Status	Comment	Author	Checker	Reviewer
1	01/11/2022	Draft	First draft	SH	CB	-
2	30/10/2023	Draft	Second draft	SH	CW	-
3	10/01/2024	Final	Final issue	SH	CW	CB

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1 Introduction

1.1 Report Context

Stantec UK Ltd (Stantec) has been instructed by Allstone Sands Gravels Aggregates Trading Co. Ltd ('Allstone') to prepare an Environmental Permit (EP, or 'Permit') application for an inert landfill at Bromsberrow North Sandpit, Bell Lane, Bromsberrow Heath, Ledbury, Gloucestershire, HR8 1NX (the 'Site'). The Operator of the EP will be Allstone.

This report has been prepared for Allstone by Stantec to consider potential risks posed by landfill gas as part of a new application for an EP in relation to the Site. The EP applied for, in accordance with the Review of Old Mineral Permits (ROMP) application (Bromsberrow Sand and Gravel Company Limited, 2022), would allow the progressive infilling of the quarry void with approximately 670,000 m^3 of imported inert materials.

The area of proposed future infilling is shown on the quarry development plans included with the accompanying Environmental Setting and Site Design (ESSD) report (Stantec, 2024a).

Details of the proposed Site design are provided in the ESSD report; details of the proposed Site operation are provided in the Site Operating Plan (Stantec, 2024b).

For the purposes of this report, the 'Site' comprises the permitted area where deposition is to take place.

1.2 Approach

This landfill gas risk assessment has been prepared with reference to the Environment Agency (EA)'s gas risk assessment (GRA) template and EA Guidance (EA, 2004), which states that:

"For inert landfills, the landfill gas risk assessment will not normally have to progress beyond the risk screening stage. New inert landfills ought not to pose landfill gas hazard. The emphasis in the risk assessment should, therefore, be placed on the Waste Acceptance Procedures and particularly the waste characterisation and compliance monitoring measures introduced to ensure that only inert waste is deposited at the site. If these measures can be shown to be robust, then the landfill gas source should be demonstrably negligible. Provisions for the monitoring of gas within the waste body will normally be required at inert waste landfills."

Waste acceptance procedures are provided in the Site Operating Plan (Stantec, 2024b). Details of the landfill gas monitoring locations and programme are presented in the Environmental Monitoring Plan (Stantec, 2024c).

The aim of this landfill gas risk assessment is to provide the EA with sufficient detail in relation to the potential risks associated with landfill gas generation to establish:

i. That appropriate measures are proposed in order to control the accumulation and migration of landfill gas.

This landfill gas risk assessment is a standalone document that will form part of the Site's Environmental Management System (EMS).

1.3 Site Context

The Site is located in Bromsberrow Heath, Gloucestershire, approximately 4.5 km southwest of Ledbury and 7 km north of Newent, close to the village of Bromsberrow in Gloucestershire. The Site is centred approximately on National Grid Reference (NGR) SO 73896 33065 and covers an area of approximately 5 hectares (ha).

The general site location is shown in Figure 1.1. The EP application boundary is outlined in green in Figure 1.2.

Further details of the Site setting are provided in the ESSD report (Stantec, 2024a).

1.4 Conceptual Site Model (Landfill Gas)

1.4.1 Gas Source

Landfill gas is produced by the biological degradation of organic components. Mature landfill gas is a mixture of predominantly methane and carbon dioxide, and small amounts of hydrogen. It may also contain varying amounts of nitrogen and oxygen derived from air that has been drawn into the landfill. These are referred to as 'bulk gases' because they are often present at percentage concentrations. Landfill gas will also contain a wide variety of trace components, such as carbon monoxide and hydrogen sulphide.

The generation of landfill gas requires the presence of readily degradable organic material within the waste types accepted. Other factors controlling the rate of landfill gas generation include the moisture content, nature of degradable material, pH, method of landfilling (in particular, the degree of compaction) and any lining/capping layer installed.

For the purposes of this landfill gas risk assessment, the source is considered to be any landfill gas either generated from waste deposited at the Site or from background sources (e.g. nearby landfilled waste, natural soils with elevated organic carbon content or 'contaminated land').

The site has been an operating quarry for around 70 years at the time of writing, following the implementation of the original planning permissions granted in January and June 1953. The Site has previously and continues to be used for sand quarrying and is to be infilled and restored for conservation and amenity in phases.

The restoration scheme includes the construction of a 1m thick artificially enhanced geological barrier (AEGB) on the base and sidewalls of the excavation, which will be compacted to achieve a maximum permeability of $1x10^{-9}$ m/s. The AEGB will comprise clean imported clay (non-waste materials) and will be placed in accordance with appropriate Construction Quality Assurance (CQA). Further details of the AEGB are provided in the accompanying ESSD and hydrogeological risk assessment (HRA) (Stantec, 2024d).

A landfill for inert waste does not require an engineered cap, and no such cap is proposed. However, a layer (up to 0.5m thick) of imported topsoil will be placed above the completed waste mass to achieve the successful establishment of the planting proposed as part of the Site restoration, as described in the ESSD.

The full list of proposed permitted waste types is provided in the Site Operating Plan (Stantec, 2024b). It is proposed that the body of the fill will comprise inert waste types only; inert wastes are those that do not undergo any significant physical, chemical, or biological transformations.

Waste acceptance procedures, as detailed in the Site Operating Plan (Stantec, 2024b) have been developed to ensure that no material with a biodegradable content is accepted. The waste materials to be deposited at the Site will meet the inert waste acceptance criteria (WAC) limits and will therefore have a low organic content (total organic carbon less than 3% weight by weight, w/w).

Consequently, there will be negligible quantities of biodegradable matter within the fill, and the probability of it providing a significant source of landfill gas is very low. No gas extraction and utilisation systems are therefore proposed at the Site.

1.4.2 Pathways

For the purposes of this landfill gas risk assessment, pathways are defined as the processes or mechanisms by which landfill gas migrates from the source to a receptor.

Potential pathways are evaluated in Table 1.1.

Table 1.1. Pathway Evaluation

Potential pathway	Applicability	Discussion
Lateral migration	No	The restoration scheme will include the construction of a 1m thick AEGB on the base and sidewalls of the excavation, which will be compacted to achieve a maximum permeability of $1x10^{-9}$ m/s under CQA. The AEGB will comprise clean imported clay. The specification of an AEGB will minimise the lateral migration of any landfill gases beyond the installation boundaries. As discussed in Section 1.4.1, the generation of appreciable quantities of landfill gas is considered highly unlikely as a consequence of the proposed restoration.
Direct release to atmosphere	Yes	Given the presence of an AEGB on the base and sidewalls of the excavation, any landfill gases generated would most likely migrate upwards, venting to atmosphere above the application area, with subsequent dispersion controlled by the prevailing wind direction and speed. Once placed, the restoration soils will serve to reduce the potential for surface emissions of any methane generated by aerobic biodegradation. As discussed in Section 1.4.1, the generation of appreciable quantities of landfill gas is considered highly unlikely as a consequence of the proposed restoration.
Indirect release to atmosphere	No	Given the inert nature of the waste to be landfilled, the potential for leachate generation and subsequent indirect release of dissolved landfill gas to atmosphere is expected to be low.

Potential pathway	Applicability	Discussion
Direct release of combustion products to atmosphere	No	Given the inert nature of the waste to be landfilled, no landfill gas will be extracted or combusted.

Based on Table 1.1, landfill gas migration is likely to be limited to direct release to atmosphere, resulting from passive advective flow influenced primarily by fluctuations in atmospheric pressure. The generation of appreciable quantities of landfill gas is however considered highly unlikely as a consequence of the proposed restoration.

1.4.3 Receptors

Under Normal Site Operation

Due to both the negligible quantities of biodegradable matter within the fill and also the use of an AEGB across the base and sides of the restored area, no lateral migration of landfill gas is anticipated beyond the boundaries of the EP application area. As such, no linkages to off-site human health receptors have been identified under normal site operation.

Under Abnormal Conditions

Under abnormal conditions, such as a failure in the AEGB (i.e. loss of containment; see Section 2.2.2), there could be a potential linkage between any landfill gas generated on site and the identified receptors.

The receptors that may be at risk from landfill gas are evaluated in Table 1.2.

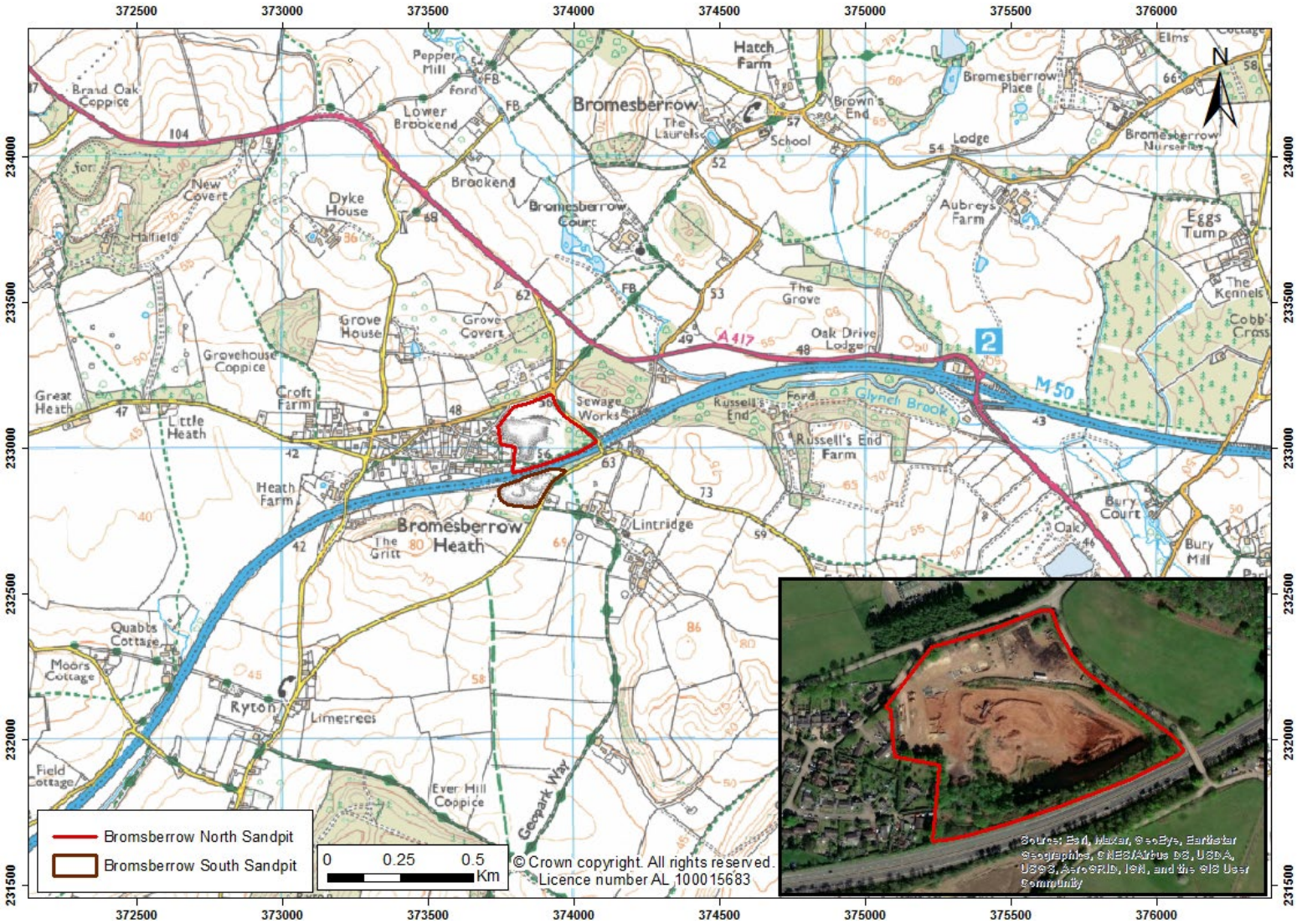
Table 1.2. Receptor Evaluation

Reference	Receptor	Applicability	Discussion
R1	Site workers and visitors	Yes	Direct releases to atmosphere have the potential to pose health risks to site occupants, including employees within the site office building and weighbridge plus any plant operatives.
R2	Residential properties (human occupation)	Yes	The nearest residential properties (<10m from Site boundary) are located off Bell Lane and Sandfields within the village of Bromsberrow Heath.
-	Hospitals	No	None marked within 1km of the Site.
-	Schools and colleges	No	None marked within 1km of the Site.

Reference	Receptor	Applicability	Discussion
R3	Offices, industrial units and commercial premises	Yes	The closest is the Severn Trent groundwater pumping station approximately 100m north of the Site.
-	Public open spaces and parks	No	None marked within 1km of the Site.
-	Allotments	No	None marked within 1km of the Site.
R4	Public footpaths and bridleways	Yes	A public footpath is marked along the southern Site boundary.
R5	Sensitive habitats and environmental areas	Yes	Bromsberrow High Bank Local Wildlife Site (LWS) located <10m from eastern Site boundary. Bromsberrow (M50) LWS <20m from eastern Site boundary. European Eel (Anguilla Anguilla) migratory route and Bullhead (Cottus Gobio) within 500m of eastern Site boundary. Vegetation cover across the restored landform may be susceptible to the effects of any landfill gas generated from the fill material.
R6	Major highways and minor roads	Yes	Beach Lane and Bell Lane are located to the immediate north of the Site. Wood End Street is located to the immediate east of the Site. The M50 motorway is located within 10m of the southern Site boundary.
R7	Farmland (e.g. crop damage)	Yes	Under abnormal operational and post-operational (aftercare) conditions, such as a failure in the AEGB, there is potential for impacts on vegetation within the neighbouring land area due to landfill gas migration.
-	Air quality management areas (AQMA)	No	The site does not fall within an AQMA.

The identified receptors are shown in Figure 1.2.

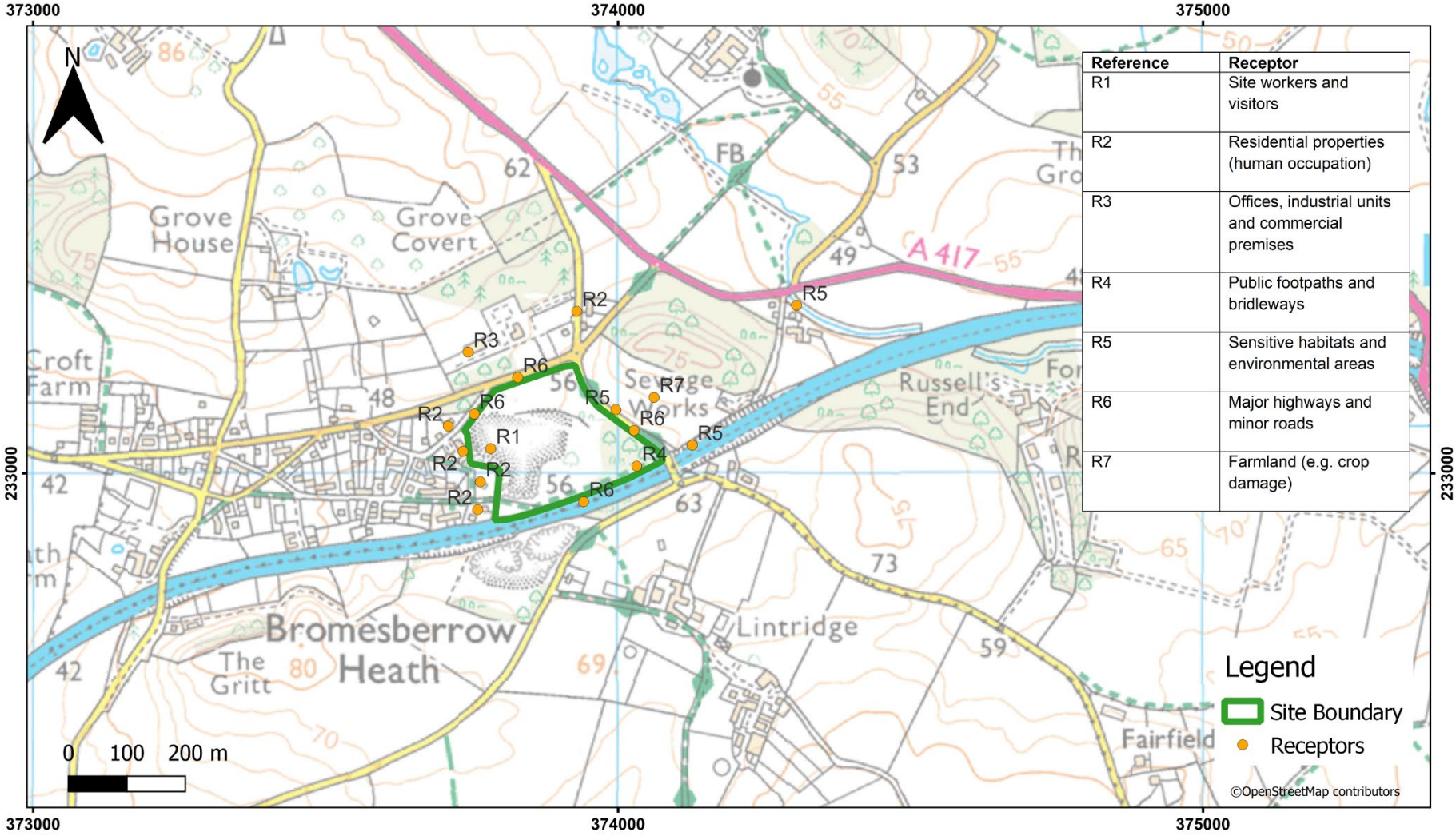
Figure 1.1 Site Location



Report Reference: 331201261R6

Report Status: Final

Figure 1.2 Receptor Plan



Reference	Receptor
R1	Site workers and visitors
R2	Residential properties (human occupation)
R3	Offices, industrial units and commercial premises
R4	Public footpaths and bridleways
R5	Sensitive habitats and environmental areas
R6	Major highways and minor roads
R7	Farmland (e.g. crop damage)

2 Landfill Gas Risk Assessment

2.1 The Nature of the Landfill Gas Risk Assessment

The Conceptual Site Model described in Section 1.4 has identified that the proposed inert landfill does not represent a significant source of landfill gas under normal operating conditions.

A qualitative assessment is considered an appropriate approach, given the absence of any significant source term, and based on the source-pathway-receptor model described previously.

2.2 The Proposed Assessment Scenarios

2.2.1 Lifecycle Phases

The assessment takes into consideration both the operational and aftercare phases of the site. Since no active gas management systems are proposed for the site, the risks associated with landfill gas are considered to be the same during all phases.

2.2.2 Accidents and their Consequences

Due to the inert nature of the fill, it is not considered necessary to control the accumulation and migration of landfill gas within the installation boundary and, therefore, no landfill gas engineering management structures have been proposed at the installation. Failure of such systems is therefore not possible.

There is a possibility that damage to the AEGB could occur as a consequence of either mechanical actions (i.e. accidental damage from machinery, vehicle movements etc.) or from land movements, resulting in possible loss of containment.

Given the level of potential risk associated with landfill gas generation and migration, a qualitative assessment of the risks posed by possible damage to the AEGB is considered adequate.

The likelihood of accidental damage will be minimised through careful and controlled Site operations, details of which are presented within the Site Operating Plan (Stantec, 2024b). The sandstone rock faces have few discontinuities in the rock mass and therefore the stability of the rock faces is dictated by the rock mass shear strength with low risk of kinematic failure (see Stability Risk Assessment Report, Key GS 2023).

Furthermore, the assessment of the geological barrier in the Stability Risk Assessment indicates that the stability of the final restoration design is acceptable in the short term. Ultimately the whole excavation area will be backfilled with inert waste and the final restoration contours are almost flat across the site, which will in turn ensure the long-term stability at the site.

Given the low probability of damage to the AEGB, the final restoration contours being almost flat and the low levels of gas production associated with inert materials, there is considered to be a very low risk from landfill gas migration away from the installation and any subsequent detrimental impacts on local receptors.

2.3 The Generated Gases to be Considered

This risk assessment principally considers methane and carbon dioxide. Risks from trace gases are considered to be low and mitigating the risks from methane and carbon dioxide will mitigate the risks from trace gases.

2.4 Numerical Modelling

No numerical modelling has been performed.

2.5 Risks to the Environment and Human Health

2.5.1 Landfill Gas Emissions

Given the inert nature of the proposed fill materials within the restoration, and the strict waste acceptance procedures that will be put in place, the risk of future methane and carbon dioxide emissions during both the operational and aftercare phases is low.

Similarly, in the absence of a significant landfill gas source, no appreciable risks are likely to result, even if damage to the AEGB were to occur.

Based on the EA qualitative method for assessing risks associated with landfill accidents (EA, 2004), the likelihood of possible loss of containment has been conservatively assessed as 'fairly probable' (i.e., characterised by incidents occurring between once every 1 and 10 years), and the severity of any such impacts resulting from loss of containment are assessed as 'minor' (i.e., nuisance on site only, with no off-site complaints). The resulting risk is classified as 'insignificant' or negligible.

In summary, based on the inert nature of the fill materials within the restoration it is not anticipated that landfill gas will be generated in significant quantities to pose a risk to the surrounding environment or to human health.

2.5.2 Sub-surface Migration and Vegetation Stress

As noted above, the proposed fill materials within the restoration are not considered to be significant sources of methane or carbon dioxide.

The principal pathway for the movement of any landfill gas generated is likely to be direct release to atmosphere influenced primarily by fluctuations in atmospheric pressure. The AEGB placed around the sides and base of the waste will limit the potential for sub-surface migration of landfill gas.

The Site is to be restored for conservation and amenity use and is located in a rural area with surrounding land used for agricultural purposes. A layer (up to 0.5m thick) of imported topsoil will be placed above the completed waste mass to achieve the successful establishment of the planting proposed as part of the Site restoration. On that basis, the most credible complete source-pathway-receptor linkage is considered to be agricultural crops in the fields immediately adjacent to the Site, were there to be failure of the AEGB under abnormal conditions.

EA, 2004 notes that: *"…landfill gas can cause damage to vegetation on adjacent land and crop die-back (chlorosis). Although plant death in many situations has been attributed to root zone oxygen displacement by the bulk components of landfill gas, several trace components of the gas are*

known to exert phytotoxic effects when borne in subsurface gas or ambient air. In addition, products of landfill gas combustion (e.g. acid gases such as hydrogen chloride, hydrogen fluoride and oxides of nitrogen and sulphur) will produce emissions that are potentially damaging to vegetation and ecosystems."

The intention is to import inert materials under strict waste acceptance procedures to restore the Site for beneficial purposes, on which basis the flux of landfill gases from the waste is anticipated to be very low, even if failure of the AEGB were to occur under abnormal conditions. Furthermore, the crops are anticipated to be of low sensitivity and the overall risk associated with this contaminant linkage is therefore considered to be low.

The risk of sub-surface gas migration and vegetation stress is therefore considered to be low.

2.5.3 Atmospheric Dispersion and Odour

The principal pathway for the movement of any landfill gas generated is likely to be direct release to atmosphere influenced primarily by fluctuations in atmospheric pressure.

Once placed, the overlying restoration soils will serve to reduce the surface emissions of any methane generated by aerobic biodegradation.

As the inert material will not represent a significant landfill gas source, it is considered that releases to air will not exceed the relevant benchmarks (Environmental Assessment Limit, EAL, or Environmental Quality Standard, EQS).

2.5.4 Exposure (Human Health)

As the inert material that will be placed in the restored area does not represent a significant gas source, it is considered that the risk of exposure to potentially harmful concentrations of gas from the landfill is very low.

2.5.5 Global Atmospheric Impact

As the inert material that will be placed in the restored area is not considered to be a significant source of landfill gas, its global atmospheric impact is considered to be insignificant.

2.6 Landfill Gas Completion Criteria

Landfill gas completion criteria refer to the conditions that must be met before an EP can be surrendered. Completion relating to landfill gas risk will have been achieved when there is no longer any unacceptable risk of pollution from the installation to the surrounding environment or harm to human health. The completion criteria for landfill gas are presented in EA, 2022.

The landfill gas completion criteria for the Site are presented in the Environmental Monitoring Plan (Stantec, 2024c).

3 Landfill Gas Management Plan

3.1 Control Measures

Landfill gas generation will be controlled through appropriate waste acceptance procedures (as detailed in the Site Operating Plan) which will ensure that no fill materials likely to generate landfill gas will be accepted.

This risk assessment has identified that the probability of the fill materials providing a significant source of landfill gas is very low. No gas extraction and utilisation will therefore be required at the Site.

Although landfill gas is not anticipated to be generated in quantities that would pose a risk to the surrounding environment or to human health, a monitoring and action plan will nevertheless be put in place to manage the risk. The monitoring and action plan is set out in the Environmental Monitoring Plan (Stantec, 2024c).

3.2 Monitoring Plan

Details of the landfill gas monitoring locations and programme are presented in the Environmental Monitoring Plan (Stantec, 2024c).

3.3 Action Plan

Details of the actions to be taken in the event of any abnormal monitoring records, reported events or operational failures are presented in Environmental Monitoring Plan (Stantec, 2024c).

Should the monitoring identify a significant gas flow, a quantitative risk assessment will be undertaken. The risk assessment will conclude with an explanation of the potential impact of the gas on the environment and human health, with recommendations for any remedial action if it is considered necessary. A course of action will be agreed with the EA.

4 Conclusions

4.1 Compliance with the Environmental Permitting Regulations

The accumulation and migration of landfill gas from the fill material will be controlled by the implementation of appropriate measures including strict waste acceptance procedures, detailed in the Site Operating Plan, which will ensure that no fill materials likely to generate significant volumes of landfill gas will be accepted. Consequently, the risk assessment has identified that the probability of the fill materials providing a significant source of landfill gas is very low. No gas extraction and utilisation will therefore be required at the Site.

Given the inert nature of the proposed fill materials within the restoration, and the strict waste acceptance procedures that will be put in place, the risk of future methane and carbon dioxide emissions during both the operational and aftercare phases is low. Similarly, in the absence of a significant landfill gas source, no appreciable risks are likely to result, even if damage to the AEGB were to occur.

An Environmental Monitoring Plan (Stantec, 2024c) has been developed to provide an early indication of gas generation that could lead to deterioration of the environment, which includes an action plan that will be followed to ensure that there is no unacceptable risk to human health. Should the monitoring identify a significant gas flow, a quantitative risk assessment will be undertaken. The risk assessment will conclude with an explanation of the potential impact of the gas on the environment and human health, with recommendations for any remedial action if it is considered necessary. A course of action will be agreed with the EA.

The landfill gas completion criteria for the Site are presented in the Environmental Monitoring Plan.

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