# Fassaroe Historic Landfills

## Non-Technical Summary



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# 1 SITE LOCATION

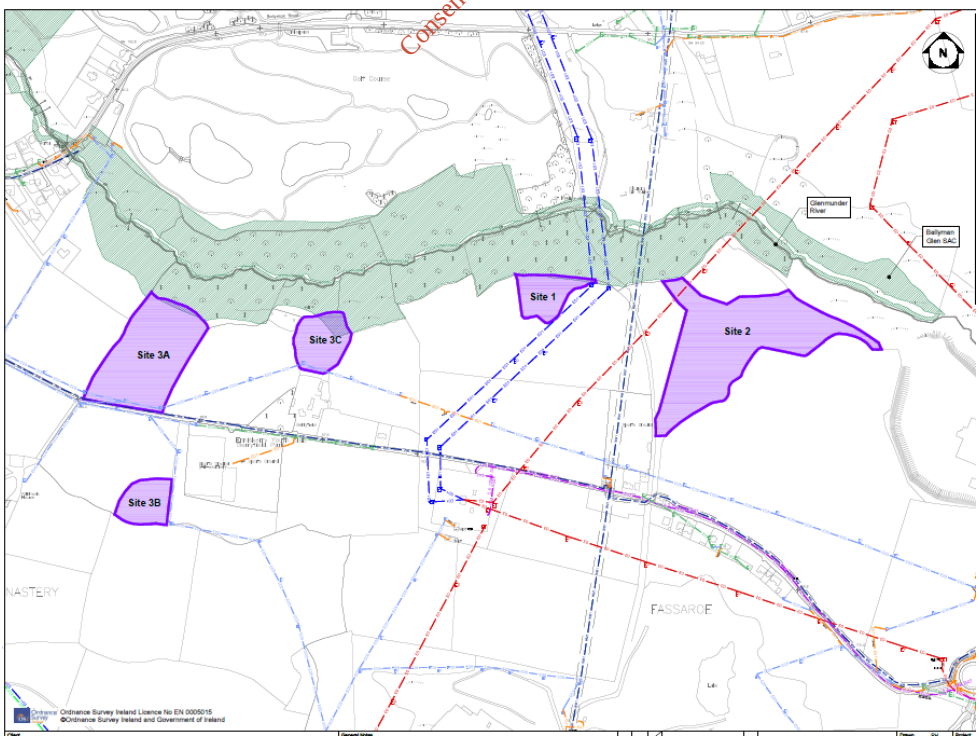
In 2017, RPS was appointed by Wicklow County Council to prepare documentation for a Certificate of Authorisation application to the Environmental Protection Agency for historic landfills located at Fassaroe, Bray, Co. Wicklow. The lands lie on the eastern side of the M11/N11 to the east of the existing built up area of Bray town. The general location is identified on **Figure 1.1** below.

**Figure 1.1: Site Location Map**


There are 5 No. distinct landfill sites at the overall Fassaroe lands. These are identified on **Figure 1.2** below.



**Figure 1.2: Location of 5 No. landfill Sites at Fassaore**



# 2 HISTORY OF THE SITE

## 2.1 SITE USE

It is understood that Sites 1, 2, 3A, 3B and 3C were previously operated as sand and gravel pits. Following the extraction activities, Wicklow County Council operated primarily municipal landfills at these sites between the early-1970s and the mid-1990s. The landfill sites were covered with topsoil and are now vegetated and form part of a wider agricultural landscape at Fassaroe.

The lands were subsequently sold to a development company. They form part of a strategic development land bank for future residential and commercial development. Based on the current zoning designations attached to the wider lands, the sites of the landfills will comprise of open space areas in the long term, with development adjacent.

## 2.2 TYPES AND VOLUMES OF WASTE

**Table 2.1: 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, 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, 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, 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, bones |
| **Total** | **8.6** | **625,500** | | | |

## 2.3 DURATION OF ACTIVITIES AND DATE OF CESSATION

| Site | Start Date | End Date | Duration |
|---|---|---|---|
| 1 | Uncertain – 1970s | Uncertain – Approx. 1976 / 1977 | Uncertain |
| 2 | 01/01/1979 | 31/12/1991 | 13 years |
| 3a | 01/01/1990 | 31/12/1996 | 7 years |
| 3b | 01/01/1994 | 31/12/1995 | 2 years |
| 3c | 01/01/1992 | 31/12/1995 | 4 years |

# 3 HYDROGEOLOGY AND ECOLOGY OF THE SITE AND SURROUNDING AREA

## 3.1 HYDROGEOLOGY

The five waste bodies on the Fassaroe site are situated above a thick sequence of unconsolidated sand and gravel deposits that were derived predominantly from limestone. The area surrounding the waste bodies are underlain by thin, well drained mineral (mainly basic) soils, with each waste body currently capped (c. 1 to 2m thick) with topsoil although the integrity of the cap is uncertain. The sand and gravel deposits are underlain by bedrock that principally comprises dark blue-grey slates of the Maulin Formation.

The unconsolidated limestone sand and gravel deposits are saturated and constitute Enniskerry groundwater body (IE_EA_G_038) that is designated a locally important gravel aquifer with a Water Framework Directive status of "Good". Although the bedrock is designated a locally important aquifer, it is expected to represent the base to the overlying Enniskerry groundwater body which is the principal aquifer unit in the local area.

The full thickness of the unconsolidated sand and gravel unit has not been established but it has been confirmed that it extends more than 35m below ground level. However, bedrock outcrop was noted in the river bed to the north of the site at an elevation of approximately 55mAOD.



Groundwater forming the Enniskerry groundwater body is typically located at relatively shallow depth in the granular sand and gravel deposits, with a flow direction that reflects surface topography. Groundwater level measurements demonstrate that a water-table is present within the sand and gravel deposits, with groundwater flow at all landfill sites orientated to the north or northeast, towards the County Brook River (Fassaroe Stream). The hydraulic gradients steepen towards the valleys and are flatter on the plateau. Groundwater underlying the site constitutes an important water environment receptor, although no private or public water supplies are situated down-hydraulic gradient from the former landfill sites.

The nearest surface water receptor is the County Brook River (Fassaroe Stream) which cuts a steep gorge (up to 40m deep) through the gravel deposits. Flow in the river is estimated to be approximately 20L/s (litres per second).

The nearest sensitive site is the Ballyman Glen SAC situated adjacent to the County Brook River (Fassaroe Stream). The Ballyman Glen SAC is designated on the basis of petrifying springs with tufa formation and alkaline fens. Lateral groundwater flow within the Enniskerry groundwater body emerges as springs and/or seepages in the SAC. These spring discharges feed the channels in which tufa deposition occurs, cross the alkaline fen and coalesce downstream to form more defined channels that ultimately discharge to County Brook River (Fassaroe Stream).

The hydrogeological conditions at each of the five waste bodies are as follows:

- **Site 1:** Surface area of 0.53 Ha with maximum proven depth of waste of 14m. Predominantly C&D waste with pockets of municipal waste. There is evidence of filling during the 1970's but the exact years of operation are uncertain. Filling did occur prior to 1977 and ended on or

about 19767 / 1977 but exact dates are not known. Active gassing of methane and carbon dioxide, although less than seen for other sites infilled with municipal waste. The leachate body appears to be perched above the groundwater observed in the Enniskerry groundwater body hence mixing of groundwater and leachate at the water table is expected. The closest spring to Site 1 (Spring SP2) is situated c. 85m down gradient of the site and characterised by clear flow, tufa formation and elevated (mildly alkaline) pH.

- **Site 2:** Surface area of 4.5 Ha with maximum proven depth of waste of 19m. Municipal waste deposited between 1979 and 1991. A discrete leachate body has been identified although there may be continuity between leachate and underling groundwater in the north of the site. Notable vegetation die back on / around landfill is recorded in 2015, with visible erosion and waste exposure in north of site. Active gassing of carbon dioxide and methane. The closest spring to Site 2 (Spring SP1) is situated c. 60m down gradient from site and is typically characterised by ochre, sheening and absence of tufa in most rounds.

- **Site 3A:** Surface area of 4.5 Ha with maximum proven depth of waste of 16m. Municipal waste deposited between 1990 and 1996. Active gassing of carbon dioxide and methane is observed. The waste mass appears to be unsaturated, with leachate only observed in the north of the site. The waste mass and leachate is therefore presumed to be perched above groundwater in the Enniskerry groundwater body with mixing of leachate and groundwater at the water table expected. The closest springs to Site 3A (Spring SP4 and SP5) are located c. 25m and c. 60m down gradient of the landfill site. SP4 characterised by ochre staining whereas SP5 characterised by clear water and tufa formation.

- **Site 3B:** Surface area of 0.44 Ha with maximum proven depth of waste of 4.9m. Municipal waste deposited between 1994 and 1995. Active gassing of carbon dioxide and methane is observed on the site. Notable vegetation die-back was recorded in 2015. The leachate body is assumed to be perched above groundwater in the Enniskerry groundwater body with mixing at the water table expected.

- **Site 3C:** Surface area of 0.9 Ha with maximum proven depth of waste of 13m. Municipal waste deposited between 1992 and 1995. Active gassing of carbon dioxide and methane is observed at the site. Notable vegetation die-back was recorded in 2015. The waste mass appears to be situated below the water table in the Enniskerry with groundwater and leachate in continuity. Several springs are situated down gradient of site 3C although none have been sampled.



## 3.2 ECOLOGY

A number of ecological surveys have been conducted at the landfill sites and surrounding lands. The following is an overview of the habitats identified in the general Fassaroe area in which the 5 No. landfill sites are located.

The predominant habitat type across the general Fassaroe area is arable land used for growing crops. The main exceptions to this in the area between Berryfield Lane and Ballyman Glen are due to the presence of Landfill Sites Nos. 1, 2, 3A and 3C, along with amenity areas and existing residential properties. Much of the land to the south of Berryfield road also comprises arable agricultural lands, along with some improved grassland, existing playing pitches and ESB substation lands. The lands within Ballyman Glen to the north of the landfill sites is composed variously of different types of woodland and scrub primarily.

Site No. 1 now comprises of scrub, Site Nos, 2 and 3B of improved grassland, and Site Nos. 3A and 3C of dry meadow / grassy verges.

Four stands of Japanese Knotweed were noted during the field surveys undertaken by ecologists between 2016 and 2018. These stands are located primarily within the scrub area of Site No. 1; there is also a stand to the adjacent to the north-eastern boundary of Site No. 2. Butterfly Bush (*Buddleja davidii*) is present scattered throughout the southern edge of woodland in Ballyman Glen, and is also present in the same area as the Japanese Knotweed at Site No. 1. No invasive species were recorded in the vicinity of site Nos. 3A- 3C.

The nearest surface water receptor to the landfill sites is the County Brook (Fassaroe Stream) which flows through Ballyman Glen SAC, (referred to as the County Brook stream by the EPA). It is noted that the County Brook (Fassaroe Stream) itself is not included as part of the Ballyman Glen SAC designation. The County Brook (Fassaroe Stream) is not a salmonid river but drains to the River Dargle, a designated salmonid river under S.I. No. 293/1988 - European Communities (Quality of Salmonid Waters) Regulations. The County Brook (Fassaroe Stream) joins the Dargle approximately 1km downstream of the proposed development area and ultimately flows into the Irish Sea at Bray, a further 2km downstream. The Dargle River and its tributaries support resident brown trout, a nationally significant population of sea trout (both *Salmo trutta*) in addition to a significant and biologically valuable population of Atlantic salmon (*Salmo salar*, listed under Annex II and V of the EU Habitats Directive). Fishery habitat and water quality are regarded as good to excellent for all salmonid life stages throughout the Dargle system and must be protected at all times.



A number of protected species have been recorded in the vicinity of the landfill sites at Fassaroe and / or are likely to be found in the wider area. Red Deer, Sika Deer and Fallow Deer have all been recorded in the general vicinity and wider area of the landfill sites. Deer are likely to use Ballyman Glen. It is quite likely that hedgehog species occur within the study area. They are found in particular within woodlands, hedgerows, gardens and meadows. While no otters were identified during field surveys in 2016 they are widespread in Ireland and it is likely that they utilise Ballyman Glen and the County Brook that runs through it for foraging and shelter. Pine Marten are similarly likely to use this area. A number of badger setts were found in the wider Fassaroe area though away from any of the landfill sites. This includes areas to the south / southwest of the landfill sites. Badger activity has also been observed in the heavy scrub areas of Ballyman Glen where additional setts are likely to exist. Bat activity has been recorded throughout the Fassaroe area in the vicinity of the landfill sites. The majority of the activity was of Pipistrelles, which were noted along the existing road, along hedgerows, in farmyards and around houses. There was also considerable Leisler's bat activity in the area and it is likely that Leisler's bats feed throughout the study area and roost in an area associated with Rannoch House to the southwest of the landfill sites. No EU protected bird species were recorded at the site.

## 3.3 PROTECTED SITES

There are 10 SACs and 4 SPAs within 15km of the proposed site. There is no connectivity between the landfill sites and 7 No. of these sites. There is remote and tenuous connection only to 5 No. of these sites. 2 No. are close to or within the landfill sites and are directly or indirectly connected. These are as shown on **Table 3.1** below.

**Table 3.1: EU Protected Sites Close to / Within and Connected to the Landfill Sites**

| Designated Area | Designation and Site Code | Qualifying Interests | Approximate Distance from Closest Landfill Site and Surface water Groundwater Connectivity |
|---|---|---|---|
| Ballyman Glen | SAC (000713) | **Annex I Habitats**<br>Petrifying springs with tufa formation (*Cratoneurion*) [7220]<br>Alkaline fens [7230] | Within and directly adjacent |
| Bray Head | SAC (000714) | **Annex I Habitats**<br>Vegetated sea cliffs of the Atlantic and Baltic coasts [1230]<br>European dry heaths [4030] | 2.9km east, indirectly connected via County Brook (Fassaroe Stream) which flows into the River Dargle and then into Killiney Bay. |

### 3.3.1 Ballyman Glen SAC (000713)

Ballyman Glen SAC is situated adjacent to and slightly overlapping with the site of the subject landfill remediation works, approximately 3km north of Enniskerry, where it straddles the Wicklow and Dun Laoghaire Rathdown county boundary. The Glen is characterised by pastoral ground sloping up from a small stream (the County Brook) that winds its way along the Glen floor. The site has been designated as an SAC due to the presence of petrifying springs with tufa formation (*Cratoneurion*) [7220], a priority Annex I habitat and Alkaline fens [7230]. The fen vegetation at this site is well developed, with an unusually large number of sedge species present. The presence of alkaline fen and of petrifying spring/seepage areas is also particularly notable, as these habitats are listed, the latter with priority status, on Annex I of the E.U. Habitats Directive. Fens are rare in Wicklow and Dublin, and this is one of only two sites in Wicklow for the Narrow-leaved Marsh orchid.



### 3.3.2 Bray Head SAC (000714)

This coastal site is situated in the north-east of Co. Wicklow between the towns of Bray and Greystones. The SAC has been designated specifically for the presence of two Annex I habitats, namely Vegetated Sea Cliffs [1230] and Dry Heath [4030]. Dry heath is the principal habitat over much of Bray Head, while Calcareous dry grassland, typically species-rich, occurs on deposits of glacial till. Rocky sea cliffs form most of the seaward boundary at this site and extend for approximately 2 km. Steep clay cliffs extend southwards for a further 1 km, with a small area of clay cliff also at the northernmost part of site. The lower cliffs are fairly steep in places but above the track they are less steep, and often support heath or dry grassland vegetation. A stand of mostly native woodland occurs in the northern part of the site. Other habitats which are found at this site include bedrock shore, a sandy/shingle beach and an area of shallow marine water. Bray Head is of high conservation importance as it has good examples of two habitats (sea cliffs and dry heath) listed on Annex I of the E.U. Habitats Directive. It also supports a number of rare plant species and has ornithological importance.

# 4 RISK CATEGORY OF THE SITE

The initial Risk Categories assigned to each of the landfill sites in accordance with the Tier 1 Risk Prioritisation process are as shown in **Table 4.1**. This risk categorisation was the driver behind the Tier 2 Site Investigation and Testing undertaken to better understand the risk to known receptors, both environmental and human health.

**Table 4.1: Risk Categories for Each Landfill Site**

| Site | Risk Category | Level of Risk | Main Factors Affecting Risk Rating |
|---|---|---|---|
| 1 | Class C | Low | ▪ Primarily C&D Waste |
| 2 | Class A | High | ▪ Municipal Nature of the Waste;<br>▪ Large extent of the waste;<br>▪ Proximity to SAC Site;<br>▪ Potential for leachate migration to surface water and to Ballyman Glen SAC; and<br>▪ Potential for lateral gas migration to a human presence. |
| 3A | Class A | High | ▪ Municipal Nature of the Waste;<br>▪ Proximity to SAC Site;<br>▪ Potential for leachate migration to surface water and to Ballyman Glen SAC; and<br>▪ Potential for lateral gas migration to a human receptor. |
| 3B | Class C | Low | ▪ Municipal Nature of the Waste;<br>▪ Modest extent of waste; and<br>▪ Proximity to receptors - Potential for lateral gas migration to a human receptor (buildings within 100m of site). |
| 3C | Class B | Moderate | ▪ Municipal Nature of the Waste;<br>▪ Proximity to SAC Site;<br>▪ Potential for leachate migration to surface water and to Ballyman Glen SAC; and<br>▪ Potential for gas migration to a human presence. |



Following completion of the Tier 2 ground investigation and associated monitoring the prinicple "pollutant linkages" that link leachate "sources" to key environmental and human "receptors" were re-evaluated. While risk categories were not altered, additional information identified the following pollutant linkages as being most significant with respect to the landfill sites:

- Vertical and horizontal transport of leachate Groundwater Dependent Terrestrial Ecosystem (GWDTE) – High Risk;
- Risk to site users from Vertical migration of Landfill Gas - Moderate to High Risk;

- Risk to adjacent building / structures from lateral migration of Landfill Gas – Moderate to High Risk;
- Vertical and horizontal transport of leachate to groundwater (Enniskerry groundwater body) – Moderate Risk;
- Vertical and horizontal transport of leachate to surface water body – Moderated Risk;
- Risk to adjacent building / structures from lateral migration of Landfill Gas through groundwater - Low to Moderate Risk; and
- Asbestos containing material to current / future site users – Low to Moderate Risk.

# 5 EXISTING ENVIRONMENTAL IMPACT OF UNREMEDIATED SITES

## 5.1 GROUNDWATER AND GROUNDWATER DEPENDENT RECEPTORS

Infiltration of rainwater through the waste bodies and decomposition of the waste has resulted in development of significant leachate bodies with the waste mass at each landfill site.

Groundwater has been shown to have been impacted by leachate generated on the landfill sites, with leachate plumes identified beneath the waste bodies. The effect of leachate extends a considerable distance below the waste bodies and migrate in the direction of the groundwater flow regime, generally to the north-east. Similarly water quality has been affected at a number of springs situated down-hydraulic gradient from the landfill site, although many springs do not show an absence of any impact being characterised by clear flow and active tufa formation.

The landfill sites have been shown to have the potential to affect surface water quality within the County Brook river (Fassaroe Stream) although water quality effects are not routinely observed and are largely restricted to upstream sections situated upstream of the landfill sites. It seems that the high dilution capacity within the County Brook River does afford protection to that watercourse from possible and localised effect of the landfills. These observations are consistent with the continued WFD Status of the County Brook Stream, which is classified as 'good'.

The evidence collected to date demonstrates that the five landfill sites have the potential to affect conditions within the alkaline fen of the Ballyman Glen SAC and its associated drainage system. It is possible that this affect could have a localised impact on tufa forming potential and water quality within a small number of the streams situated downstream of affected springs, as evidenced at two springs.



The results of the Detailed Quantified Risk Assessment suggest that the mixing of leachate with laterally flowing groundwater in the saturated gravel aquifer affords significant protection to the SAC, its drainage system and watercourses situated down gradient of the landfill sites. The DQRA demonstrates that most significant effects of the landfills is expected to be restricted to those areas where leachate body and groundwater are found to be in direct continuity (i.e. submerged landfill waste mass) although this is only occurs locally at some of the landfill sites.

## 5.2 GAS

The review of the gas regime at the each landfill site demonstrates gas generation by the waste mass within the landfills. The main pathway for gas migration from the waste materials is considered to be through the permeable superficial deposits, the potentially poor integrity of current landfill capping, with limited contributions through groundwater.

An assessment of the risk associated with gas emissions has identified a variety of gas protection measures that will be needed to protect human health. These include gas barriers to prevent migration of gases from the landfills where further monitoring cannot dismiss the risk from gas within the proposed development areas. On this basis a gas management strategy is required for the developed for the site, taking account of the available data and any future development layout. This

strategy should identify the gas protection measures that can be installed to limit gas migration from the landfills and the protection measures that will be required to properties, supported by relevant appraisal / assessment.

## 5.3 HUMAN HEALTH RISK

An evaluation of the risk that contaminants of concern present within capping materials and landfill materials pose to human health risk has been evaluated and shown to be generally below the selected screening criteria for a public open space (parks) use. Locally elevated concentrations of PAHs within the landfill materials have been identified in Site 1, with elevated concentrations of lead and PAHs within the landfill materials in Site 2. In addition, asbestos containing materials have been encountered at 1 location within the landfill materials in Site 1. Finally, elevated concentrations of lead and PAHs within the landfill materials in Site 2 and elevated concentrations of PAH within the capping materials in Site 2.

Despite the presence of elevated concentrations of contaminants and the presence of asbestos within the landfilled materials, it is not considered that future site users are likely to be exposed to the contamination due to the depth at which the contamination is present (>1.0 m). With regard to the PAH contamination within the capping materials within Site 2, additional sampling may be considered to further determine levels of contamination within these materials.

## 5.4 PROTRUSION OF WASTE / SLIPPAGE

When the landfill operations at Fassaroe were ceased the sites were covered with soil / topsoil material. There are areas along the northern boundary of a number of the landfill sites where waste can be seen to be protruding.

At Site No. 2 and also potentially at 3A and 3C there is evidence of slope slippage on the northern side of the sites where they adjoin / overlap with Ballyman Glen. Waste has current potential to slip into the Glen which is an SAC.



## 5.5 ECOLOGY

The main habitat type in the wider Fassaroe area is arable land. The habitat types of the former landfill sites have been impacted by their historic use and the extent of remediation previously undertaken in the form of a topsoil capping. Site No. 1 now comprises of scrub, Site Nos, 2 and 3B of improved grassland, and Site Nos. 3A and 3C of dry meadow / grassy verges.

No protected species of flora or fauna have been identified on the landfill site, but a number have been identified in the wider Fassaroe area.

## 5.6 PROTECTED SITES

### 5.6.1 Ballyman Glen SAC

As noted above two qualifying interests of Ballyman Glen SAC are petrifying springs with tufa formation and alkaline fens.

Three petrifying springs with tufa formation were previously recorded in Ballyman Glen in 2013 for work undertaken on behalf of the NPWS. Two further springs were identified during field work undertaken by RPS with visual evidence of ochre staining which indicates contamination from leachate. Monitoring results show that there is a difference in chemistry between the two sets of springs (i.e. those identified as petrifying springs and those with ochre deposits). In general, springs characterised by ochre staining also had the highest concentrations of ammoniacal nitrogen (albeit not elevated in all rounds) and lower (average) pH. A lower pH is generally consistent with a reduced calcium carbonate saturation of groundwater and hence a reduction in the potential for tufa forming at the springs. The tufa springs had lower ammonia and higher pH which allows a higher calcium carbonate saturation level which then promotes the precipitation of tufa. It is concluded therefore that the existing landfill waste at certain sites (i.e., Site 2 and Site 3A) may have had a localised effect on tufa formation on some of the springs. The results also showed that the water quality at the three petrifying springs is compromised with some elevated BOD and metals concentrations.

An area of rich fen and flush was identified to the north east of landfill site Nos. 3A and 3C, during the ecological survey conducted in June 2016 by RPS. The area of fen and flush occurred near the southern boundary of Ballyman Glen, within a woodland opening. This area supported an extensive cover of Great Horsetail but also had a relatively diverse assemblage of fen species or species indicative of flowing water. No particular impacts of the existing landfill sites are evident at the fen.



### 5.6.2 Bray Head SAC

No impacts of the landfill sites on Bray Head SAC are identified.

# 6 PROPOSED REMEDIATION

A remediation options appraisal was undertaken and supported by further detailed quantitative risk assessment. The appraisal identified the following remediation options as likely to be most suited to addressing the pollutant linkages identified on the Fassaroe site:

- Waste Removal;
- Engineered Low Permeability Landfill Cap and Gas Protection Measures for Land-use;
- Permeable Reactive Barriers; and
- Gas Protection Measures.

Although waste removal would remove the contamination source, thus severing the pollutant (SPR) linkage entirely, short term impacts at the SAC and watercourse could be exacerbated and stability issues may affect its delivery. Notwithstanding the high cost of full waste removal it is uncertain whether there are appropriate sites for the disposal of the volume excavated materials that would be required. It is for this reason an engineered low permeability capping solution allied with gas management and controlled water / ecological monitoring would represent the preferred strategy for managing the risks associated with the historical landfill sites, where a net betterment approach is acceptable to the regulator.



## 6.1 CAPPING PROPOSAL

Based on the Environmental Risk Assessment undertaken the capping of the five landfills with a low permeability barrier system is considered the preferred remedial option. Capping 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 the landfills and result in a net betterment to the water environment by improving water quality without significant reducing groundwater flow to the Ballyman Glen SAC. Furthermore an engineered low permeability capping system would also enable landfill gas management measures for any future development of the sites.

The proposed capping works will be carried out in accordance with the Environmental Protection Agency *Landfill Manual: Landfill Site Design* (EPA 2000). Based on the investigations carried out to date at each of the five sites, the sites can be classed as non-hazardous biodegradable landfills for the purposes of capping.

In all landfill areas to be capped the following minimum capping system will be installed (in order of placement):

- Regulation layer to prepare the existing ground to receive the capping system
- Gas collection layer;
- 1mm thick low permeability plastic (LLDPE) liner
- Surface water collection layer:
- 850mm Subsoil layer; and
- 150mm Topsoil layer.

Given the mixed use zoning of the lands, it is possible in the future that development of some infrastructure other than open space (e.g. an access road) may be required within part of the footprint of one of the landfills. Should such need arise, it is likely that minor quantities of waste would need to be excavated and disposed offsite in order to accommodate suitable foundations for such infrastructure. In any event, a risk assessment and implementation of appropriate mitigation measures would be required during such works.

## 6.2 GAS MANAGEMENT

The five sites lie within the area of Fassaroe which is zoned for major new development under the Bray Municipal District Local Area Plan 2018. The lands are zoned for residential high density new development with existing residential, open space, active open space, and neighbourhood centre. Protection measures will need to include gas barriers to prevent migration of gases from the landfills where further monitoring cannot dismiss the risk from gas within existing and any future proposed development areas.

With the installation of the capping system, 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 off-site receptors. To prevent this occurring a gas management system will be incorporated into the remediation measures on each of the five sites. The proposed landfill gas management measures would typically consist of a perimeter trench known as a Virtual Gas Curtain (VGC) around each of the five landfill sites. The VGC forms a low pressure or low gas concentration area relative to the surrounding gassing ground to encourage gas to flow towards the VGC barrier, and allow subsequent venting to atmosphere.



A tailored gas management strategy is proposed to be developed for the site, taking account of the available data and any future development layout. This strategy should identify the gas protection measures that can be installed to limit gas migration from the landfills and the protection measures that will be required to future properties, supported by relevant appraisal/ assessment.

## 6.3 LEACHATE MANAGEMENT

The generation of leachate will be significantly reduced by the installation of the capping system. 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 layers. Based on the waste composition and existing cover materials it is expected that these breakouts would be minor. It is proposed that the capping system layers will be installed such that any breakout would be redirected back into the waste body.

## 6.4 SURFACE WATER DRAINAGE

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 dedicated filter 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. This will consist of a perforated pipe installed at a depth of 1.2m bgl, within a granular stone-filled trench. This surface drain will be laid at grade with the existing site topography and will be connected by a series of manholes directing surface water by gravity to two low points (Site 3A/3A and Site 1/2) prior to outfalling to the river. Given the location of Site 3B, away from the river valley alternative outfall arrangements will need to be incorporated at detailed design stage for management of surface water runoff from the capped landfill.

## 6.5 SLOPE STABILISATION

Slope failures and potentially unstable slopes have been recorded along the northern boundary of landfill Site 2 above Ballyman Glen. Anecdotal evidence also suggests that landfill Site 3A and 3C have previously suffered slope failures/slips on their northern boundaries along the Glen and SAC. In order to accommodate both the construction of the landfill capping system and any subsequent development, slope stabilisation measures will need to be undertaken at the affected landslip areas and potentially unstable fill areas prior to the installation of the capping system.

## 6.6 LANDSCAPING

As the afteruse of the five sites will require the establishment of vegetation, there needs to be a recuperation period during which the soil is allowed to recover from the movement, storage and replacement of materials during the construction period. Following this, 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.

# 7 POTENTIAL IMPACTS OF REMEDIATED SITES

## 7.1 GROUNDWATER AND GROUNDWATER DEPENDENT RECEPTORS

The new capping system will reduce the infiltration of rainwater through the waste and therefore reduce the volume of leachate entering the underlying aquifer and ultimately the stream. The results of the DQRA demonstrate that a significant net betterment, in terms of water quality, can be achieved by controlling infiltration using an engineered low permeability cap. The construction of new engineered capping layer has the potential to reduce flow to the down-gradient flows by up to 7% and hence may affect the hydrology of the down-gradient tufa springs.

Although a reduced spring discharge may occur as a result of the capping, this effect would be mitigated by the expected improvement in groundwater quality which will lead to the potential for improved tufa depositions rates or new tufa deposits.

Where the runoff from the capping layer can be reintroduced to groundwater, such that it does not re-saturate the waste and is sufficiently far enough up gradient from the springs to allow the hydrochemistry to equilibrate with the in-situ groundwater, this will mitigate the potential reduction in groundwater recharge the impact on the spring hydrology.

## 7.2 LANDFILL GAS GENERATION

Through the delivery of a gas management strategy the appropriate gas protection measures to be installed with capping shall be identified. These measures shall sever active pollutant linkages, thus minimise risk for future site users. The measures implement will depend on the future land-use proposed for the landfill sites and their immediate surroundings.



## 7.3 HUMAN HEALTH RISK

A new, clean cap should be placed to mitigate potential ground gas risks and / or risks to the water environment at this location. This cap will also mitigate risk to future site users by preventing exposure to the contamination.

It is considered however that the concentrations of contaminants identified during the ground investigation are unlikely to constitute a risk to construction workers during any future development where appropriate measures are adopted. Due to the heterogeneous nature of landfilled materials however, there is a possibility that asbestos and areas of gross contamination may be present and a suitable watching brief should be employed during construction for any such contamination. 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. Appropriate procedures should also be in place to remediate any such contamination encountered during construction in line with the 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.

## 7.4 ECOLOGY

The proposed remediation will not impact on any habitats of significance as they currently comprise of improved grassland, scrub and dry meadow / grassy verges. The remediated sites will be returned to grassland and possibly amenity use in the future.

Improvements to water quality within the County Brook as a result of the remediation will have slight positive benefits for aquatic ecology in the stream and in the Dargle River into which it flows.

While a number of protected species have been identified in the wider Fassaroe area and beyond no adverse impacts on same are identified as a consequence of the proposed remediation. No protected species have been recorded on or within the immediate vicinity of the landfill sites.

### 7.4.1 Protected Sites

The landfill sites are connected to 2 No. protected sites only. There is no potential for impact on any other EU sites identified within 15km of the landfill sites. The potential impacts on the Ballyman Glen SAC and Bray Head SAC are outlined below, along with mitigation measures proposed and finally the residual impacts predicted.



#### 7.4.1.1 Ballyman Glen SAC

The proposed remediation works could potentially impact on some of the key aspects of ecological importance for these sites. The petrifying springs with tufa formation (which is a protected habitat type – Annex I), could be impacted by alterations to groundwater quality due to construction works. Petrifying springs with tufa formation which are fed by groundwater and an impact on groundwater quality due to any construction pollutants could impact on the springs and tufa formation in turn. This would be a short term negative potential impact. Rigorous sediment, erosion and pollution control measures however will be implemented for the proposed works, and good practice measures for the prevention of pollution of groundwater and surface waters will be employed at all times during the construction and post-remediation period of the development. In addition, following completion of the physical works the capping system will result in a reduction of leachate generation in the groundwater feeding the petrifying spring habitat which is a long term positive impact. As noted above there is evidence of current contamination (ochre staining) at two spring locations. On balance then with the construction mitigation measures employed, combined with the long term predicted impacts due to improved water quality, the overall residual impact on the quality of the groundwater feeding the springs is anticipated to be positive.

Alterations to ground water quality during construction also have potential to negatively impact on alkaline fens (also protected habitat) which it is feeding. As noted above, these potential negative impacts during construction can be mitigated. The long term benefits from improved groundwater quality due to the placing of the cap on the landfills will have an overall positive long term impact on the alkaline fens similar to the petrifying springs.

The capping of the landfills will reduce the amount of water which currently recharges to groundwater within the groundwater catchment area. As the springs and tufa formation and alkaline fens are fed by groundwater, alterations to groundwater levels have potential for impact on the habitat. Given the extent of landfill cap in the context of the overall catchment area however,

the expected loss to groundwater is estimated to result in a relatively modest drop in level of groundwater within Ballyman Glen. The reduced level will still be above the level (location) of the petrifying springs and alkaline fens and accordingly, combined with the long term improvements in water quality, its impact is not predicted to be significant on the springs or tufa formation.

The physical works have potential for direct impact on the protected habitat by degradation (due to excavation and earthworks leading to suspended solid runoff), or loss (by direct impact on habitat due to works being carried out within the SAC boundary. Given the construction mitigation and good practice measures specified however along with the restricted intrusion of the works area into the SAC (and away from the protected habitat types), the overall impact is not deemed likely to be significant and no direct impacts of the protected habitats are identified.

#### 7.4.1.2 Bray Head SAC

No impact on the Bray Head SAC is identified as a result of the proposed remediation measures.