TIER 1 ENVIRONMENTAL RISK ASSESSMENT

HISTORIC LANDFILL AT KILLYCRONAGHAN LANDFILL CO. MONAGHAN

JUNE 2018

FEHILY TIMONEY & COMPANY

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Abstract: This report represents the findings of a Tier 1 risk assessment conducted at the historic landfill at Killycronaghan Landfill, Co. Monaghan in accordance with the EPA Code of Practice on Environmental Risk Assessment for Unregulated Waste Disposal Sites.

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PREAMBLE

Fehily Timoney & Co. (FT) was appointed by Monaghan County Council (MCC) to complete a Tier I environmental risk assessment (ERA) of the existing environment for a historical landfill located in Killycronaghan, Co. Monaghan. This ERA was carried out in accordance with the EPA Code of Practice (CoP) on ERA for Unregulated Waste Disposal Sites (2007).

The historic landfill is located approximately 8km North-East of Clones town approximately 1km off the N54 close to the village of Smithboro. The entire site covers approximately 9 hectares although the interred waste body is believed to be contained within a smaller area.

A Tier I assessment was conducted by FT which included a detailed desk study and site walkover. This concluded that a **high-risk classification (Class A) can be assigned to the site**.

A Tier II risk assessment is required for a site which is classified as high risk. FT recommend intrusive site investigations and sampling as part of the Tier 2 assessment.

For a high-risk site, the CoP directs that the site will have to apply for a certificate of authorisation to certify compliance with Regulation 7(7) of the Waste Management (Certification of Historic Unlicensed Waste Disposal and Recovery Activity) Regulations, 2008.

1. INTRODUCTION

1.1. Background

Killycronaghan historic landfill is located approximately 8km North-East of Clones town circa 1km off the N54 national road, close to the village of Smithboro. Anecdotal evidence suggests landfilling of the site commenced in the 1970s and operations ceased in 1984.

The site is approximately 9 hectares in size. The site is bounded to the southeast, east and north by the Kilgormly river. The Magheramey river bounds the site to the northwest. There are no dwelling houses located within 100m of the site though there are poultry house sites close to the north-eastern boundary of the site.

Since its closure the site has reverted to private ownership and the lands are presently used for agriculture. The site has been capped with soil but no other remediation works have been carried out.

MCC requested that an ERA be carried out for the site in accordance with the EPA CoP on ERA for Unregulated Waste Disposal Sites.

1.2. Scope of Works and Project Objectives

The scope of work was to undertake a Tier 1 assessment of the site based on the risk assessment methodology approach, in accordance with the EPA CoP. This approach requires the carrying out of a:

- Desktop Study
- Detailed Site Walkover
- Environmental Risk Assessment (ERA)
- Development of Conceptual Site Model (CSM)

1.2.1. Project Objectives

As part of the initial desk study a preliminary assessment of available information was undertaken. This was followed-up with a site walkover. The desk study and site walk-over were used to inform the development of both the preliminary conceptual site model (CSM) and the ERA.

This report presents the findings of the assessment.

2. METHODOLOGY

2.1. Introduction

A desktop review of available documentation for the site was conducted and a visit was undertaken to carry out a detailed site walkover on 12th June 2018.

The documentation made available to FT for the desktop review included:

- Ordnance Survey of Ireland (OSI), www.osi.ie
- Geological Survey of Ireland (GSI), www.gsi.ie
- EPA http://gis.epa.ie/Envision
- Office of Public Works (OPW), http://www.opw.ie/hydro/index.asp?mpg=main.asp
- Water Maps, http://watermaps.wfdireland.ie
- Monaghan County Council Site Plans and Drawings

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 landfill is located within a primarily rural setting in an area of rolling topography dominated by drumlins. Areas between the drumlins are often boggy, while more free-draining ground is found on the drumlins themselves. The site is generally described as flat with a hill rising on the southwestern portion of the site. The land use in the area is primarily agricultural with the subject site currently used for pasture.

The site is surrounded by agricultural land with poultry buildings located to the northeast of the site.

2.2.2 Existing Bedrock Geology

According to the GSI the site is found on two primary formations. The northern and western sections of the site and surrounding area are underlain by the Cooldaragh formation (CH) which is generally made up of '*Pale brown-grey flaggy, silty mudstone'.* The southern and eastern sections of the site are underlain by the Feranaght formation (FT), which is generally made up of '*Pale conglomerate & red sandstone'.*

2.2.3 Existing Overburden Geology

The landfill site is underlain by shallow rocky, peaty/non-peaty mineral complexes overlying a regionally important aquifer. The subsoils are typically of glaciofluvial sands and gravels. According to the GSI, the glacial overburden is mapped as 'Gravels derived from Limestones' (GLs) as shown in Figure 2.3.

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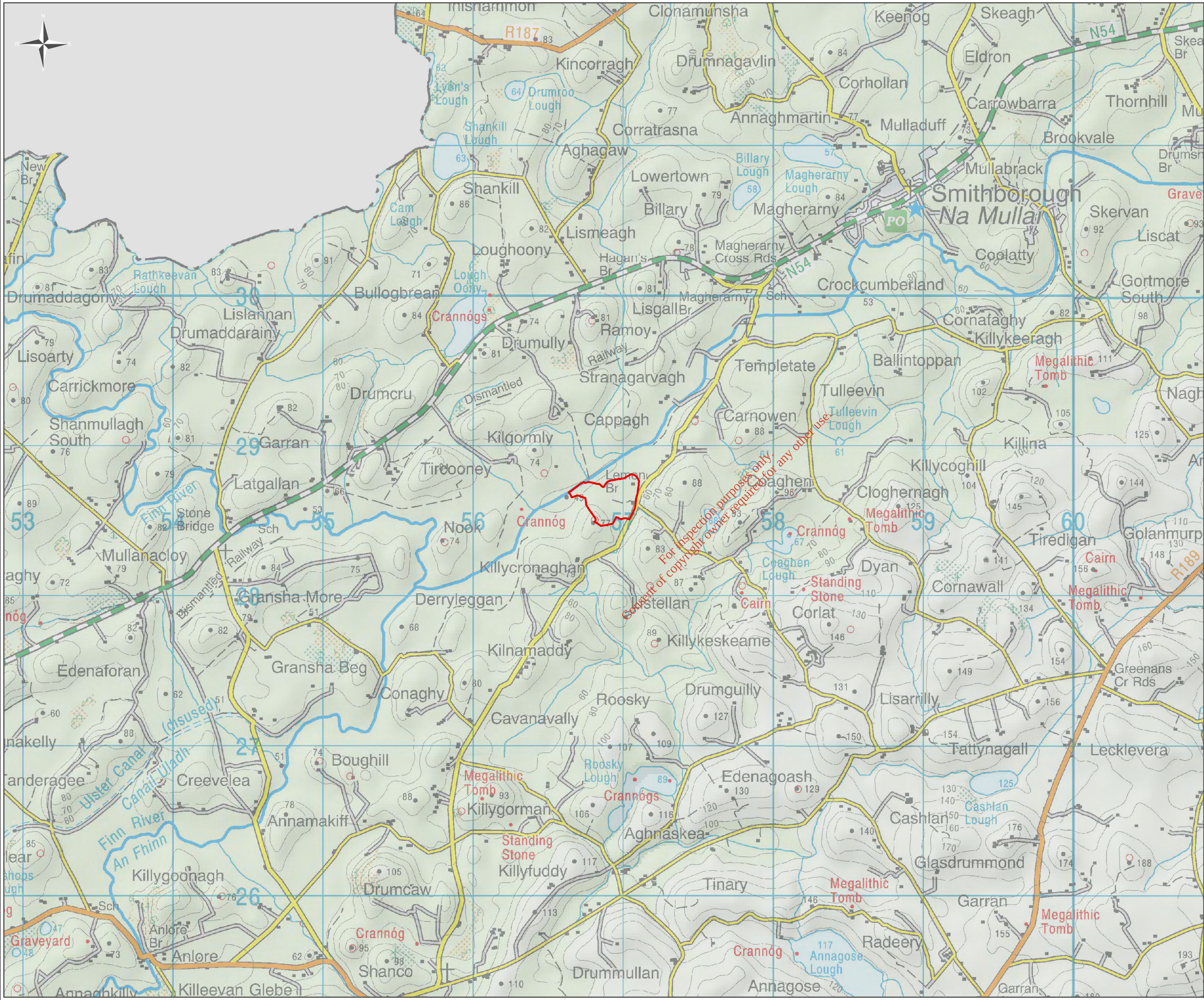

Co. Monaghan

Legend

Site Boundary

Figure Title	Site Location Knockcronaghan
Figure No.	2.1
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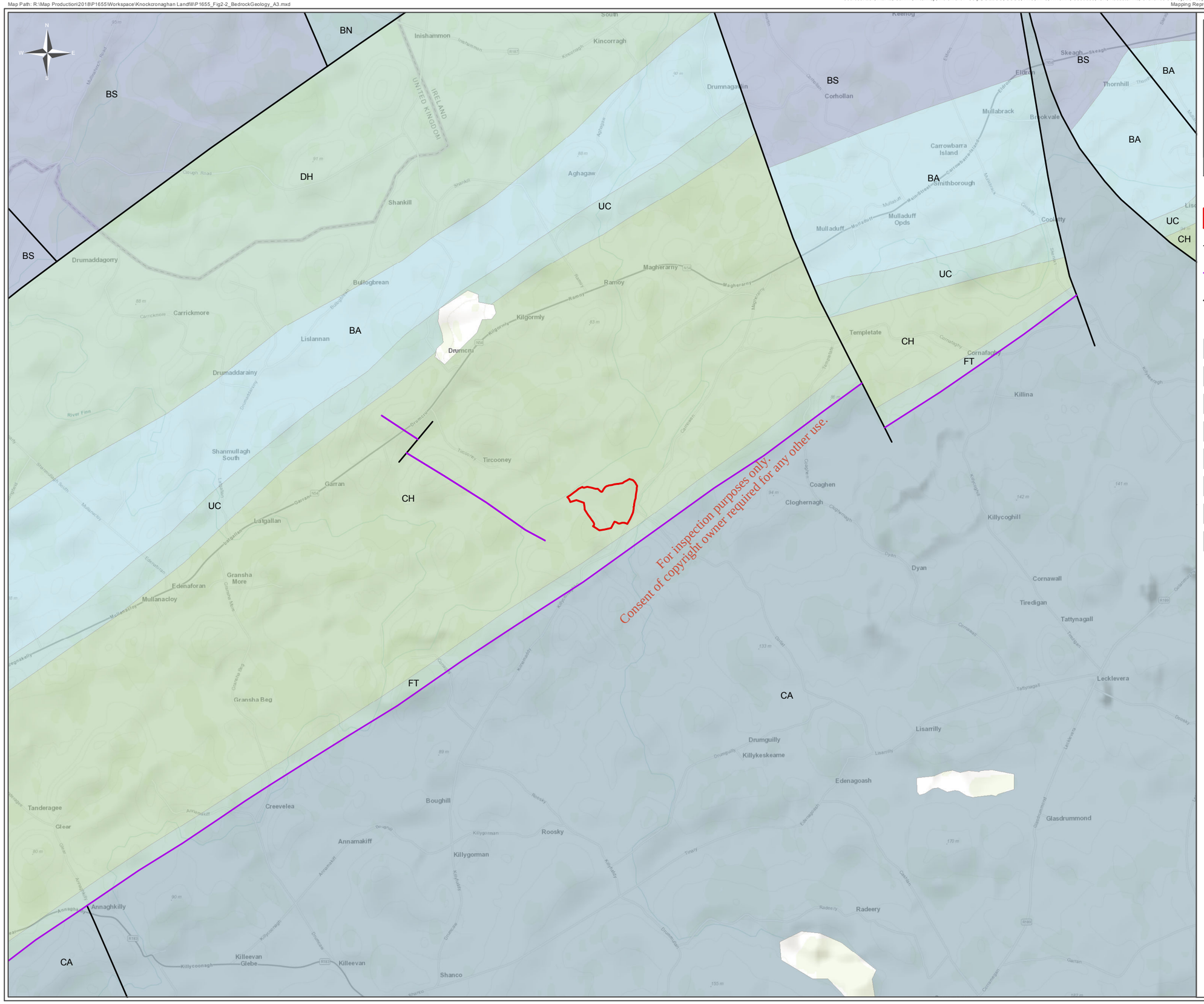

Legend

- Site Boundary
- Dip of Bedding in Degrees
- Stratigraphical Linework
- Structural Linework

Bedrock Geology

- BA: Ballysteen Formation
- BN: Bundoran Shale Formation
- BS: Ballyshannon Limestone Formation
- CA: Coronea Formation
- CH: Cooldaragh Formation
- DH: Drumgesh Shale Formation
- FT: Fearnaght Formation
- UC: Ulster Canal Formation

Figure Title
Bedrock Geology
Knockcronaghan

Figure No. 2.2

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Tier 1 Assessment of Historical Landfills in Monaghan

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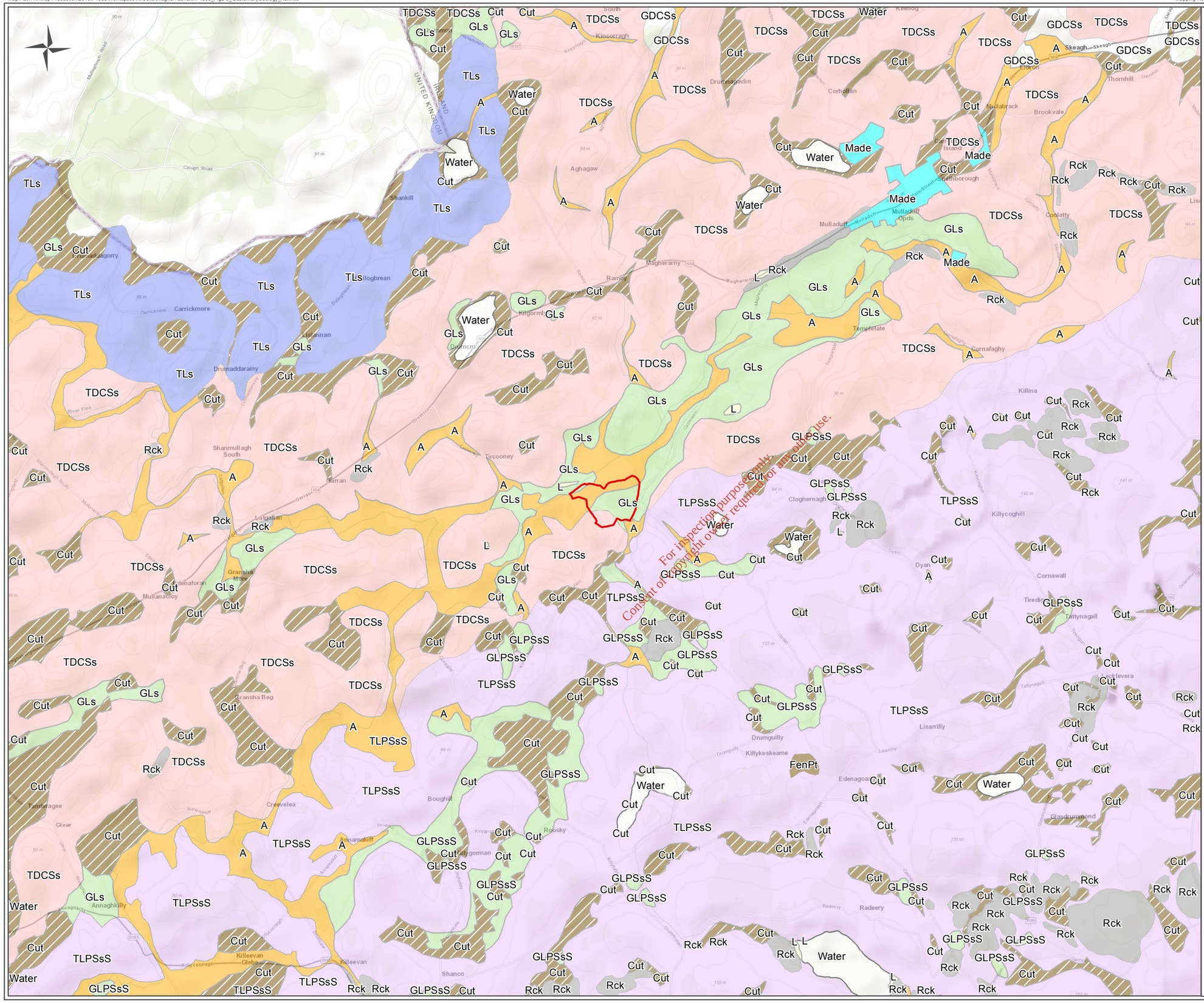

Co. Monaghan

Legend

- Site Boundary

Subsoils Data

- A, alluvium
- Cut, cutover peat
- FenPt, fen peat
- GLPSsS, sandstone & shale sands and gravels
- GLs, limestone sands and gravels - Carboniferous
- L, lake sediment
- Made, made ground
- Rck, bedrock at surface
- TDCSs,
- TLPSsS, sanstone and shales till - Lower Paleozoic
- TLs, limestone till - Carboniferous
- Water, water

Figure Title
Quaternary Geology
Knockcronaghan

Figure No. 2.3

Project
Tier 1 Assessment of Historical Landfills in Monaghan

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2.2.4 Hydrogeology

The site lies within the Clones Groundwater Body (IEGBNI_NW_G_063) which is defined as being at *Good Status* under the Water Framework Directive.

There are no karst landforms within the site boundary. The nearest karst landform is a spring named St. Maudain's Well, approximately 22.3km north of the site boundary. The spring lithology is muddy limestone.

The GSI national recharge map defined the annual recharge as 515mm/yr. The effective rainfall for the area is 606mm/yr, indicating the recharge coefficient is 85%.

Historical mapping for the area shows several springs in the surrounding area. A number of these springs are located at the base of the drumlins and may represent groundwater discharging from the drumlin sediments where these spread out at the base of the drumlins.

There are no recorded public groundwater supplies and no recorded groundwater dependent ecosystems in the area.

There are a number of residences within 250m of the site where it is likely that unregistered private wells may be present.

Locations of wells and springs are presented in Figure 2.5.

Table 2.1: Distance of wells and springs from the Site

BH / Spring	Yield class	Yield	Use	Depth (m)	Depth to Rock confidence (m)	Distance from site (km)	Date
2331NEW078	Poor	25.9	--	3.0	--	0.20	1899
2331NEW079	Poor	25.9	--	3.0	--	0.7	1899
2331NEW048	Poor	25.9	--	3.0	--	0.48	1899
2331NEW077	Poor	25.9	--	3.0	--	0.56	1899
2331NEW050	Moderate	51.8	--	40	21	0.46	1899
2331NEW159	Poor	32.7	--	2.4	--	<1	1973
2331NEW158	Poor	32.7	--	2.4	--	<1	1967
2331NEW154???	Moderate	65.5	--	35.7	4.3	<1	1970

According to GSI, there are no Groundwater Drinking Water Protection Areas within the site boundaries, the closest groundwater protection area to the sites is the Monaghan Town outer protection areas, approximately 6km north-east of the site boundary. The outer protection area is 3.76 km^2.

2.2.5 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 could be contaminated by human activities.

The vulnerability of an aquifer to contamination is influenced by the leaching characteristics of the topsoil, the permeability and thickness of the subsoil, the presence of an unsaturated zone, the type of aquifer, and the amount and form of recharge (the hydrologic process where water moves downward from surface water to groundwater).

Groundwater vulnerability is determined mainly according to the thickness and permeability of the subsoil that underlies the topsoil, as both properties strongly influence the travel times and attenuation processes of contaminants that could be released into the subsurface from below the topsoil.

The Cooldaragh formation is classified as a Regionally Important Aquifer – Fissured Bedrock (Rf). The aquifer vulnerability of the site is high. The vulnerability at the drumlins themselves is lower due to the thicker subsoils comprising the drumlins.

The groundwater vulnerability for the site is presented in Table 2.2. This table outlines the standard ratings of vulnerability used by the GSI, with the existing site conditions highlighted based on the findings of the site investigations.

Table 2.2: Groundwater Vulnerability

Vulnerability Rating	Hydrogeological Conditions		
	Subsoil Permeability (Type) and Thickness		
	High Permeability (sand/gravel)	Moderate Permeability (sandy soil)	Low Permeability (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: 1. N/A = not applicable.
2. Precise permeability values cannot be given at present.

2.2.6 Hydrology

The site is located within the catchment of the River Erne which flows towards the west. The site is bounded to the southeast, east and north by the Kilgormly river. The Magheramey river bounds the site to the northwest. Surface water ditches bound the site to the southwest and south.

There are a number of small lakes located in the vicinity of the site. Coaghen Lough is located approximately 0.9km to the east of the site. Two smaller unnamed lakes are located approximately 0.5km and 0.7km east of the site, while Lough Oony is located approximately 1.2km northwest of the site.

2.2.7 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 6km east of the site boundary at Calliagh. Calliagh is described as *"this site consists of a small 19th Century excavation or quarry on the summit of an unnamed hill"* and the geological feature of note is *"the first recorded location in Ireland and Britain of manganaxinite".*

2.2.8 Existing Geotechnical Stability

The GSI landslides database indicates that the nearest recorded geo-hazard was at Carrowmaculla, Lisnaskea Co. Fermanagh (ITM 643496 835192) in 1979, approximately 14.6 km northwest of the site boundary.

2.2.9 Site History

OSI Historic Map (1888-1913 and 1837-1842) identifies that the land within the site boundary was previously a gravel pit and arable land, with the surrounding area previously arable land. The historic map of the site is shown in Figure 2.4 below.

Figure 2.3.1: OSI Site Historic Map

2.2.10 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). Protected sites within the vicinity of the site include Lisarilly Bog proposed NHA (pNHA), approximately 1.8km southeast of the site. Lislallan Bog proposed NHA (pNHA) lies approximately 2.4km northwest of the site.

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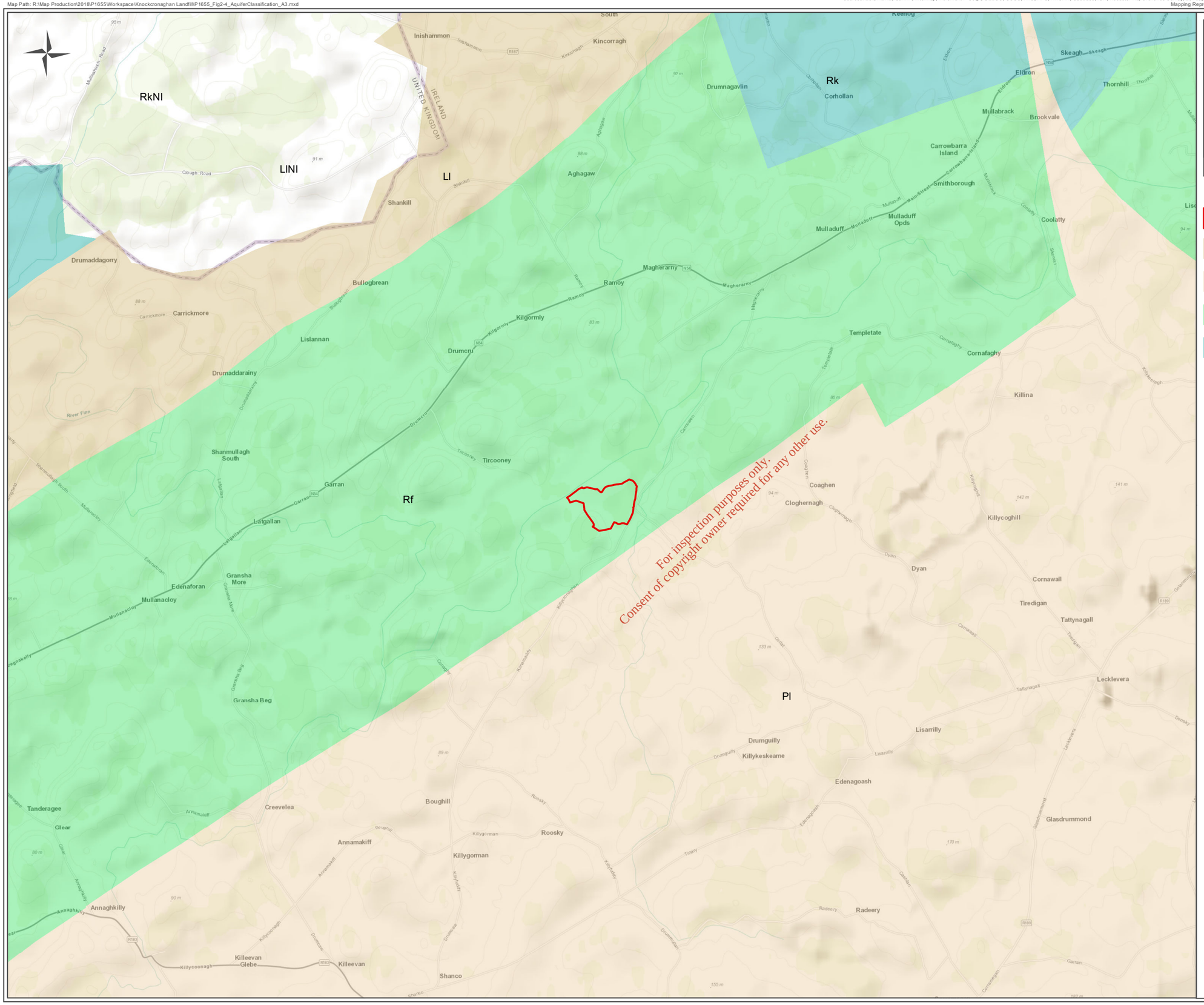

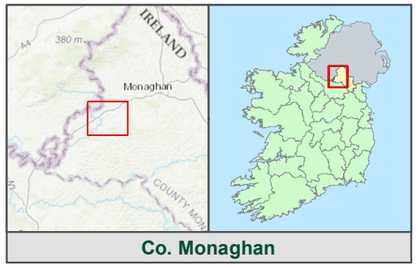

Legend

- Site Boundary
- LI: Locally Important Aquifer - Bedrock Mod Productive Locally
- Pl: Poor Aquifer Bedrock Generally Unproductive Except Locally
- Rf: Regionally Important Aquifer - Fissured Bedrock
- Rk: Regionally Important Aquifer - Karstified

0 0.5 1 2 Kilometers

Figure Title
Aquifer Classification
Knockcronaghan

Figure No. 2.4

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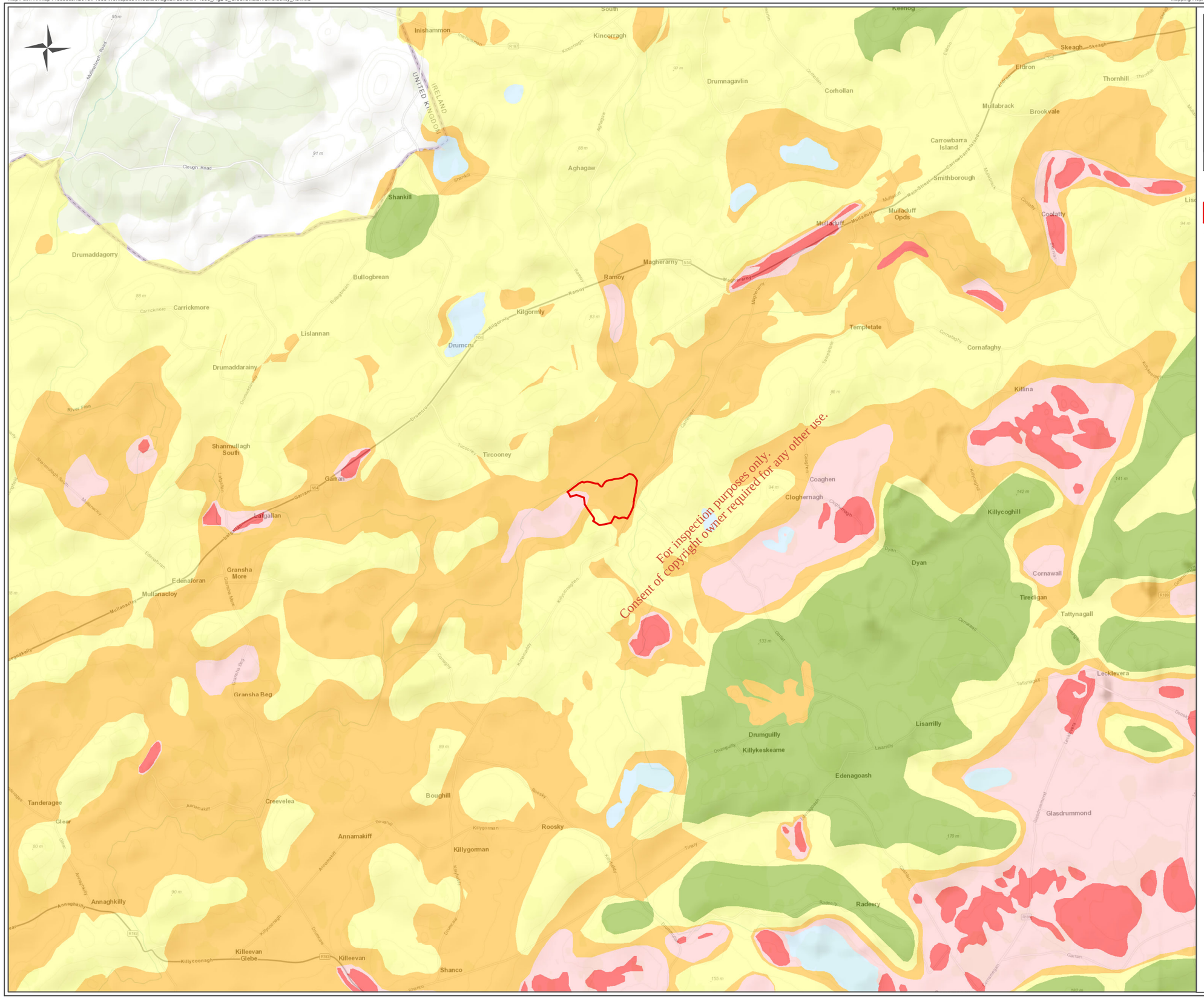
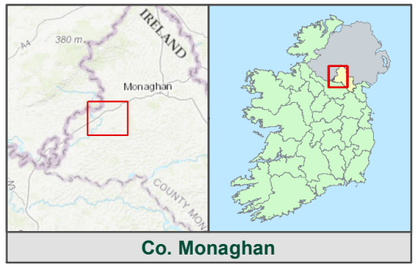
Map Path: R:\Map Production\2018\P1655\Workspace\Knockcronaghan Landfill\P1655_Fig2-5_GroundwaterVulnerability_A3.mxd





Legend

- Site Boundary

Groundwater Vulnerability

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

0 0.5 1 2 Kilometers

Figure Title	Groundwater Vulnerability Knockcronaghan
Figure No.	2.5
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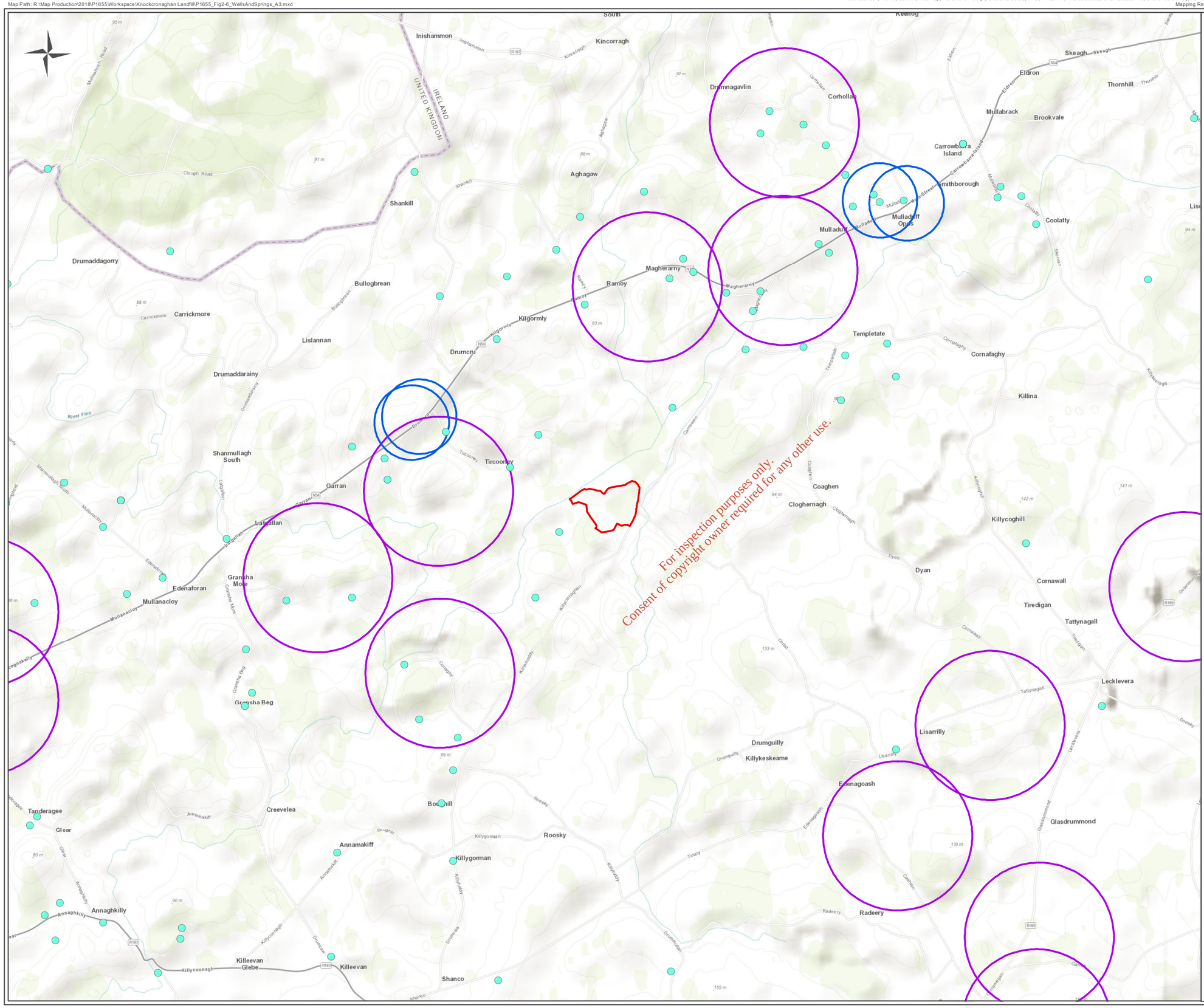
Map Path: R:\Map Production\2018\P1655\Workspace\Knockcronaghan Landfill\P1655_Fig2-6_WellsAndSprings_A3.mxd



0 0.5 1 2 Kilometers

Legend

- Site Boundary
- Groundwater Well (10-50m Accuracy)
- Groundwater Well (200-500m Accuracy)
- Groundwater Well (500m-1km Accuracy)

Figure Title
Wells and Springs
Knockcronaghan

Figure No. 2.6

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2.3. Site Investigation

The site investigation comprised of a detailed site walkover by an FT Project Scientists The site walkover was conducted on the 12th June 2018. The completed site walkover checklist, in accordance with the EPA CoP, is included in Appendix II to this report.

2.3.1. Site Walkover

The FT Project Scientist noted that the site is currently used as agricultural pasture and that the ground level is undulating. The walkover paid considerable attention to the surface water drainage network surrounding the site along the perimeter along with waterlogged depressions in the field.

The Kilgormley river bounds the site on the east and north sections of the site. The site is bounded by the Ulster Canal to the Northwest where the Kilgormley river flows into the canal. Large sections of the remaining site perimeter to the South and Sothwest are defined by surface water ditches. The ditch to the southeast of the site was found to be blocked causing drainage water to stagnate along this section. Anecdotal evidence collected during site walkover suggests that this ditch was blocked during road resurfacing works carried out by Monaghan County Council.

There were two old wells found onsite during site walkover, located within the waste body and show in photos 13 and 14 of Appendix III. Anecdotal evidence from Monaghan County Council and the landowner suggests that these are old landfill gas wells.

The site walkover noted evidence of settlement with indications of leachate seepage identified near the centre of the site as shown in photos 15 and 16 in Appendix III.

Anecdotal evidence obtained during the site walkover suggests that waste placement occurred mainly on the southern, eastern and western areas of the site.

A detailed photographic log is included in Appendix III to this report.

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Co. Monaghan

Legend

Site Boundary

0 50 100 200 Meters

Figure Title
Existing Site Layout
Knockcronaghan

Figure No. 2.7

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3. RISK ASSESSMENT

3.1. Introduction

Risk assessment considers the likelihood of occurrence and the consequence of occurrence of an event (Royal Society, 1992[1]). ERA 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 site walkover undertaken, this CSM takes the source of the contamination to be the interred waste material deposited in the historic landfill, the pathway to involve the Kilgormly and Magheramey rivers, surface water drainage and groundwater and the ultimate receptors to be the groundwater and the Kilgormly and Magheramey rivers located west, east and north of the historic landfill to the north and all human presence nearby the former landfill.

3.2. Potential Pathways and Receptors

A pathway is a mechanism or route by which a contaminant comes into contact with, 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 generation of landfill gas from the degradation of the biodegradable fraction of deposited waste.

The potential pathways associated with the site are:

- Groundwater/Leachate migration through the bedrock aquifer to the adjacent stream to the east and north and canal to the northwest;
- Landfill Gas migration

3.2.1. Groundwater/Leachate Migration

The three main pathways for leachate migration 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 or stream.
- 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. The main receptors to leachate migration from this site are:

- Aquifer; and,
- Surface water bodies

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

3.2.2. Landfill Gas Migration

The two main pathways for landfill gas migration 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

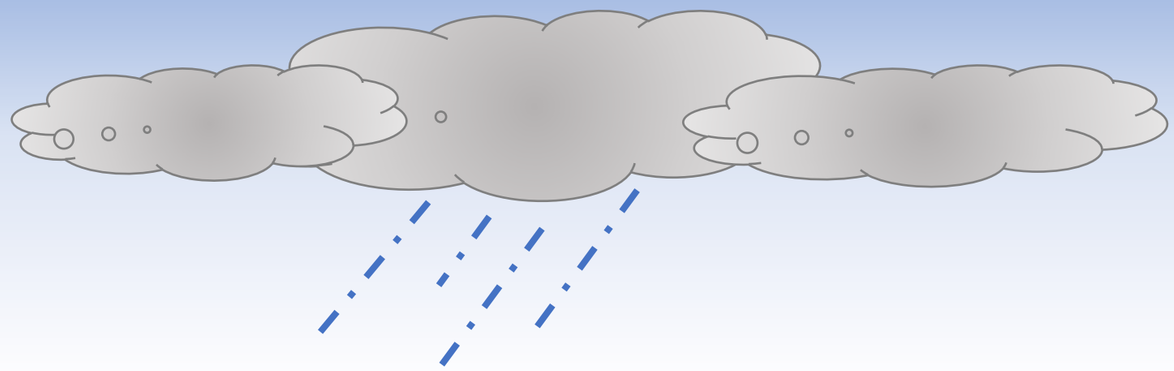
Landfill gas has the potential to collect in confined spaces such as ducts, chambers, and manholes. As a result, the farm buildings near the site entrance and the poultry buildings to the northeast of the site area areas that may be at particular risk from landfill gas produced at the site.

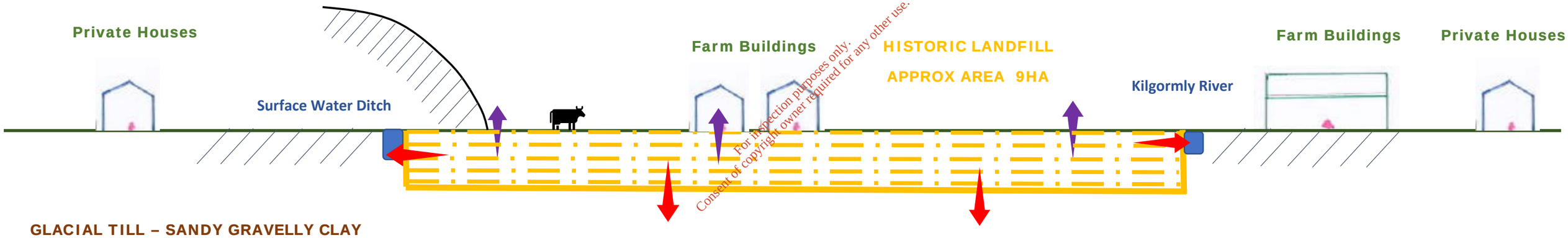
3.3. Conceptual Site Model

Based on the desktop investigation and site walkover undertaken, 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 basic conceptual model to be produced, which is presented in Figure 3.1, overleaf.

LANDFILL GAS

LEACHATE MIGRATION





CROSS SECTION SOUTH – NORTH

FIGURE 3.1 KILLYCRONAGHAN HISTORIC LANDFILL CONCEPTUAL SITE MODEL

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3.4. 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. Where there is insufficient information available (i.e. where there is a high degree of uncertainty) the highest score is assumed.

The scoring matrixes 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 3.1 calculates the points awarded to each of the headings listed above.

Table 3.1: Risk Classification Calculation

EPA Ref	Risk	Points	Rationale
1a	Leachate; source/hazard scoring matrix, based on waste footprint.	10	Based on a waste footprint of >5 ha and a site that operated as a landfill post 1980.
1b	Landfill gas; source/hazard scoring matrix, based on waste footprint.	10	Based on a waste footprint of >5 ha and a site that operated as a landfill post 1980.
2a	Leachate migration: Pathway (Vertical)	2	GSI describes the groundwater vulnerability as High.
2b	Leachate migration: Pathway (Horizontal)	3	The bedrock is classified by the GSI as a Regionally Important Fissured Bedrock Aquifer (Rf).
2c	Leachate migration: Pathway (Surface water drainage)	2	Connection between the waste body and surface water
2d	Landfill gas: Pathway (Lateral migration potential)	3	Sand and Gravel, Made ground, urban, karst. Previously an historic gravel pit.
2e	Landfill gas: Pathway (Upwards migration potential)	5	Sand and Gravel, Made ground, urban, karst.

EPA Ref	Risk	Points	Rationale
3a	Leachate migration: Receptor (Human presence)	3	On or within 50m of the waste body - farm buildings onsite and adjacent to site.
3b	Leachate migration: Receptor (Protected areas – SWDTE or GWDTE) (Surface water/ groundwater dependent terrestrial ecosystems)	0	Greater than 1km from the waste body.
3c	Leachate migration: Receptor (Aquifer category – Resource potential)	5	Regionally important aquifers (RK, Rf, Rg).
3d	Leachate migration: Receptor (Public water supplies – other than private wells)	0	Greater than 1km (no karst aquifer).
3e	Leachate migration: Receptor (Surface water bodies)	3	Within 50m of site boundary. Surface water ditch, Kilgormly and Magheramey rivers bound the site.
3f	Landfill Gas: Receptor (Human presence)	5	On site or within 50m of site boundary - farm buildings onsite and adjacent to site.

Table 3.2: 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	10 x (2+3+2) x 3 = **210**	300	Leachate => surface water	70%
SPR2	1a x (2a + 2b + 2c) x 3b	10 x (2+3+2) x 3 = **210**	300	Leachate => SWDTE	70%
Leachate migration through groundwater pathway					
SPR3	1a x (2a + 2b) x 3a	10 x (2+3) x 3 = **150**	240	Leachate => human presence	62.5%
SPR4	1a x (2a + 2b) x 3b	10 x (2+3) x 0 = **0**	240	Leachate => GWDTE	0%
SPR5	1a x (2a + 2b) x 3c	10 x (2+3) x 5 = **250**	400	Leachate => Aquifer	62.5%
SPR6	1a x (2a + 2b) x 3d	10 x (2+3) x 0 = **0**	560	Leachate => Surface Water	0%
SPR7	1a x (2a + 2b) x 3e	10 x (2+3) x 3 = **150**	240	Leachate => SWDTE	62.5%
Leachate migration through surface water pathway					
SPR8	1a x 2c x 3e	10 x 2 x 3 = **60**	60	Leachate => Surface Water	**100%**
SPR9	1a x 2c x 3b	10 x 2 x 0 = **0**	60	Leachate => SWDTE	0%
Landfill gas migration pathway (lateral & vertical)					
SPR10	1b x 2d x 3f	10 x 3 x 5 = **105**	150	Landfill Gas => Human Presence	70%
SPR11	1b x 2e x 3f	10 x 5 x 5 = **250**	250	Landfill Gas => Human Presence	**100%**
Site maximum S-P-R Score					**100%**
Risk Classification					**A - High**

Table 3.2 shows the maximum S-P-R scoring for the site is **100%** based on the potential for landfill gas and leachate migration at the site.

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 **high-risk classification (Class A)**. The EPA describes these sites as a “high risk posed to the environment or human health”. Detailed site investigations are required to be carried out on all high and moderate risk sites.

4. CONCLUSIONS & RECOMMENDATIONS

A Tier 1 study was conducted by FT. The study consisted of a desktop study and a detailed site walkover. These works informed the development of the CSM and risk screening model.

The results of the Tier 1 assessment and risk model indicate that the site is a **Class A – high risk**. The EPA describes these sites as a "high risk posed to the environment or human health". Detailed site investigations are required to be carried out on all high and moderate risk sites.

Given that there is no landfill liner or capping present there remains a pathway between the leachate and the groundwater body beneath. There is also believed to be a direct pathway between the leachate and surface water seepage from the landfill.

A Tier 2 quantitative risk assessment is required for a site which is classified as high risk. FT recommend further intrusive site investigations and sampling as part of the Tier 2 assessment.

For a high-risk site, the CoP directs that the site will have to apply for a certificate of authorisation to certify compliance with Regulation 7(7) of the Waste Management (Certification of Historic Unlicensed Waste Disposal and Recovery Activity) Regulations, 2008.

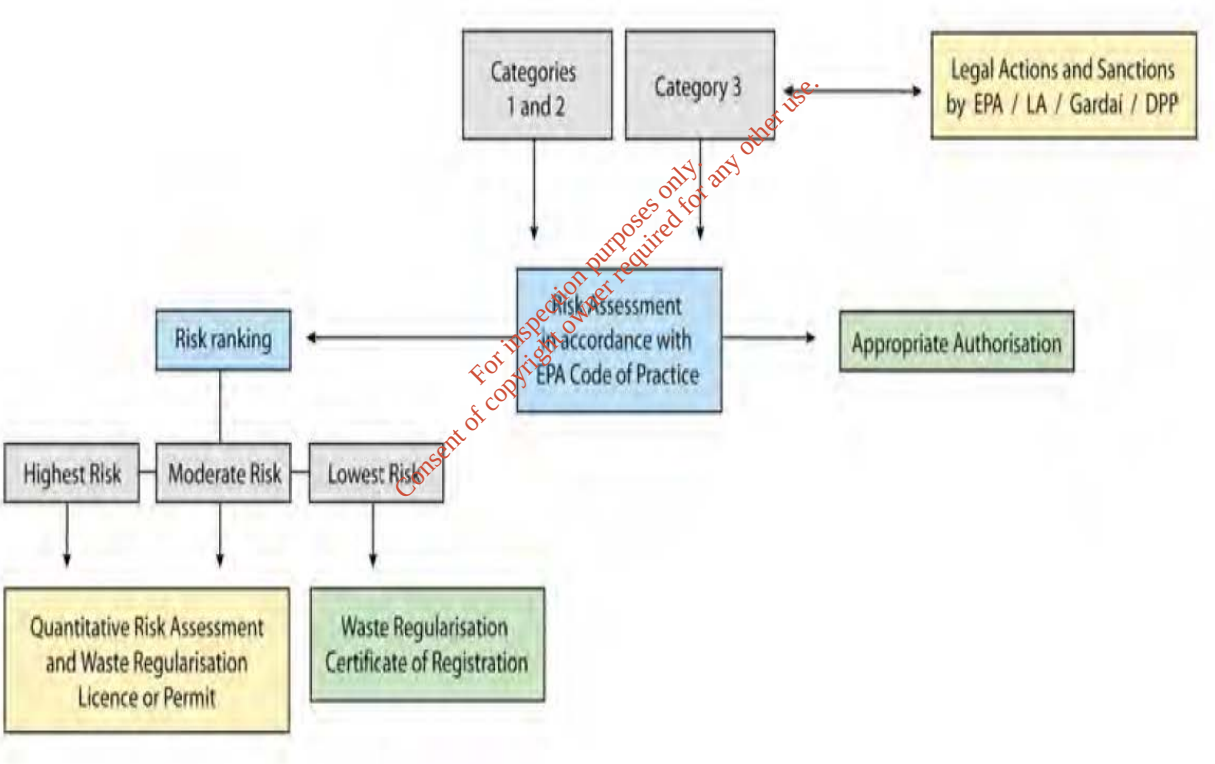

Figure 4-1: Extract from Section 1.3 of the EPA CoP

4.1. Recommendations

FT recommends intrusive site investigations will be required, using trial pits, boreholes and slit trenches to confirm waste volumes, footprint and depths, and to assess and characterise waste types and compositions. An environmental monitoring program including surface water, groundwater, leachate sampling and landfill gas migration monitoring is also recommended.

The scope of the site investigation recommended is detailed in the following section.

4.1.1. S.I. Design

FT recommend that a site investigation in line with the Tier Ii CoP be undertaken at the site. It is proposed that the Site Investigation programme should consist of the following items:

- Geophysical Investigation
- Trial Pitting
- In-situ testing
- Cable Percussion with Rotary Follow-on Boreholes for the purposes of groundwater and landfill gas monitoring
- Groundwater Monitoring & Sampling
- Laboratory testing
- Factual reporting

The following sections outline the overall approach that may be adopted.

Geophysics Survey

It is recommended that a geophysical survey is undertaken to determine the full vertical and lateral extent of the interred waste body and ground conditions beneath the waste. Procurement of a suitably qualified surveyor will be required to undertake a geophysical survey of the site using EM31 conductivity, 2D resistivity profiling and seismic refraction.

Trial Pitting

Trial pits are recommended across the site to investigate the nature, vertical and horizontal extent of the interred waste material. The number and location of trial pits will depend on site access and location of existing services. FT recommends the excavation of trial pits across the target site to a maximum depth of 4.0m, or until natural ground is confirmed beyond the base of the interred waste body. All trial pits should be logged in accordance with BS5930.

Waste Quantification, Sampling and Analysis

Wastes encountered during trial pitting shall be subject to descriptive logging and bulk sampling at appropriate intervals. A proportion of the waste samples collected during trial pitting shall be subject to Waste Acceptance Criteria analysis for the purposes of classification into inert, non-hazardous or hazardous criteria.

Landfill Leachate if encountered should also be subject to sampling and suitable leachate indicator analysis. Results should be compared to reference values to assess the type and strength of the leachate encountered.

Groundwater/Landfill Gas Monitoring Boreholes

FT propose the installation of groundwater/leachate monitoring wells at the site. A minimum of three number wells is recommended. The borehole installations will be multi-purpose and allow for sampling of groundwater, landfill gas as required.

In-situ Falling/Rising head tests are recommended to assess the permeability of the underlying strata.

GPS way finders and physical markers should be used to record proposed SI locations allowing for accurate mapping and setting out of actual works.

Groundwater / Leachate / Landfill Gas Sampling and Potentiometric Mapping

The borehole installations should be multi-purpose and allow for sampling of groundwater and landfill leachate as required. Post installation and development of the wells, a minimum of two rounds of groundwater sampling should be undertaken from each of the well locations and analysed for the parameters listed in Table C.2 of the EPA Landfill Monitoring Manual (2003).

Groundwater: groundwater sampling should be designed to assess the overall groundwater quality versus the published Groundwater Regulations (2010) (SI No. 9 of 2010) groundwater threshold values (GTVs), and to allow for the detection of key leachate indicators i.e. ammonia, heavy metals etc.

Landfill Gas: borehole installations will be subject to regular monitoring as part of the proposed schedule. Landfill Gas sampling should allow for the measurement of the following parameters:

- CH4
- CO2
- O2
- N
- H2S
- Barometric Pressure (mB)
- Flow
- Balance Gases

Potentiometric Groundwater Mapping

The groundwater flow gradient on site should be determined from the groundwater depth/head information collected at the site. A standard dip meter should be used to measure the natural level of groundwater / leachate. The potentiometric groundwater head measurements should be combined to map the groundwater flow direction beneath the site. The potentiometric mapping will allow the upstream and downstream groundwater locations to be identified which will aid conceptualising the flow direction of any contaminated leachate plumes exiting the site.

Surface Water Sampling

The monitoring schedule adopted should allow at a minimum for the sampling of surface water bodies upstream, onsite and downstream of the historic landfill waste body to assess the impact (if any) of the landfill on local surface water quality.

It is envisaged to sample the upstream and downstream surface water sampling locations set out in in Table 4.1 below

Table 4.1: Potential Surface water Sampling Locations

Site	Receiving Watercourse	Upstream Location	Onsite Location	Downstream Location
Killycronaghan Historic Landfill	Kilgormly River.	South of site perimeter.	Along northern site perimeter.	At confluence of Kilgormly and Magheramey Rivers.
Killycronaghan Historic Landfill	Magheramey River.	North of site perimeter.	N/A	West of site perimeter.

A minimum of two rounds of surface water sampling should be undertaken from each location and analysed for the parameters listed in Table C.2 of the EPA Landfill Monitoring Manual (2003). The results of the surface water monitoring will be assessed against the current published surface water standards (S.I. No. 272 of 2009).