FASSAROE PHASE 1 DEVELOPMENT

Historic Landfill Remediation Strategy Report

Historic Landfill Remediation
Strategy Report
Fassaroe Phase 1
Development
S03.P02
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1 INTRODUCTION

1.1 Background

Cosgrave Property Group intends to develop lands at Fassaroe, Bray, Co. Wicklow to comprise mixed use including residential and commercial development proposals (Refer to EIA Main Report for full details of proposed development). RPS was commissioned by Cosgrave Property Group to prepare a Remediation Strategy Report for five historical landfills located within the site boundary of Phase 1 of the development.

The five landfills, known as Site 1, Site 2, Site 3A, Site 3B and Site 3C, are located as shown on RPS application drawing **CP19001-RPS-00-XX-DR-C-DG0001-01 S3 P02** and were filled from the early-1970s to the mid-1990s. Four of the sites (Site 2, Site 3A, Site 3B and Site 3C) are now authorised under Certificates of Authorisation (CoA) granted by the EPA to Wicklow County Council in November 2019. Site 1 does not fall under the CoA requirements. However, its remediation is being treated in the same manner as that authorised for the other four sites.

While Sites 2, 3A, 3B and 3C are located in lands owned by Cosgrave Property Group, Wicklow County Council as the CoA holder, is responsible for the remediation and ongoing monitoring of these sites and for ensuring the conditions of the Certificates of Authorisation are complied with.

Agreement has therefore been obtained by Cosgrave Property Group from Wicklow County Council to include the capping of the landfills within the proposed Phase 1 development as it is acknowledged that the remediation of the sites in accordance with the Certificates of Authorisation is intrinsically linked to the future use of the sites post-development.

1.2 Objectives

The objective of this report is to set out the detailed proposals for the landfill remediation measures required at each of the Sites 1, 2, 3A, 3B and 3C in order to facilitate the proposed Phase 1 Development, based on the recommendations of the Environmental Risk Assessment (ERA) (RPS ref. MDR1206RP0001) and Certificates of Authorisation for Sites 2, Site 3A, Site 3B and Site 3C.

The proposal for a capping system on all five sites as recommended by the ERA is to break the pathway associated with risks to human health by preventing direct contact with the identified source for future site users, and secondly, to reduce infiltration of rainwater and therefore contaminant leaching to groundwater and migration to receptors.

The proposed landfill capping measures comprise mitigation and management proposals to eliminate adverse impacts of the landfills on the development proposed, and in particular any potential to impact on human health or the uses proposed which include residential and amenity uses. The proposals will effectively close off any potential pathways from the landfills to the proposed new uses, including amenity uses on top of the landfills and residential uses adjacent to them, all in accordance with best practice.

1.3 Scope of Report

The scope of this report is to:

- Provide a description of the existing historical landfill sites to be remediated;
- Review the recommendations made in the ERA report;
- Present the requirements of the EPA Certificates of Authorisation;
- Present capping design proposals for each of the five landfills; and,
- Present proposals for aftercare management and monitoring of the three landfill sites.

1.4 Previous Relevant Investigations and Studies

The following reports were previously carried out for the development:

- Environmental Risk Assessment – RPS, May 2018;
- Environmental Risk Assessment – RPS, June 2016;
- Tier 2-3 Environmental Risk Assessment Landfills No. 3A and 3C - Wicklow County Council, December 2012 (amended April 2013);
- Disused Wicklow County Council Landfill Sites 3A, 3B and 3C at Fassaroe, County Wicklow Appropriate Assessment Screening Report – Altemar in association with Environmental Management Services, April 2013;
- Fassaroe Business Park Geotechnical Interpretative Report – Atkins McCarthy, July 2001;
- Fassaroe Historic Landfill Environmental Risk Assessment – Atkins, June 2010;
- Fassaroe AGS and Excel ground investigation data (IGSL and Glovers logs) received from Atkins on the 19th of October 2015; and,
- Environmental Ground and Geotechnical Site Evaluation Report for Site at Fassaroe, Bray – Muir Associates, January 1998.

2 SITE DESCRIPTION

2.1 Description of Sites

2.1.1 Site Location & Land-use

The landfill sites are situated adjacent to Berryfield Lane and the County Brook River (Fassaroe Stream). The valley which is known as Ballyman Glen is designated a Special Area of Conservation (SAC) (Site Code: 000713) designated on the basis of the following habitats and/or species listed on Annex I/II of the EU Habitats Directive: petrifying springs with tufa formation; and alkaline fens.

Berryfield Lane is characterised by one-off housing developments in a predominantly agricultural setting. As shown in drawing **CP19001-RPS-00-XX-C-DG0001-01 S3 P02** a sports ground and associated facilities are located in lands immediately to the east of Site 3B.

An integrated waste management facility (EPA Ref. W0053-03) is located immediately to the east of Site 2.

A sand and gravel quarry is located to the south of Berryfield Lane which is operated by Roadstone Limited.

A number of utilities/services are located within the vicinity of the existing landfills as shown on drawing **CP19001-RPS-00-XX-DR-C-DG0002-01 S3 P02**

- An ESB 38kV overhead powerline traverses the north west margin of Site 1;
- A twin 110kV overhead ESB pylon traverses the western margin of Site 1;
- A water main runs in a north south direction between Sites 1 and 2;
- A MV ESB overhead traverses the southern margins of Sites 3A and 3C; and,
- A MV ESB overhead traverses the western margin of Site 3B.

2.1.2 Aerial Photographs

Aerial photography indicates that Site 2, 3A, 3B and 3C are grassed with evidence of vegetation die-back. Site 1 consists of scrub and gorse with some surface debris.

2.1.3 Site Ownership

All five sites are located within lands currently owned by Cosgrave Property Group or its associated companies.

2.1.4 Historical Land Use

It is understood that Sites 1, 3A and 3C were previously operated as sand and gravel pits. Wicklow County Council's report entitled '*Tier 2-3 Environmental Risk Assessment Landfills No. 3A and 3C - Wicklow County Council'*, December 2012 (amended April 2013) states:

> *'Between the early-1970s and the mid-1990s, Wicklow County Council operated a number of municipal landfills in the Fassaroe area, to the west of Bray, in north County Wicklow. Four landfills were sited on the northern side of Berrysfield Lane with a fifth small landfill located to the south of the road'*.

Available information regarding the volumes and types of waste deposited as well as the duration of filling have been taken from the EPA's Section 22 register and presented in **Table 2-1** below. Information has been provided for Sites 2, 3B and 3C only.

Table 2.1 Data from EPA Section 22 Register

Site Name	Waste Type	Hazardous Waste	Waste Quantity	Verification	Start Date	End Date	Holder of Waste
Fassaroe 2	Municipal	-	150,000	Local Knowledge	01/01/79	31/12/91	Wicklow Co Co
Fassaroe 3B	Municipal	-	9,000	Local Knowledge	01/01/94	31/12/95	Wicklow Co Co
Fassaroe 3C	Municipal	-	30,000	Walkover Survey	01/01/92	31/12/95	Wicklow Co Co

Source: EPA

2.1.5 Findings of Previous Ground Investigations

A summary of the landfill site areas, depth of waste, estimated tonnages and types of waste present is provided in **Table 2-2**, which has been developed from a review of the available ground investigations as included in the 2018 ERA, which formed the basis of the application to the EPA for Certificates of Authorisation.

Table 2.2 Estimated Landfilled Waste at Each Site

Site	Site area (Ha)	Estimate of waste tonnage present (tonnes)	Depth of waste (mbgl)	General waste description	Waste types recorded
1	0.59	110,000	14	Predominantly comprised of construction and demolition waste with pockets of municipal waste. One fragment of asbestos cement encountered within the waste mass.	Plastic, glass, metal, concrete blocks, tyres, brick, wood, plastic piping, reinforced concrete, glass and ceramics.
2	4.72	340,000	19	Predominantly comprised of municipal waste.	Plastic bags, bottles, concrete, fabric, timber, waving piping, wood, newspaper, metal, glass, brick, concrete blocks, textiles, rubble and tins.
3A	1.90	120,000	16	Predominantly comprised of municipal waste.	Household waste, rubber, glass, paper, metal, textiles, footwear, car tyre, plastics, perspex, metals, wire, paper and timber.
3B	0.49	8,500	4.9	Predominantly comprised of municipal waste.	Household waste, plastics, glass, timber, textiles and footwear, plastics, household refuse, paper, metals, timber and textiles.
3C	0.90	47,000	13	Predominantly comprised of municipal waste.	Household waste, plastics, rope, mattress, glass, paper, timber, textiles including rugs, pipes, shoes, coins, metals, rubber tyres and bones.
Total	**8.6**	**625,500**			

2.1.6 Certificates of Authorisation

A "closed landfill" is defined in the Waste Management (Certification of Historic Unlicensed Waste Disposal and Recovery Activity) Regulations, 2008 as a landfill site operated by a local authority for the recovery or disposal of waste without a waste licence on any date between 15/07/1977 and 27/03/1997 (i.e. prior to the entry into force of the Waste Management (Licensing) Regulations, 1997 (S.I. No. 133 of 1997)). "Closed landfills" are also commonly referred to as historic landfills.

Under the Waste Management (Certification of Historic Unlicensed Waste Disposal and Recovery Activity) Regulations 2008, Historic Landfill Certificates of Authorisation (CoA) have been issued by the Environmental Protection Agency (EPA) to Wicklow County Council (the CoA Holder) for Sites 2, 3A, 3B, and 3C as presented in **Table 2-3** below.

Table 2.3 EPA Certificate of Authorisation Number

Site	Certificate of Authorisation Number	Date Issued	Available to download
1	N/A		
2	H0475-01	22/11/19	http://www.epa.ie/licences/lic_eDMS/090151b2807228e6.pdf
3A	H0477-02	22/11/19	http://www.epa.ie/licences/lic_eDMS/090151b2807228ee.pdf
3B	H0476-01	22/11/19	http://www.epa.ie/licences/lic_eDMS/090151b2807228ea.pdf
3C	H0474-02	22/11/19	http://www.epa.ie/licences/lic_eDMS/090151b2807228e2.pdf

The purpose of the Certificate of Authorisation is to certify compliance with the requirements of the Regulations.

A certificate of authorisation:

a. *Shall determine the adequacy of the Risk Assessment (including any necessary measures recommended therein) submitted by a local authority as part of the application for a certificate of authorisation;*

b. *May specify further necessary measures in addition to those identified by the Risk Assessment having regard to ensuring appropriate protection for human health and the environment to ensure conformity with the provisions of Council Directive 2006/12/EC1 and Council Directive 80/68/EEC2; and,*

c. *Shall require that a validation report is compiled by the authorisation holder in accordance with the requirements of Chapters 7.3 and 8.2.4 of the Code of Practice.*

The Risk Assessment (ERA), required under item ‘a’ above, was prepared by RPS in 2018 and formed the basis of the applications for Certificates of Authorisation for Sites 2, 3A, 3B and 3C. It was carried out in accordance with the EPA '*Code of Practice - Environmental Risk Assessment for Unregulated Waste Disposal Sites'* . While Site 1 does not have a CoA, it does contain historical waste and was therefore included in the Environmental Risk Assessment.

2.1.7 Local Sensitive Sites

Sites 1, 2, 3A and 3C are located adjacent to the Ballyman Glen SAC (Site Code: 000713) designated on the basis of petrifying springs with tufa formation and alkaline fens. The tufa deposits are not explicitly mapped within the SAC area, however numerous isolated instances of tufa deposits were noted along the southern banks of the County Brook River (Fassaroe Stream), typically associated with seepages from the bank.

2.1.8 Topography

2.1.8.1 Site 1

Site 1 covers an area of approximately 0.59 Ha. The cross-section (RPS Drg. No. CP19001-RPS-00-XX-DR-C-DG0003-01) shows the profile of the landfill to be relatively flat (1V:35H) with a maximum height of 96mOD and a gradual increase in slope towards the northern section of the site at the top of the river valley. The site is currently vegetated with scrub and gorse.

2.1.8.2 Site 2

Site 2 covers an area of approximately 4.72 Ha. The western and central portions of the site are currently grassed. The cross-section (RPS Drg. No. CP19001-RPS-00-XX-DR-C-DG0003-02) shows the profile of Site 2 to be relatively flat in the western portion of the site with a maximum height of 85mOD. From the centre of the site however, the slope increases in an eastward direction to approximately 1V:8H. The eastern portion of the site, which is densely vegetated with mature trees and bushes, extends down a very steep section of the valley for approximately 50m at a slope of between 1V:2.5H to 1V:3H, dropping from 63mOD to 43mOD. At two locations on this section of the valley, slope failure has occurred, which has exposed waste material.

2.1.8.3 Site 3A

Site 3A covers an area of approximately 1.9 Ha. The cross-section (RPS Drg No. CP19001-RPS-00-XX-DR-C-DG0003-03) shows that the profile of Site 3A is relatively level along the centre with the site falling 5m from 106mOD in the west to 101mOD in the east. The northeast tip of Site 3A has a steeper slope at approximately 1V:2.5H falling from 102mOD to 90mOD in a south to north direction. Similarly, the northwest tip has a 1V:6H slope, dropping from 105mOD to 100mOD over 30m in a south to north direction. A shallow slope is located at the southeast corner, with an approximate slope of 1V:10H.

2.1.8.4 Site 3B

Site 3B covers an area of approximately 0.49 Ha. The cross-section (RPS Drg No. CP19001-RPS-00-XX-DR-C-DG0003-04) shows the profile of the landfill to be relatively flat with a gradual slope of 1V:30H occurring in a south to north direction from 101mOD to 99mOD.

2.1.8.5 Site 3C

Site 3C covers an area of approximately 0.9 Ha. The cross section (RPS Drg No. CP19001-RPS-00-XX-DR-C-DG0003-05) shows that the site slopes downwards from south to north, dropping 11 metres from 95mOD to 84mOD. The northern portion of the site has a steeper slope of 1V:2H.

3 ENVIRONMENTAL RISK ASSESSMENT

3.1 Environmental Risk Assessment for CoA Application

An Environmental Risk Assessment (ERA) which formed the basis of the application for the Certificates of Authorisation was prepared by RPS and submitted to the EPA by Wicklow County Council in May 2018 (Fassaroe Historic Landfill - Environmental Risk Assessment - Document Ref MDR1206RP0007). This ERA has been updated to reflect the pumping trials carried out on foot of the CoA grant and to support the planning application for the Phase 1 Development.

The ERA assesses and presents potential risks to human or environmental receptors associated with the presence of the waste material in the landfills. The Environmental Risk Assessment (ERA) also provides an outline assessment of options for managing risks identified and sets out recommendations for remedial options.

3.2 Conceptual Site Model

As part of the ERA, a conceptual site model (CSM) was prepared for each site. The refined CSMs were based on the initial regional geological and hydrogeological data from the GSI and site investigation data from trial pits, boreholes, geophysical surveys, quality data and groundwater levels. The CSMs for each of the sites are shown in Appendix A (Extracted from ERA-Figures 19 to 22). The models show the source, pathways and receptors for each of the sites.

3.3 Recommended Remedial Measures from ERA

The capping of the five landfills with a low permeability barrier is considered the preferred remedial option as set out in the Environmental Risk Assessment (document ref. MDR01206Rp0007). Landfill capping is an accepted method for reducing leachate generation on landfill sites. A capping option is considered viable on the historical landfill sites, would be cost effective and would be a low impact approach that will mitigate human health risks associated with asbestos and PAHs within the soils. It will result in a net betterment to the water environment by improving water quality without significantly reducing groundwater flow to the Ballyman Glen SAC. Furthermore an engineered low permeability cap will also enable landfill gas management measures for any future development of the site.

4 LANDFILL REMEDIATION DESIGN

4.1 Scope of Landfill Remediation Measures

The proposed landfill capping remedial measures, as set out in the following sections of this report, have been designed to meet the requirements of the Certificates of Authorisation and to accommodate the construction of the Phase 1 Cosgrave Development, specifically to:

- Minimise infiltration of water and maximise clean run-off from the landfill areas;
- Promote surface drainage and maximise clean run-off from the landfill areas;
- Control landfill gas migration; and,
- Provide a physical separation between waste and human and environmental receptors.

The proposed landfill capping measures comprise mitigation and management proposals to eliminate any potential adverse impacts of the landfills on the development proposed, and in particular any potential to impact on human health or the uses proposed which include residential and amenity uses. The proposals will effectively close-off any potential pathways from the landfills to the proposed new uses, including amenity uses on top of the landfills and residential uses adjacent to them, all in accordance with best practice.

It should be noted that while the lands on which Sites 2, 3A, 3B and 3C are located are owned by Cosgrave Developments, Wicklow County Council as the CoA holder is responsible for the operation, control and maintenance of the sites and for ensuring the conditions of the Certificates of Authorisation are complied with. Agreement has been obtained from Wicklow County Council to include the capping of the landfills (including Site 1) within the proposed Phase 1 development as it is acknowledged that the remediation of the sites in accordance with the Certificates of Authorisation is intrinsically linked to the future afteruse of the site post-development.

4.2 Proposed Site Afteruse

4.2.1 Site 1

As shown on drawing **CP19001-RPS-00-XX-DR-DG0006 S3 P02**, Site 1 is to be developed as a parkland amenity area consisting of densely planted trees to the west, with open green areas and pedestrian pathways to the centre and east.

4.2.2 Site 2

As shown on drawing **CP19001-RPS-00-XX-DR-DG0006 S3 P02**, Site 2 is to be developed as a parkland amenity area with the following features:

- Open green areas;
- Areas of planted trees;
- Pedestrian pathways;
- Two surface water attenuation ponds for amenity features and to accommodate storm run-off from the proposed development;
- A main access road to be constructed in fill; and,
- Stepped outdoor amphitheatre.

4.2.3 Site 3A

As Site 3A does not lie within the proposed footprint of the Phase 1 development this site will receive a landfill capping system and will be restored to its current use as grassland.

4.2.4 Site 3B

The main access road to the east of the proposed development will pass through Site 3B as shown on drawing **CP19001-RPS-00-XX-DR-C-DG0007 S3 P02.** The road will be constructed in cut (below the existing ground levels). The southern portion of Site 3B will be restored to its current use as grassland.

4.2.5 Site 3C

As Site 3C does not lie within the proposed footprint of the Phase 1 development this site will receive a landfill capping system and be reinstated to its current use as grassland.

4.3 Proposed Capping System Design

4.3.1 EPA Landfill Capping Guidelines

The proposed capping remediation works will be carried out in accordance with the Environmental Protection Agency (EPA) Landfill Capping Guidelines. The *EPA Landfill Manual: Landfill Site Design* (EPA 2000) provides guidance on landfill capping and construction of the various capping system components which includes the following:

- Topsoil;
- Subsoil;
- Drainage Layer;
- Barrier (infiltration) layer; and,
- Gas drainage layer.

Based on the investigations carried out to date at each of the landfill sites, the sites can be classed as non-hazardous biodegradable landfills for the purposes of capping. The EPA guidelines recommend the following capping system for a non-hazardous biodegradable landfill:

- “Topsoil (150-300mm) and subsoil of at least 1m total thickness;
- Drainage layer of 0.5m thickness having a minimum hydraulic conductivity of 1x10-4m/s;
- Compacted mineral layer of a minimum 0.6m thickness having a hydraulic conductivity of less than or equal to 1x10-9m/s or a geosynthetic material (e.g. GCL) or similar that provides equivalent protection; and,
- A gas collection layer of natural material (minimum 0.3m) or a geosynthetic layer”.

4.3.2 Proposed Capping System Details

As noted in **Section 4.2** above, the proposed land afteruse in each of the sites to be capped varies both from site to site and within each site. Therefore the material make up of each area, depending on afteruse, will be different. However, in all landfill areas to be capped the following minimum capping system will be installed (in order of placement):

- Regulation layer (maximum thickness 300mm);
- Gas collection geocomposite (approximately 4-6mm thickness);
- 1mm thick low permeability geomembrane (LLDPE-linear low density polyethylene) liner having a hydraulic conductivity of less than or equal to $1x10^{-9}$m/s*;*
- Surface water drainage geocomposite (approximately 4-6mm thickness);
- 850mm Subsoil layer; and,
- 150mm Topsoil layer.

In areas to receive roads or pavements, the subsoil and topsoil layers will be replaced with suitable engineering materials, and will maintain the minimum of 1m cover from the surface water geocomposite to finished road/pavement level.

The proposed minimum capping system is presented graphically in **Figure 4.1**. As shown the minimum finished ground level shall be 1m above the capping surface water geocomposite and liner and a maximum of 1.3m above existing ground.

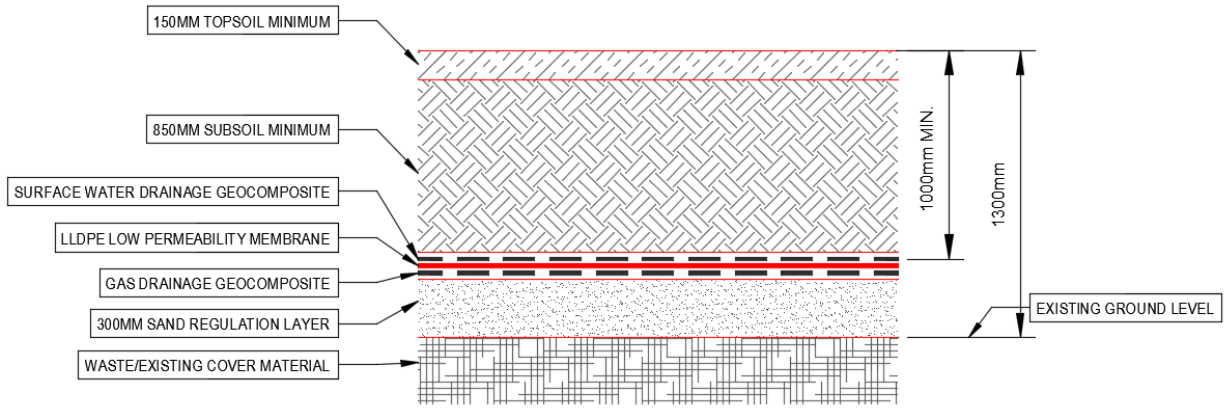


Figure 4.1 Proposed minimum capping system

The purpose of the subsoil and topsoil layers in a normal landfill application is to provide a 1m physical barrier to the capping system geocomposite and geomembrane layers. Therefore in areas which are to be raised by >1.3m above existing ground level, additional depths of general fill or subsoil materials will be used to make up the depth required. This will then be overlain by topsoil in landscaped areas to the required depth for planting. Areas to receive roads or pavements will similarly need to maintain the 1m cover from the surface water geocomposite to finished road/pavement level. To represent this, the minimum capping system and the overlying materials proposed for the various proposed post-capping land uses throughout the various sites are shown in drawing **CP19001-RPS-00-XX-DR-C-DG0004-01 S3 P02**.

4.3.3 Proposed Capping System Materials

The properties and function of the capping system materials are discussed below:

- **Regulation layer**: This is required to provide a smooth surface on which to lay the geocomposites and capping system and to ensure that when the overlying materials are being compacted and rolled, there is a physical barrier to any underlying sharp objects or protrusions. This will be particularly important in Sites 1 and 2 where trees and vegetation are to be stripped in order to install the capping system. It is proposed that the thickness of the layer will be a maximum of 300mm. Where it can be demonstrated onsite during construction that the existing cover material over the waste is sufficiently 'regular', the thickness of the sand regulation layer may be reduced.
- **Gas collection geocomposite:** The primary purpose of the gas geocomposite is to provide flow capacity to maintain the landfill gas pressure within the geocomposite at an acceptable rate below the geomembrane. From a slope-stability point of view, gas pressure is an excess pore pressure that serves to reduce the effective normal stress. This pressure results in a decrease in the effective stress beneath the geomembrane that, ultimately, can lead to slope stability failure.

  The gas geocomposite layer will be a two or three layered, three dimensional geosynthetic material consisting of a HDPE drainage core mechanically bonded to geotextile filter layers on both sides. The geotextile will be non-woven needle-punched HDPE or Polypropylene. The thickness and compressive strength of the geocomposite will be specified at detailed design stage depending on the depth and loading of material to be placed above it.
- **Low Permeability LLDPE liner:** The purpose of the LLDPE geomembrane liner is to act as the low permeability ($1x10^{-9}$m/s) barrier minimising infiltration of rainwater and migration of landfill gas through the capped landfill. A geomembrane is used when low permeability clay is not available locally. Whilst some clay will be excavated as part of the proposed development, it is unlikely that the volume and properties of the clay onsite would meet the EPA guidance requirements. The LLDPE geomembrane will be a 1mm thick liner which will be laid on top of the gas collection geocomposite.

- **Surface water drainage geocomposite:** The surface water drainage geocomposite will be the same or similar material to the gas collection geocomposite. This fulfils the function of the 0.5m drainage layer proposed in the EPA Landfill Site Design Manual. Its purpose is to provide flow capacity above the LLDPE liner for rainfall which infiltrates through the overlying subsoil and topsoil.
- **Subsoil (850mm minimum) and topsoil (150mm minimum):** Subsoil and topsoil will be sourced from onsite excavations, or imported where required and will be placed in layers in accordance with the requirements of Series 600 of the NRA Specification for Roadworks. Care shall be taken during placement to avoid damage to the underlying geocomposites and geomembrane. In areas where there is a requirement for roads, or other structures the subsoil and topsoil will be replaced with a similar depth of structural material to the Engineers specification. Protection will be afforded to the lining materials to ensure that this material does not have any adverse impact.

4.3.4 Confirmatory Slit Trenches

To date, the extent of the waste footprint at each of the landfill sites has been determined through a combination of borehole, trial pit and geophysical survey investigations. Prior to installation of the capping systems a series of slit trenches will be excavated along the current interpretation of the waste perimeter to determine the exact location of the perimeter.

4.3.5 Landfill Gas Management Design

At all five Sites, despite their age, waste is currently generating a residual amount of landfill gas and will continue to do so for some years. Landfill gas migrates along the path of least resistance. At present, the gas simply migrates towards the surface of the landfills. In areas where the existing cover material is not well compacted the landfill gas will migrate through the cover material and into the atmosphere. In areas where the existing clay cover material is well compacted the landfill gas will be prevented from venting through the surface and will therefore migrate laterally through the underlying sand and gravel deposits. This lateral migration of landfill gas is evident in a number of boreholes which have been drilled outside of the waste areas.

With the installation of a low permeability capping layer the gas will be prevented from venting through the surface of the landfill and will therefore build up in pressure and eventually migrate laterally beneath the edges of the sites, potentially towards residential units. To prevent this occurring a gas management system shall be incorporated into the rehabilitation measures.

The proposed landfill gas management measures are described in detail in the **Landfill Gas Management Strategy** (Report Ref. JER8746) .

4.3.6 Leachate Interception

As shown on the CSMs for each of Sites 1, 2, 3A, 3B and 3C described in **Section 3.1** and illustrated in the ERA [**Appendix A]** infiltration of rainwater and decomposition of the waste has resulted in leachate plumes beneath the waste bodies. These leachate plumes extend a considerable distance below the waste bodies (approximately 40m below the waste in the case of Site 2) and migrate in the direction of the groundwater flow regime, generally to the north-east. In some areas also, for example Site 1, there is evidence of perched leachate which is as a result of an intermediate stratum of over-compacted waste or cover material preventing or reducing infiltration of liquid beneath it and resulting in a localised head of leachate.

Given the nature of the waste and the likely ad-hoc fashion in which it was filled, it is possible that, following removal of vegetation and grading of the waste surface to receive the capping system, seepage from wet/saturated pockets of waste may result in a build-up of leachate against the underside of the capping system geocomposites. This would be more likely to occur on the down-gradient side of the waste bodies.

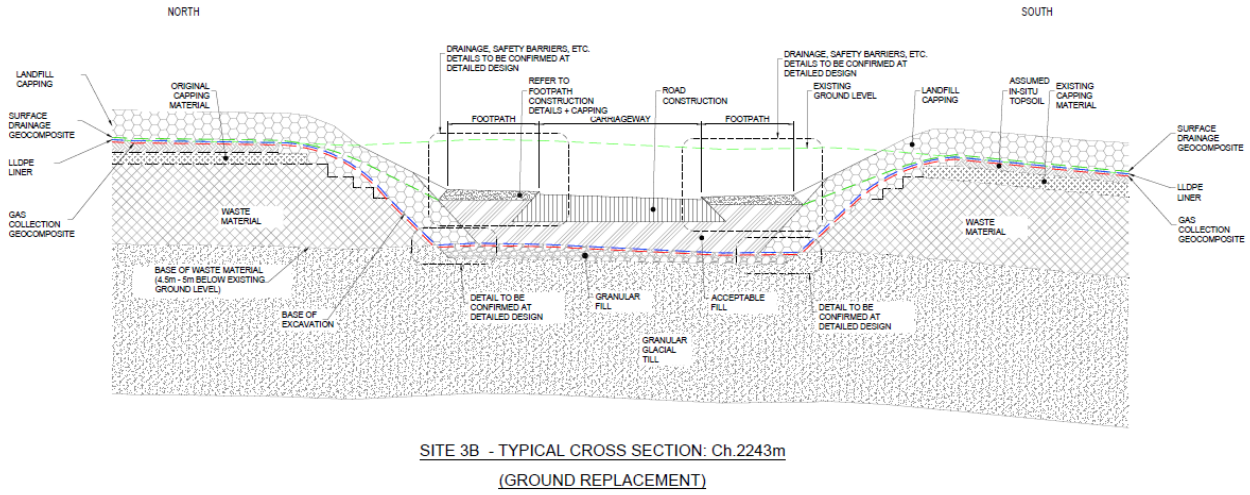
This leachate could then travel between the surface of the waste and the gas drainage geocomposite and make its way to the perimeter of the waste body. However, the nature of such leachate breakouts, if any, would be sporadic, localised and random to a degree. It is also more likely that leachate would seep back down into the waste body again locally without traveling to the edge of the waste.

In order to redirect any localised leachate seepages back into the waste, it is proposed that the gas drainage geocomposite shall be returned into the ground at the edge of the waste body as shown in drawing **CP19001-RPS-00-XX-DR-C-DG0004-01 S3 P02**.

This will mean that any minimal amounts of leachate which may have seeped upwards into the geocomposite, will be directed back down into the waste body by the vertical element of the geocomposite. This volume of leachate would be minuscule in comparison to the total volume of leachate currently within and below the waste body.

It is also important to note that leachate generation, and therefore the likelihood of any seepage, will be greatly reduced by the installation of the proposed best practice low permeability capping system, which will minimise infiltration of rainfall.

At Site 3B, in order to accommodate the access road which will be constructed in cut through the site, it is proposed that all of the waste beneath the pavement layers will be excavated down to clean material. As the existing ground is generally flat, there is no risk of stability issues due to a build-up of leachate head. Notwithstanding this, a granular fill blanket will be laid at the base of the road pavement beneath the capping lining materials as shown in **Figure 4.2**, this will facilitate the draining away of leachate from the capping materials in the direction of the groundwater gradient (i.e. north-eastwards), which will maintain the current situation.



SITE 3B - TYPICAL CROSS SECTION: Ch.2243m

(GROUND REPLACEMENT)

From Atkins Planning Application drawing 5186693/HTR/01/DR/0606

Figure 4.2 Cross Section through proposed access road at Site 3B

4.3.7 Surface Water Drainage Design

Once the low permeability geomembrane liner has been installed, infiltration of surface water through the capping system will be minimal. Surface water at finished ground level (e.g. on grassed areas, pathways etc.) will drain overland towards the river, as currently takes place. However some infiltration of surface water will continue to occur through the soils overlying the capping system. This will need to be managed independently in a subsurface drainage system.

In order to prevent ponding of this water on the capping materials, a surface water collection geocomposite will be installed above the LLDPE geomembrane. As noted above, the surface water geocomposite will provide sufficient flow capacity above the LLDPE geomembrane to ensure that the water is drained towards the perimeter of the waste body. Here the LLDPE liner and surface water geocomposite will be continued through a subsurface drain as shown on drawing **CP19001-RPS-00-XX-GR-C-DG0004-01 S3 P02**.

This will consist of a perforated pipe installed at a depth of 1.2m bgl, within a granular stone-filled trench. The plan layout of this subsurface drain is shown on drawing **CP19001-RPS-00-XX-DR-C-DG0007 S3 P02**.This subsurface drain will be laid at grade with the existing site topography for Sites 1 and 2 and will be connected by a series of manholes. This subsurface drain will connect to the main development surface water drainage system, prior to the outfall at the river.

The capping system will provide attenuation for the runoff from the capped sites. The manner by which these areas are attenuated , and its effect on the peak flow and greenfield run-off rate is described below:

- Based on a permeability of 1 x 10^{-5} m/s for the backfill and a hydraulic conductivity of 1 x 10^{-4} m/s for the surface water geocomposite in the capping system (which is 1m minimum below the finished ground

surface), the average time of concentration in the sub-surface infiltration drain is approximately 23.5 days.

- In a storm event, the precipitation which does not flow as surface run-off will infiltrate through to landfill cover soils, attenuating naturally through the cover soils as it does so, until it hits the geocomposite, where it will be further attenuated at $1x10^{-4}$m/s. This attenuation and lengthy time of concentration means that there will not be a peak flow from the subsurface infiltration drain and therefore will be no increase to the greenfield run-off rate.
- Even when the ground is already saturated prior to a storm event, the cover soils would not have capacity to hold the water so the majority of the water flows as surface run-off, as would occur naturally in the absence of a capping system.
- To summarise, any infiltrating water will be naturally attenuated through the capping cover soils and surface water geocomposite as it makes its way to the perimeter drain. Due to the lengthy time of concentration, there will be no peak flow associated with the sub-surface infiltration drain.

At Site 3B, as the road is to be constructed and cut through the waste, any surface water infiltrating through to the capping system will be allowed to discharge to the road surface water drain on either side of the carriageway as shown on the cross section in **Figure 4.2**. To the north of the road cut, the waste footprint remaining following construction of the road will be approximately 300m^2 of grass surface. Therefore the anticipated infiltration of surface water through to the capping system will be negligible, so no subsurface drainage is proposed on the north of the road.

4.4 Slope Stabilisation

In order to accommodate both the construction of the landfill capping system and the Phase 1 development, slope stabilisation measures will need to be installed in the four areas where landslips and potentially unstable fill areas have been identified to the north of Site 2. This will need to be undertaken at an early stage in the Phase 1 development and prior to the installation of the capping system or loading/surcharging on the landfill areas. These measures have been designed by Atkins and are discussed below.

4.4.1 Section A - Atkins Planning Drawing 5186693/HTR/01/DR/0609

The typical cross-section for the slope stabilisation works in Section A is shown on Atkins planning drawing 5186693/HTR/01/0609.

As part of the stabilisation works in this section all material above the slip surface will be excavated and replaced with acceptable fill material at a gradient of 1(V):3(H). The toe of the new slope will then extend slightly further toward the river than the existing toe. Above the shoulder of the existing top of the slope, the earthworks will be cut in order to provide a shallower gradient of 1(V):4(H). This area can then be considered to be part of the park. Additional fill will be placed on the area above the proposed remediation area if required.

The new fill material will be benched into the existing slope at a gradient of 1(V):5(H) or steeper if required. All newly formed slopes will be backfilled following the excavation of material.

The landfill capping system will be installed above the waste material prior to the placement of new fill material on top of this.

4.4.2 Section B - Atkins Planning Drawing 5186693/HTR/01/DR/0609

The typical cross-section for the slope stabilisation works in Section B is shown on Atkins planning drawing 5186693/HTR/01/DR/0609.

It has been reported that slope failures have previously occurred at Section B, one while undertaking the geophysical surveys in May 2016 and another following this.

Stabilisation works for Section B will be similar to those proposed for Section A. Slipped material on the lower half of the slope will be excavated and the area regraded and filled with acceptable fill material at a slope of 1(V):3(H). The results of the geophysical survey showed the material underlying the slip surface to consist of natural sand/gravel. However it is possible that some slip material consists of waste. Therefore it may be necessary to treat all material to be removed as waste material.

Due to landtake constraints it will be necessary to construct a reinforced earth slope at a gradient of 1(V):2(H), with an approximate height of 5-6m. Fill will then be placed above this at a gradient of 1(V):3(H) to tie in with the top of the landfill capping to be provided in the park area. All material above the slip surface will be excavated.

The landfill capping system will be provided at the base of the new fill above the waste material for the upper half of the slope and if waste is encountered, on the lower half also.

4.4.3 Section C - Atkins Planning Drawing 5186693/HTR/01/DR/0610

The typical cross-section for the slope stabilisation works in Section C is shown on Atkins planning drawing 5186693/HTR/01/DR/0610.

There is evidence of a slope failure at Section C. However it was not possible to inspect the slope surface due to the presence of vegetation and therefore the slope profile was estimated.

The stabilisation works for Section C will be the same as those described for Section A with a new approximate slope of 1(V):2.5(H). The material to be excavated at the base of the slip surface is thought to consist of natural ground. Should this be confirmed, the landfill capping system will not be required in this area.

4.4.4 Section D - Atkins Planning Drawing 5186693/HTR/01/DR/0610

The typical cross-section for the slope stabilisation works in Section D is shown on Atkins planning drawing 5186693/HTR/01/DR/0610.

There is evidence onsite that slope failures have occurred in this area. The slope in this area is quite steep which is not adequately represented on the LIDAR survey due to the presence of vegetation.

The proposed stabilisation works for Section D will consist of regrading works to the area at a slope of 1(V):2(H). The existing slope will be benched prior to the placement of acceptable fill material. It is also proposed to construct a wedge of coarse granular material at the toe of the slope as scour protection for the river and relatively flat ground on the riverbank.

4.5 Settlement

It is possible, given the history of each of the Sites 1, 2, 3A, 3B and 3C that only low levels of compaction of waste occurred during filling operations. As such, with the installation of a minimum of 1 m of cover soils above the waste and additional fill above this to make up the finished ground level, this loading may result in settlement of the landfill areas. During the detailed design, consideration will therefore be given to measures to minimise the impact of potential settlement, including the inclusion of a geogrid system, at critical locations in the capping system, to reduce differential settlement.

In addition, the earthworks programme for the Phase 1 development will be devised to consider provision for the surcharging of Site 1, 2, 3A, 3B and 3C with clean excavated material at an early stage in the development works (once the slope stabilisation works on Site 2 have been completed and prior to installation of the capping system). This will promote settlement so that post-capping settlement of the landfill areas is reduced as much as possible.

4.6 Excavation and Removal of Waste off-site

4.6.1 Site 1

There is the requirement for modest excavations within the waste body of Site 1. Where possible the material will be utilised on site in an appropriate manner to assist in the reprofiling of the waste body, and excess material will be excavated from this location and removed off-site to a licenced waste facility.

4.6.2 Site 2

There is the requirement for modest excavations within the waste body of Site 2. Where possible the material will be utilised on site in an appropriate manner to assist in the reprofiling of the waste body, and excess material will be excavated from this location and removed off-site to a licenced waste facility.

During the piling process for the road embankment which traverses the southern point of Site 2 (piling options shown on Atkins Drawing 5186693/HTR/01/DR/0607-0608), waste will be brought to the surface. This material will be placed beneath the capping system or if necessary will be moved off site to a licenced waste disposal facility.

4.6.3 Site 3B

It is proposed to construct a new access road through Site 3B as shown on Atkins Drawing 5186693/HTR/01/DR/0606, drawing **CP19001-RPS-00-XX-DR-C-DG0007 S3 P02** and **Figure 4.2**. In order to accommodate the required levels for the road, the final profile level of Site 3B must be lowered. This will be achieved through the excavation of waste from Site 3B and transportation to a licenced waste disposal facility.

As waste below the road would result in long term settlement, measures would be required to mitigate this impact (e.g. rigid platform, piles, ground replacement). As most of the waste will be excavated to reach the required levels, the option of excavating the remaining waste and replacing it with acceptable material to the base of the road construction is considered the most economical and time efficient approach

Waste within Site 3B currently extends to 4-4.5m bgl. It is proposed that all waste within the footprint of the road pavement in Site 3B will be excavated down to clean material and removed offsite. Where possible the material will be utilised on site in an appropriate manner to assist in the reprofiling of the waste body, and excess material will be excavated from this location and removed off-site to a licenced waste facility.

4.6.4 Excavation of Waste

The following mitigation and management measures will be required to be implemented during the excavation of waste from landfill Sites 1, 2 and 3B.

4.6.4.1 Site Access

To protect the personnel outside the work area and for proper control of the areas being worked in, it will be necessary to take complete and secure possession of the site. Secure temporary fencing shall be erected around the waste excavation area. An area shall be delineated around the proposed excavation which will be regarded as a safety zone beyond which the contractor's plant shall not be permitted to leave unless it undergoes full decontamination to ensure waste is not exported from site.

Measures will be required to ensure that only authorised persons can enter the work area and that they are trained, competent and inducted for the operations being carried out within the site. The contractor must put in place rigorous accident and emergency procedures and ensure that all persons on site are familiar with these.

Due to the nature of the material in question, all excavation and movement of waste should be carried out by mechanical means.

4.6.4.2 Personal Protective Equipment

Strict rules and standards will be enforced regarding PPE around the works area. This will include at a minimum; helmets, gloves, tyvek suits, steel toed sole protective boots and safety glasses. Appropriate respiratory equipment will be maintained on site and there will be ongoing monitoring for gaseous hazards. The monitoring will be agreed with the contractor but provision must be made for raising the alarm, emergency procedures and a plan for alerting those outside the work areas.

In addition, suitable hygiene and welfare facilities and PPE should be provided in accordance with the requirements of the Safety, Health and Welfare at Work (General Application) Regulations 2007, Safety Health and Welfare at Work (Exposure to Asbestos) Regulations 2006 and 2010 amendments and the

Safety Health and Welfare at Work (Construction) Regulations 2013 to manage potential risks to construction workers.

4.6.4.3 Dust Suppression

The excavation of the works must be planned to minimise the risk of any material becoming airborne through the creation of dust. The contractor will have to put measures in place for dust suppression (water bowser) and have regard to weather conditions during the works to avoid run-off or severe dryness which could lead to problems with containment.

4.6.4.4 Gas and Odour Control

The anaerobic decomposition of putrescible waste generates landfill gas which comprises methane and carbon dioxide. Gas monitoring carried out on Site 3B to date has consistently recorded methane concentrations ranging from 25.8% v/v to 70.4% v/v and carbon dioxide ranging from 17.2%v/v to 36.6%v/v. Therefore it is expected that methane and carbon dioxide will be encountered during the Site 3B excavations.

A detailed construction methodology for the excavation works shall be prepared by the contractor and communicated to all site personnel to minimise creating confined spaces or trenches deeper than 1m during the excavation of waste. Where confined spaces or trenches greater than 1m are created, gas detection equipment and appropriate breathing apparatus should be used by all personnel in the vicinity of the confined space/trench.

The works must be planned to minimise the risk of the release of odours and gases to surrounding areas including the contractor's compound and the wider community. Site operatives in the Site 3B area will be instructed to report all unusual, concentrated or significant odours on-site, so that measures may be taken to identify the source of the odour and eliminate it. Gas monitoring techniques will be put in place by the contractor.

For nuisance odours, automated odour control systems may need to be put in place, as necessary, to periodically release a fragrance to mask or neutralise unpleasant odour. A wheel-washing facility shall be established for trucks leaving the site to minimise the transport of potentially odorous clay particles onto adjacent roads.

A no smoking policy will be strictly enforced onsite.

4.6.4.5 Exposed Waste Material

During the excavation works the waste material will be exposed, increasing the risk for windblown litter. Waste material and contaminated material may also be exported offsite attached to equipment and machinery.

To mitigate the impacts arising from the exposed waste the following measures will be implemented:

- The contractor shall excavate the waste in areas as small as possible in order to limit the exposure of the waste. The contractor shall prepare an excavation plan which supports this ethos;
- Should excessive wind conditions prevail, such that there is a risk of uncontrolled exposure to the waste with the consequences of it becoming windblown then the excavation shall cease until the weather becomes more amenable to the safe excavation of the waste. Any exposed areas of waste shall be covered with compacted clean material at the end of every working day as a minimum, in order to minimise the exposure of the waste to the winds;
- An area around the proposed excavation will be delineated which will be regarded as a safety zone beyond which the contractor's machinery is not permitted to leave unless it undergoes full decontamination;
- Only fully sealed containers shall be used for the removal of waste offsite; and,
- Prior to demobilisation, the contractor shall properly decontaminate all equipment and appropriately dispose of the decontamination water, field waste and contaminated personal protective equipment (PPE).

4.6.4.6 Asbestos

During the site investigations to date only 1 of 53 samples of waste tested positive for asbestos. This waste was in Site 1. Nonetheless there remains a risk that asbestos or Asbestos Containing Material (ACM) could be uncovered during the excavation of waste in Site 3B. It shall therefore be a requirement that the contractor for the works has in place, prior to the works, an Asbestos Management Plan, prepared in accordance with the following guidance and regulations:

- AGS 2012, Interim Guidance 'Site Investigation Asbestos Risk Assessment for the Protection of Site Investigation and Geotechnical Laboratory Personnel';
- CIRIA 2014, C733 A Guide to Understanding and Managing Risks; and,
- Safety Health and Welfare at Work (Exposure to Asbestos) Regulations 2006 and 2010.

4.7 Proposed Final Profile

The final profile (finished ground levels) of each of the sites are shown on the various architectural, landscaping and road layout drawings of the Phase 1 Planning Application Drawings Package.

4.8 Capping System Construction Quality Assurance (CQA)

4.8.1 CQA Plan

As part of the design, a CQA Plan will be prepared for the installation of the capping system in accordance with the requirements of the *EPA Landfill Manual: Landfill Site Design*. The CQA Plan will set down the procedures for sourcing, transporting, placing, testing, repairing and protecting the capping materials prior to, during and after construction. The CQA Plan will set out the roles and responsibilities of the various parties on site and the reporting to be provided by the manufacturer, installer and CQA Monitor. This plan will help to ensure the design of the capping system is not compromised during its construction.

4.8.2 CQA Supervision

Third party supervision of the capping works by a specialist CQA consultant is required by the *EPA Landfill Manual: Landfill Site Design* and will be provided by a suitably qualified and experienced company. The CQA contractor will be responsible for overseeing the capping works and ensure that the main contractor adheres to the Works Requirements. A CQA validation report will be submitted to the EPA following the construction for the capping system. The CQA validation report will set out all aspects of the construction from supply through to final placement and testing.

A quality control system will be put in place for all documentation relating to the capping works. All documentation will be kept on-site and available for inspection at all times. CQA documentation will include the following:

- Delivery, handling and storage of materials;
- Geomembrane panel layout and programme;
- Geocomposite panel layout and programme;
- Monitoring programme;
- Geomembrane seam testing;
- Geocomposite seam testing;
- Soil inspection; and,
- Laboratory testing results.

4.9 Landscaping

As the afteruse of the sites 3B will require the establishment of vegetation, there needs to be a recuperation period during which the soil is allowed to recover from the effects of movement, storage and replacement. Following this period, a landscape plan will be implemented to establish, maintain and monitor vegetation in order to successfully develop the landscaped areas of the site to their intended after-use. This will include cultivating and improving the soil to allow for the establishment of vegetation. Timing of the final landscaping works will be influenced by a number of factors:

- Settlement rates across the site;
- Installation of environmental pollution control systems; and,
- Seasonal conditions.

5 POST CAPPING MANAGEMENT AND MONITORING

All management and monitoring will comply with the requirements of the granted Certificate of Authorisation for the sites.

5.1 Landfill Gas

Proposals for post-capping monitoring of the landfill gas on site are described in detail in the **Landfill Gas Management Strategy**.

5.2 Surface Water

To ensure that the constructed subsurface water management system for the landfill cap is functioning effectively following the rehabilitation works, monitoring of the surface waters, upstream and downstream of the closed landfills, shall be carried out twice a year.

5.3 Leachate

Monitoring for the presence of leachate should be carried out at all leachate monitoring boreholes, in accordance with the Certificate of Authorisation. This requires the biannual, sampling, analysis and characterisation of all leachate monitoring boreholes.

5.4 Topography/Settlement

As the waste landfilled at the site to date has received only a small degree of compaction, it is expected that following the installation of the capping system and restoration soils/fill above the capping system, settlement will occur. In general, most of the settlement occurs in landfills in the first two years following rehabilitation.

It is therefore proposed that annual topographical surveys be undertaken at the site to monitor the settlement rate for the first two years. Following this, topographical surveys will be conducted every two years (up to 10 years post rehabilitation), unless the settlement rate observed indicates that more frequent surveys are required. By this time it is anticipated that settlement will be very minor so surveys of the site should be undertaken every 5 years, or until the topography of the cell has stabilised.

6 REQUIREMENTS OF CERTIFICATES OF AUTHORISATION

6.1 Validation Report

The local authority shall compile a validation report in accordance with the requirements of the Code of Practice.

> *3.3 - The local authority shall compile a validation report in accordance with the requirements of the Code of Practice. Unless otherwise agreed, the validation report shall be submitted to the Agency within 30 months of the date of grant of this Certificate of Authorisation.*

6.2 Ongoing Monitoring

The local authority shall biannually conduct and record:

a. A visual inspection of the landfill to ensure that the condition of the site has not deteriorated;

b. Monitoring for leachate (sample, analyse, characterise and measure the level of leachate) in all leachate monitoring boreholes;

c. Quarterly monitoring to detect the presence and concentration of landfill gas in all monitoring boreholes;

d. Monitoring (sample, analyse, and characterise) of relevant surface waters both upstream and downstream of the closest landfill;

e. Monitoring (sample, analyse, and characterise) of groundwater from at least three available groundwater monitoring boreholes, two of which shall be downgradient of the closed landfill; and,

f. The assessment of monitoring results against trigger levels and/or standard reference values for relevant pollutants including environmental quality standards in the European Communities Environmental objectives (Surface waters) Regulations 2009 and European Communities Environmental Objectives (Groundwater) regulations 2010, as amended.

6.3 Trigger Levels

Trigger levels for landfill gas emissions and surface water are identified below;

- The following are the trigger levels for landfill gas emissions from the facility measured in any service duct or manhole on, at or immediately adjacent to the facility and/or at any other point located outside the body of the waste:-

  a) Methane, greater than or equal to 1 .O% v/v; or

  b) Carbon dioxide, greater than or equal to 1.5% v/v

- In relation to surface emissions measured over the waste body and identified features, the following shall constitute a trigger level:-

  a) VOC greater than or equal to 5Oppmv as methane average over capped area;

  b) VOC greater than or equal to 1OOppmv as methane instantaneous reading on open surfaces within the landfill footprint; or

  c) VOC greater than or equal to 5OOppmv as methane around all identified features.

6.4 Incidents and Reporting Requirements

Incidents

In the event of an incident the local authority shall immediately:

i. If necessary contact the emergency services;

ii. Carry out an investigation to identify the nature, source and cause of the incident and any emission arising therefrom;

iii. Isolate the source of any such emission;

iv. Evaluate the environmental pollution, if any, caused by the incident;

v. Identify and execute measures to minimise the emissions/malfunction and effects thereof;

vi. Identify the date, time and place of the incident; and,

vii. Notify the Agency (in accordance with Condition 2.1) and all other relevant authorities including, where relevant, the Water Services Authority and Inland Fisheries Ireland.

6.5 Communications

a. The local authority shall establish, maintain and implement a communications program to inform the occupiers and owners of land and buildings adjacent to the closed landfill of the risk posed by landfill gas and its migration.

b. The communications program shall inform future occupiers and owners of properties what they can and should do to protect their property and health and members of the public.

c. The local authority shall communicate directly either in writing or in person at least once each year with said occupiers and owners of properties.

d. The local authority as part of the communications program publish gas monitoring data quarterly and water monitoring data biannually in a manner accessible to the public.

7 CONCLUSIONS

A capping system is required on all five sites as recommended by the ERA (Site No. 1 not formally covered by CoA requirements but treated in same manner) in order to break the pathway linkage between the source of environmental pollution (the landfilled waste) and the receptors (humans). The capping system will also reduce infiltration of rainwater and therefore contaminants leaching to groundwater and migration to receptors.

The proposals will effectively close off the main pathways of environmental pollution from the landfills and increase the safety of the proposed development area for the proposed new uses, including amenity uses on top of the landfills and residential uses adjacent to them, all in accordance with best practice. The development proposals however will not comprise remediation proposals for any existing environmental impacts of the landfill sites as this is the responsibility of Wicklow County Council and is outside of the scope of remediation measures necessary for the proposed new development.

There is evidence of a number of landslides in the vicinity of Site 2 on the north facing side of the river valley. In order to accommodate both the construction of the landfill capping system and the Phase 1 development, slope stabilisation measures will need to be installed where landslides have been identified. This will need to be done at an early stage in the Phase 1 development and prior to the installation of the capping system or loading/surcharging on the landfill areas.

As part of the ERA a CSM was prepared for each site using hydrogeological data from the GSI and site investigation data from trial pits, borehole, geophysical surveys, quality data and groundwater levels. The CSMs illustrate clearly the linkages between the sources of environmental pollution and their pathways to receptors.

Given the continuing presence of landfill gas both within and offsite at the various sites a Landfill Gas Management Strategy (Report Ref. JER8746) has been prepared. This identifies the gas protection measures which shall be installed to limit gas migration from the landfills.

Based on the investigations carried out to date, the sites can be classed as non-hazardous biodegradable landfills for the purposes of capping. The proposed capping system will be in accordance with the EPA guidelines and will include a low permeability barrier, surface water and gas collection layers and a minimum of 1m of cover soils.

A surface water drain will also be installed along the downgradient perimeter of Sites 1 and 2. This will be connected to the main Phase 1 development outfall to the County Brook (Fassaroe Stream).

Excavation of some small areas of waste to facilitate the installation of the gas management infrastructure will be required at Site 1 and 2. This waste will be utilised in reprofiling where possible, if this is not possible it will be removed off-site to a licenced facility. Mitigation and management measures will be required to be implemented during the excavation of waste.

As part of the landfill capping detailed design, a CQA Plan will be prepared for the installation of the capping system in accordance with the requirements of the *EPA Landfill Manual: Landfill Site Design*. The CQA Plan will set down the procedures for sourcing, transporting, placing, testing, repairing and protecting the capping materials prior to, during and after construction.

Following capping of the landfill and during and post-Phase 1 development construction, a monitoring programme for leachate, surface water, landfill gas and settlement shall be implemented to ensure that the systems installed are operating effectively.

Appendix A

Conceptual Site Models (extracted from ERA)