ENVIRONMENTAL BALANCE IN DESIGN AND CONSTRUCTION

TIER 2 RISK ASSESSMENT

HISTORIC LANDFILL AT KILLYCARD, CO. MONAGHAN

NOVEMBER 2018

FEHILY TIMONEY
30 YEARS

TIER 2 RISK ASSESSMENT

HISTORIC LANDFILL AT KILLYCARD, CO. MONAGHAN

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Abstract: This report represents the findings of a Tier 2 site investigation carried out at Killycard Historic Landfill, Castleblayney, Co. Monaghan, and conducted in accordance with the EPA Code of Practice for unregulated landfill sites. The site investigation was undertaken to determine the extent of the historic landfilling at the site.

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EXECUTIVE SUMMARY

Fehily Timoney & Company (FT) was appointed by Monaghan County Council (MCC) to complete a Tier 2 environmental risk assessment (ERA) of Killycard Historic Landfill in accordance with the Environmental Protection Agency (EPA) Code of Practice (CoP) (2007): *Environmental Risk Assessment for Unregulated Waste Disposal Sites*.

The site is located approximately 8km North-East of Clones town circa 1km off the N54 national road, close to the village of Smithborough. It was previously reported by MCC that the landfill accepted waste throughout the 1970s and early 1980s, ceasing in 1984.

A Tier 1 study conducted by FT in June 2018 determined the site to be a high-risk classification (Class A). The primary risks identified related to the risk of leachate runoff entering the Corrinshigo Lough and the risk of leachate migration into the groundwater aquifer. The completed Tier I study is included as an Appendix 1.

The Tier 2 study, presented herein, consisted of a desktop study, geophysical survey, intrusive site investigation works, environmental monitoring (waste, surface water, landfill gas and groundwater sampling) and laboratory analysis. The results of these works informed the development of the CSM (conceptual site model) and risk screening model.

The following site investigation works were undertaken at the site:

- 13 No. Trial pit excavations
- Installation and monitoring of 3 No. groundwater boreholes
- 1 No. Geophysical survey (2D resistivity and seismic refraction profiling)
- Environmental Sampling: surface water, groundwater and landfill gas
- Topographical Survey
- Factual reporting

The findings of the site investigation work and geophysical surveying suggest the waste material is deposited in a single infill area tending west to east in the centre of the site and between approximately 140m in length and 120m in width. The geophysical survey delineated the survey area into zones based on an interpretation of the ground conditions across the site. The following 2 No. zones were identified:

- Zone A: made ground/waste (predominantly organic) over very soft Peat/Clay with Leachate
- Zone B: made ground/waste (mixed with Clay/Silt) over very soft Peat/Clay

The maximum waste footprint including Zone A and Zone B is calculated to be approximately 1.15 hectares.

A volume calculation based on the surveyed surface profiles for the existing ground level and the base of waste as interpreted, estimates an interred waste volume of approximately 29,700 m^3 at the site. This is in line with MCCs initial estimate which was in the region of 30,000 cubic meters.

Analysis of waste samples from the trial pits excavated, when assessed against the 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.

Analysis of groundwater samples recovered from the three monitoring wells GW01 to GW03 have reported ammonia concentrations which exceed guideline threshold values. Given that all monitoring wells were installed within the waste body, as confirmed by the trial pit and geophysical findings, the landfill is contributing to a deterioration in groundwater quality locally. The monitoring boreholes were installed within the waste body due to the restricted space available within the site.

Based on the presence of elevated ammonia concentrations typical of landfill leachate, the shallow soil cap is not considered suitable at preventing rainfall infiltration into the waste body. The groundwater table also appears to be intersecting the waste body and contributing to leachate migration from the landfill.

The presence of peat underlying the waste body across the site may also be contributing to the elevated ammonia concentrations detected in the groundwater locally. The combined presence of elevated ammonia and coliform concentrations in all monitoring wells GW01 to GW03 may also be evidence of localised contamination due to agricultural land spreading or poorly functioning septic tanks in the area.

Landfill gas monitoring from perimeter wells GW01 to GW03 at the site indicates gas concentrations detected are within the range typical of inert waste with the exception of a slightly elevated methane concentration detected at upgradient sampling location GW01. Based on the detection of slightly elevated gas concentrations and the proximity of the industrial buildings to the eastern boundary of the waste body, additional gas monitoring should be considered as part of future works.

Analysis of surface water samples recovered from the watercourses surrounding the site indicated 2 No. exceedances of the EQS (2009) guideline limit values for ammonia and BOD. Given that the determined groundwater flow direction is west-south-west from the waste body, the detected ammonia and BOD at these levels may be evidence of impact from the landfill. However, the presence of ammonia and BOD at these levels may also be an indication of slurry spreading runoff from the surrounding agricultural fields in the area, rather than solely from the landfill.

Based on the results of the Tier 2 site assessment, the site can be classified as a **High Risk Classification (Class A)**. The principal risks identified on the site are the risk to Corrinshigo Lough from the migration of leachate from the landfill into the surface water receptor, the shallow permeable soil cap across the site contributing to leachate generation and the risk to the adjacent industrial building receptor from the migration of landfill gas from the waste material encountered at the site.

It is recommended by FT that a Tier 3 DQRA be undertaken. As part of the Tier 3 assessment, further groundwater, surface water monitoring and landfill gas monitoring and analysis is being recommended at each monitoring location GW01 to GW03, SW1 and SW2 inclusive. The results of this analysis should be used to confirm the conclusion of the Tier 3 report and inform works.

1 INTRODUCTION

1.1 Background

Killycard historic landfill is located approximately 1.7km to the North-West of Castleblayney town on the R183 Castleblayney to Ballybay Regional Road. According to information provided by Monaghan County Council (MCC), the landfill ceased operations in 1987.

Since its closure the site has been covered with a soil cap, no other remediation works have been carried out. The exact quantity of waste deposited on site is unknown however MCC have estimated the quantity to be in the region of 30,000 cubic metres.

MCC 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 Fehily Timoney & Co. (FT) in June 2018 determined the site has a risk classification of High (Class A) based on risk of leachate runoff entering Corrinshigo Lough and the risk of landfill gas migration to nearby human receptors.

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
- Surface water, groundwater and landfill gas monitoring
- Environmental Risk Assessment (ERA)
- Geophysical and surveying to estimate extents and depths of waste
- 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 three onsite groundwater monitoring boreholes. APEX Geoservices were also appointed by FT to undertake geophysical surveying of the site.

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, surface water 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 both 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
- Water Maps, http://watermaps.wfdireland.ie
- Monaghan 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
- EPA's Historic Mine Sites - Inventory and Risk Classification (2009)
- EPA - Assessing and Developing Natural Background Levels for Chemical Parameters in Irish Groundwater (2017)

A desktop review of available documentation for the site was conducted followed by a site walkover.

2.2 Desk Study

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

2.2.1 Site Description & On-Site Conditions

The site is located approximately 1.7km to the North-West of Castleblayney town on the R183 Castleblayney to Ballybay Regional Road. The site covers approximately 2.0 hectares in size.

There are 3 No. dwelling houses within 150 metres of the site boundary. Commercial developments have been constructed on site including mushroom houses (now derelict) and an operational industrial building in the eastern portion of the site. The western portion of the site shares a boundary with Corrinshigo lake. A steeply sloped agricultural field is located to the north of the site. The land use in the area is primarily agricultural with this site currently used for the production of silage.

The location of the site is shown in Figure 2.1, overleaf.

2.2.2 Previous Studies

A Tier 1 Risk Assessment completed by FT on 22nd June 2018 which comprised the following:

- Development of a conceptual site model (CSM);
- Identification of contaminant sources, pathways of contaminant migration and potential receptors which may be vulnerable if exposed to those contaminants; i.e. the identification of Source- Pathway-Receptor (SPR) linkages; and
- The prioritisation of sites and SPR linkages based on their perceived risk.

Based on the available information, the Tier 1 Assessment determined that the overall risk score for Killycard Landfill was 70%, resulting in a risk classification of High (Class A).

A copy of this assessment is included in Appendix 1.

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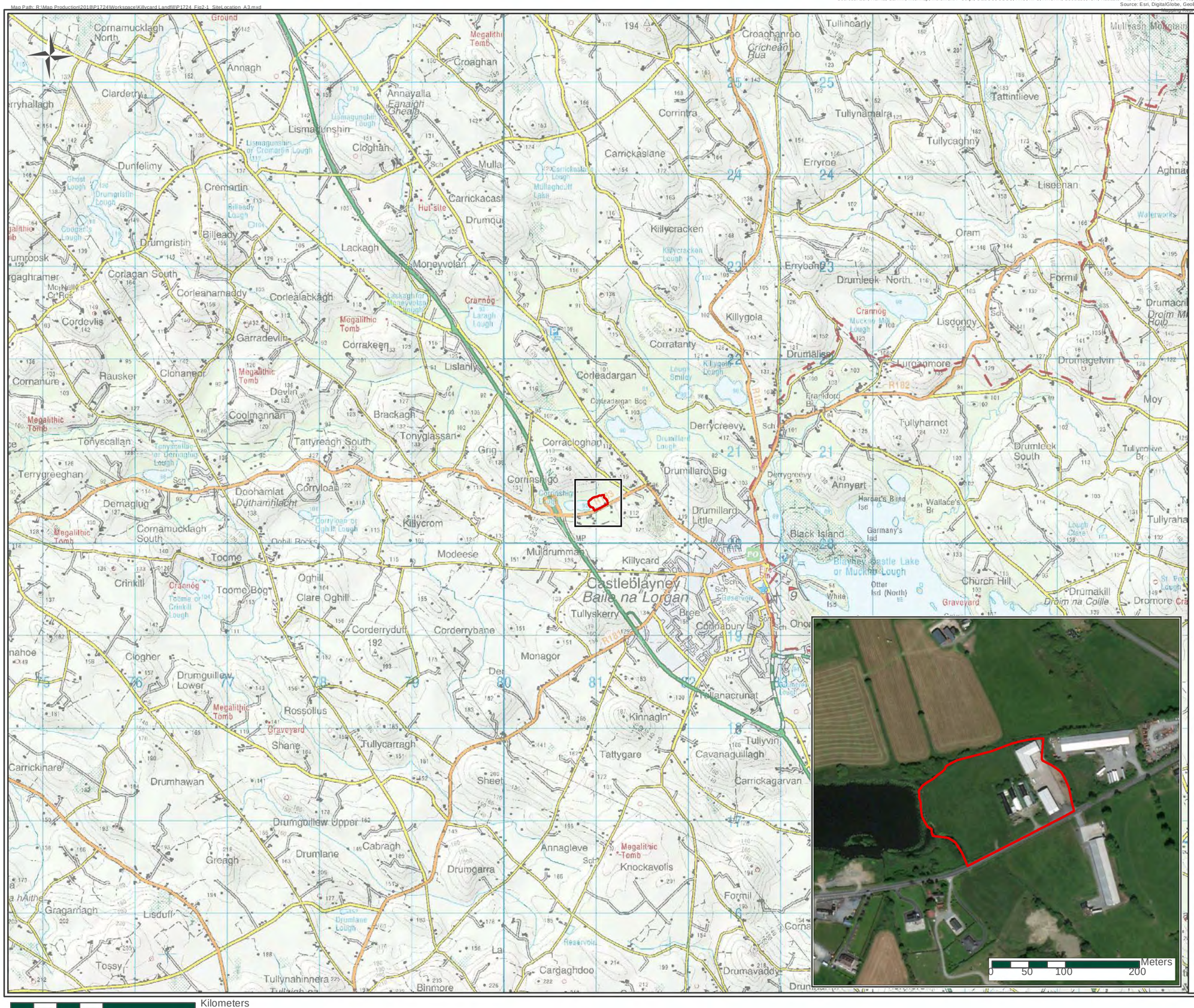

Figure Title Site Location

Figure No. 2.1

Project ERA of Historic Landfill at Killycard, Co. Monaghan

Client Monaghan County Council

Scale 1:40,000 **Page Size** A3

Revision A **Date** 17/10/2018

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2.2.3 Topography

The landfill is located in a low-lying valley within a primarily rural setting in an area of rolling topography. The site is generally described as flat with a hill rising from the northern boundary of the site. The low-lying valley gives rise to the Corrinshigo lake which defines the western boundary of the site.

The site is at an elevation of between 93 m and 95 m above Ordnance Datum (OD).

The completed topographical surveys for the site is provided in Appendix 6.

2.2.4 Geology

Drift/Quaternary Geology

The Quaternary Map provided by GSI Online identifies the quaternary sediments at the site as 'cut-over raised peat'. The landfill site is underlain by cut over raised peat overlying a poorly productive bedrock aquifer. The subsoils are typically of cutover/cutaway peat.

Beyond the northern and southern site boundaries the superficial geology is made up of glacial tills derived from 'Lower Palaeozoic sandstones and shales.'

During the installation of boreholes during the site investigation, the presence of peat is described in the drillers logs to a depth ranging from of 4.0m to 4.8m BGL at boreholes GW01 to GW03, as referenced in the CGL borehole logs, Appendix 2.

The quaternary geology is presented in Figure 2.2.

Solid or Bedrock Geology

The GSI online 1:100,000 scale bedrock geology map, the site and surrounding area is underlain by the Silurian Oghill formation (OL) which is generally made up of

> '*grey to grey-green massive sandstone (greywacke), microconglomerate and amalgamated beds with subordinate thin to thick-bedded greywacke and locally, at least partly, infaulted dark grey or black pyritic, occasionally graptolitic shale-mudstone*'.

The GSI bedrock geology map shows a fault travelling north-south across the eastern area of the site.

The nearest bedrock outcrop to the site has been mapped approximately 80m from the southern site boundary just off the R183 roadway. The bedrock geology is presented in Figure 2.3.

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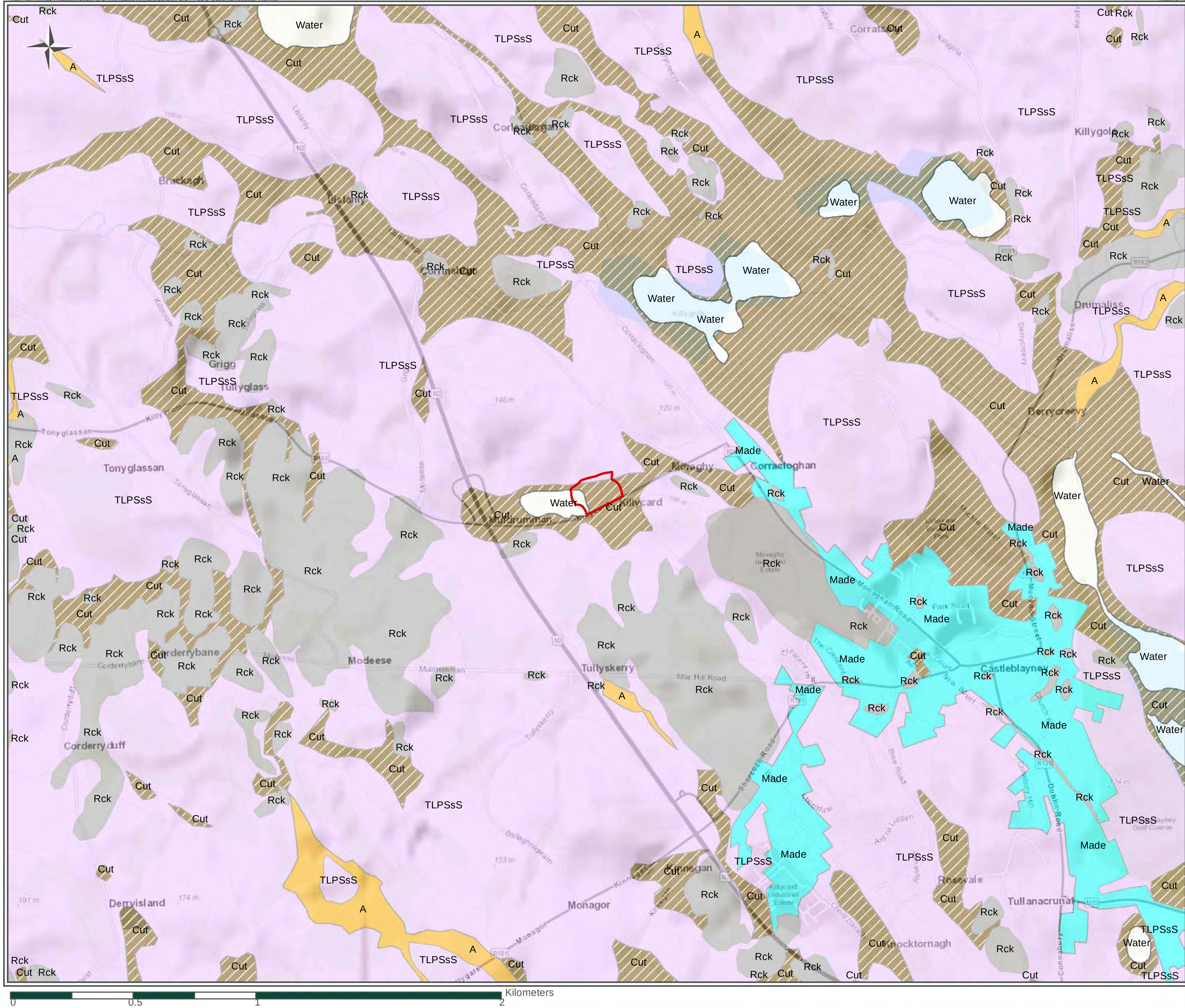

Legend

- Site Boundary

Subsoils Data

- A, alluvium
- Cut, cutover peat
- Made, made ground
- Rck, bedrock at surface
- TLPSsS, sanstone and shales till - Lower Paleozoic
- Water, water

Figure Title	Quaternary Geology
Figure No.	2.2
Project	ERA of Historic Landfill at Killycard, Co. Monaghan
Client	Monaghan County Council
Scale	1:15,000
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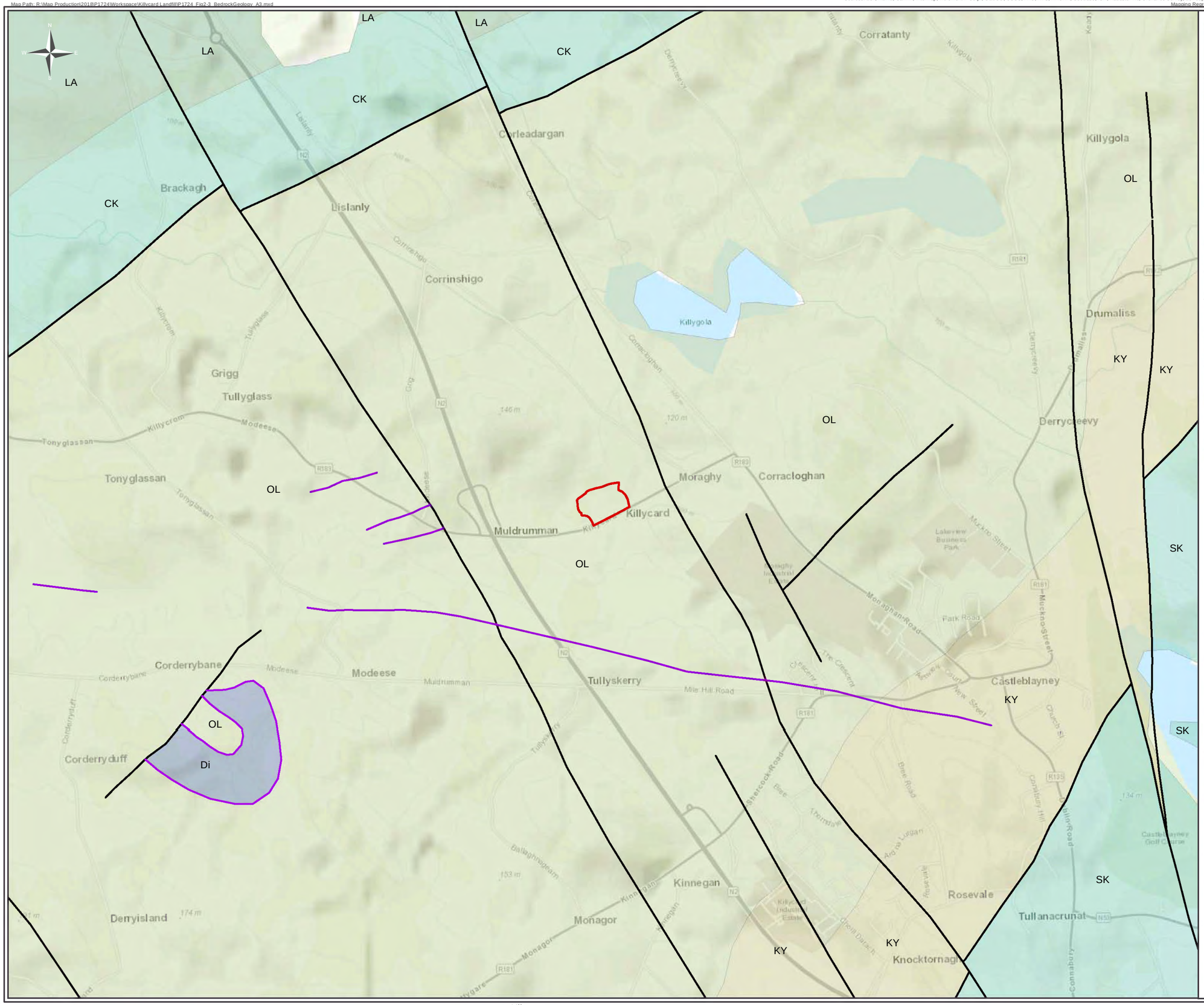
Map Path: R:\Map Production\2018\P1724\Workspace\Killycard Landfill\P1724_Fig2-3_BedrockGeology_A3.mxd



Legend

- Site Boundary
- Stratigraphical Linework
- Structural Linework

Bedrock Geology

- CK: Carrickatee Formation
- Di: Diorite
- KY: Kehernaghkilly Formation
- LA: Lough Avaghon
- OL: Oghill Formation
- SK: Shercock Formation

Kilometers
0 0.5 1 2

Figure Title	Bedrock Geology
Figure No.	2.3
Project	ERA of Historic Landfill at Killycard, Co. Monaghan
Client	Monaghan County Council
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2.2.5 Hydrogeology

An examination of the national bedrock aquifer map on the GSI online mapping classifies the Silurian Oghill formation as a Poor Aquifer (PI) – bedrock which is generally unproductive except for local zones. The bedrock aquifer mapping is presented in Figure 2.4.

The site lies within the Louth Groundwater Body (GWB No. IEGBNI_NB_G_019) 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 series of enclosed depressions approximately 10.8km south of the site boundary.

The GSI national recharge map defined the annual recharge as 100mm/yr. The effective rainfall for the area is 654mm/yr, indicating the recharge coefficient is 22.5%, which implies the majority of available recharge runs off due to a shallow water table in the subsoil that results from the low permeability of the bedrock aquifer. This will result in flashy streams with reduced baseflow.

Historical mapping for the area shows several springs in the surrounding area. There are no public groundwater supplies and no groundwater dependent ecosystems in the area. The site walkover confirmed the presence of public supply water mains outside the entrances to the residential housing within 250m of the landfill and outside the industrial units adjacent to the site.

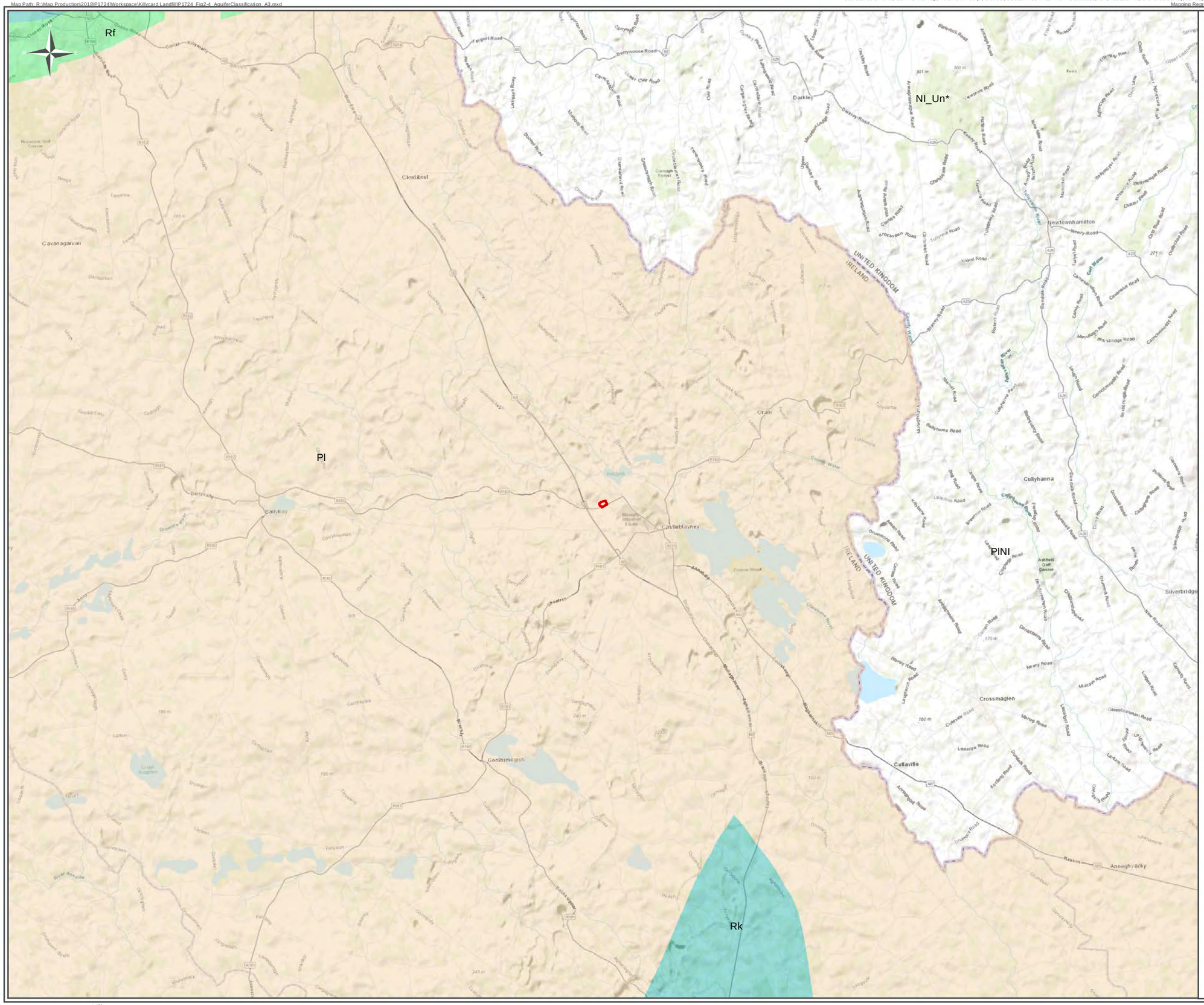
Locations of wells and springs are presented in Figure 2.5.

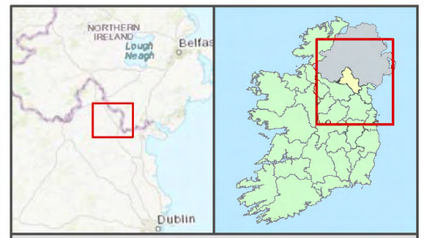
Table 2-1: Distance of wells and springs from the Site

BH/Spring	Yield class	Yield	Use	Depth (m)	Depth to Rock confidence (m)	Distance from site (km)	Date
2631NEW002	Poor	34.6	--	28.0	6.0	0.32	1899
2631NEW091	Poor	13.1	--	4.3	1.2	<1	1899
2631NEW078	Poor	10.9	--	6.1	1.2	<1	1969
2631NEW084	Poor	9.8	--	2.4	0.3	<1	1971
2631NEW087	Poor	10.9	--	4.6	1.2	<1	1970
2631SEW009	Poor	16.4	--	7.3	--	<1	1899
2631NEW040	Poor	32.7	--	16.2	3.1	<1	1970

There are no Groundwater Drinking Water Protection Areas within the site boundaries, according to GSI. The closest groundwater protection area to the sites is the Monaghan Town outer protection areas, approximately 18km north-west of the site boundary. The outer protection area is 3.76km^2.

Map Path: R:\Map Production\2018\P1724\Workspace\Killycard Landfill\P1724_Fig2-4_AquiferClassification_A3.mxd





Legend

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

Figure Title	Aquifer Classification
Figure No.	2.4
Project	ERA of Historic Landfill at Killycard, Co. Monaghan
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Scale	1:100,000
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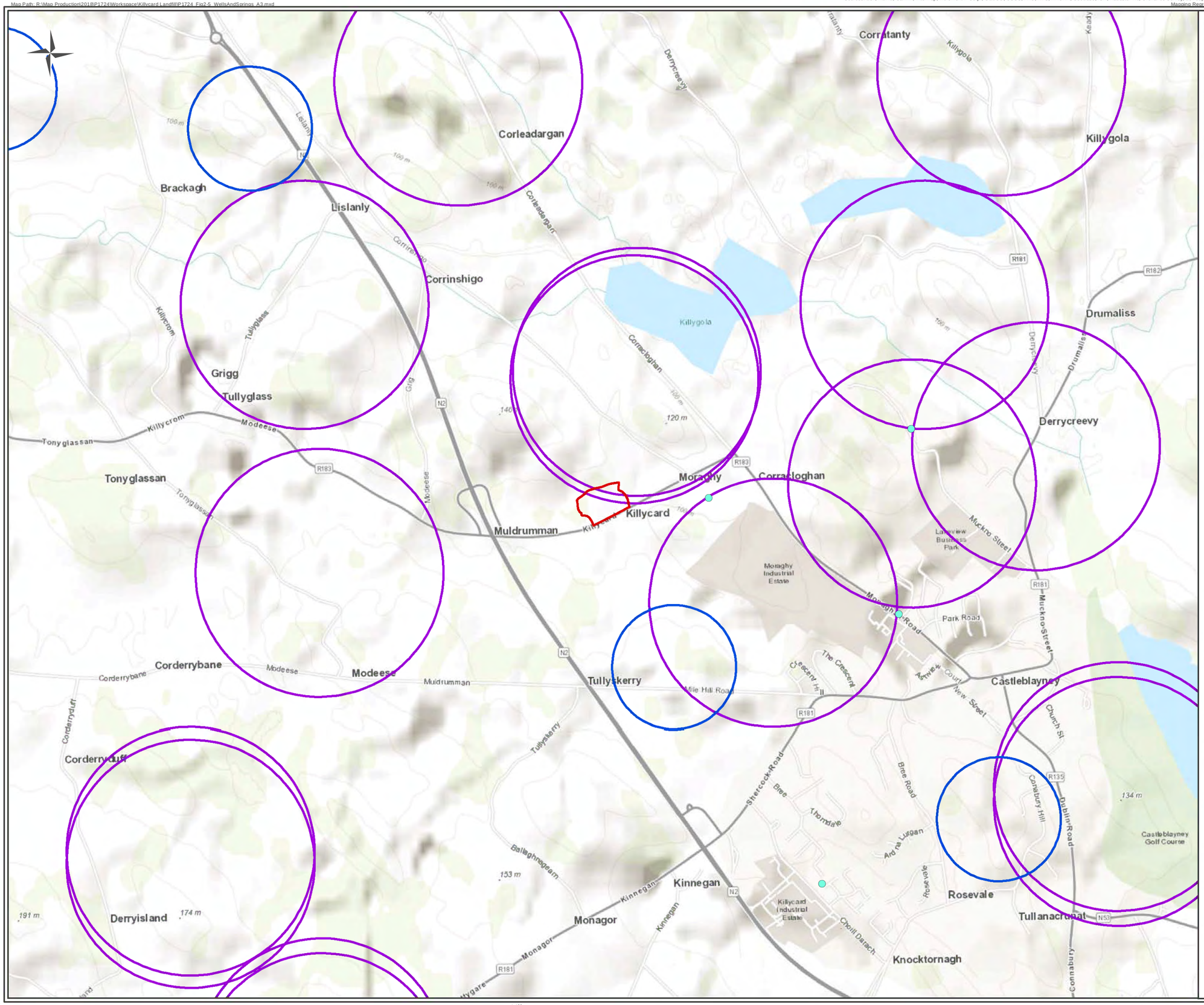
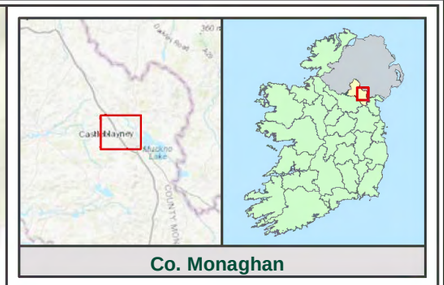
Map Path: R:\Map Production\2018\P1724\Workspace\Killycard Landfill\P1724_Fig2-5_WellsAndSprings_A3.mxd





Legend

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

0 0.5 1 2 Kilometers

Figure Title	Wells and Springs
Figure No.	2.5
Project	ERA of Historic Landfill at Killycard, Co. Monaghan
Client	Monaghan County Council
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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 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 Oghill formation is classified as a Poor Aquifer (Pl) that is generally unproductive except in local zones. The aquifer vulnerability of the site is Extreme. The recharge coefficient associated with the western section of the site is 22.5% and the recharge rate is 100mm/year.

The Groundwater Vulnerability mapping is presented in Figure 2.6.

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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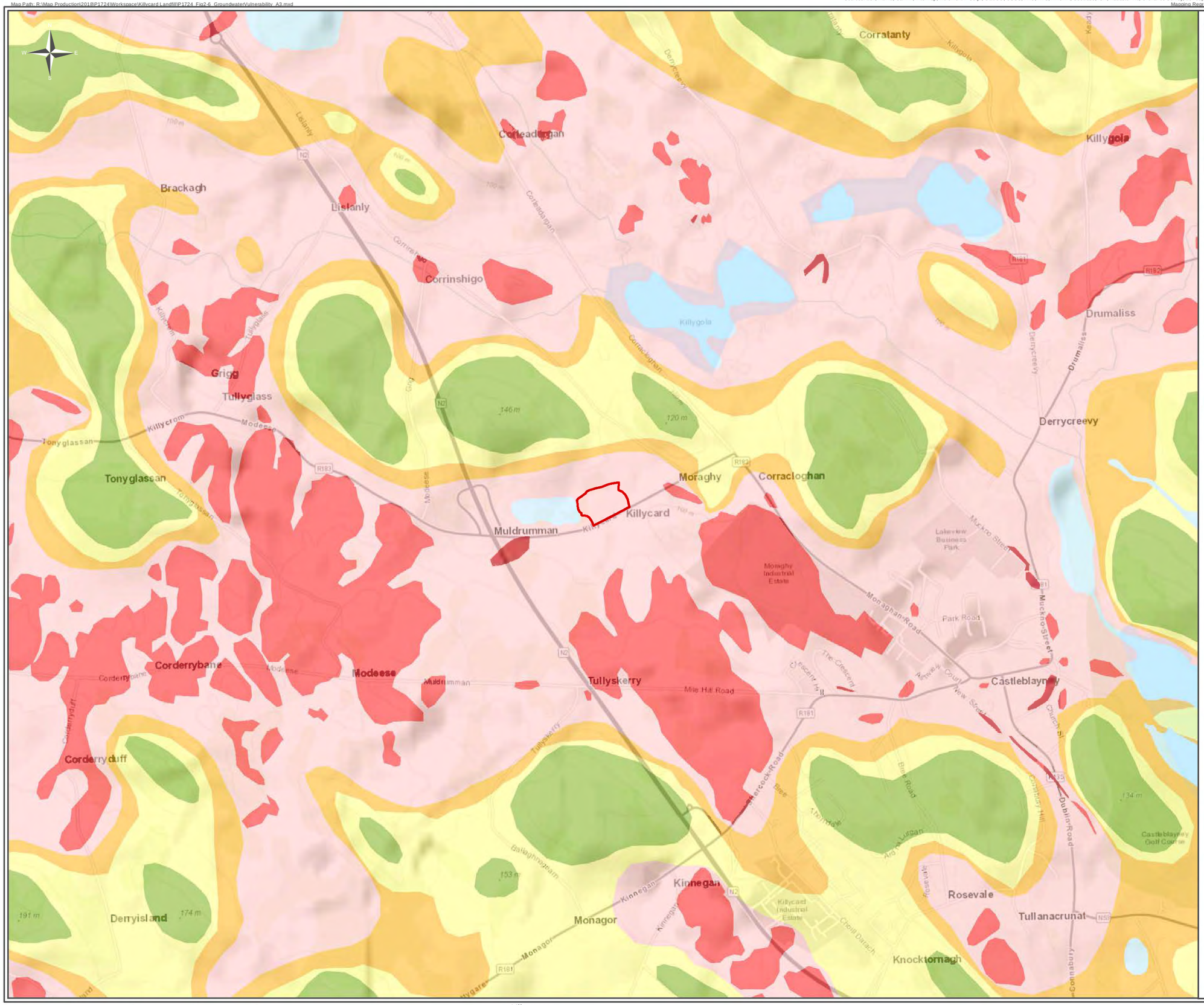

Legend

- Site Boundary

Groundwater Vulnerability

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

Figure Title	Groundwater Vulnerability
Figure No.	2.6
Project	ERA of Historic Landfill at Killycard, Co. Monaghan
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2.2.7 Hydrology

The site is located within the catchment of the River Erne which flows towards the west. The site is bounded to the southwest by the source stream for Corrinshigo Lough, to the west by Corrinshigo Lough itself and to the north by the lake outlet stream which is a tributary of the Carrickaslane Lough stream. Carrickaslane Lough stream and Corracloghan stream lie northeast of the site and are tributaries of the River Fane.

There are several small lakes located in the vicinity of the site. Drumillard Lough is located approximately 0.6km to the northeast of the site while an unnamed surface water area located approximately 0.5km to the east of the site. Killygola Lough and Lough Smiley are located approximately 1km northeast of the site.

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). However, the following pNHAs and NHA are located within the vicinity of the site:

Lough Smiley proposed NHA (pNHA) lies approximately 0.5km northeast of the site. Muchno Lake NHA lies approximately 1.6km east of the site.

There are no SACs or SPAs within 15km of the site. The ecologically protected areas mapping is presented in Figure 2.7.

During the site walkover, Japanese Knotweed was identified along the western banks of the site and evidence of eradication was identified, see Plate 2-1. The lake is eroding the banks of the site exposing the interred waste.

Plate 2-1: Japanese Knotweed and exposed waste material

2.2.9 Site History

The earliest historical map available on the OSI website dates from 1837-1842. OSI Historic Map identifies the land within the site boundary and the surrounding area was previously 'Bog or uncultivated land'.

The OSI Historical Mapping is presented in Figure 2.8.

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 5.8km north of the site boundary at Tassan. Tassan is described as *"the largest and most productive of the Monaghan district lead mines, from c. 1840-1866"* and the geological feature of note is a *"good mixture of extant mine features, including mine buildings and solid waste".*

The geological heritage mapping is presented in Figure 2.9.

2.2.11 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 40 km west of the site boundary.

According to the GSI, the site and surrounding area is underlain by cutaway blanket peat.

2.2.12 Archaeological Heritage

There are no Archaeological Heritage sites with the site boundary according to the Heritage Ireland GSI Geological Heritage map layer.

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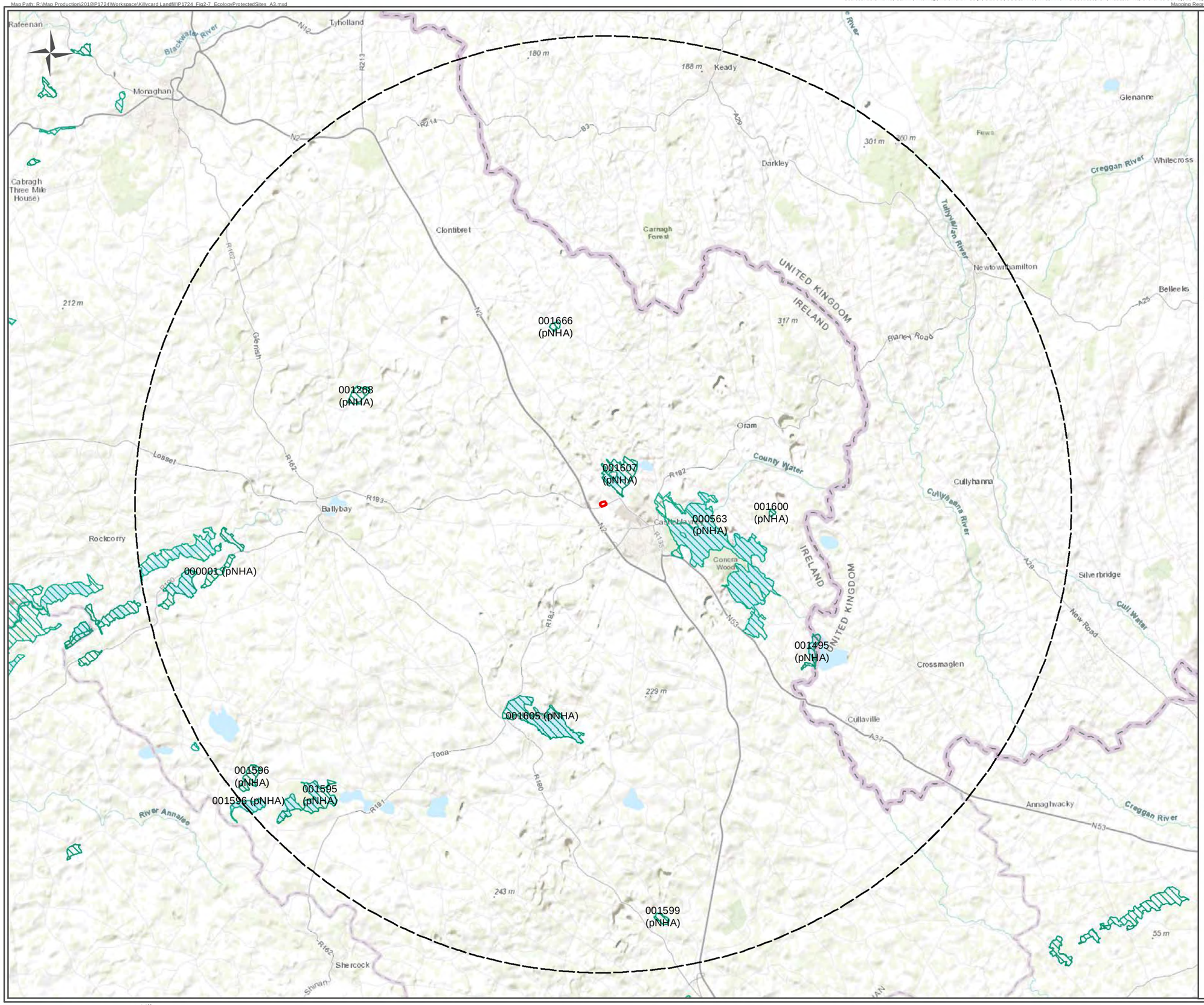

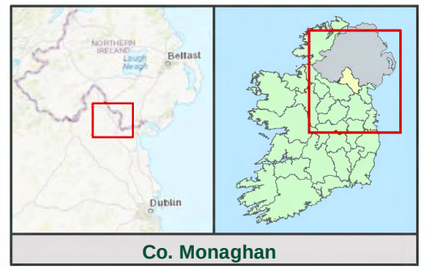

Legend

- Site Boundary
- 15km Distance from Site Boundary

Proposed Natural Heritage Area (pNHA)

- Closest Site: 0.5km

Figure Title	Ecology: Protected Sites
Figure No.	2.7
Project	ERA of Historic Landfill at Killycard, Co. Monaghan
Client	Monaghan County Council
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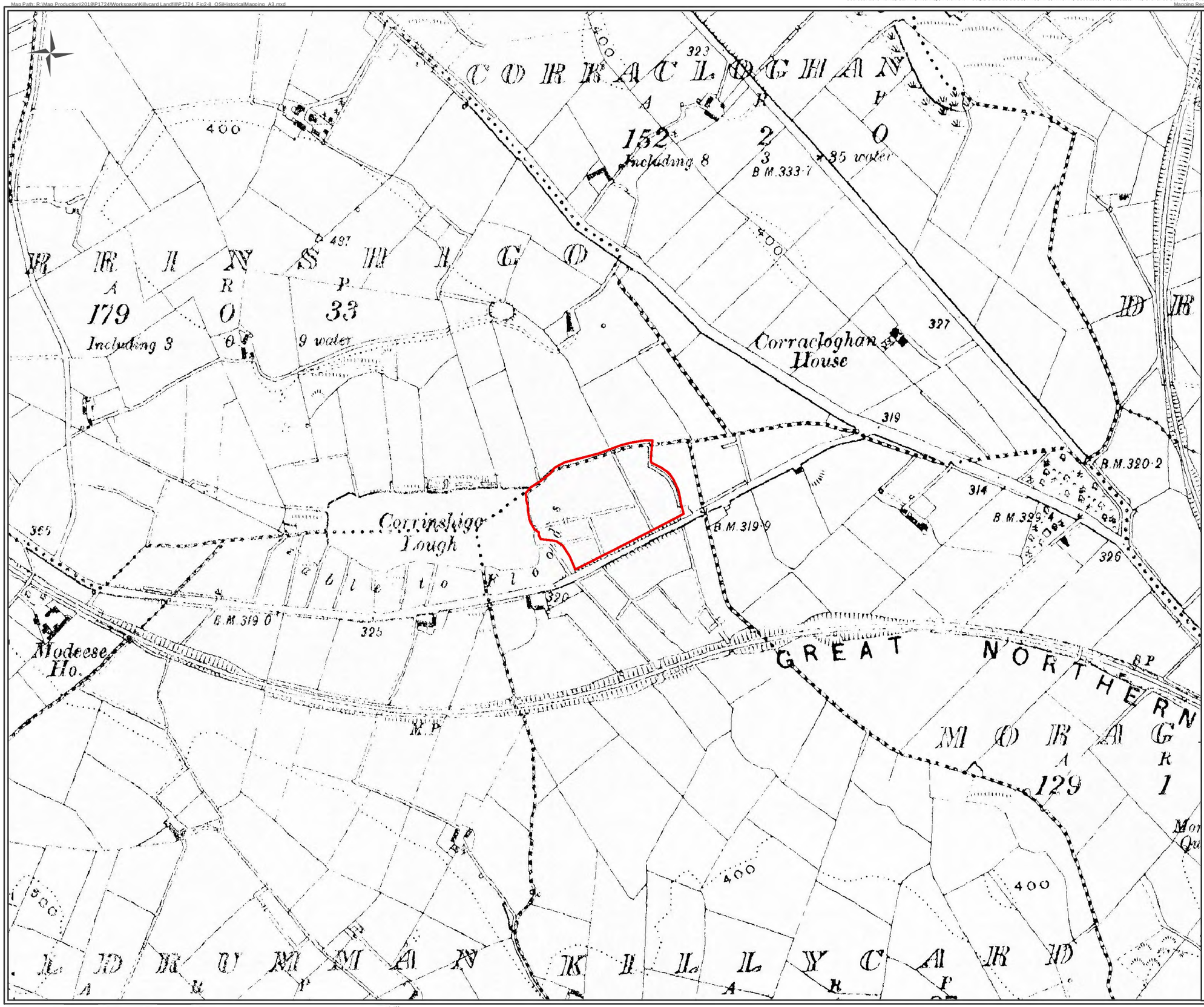
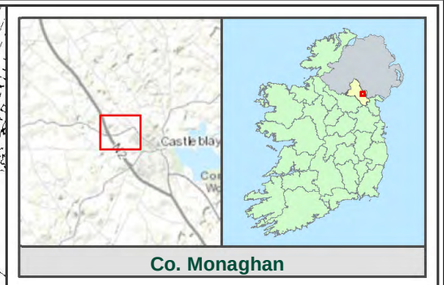
Map Path: R:\Map Production\2018\P1724\Workspace\Killycard Landfill\P1724_Fig2-8_OSiHistoricalMapping_A3.mxd





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Site Boundary

Figure Title	OSi Historical Mapping
Figure No.	2.8
Project	ERA of Historic Landfill at Killycard, Co. Monaghan
Client	Monaghan County Council
Scale	1:5,000
Page Size	A3
Revision	A
Date	17/10/2018

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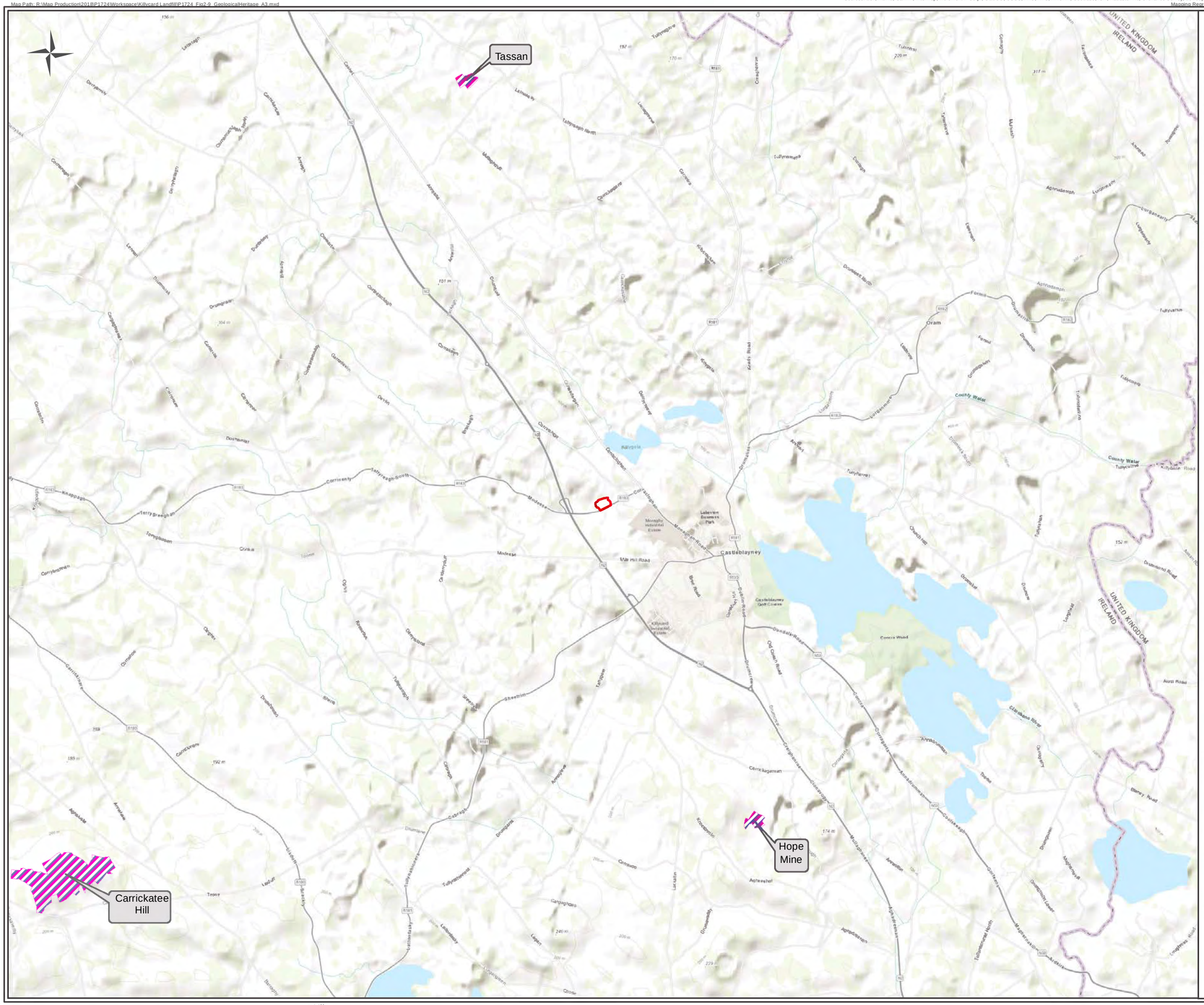
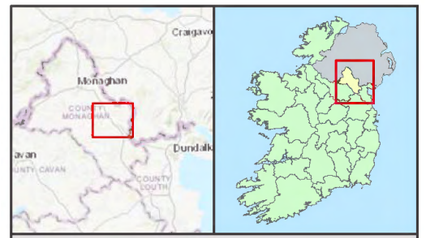
Kilometers
0 0.125 0.25 0.5

Map Path: R:\Map Production\2018\P1724\Workspace\Killycard Landfill\P1724_Fig2-9_GeologicalHeritage_A3.mxd





Co. Monaghan

Legend

- Site Boundary
- Geological Heritage Sites

Figure Title	Geological Heritage
Figure No.	2.9
Project	ERA of Historic Landfill at Killycard, Co. Monaghan
Client	Monaghan County Council
Scale	1:50,000
Page Size	A3
Revision	A
Date	17/10/2018

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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:

- 13 No. Trial pit excavations
- Installation and monitoring of 3 No. groundwater boreholes
- 1 No. Geophysical survey (2D resistivity and seismic refraction profiling)
- 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

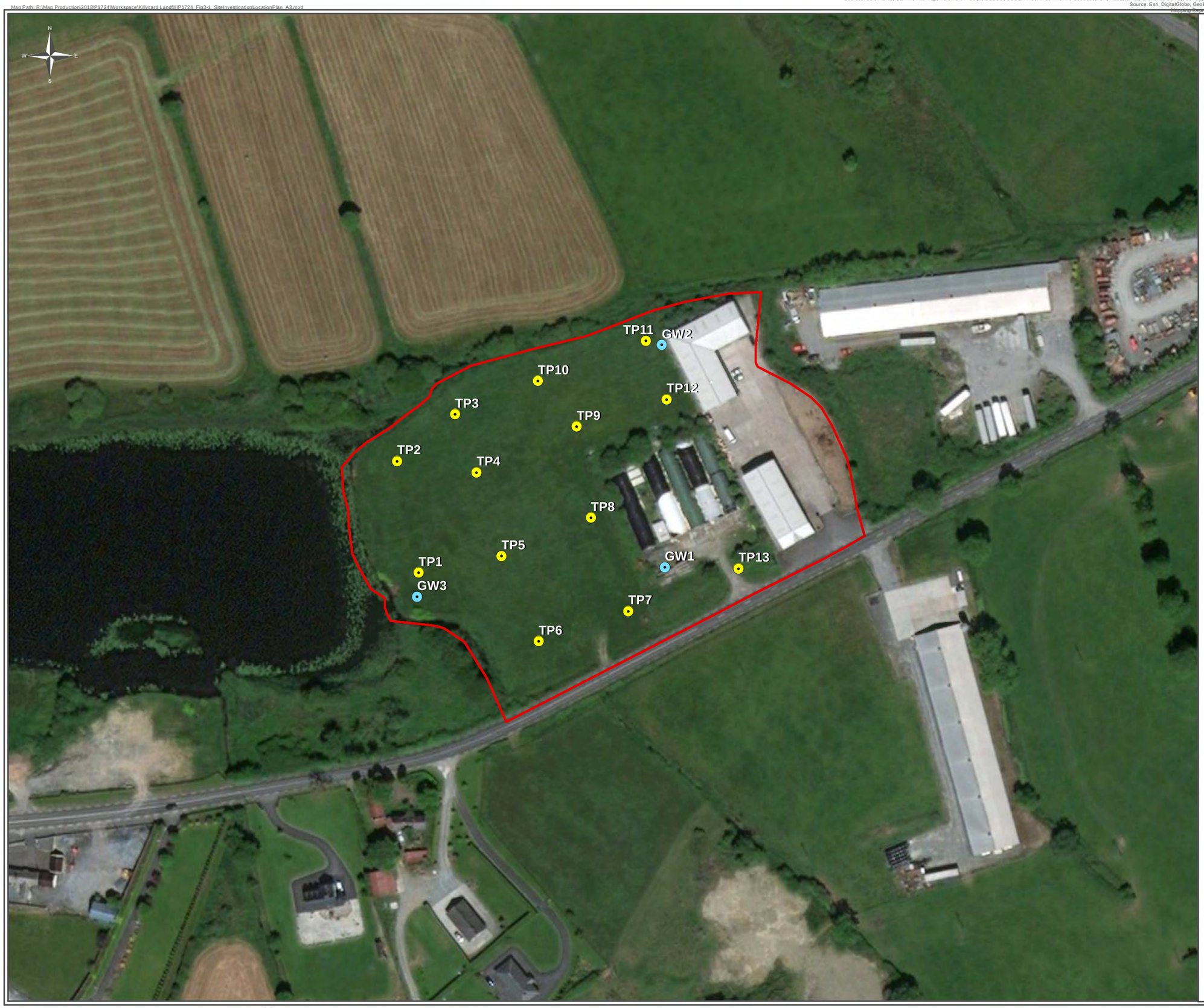
A site walkover was conducted prior to site investigation works by an FT Engineer and a CGL Engineer. During the site walkover the scope of the investigative works were evaluated based on the findings in the Tier I assessment.

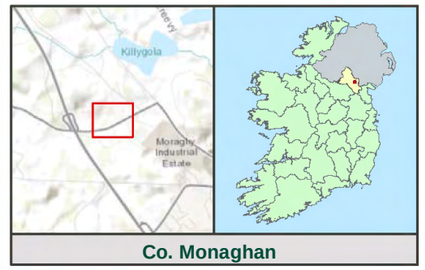
The scope was agreed based on the site walkover assessment, historic aerial photography and other information received by MCC.

During the site walkover, Japanese Knotweed was identified along the western banks of the site. Evidence of eradication efforts by means of spraying was confirmed as discussed previously in Section 2.2.8. The lake also appears to be eroding the banks of the landfill and exposing the interred waste in this area.

The site walkover also confirmed the presence of public supply water mains outside the entrances to the residential housing within 250m of the site and outside the industrial units adjacent to the site.

The site walkover checklist and photo log are included in Appendix 4.





Legend

- Groundwater Well Locations
- Trial Pit Locations
- Site Boundary

Meters
0 25 50 100

Figure Title
Site Investigation Location Plan

Figure No. 3.1

Project
ERA of Historic Landfill at Killycard, Co. Monaghan

Client
Monaghan County Council

Scale 1:1,500 **Page Size** A3

Revision A **Date** 09/11/2018

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3.1.2 Trial Pitting

A Causeway Geotech (CGL) Engineering Geologist supervised the advancement of 13 No. trial pits, shown in Figure 3.1, on the 20th September and 21st September 2018.

The trial pits (TP01 to TP13) were excavated to depths of 4.20m to 4.50m below existing ground level (bgl) using a JCB 3CX back-hoe excavator.

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 below 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	0.10 (Topsoil) 0.1 – 2.2 (Made Ground) 2.2 – 3.4 (Peat) 3.4 – 4.5 (Clay)	4.5 (base of excavation)	MADE GROUND: Black waste with sandy gravelly SILT - 40% plastic, 5% glass bottles, fertiliser bags, shoes, mattress, steel pipe, cloths and 2 rolls of industrial cardboard. Spongy brown fibrous PEAT. Soft bluish grey silty CLAY.
TP02	0.10 (Topsoil) 0.1 – 2.6 (Made Ground) 2.6 – 4.2 (Peat) 4.2 – 4.5 (Clay)	4.5 (base of excavation)	MADE GROUND: Black waste with sandy gravelly SILT - 50% plastic, 5% glass bottles, planks of wood, foam, plastic, pipes, kitchen knife, metal straps, shoes, wellies. Spongy brown fibrous PEAT. Soft bluish grey silty CLAY.
TP03	0.10 (Topsoil) 0.1 – 2.3 (Made Ground) 2.3 – 3.6 (Peat) 3.6 – 4.2 (Clay)	4.2 (base of excavation)	MADE GROUND: Brownish black waste with sandy gravelly SILT - 30% office waste, shredded paper, old clothes, mattress springs, zinc, wood, shoes, tiles, blankets and fertiliser bags. Spongy brown fibrous PEAT. Soft bluish grey silty CLAY.
TP04	0.10 (Topsoil) 0.1 – 2.1 (Made Ground) 2.1 – 4.2 (Peat) 4.2 – 4.5 (Clay)	4.5 (base of excavation)	MADE GROUND: Black waste with sandy gravelly SILT - 40% plastic, fertiliser bags, 10% glass bottles, shoes, clothes. Spongy brown fibrous PEAT. Soft bluish grey silty CLAY.
TP05	0.10 (Topsoil) 0.1 – 2.2 (Made Ground) 2.2 – 3.8 (Peat) 3.8 – 4.5 (Clay)	4.5 (base of excavation)	MADE GROUND: Black waste with sandy gravelly SILT - 60% plastic, 10% clothes, 5% glass bottles, wood, plastic bottles, metal pipes. Spongy brown fibrous PEAT. Firm blue silty CLAY.
TP06	0.10 (Topsoil) 0.1 – 2.4 (Made Ground)	4.5 (base of excavation)	MADE GROUND: Black waste with sandy gravelly SILT with fragments of red brick,

Trial Pit ID	Depth of cover material (m BGL)	Depth to base of made ground / waste (m BGL)	Profile Description
	2.4 – 4.0 (Peat) 4.0 – 4.5 (Clay)		pipes, plastic, steel pipes, glass bottles, ropes and metal wires. Spongy brown fibrous PEAT. Firm bluish grey silty CLAY.
TP07	0.10 (Topsoil) 0.1 – 1.9 (Made Ground) 1.9 – 3.7 (Peat) 3.7 – 4.5 (Clay)	4.5 (base of excavation)	MADE GROUND: Firm greyish black slightly sandy slightly gravelly CLAY with fragments of red brick, plastic, old wires, wood, glass bottles and milk cartons. Spongy brown fibrous PEAT. Firm bluish grey silty CLAY.
TP08	0.10 (Topsoil) 0.1 – 4.4 (Made Ground) 4.4 – 4.5 (Peat)	4.5 (base of excavation)	MADE GROUND: Firm grey slightly sandy slightly gravelly CLAY with black waste, plastic, wires and ropes. Spongy brown fibrous PEAT.
TP09	0.10 (Topsoil) 0.1 – 2.7 (Made Ground) 2.7 – 3.5 (Peat) 3.5 – 4.5 (Clay)	4.5 (base of excavation)	MADE GROUND: Brownish black waste – 60% plastic, 10% clothes, glass bottles and pipes. Spongy brown fibrous PEAT. Soft bluish grey silty CLAY.
TP10	0.10 (Topsoil) 0.1 – 1.9 (Made Ground) 1.9 – 3.2 (Peat) 3.2 – 4.5 (Clay)	4.5 (base of excavation)	MADE GROUND: Black waste with sandy gravelly SILT - 30% plastic, old clothes, glass bottles and metal pipes. Spongy brown fibrous PEAT. Soft bluish grey silty CLAY.
TP11	0.10 (Topsoil) 0.1 – 3.4 (Made Ground) 3.4 - 4.3 (Clay)	4.3 (base of excavation)	MADE GROUND: Black waste with sandy gravelly SILT - 50% plastic, 10% rubber, 15% glass bottles, washing machines, cups, springs, coal bags, clothes, nets, planks of wood and fertiliser bags. Soft blue silty CLAY.
TP12	0.10 (Topsoil) 0.1 – 2.7 (Made Ground) 2.7 – 3.7 (Peat) 3.7 – 4.5 (Clay)	4.5 (base of excavation)	MADE GROUND: Soft brown slightly sandy slightly gravelly CLAY with plastic, glass bottles, planks of wood, wire, plastic pipe, red brick, clothes and fertiliser bags. Spongy brown fibrous PEAT. Soft bluish grey silty CLAY.
TP13	0.10 (Topsoil) 0.1 – 2.4 (Made Ground) 2.4 – 3.8 (Peat) 3.8 – 4.5 (Clay)	4.5 (base of excavation)	MADE GROUND: Firm brown slightly gravelly sandy CLAY with steel pipes, 30% plastic, 10% clothes. milk cartons, glass bottles, coal bags and fertiliser bags. Spongy brown fibrous PEAT. Soft bluish grey silty CLAY.

Made ground comprising waste was encountered in all 13 No. trial pits (TP01 - TP13). The cover material at these trial pit locations comprised 0.05m to 0.10m topsoil. The shallow topsoil depth across the site do not comply with the capping design specification set out in the Landfill Design Manual. No bedrock was encountered during the trial pitting works.

Waste material was encountered between 0.1m – 3.4m in all trial pits TP01 to TP13 where natural ground was confirmed. Natural ground comprising of cut-over peat and glacial till was confirmed in all trial pits except for TP11 where Made Ground was underlain by glacial till only.

Groundwater was encountered in 10 of 13 No. trial pits as detailed in Table 3.2.

Table 3-2: Groundwater strikes encountered during trial pitting

Trial Pit ID	Water Level (mBGL)	Flow Rate
TP01	2.1	Fast Flow
TP02	1.8	Fast Flow
TP03	2.1	Seepage
TP04	4.1	Seepage
TP06	1.2	Heavy Flow
TP07	1.0	Seepage
TP10	1.6	Seepage
TP11	3.0	Fast Flow
TP12	2.8	Seepage
TP13	2.1	Fast Flow

3.1.3 Waste Sampling

A total of 2 No. samples of the made ground / waste at the site was collected from trial pits TP04 and TP08 advanced in the centre of the site.

All samples were 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 G of the CGL Ground Investigation report, Appendix 2 of this report.

3.1.4 Evidence of Contamination

The trial pit excavation works identified waste material tending west-east across the entire site to a maximum depth of 4.4m BGL. Evidence of waste material was identified at all trial pit locations (TP01 – TP13). The waste encountered was typically described as black bag type waste with 30% to 50% plastic, 10% rubber, 15% glass bottles, washing machines, cups, springs, coal bags, clothes, nets, planks of wood and fertiliser bags. The waste material description as described by CGLs Engineering Geologist is typical of domestically sourced Municipal Solid Waste.

The base of the waste was encountered between 2.2m – 4.4m in all trial pits advanced across the site where natural ground was confirmed.

3.1.5 Geophysical Investigation

Apex Geoservices Ltd. (Apex) were instructed by FT to undertake a geophysical investigation of the site. The survey was carried out on the 1st and 2nd November 2018.

The geophysical survey consisted of reconnaissance EM Ground Conductivity Mapping with follow-up Electrical Resistivity Tomography (ERT), Seismic Refraction profiling and the MASW (multichannel analysis of surface waves) method used to estimate shear-wave velocities (Vs) in the ground material. A total of 516m 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 into zones based on an interpretation of the ground conditions across the site. The following 2 No. zones were identified:

- Zone A: made ground/waste (predominantly organic) over very soft Peat/Clay with Leachate
- Zone B: made ground/waste (mixed with Clay/Silt) over very soft Peat/Clay

A map showing a delineation of the identified zones is presented in Figure 3.2.

Seismic Refraction Profiling & Electrical Resistivity Tomography (ERT)

Apex recorded 5 no. ERT profiles data along three designated profiles. ERT profiles are named R1 through R5. The location of these profiles is given in Drawing No. AGL18164_01 and interpreted cross sections were compiled for the profiles on Drawing No. AGL18164_R1-R5.

Three seismic refraction profiles (S1-S3) were recorded across the site. The locations are shown on Drawing No. AGL18164_01 and the interpreted cross sections are presented in Drawing No. AGL18164_R1-R5.

An interpretation of the results is included in the Apex geophysical survey report, Appendix 2.

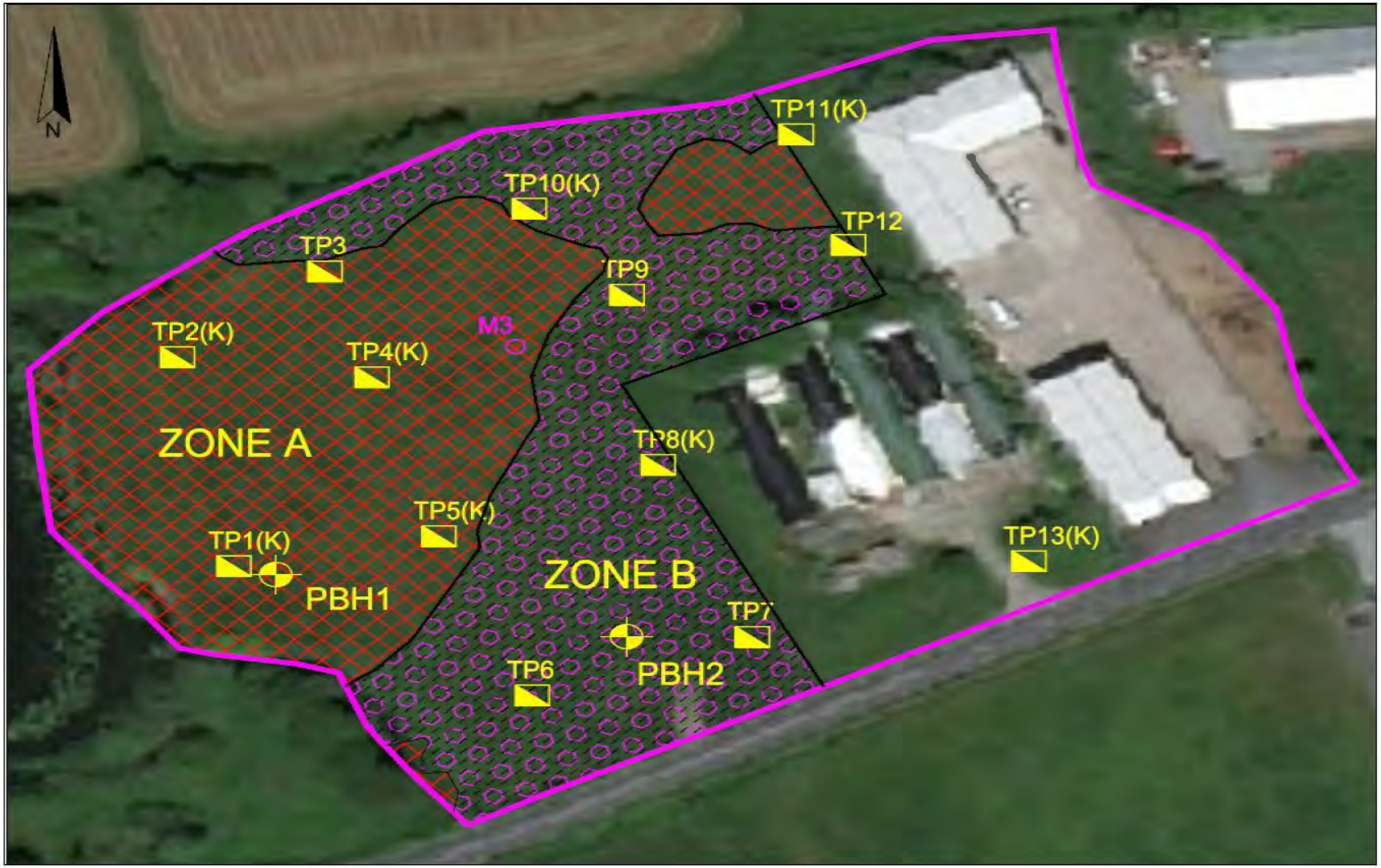

Figure 3-2: Maximum Waste Footprint