FEHILY TIMONEY

CONSULTANTS IN ENGINEERING,
ENVIRONMENTAL SCIENCE & PLANNING

TIER 2 RISK ASSESSMENT
HISTORIC LANDFILL AT ARDFERT, CO. KERRY

Prepared for: Kerry County Council

Comhairle Contae Chiarraí
Kerry County Council

Date: August 2021

Core House, Pouladuff Road, Cork,
T12 D773, Ireland

T: +353 21 4964133 | E: info@ftco.ie

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www.fehilytimoney.ie

Tier 2 Risk Assessment

Historic Landfill at Ardfert, Co. Kerry

REVISION CONTROL TABLE, CLIENT, KEYWORDS AND ABSTRACT
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Abstract: This report represents the findings of a Tier 2 assessment carried out at Ardfert Historic Landfill, Co. Kerry, conducted in accordance with the EPA Code of Practice for unregulated landfill sites.

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EXECUTIVE SUMMARY

A Tier 2 study was conducted by Fehily Timoney (FT) in accordance with the EPA CoP for Ardfert Historic Landfill.

The study consisted of a desktop study, site walkover, topographical survey, geophysical survey, intrusive site investigation works and environmental monitoring. These works informed the development of the CSM and risk screening model.

A volume calculation based on the results of the geophysical survey indicate an interred waste volume of approximately 5,025 m^3 (7,015 tonnes) at the site.

Trial pitting confirms waste material is deposited near the surface with a shallow an impermeable topsoil / subsoil cover present across the site.

Analysis of waste samples from the trial pits excavated, when assessed against the inert waste acceptance criteria indicated that much of the waste material within the site can be classified as typically inert.

Laboratory analysis of groundwater samples from the monitoring well BH01 installed at the site report ammoniacal nitrogen (as N), chloride and potassium concentrations which exceed the guideline OTV limit values. Based on the presence of elevated ammonia, chloride and potassium concentrations, the landfill waste body appears to be impacting groundwater quality downgradient of the site.

The desk study conducted shows the nearest groundwater protection zone (outer source protection zone) is located approximately 270m north of the site at its closest point. This groundwater protection zone relates to the Ardfert Group Water Supply Scheme/Ardfert South Boreholes. The potential presence of karstified bedrock below the waste body may represents a risk of leachate migration northwards towards the outer source protection zone.

Analysis of two rounds of surface water sampling from the River Tyshe found all results to be below the MAC (1989) and EQS (2009) guideline limit values in all assessments. The results indicate the landfill is not having an impact on surface water quality.

Based on the results of the Tier 2 site assessment, the site can be classified as a **Moderate Risk Classification (Class B)**. The principal risks identified on the site are the risk posed to underlying groundwater aquifer from the migration of leachate from the waste body.

Based on the results of the initial Tier 2 assessment the site is classified as Moderate Risk. For a moderate-risk site, the CoP indicates that a Tier 3 Environmental risk assessment be undertaken including a Detailed Quantitative Risk Assessment (DQRA). Further, the site be regularised/authorised in accordance with current waste management legislation.

FT recommends that a Tier 3 DQRA be undertaken for the site in conjunction with an application for a Certificate of Registration for this site.

1. INTRODUCTION

1.1 Background

Ardfert Historical Landfill is in a relatively small area of open land located at the northern edge of Ardfert village, immediately north-west of Ardfert Cathedral of St. Brendan and c. 240m north-west of centre of Ardfert village. Ardfert village is located approximately 8km north-west of Tralee town. Available evidence suggests that the site closed, and landfilling ceased in 1980. Fehily Timoney (FT) understands that since its closure the site has reverted to private ownership, with the lands currently used for agriculture. The site has been capped with a soil cover, but no other remediation works have been carried out.

Kerry County Council (KCC) is required to complete a tiered risk assessment of unregulated waste disposal sites in accordance with the Environmental Protection Agency (EPA) code of practice for unregulated waste disposal sites.

A Tier 1 Assessment completed by KCC in September 2009 determined the site has a risk classification of Moderate (Class B). The highest normalised scores of 50% were calculated for SPR 3, SPR5 and SPR11. These scores were assigned based on the moderate risk of leachate impacting on private groundwater wells, impact on the underlying aquifer groundwater quality and impact of vertical landfill gas migration on human receptors.

Following a site walkover by FT in February 2019 it was noted that the location of the KCC site walkover was incorrect. The KCC report had identified the potential waste body in an adjacent field <10-20m away.

For completeness, FT in completing this Tier 2 prepared a revised Tier 1 assessment in October 2019 which also determined a site classification of Moderate - Class B. The principal risk identified on the site were leachate migration via a groundwater pathway to groundwater receptor.

A copy of FT's Tier 1 assessments is included in Appendix 1.

1.2 Scope of Works

FT's scope of work was to undertake a Tier 2 assessment of the site in accordance with the EPA Code of Practice (CoP) 2007: *Environmental Risk Assessment for Unregulated Waste Disposal Sites*. This approach required the completion of the following:

- Desk Study
- Site Walkover
- Intrusive Site Investigation
- Leachate Testing
- Environmental Risk Assessment (ERA)
- Geophysical and surveying to estimate extents and depths of waste
- Topographical Survey
- Development of a conceptual site model (CSM)

As part of the initial desk study, a review of available information was undertaken. This was followed-up with a site walkover by FT personnel. The desk study and site walkover were used to determine the locations for the intrusive site investigation.

FT appointed Causeway Geotech Limited (CGL) to conduct the intrusive site investigation which included; excavation of trial pits and the installation of two onsite groundwater monitoring boreholes.

A full geotechnical report is included in Appendix 2 of this document.

Minerex Geophysics Limited (Minerex) were appointed by FT to undertake a geophysical survey of the site. Geophysical surveying including EM31 Ground Conductivity, 2D-Resistivity and Seismic Refraction surveying methods.

The full geophysical survey report is included in Appendix 3 to this document.

The purpose of the geophysical study was to attempt to define the vertical and lateral extents of any waste body. Trial pits were excavated to provide a preliminary assessment of the volume, extent and type of waste infilled at the site. The groundwater monitoring boreholes were installed to assess the impact, if any, of the onsite groundwater.

Laboratory analysis of waste samples and groundwater were conducted to assess and quantify any potential or ongoing environmental impacts.

The information gathered from the desk study, intrusive site investigation and geophysical survey were used to inform the development of the CSM and the Environmental Risk Assessment (ERA). This report presents the findings of the assessment.

2. DESK STUDY

2.1 Introduction

The desk study included the review of the following literature sources and websites:

- Geological Survey of Ireland, Groundwater Web Mapping: www.gsi.ie
- Environmental Protection Agency Maps: http://gis.epa.ie/Envision
- National Parks and Wildlife Service Map Viewer: www.npws.ie
- DoHPLG/EPA/Local Authority maps: www.catchments.ie
- Kerry County Council Site Plans and Drawings
- BS 5930: 1999, Code of Practice for Site Investigations
- BS 10175: 2000, Investigation of Potentially Contaminated Sites – Code of Practice
- Protection of New Buildings and Occupants from Landfill Gas (1994).
- Guidance on the Authorisation of Discharges to Groundwater, EPA 2011

A desktop review of available documentation for the site was conducted followed by a site walkover on 14th February 2019. A copy of the site walkover checklist and photolog is included in Appendix 5.

2.2 Desk Study

This section of the report presents the findings of the desk study.

2.2.1 Site Description and On-Site Conditions

The site is approximately 1.01 hectares. The site is bounded to the west by the R551 road and further west beyond the road is agricultural land. To the south and east the site is bound by lands connected to Ardfert Cathedral of St. Brendan. An access road runs along the northern and eastern boundary of the site. The site is bound by agricultural land to the north. A single dwelling is also located on this land.

The location of the site is shown in Figure 2.1.

2.2.2 Previous Studies

A Tier 1 environmental risk assessment (ERA) of the Ardfert Historic Landfill was undertaken by FT based on the risk assessment methodology approach set out in the EPA CoP.

The assessment required the completion of a:

- Desktop Study;
- Site Walkover;
- Environmental Risk Assessment (ERA); and,
- Development of a Conceptual Site Model (CSM)

The highest normalised score of 50% was calculated for SPR5. This score was assigned based on the moderate risk of leachate migrating into the underlying aquifer and impacting groundwater quality.

FT submitted the report to KCC in October 2019. A copy of this assessment is included in Appendix 1.

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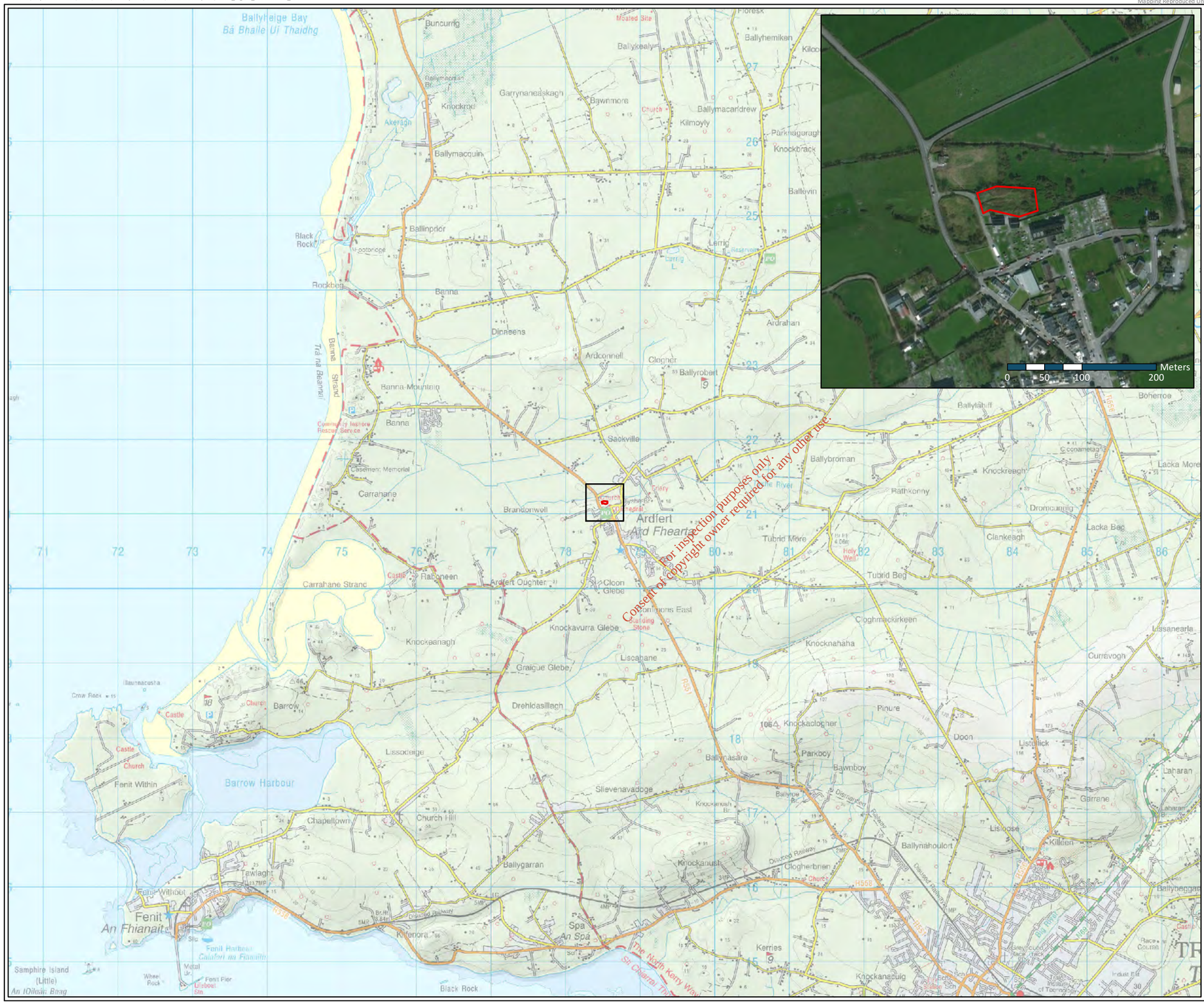

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FIGURE NO:	2.1
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REVISION:	0
DATE:	29/10/2019
PAGE SIZE:	A3

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2.2.3 Topography

The landfill is located within a relatively rural setting on the edge of Ardfert village which is located ca. 8km north-west of Tralee town. Regional topography is characterised by relatively flat land from the western side of Ardfert town gently slope to the west towards the coast.

In contrast, elevations increase further east and south-east from Ardfert with the Stack Mountains located approximately 9 to 10 km east of the village. With respect to local topography the site itself is undulating sporadically across the entirety of the site and ground is generally uneven. The site is at an elevation of approximately 10 m above Ordnance Datum (OD).

2.2.4 Geology

Drift/Quaternary Geology

The Quaternary Map provided by GSI Online identifies the quaternary sediments at the site as 'Karstified bedrock outcrop or subcrop (KaRck)' indicating shallow rock and outcrops dominate locally. To the north and south of this band of rock outcrop, quaternary sediments are characterised as 'Till derived from Namurian sandstones and shales'. Further north alluvium deposits are present following the Tyshe River. In general, wet, poorly drained soils and peats occupy the landscape. The GSI identifies areas of cut-over peat beyond the southern site boundary. See Figure 2.2.

During the installation of boreholes during the site investigation, the presence of silty gravels is described in the driller's logs to a depth of approximately 1.10 m BGL at borehole GW01, as referenced in the CGL borehole logs, Appendix 2.

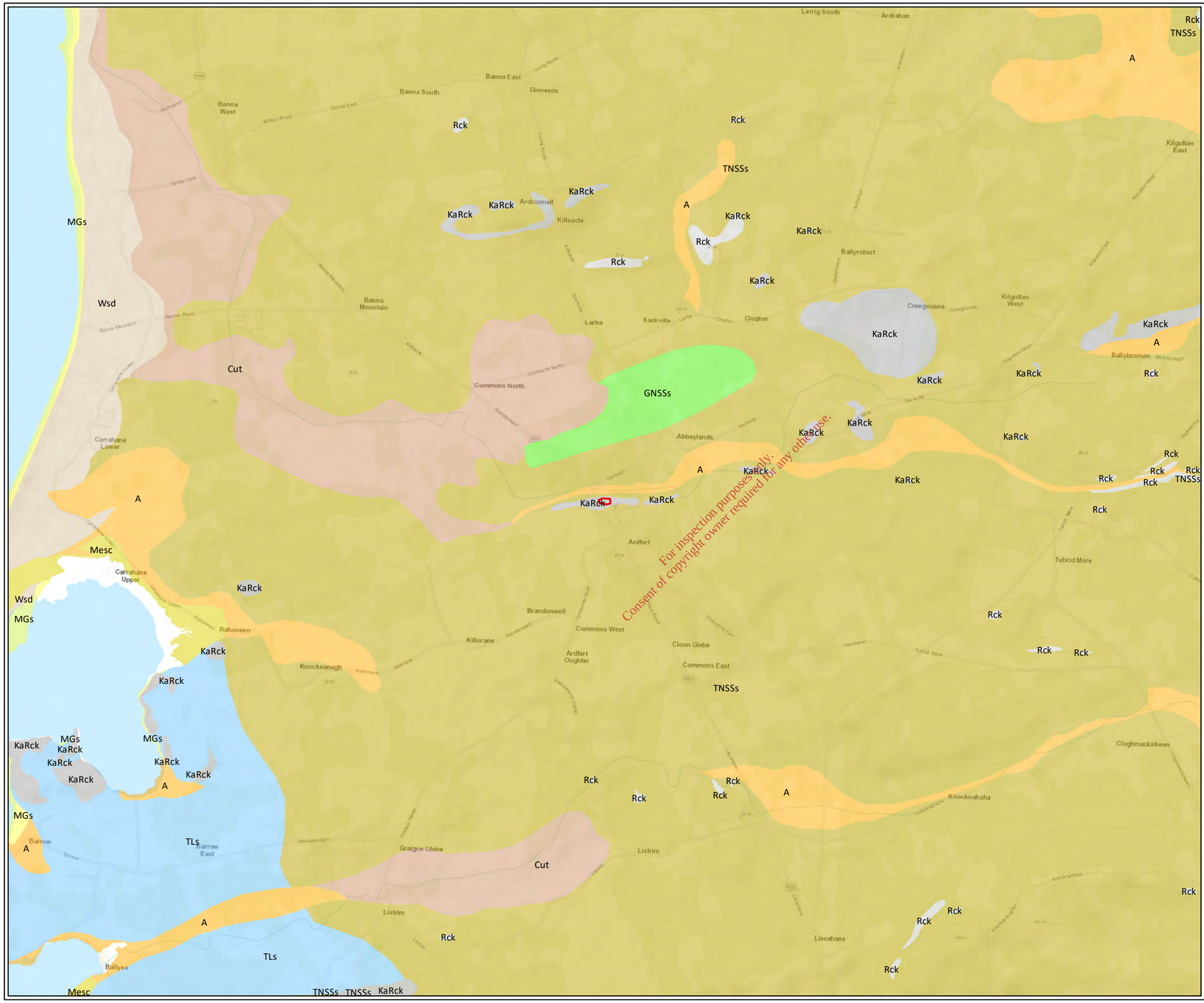
Solid or Bedrock Geology

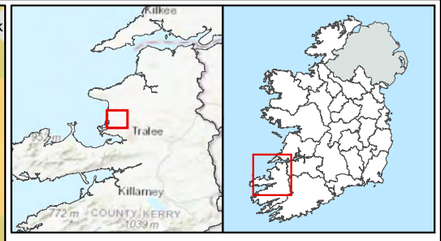
The GSI online 1:100,000 scale bedrock geology map, shows the bedrock beneath to be found on a single formation. The entirety of the site and surrounding area are underlain by the Cloonagh Limestone formation (CDCLNH) which is generally made up of Dinantian '*Bedded bioclastic limestone*'. Field observations from the Ardfert SPZ Project[1] (see full report Appendix 6) shows that the Cloonagh Formation, where exposed in the surrounding area, is karstified in the upper 5 m, as seen in at Ardfert Quarry located approximately 2 km northeast of the site.

GSI mapping indicates that bedrock outcrop is present within a portion of site, at the north-eastern corner. This outcrop extends further east beyond the site boundary. Bedrock outcrops are identified in the wider region. Ardfert Quarry, a limestone aggregate and agricultural lime producing quarry is located approximately 2km north-east of the site. The bedrock geology is presented in Figure 2.3.

The presence of limestone was detected at shallow depths between approximately 1.10m to 4.5 m at borehole BH01 and BH02, as referenced in the CGL borehole logs, Appendix 2.

[1] Establishment of Groundwater Source Protection Zones for the Ardfert Water Supply Scheme (EPA/GSI,2012)





Site Boundary

Quaternary Sediments

- A, Alluvium
- Cut, Cut over raised
- GNSSs, Gravels derived from Namurian sandstones and shales
- KaRck, Kartsified bedrock outcrop or subcrop
- MGs, Marine gravel and sands (often
- Mesc, Esturine silts and clays
- Rck, Bedrock outcrop or subcrop
- TLs, Till derived from limestones
- TNSSs, Till derived from Namurian sandstones and shales
- Wsd, Windblown sands and dunes

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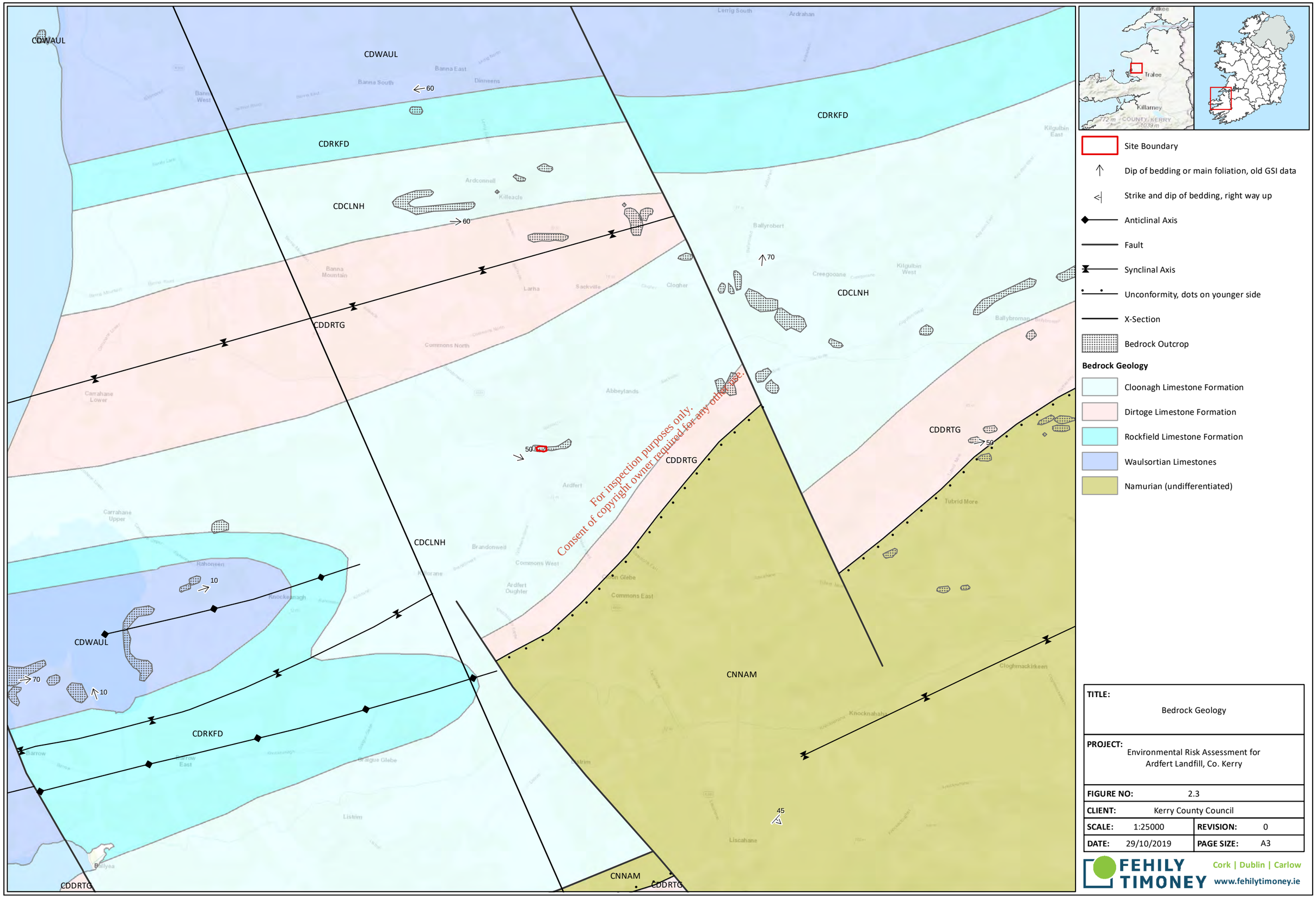

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2.2.5 Hydrogeology

An examination of the national bedrock aquifer map on the GSI online mapping classifies the Cloonagh formation as a Regionally Important Aquifer – Karstified (Diffuse) Bedrock (Rkd), i.e., dominated by diffuse rather than conduit flow. The Ardfert Gravel body is located approximately 340m north of the site, an encompasses an area of approximately 520 m^2. The bedrock aquifer mapping is presented in Figure 2.4.

There are no karst landforms within the site boundary. The nearest karst landform is a limestone cave located in Lissodeige approximately 3.8km south-west of the site boundary.

Historical mapping for the area shows no springs in the immediate vicinity of the site or the surrounding area. There are several residences within 250m of the site where unregistered private wells may be present.

Table 2.1 presents the details of the registered boreholes and springs within 1km of the site.

Table 2.1: Borehole and Spring Descriptions near the Project Site

BH/Spring	Yield class	Yield (m^3/day)	Use	Depth (m)	Depth to Rock confidence (m)	Distance from site (km)	Date
0511NEW009	-	-	-		17.5	0.24	1969
0511NEW008	-	-	-	-	13.7	0.37	1969
0511NEW027	Excellent	2182	Public Supply	18.6	18.6	0.53	1969

There are no Groundwater Drinking Water Protection Areas within the site boundaries according to GSI. The nearest groundwater protection zone (outer source protection zone) is located approximately 270m north of the site at its closest point. This groundwater protection zone relates to the Ardfert Group Water Supply Scheme/Ardfert South Boreholes. The group water scheme wells are located approximately 0.5km north of the site and correspond with GSI borehole ID-0511NEW027 as shown in above, which refers to the original well at the site. The Ardfert sand gravel deposit aquifer is the source of groundwater for this public supply. The total zone of contribution / source protection zone encompasses 1.5km^2.

An extract from the Ardfert SPZ Project Report (see full report Appendix 6) stated that uncertainty exists in relation to the geometry and lateral extent of the sand and gravel aquifer, in particular the southern boundary. The report stated the following in relation to the delineation of the southern source protection boundary:

*'The **Southern** boundary is based on topography and the extent of the sand and gravel body and conceptualised flow lines. There is considerable uncertainty to this boundary.''*

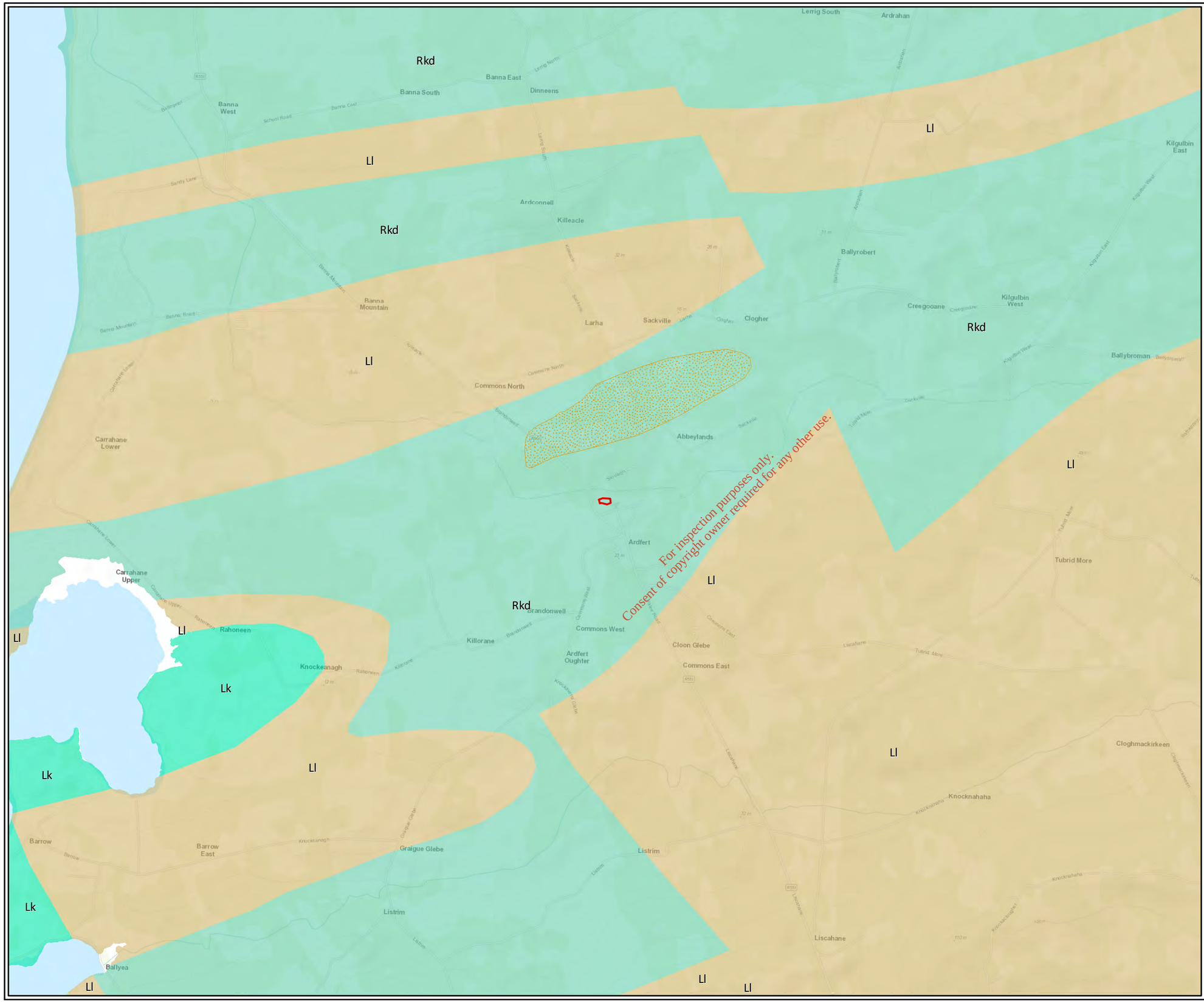
Groundwater monitoring data was not available for review for the supply well borehole ID-0511NEW027 during the preparation of this report.

The GSI shows that the groundwater body (GWB) is named Ardfert GWB and has a karstic flow regime and is defined as being at *Good Status* under the Water Framework Directive (WFD).

There are no recorded groundwater dependent ecosystems in the area.

GSI mapping shows groundwater recharge to be variable in the region. The GSI national recharge map defined the annual recharge for the site as 670 mm/yr. The effective rainfall for the area is 788 mm/yr, returning a recharge coefficient of 85%.

The GSI mapping showing approximate locations of known wells and springs is included in Figure 2.4.



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PROJECT:	Environmental Risk Assessment for Ardfert Landfill, Co. Kerry		
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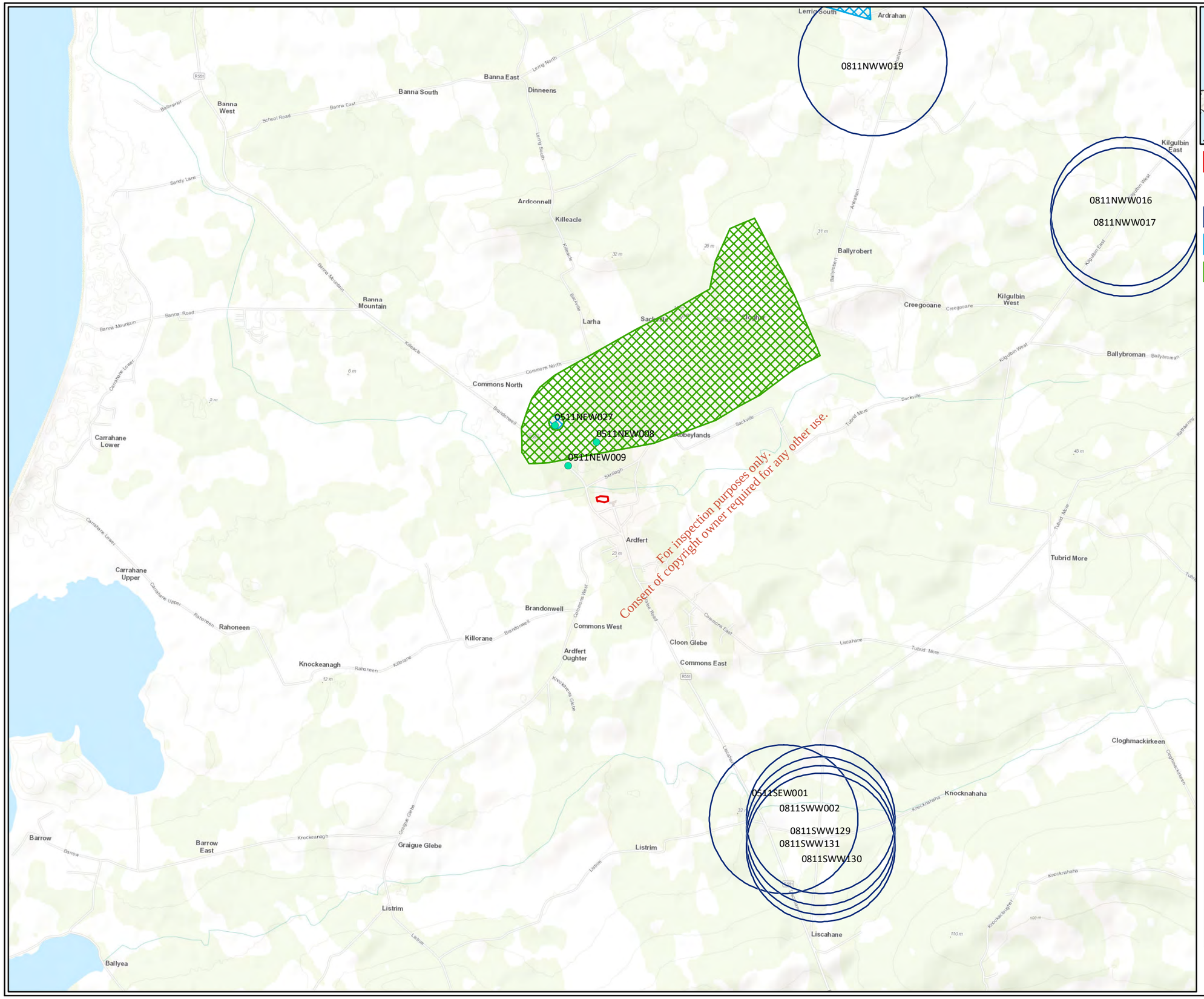

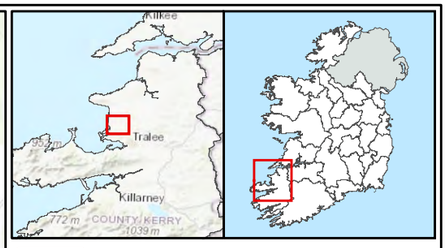

- Site Boundary
- Wells and Springs (10-50m Accuracy)
- Wells and Springs (500m-1km Accuracy)
- Source Protection Area (Inner)
- Source Protection Area (Outer)

Kilometers
0 0.5 1 2

TITLE:	GSI Wells and Springs		
PROJECT:	Environmental Risk Assessment for Ardfert Landfill, Co. Kerry		
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DATE:	31/10/2019	**PAGE SIZE:**	A3

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2.2.6 Groundwater Vulnerability

Groundwater vulnerability, as defined by the GSI, is the term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The factors used in assessing groundwater vulnerability include subsoil type and thickness and recharge type as indicated in Table 2.2. The GSI procedure whereby groundwater protection is assessed is outlined in the EPA-GSI publication *Groundwater Protection Schemes* (DELG/EPA/GSI, 1999).

The GSI Online mapping data set identifies the vulnerability of groundwater to contamination is classified as rock at or near surface or karst and extreme vulnerability, given the presence of bedrock outcrop at the site and thin overburden cover. The Groundwater Vulnerability mapping is presented in Figure 2.5.

Table 2.2: GSI Guidelines – Aquifer Vulnerability Mapping

Vulnerability Rating	Hydrogeological Conditions		
	Subsoil Permeability (Type) and Thickness		
	High Permeability (Shallow Bedrock)	Moderate Permeability (e.g., Sandy soil)	Low Permeability (e.g., Clayey subsoil, clay, peat)
Extreme (E)	0 - 3.0 m	0 - 3.0 m	0 - 3.0 m
High (H)	>3.0 m	3.0 -10.0 m	3.0 - 5.0 m
Moderate (M)	N/A	>10.0 m	5.0 - 10.0 m
Low (L)	N/A	N/A	>10 m

Notes:
N/A = Not Applicable
Precise permeability values cannot be given at present

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Legend

Site Boundary

Groundwater Vulnerability

- E - Extreme
- H - High
- M - Moderate
- L - Low
- X - Rock Near Surface or Karst

TITLE:	Groundwater Vulnerability
PROJECT:	Tier 2/3 Assessment for Ardfert Landfill
FIGURE NO:	2.6
CLIENT:	Kerry County Council
SCALE: 1:10000	**REVISION:** 0
DATE: 20/04/2021	**PAGE SIZE:** A3

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N W E S

0 0.25 0.5 1 Kilometers

2.2.7 Hydrology

The site is located within the catchment of the Tralee Bay-Feale, Sub-catchment Ardfert-Oughter and river sub-basin Tyshe_020. The River Tyshe is located approximately 70m north of the site and flows in a westerly direction before turning north-west and north eventually meeting the sea at Black Rock on Banna Beach approximately 5km north-west of the site.

The EPA has water quality stations on the River Tyshe and data from this station is as follows:

- West Bridge. Ardfert at Friary (RS23T020400) approximately 580m east and upstream of the site. The most recent water quality status (2017) assigned to this section of the River Tyshe was 'Poor' (Q3). Status at this point has been consistently shown to be between Q3 and Q3-4 since 1993.
- Downstream ambient (RS23T020430) approximately 515m west, downstream of the site. Historical monitoring has not been conducted at this location. The most recent water quality status (2017) at this location on the River Tyshe was 'Moderate' (Q3-4).

2.2.8 Ecology

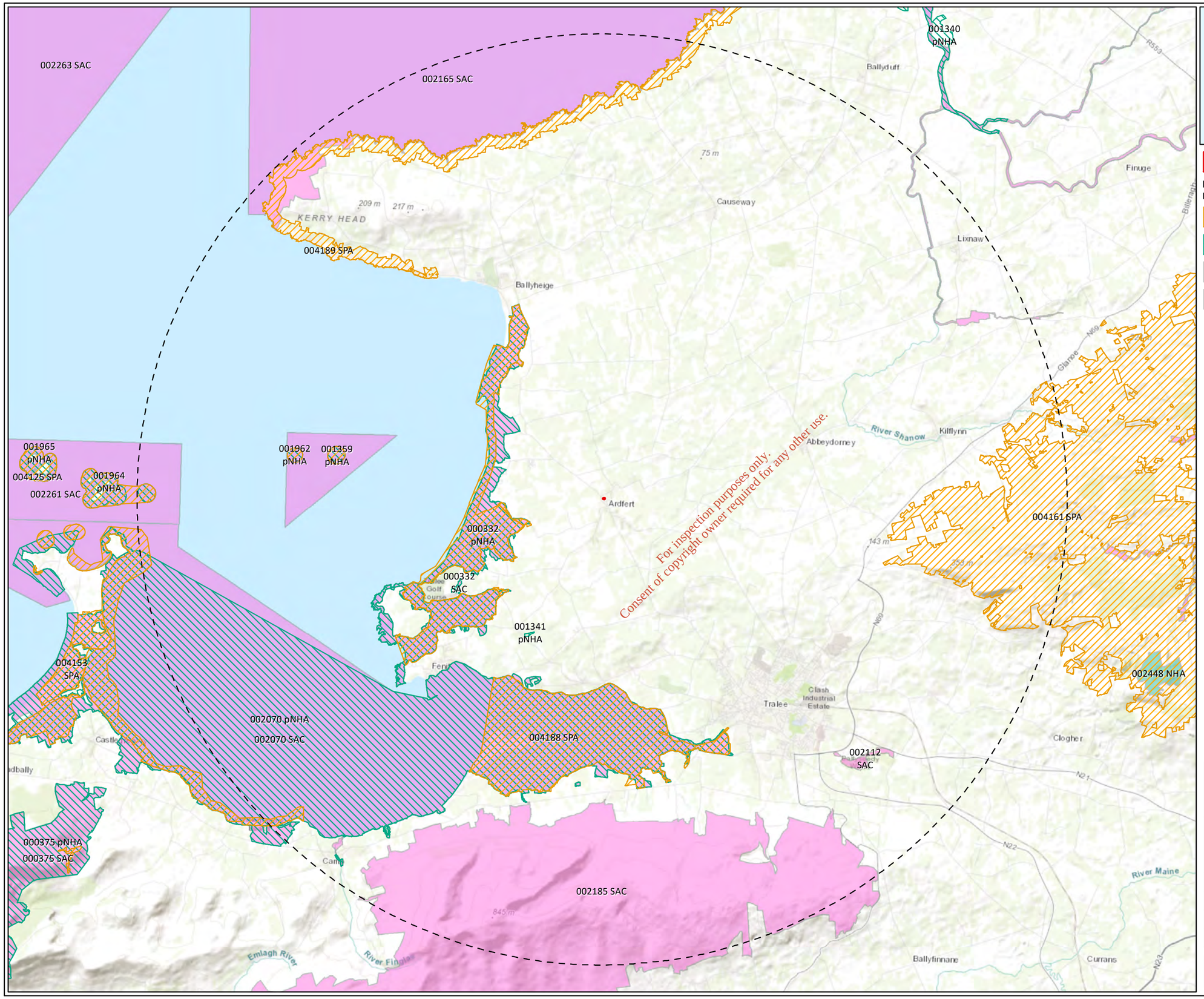
The site is not within or directly adjacent to any Natural Heritage Area (NHA), proposed NHA (pNHA), Special Area of Conservation (SAC) or Special Protection Area (SPA). The nearest SAC is Akeragh, Banna and Barrow Harbour SAC (Site Code:000332) located approximately 2.4km west of the site. This SAC is also classified as a proposed Natural Heritage Area (pNHA). The nearest SPA is Tralee Bay Complex (Site Code: 004188), located approximately 2.4km west of the site.

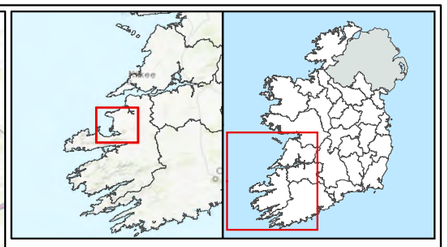
The ecology protected areas mapping is presented in Figure 2.7.

2.2.9 Site History

The earliest historical map available on the OSI website dates from 1837-1842. The OSI identifies the land within the site boundary was previously a quarry with the surrounding area previously arable land. Review of the 1888 – 1913 historical map shows that lands to the west of the R551 road were used for quarrying, a historical quarry also existed to the east of the site.

The OSI Historical Mapping is presented in Figure 2.8.





- Site Boundary
- 15km Distance from Site Boundary
- Special Protection Area (SPA)
- Proposed Natural Heritage Area (pNHA)
- Special Area of Conservation (SAC)
- Natural Heritage Area (NHA)

N E S W

0 1 2 4 Kilometers

TITLE:	Ecologically Protected Areas		
PROJECT:	Environmental Risk Assessment for Ardfert Landfill, Co. Kerry		
FIGURE NO:	2.7		
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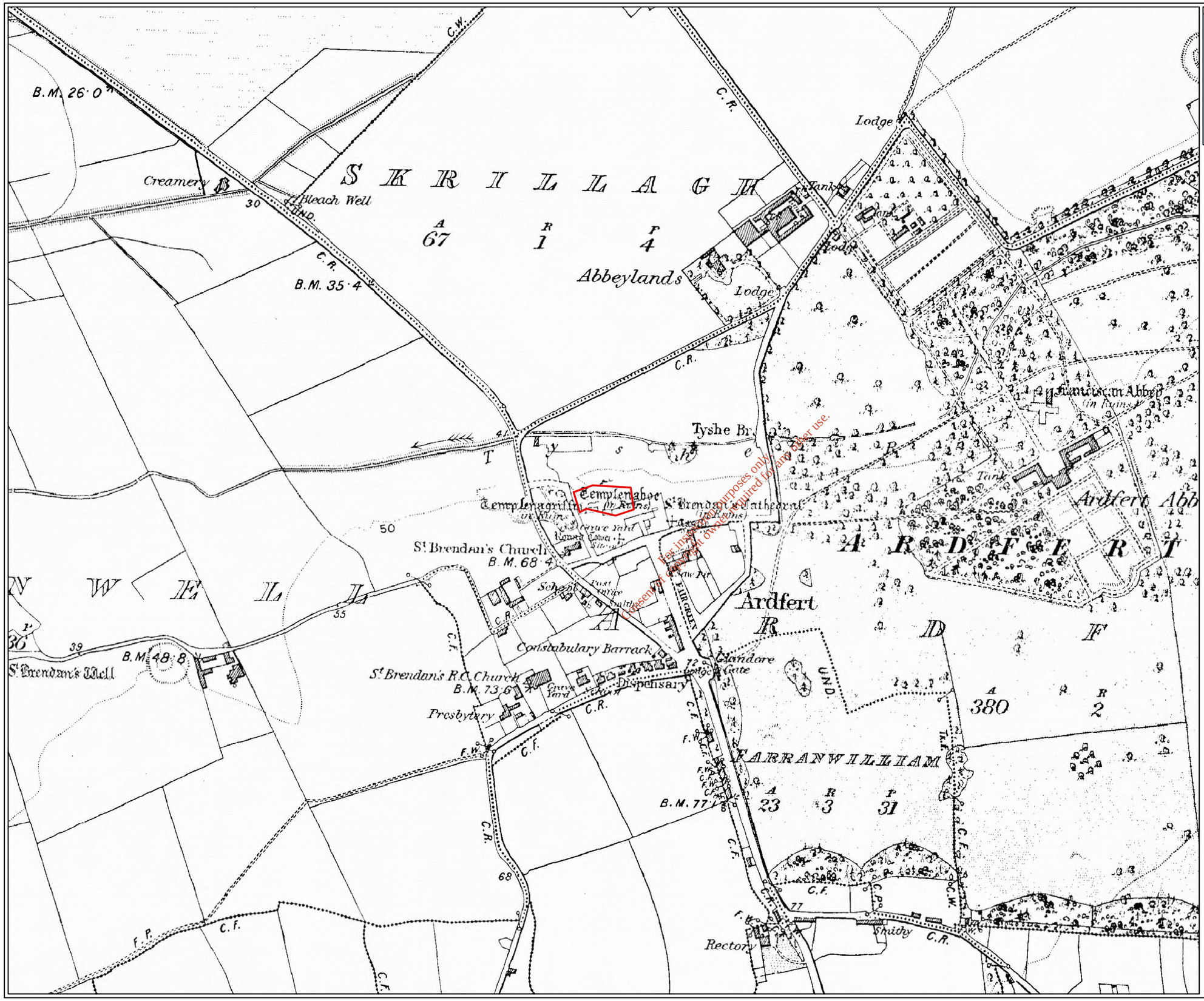

Site Boundary

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SCALE:	1:5000	**REVISION:**	0
DATE:	29/10/2019	**PAGE SIZE:**	A3

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2.2.10 Existing Geological Heritage

The GSI holds no records of areas of Geological Heritage within the site boundary or in the immediate vicinity of the site.

The nearest recorded of geological heritage held by the GSI is approximately 2.4km north-east of the site boundary at a historical Ardfert Quarry site. Calliagh is described as *"A similar site to Plover Hill, good karst with infills"*.

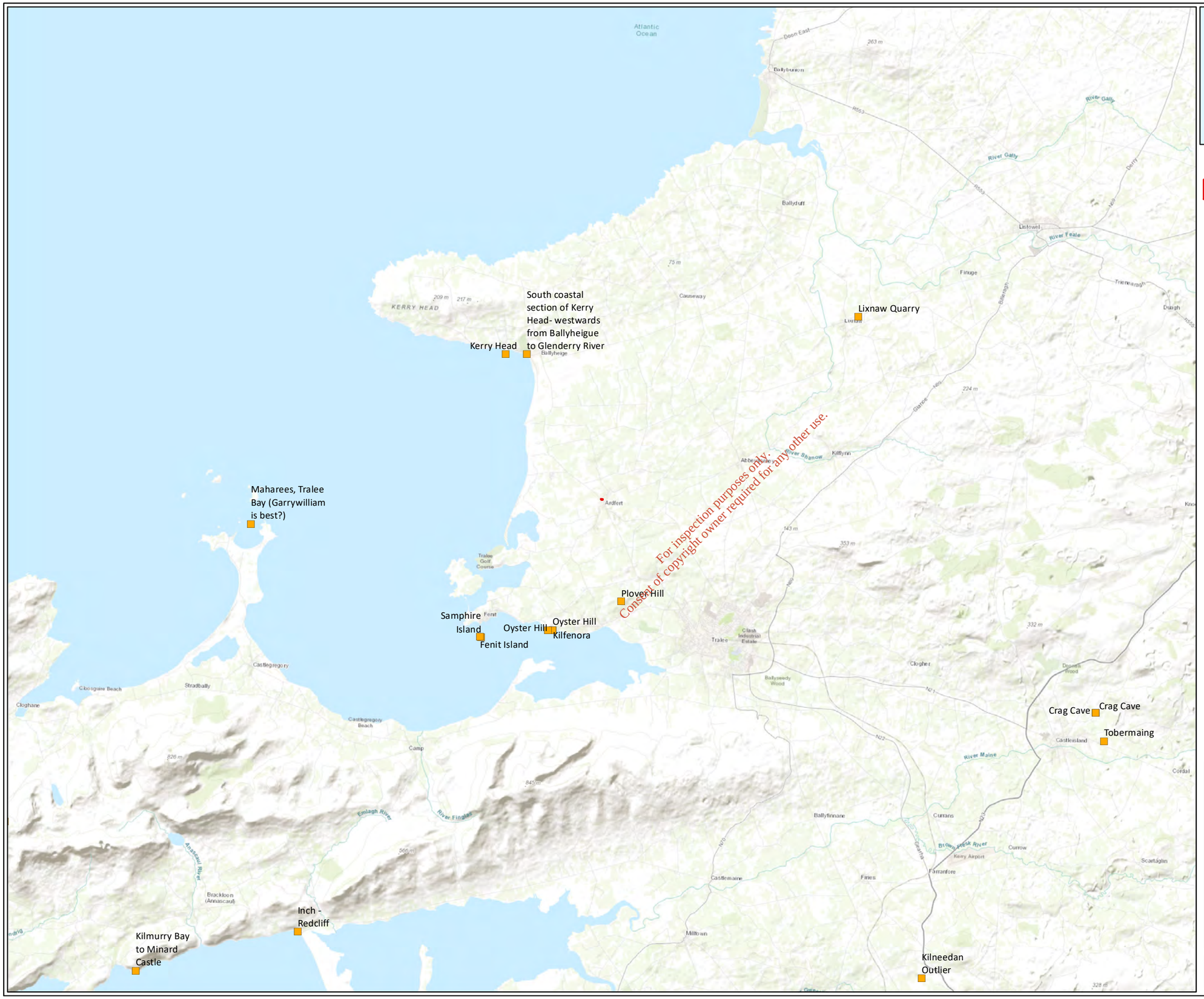
The geological heritage mapping is presented in Figure 2.9. The disused quarry locations to the north and west of Ardfert Landfill are presented in Figure 2.10.

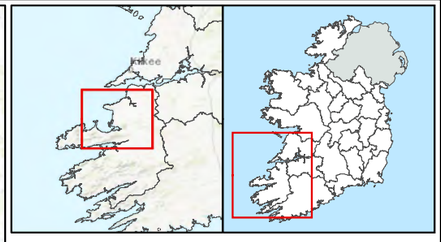
2.2.11 Existing Geotechnical Stability

The GSI landslides database indicates that there are no recorded geo-hazards within the site boundary or in the surround area or region.

2.2.12 Archaeological Heritage

The Ardfert historical landfill site is immediately adjacent to an area of significant archaeological and historical interest. The archaeology is ecclesiastical in nature. St. Brendans Cathedral is located east of the site. The Cathedral structure is a significant historical and archaeological feature. The surrounding cathedral grounds also houses several registered monuments. These include two additional churches (Templenagriffin and Templenahoe), the ruins of Ardfert castle and ruins of a round tower. Other archaeological features at this site include grave slabs, ogham stones and stone carvings.





Geological Heritage Sites

Site Boundary

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CLIENT:	Kerry County Council		
SCALE:	1:175000	**REVISION:**	0
DATE:	29/10/2019	**PAGE SIZE:**	A3

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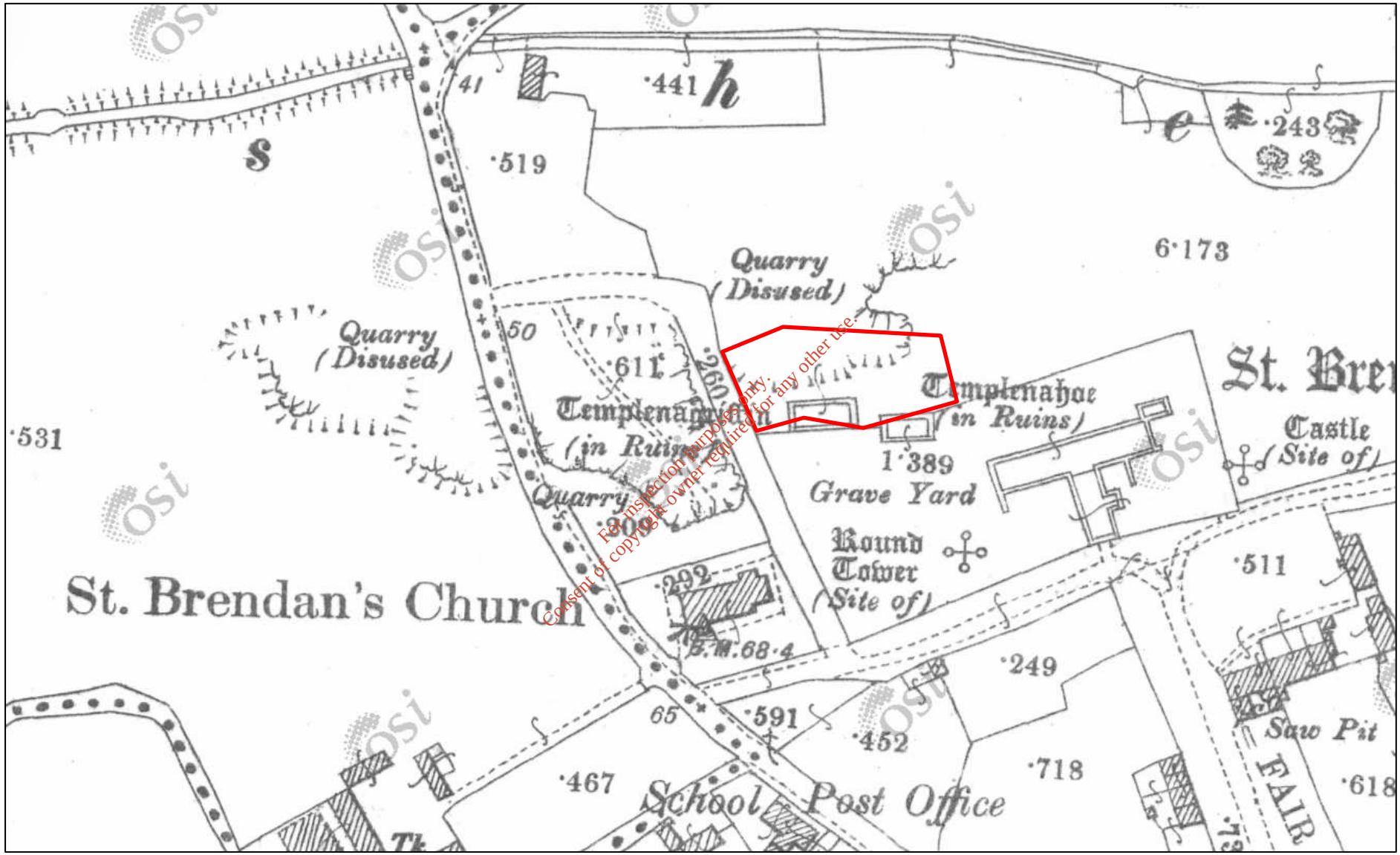


Source Reference: www.map.geohive.ie

Figure 2.10: OSI Historical Mapping (1888 – 1913)

3. TIER 2 SITE INVESTIGATION

3.1 Site Investigation Works

A site investigation rationale was devised based on findings of the Tier 1 assessment, site walkover, historical aerial photography and the preliminary risk assessment which formed part of that report.

The scope of site investigation works included:

- Site Walkover
- 1 No. Geophysical survey (2D resistivity and seismic refraction profiling)
- 4 No. Trial pit excavations
- Installation and monitoring of 2 No. groundwater boreholes
- Topographical Survey
- Factual reporting

The locations of the intrusive works at the site are presented in Figure 3.1.

The site investigation included the review of the following literature sources and websites:

- EPA 2003, Landfill Manuals: Landfill Monitoring (2nd Edition)
- EPA 1999, Landfill Manuals: Site Investigations
- BS 5930: 1999, Code of Practice for Site Investigations
- BS 6068 Water Quality: Sampling (parts 6.1-6.6 and 6.11-6.12, 6.14)
- BS 8855 Soil analysis (all parts)
- CLM: Ready Reference 2002, Section 3.1 Soil sampling strategies
- CLM: Ready Reference 2002, Section 3.2 Groundwater sampling/monitoring strategies
- CLM: Ready Reference 2002, Section 3.3 Gas sampling/monitoring strategies

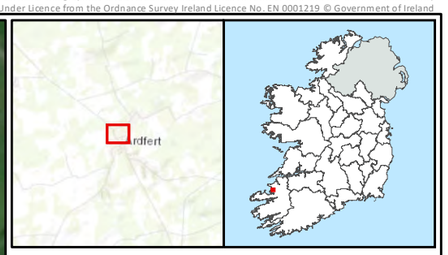
3.1.1 Site Walkover

A site walkover was conducted prior to site investigation works by an FT Engineer in February 2019.

The scope of the S.I. was agreed based on the site walkover assessment, desktop study, historic aerial photography and other information received by KCC.

The site walkover checklist and photo log are included in Appendix 5.

As previously noted during the site walkover the FT Engineer identified the location of the site was not as identified in the original KCC Tier 1 and was in the adjacent landholding <10m-20m away. FT prepared a revised Tier 1 for completeness in October 2019.



Borehole Locations

Site Boundary

N
W E
S

0 25 50 100 Meters

TITLE: Site Investigation Location Plan			
PROJECT: Ardfert Landfill, Co. Kerry			
FIGURE NO:	3.1		
CLIENT:	Kerry County Council		
SCALE:	1:1500	**REVISION:**	0
DATE:	31/10/2019	**PAGE SIZE:**	A3

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3.1.2 Geophysical Investigation

A geophysical investigation of the site was carried out on the 8th and 28th of March 2019 by Minerex under instruction from FT.

The geophysical survey consisted of reconnaissance EM31 Ground Conductivity Mapping with follow-up 2D Resistivity and Seismic Refraction profiling methods used to estimate shear-wave velocities (Vs) in the ground material. A total of 108 m of electrical resistivity profiles were collected.

The geophysical survey, calibrated against the findings of the trial pitting and borehole installations, was used to estimate a general profile of the buried waste above the in-situ bedrock.

The geophysical survey delineated the survey area based two resistivity / seismic profiles and on an interpretation of the ground conditions across the site. The following conclusions were made:

- Profile R1/S1: Profile R1 reaches a depth of 4.2 m. A small possible karstified area near the start of this profile could allow the migration of leachate from the landfill.

- Profile R2/S2: Profile R2 does not reach the base of the landfill however profile S2 indicates it reaches depths of 4.2 m while becoming shallower (ca. 2.5 m) towards the end of the profile. A slight decrease in resistivities at depth (see Ch 20 m) may indicate some karstification of the limestone in this area.

Results confirm there is no engineered capping layer over the landfill. Very low resistivities at the ground surface indicates that the topsoil layer on site is very thin.

3.1.3 Trial Pitting

A Causeway Geotech (CGL) Engineering Geologist supervised the advancement of 4 No. trial pits, shown in Figure 3.1, on the 29th May 2019.

The trial pits (TP01 to TP04) were excavated to depths of 2.0m to 4.0m below existing ground level (bgl) using a 3T tracked excavator fitted with a 600mm wide bucket.

The geophysical survey used in conjunction with the profiles identified during trial pitting provided a picture of the underlying geology of the site and a general profile of the buried waste.

A summary of the ground conditions is presented in Table 3.1 with photographs and exploratory hole logs provided in the CGL site investigation report, Appendix 2.

Table 3.1: Summary of Ground Conditions

Trial Pit ID	Depth of cover material (m BGL)	Depth to base of made ground / waste (m BGL)	Profile Description
TP01	0.50 (Topsoil) 0.50 – 1.30 (Clayey Silt) 1.30 – 4.00 (Made Ground)	4.0 (base of excavation)	Firm dark grey clayey SILT. MADE GROUND: Firm dark brown, dark grey slightly sandy slightly gravelly silty CLAY with some fragments of plastic sheeting.
TP02	0.20 (Topsoil) 0.20 – 0.9 (Silty Clay) 0.9 – 2.6 (Made Ground)	2.6 (base of excavation – terminated due to >1.5m of landfill material present)	Firm brown slightly sandy slightly gravelly silty CLAY. MADE GROUND: Firm dark brown to very dark grey slightly sandy slightly gravelly silty CLAY with plastic bags, and bottles.
TP03	0.20 (Topsoil) 0.20 – 1.2 (Made Ground) 1.2 – 2.0 (Made Ground)	2.0 (base of excavation - terminated on large obstruction)	MADE GROUND: Firm greyish brown slightly sandy slightly gravelly silty CLAY with cobbles and boulders of concrete building material. MADE GROUND: Firm brown slightly sandy slightly gravelly silty CLAY with rubbish including plastic bags, bottles, cloth and shoes.
TP04	0.20 (Topsoil) 0.20 – 0.7 (Silty Clay) 0.7 – 2.5 (Sand)	2.5 (base of excavation - terminated due to >1.5m of landfill material present)	MADE GROUND: Firm brown slightly sandy slightly gravelly silty CLAY Firm dark greyish brown sandy gravelly silty CLAY with rubbish including plastic, plastic bags and glass bottles. Thick layer of refuse sacks from 0.95m – 1.05m.

3.1.4 Waste Sampling

One sample of the made ground / waste at the site was collected from trial pit TP03 advanced in the eastern portion of the site.

The sample was submitted for Waste Acceptance Criteria (WAC) testing to ALS Environmental Ltd, a UKAS/MCERTS approved laboratory. Samples were collected from site under Chain of Custody procedures.

The results are provided in Appendix F of the CGL Ground Investigation report, Appendix 2 of this report. An interpretation of the waste sampling results is detailed in Section 4.2.2.

3.1.5 Evidence of Historic Landfilling

The trial pit excavation works identified waste material tending east-west within a central location of the site with thicknesses ranging from 0.9 – 4.0m BGL. Evidence of waste material was identified in each 4 No. trial pit locations (TP01 – TP04). The waste encountered was typically described as clothing items (shoes), glass bottles, plastic bottles, plastic sheeting, cloth, with some refuse sacks. The waste material description as described by CGLs Engineering Geologist is typical of municipal solid waste (MSW) material.

The base of the waste material was not reached at the termination depth of 4.0 m BGL in all four trial pits advanced. The base of the waste was encountered at 4.5m in borehole BH02 advanced in the centre of the site where limestone bedrock was confirmed.

As noted, most of the Made Ground waste material encountered comprised sandy slightly gravelly silty CLAY mixed with MSW.

3.1.6 Waste Delineation

The combined findings of the geophysical survey and intrusive site investigation were used to interpret the aerial extent of the waste mass.

The geophysical survey succeeded in validating the general location of the waste material. Both the elevated EM conductivity readings in combination with the trial pit logs show the waste to be present within the central portion of the survey area.

The findings of the site investigation work suggest the waste material is deposited in a single infill area tending west to east across the site and between approximately 58m in length and 25m in width. The total area covered by the waste body is approximately 1,675 m^2.

An accurate measurement of the volume of waste was difficult due to the changes in thickness of the landfill. Using different depths for a peripheral area and the centre of the waste body, estimates from the conductivity map gives an estimated waste volume of 5,025 m^3, 7,015 tonnes (at an assumed waste density of 1.4 tonne/m^3).

Minerex interpreted the low resistivities and seismic velocities measured were consistent with industrial and domestic waste rather than C & D type waste.

An extract from the geophysical report showing a delineation of the identified waste body is presented in Figure 3.2. The map shows the EM31 ground conductivity contours. The low (light blue) conductivities indicate natural ground. The middle range (dark blue – green – yellow) values indicate interred waste material and the negative readings (blank) in the north indicate buried metal.

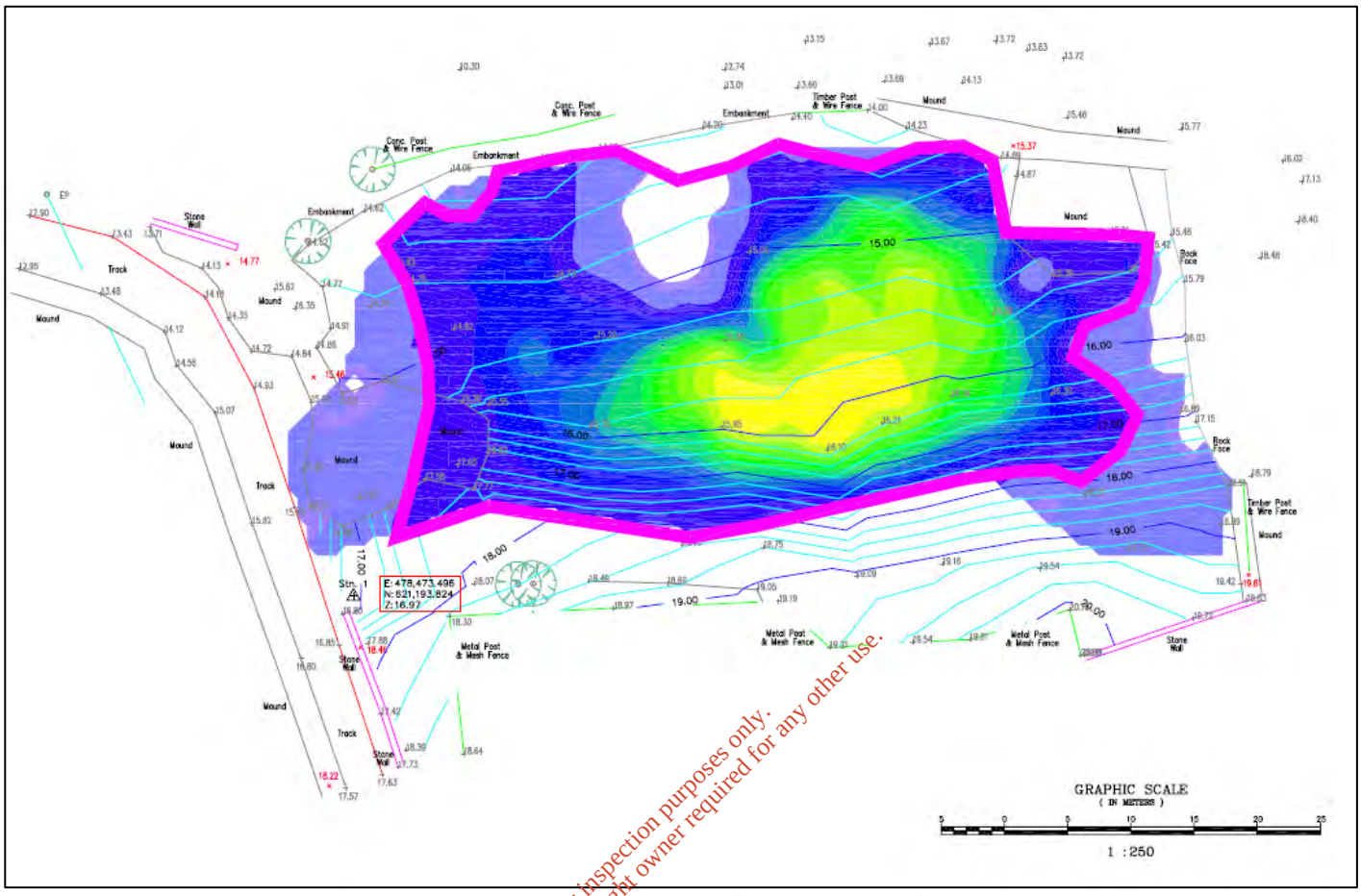

Figure 3.2: Delineation of the Waste Profile

3.1.7 Borehole Installation and Groundwater Sampling

Two boreholes (BH01 and BH02) were drilled to a total depth of 14.5 m bgl at the site on the 21st June 2019. The boreholes were drilled and installed for groundwater monitoring purposes.

Exploratory hole BH01 was advanced at a location near the western boundary of the site screened within the limestone bedrock. Based on the findings of the geophysical survey and trial pitting, borehole BH02 was installed within the waste body. The purpose of borehole BH01 was to intercept the groundwater flow direction downstream of the identified waste body.

Two rounds of groundwater quality monitoring were attempted at BH01 and BH02 on the 16th July and 3rd September 2019.

Groundwater monitoring was successfully undertaken in borehole BH01 on 3rd September 2019. BH01 and BH02 were dry on July 16th, borehole BH02 remained dry during both monitoring events.

Prior to sampling, borehole BH01 was purged and developed with Waterra groundwater sampling pipework / foot valves and gas caps installed.

All samples were appropriately bottled (using prepared laboratory bottle ware) and packaged for submission to the laboratory. The samples were submitted for laboratory testing to ALS Global Ltd. The analytical results are contained in Appendix 3 and are further discussed in the proceeding sections.

3.2 Geotechnical Analysis

3.2.1 In-Situ Capping Permeability Testing

One bulk disturbed soil sample from TP03 was submitted for geotechnical analysis by Causeway Geotech Ltd for analysis of moisture content and permeability testing by triaxial compression. The results of the geotechnical analysis are included in Appendix E of the intrusive Site Investigation Report prepared by Causeway Geotech, see Appendix 2 of this report.

This testing was undertaken to assess the ability of the existing capping material to minimise rainfall infiltration and leachate generation from the waste body.

The k-value calculated for sample TP03 classified the existing capping material as a brown slightly gravelly slightly sandy CLAY.

Details of permeability for sample TP03 at 0.5m bgl calculated using an 11-day triaxial compression test is shown in Table 3.2.

Table 3.2: Permeability by Triaxial Compression

Sample ID	B-Value (%)	Mean Flow Rate (ml/min)	K (m/s)
TP03	0.96	0.0009	9.0×10^{-11}

In accordance with the EPA Landfill Site Design Manual an engineered capping material should have a permeability less than or equal to 1×10^{-9} m/s to minimise infiltration of rainwater into the waste body. The permeability estimated for sample TP03 analysed at the Ardfert site is below the EPA guidance and is suitable as a low permeability capping material.

The shallow topsoil depth of 0.2m and clay subsoil depth of 0.2 - 0.9m do not comply with the capping design specification set out in the Landfill Design Manual for Inert Landfills. The existing soil cover may however be minimising rainfall ingress and thus minimising leachate generation within the waste body.

4. ENVIRONMENTAL ASSESSMENT

4.1 Chemical Assessment Criteria

- Council Decision 2003/33/EC – Waste Acceptance Criteria
- European Communities, Environmental Objectives (Groundwater)(Amendment) Regulations, 2010 (S.I. No. 9 of 2010) as amended in 2011, 2012 and 2016
- Interim Guideline Values (IGV) set out in the EPAs Groundwater *Towards Setting the Guideline Values for the Protection of Groundwater in Ireland*.
- European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations, 2012 (S.I. No. 327 of 2012)
- European Communities Environmental Objectives (Surface Waters) Regulations, 2009 (S.I No. 272 of 2009) as amended in 2015 and 2019.
- European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989 (S.I. No. 294/1989).

The results of the environmental assessment at the Ardfert Historic Landfill site are presented in the following sections.

4.2 Waste/Made Ground Assessment

The soil / made ground samples analysed during this assessment have been compared against Waste Acceptance Criteria (WAC) to determine the appropriate waste classification rating associated with the interred waste. WAC screening is chosen for this assessment to suitably categorise the interred waste as inert, non-hazardous or hazardous material.

4.2.1 Chemical Results for Waste Samples

The proposed maintenance building will be primarily used for the storage of existing plant and equipment at the site. A preliminary inventory of the existing plant and equipment has been prepared along with a list of key building requirements/design features.

4.2.2 Soil Samples

The soil samples analysed from the site investigations were assessed against the Waste Classification Assessment Criteria. A summary of the results for Ardfert Landfill is outlined in Table 4.1 below, while the laboratory reports are presented in Appendix F of the CGL site investigation report, Appendix 2 of this report.

Table 4.1: Waste Sampling Results – Solid Waste Analysis

Parameter	Units	Inert Waste Acceptance Criteria	Non-Hazardous Waste Acceptance Criteria	Hazardous Waste Acceptance Criteria	Sampling Results - Sample ID
					TP03 (at 2.0 m)
Total Organic Carbon	%	**3**	**5**	**6**	3.7
Loss on Ignition	%	--	--	**10**	7.0
Total BTEX	mg/kg	**6**	--	--	< 0.010
Total PCBs (7 Congeners)	mg/kg	**1**	--	--	< 0.10
TPH Total WAC (Mineral Oil)	mg/kg	**500**	--	--	< 10
Total (of 17) PAH's	mg/kg	**100**	--	--	< 2.0
pH		--	**>6**	--	8.1
Acid Neutralisation Capacity	mol/kg	--	--	--	0.038
Arsenic	mg/kg	**0.5**	**2**	**25**	< 0.050
Barium	mg/kg	**20**	**100**	**300**	< 0.50
Cadmium	mg/kg	**0.04**	**1**	**5**	< 0.010
Chromium	mg/kg	**0.5**	**10**	**70**	< 0.050
Copper	mg/kg	**2**	**50**	**100**	< 0.050
Mercury	mg/kg	**0.01**	**0.2**	**2**	0.015
Molybdenum	mg/kg	**0.5**	**10**	**30**	< 0.050
Nickel	mg/kg	**0.4**	**10**	**40**	< 0.050
Lead	mg/kg	**0.5**	**10**	**50**	0.015
Antimony	mg/kg	**0.06**	**0.7**	**5**	0.012
Selenium	mg/kg	**0.1**	**0.5**	**7**	0.014
Zinc	mg/kg	**4**	**50**	**200**	< 0.50
Chloride	mg/kg	**800**	**15000**	**25000**	32
Fluoride	mg/kg	**10**	**150**	**500**	1.3
Sulphate	mg/kg	**1000**	**20000**	**50000**	140
Total Dissolved Solids	mg/kg	**4000**	**60000**	**100000**	1200
Phenol Index	mg/kg	**1**	-	-	< 0.30
Dissolved Organic Carbon	mg/kg	**500**	**800**	**1000**	120
Moisture	%				19

* Hazardous Waste Landfill Criteria: >6% TOC
* Items in **bold** are in exceedance of the Inert WAC limit value
* Items shaded in **green** are in exceedance of the Non-Hazardous WAC limit value
* Items shaded in **orange** are in exceedance of the Hazardous WAC limit value

4.2.2 Waste Classification

As can be seen in Table 4.1, analysis of waste samples collected from trial pit TP03 demonstrate the interred waste to be broadly within the inert threshold limit values when assessed against the waste acceptance criteria (WAC). The WAC testing indicates the spoil material has a high organic content which may be due to the degradation of organic fractions within the MSW or domestic waste. Levels of mercury in the soil sample have been detected above the inert WAC limit value at 0.015 mg/l.

Due to the presence of MSW within the landfill, as confirmed during trial pitting, the results indicate that the waste material is likely stabilised due to the age of the waste.

4.3 Groundwater Analysis

Two rounds of groundwater quality monitoring were attempted at the site on the 16th July and 3rd September 2019.

It is noted that groundwater monitoring wells BH01 and BH02 were dry on the 16th July and no groundwater samples could be recovered.

On the 3rd of September a groundwater sample was retrieved from BH01, BH02 however remained dry. The findings from the monitoring and an interpretation of the results is presented in the following sections.

4.3.1 Groundwater Depth Analysis

Groundwater depth analysis was undertaken during the second round of monitoring when groundwater was present at downgradient well BH01. The static groundwater level from the 3rd September 2019 is calculated below.

Table 4.2: Groundwater Depth Analysis

Borehole ID	Location Gradient	Ground Level (mAOD)	Depth to Water (m bgl)	Groundwater Level (mAOD)
BH01	Western Site Boundary	12.01	11.05	0.96

*Note: Location gradient is in reference to the identified waste deposition area

Based on the above field survey measurements, groundwater levels were present below the surface at over 11 m below ground level (m bgl). Therefore, based on this standalone measurement, it is assumed that the potentiometric groundwater surface does not intersect the waste body further upgradient. This assumption may be valid as no groundwater was encountered within borehole BH02 during this period.

It is recommended to undertake additional groundwater level measurements in the winter months to assess potential for seasonal variations.

It is noted that the measured groundwater level indicates the local groundwater regime is not connected to the River Tyshe surface water body to the north of the site.

4.3.2 Groundwater Borehole Position

The location of the groundwater boreholes installed at the site where based on the anticipated groundwater flow direction. A desktop analysis of the site in tandem with a site walkover estimated that the likely groundwater flow direction was west/north-west based on the topography of the site and location of the coast further west.

The presence of groundwater in one monitoring well BH01 during the second round of groundwater monitoring makes it difficult to accurately predict groundwater flow direction.

A review of the GSI groundwater flow contours indicates flow direction is due north/north-west. BH01 is therefore considered to be down or cross-gradient of the waste mass identified.

Path: R:\Map Production\2019\P1766\Workspace\Ardfert\Tier 2 ERA Report\P1766_Fig4-1_GWFlowDirection_A3.mxd

Borehole Locations

Groundwater Flow Direction

Site Boundary

1m Contours

TITLE:	Groundwater Flow Direction		
PROJECT:	Ardfert Landfill, Co. Kerry		
FIGURE NO:	4.1		
CLIENT:	Kerry County Council		
SCALE:	1:1500	**REVISION:**	0
DATE:	31/10/2019	**PAGE SIZE:**	A3

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4.3.3 Groundwater Quality Monitoring

The results of groundwater samples analysed from borehole BH01 to the west of the site have been compared to the EPA's Interim Guideline Values (IGVs) and the European Communities Environmental Objectives (Groundwater) Regulations 2010 (as amended). A summary of the results reported for each parameter is outlined in Table 4.3, while the laboratory reports are presented in Appendix 3.

Table 4.3: Groundwater Sampling Results

Parameter	Units	EPA IGV Standards [1]	S.I. No. 9 of 2016 Standards [2]	BH01
Inorganics				
Ammoniacal Nitrogen as N	mg/l	**0.15**	**0.175**	**0.296**
Conductivity @ 20 deg.C	mS/cm	**1**	**1.875**	0.834
Total Dissolved Solids	mg/l	**1000**		605
Fluoride	mg/l	**1**		<0.5
Dissolved Oxygen	mg/l		**NAC**	9
pH	pH Units	**6.5-9.5**		7.64
Phosphate (Ortho as PO4)	mg/l		**0.03**	<0.05
Chloride	mg/l	**30**	**24-187.5**	73.2
Total Cyanide	mg/l	**0.01**	**0.0375**	<0.05
Total Alkalinity as CaCO3	mg/l		**NAC**	346
Total Suspended Solids	mg/l			-
Total Oxidised Nitrogen as N	mg/l			5.82
Sulphate (soluble) as S	mg/l	**200**	**187.5**	11.2
Total Organic Carbon	mg/l			3.78
Dissolved Metals (Filtered)				
Mercury (diss.filt)	µg/l	**1**	**0.75**	<0.01
Arsenic (diss.filt)	µg/l	**10**	**7.5**	2.65
Barium (diss.filt)	µg/l	**100**		32.4
Boron (diss.filt)	µg/l	**1000**	**750**	68.4
Cadmium (diss.filt)	µg/l	**5**	**3.75**	<0.08
Chromium (diss.filt)	µg/l	**30**	**37.5**	<1
Copper (diss.filt)	µg/l	**30**	**1500**	1.07
Lead (diss.filt)	µg/l	**10**	**7.5**	3.84
Manganese (diss.filt)	µg/l	**50**		**119**
Nickel (diss.filt)	µg/l	**20**	**15**	2.27

Parameter	Units	EPA IGV Standards [1]	S.I. No. 9 of 2016 Standards [2]	BH01
Phosphorus (diss.filt)	µg/l			38.3
Selenium (diss.filt)	µg/l			3.24
Thallium (diss.filt)	µg/l			<2
Zinc (diss.filt)	µg/l	**100**	**75**	2.8
Sodium (Dis.Filt)	mg/l	**150**	**150**	36.5
Magnesium (Dis.Filt)	mg/l	**50**		9.74
Potassium (Dis.Filt)	mg/l	**5**		**14**
Calcium (Dis.Filt)	mg/l	**200**		135
Iron (Dis.Filt)	mg/l	**0.2**		**0.355**
Mineral Oil / Oils & Greases				
Mineral oil >C10 C40 (aq)	µg/l	**10**		<100
PCB's				
PCB congener 28	µg/l	**0.01**		<0.015
PCB congener 52	µg/l	**0.01**		<0.015
PCB congener 101	µg/l	**0.01**		<0.015
PCB congener 118	µg/l	**0.01**		<0.015
PCB congener 138	µg/l	**0.01**		<0.015
PCB congener 153	µg/l	**0.01**		<0.015
PCB congener 180	µg/l	**0.01**		<0.015
Sum of detected EC7 PCB's	µg/l	**0.01**		<0.105
Semi-Volatile Organic Compounds (SVOCs)				
1,2,4-Trichlorobenzene	µg/l	**0.40**		<1
1,2-Dichlorobenzene	µg/l	**10**		<1
2,4,6-Trichlorophenol	µg/l	**200**		<1
2-Chlorophenol	µg/l	**200**		<1
Anthracene	µg/l	**10000**		<1
Bis(2-Ethylhexyl) phthalate	µg/l	**8**	**6**	<2
Benzo(b)fluoranthene	µg/l	**0.5**		<1
Benzo(k)fluoranthene	µg/l	**0.05**		<1
Benzo(a)pyrene	µg/l	**0.01**	**0.0075**	<1
Benzo(g,h,i)perylene	µg/l	**0.05**		<1
n-Dibutyl phthalate	µg/l	**2**		<1
Fluoranthene	µg/l	**1**		<1
Hexachlorobenzene	µg/l	**0.03**		<1
Hexachlorobutadiene	µg/l	**0.1**		<1

Parameter	Units	EPA IGV Standards [1]	S.I. No. 9 of 2016 Standards [2]	BH01
Nitrobenzene	µg/l	10		<1
Naphthalene	µg/l	1	0.075	<1
Pentachlorophenol	µg/l	2		<1
Phenol	µg/l	0.5		<1
Indeno(1,2,3-cd)pyrene	µg/l	0.05		<1
Volatile Organic Compounds (VOCs)				
Dichlorodifluoromethane	µg/l	15		<1
Vinyl chloride	µg/l		0.375	<1
Trichlorofluoromethane	µg/l	12		<1
1,1-Dichloroethene	µg/l		0.375	<1
Dichloromethane	µg/l	10	15	<3
Methyl tertiary butyl ether (MTBE)	µg/l	30	10	<1
1,1,1-Trichloroethane	µg/l	500		<1
Carbontetrachloride	µg/l	2		<1
1,2-Dichloroethane	µg/l	3	2.25	<1
Benzene	µg/l	1	0.75	<1
Trichloroethene	µg/l	70	7.5	<1
Toluene	µg/l	10	525	<1
Tetrachloroethene	µg/l	40	7.5	<1
Chlorobenzene	µg/l	1		<1
Ethylbenzene	µg/l	10		<1
m,p-Xylene	µg/l	10		<1
o-Xylene	µg/l	10		<1
4-iso-Propyltoluene	µg/l		0.75	<1
1,2-Dichlorobenzene	µg/l	10		<1
1,2,4-Trichlorobenzene	µg/l	0.4		<1
Hexachlorobutadiene	µg/l	0.1		<1
Combined Pesticides / Herbicides				
1,2,4-Trichlorobenzene	µg/l	0.4		<0.01
Aldrin	µg/l	0.01		<0.01
Alachlor	µg/l	20		<0.01
Atrazine	µg/l	1	0.075	<0.01
Chlorfenvinphos	µg/l	5		<0.01
Chlorpyriphos	µg/l	90		<0.01
Dichlobenil	µg/l		0.075	<0.01
Dichlorvos	µg/l	0.001		<0.01

Parameter	Units	EPA IGV Standards [1]	S.I. No. 9 of 2016 Standards [2]	BH01
Dieldrin	µg/l	**0.01**	**0.075**	<0.01
Endosulphan I	µg/l	**0.001**		<0.01
Endosulphan II	µg/l	**0.001**		<0.02
Hexachlorobenzene	µg/l	**0.03**		<0.01
Hexachlorobutadiene	µg/l	**0.1**		<0.01
Malathion	µg/l	**0.01**		<0.01
Parathion	µg/l	**0.01**		<0.01
Pentachlorobenzene	µg/l	**1**		<0.01
Permethrin I	µg/l	**20**		<0.01
Permethrin II	µg/l	**20**		<0.01
Prometryn	µg/l	**0.01**		<0.01
Simazine	µg/l	**1**	**0.075**	<0.01
Trifluralin	µg/l	**0.1**		<0.01
4,4 – DDT	µg/l	**0.075**		<0.01
Miscellaneous Organics				
MCPA	µg/l		**0.075**	<0.05
Mecoprop	µg/l	**10**	**0.075**	<0.04
Dichlorprop	µg/l	**100**		<0.1
2,4-Dichlorophenoxyacetic acid	µg/l		**0.075**	<0.05
Bromoxynil	µg/l	**5**		<0.04
Pentachlorophenol	µg/l	**2**		<0.04

[1] IGV-Interim Guideline Values, from EPA, Towards Setting Guideline Values for the Protection of Groundwater in Ireland, 2003.
[2] OTV-Overall threshold value, European Communities Environmental Objectives (Groundwater) Regulations, 2010 (S.I. No. 9 of 2010) as amended in 2011, 2012, 2016.
* Items shaded in **bold** are in exceedance of the EPA IGV Standards
* Items shaded in **orange** are in exceedance of the Drinking Water Regulations

4.3.4 Groundwater Analysis Discussion

The results of the groundwater monitoring from BH01 have reported several exceedances of the IGVs and OTV groundwater limit values.

Samples recovered from monitoring well BH01 reported an ammoniacal nitrogen (as N) concentration of 0.296 mg/l, which exceeds OTV and IGV limit values. Ammoniacal N at this concentration indicates the landfill may be impacting groundwater quality downgradient of the landfill.

Chloride levels at 73.2 mg/l exceed the OTV limit value and may be evidence of impact from the landfill given the location of the monitoring well downgradient of the landfill.

Groundwater quality monitoring undertaken for the Ardfert SPZ Project in 2012 (see Appendix 6) at abstraction boreholes 500 m north of the site detected chloride concentrations ranging from 40 to 50.5 mg/l with a mean of 46.5 mg/l. The report concluded the elevated chloride levels were likely attributed to low elevation position of the boreholes and the proximity to the coast (ca. 3 km) resulting in saline intrusion. Notwithstanding the findings of the Ardfert SPZ Project and given the chloride levels detected at BH01 are 1.5 times greater than these mean levels, the landfill may be the cause of elevated chloride locally.

The slightly elevated iron concentration of 0.355 mg/l at borehole BH01 and elevated manganese concentration of 119 µg/l are considered to be typical of the local bedrock hydrochemistry.

Potassium levels of 14.0 mg/l was detected at BH01 exceeds the OTV limit. Potassium concentrations at this level may be an indication of impact on groundwater quality from the landfill.

The alkalinity (CaCO3) level of 346 mg/l is a factor of local limestone bedrock hydrochemistry.

The results of groundwater monitoring when assessed against typical leachate constituents (List 1 and List 2 substances – SVOCs, pesticides, herbicides, organics) shows all results are below the laboratory limit of detection in all assessments across all three sampling locations. A full list of all List 1 and List 2 substances analysed in presented in the groundwater laboratory reports presented in Appendix 3.

Based on the presence of elevated ammonia, chloride and potassium concentrations, the landfill waste body may be impacting groundwater quality locally.

4.4 Landfill Gas Monitoring

FT carried out monitoring of landfill gas (LFG) parameters at monitoring borehole location BH01 as indicated on Figure 4.1. In accordance with the EPA CoP, methane, carbon dioxide, oxygen and atmospheric pressure were analysed at the groundwater monitoring well located within the waste body using a geotechnical instrument GEM5000 Landfill Gas analyser.

4.4.1 Monitoring Results

In accordance with the CoP, the trigger level for methane outside the waste body is 1.0% v/v and for carbon dioxide is 1.5% v/v. The monitoring results for methane, carbon dioxide and oxygen levels for the perimeter borehole are summarised in Table 4.4.

Table 4.4: Perimeter Well Monitoring Results October 2019

Date: 23-10-2019						
Sample Station	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	Atmospheric Pressure (mbar)	Staff Member	Weather
BH01	**1.2**	1.3	21.8	1005	Emily Archer	Overcast, heavy rain, showers, 12°C
BH02	1.0	0.8	20.9			

As can be seen in Table 4.4, concentrations of methane at monitoring boreholes BH01 were slightly above the 1.0% v/v threshold value set by the CoP during monitoring on the 23rd October 2019. Methane levels at BH02, installed within the waste body, were measured at the 1.0% v/v trigger level and did not increase above the trigger. Given the position of the boreholes within and outside the waste body, methane levels are likely an indication of biological breakdown from the landfill.

Concentrations for carbon dioxide were detected below the 1.5% v/v threshold value set by the CoP.

4.5 Surface Water Monitoring

4.5.1 Monitoring Locations

The surface water monitoring locations were selected upstream and downstream of the landfill footprint, as shown on Figure 4.2. Monitoring location SW1 was selected as the furthest upstream location and samples the River Tyshe to the north-east of the landfill. Monitoring location SW2 is located north-west of the landfill and samples the furthest downstream point of the River Tyshe.

Two surface water monitoring rounds were carried out on the 19th July and 6th September 2019.

4.5.2 Monitoring Parameters

The results of surface water sampling analysed from the 2 No. sampling locations (SW1 and SW2) at the site have been assessed against the Maximum Admissible Concentration (MAC) Regulations (1989) and the Environmental Quality Standard (EQS) for Surface Waters Regulations (2009) assessment criteria.

A summary of the results reported for each parameter from the two monitoring rounds is outlined in Table 4.5, while the full laboratory reports are presented in Appendix 4.

Table 4.5: Surface Water Sampling Results

Parameter	Units	MAC[1]	EQS[2]	Upstream	Downstream	Upstream	Downstream
				SW01 16.07.2019	SW02 16.07.2019	SW01 03.09.2019	SW02 03.09.2019
Inorganics							
Ammoniacal Nitrogen as N	mg/l	--	**≤0.140 (95%ile)**	<0.2	<0.2	<0.2	<0.2
Conductivity @ 20 deg.C	mS/cm	**1**	--	0.691	0.684	0.655	0.646
Fluoride	mg/l	**0.5**	--	<0.5	<0.5	<0.5	<0.5
Dissolved Oxygen	mg/l	--	**95%ile>80% saturation, 95%ile<120% saturation**	93.64	84.66	103.61	100.65
pH	pH Units	--	**6.0-9.0**	8.09	7.99	8.11	8.23
Phosphate (Ortho as PO4)	mg/l	**0.5**	--	<0.05	<0.05	0.08	0.064
Chloride	mg/l	**40**	--	45.7	45.8	48.7	48.8
COD, unfiltered	mg/l	**250**	--	19.8	<7	<7	<7
Total Cyanide	mg/l	**0.01**	--	<0.05	<0.05	<0.05	<0.05
BOD, unfiltered	mg/l	--	**≤2.6 (95%ile)**	1.9	--	--	--
Total Alkalinity as CaCO3	mg/l	--	--	288	298	291	292
Total Suspended Solids	mg/l	**50**	--	<2	3.6	14.3	15.9
Total Oxidised Nitrogen as N	mg/l	**2**	--	4.84	4.89	4.94	4.95
Sulphate (soluble) as S	mg/l	**200**	--	9.33	7.9	8.1	7.67
Total Organic Carbon	mg/l	**NAC****	--	<3	<3	<3	<3

Parameter	Units	MAC[1]	EQS[2]	Upstream SW01 16.07.2019	Downstream SW02 16.07.2019	Upstream SW01 03.09.2019	Downstream SW02 03.09.2019
Dissolved Metals (Filtered)							
Mercury (diss.filt)	µg/l	--	**0.07**	<0.01	<0.01	<0.01	<0.01
Arsenic (diss.filt)	µg/l	--	**25**	<0.5	<0.5	0.52	<0.5
Barium (diss.filt)	µg/l	**1.0**	--	6.41	6.61	5.62	5.71
Boron (diss.filt)	µg/l	**2.0**	--	18.7	25.8	21.6	22.2
Cadmium (diss.filt)	µg/l	**0.45**	**0.08**	<0.08	<0.08	<0.08	<0.08
Chromium (diss.filt)	µg/l	**32**	**4.7**	<1	<1	<1	<1
Copper (diss.filt)	µg/l	**100**	**30**	2.67	3.14	1.22	2.03
Lead (diss.filt)	µg/l	--	**7.2**	<0.2	<0.2	<0.2	0.29
Manganese (diss.filt)	µg/l	**300**	--	5.52	6.41	<3	4.78
Nickel (diss.filt)	µg/l	--	**20**	1.79	2.11	0.756	0.839
Phosphorus (diss.filt)	µg/l	--	**0.075**	<10	<10	16	28
Selenium (diss.filt)	µg/l	**0.01**	--	1.12	1.18	<1	<1
Thallium (diss.filt)	µg/l	--	--	<2	<2	<2	<2
Zinc (diss.filt)	µg/l	--	**100**	24.6	25.6	3.92	7.36
Sodium (Dis.Filt)	mg/l	**200**	--	25.2	25.4	24.3	25.9
Magnesium (Dis.Filt)	mg/l	--	--	8.76	8.91	8.05	7.48
Potassium (Dis.Filt)	mg/l	--	--	3.46	3.54	2.99	2.98
Calcium (Dis.Filt)	mg/l	--	--	126	124	118	112
Iron (Dis.Filt)	mg/l	**0.2**	--	<0.019	<0.019	<0.019	<0.019
Mineral Oil / Oils & Greases							
Mineral oil >C10 C40 (aq)	µg/l	--	--	<100	<100	<100	<100

Parameter	Units	MAC[1]	EQS[2]	Upstream SW01 16.07.2019	Downstream SW02 16.07.2019	Upstream SW01 03.09.2019	Downstream SW02 03.09.2019
PCB's							
PCB congener 28	µg/l	--		<0.015	<0.015	<0.015	<0.015
PCB congener 52	µg/l	--		<0.015	<0.015	<0.015	<0.015
PCB congener 101	µg/l	--		<0.015	<0.015	<0.015	<0.015
PCB congener 118	µg/l	--		<0.015	<0.015	<0.015	<0.015
PCB congener 138	µg/l	--		<0.015	<0.015	<0.015	<0.015
PCB congener 153	µg/l	--		<0.015	<0.015	<0.015	<0.015
PCB congener 180	µg/l	--		<0.015	<0.015	<0.015	<0.015
Sum of detected EC7 PCB's	µg/l	--	--	<0.105	<0.105	<0.105	<0.105
Semi-Volatile Organic Compounds (SVOCs)							
1,2,4-Trichlorobenzene	µg/l	--	**0.4**	<1	<1	<1	<1
1,2-Dichlorobenzene	µg/l	--	--	<1	<1	<1	<1
2,4,6-Trichlorophenol	µg/l	--	--	<1	<1	<1	<1
2-Chlorophenol	µg/l	--	--	<1	<1	<1	<1
Anthracene	µg/l	**0.4**	**0.1**	<1	<1	<1	<1
Bis(2-Ethylhexyl) phthalate	µg/l	--	--	<2	<4	<4	<2
Benzo(b)fluoranthene	µg/l		**0.03**	<1	<1	<1	<1
Benzo(k)fluoranthene	µg/l		**0.03**	<1	<1	<1	<1
Benzo(a)pyrene	µg/l	**0.1**	**0.05**	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/l		**0.002**	<1	<1	<1	<1
Indeno(1,2,3-cd)pyrene	µg/l		**0.002**	<1	<1	<1	<1

Parameter	Units	MAC[1]	EQS[2]	Upstream	Downstream	Upstream	Downstream
				SW01 16.07.2019	SW02 16.07.2019	SW01 03.09.2019	SW02 03.09.2019
n-Dibutyl phthalate	µg/l	--	--	<1	<1	<1	<1
Fluoranthene	µg/l	--	--	<1	<1	<1	<1
Hexachlorobenzene	µg/l	0.05	0.01	<1	<1	<1	<1
Hexachlorobutadiene	µg/l	0.6	0.1	<1	<1	<1	<1
Nitrobenzene	µg/l	--	--	<1	<1	<1	<1
Naphthalene	µg/l	--	2.4	<1	<1	<1	<1
Pentachlorophenol	µg/l	1	0.4	<1	<1	<1	<1
Phenol	µg/l	46	8	<1	<1	<1	<1
Volatile Organic Compounds (VOCs)							
Dichlorodifluoromethane	µg/l	--	--	<1	<1	<1	<1
Vinyl chloride	µg/l	0.5	--	<1	<1	<1	<1
Trichlorofluoromethane	µg/l	--	--	<1	<1	<1	<1
1,1-Dichloroethene	µg/l	--	10	<1	<1	<1	<1
Dichloromethane	µg/l	--	20	12.8	9.78	<3	<3
Methyl tertiary butyl ether (MTBE)	µg/l	--	--	<1	<1	<1	<1
1,1,1-Trichloroethane	µg/l	--	10	<1	<1	<1	<1
Carbontetrachloride	µg/l	--	--	<1	<1	<1	<1
1,2-Dichloroethane	µg/l	--	10	<1	<1	<1	<1
Benzene	µg/l	50	10	<1	<1	<1	<1
Trichloroethene	µg/l	--	--	<1	<1	<1	<1
Toluene	µg/l	--	10	<1	<1	<1	<1

Parameter	Units	MAC[1]	EQS[2]	Upstream	Downstream	Upstream	Downstream
				SW01 16.07.2019	SW02 16.07.2019	SW01 03.09.2019	SW02 03.09.2019
Tetrachloroethene	µg/l	--	**10**	<1	<1	<1	<1
Chlorobenzene	µg/l	--	--	<1	<1	<1	<1
Ethylbenzene	µg/l	--	--	<1	<1	<1	<1
m,p-Xylene	µg/l	--	**10**	<1	<1	<1	<1
o-Xylene	µg/l	--	**10**	<1	<1	<1	<1
4-iso-Propyltoluene	µg/l	--	--	<1	<1	<1	<1
1,2-Dichlorobenzene	µg/l	--	--	<1	<1	<1	<1
1,2,4-Trichlorobenzene	µg/l	--	--	<1	<1	<1	<1
Hexachlorobutadiene	µg/l	**0.6**	**0.1**	<1	<1	<1	<1
Combined Pesticides / Herbicides							
1,2,4-Trichlorobenzene	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Aldrin	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Alachlor	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Atrazine	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Chlorfenvinphos	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Chlorpyriphos	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Dichlobenil	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Dichlorvos	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Dieldrin	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Endosulphan I	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Endosulphan II	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Hexachlorobenzene	µg/l	--	--	<0.01	<0.01	<0.01	<0.01

Parameter	Units	MAC[1]	EQS[2]	Upstream	Downstream	Upstream	Downstream
				SW01 16.07.2019	SW02 16.07.2019	SW01 03.09.2019	SW02 03.09.2019
Hexachlorobutadiene	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Malathion	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Parathion	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Pentachlorobenzene	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Permethrin I	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Permethrin II	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Prometryn	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Simazine	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
Trifluralin	µg/l	--	--	<0.01	<0.01	<0.01	<0.01
4,4 – DDT	µg/l	--	--	<0.01	<0.01	<0.01	<0.01

Notes:

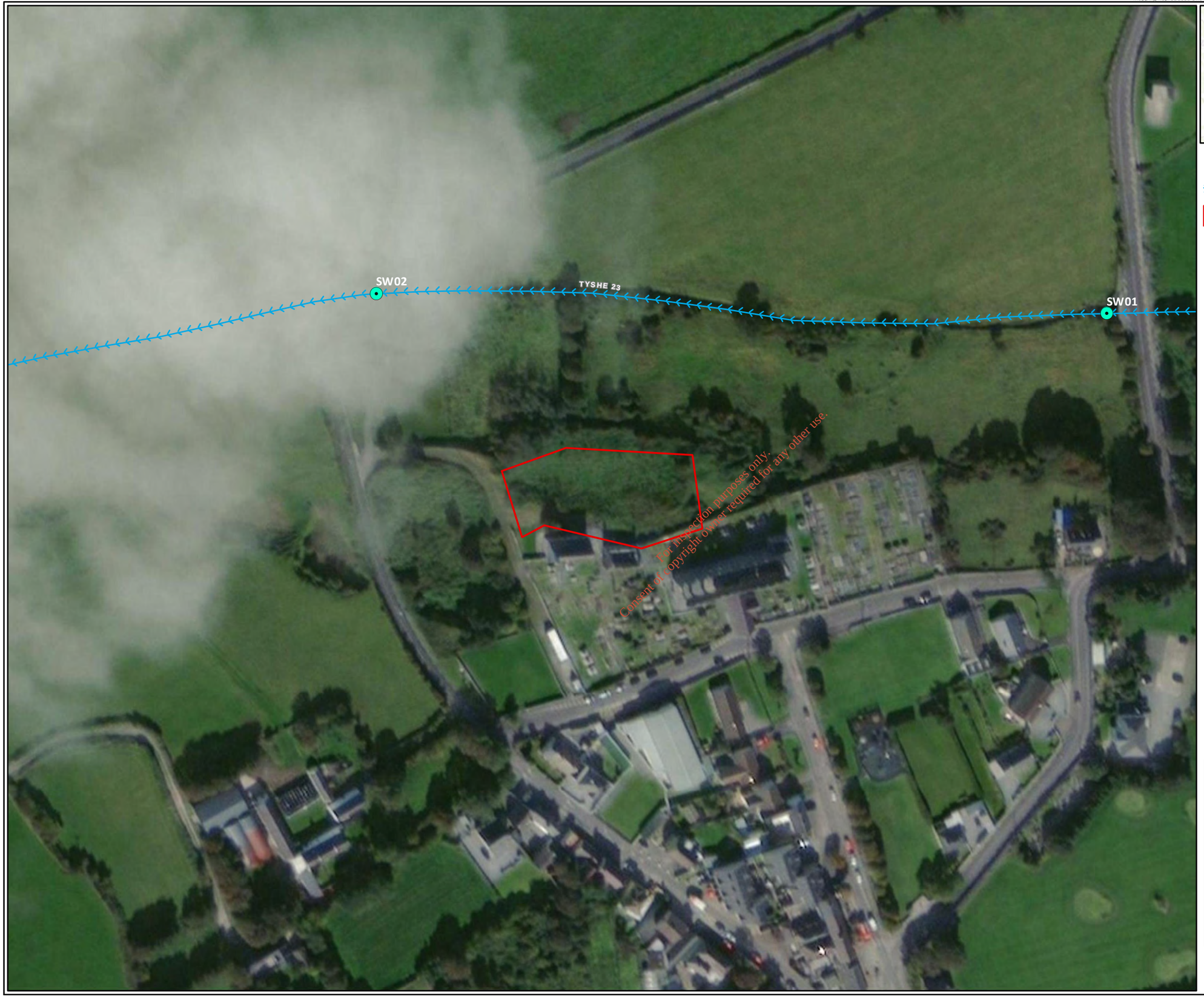
[1] Maximum Admissible Concentration (MAC), as classified by European Communities (Quality of Surface Water intended for abstraction of drinking water) Regulations 1989 (S.I No. 294 of 1989)
[2] Environmental Quality Standard (EQS), European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I No. 272 of 2009)
* Items shaded in **bold** are in exceedance of the European Communities MACs
* * Items shaded in **orange** are in exceedance of the 2009 EQS Regulations
** * NAC – no abnormal change

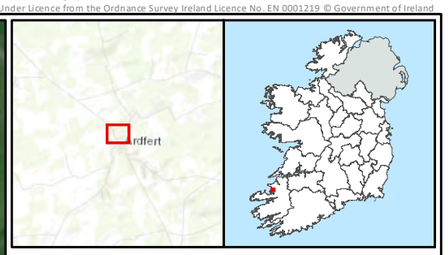
4.5.3 Surface Water Analysis Discussion

The results of the surface water laboratory analysis as presented in Table 4.5, when assessed against the MAC (1989) and EQS (2009) quality standards were found to be below the guideline values in all assessments.

Results show very little variation in parameter levels was observed between upstream and downstream sampling locations.

Path: R:\Map Production\2019\P1766\Workspace\Ardfert\Tier 2 ERA Report\P1766_Fig4-2_SWSamplingLocations_A3.mxd





Surface Water Sampling Locations

Rivers

Site Boundary

N
W E
S

0 25 50 100 Meters

TITLE: Surface Water Sampling Locations			
PROJECT: Ardfert Landfill, Co. Kerry			
FIGURE NO:	4.2		
CLIENT:	Kerry County Council		
SCALE:	1:1500	**REVISION:**	0
DATE:	31/10/2019	**PAGE SIZE:**	A3

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5. RISK ASSESSMENT

5.1 Introduction

Risk assessment considers the likelihood of occurrence and the consequence of occurrence of an event (Royal Society, 1992[2]). ERA (Environmental Risk Assessment) is based on the development of a Conceptual Site Model (CSM) which is used to determine the potential exposure of a vulnerable receptor to a contaminant. The CSM is used as the basis for the risk assessment. It is used to identify all possible sources (S), pathways (P) and receptors (R) as well as the processes that are likely to occur along each of the source-pathway-receptor (S-P-R) linkages and uncertainties.

Based on the desktop investigation and completed site investigation, this CSM assumes the source to be the made ground containing waste deposit, the pathway to involve the migration of landfill gas, surface water and groundwater and the ultimate receptors to be the surface water features, groundwater, groundwater abstraction well and all human presence near the waste material.

5.2 Potential Pathways and Receptors

A pathway is a mechanism or route by which a contaminant encounters, or otherwise affects, a receptor. Contaminants associated with deposited waste may include leachate generated from groundwater/rainwater infiltration into the waste material and/or the lateral or vertical migration of landfill gas to human receptors.

The potential pathways associated with the Ardfert site are:

- Groundwater migration; and
- Surface water infiltration;

5.2.1 Groundwater/Leachate Migration

According to the EPA CoP, there are three main pathways for leachate migration. These are:

- Vertically to the water table or top of an aquifer, where groundwater is the receptor
- Vertically to an aquifer and then horizontally in the aquifer to a receptor such as a well, spring, stream or in this case, the adjacent coastline
- Horizontally at the ground surface or at shallow depth to a surface receptor

The migration and attenuation of leachate from the site depends on the permeability and thickness of subsoil and on both the bedrock permeability value and type. These elements are encompassed in groundwater vulnerability, groundwater flow regime and surface water drainage.

[2] Royal Society 1992, Risk: Analysis, Perception and Management. The Royal Society, London (ISBN 0-85403-467-6).

The main receptors to leachate migration from this site are:

- Aquifer;
- Surface water features; and
- Human presence nearby the site

5.2.2 Landfill Gas Migration

According to the EPA CoP, there are two main pathways for landfill gas migration. These are:

- Lateral migration via subsoil
- Vertical migration via subsoil

The migration of landfill gas from the site depends on the nature of the material deposited and the nature, permeability and thickness of the surrounding subsoil or bedrock.

The main receptors to potential landfill gas migration from this site are:

- Human Presence/Buildings nearby the waste body

5.3 Conceptual Site Model

Based on the review of the Tier 1 assessment and site investigation works completed for Ardfert Historic Landfill, an assessment of the risk is made to confirm the source – pathway – receptor (S-P-R) linkages identified in the preliminary investigation. The results and analysis of the investigation has enabled a revised conceptual model to be produced for the site, which is presented in Figure 5.1, overleaf.

Landfill Gas Migration

Leachate Migration

Measured Groundwater Level

Dwelling 250m North

River Tyshe

Lower Field Boundary

BH01 12.01mOD

BH02 16.98mOD

ST. BRENDANS CATHEDRAL

Upper Field Boundary

Shallow 1.0m Topsoil / Clay Cap

WASTE BODY

Depth of waste ~4.2m BGL

Sandy Gravelly Silty Clay

BEDROCK: LIMESTONE

Bedded bioclastic limestone

Karstified Limestone

0.96mOD

Regionally Important Aquifer – Karstified Bedrock

Vulnerability - Extreme

GW FLOW DIRECTION

North-West

Ardfert Group Water Supply Scheme

270m North

CROSS SECTION NORTH-WEST / SOUTH-EAST

FIGURE 5.1 ARDFERT HISTORIC LANDFILL CONCEPTUAL SITE MODEL

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5.4 Risk Prioritisation

Risk prioritisation enables resources to be prioritised on the highest risk facilities and on the highest source – pathway – receptor linkage potential.

The risk prioritisation process assigns a score to each linkage and the overall score is the maximum of the individual linkages for the site. The higher the score a site/linkage receives the higher the risk.

To classify the risk, scores will be applied to the information obtained during the site investigation of Ardfert Historic Landfill. Where there is insufficient information available (i.e., where there is a high degree of uncertainty) the highest score is assumed.

In accordance with the EPA CoP (2007) the scoring matrices are as follows:

- Leachate: Source/hazard scoring matrix, based on waste footprint
- Landfill gas: Source/hazard scoring matrix based on waste footprint
- Leachate migration: Pathway (Vertical)
- Leachate migration: Pathway (Horizontal)
- Leachate migration: Pathway (Surface water drainage)
- Landfill gas: Pathway (Lateral migration potential)
- Landfill gas: Pathway (Upwards migration potential)
- Leachate migration: Receptor (Surface water drainage)
- Leachate migration: Receptor (Human presence)
- Leachate migration: Receptor (Protected areas – SWDTE or GWDTE) (Surface water/groundwater dependent terrestrial ecosystems)
- Leachate migration: Receptor (Aquifer category – Resource potential)
- Leachate migration: Receptor (Public water supplies – other than private wells)
- Leachate migration: Receptor (Surface water bodies)
- Landfill gas: Receptor (Human presence)

Table 5.1 calculates the points awarded to each of the headings listed above.

Table 5-1: Risk Classification Calculation – Ardfert Landfill

EPA Ref	Risk	Points	Rationale
1a	Leachate; source/hazard scoring matrix, based on waste footprint.	5	Based on a waste footprint of 0.14 ha and the presence of municipal and domestic waste the score of 5 is being maintained.
1b	Landfill gas; source/hazard scoring matrix, based on waste footprint.	5	Based on a waste footprint of 0.14 ha and the presence of municipal and domestic waste the score of 5 is being maintained.

EPA Ref	Risk	Points	Rationale
2a	Leachate migration: Pathway (Vertical)	3	GSI describes the groundwater vulnerability as extreme across the entire site. The geophysical site survey identified a possible small karstified area underlying the waste body and waste above possible bedrock as indicated during trial pitting at TP6.
2b	Leachate migration: Pathway (Horizontal)	5	A significant portion of the site is underlain by Regionally Important Aquifer – Karstified (Rkd).
2c	Leachate migration: Pathway (Surface water drainage)	0	No land drains are present at the site, no direct surface water pathway to the River Tyshe.
2d	Landfill gas: Pathway (Lateral migration potential)	3	The intrusive site investigation identified the shallow bedrock as karstified bedrock outcrop.
2e	Landfill gas: Pathway (Upwards migration potential)	0	No buildings located directly above estimated waste footprint area.
3a	Leachate migration: Receptor (Human presence)	2	One residential dwelling is located between 50m and 250m to the north-west of the site boundary.
3b	Leachate migration: Receptor (Protected areas – SWDTE or GWDTE) (Surface water/ groundwater dependent terrestrial ecosystems)	2	The nearest groundwater source protection zone (SPZ) is located approximately 270m north of the site at its closest point. A score of 2 is applied due to the presence of karst bedrock and the SPZ being just over the CoP distance threshold of 250m.
3c	Leachate migration: Receptor (Aquifer category – Resource potential)	5	The Cloonagh formation as a Regionally Important Aquifer – Karstified (Diffuse) Bedrock (Rkd).
3d	Leachate migration: Receptor (Public water supplies – other than private wells)	3	The nearest groundwater protection zone (outer source protection area) is located approximately 270m north of the site at its closest point. The inner source protection abstraction boreholes are approximately 500m north of the site.
3e	Leachate migration: Receptor (Surface water bodies)	2	The River Tyshe is located approximately 70m north of the site.
3f	Landfill Gas: Receptor (Human presence)	5	Ardfert Cathedral located within 50m south of the identified waste body.

Table 5-2: Normalised Score of S-P-R Linkage

Calculator		S-P-R Values	Maximum Score	Linkage	Normalised Score
Leachate migration through combined groundwater and surface water pathways					
SPR1	1a x (2a + 2b + 2c) x 3e	80	300	Leachate => surface water	27%
SPR2	1a x (2a + 2b + 2c) x 3b	40	300	Leachate => SWDTE	13%
Leachate migration through groundwater pathway					
SPR3	1a x (2a + 2b) x 3a	80	240	Leachate => human presence	33%
SPR4	1a x (2a + 2b) x 3b	40	240	Leachate => GWDTE	33%
SPR5	1a x (2a + 2b) x 3c	200	400	Leachate => Aquifer	**50%**
SPR6	1a x (2a + 2b) x 3d	120	560	Leachate => Surface Water	21%
SPR7	1a x (2a + 2b) x 3e	80	240	Leachate => SWDTE	33%
Leachate migration through surface water pathway					
SPR8	1a x 2c x 3e	0	60	Leachate => Surface Water	0%
SPR9	1a x 2c x 3b	0	60	Leachate => SWDTE	0%
Landfill gas migration pathway (lateral & vertical)					
SPR10	1b x 2d x 3f	25	150	Landfill Gas => Human Presence	17%
SPR11	1b x 2e x 3f	25	250	Landfill Gas => Human Presence	10%
Site maximum S-P-R Score					**50%**
Risk Classification					**Class-B**

Table 5.2 shows the maximum S-P-R scoring for the site is **50%.**

The following are the risk classifications applied:

- Highest Risk (Class A) Greater than 70 for any individual SPR linkage
- Moderate Risk (Class B) 41-69 for any individual SPR linkage
- Lowest Risk (Class C) Less than 40 for any individual SPR linkage

Based on this, the site can be classified as a **Moderate Risk Classification (Class B)**. The principal risks identified on the site are the risk posed to underlying groundwater aquifer from the migration of leachate from the waste body.

6. CONCLUSION

A Tier 2 study was conducted by FT in accordance with the EPA CoP for Ardfert Historic Landfill. The study consisted of a desktop study, geophysical survey and intrusive site investigation works. These works informed the development of the CSM and risk screening model.

The findings of the site investigation work and geophysical surveying show that waste material is deposited in a single infill area tending east to west in the centre of the site and between approximately 58m in length and 25m in width. The total area covered by the waste body is approximately 1,675 m^2.

A volume calculation based on the geophysical survey results indicate an interred waste volume of approximately 5,025 m^3 (7,015 tonnes) at the site.

Trial pitting confirms waste material is near the surface with a shallow and impermeable topsoil / subsoil cover present across the site.

Analysis of waste samples from the trial pits excavated, when assessed against the inert waste acceptance criteria indicated that much of the waste material within the site can be classified as typically inert. The waste classification is considered to reflect the level of degradation over time since landfilling ceased in 1980. The WAC testing indicates the spoil material has a high organic content which may be due to the degradation of organic fractions within the MSW or domestic waste. Levels of mercury in the soil sample have been detected above the inert WAC limit value at 0.015 mg/l.

Groundwater depth analysis was undertaken on one occasion in September 2019 at BH01 to the north-west of the site. Field survey measurements inferred groundwater levels were present below the surface at over 11 m below ground level (m bgl). Based on this standalone measurement, it is assumed that the potentiometric groundwater surface does not intersect the waste body further upgradient. No groundwater was encountered at BH02 during both monitoring rounds in July and September 2019.

Site monitoring results to date has not determined definitively if the groundwater table intersects the waste body potentially contributing to leachate impact from the landfill. Seasonal variations in groundwater levels may intersect the waste body, this should be determined through further investigation.

Analysis of groundwater samples from monitoring well BH01 reported ammoniacal nitrogen (as N), chloride and potassium concentrations which exceed the guideline OTV limit values. Based on the presence of elevated ammonia, chloride and potassium concentrations, it appears the landfill waste body may be impacting groundwater quality downgradient of the site.

The nearest groundwater protection zone (outer source protection zone) is located approximately 270m north of the site at its closest point. This groundwater protection zone relates to the Ardfert Group Water Supply Scheme/Ardfert South Boreholes. The potential presence of karstified bedrock below the waste body represents a risk of leachate migration northwards towards the outer source protection zone.

Landfill gas monitoring from perimeter well BH01 and in-waste well BH02 at the site indicates gas concentrations detected are just above or equal the 1.0% v/v methane threshold level set by the EPA CoP.

Analysis of two rounds of surface water sampling from the River Tyshe found all results to be below the MAC (1989) and EQS (2009) guideline limit values in all assessments. The results indicate the landfill is not having an impact on surface water quality. The findings tally with the findings that the local groundwater and surface water regimes are not hydrologically linked at this location.

Based on the results of the Tier 2 site assessment, the site can be classified as a **Moderate Risk Classification (Class B)**. The principal risks identified on the site are the risk posed to underlying groundwater aquifer from the migration of leachate from the waste body.

6.1 Recommendations

Based on the results of the initial Tier 2 assessment the site is classified as Moderate Risk. For a moderate-risk site, the CoP indicates that a Tier 3 Environmental risk assessment be undertaken including a Detailed Quantitative Risk Assessment (DQRA).

It is therefore recommended by FT that a Tier 3 DQRA be undertaken for the site in conjunction with an application for a Certificate of Registration for this site.

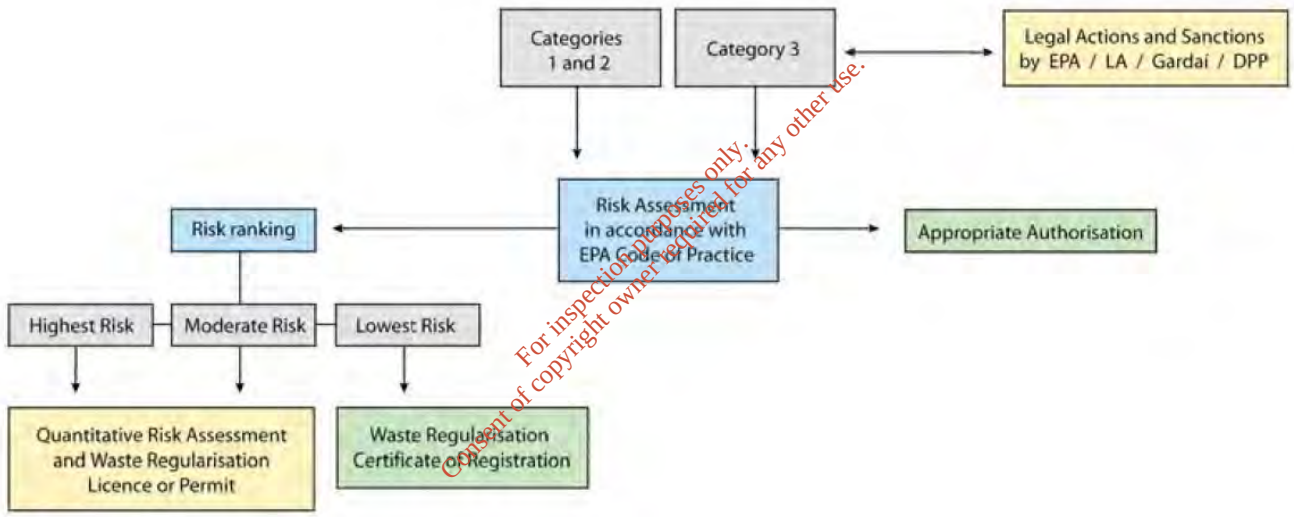

Figure 6-1: Extract from Section 1.3 of the EPA Code of Practice