January 2020

Environmental Risk Assessment

Site at Greenhills

Kildare County Council

Athy, Co. Kildare

MALONE O'REGAN ENVIRONMENTAL

MALONE O'REGAN

Form ES - 04

MALONE O'REGAN ENVIRONMENTAL

Ground Floor – Unit 3
Bracken Business Park
Bracken Road, Sandyford
Dublin 18, D18 V32Y
Tel: +353- 1- 567 76 55
Email: enviro@mores.ie

Title: Environmental Risk Assessment, Site at Greenhills, Kildare County Council, Athy, Co. Kildare

Job Number: E1506

Prepared By: Nuria Manzanas **Signed:** Nuria Manzanas

Checked By: Stephen Coakley **Signed:**

Approved By: Thomas Vainio-Mattila **Signed:** Thomas Vainio-Mattila

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Contents

FIGURES

TABLES

TABLES (Appendices)

Table 1: Groundwater Levels
Table 2: Soil Tabulated Laboratory Results
Table 3: Groundwater Tabulated Laboratory Results
Table 4: Leachate Tabulated Laboratory Results
Table 5: Surface Water Tabulated Results
Table 6: Landfill Gas Tabulated Results

DRAWINGS

Drawing 1: Subsoils Map
Drawing 2: Bedrock Map
Drawing 3: Bedrock Aquifer Map
Drawing 4: Sand and Gravel Aquifer Map
Drawing 5: Groundwater Vulnerability Map
Drawing 6a/6b: Groundwater Flow Direction Map
Drawing 7: Groundwater Well Database Map
Drawing 8: Hydrological Receptors Map
Drawing 9: Groundwater Source Protection Areas (SI/SO) Map
Drawing 10: Natura 2000 Sites Map
Drawing 11: Nationally Designated Sites Map
Drawing 11: Services (Eircom, Gas Networks Ireland, Irish Water and ESB)
Drawing 12: Trial Pit Locations
Drawing 13: Leachate/Gas Well Locations

APPENDICES

1 INTRODUCTION

Malone O'Regan Environmental (MOR) was appointed by Kildare County Council (KCC) to undertake an Environmental Risk Assessment (ERA), Appropriate Assessment and, where appropriate, preparation of a site-specific remediation plan for the former Greenhills refuse depot located in Athy, Co. Kildare (the Site).

This report has been prepared in accordance with the Environmental Protection Agency's (EPA) published Code of Practice: Environmental Risk Assessment for Unregulated Waste Disposal Sites (2007), hereafter referred to as the 'CoP'.

1.1 Project Understanding

The Site has been identified as a legacy landfill Site and has been added to KCC's Section 22 Register of Unregulated Waste Disposal Sites under the Waste Management Act, 1996 (as amended).

In accordance with the CoP, the Tier 1 assessment carried out by KCC classified the Site as a High Risk Site, due to the proximity of the River Barrow (adjacent to the eastern boundary of the Site), the possibility of leachate migration to a protected area (SWDTE) and the possibility of landfill gas migration to human receptors on and off site (public amenity development and residential dwellings).

Greenhills refuse depot was operated by the local authority and is believed to have been operational from 1980 to 1985 and to have accepted mainly municipal and some commercial and industrial wastes, although there are no supporting records. In this regard, under the CoP and Waste Regulations, KCC has a responsibility to assess the intrinsic risk to potential receptors, which will be evaluated by intrusive and non-intrusive site investigations.

1.2 Background Information Reviewed

The following document was reviewed during this assessment:

- Conceptual Site Model and Risk Assessment (Tier 1 – Risk Assessment) completed by Kildare County Council (Environment Section);

Other information sources were reviewed during this assessment, which included the following:

- Geological Survey Ireland (GSI database online);
- Environmental Protection Agency – EPA Envision online mapping; and,
- National Parks and Wildlife Services – Map viewer.

1.3 Project Objectives

This report presents the findings of the Tier 1 Risk Screening (KCC and MOR), Tier 2 Site Investigations and Testing, Tier 3 Refinement of Conceptual Site Model (CSM) and Quantitative Risk Assessment (QRA) and the recommendations for the unlicensed Greenhills refuse depot in accordance with the CoP. The overall project objectives of the ERA were as follows:

a) To confirm whether there are any risks posed by the imported material to the receiving environment, i.e. risks of landfill gas migration to the sports and leisure centre (on site) and/or migration to bordering residential dwellings. To confirm the risk of leachate migration to nearby surface water (River Barrow) and to groundwater beneath the Site;

b) To develop and update the preliminary conceptual site model (CSM) for the Site, which identifies contamination sources, migration pathways and receptor linkages and to refine the CSM through all stages of the investigation;

c) To determine, where necessary, the requirements for any remediation works at the Site and costing for any specified remedial works;

d) To provide the basis for the Council's application to the EPA for a Certificate of Authorisation as required under S.I. No. 524 of 2008 Waste Management Regulations, 2008 (Certification of Historic Unlicensed Waste Disposal and Recovery Activity).

1.4 Scope of Works

The scope of works undertaken by MOR comprised of the following:

- **Desk based study** of the Site, walkover survey and update of the preliminary Conceptual Site Model (CSM);
- **Geophysical survey** to assess subsurface conditions, including the extent of the imported materials, and to assist in the targeting of locations for site investigations;
- **Excavation of five (5 No) trial pits** at locations across the Site to delineate the extent (horizontal and vertical) and composition of the imported material;
- **Collection of three (3 No) soil samples** from the trial pit locations for laboratory analysis;
- **Collection of one (1 No) soil sample** from the clay capping material to assess for permeability, moisture and particle size distribution;
- **Installation of three (3 No) combined leachate and landfill gas monitoring wells** within the body of the imported material to determine the presence of landfill gas and/or leachate;
- **Installation of three (3 No) groundwater monitoring wells** to characterise groundwater quality upgradient and downgradient of the imported material;
- **Topographical survey** of the site investigation locations (groundwater and leachate/landfill gas wells) to Ordnance Datum;
- **Environmental monitoring** including the collection of groundwater and leachate samples from the newly installed monitoring wells, and of surface water samples on two (2 No) occasions;
- **Landfill gas monitoring** undertaken during three (3 No) monitoring events from the newly installed wells;
- **Gas monitoring survey** of surface emissions, within and outside the site boundary and an internal survey within the leisure centre on one occasion. These surveys utilised an Inficon IRwin Detector (Inficon) to assess the existence of a potential linkage between landfill gas and identified receptors;
- Preparation of a Screening for **Appropriate Assessment (AA)** which complies with Article 6 of the Habitats Directive 92/43/EEC (EC 2001) and S.I. No. 477/2011 (European Communities (Birds and Natural Habitats) Regulations 2011);
- **Generic Risk Assessment** Tier 2 Site Investigation and Testing, Tier 3 Refinement of CSM and Quantitative Risk Assessment and Recommendations in accordance with the EPA Code of Practice; and,
- Preparation of an **Environmental Risk Assessment Report**.

All intrusive site investigation works were undertaken in accordance with BS10175-2011+A2:2017 'Investigation of Potentially Contaminated Sites - Code of Practice'.

1.5 Competent Person

To ensure the quality of the data and conclusions presented in this report, all work was carried out by appropriately qualified and experienced MOR personnel and overseen by Thomas Vainio-Mattila (PGeo), who is qualified, trained and experienced to the standard set out in section 2.3 of Code of Practice: Environmental Risk Assessment for Unregulated Waste Disposal Sites (EPA, 2007) and listed on the IGI Register of Qualified Geoscientists/Competent Persons.

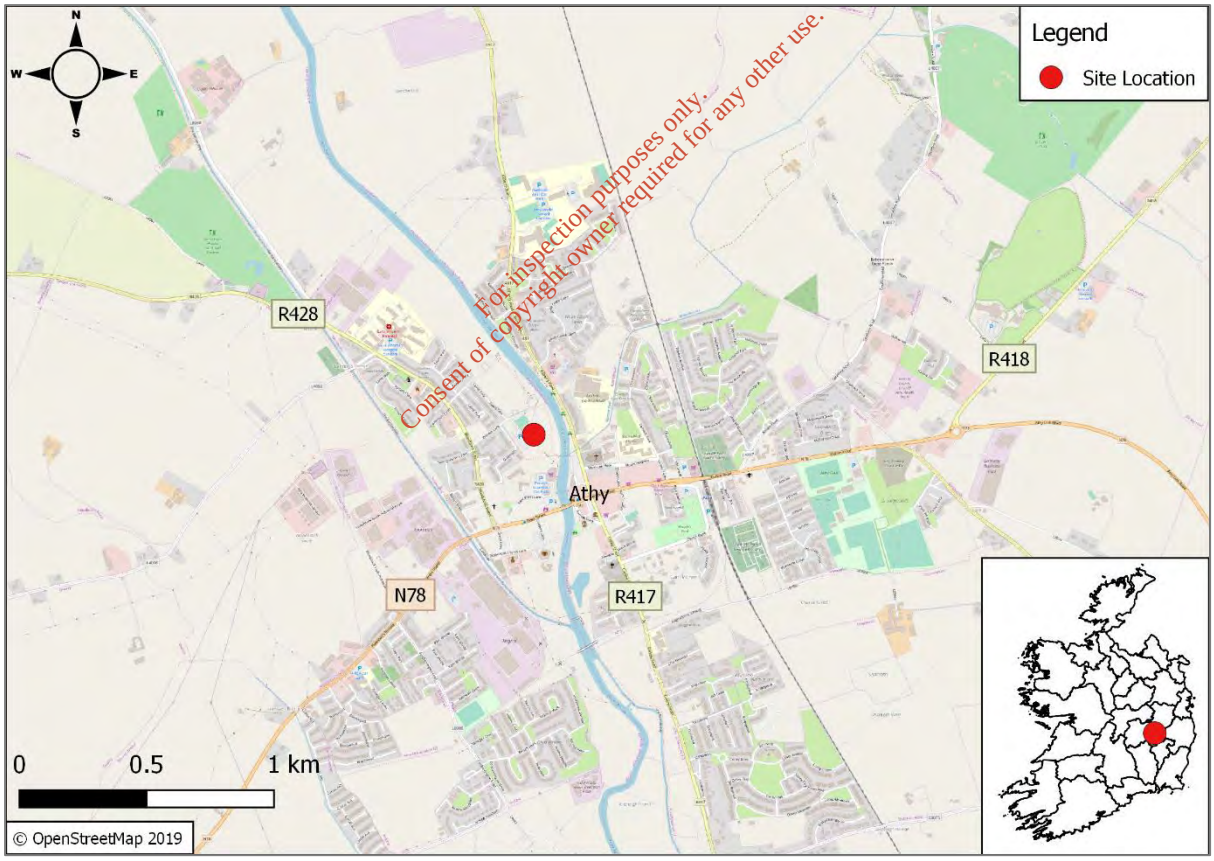
2 SITE SETTING

2.1 Site Location

The Site is located in the centre of Athy town, County Kildare, along the national road N78, within the Townlands of Athy and Townparks (Narragh and Reban West) refer to Figure 2-1. The area of the Site is approximately 4.09 hectares (ha) and is currently occupied by a public amenity building (sports and leisure facility), which is surrounded by green areas.

There are several residential properties along the western boundary of the Site, with the closest property at c. 15m distance from the boundary. A shopping centre (Supervalu) and visitors' car park adjoins the south-eastern boundary of the Site. The River Barrow adjoins the eastern boundary of the Site and there is a school (Ardscoil Na Trionoide) and a number of residential properties beyond the river. A green field with football pitches is located to the north of the Site. A trial well drilled in 1899, a public supply well (KCC) drilled in 2001 and an infiltration gallery (public supply (KCC) drilled in 1899 are located c. 25m, 28m and 45m respectively, north of the Site. Another public supply well (KCC) drilled in 1977 is located c. 252m north/north-west of the Site.

Figure 2-1: Site Location



2.2 Site History

The Historic 25" map of the Site published c.1888-1913 by the OSI and available on the OSI database (Geohive, 2018) shows a stream traversing the Site from west to north-east and ultimately discharging to the River Barrow. Currently, the sports and leisure facility and car park are located within the outline of the stream.

OSI orthophotography images from 1995 show no activity on site. Images from 2000 and 2005 show the same area covered by grass. The mapped stream is not visible on the Site.

Historical Google Earth aerial imagery dated 18th April 2009 shows the sports and leisure facility and car park area in place. Residential properties are also visible on the western and eastern boundary. The aerial imagery from 5th October 2009 shows vegetation covering the Site to a similar extent as the current vegetation coverage at the Site.

It is believed that the Site was used as a refuse depot, operated by KCC, from early 1980 to the end of 1985. However, there are no historical records available to confirm this.

2.3 Environmental Site Setting

2.3.1 Geology

2.3.1.1 Subsoils

Based on the Teagasc subsoil maps the Site is largely underlain by undifferentiated Alluvium, refer to Drawing No. 1.

2.3.1.2 Bedrock

Based on the GSI database (GSI, 2018), the bedrock underlying the quaternary deposits is generally comprised of the Milford Formation, which consists of peloidal calcarenitic limestone, refer to Drawing No. 2.

2.3.2 Hydrogeology

2.3.2.1 Aquifer Classification

Bedrock Aquifer

The bedrock aquifer beneath the Site is classified by the GSI (2018) as Regionally Important Aquifer – Karstified (diffuse – Rkd), refer to Drawing No. 3.

Sand and Gravel Aquifer

The gravel aquifer beneath the Site is comprised of the Barrow Gravels and is classified by the GSI (2018) as being a 'Regionally Important Gravel Aquifer (Rg)', refer to Drawing No. 4.

2.3.2.2 Groundwater Vulnerability

Groundwater vulnerability provides a measure of the ability of contaminants to migrate vertically to an aquifer and is a function of the subsoil permeability (usually dependent on subsoil type) and its thickness (EPA, 2007). According to the GSI database (GSI, 2018), the vulnerability rating at the Site is classified as Moderate (M), refer to Drawing No. 5.

2.3.2.3 Groundwater Flow Direction

Based on a review of available information, including the topographical gradient, the inferred groundwater flow direction is to the east / north-east towards the River Barrow. Refer to Drawing No. 6A and 6B.

2.3.2.4 Groundwater Use and Protection

A search of the GSI groundwater well database was conducted to identify existing wells within a 2km radius of the Site, refer to Drawing No. 7.

2.3.3 Hydrology

2.3.3.1 Hydrological Receptors

The River Barrow adjoins the Site along the eastern boundary and runs north to south. The Athy Stream is a tributary of the River Barrow and it is located c. 40m east of the Site, where

it discharges into the River Barrow. The Grand Canal is located c. 350m west, south-west of the Site. The Bennetsbridge Stream is located approximately 1.3km south-west of the Site. The Site is located within the Barrow hydrometric area and the sub-catchment Barrow_SC_070 (EPA, 2018). Refer to Drawing No. 8.

2.3.3.2 Protected Area Receptors

A Public Supply Source of Inner Protection Area (SI) was identified within the Site in the townland of Athy. The Outer Protection Area (SO) was identified at 0.64km west of the Site. Refer to Drawing No. 9.

2.3.4 Ecology

2.3.4.1 European Designated Sites

There are two European designated Natura 2000 Sites located within 10km of the Site. These are identified in Drawing No. 10 and listed in Table 2-1 below.

Table 2-1: European Designated Sites

Site Name	Site Code	Distance (km) & Direction
Special Area of Conservation		
River Barrow and River Nore SAC	002162	Easter boundary of the Site
Ballyprior Grassland SAC	002256	c. 9.5km west of the Site

An Appropriate Assessment Stage 1 Screening Report (AA) that forms part of the project was prepared for the Site and has been included as a stand-alone document (refer to Appendix I), at the end of this report. The screening assessment concluded that the Site does not currently have any adverse effect on any European Designated sites or any of their designated features of interest.

2.3.4.2 Natural Heritage Areas

No Natural Heritage Areas (NHAs) were identified within 2 or 5km of the Site. One (1 No) proposed Natural Heritage Areas (pNHA) was located within 2km of the Site. A single (1 No) pNHA was located within a 5km radius of the Site. Refer to Drawing No. 11 and Table 2-2 below.

Table 2-2: Nationally Designated Sites

Site Name	Code	Distance (km) & Direction
Proposed Natural Heritage Areas (pNHAs)		
Grand Canal	002104	At c. 350m west
Barrow Valley At Tankardstown	000858	At c. 4.24km south-east

2.3.5 Infrastructure

Service ducts and infrastructure can provide a pathway for the migration of contaminants from the Site to identified receptors. The utility providers Gas Networks Ireland, ESB and Eircom were contacted in October 2018 and the responses indicated that there were several underground services present within the proposed site investigation area. KCC provided MOR with a map from Irish Water that shows a “150mm uPVC 1990 pipe” crossing the Site on the eastern side from North to South, which was not shown on any of the other maps.

A number of planning drawings for the sports and leisure facility were reviewed to assist with the identification of underground services. During the site walkover the presence of above ground ESB transmission wires and pylons was noted on the Site.

3 EXISTING SITE CONDITIONS

3.1 Walkover Survey

A walkover survey was completed by a MOR Consultant on the 13th of November 2018. The purpose of this walkover survey was to establish the current land use of the Site and the surrounding area. The Site inspection examined each of the possible SPR linkages and attempted to delineate, from visual inspection, the extent of the imported material.

In general, the topography of the Site is flat around the green areas (park – open grounds) with a downward slope from the amenity building (sports and leisure facility) towards the River Barrow. The Site is largely grass covered with some tarmacadam hardstanding areas within the fenced-off sports and leisure facility premises. Many passers-by (adults and children) and dogs were observed during the walkover.

There was no evidence of landfill gas during the walkover survey (i.e. odour or vegetation die back).

The ground was observed to be mostly firm, but boggy towards the River Barrow at the eastern boundary of the Site.

No noxious/notifiable species (i.e. Japanese Knotweed) were observed within the Site or around the perimeter of the Site.

4 TIER 1 - RISK SCREENING, PRELIMINARY CONCEPTUAL SITE MODEL AND RISK PRIORITISATION

4.1 Risk Screening

In accordance with the EPA CoP a Risk Screening, i.e. an assessment of the source-pathway-receptor (SPR) linkages was undertaken by developing a Preliminary Conceptual Site Model (CSM) for the Site.

4.2 Preliminary Conceptual Site Model

An initial CSM was developed by KCC as part of its Tier 1 assessment of the Site to identify possible source-pathway-receptor linkages. Refer to Appendix A for the Tier 1 assessment.

MOR reviewed and updated the CSM, refer to Table 4-1 below and Appendix B.

Table 4-1: Preliminary Conceptual Site Model Summary

Element	Description	Rationale
Source	Imported Material	• The principal potential source of contamination was the imported material, which has the potential to generate leachate and landfill gas. • Type of Imported Material - It is believed that the Site was operated by the local authority and accepted mainly municipal, but also some commercial and industrial wastes. No supporting records were available. • It is understood that the Site was used as refuse depot from approximately 1st January 1980 to 31st December 1985. • Extent of Imported Material has not been quantified, however, the entire area of the site is estimated to be c. 4.09ha. • It is understood that the site was capped with clay.
Pathway	Aquifer Beneath the Site	• A shallow sand & gravel aquifer (Regionally Important Gravel Aquifer) and a bedrock aquifer (Rkd – Regionally Important Aquifer (Karstified (diffuse)) identified beneath the Site, according to the GSI mapping
	Landfill gas migration via soil and subsoils	• Possibility of landfill gas migrating via permeable sand and gravel materials towards identified receptor locations.
	Leachate	• Migration of leachate through the imported material.
	Surface water Body	• Surface water bodies (River Barrow) parallel to the eastern boundary of the site.
Receptor	Properties	• Human presence – the Site is bounded to the west and east by residential properties, to the south-east by a shopping center and also to the east by a school.
	Private Wells	• Approximately thirty-nine (39 No) wells were identified within a 2km radius of the Site.
	Public Water Supply Well	• A trial well, a public supply well (KCC) and an infiltration gallery (KCC) were identified to the north of the Site, which KCC confirmed are no longer in use. • A Public Supply Source of Inner Protection Area (SI) identified within the Site and the Source of Outer Protection Area (SO) identified at c.0.64km west of the Site.
	Surface Water	• River Barrow adjoining the Site to the east flowing in a north-south direction. • Grand Canal located at c. 350m to the west to the Site.
	Aquifer Beneath the Site	• Regionally Important Sand and Gravel Aquifer (Regionally Important Gravel Aquifer) – Potential usage not known.

Element	Description	Rationale
		• Regionally Important Aquifer – Karstified (diffuse – Rkd) – Potential usage not known.
	Protected Sites	• Site located within a receiving environment with a high environmental sensitivity, as it overlies an important sand and gravel aquifer which is potentially connected to the River Barrow and River Nore SAC. • Located at c. 350m west of the proposed Grand Canal NHA.

4.3 Risk Prioritisation

Risk prioritisation was completed for the Site in accordance with the EPA Code of Practice (EPA, 2007). The risk prioritisation process assigns a score to each linkage where the overall site score is the maximum of the individual linkages. The scoring system allocates higher numbers for the higher risk elements and thus allows a meaningful comparison to be made between different linkages.

Using the methodology developed by the EPA, the individual linkages were normalised to a rating of 100. The result calculated provides an indication of the relative risk associated with the SPR linkage at the Site. Table 4-2 below contains a summary of the results for a preliminary risk prioritisation exercise.

Table 4-2: Preliminary Risk Prioritisation Summary

SPR	Linkages	Pathway via	SPR Value	Maximum Score	Normalised
SPR1	Leachate c:>Surface Water	Combined groundwater and surface water	168	300	56%
SPR2	Leachate c:> SWDTE	Combined groundwater and surface water	168	300	56%
SPR3	Leachate c:> Human Presence (private well)	Groundwater Pathway	126	240	53%
SPR4	Leachate c:> GWDTE	Groundwater Pathway	126	240	53%
SPR5	Leachate c:> Aquifer	Groundwater Pathway	210	400	53%
SPR6	Leachate c:> Public Supply	Groundwater Pathway	294	560	53%
SPR7	Leachate c:> Surface Water	Groundwater Pathway	126	240	53%
SPR8	Leachate c:> Surface Water	Surface Water Pathway	42	60	70%
SPR9	Leachate c:> SWDTE	Surface Water Pathway	42	60	70%
SPR10	Landfill Gas c:> Human Presence – off-site	Lateral and Vertical	105	150	70%
SPR11	Landfill Gas c:> Human Presence – onsite	Lateral and Vertical	35	250	14%
OVERALL RISK SCORE			**HIGH**		

Risk Classification	Range of Risk Scores
HIGH Risk (Class A)	Score greater than or equal to 70% for any individual SPR linkages
MODERATE Risk (Class B)	Score between 40% and 70% for any individual SPR linkages
LOW Risk (Class C)	Score less than 40% for any individual SPR linkages

Sites with a score greater than or equal to 70% for any of the site specific SPR linkages are considered to represent potential high risk or high uncertainty sites (Class A).

Sites with a score ranging between 40% and 70% for any of the site specific SPR linkages are considered to represent potential moderate risk (Class B).

Sites with a score less than 40% for all of the site specific SPR linkages are considered to represent potential low risk (Class C).

The risk classification assigned to the Site after the desk study was Class A (High Risk). It represents the intrinsic risk that the Site (imported material) poses to the environment. The SPR linkages that represent a potential higher risk are SPR8 (potential for leachate migration through surface water drainage to the surface water body), SPR9 (potential for leachate migration through surface water drainage to the protected area (SWDTE)) and SPR10 (potential for landfill gas to migrate laterally through the subsoil to a nearby receptor) with scores of 70%. The remaining SPR linkages were determined as moderate risk (SPR1 to SPR7) and low risk (SPR11).

SPR8 and SPR9 (normalised score – 70%) were considered further, as a precautionary measure, due to the evidence that a historical stream crossed the site from west to east and discharged into the River Barrow, which is a SAC. Due to the public supply source of inner protection area (SI) identified within the Site and the public supply wells in the north of the Site, SPR6 (normalised score – 53%) was considered further. According to KCC, the supply wells are no longer in use, however, as a precautionary measure, it was determined that SPR6 required consideration as a potential pollutant linkage. SPR11 (normalised score – 14%) was considered further due to the potential for landfill gas to migrate vertically through the subsoil to receptors on site.

The pollutant linkages not considered further in this assessment were:

- SPR1 linkage (normalised score – 56%), which assesses the potential for leachate migration through on-site drainage ditches to surface water receptors. This pollutant linkage was deemed negligible during the site walkover, as there were no on-site ditches on Site, and has not been considered further; and,

- SPR4 (normalised score – 53%), which assesses the potential for leachate migration (vertical and horizontal) to groundwater dependent terrestrial ecosystems (GWDTE). This pollutant linkage was deemed negligible as there was no GWDTE identified during the desk study and has not been considered further.

The potential risk for the identified SPR linkages was assessed and reviewed further during the Site Tier 2 – Exploratory and Main site investigation stage.

5 TIER 2 - EXPLORATORY AND MAIN SITE INVESTIGATION - METHODOLOGY

The following sections describe the works carried out for the Tier 2 Exploratory and Main Site Investigations in compliance with the EPA CoP.

5.1 Non-Intrusive Site Investigation

5.1.1 Preparatory Works – Health and Safety

The Site Works were carried out in strict accordance with MOR's safety protocols and all recognised best practice health and safety procedures.

5.1.2 Underground Utility Identification

An underground utility identification and location procedure was completed prior to initiating any ground disturbance activities at the site. The utility providers Gas Networks Ireland, ESB and Eircom were contacted in October 2018 – the responses indicated that there were a number of underground services within the proposed site investigation area.

5.1.3 Geophysical Survey

A geophysical survey was completed on the 5th of November 2018 on the Site by Apex Geoservices Ltd (Apex) and involved the collection of 780 Electromagnetic (EM) conductivity data points, five (5 No) Electrical Resistivity Tomography (ERT) profiles, three (3 No) seismic refraction profiles across the Site and three (3 No) 1D Multi-Channel Analysis of Surface Waves (MASW). A copy of the Apex report is included in Appendix C. The primary objective was to assess the subsurface conditions as far as possible (depth to bedrock and information on groundwater) and to determine the thickness, extent and volume of imported material present on Site.

The brief overview of works provided by Apex is set out below:

1. EM ground conductivity survey across the site. The conductivity survey provided information on the extent of the imported material and any variations within the imported material. It was also used to screen for any leachate plumes and obtain background values for the soils;
2. ERT provided information on the thickness and extent of the imported material and identified areas of possible leachate; and,
3. Seismic refraction profiles were carried out to aid the interpretation of the resistivity data and to provide detail on the depth to bedrock.
4. MASW provided information about the soil cohesion ranges and indication of the base of waste material. Shear wave and velocity values were determined for the made ground/imported material and underlying soil material.

5.1.4 Topographical Survey

A topographical survey was undertaken after the installation of the boreholes in order to survey all locations to Ordnance Datum as part of the Tier 2 site investigations. The survey was carried out on the 26th April 2019.

5.2 Intrusive Site Investigation

The intrusive site investigation works were undertaken in accordance with BS10175 – 2011+A2:2017 "Investigation of Potentially Contaminated Sites – Code of Practice'' and supervised on a full-time basis by MOR environmental personnel. The number and locations of the site investigation (trial pits and groundwater / leachate wells) were determined in accordance with BS10175. The first phase of works (installation of leachate/gas wells and

trial pits) was carried out during January 2019, the second phase of site works was carried out in April 2019 (installation of groundwater wells). The scope of work completed is described in the following sections.

5.2.1 Trial Pit Excavation

Trial pit excavations at five (5 No) locations were carried out on the 16th of January 2019 to characterise the imported fill materials. The objective of the trial pitting was to assess the lateral extent and composition of the imported material. In this regard any visual or olfactory evidence of contamination was recorded including photographic evidence. A MOR environmental consultant was on site during all of the trial pit excavations.

The excavation of the trial pits to a maximum depth of approximately 4.4mbgl was undertaken using a 13-tonne tracked excavator. Each trial pit was logged in accordance with the BS 5930:2015 standards. Locations for the trial pits were selected based on initial discussions with KCC, findings of the desk-based studies, the site walkover and the results of the geophysical survey. Each trial pit was re-instated to as close to its original condition as possible. Exact locations are shown in Drawing No. 12. Refer to Appendix D for trial pit logs and also for photographic records of all trial pits. Two (2 No) profiles at the Site were recorded;

- Profile 1 – Trial pits along the River Barrow (TP1, TP2 and TP3); and,
- Profile 2 – Trial pits located on the raised areas along the eastern and southern parts of the sports and leisure facility (TP4 and TP5).

Table 5-1 below depicts the first soil profile (Profile 1) encountered at the Site during trial pitting.

Table 5-1: Typical Trial Pit Profile 1

Depth ranges (mbgl)	Profile
0.0 – 1.7	Made Ground – Gravelly, clay with rare plastic, bricks and metal.
1.1 – 3.0	Natural Soil – Sand and gravels with cobbles / very sandy, clay with gravels and cobbles.

mbgl - metres below ground level

Table 5-2 below depicts the second soil profile (Profile 2) encountered at the Site during trial pitting.

Table 5-2: Typical Trial Pit Profile 2

Depth ranges (mbgl)	Profile
0.0 – 4.4	Made Ground – Gravelly, clay with cobbles and some plastic, metal, wood, cloths and red bricks.
3.6 – 4.3	Natural Ground – Clay with some sand and gravels.

mbgl - metres below ground level

5.2.2 Leachate and Gas Wells

A shell and auger rig was mobilised to the Site from the 3rd to the 8th of January 2019 to install shallow leachate/gas boreholes (L1 to L3). The three (3 No) combined leachate and gas monitoring wells were installed to 2.5 to 6.7mbgl. During the installation works the MOR consultant noted any field evidence of contamination through the soil/lithological profile to ensure that a conduit was not provided to the underlying aquifer. The borehole logs are shown in Appendix E. Refer to Table 5-3 for details on the installation and Drawing No. 13 for leachate/gas borehole locations.

Table 5-3: Installation Details

Borehole ID	Final Depth (mbgl)	Screened Depth (mbgl)	Depth of Imported material (mbgl)
L1	5.5	1.0 – 4.0	4.8
L2	2.5	1.0 – 1.85	2.5
L3	6.8	1.0 – 6.2	6.7

mbgl - metres below ground level

5.2.3 Groundwater Wells

Three (3 No) groundwater monitoring wells were installed between the 4th and the 9th of April 2019 to a maximum depth of 14.4mbgl using an air rotary drill rig. The wells were installed in order to characterise groundwater quality upgradient and downgradient of the imported fill materials, refer to Drawing No. 14 for groundwater monitoring well locations. The borehole logs are shown in Appendix E.

Table 5-4 shows details of the groundwater well installation and static water level taken after the completion of the well installation.

Table 5-4: Summary – Groundwater Well Installation

Sample ID	Final Depth (mbgl)	Screened Depth (mbgl)	Static Water Level (mbgl)
GW1	9.8	0.7 – 9.8	3.8 (08/04/2019)
GW2	14.4	3.5 – 14.4	4.9 (09/04/2019)
GW3	9.8	3.0 – 9.8	3.25 (05/04/2019)

mbgl - metres below ground level

Both the groundwater monitoring and leachate / gas wells were constructed with 50mm PVC blank casing, slotted screen and fitted with a rubber bung seal and gas valve. The wells were finished flush to the ground. In accordance with best practice, the borehole annulus at all locations was backfilled with pea gravel to approximately 0.5m above the screened interval followed by a bentonite seal to the surface.

5.3 Imported Material Laboratory Analysis

Three (3 No) soil samples were collected during the trial pit excavation at the Site. Samples were sealed in appropriate laboratory supplied containers and stored in cool dark conditions for transfer to Exova (Jones Environmental Ltd), a UKAS accredited laboratory for analysis. Sample details including location and depth of samples were recorded on chain of custody (COC) records and kept for tracking purposes.

The soil samples were analysed for the inert criteria as stipulated in 2003/33/EC European Waste Acceptance Criteria (WAC), as previously agreed with KCC, as follows:

Soil:

- Metals: antimony, arsenic, barium, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, sulphate, boron;
- pH;
- Moisture content;
- Total cyanide;
- Total organic carbon (TOC);
- Sulphide and Elemental Sulphur;
- Hexavalent Chromium and Chromium III;

- MTBE, Benzene, toluene, ethylbenzene and total xylenes (BTEX) and phenol;
- Polychlorinated biphenyls (PCBs);
- Mineral oil;
- Asbestos;
- Polycyclic aromatic hydrocarbons (PAHs); and,
- Total petroleum hydrocarbons (TPH CWG).

Soil/Waste Leachate (CEN 10:1):

- Indicators and inorganics: chloride, fluoride, sulphate, dissolved organic carbon (DOC), ammoniacal nitrogen and total dissolved solids (TDS);
- Metals: antimony, arsenic, barium, cadmium, chromium, copper, lead, molybdenum, nickel, selenium, zinc, mercury, and boron; and,
- Phenol.

5.4 Environmental Monitoring

Monitoring was carried out at the Site on 23rd April 2019, 25th April 2019, 8th May 2019, 9th May 2019, 29th May 2019 and 19th December 2019. The details of the scope of the monitoring completed are summarised in Table 5-5 and the methodology is outlined below. All sampling locations are shown in Drawing No. 15.

The monitoring events were conducted, and samples collected by appropriately qualified and experienced MOR consultants in accordance with MOR ISO procedures and industry best practice standards (i.e. ISO 5667).

Table 5-5: Summary of Environmental Monitoring

Date	Groundwater Monitoring Events	Leachate Monitoring Events	Surface Water Monitoring Events	Gas Monitoring Events	Surface VOC Emissions Survey (FID)
23rd April 2019	GW1, GW2 and GW3	L1, L2 and L3	SW1 and SW2	L1, L2 and L3	
25th April 2019				GW1, GW2 and GW3	
8th May 2019	GW1, GW2 and GW3	L1, L2 and L3		L1, L2, L3, GW1, GW2 and GW3	
9th May 2019			SW1 and SW2		
29th May 2019				L1, L2, L3, GW1, GW2 and GW3	Locations within and outside of the Site
19th Dec 2019					Locations within the leisure centre building

5.4.1 Leachate

Leachate monitoring was undertaken over two (2 No) monitoring events, on 23rd April 2019 and 8th May 2019 at the new combined leachate/gas monitoring wells. The monitoring location L2 was dry during both monitoring events and no leachate samples could be retrieved. Leachate samples were retrieved from the monitoring locations L1 and L3 during both monitoring events.

All leachate samples were collected in accordance with best practice procedures (ISO 5667-11:2009) using a disposable bailer to avoid cross contamination. The sample containers were kept cool and in darkness and were sent to a UKAS accredited laboratory (Exova Ltd.) for analysis. In order to maintain sample integrity, a chain of custody (COC) record was completed

to track sample possession from time of collection to time of analysis. Refer to Appendix F for the COC records.

Leachate samples were analysed in the laboratory for a broad range of potential contaminants. The leachate analytical suite closely followed the parameters set out in Table C.2 of the EPA Landfill Monitoring Manual (2003) for 'Groundwater Baseline'. The requirements of Table D2 are also included in the proposed suite of analysis for the full screen. The leachate analytical suite for this site included the following parameters;

- Temperature, Dissolved Oxygen, Electrical Conductivity, Oxidation Reduction Potential and pH;
- Metals (Arsenic, Boron, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Nickel, Potassium, Sodium and Zinc);
- Sulphate, Chloride and Fluoride;
- Ammoniacal Nitrogen;
- Total Oxidised Nitrogen (TON);
- Molybdate Reactive Phosphorous (MRP);
- Total Cyanide;
- Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD);
- Acid Herbicides;
- Organochlorine Pesticides (33 compounds);
- Organophosphorous pesticides (21 compounds);
- Pesticides (Atrazine & Simazine);
- Semi-Volatile Organic Compounds SVOCs (including PAHs, phenols and chlorinated phenols);
- Volatile Organic Compounds (including BTEX/MTBE);
- Total Monohydric Phenols – HPLC;
- Tributyltin, Triphenyltin, Dibutyltin;
- Extractable Petroleum Hydrocarbons (EPH) including mineral oil; and,
- Total Petroleum Hydrocarbons (TPH).

5.4.2 Groundwater

Groundwater monitoring was undertaken over two (2 No) monitoring events, on 23rd April 2019 and 8th May 2019 at the groundwater monitoring locations (GW1 to GW3).

Each well was purged prior to sample collection in accordance with standard best practice methods using dedicated equipment. During purging, water quality measurements were taken as well as notes on the physical appearance of the purged water. After purging, the groundwater samples were decanted into labelled containers supplied by the laboratory. All samples were collected in accordance with best practice procedures (ISO 5667-11:2009) using dedicated sampling equipment to avoid cross contamination. The sample containers were kept cool and in darkness and were sent to a UKAS accredited laboratory (Exova Ltd.) for analysis. In order to maintain sample integrity, a chain of custody record was completed to track sample possession from time of collection to time of analysis.

Groundwater samples were analysed in the laboratory for a broad range of potential contaminants. The groundwater analytical suite closely followed the parameters set out in Table C.2 for the EPA Landfill Monitoring Manual (2003) for 'Groundwater Baseline'. The requirements of Table D2 were also included in the suite of analysis for the full screen. The groundwater analytical suite for the Site included the following parameters.

- Temperature, Dissolved Oxygen, Electrical Conductivity, Oxidation Reduction Potential and pH;

- Sulphate, Chloride, Fluoride;
- Metals (Arsenic, Boron, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Nickel, Potassium, Sodium and Zinc);
- Ammoniacal Nitrogen;
- Molybdate Reactive Phosphorous (MRP);
- Total Dissolved Solids (TDS), Total Organic Carbon (TOC);
- Total Oxidised Nitrogen;
- Total Alkalinity as $CaCO_3$;
- Total Cyanide;
- Acid Herbicides;
- Organochlorine Pesticides (33 compounds);
- Organophosphorous pesticides (21 compounds);
- Pesticides (Atrazine & Simazine);
- Semi-Volatile Organic Compounds SVOCs (including PAHs, phenols and chlorinated phenols);
- Volatile Organic Compounds (including BTEX/MTBE);
- Total Phenols – HPLC;
- Tributyltin, Triphenyltin, Dibutyltin;
- Extractable Petroleum Hydrocarbons (EPH) including mineral oil; and,
- Total Petroleum Hydrocarbons (TPH); and,
- Faecal and Total Coliforms.

5.4.3 Surface Water

Two (2 No) surface water samples (SW1 and SW2) were collected upstream and downstream of the River Barrow at the eastern boundary of the Site over two monitoring events on 23rd April 2019 and 9th May 2019. The surface water monitoring locations are shown in Drawing No. 16.

All samples were collected in accordance with best practice procedures (ISO 5667-11:2009). During sample collection, water quality measurements of EC, temperature and DO, were taken as well as notes on the physical appearance of the water samples. Surface water samples were collected and decanted into labelled containers supplied by a UKAS and ISO 17025 accredited laboratory. The sample containers were kept cool and in darkness and were sent to the laboratory for analysis. In order to maintain sample integrity, a chain of custody document was completed to track sample possession from time of sample collection to time of analysis.

Surface water samples were analysed for the following parameters:

- Temperature, Dissolved Oxygen, Electrical Conductivity, Oxidation Reduction Potential and pH;
- Metals (Arsenic, Boron, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Nickel, Potassium, Sodium and Zinc);
- Sulphate, Chloride and Fluoride;
- Ammoniacal Nitrogen;
- Total Oxidised Nitrogen (TON);
- Total Suspended Solids (TSS);
- Molybdate Reactive Phosphorous (MRP);
- Total Cyanide;
- Total Alkalinity as $CaCO_3$;
- Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD);
- Acid Herbicides;

- Organochlorine Pesticides (33 compounds);
- Organophosphorous pesticides (21 compounds);
- Pesticides (Atrazine & Simazine);
- Semi-Volatile Organic Compounds SVOCs (including PAHs, phenols and chlorinated phenols);
- Volatile Organic Compounds (including BTEX/MTBE);
- Total Monohydric Phenols – HPLC;
- Tributyltin, Triphenyltin, Dibutyltin;
- Extractable Petroleum Hydrocarbons (EPH) including mineral oil; and,
- Total Petroleum Hydrocarbons (TPH).

5.4.4 Landfill Gas

As part of the Site Investigations, gas monitoring was undertaken on three (3 No) occasions, 23rd – 25th April 2019, 8th May 2019 and 29th May 2019. Landfill gas monitoring was undertaken at the three (3 No) new combined leachate/gas monitoring wells (L1, L2 and L3) and on the three (3 No) groundwater wells (GW1, GW2 and GW3). Landfill gas was monitored via a gas valve fitted to the gas wells using a portable GA2000 gas meter.

The following parameters were recorded during each monitoring event:

- Stable and peak methane;
- %LEL methane;
- Carbon dioxide;
- Oxygen;
- Hydrogen sulphide;
- Carbon monoxide;
- Barometric pressure;
- Relative pressure; and,
- Flow.

5.4.5 Surface VOC Monitoring Survey

Surface VOC emission monitoring was undertaken within the Site boundary on 29th May 2019. The survey was undertaken using a portable natural gas detector Inficon IRwin Detector (Inficon). The Inficon measures VOCs in parts per million (ppm). The Inficon can identify the ingress of low levels of VOCs into buildings e.g. along cracks in the foundations. The range of detection is from 1ppm to 100 % CH_4.

The surface VOC emission monitoring was undertaken at forty-two (42 No) locations within and outside the Site boundary. All surface locations measured were recorded and if an elevated CH_4 reading was measured the location was noted using a handheld GPS.

5.4.6 Internal VOC Monitoring Survey – Building

Comprehensive internal VOC emission monitoring was undertaken at fifty-eight (58 No) locations within the leisure centre on 19th December 2019. The survey was undertaken using a portable natural gas detector as described in section 5.4.5.

The measurements were taken in the following locations:

- Ladies changing room - A number of spot measurements along the skirting board and in drain areas;
- Gym - A number of spot measurements along the skirting board;
- Aerobics gym - All four (4 No) corners at the skirting board;
- Hair drying area - A number of spot measurements along the skirting board;
- Disabled toilets in public area - All four (4 No) corners at the skirting board;

- Staff only kitchen - All four (4 No) corners at the skirting board;
- Cleaning room beside staff kitchen - A number of spot measurements along the skirting board;
- Vending machines – Two (2 No) locations along the skirting board;
- Inside office and Management office - A number of spot measurements along the skirting board;
- Emergency exit door at reception – One (1 No) location along the skirting board;
- Second office staff (closest to reception area) - All four (4 No) corners at the skirting board;
- Family changing room - A number of spot measurements along the skirting board;
- Reception area - A number of spot measurements along the skirting board;

5.5 Assessment Criteria

Field measured parameters and laboratory analytical results for groundwater and leachate samples collected were compared, where applicable, to the following groundwater generic assessment criteria (referred to hereafter as groundwater GAC):

- Statutory Instrument S.I. No. 9 of 2010: European Communities Environmental Objectives (Groundwater) Regulations 2010, as amended 2012 (S.I. No. 149 of 2012) and 2016 (S.I. No.366 of 2016).

In the absence of Groundwater Regulation Values for specific parameters, the following assessment criteria were used for indicative purposes;

- The Interim Guideline Values (IGVs) for Groundwater from the Environmental Protection Agency (EPA) (2003), 'Towards setting guideline values for the protection of groundwater; Interim Report'; and,
- European Communities (Drinking Water) (S.I. No. 278 - No. 2) Regulation 2007, as amended 2014 (S.I. No. 122 of 2014), as amended 2017 (S.I. No. 464 of 2017).

Furthermore, the SoBRA GAC were used to assess the risk of vapour migration into the onsite building (sports and leisure facility);

- SOBRA Residential and Commercial Guideline Values, Development of Generic Assessment Criteria for Assessing Vapour Risk to Human Health from Volatile Contaminants in Groundwater, February 2017 (SOBRA Residential and Commercial GAC).

The laboratory analysis for surface water samples and leachate samples were compared, where applicable, to the following generic assessment criteria:

- Surface Water Regulations 2009 (SI No. 272 of 2009) as amended (S.I. No. 372 of 2012 and S.I. No. 386 of 2015.

The laboratory analysis for soil samples were compared, where applicable, to the following generic assessment criteria:

- The 2003/33/EC European Waste Acceptance Criteria (referred to hereafter as WAC); and,

Landfill gas results were compared to published standards values contained, as applicable, in the following:

- EPA 1997 Thresholds (Environmental Protection Agency (EPA) 1997: Landfill Manuals - Landfill Operational Practices. EPA, Ireland).

6 TIER 2 - RESULTS

6.1 Geophysical Survey

The integrated interpretation of the geophysical survey identified imported material across an approximate area of 1.62ha on Site. A layer of topsoil/capping layer comprising silty clay c. 0.5-2.2m thick was present, overlying the imported material, in areas where made ground/waste was interpreted. Made ground was interpreted to be soft and loose. The geophysical report is included in Appendix C.

According to the geophysical report, the type of waste encountered on Site was as follows:

- Made ground/waste (municipal, including minor organic, mixed with C&D material and clay), with a thickness of c. 0.2-5.6mbgl, where present, with thickest areas east and south of the main building (sports and leisure facility) on site.

The imported material was underlain by sandy gravelly clay, silty clay and limestone bedrock. The depth to bedrock varies across the Site from 3.7 to more than 16.0mbgl.

6.2 Topographical Survey

The topographical survey confirmed that groundwater monitoring well with the lowest elevation is in the north-eastern part of the Site (GW1) at 53.72maOD (ground level), and the groundwater monitoring well with the highest elevation is located south of the Site (GW2) at 57.86maOD. Refer to Drawing No. 6A and 6B for the recorded maOD levels at the Site used to infer the groundwater flow direction.

6.3 Surface

No evidence of surface contamination was observed within the Site during the Site walkover, in regard to spillages or surface run-off contamination (i.e. visual sheen).

6.3.1 Surface VOC Monitoring Results

Surface VOC emissions were measured at 42 locations within and outside of the Site on the 29th May 2019. The survey extended to the perimeter of the leisure centre to assess for potential gas entering the building. No elevated VOC's were detected at any of the locations monitored. Refer to Drawing No. 17.

6.3.2 Internal VOC Monitoring Results – Building

The internal VOC emissions survey of the leisure centre area was undertaken on the 19th December 2019. VOC readings were observed to be within the typical background concentration range at all surveyed areas. A combination of chlorine in the swimming pool and cleaning products had an impact on the VOC readings at some of the locations. However, the recorded levels (up to 40ppm VOC) are considered to remain within the typical background concentration range.

The following Table 6-1 depicts details the locations included in the internal VOC survey and the range of concentrations identified.

Table 6-1: Summary Results – Internal VOC Emissions

Location	Ranges (ppm)
Ladies changing room	0-40
Gym area	6-16
Aerobics gym area	5-8
Hair drying area	9-10
Disabled toilets in public area	9-14
Staff only kitchen	17-40

Cleaning room beside staff kitchen	11-17
Vending machines	10
Inside office and management office	6-15
Emergency exit door at reception	16
Second office staff (closest to reception area)	0-13
Family changing room	11-14
Reception area	0-16

6.4 Subsurface Material

6.4.1 Trial Pitting, Leachate/gas Wells and Groundwater Wells

The subsurface profile encountered during trial pitting consisted of a capping layer (made ground) comprised of brown gravelly clay / brown clay, with a thickness ranging from 0.5m to 1.1m overlaying the imported material layer (made ground). The imported material layer was observed at a thickness ranging from 1.1 to 4.4m and was generally comprised of brown gravelly clay / brown clay. The imported material overlies a layer of natural ground comprised of mainly dark/light grey clay.

Imported material comprising rare / occasional plastic, wood, cloths, metal, terram and bricks was encountered within the made ground layer to maximum depths ranging from 1.1mbgl (TP2 & TP3) to 4.4mbgl (TP5). Trial pit TP5 terminated in the imported material, whereas TP1 to TP4 terminated in clay (natural ground). Please refer to Table 6-2 for details.

Table 6-2: Trial Pit Summary

Sample ID	Final Depth (mbgl)	Imported Material Depth (mbgl)	Composition of Imported Material	Comments
TP1	2.4	1.7	Brown gravelly clay / brown clay with rare plastic	Slight hydrocarbon odour
TP2	3.0	1.1	Brown gravelly clay / dark brown clay with rare plastic and metal	Slight hydrocarbon odour
TP3	2.2	1.1	Dark brown clay with gravels and with rare red bricks	No odour
TP4	4.3	3.6	Brown gravelly clay with rare plastic, red bricks and metal	Slight hydrocarbon odour
TP5	4.4	4.4	Brown gravelly clay with rare / occasional plastic, red bricks, cloths, hard black plastic and wood	No odour

Imported material was encountered in all leachate borehole locations (L1 to L3) installed within the waste body of the Site. The imported material consisted predominantly of gravelly clay with rare / occasional wood, concrete, cloths, black fibres, pieces of tiles, rubber black plastic, red bricks, metal, plastic, bitumen, broken glass and styrofoam pieces. The natural material

encountered in the leachate wells, underlying the imported material consisted of mainly light grey clay.

The depth of the leachate/gas wells ranged from 2.5mbgl (L2), 5.5mbgl (L1) to 6.8mbgl (L3). L1 and L3 terminated in natural ground at 4.8mbgl (L1) and 6.7mbgl (L3). No natural ground was encountered in the leachate well location L2. Leachate was encountered during drilling at L2 and L3. Refer to Table 6-3 for details.

Table 6-3: Leachate Wells Summary

Sample ID	Final Depth (mbgl)	Depth of Imported Material (mbgl)	Composition of Imported Material	Leachate (mbgl)
L1	5.5 – Clay layer	0.0-4.8	C&D material	-
L2	2.5 – Made ground	0.0-2.5	C&D material	1.7
L3	6.8 - Clay layer	0.0-6.7	C&D material	4.7

mbgl – metres below ground level

Groundwater monitoring wells GW1 to GW3 were drilled outside the landfilled area. The geology encountered in these wells comprised 0.3 to 0.5m topsoil, underlain by 0.9 to 5.0m thickness gravelly clay, underlain by 0 to 5.4 m thickness of sand and gravel, underlain by weathered limestone bedrock. The sand and gravel deposits were not encountered in GW3. The depth to the weathered limestone bedrock ranged from 5.4mbgl (GW3) to 7.9mbgl (GW1).

Groundwater strikes were encountered at 0.85mbgl within the gravelly clay layer, 9.1mbgl and 9.7mbgl within the weathered bedrock at GW1, at 5.3mbgl on top of the gravel layer, 6.3mbgl and 9.0mbgl with the weathered bedrock and 10.9mbgl with the karstified bedrock at GW2 and at 5.4mbgl on top of the weathered bedrock and 9.2mbgl within the weathered bedrock at GW3.

Refer to Table 6-4 for the geology encountered during the Site Investigations.

Table 6-4 Geology confirmed during the Site Investigation

Lithology	Description	Depth to base (mbgl)	Thickness (m)
Made Ground	Imported material: gravelly clay with C&D imported material	0 – 6.7	0 – 6.7
Alluvium	Gravelly clay	1.7 – 5.3	0.9 – 5.4
Barrow Gravels	Sand and gravel	5.4 - 7.9	0 – 6.2
Milford Formation Limestone	Weathered Limestone	Not applicable	Not applicable

6.5 Extent of Imported Material

6.5.1 Vertical Extent of Imported Material

The maximum vertical extent of imported material observed during the trial pitting and borehole installation was 6.7mbgl (L3). The geophysical survey (Apex Geoservices Ltd) indicated a thickness of waste ranging from c. 0.2 to 5.6m, with the thickest areas to the east and south of the main building (sports and leisure facility).

6.5.2 Horizontal Extent of Imported Material

The horizontal extent of waste materials has been delineated according to the findings of the site investigations, including trial pit and borehole investigations, and the geophysical survey.

The western boundary was defined by the Greenhills road at the edge of the Greenhills residential estate, whose construction predated the fill activity.

The area of the site underlain by the imported material was calculated to be approximately 1.62ha. Refer to Drawing No. 18 for an approximation of the waste delineation drawn by MOR as supplied by Apex.

6.5.3 Volume of Waste

Volumetric calculations of waste were completed by Apex Geoservices Ltd using measurements of the thickness of the imported material from the investigation locations on Site and geophysical survey data. Apex have estimated the total volume of the imported material to be in the region of 48,600m^3 (i.e. 68,040tonnes, using a multiplier of 1.4tonnes/m^3). Refer to Table 6-5 below.

Table 6-5: Estimated Volume of Waste

Extent (ha)	Average Thickness (m)	Volume (m^3)	Tonnes (1.4tonnes/m3)
1.62	3.0	48,600	68,040

Tonnes – Using a conversion factor of 1.4tonnes/m^3

6.6 Groundwater Levels

6.6.1 Water Levels Results

Monitoring wells GW1 to GW3 were screened within the overburden and the Milford Formation.

Static groundwater levels were measured at each monitoring well (groundwater and leachate wells) and the groundwater level was recorded relative to a fixed reference point; the top of the inner casing at all of the wells. The fixed reference point at each well was surveyed to Ordnance Datum to enable an inferred groundwater flow direction at the Site to be derived, refer to Table 6-6 below and Table 1 (See table at the end of the report).

Table 6-6: Summary - Groundwater Levels

Sample ID	Water Level (mbtoci) – 23rd April 2019	Groundwater Level (mAOD)	Water Level (mbtoci) – 8th /May 2019	Groundwater Level (mAOD)
GW1	0.52	53.20	0.56	53.16
GW2	3.71	54.15	3.79	54.07
GW3	2.05	54.27	2.11	54.21
L1	2.30	53.97	2.24	54.03
L2	Dry	-	Dry	-
L3	4.75	54.35	4.79	54.31

mAOD – meters above Ordnance Datum
mbtoci – meters below top of casing inner
mbtoc – meters below top of casing

6.6.2 Inferred Groundwater Flow Direction

The results confirm that the groundwater flow direction beneath the Site is to the east / north-east. Refer to Drawing No. 6A and 6B.

6.7 Laboratory Analytical Results

6.7.1 Imported Material Results

The three (3 No) soil analytical results from the samples collected during the trial pitting at TP3, TP4 and TP5 were assessed relative to the industry standard criteria outlined in the document 'Establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (2003/33/EC)'. The criteria used were as follows:

- Criteria for landfills for inert waste;
- Criteria for landfills for non-hazardous waste; and,
- Criteria for landfills for hazardous waste.

The results are described in detail below and soil analytical results are presented in Table 2 (See table at the end of the report). Refer to Appendix G for laboratory results (Exova).

Indicators and Inorganics

Total Organic Carbon (TOC)
The TOC concentration at sampling location TP3 was below the inert WAC (3%). No determination was possible at sampling locations TP4 and TP5.

Asbestos

No asbestos was identified at sampling location TP3. Chrysotile fibre bundles were visually detected in the laboratory at sampling locations TP4 and TP5. A further quantification in the laboratory recorded concentrations of <0.001%.

Petroleum Hydrocarbons

TPH/EPH/Mineral Oil/PCB's
Mineral oil concentrations were <30mg/kg at all sampling locations and did not exceed the relevant WAC for inert landfills (500mg/kg).

The interpretation of EPH indicated a "trace of possible PAH's" at TP5 sampling location.

Benzene, Toluene, Ethylbenzene and Xylenes (m/p-xylene and o-xylene) concentrations did not exceed the inert WAC (6mg/kg) at any sample locations.

TPH (Aliphatic and Aromatic) concentrations ranged from <0.1mg/kg to 63mg/kg. There is no WAC for TPH's.

The total concentrations for Polychlorinated Biphenyls (PCBs - 7 congeners) were <35ug/kg and did not exceed the inert WAC (1,000ug/kg) at any sample locations.

MTBE
MTBE concentrations were <5ug/kg at all sample locations. There is no WAC limit for MTBE.

Polycyclic Aromatic Hydrocarbons (PAH's)

The total PAH's 17 ranged from <0.64 to 4.62mg/kg and did not exceed the inert WAC limit (100mg/kg) at any sample locations.

Soil Leachate

Metals

Antimony
Antimony concentrations at all sampling locations were below the inert WAC (0.06mg/kg) and ranged from <0.02 to 0.06mg/kg at TP3 and TP5 respectively.

Arsenic
Arsenic concentrations at all sample locations did not exceed the inert WAC (0.5mg/kg) and ranged from <0.025mg/kg (TP3 and TP4) to 0.053mg/kg (TP5).

Barium
Barium concentrations at all sample locations did not exceed the inert WAC (20mg/kg) and ranged from 0.19 to 0.55mg/kg at TP5 and TP3 respectively.

Boron
Boron concentrations ranged from 0.2mg/kg to 0.50mg/kg at TP4 and TP5 respectively. There is no WAC for Boron.

Cadmium
Cadmium concentrations did not exceed the inert WAC (0.04mg/kg) and were reported at <0.005mg/kg at all sample locations.

Chromium
Chromium concentrations did not exceed the inert WAC (0.5mg/kg) and were reported at <0.015mg/kg at all sample locations.

Copper
Copper concentrations did not exceed the inert WAC (2mg/kg) and were reported at <0.07mg/kg at all sample locations.

Lead
Lead concentrations did not exceed the inert WAC (0.5mg/kg) and were reported at <0.05mg/kg at all sample locations.

Molybdenum
Molybdenum concentrations at all sample locations did not exceed the inert WAC (0.5mg/kg) and ranged from <0.02 to 0.16mg/kg at TP3 and TP5 respectively.

Nickel
Nickel concentrations at all sample locations did not exceed the inert WAC (0.4mg/kg) and were reported at <0.02mg/kg at all sample locations.

Selenium
Selenium concentrations at all sample locations did not exceed the inert WAC (0.1mg/kg) and were reported at <0.03mg/kg at all sample locations.

Zinc
Zinc concentrations at all sample locations did not exceed the inert WAC (4mg/kg) and were reported at <0.03mg/kg at all sample locations.

Mercury

Mercury concentrations at all sample locations did not exceed the inert WAC (0.01mg/kg) and were reported at <0.0001mg/kg at all sample locations.

Indicators and inorganics

Sulphate
Sulphate concentrations at all sample locations did not exceed the inert WAC (1,000mg/kg) and ranged from 138 to 253mg/kg at TP3 and TP4 respectively.

Ammoniacal Nitrogen
Ammoniacal Nitrogen concentrations ranged from 0.7mg/kg to 3mg/kg at TP3 and TP5 respectively. There is no WAC limit for ammoniacal nitrogen.

Chloride
Chloride concentrations at all sample locations did not exceed the inert WAC (800mg/kg) and ranged from <3mg/kg at TP4 and TP5 to 8mg/kg at TP3.

Fluoride
Fluoride concentrations at all sample locations did not exceed the inert WAC (10mg/kg) and were reported at <3mg/kg at all sample locations.

Dissolved Organic Carbon (DOC)
DOC concentrations at all sample locations did not exceed the inert WAC (500mg/kg) and ranged from 30 to 50mg/kg at TP4 and TP3 respectively.

Total *Dissolved Solids (TDS)*
TDS concentrations at all sample locations were below the inert WAC (4,000mg/kg) and ranged from 1,880 to 2,160mg/kg at TP3 and TP5 respectively.

Phenols

Phenol concentrations at all sample locations did not exceed the inert WAC (1mg/kg) and were reported at <0.1mg/kg at all sample locations.

6.7.2 Soil Geotechnical Results

One (1 No) undisturbed sample (GW04) was collected from the capping layer on 9th April 2019 and sent to Causeway Geotechnical limited for geotechnical (permeability) testing, please refer to Appendix H for complete report. Refer to Table 6-7 for a summary of the laboratory tests.

Table 6-7 Geotechnical Testing Laboratory Results.

Sample ID / Depth (mbgl)	Soil Description	Moisture Content %	Bulk Density (mg/m^3)	Dry Density (mg/m^3)	Permeability (m/s)
GW04 **0.0-0.45**	Brown slightly sandy gravelly CLAY	16	2.15	1.85	$2.3x10^{-8}$

Soil permeability results indicated that the capping layer overlying the imported material has a low permeability, thus impeding rainfall infiltration into the waste material.

GW04 was also tested for Particle Size Distribution (PSD) in accordance with BS1377:1990: Part 2: Clauses 9.2 & 9.4. The sample was reported by the geotechnical testing laboratory to be brown slightly sandy gravelly CLAY.

6.7.3 Groundwater Results

Groundwater results were assessed relative to available Irish legislative and guideline standards. The results are described in detail below and groundwater analytical results are presented in Table 3 (See table at the end of the report). Refer to Appendix G for laboratory results (Exova).

Indicators
Field Indicators
Field measured parameters including pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Temperature and Oxidation Reduction Potential (ORP) were measured during the groundwater sampling. EC values measured ranged from 688µS/cm (GW1-first sampling event) to 787µS/cm (GW2-first sampling event) which were below the groundwater regulation value of 800µS/cm. pH values ranged from 7.30pH units (GW2-second sampling event) to 7.57pH units (GW1-first sampling event), which were below the groundwater regulation values (6.5-9.5 pH units).

There are no guideline values for DO or ORP. DO concentrations measured ranged from 36.02% (GW1-second sampling event) to 54.29% (GW2-first sampling event). ORP concentrations ranged from 165.78mV (GW1-second sampling event) to 335.51mV (GW2-first sampling event). A positive ORP is indicative of oxidising conditions.

Indicators and inorganics
Ammoniacal Nitrogen
Ammoniacal nitrogen concentrations ranged from <0.03mg/l (GW1-second sampling event and GW2-second sampling event) to 0.05mg/l (GW1-first sampling event). Ammoniacal Nitrogen concentrations did not exceed the relevant groundwater regulation value of 0.065mg/l N at each location for both monitoring sampling events.

Molybdate Reactive Phosphorus (MRP)
MRP concentrations were reported <0.03mg/l at each location for both monitoring sampling events and did not exceed the relevant groundwater regulation value of 0.035mg/l as P.

Fluoride
Fluoride concentrations were reported <0.3mg/l at each monitoring sampling location for both monitoring sampling events. Concentrations did not exceed the relevant drinking water regulation value of 0.8mg/l or the IGV of 1mg/l. There is no groundwater regulation value for Fluoride.

Sulphate
Sulphate concentrations ranged from 26.8mg/l (GW1-first sampling event) to 75.9mg/l (GW3-first sampling event) and did not exceed the relevant groundwater regulation value of 187.5mg/l.

Chloride
Chloride concentrations ranged from 12.8mg/l (GW2-second sampling event) to 32.7mg/l (GW3-second sampling event). Concentrations did not exceed the relevant groundwater regulation value of 187.5mg/l.

Reported concentrations of Total Dissolved Solids, Total Oxidised Nitrogen, Total Alkalinity, Total Cyanide and Total Organic Carbon were below the relevant groundwater regulation values for all parameters, where applicable.

Microbiological parameters

Total Coliforms
Total coliforms ranged from <1cfu/100ml (GW3-first sampling event) to 1,090cfu/100ml (GW1-second sampling event). The EPA IGV of 0 MPN/100ml was exceeded at GW1 (both sampling events), GW2 (both sampling events) and GW3 (second sampling event).

Faecal Coliforms
Faecal coliforms ranged from <1cfu/100ml (GW2-first and second sampling events and GW3-first sampling event) to 48cfu/100ml (GW1-second sampling event). The EPA IGV of 0MPN/100ml was exceeded at GW1and GW3 (second sampling event).

Dissolved Metals
Concentrations of the dissolved metals – Arsenic, Boron, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Nickel, Sodium and Zinc were below the relevant groundwater regulation values for all parameters.

Potassium
Potassium concentrations ranged from 1.7mg/l (GW1-both sampling events) to 10.4mg/l (GW3-first sampling event). Concentrations exceeded the relevant EPA IGV of 5mg/l at GW3 (both sampling events).

sVOCs
Reported concentrations of phenols, phthalates, PAHs and Additional sVOCs were below the relevant groundwater regulation values for all parameters at GW1, GW2 and GW3, where applicable.

VOCs
Reported concentrations of VOCs were below the relevant groundwater regulation values for all parameters at GW1, GW2 and GW3, where applicable.
Pesticides
Reported concentrations of atrazine and simazine were below the groundwater quality values at GW1, GW2 and GW3.

Organochlorine and Organophosphorus Pesticides
Concentrations of the organochlorine and organophosphorus pesticides were below the relevant groundwater regulation values for all parameters at GW1, GW2 and GW3, where applicable.

Herbicides
Reported concentrations of acid herbicides were below the relevant groundwater regulation values for all parameters at GW1, GW2 and GW3, where applicable.

Total Petroleum Hydrocarbons (TPH CWG)
Reported concentrations of TPH CWG were below the groundwater quality values for all parameters at GW1, GW2 and GW3, where applicable.

MTBE and BTEX
Reported concentrations of benzene, toluene, ethylbenzene, xylenes and methyl tertiary butyl ether did not exceed the relevant groundwater and IGV, where applicable.

6.7.4 Leachate Results

Leachate samples were analysed and screened against the groundwater and surface water criteria to clearly define if there were any risks to human, groundwater or environmental health;

Leachate results together with the relevant assessment criteria are presented in Table 4 (See table at the end of the report).

Indicators
Field Indicators
Similarly to the groundwater samples (section 6.7.3), field measured parameters such as pH, EC, DO, temperature and ORP were measured at monitoring sampling locations L1 and L3. EC values measured ranged from 1,449µS/cm (L1-first sampling event) to 2,078µS/cm (L3-second sampling event) and exceeded the groundwater regulation of 800 µS/cm at L1 and L3 during both monitoring sampling events. pH values measured ranged from 7.22pH units (L1-first sampling event) to 7.29pH units (L3-second sampling event), which were below the groundwater regulation values (6.5-9.5 pH units). DO concentration measured ranged from 2mg/l (L3-second sampling event) to 6mg/l (L1-second sampling event). There is no assessment criteria available for DO. The ORP reading ranged from -109.24V (L3-second sampling event) to 304.28mV (L1-first sampling event). There is no assessment criteria available for ORP.

Indicators and inorganics
Ammoniacal Nitrogen
Ammoniacal nitrogen concentrations ranged from 6.06mg/l N (L1-second sampling event) to 40.56mg/l N (L3-second sampling event), which exceeded the groundwater regulation value (0.065mg/l) and surface water regulation (0.040mg/l) during both monitoring sampling events at L1 and L3.

Molybdate Reactive Phosphorus (MRP)
MRP concentrations were <0.03mg/l P at L1 and L3 and did not exceed the relevant groundwater regulation value of 0.035mg/l P and surface water regulation of 0.025mg/l during both monitoring sampling events.

BOD
Biochemical Oxygen Demand (BOD) concentrations ranged from 16mg/l (L1-both sampling events) to 24mg/l (L3-second sampling event. Concentrations exceeded the relevant surface water regulation value of 1.3mg/l at L1 and L3 (both sampling events).

Sulphate
Sulphate concentrations ranged from <0.5mg/l (L3-second sampling events) to 212.5mg/l (L1-second sampling event). Concentrations exceeded the relevant groundwater regulation value of 187.5mg/l at L1 (both sampling events).

Concentrations of the remaining indicators and inorganics – Fluoride, Cyanide, COD and TON were below the relevant groundwater regulation values for all parameters at each monitoring sampling locations, where applicable.

Metals
Calcium
Dissolved calcium concentrations ranged from 293.6mg/l (L1-both sampling events) to 353.5mg/l (L3-second sampling event). Concentrations exceeded the EPA IGV value of 200mg/l at L1 and L3 (both sampling events).

Iron
Dissolved iron concentrations ranged from <20ug/l (L1-both sampling events) to 332ug/l (L3-second sampling event). Concentrations exceeded the EPA IGV value of 200ug/l at L3 (second sampling event).

Manganese
Dissolved manganese concentrations ranged from 1,690ug/l (L1-first sampling event) to 3,546ug/l (L1-second sampling event). Concentrations exceeded the EPA IGV value of 50ug/l at L1 and L3 (both sampling events).

Potassium
Dissolved potassium concentrations ranged from 8.7mg/l (L1-second sampling event) to 24.7mg/l (L3-second sampling event). Concentrations exceeded the EPA IGV value of 5mg/l at L1 and L3 (both sampling events).

Concentrations of the remaining dissolved metals – Arsenic, boron, cadmium, chromium, copper, lead, magnesium, mercury, nickel, sodium and zinc were below the relevant groundwater regulation values, IGV and surface water regulations for all parameters.

Pesticides
Reported concentrations of atrazine and simazine were below the groundwater and surface water regulation values and IGV at both monitoring sampling locations (L1 and L3).

Organochlorine and Organophosphorus Pesticides
Concentrations of the organochlorine and organophosphorus pesticides did not exceed their groundwater, surface water regulation values and IGV, for all parameters analysed, at both monitoring sampling locations (L1 and L3), with the exception in o,p'-DDT (0.04ug/l - organochlorine pesticide) at L3 (second sampling event), which exceeded the relevant surface water regulation value of 0.01ug/l.

Total Petroleum Hydrocarbons (TPH's)
TPH's
Reported concentrations of total aliphatics and aromatics (C5-35) exceeded the EPA IGV of 10ug/l at L3 during both monitoring sampling events (2,800 and 19,024ug/l).

MTBE and BTEX
Reported concentrations of benzene, toluene, ethylbenzene, xylenes and methyl tertiary butyl ether did not exceed the relevant groundwater regulations, where applicable.

sVOCs
Reported concentrations of phenols and additional sVOCs were below the relevant groundwater regulation values for all parameters at L1 and L3, where applicable.

There were exceedances observed for a number of PAH's at L1 and L3, which exceeded the groundwater and surface water regulation value and the EPA IGV, where applicable as follows:

- Anthracene – Reported concentrations exceeded the surface water regulation values of 0.1ug/l at L3 (1.7 and 1.8ug/l) during both monitoring events.
- Fluoranthene – Reported concentrations exceeded the surface water regulation values of 0.0063ug/l at L1 (1.7 and 0.5ug/l) and L3 during (16.3 and 17.4ug/l) during both monitoring events.
- Benz(a)anthracene - Reported concentrations exceeded the IGV's of 1ug/l at L1 (1.1ug/l – first sampling event) and L3 (9.6 and 12.1ug/l – first and second sampling event).
- Benzo(bk)fluoranthene - Reported concentrations exceeded the groundwater regulation value of 0.075ug/l at L1 (2ug/l – first sampling event) and L3 (21 and 22ug/l – first and second sampling event).

- Benzo(a)pyrene - Reported concentrations exceeded the groundwater regulation value of 0.0075ug/l at L1 (1ug/l – first sampling event) and L3 (12 and 13ug/l – first and second sampling event).
- Indeno(123cd) pyrene - Reported concentrations exceeded the groundwater regulation value of 0.075ug/l at L3 (7 and 8ug/l – first and second sampling event).
- Benzo(ghi)perylene - Reported concentrations exceeded the groundwater regulation value of 0.075ug/l at L1 (0.8ug/l) and at L3 (9.3 and 10.5ug/l – first and second sampling event).

There were exceedances observed for phthalate (Bis (2-ethylhexyl) phthalate) at L3 (22 and 26ug/l), which exceeded the EPA IGV and surface water regulation value of 8ug/l and 1.3ug/l respectively, during both monitoring events.

VOCs
Reported concentrations of VOCs were below the relevant groundwater regulation values for all parameters at L1 and L3, where applicable.

Leachate samples (L1 and L3) were also screened against the SoBRA Commercial Guideline Values to clearly define if there were any risks to human health of vapour migration into the onsite building. Leachate results together with the relevant assessment criteria are presented in Table 4 (See table at the end of the report).

All leachate analytical results for volatile compounds (were observed to be below the SoBRA vapour risk GAC for human health.

6.7.5 Surface Water Results

The surface water results were assessed relative to the Irish Surface Water Standards (S.I. No. 272 of 2009 as amended (S.I. No. 372 of 2012 and S.I. No. 386 of 2015). Surface water analytical results together with relevant assessment criteria are described in detail below. Surface water analytical results are presented in Table 5 (See table at the end of the report). Refer to Appendix G for laboratory results (Exova).

Field indicators
Field measured parameters including pH, EC, DO, temperature and ORP were measured at SW1 and SW2. pH results ranged from 8.26pH units at SW1 (first sampling event) and SW2 (second sampling event) to 8.29pH units at SW2 (first sampling event). All samples were within the guideline range of 6.0-9.0 pH units. EC concentrations ranged from 644µS/cm (SW1-second sampling event) to 688µS/cm (SW2-first sampling event). There is no guideline value for EC. DO concentrations ranged from 90.13% at SW1 (first sampling event) to 100% at SW1 (second sampling event) and SW2 (second sampling event). All samples were within relevant standard range. Measurements for ORP ranged from 91.16mV at SW1 (second sampling event) to 175.32mV at SW2 (first sampling event). There is no guideline value for ORP.

Indicators and inorganics
Ammoniacal nitrogen
Ammoniacal nitrogen concentrations were <0.03mg/l at SW1 and SW2 during both monitoring sampling events and did not exceed the relevant surface water regulation value of 0.04mg/l N annual mean.

Molybdate Reactive Phosphorus (MRP)
MRP concentrations were <0.03mg/l at SW1 and SW2 and did not exceed the relevant surface water regulation value of 0.025mg/l as P annual mean.

Biological Oxygen Demand (BOD)
BOD concentrations ranged from <1mg/l at SW1 (second sampling event) to SW2 (second sampling event) to 1mg/l at SW1 (first sampling event) and SW2 (first sampling event) and did not exceed the relevant surface water regulation value of 1.3mg/l.

Reported concentrations of TON, Total Cyanide, Total Alkalinity as $CaCO_3$, COD, TSS, Chloride, Fluoride and Sulphate were below the relevant surface water regulation values at SW1 and SW2, where applicable.

Metals
There were no reported exceedances for any of the metals analysed - Arsenic, Boron, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Nickel, Potassium, Sodium and Zinc, when compared to the relevant surface water regulation values, where applicable.

sVOCs
Reported concentrations of phenols, PAH's, phthalates and additional sVOCs were below the relevant surface water regulation values for all parameters at SW1 and SW2, where applicable.

VOCs
Reported concentrations of VOCs were below the surface water regulation values for all parameters at SW1 and SW2, where applicable.

MTBE and BTEX
Methyl tertiary butyl ether concentrations were <0.1ug/l at SW1 and SW2. There is no surface water regulation value for MTBE.

Benzene, Toluene, Ethylbenzene and p/m-o Xylenes were all below the surface water regulation values at SW1 and SW2.

Total Petroleum Hydrocarbons (TPH's)
TPH's
Reported concentrations of total aliphatics and aromatics (C5-35) and individual parameters ranged from <5 to <10ug/l at both monitoring sampling locations (SW1 and SW2). There is no surface water regulation value for TPH's.

Pesticides
Reported concentrations of atrazine and simazine were below the surface water regulation values at SW1 and SW2.

Organochlorine and Organophosphorus Pesticides
Concentrations of the organochlorine and organophosphorus pesticides were below the surface water regulation values for all parameters at SW1 and SW2, where applicable.

6.7.6 Landfill Gas Results

In total, three (3 No) landfill gas monitoring events were completed at the Site as part of the Environmental Site Investigation during April and May 2019 for the groundwater and leachate/ gas wells.

Methane and carbon dioxide results (concentrations expressed as a percentage in volume (%v/v) were assessed relative to the EPA 1997 threshold values outlined in the document

'Landfill Manuals – Landfill Operational Practices' (EPA, 1997). Refer to Table 6 (See table at the end of the report) for gas monitoring results together with the relevant assessment criteria.

Landfill Gas "Within the Imported Material"

L1
Stable methane concentration ranged from 0.0% v/v (third monitoring event) v/v to 3.2% v/v (second monitoring event). The threshold value for stable methane is 1.0% v/v. Carbon dioxide concentration ranged from 11.2% v/v (first and third monitoring events) to 11.6% v/v (second monitoring event). The threshold value for carbon dioxide is 1.5% v/v. Hydrogen sulphide was not detected at this well for any of the gas sampling events. Carbon monoxide was also not detected. The gas monitoring events indicated no flow in the well.

L2
Stable methane concentration ranged from 0.0% v/v (first and third monitoring events) v/v to 0.1% v/v (second monitoring event). Carbon dioxide concentration ranged from 12.1% v/v (first monitoring event) to 12.7% v/v (second monitoring event). Hydrogen sulphide was not detected at this well for any of the gas sampling events. Carbon monoxide was also not detected. The gas monitoring events indicated no flow in the well.

L3
Stable methane concentration ranged from 0.3% v/v (third monitoring event) v/v to 20.3% v/v (second monitoring event). Carbon dioxide concentration ranged from 11.3% v/v (first monitoring event) to 12.0% v/v (second monitoring event). Hydrogen sulphide was not detected at this well for any of the gas sampling events. Carbon monoxide was also not detected. The gas monitoring events indicated no flow in the well.

Landfill Gas "Outside the Imported Material"

GW1
Stable methane concentration ranged from 0.0% v/v (first and third monitoring events) v/v to 0.1% v/v (second monitoring event). Carbon dioxide concentration ranged from 0.0% v/v (third monitoring event) to 0.1% v/v (first and second monitoring events). Hydrogen sulphide was not detected at this well for any of the gas sampling events. Carbon monoxide was also not detected. The gas monitoring events indicated no flow in the well.

GW2
Stable methane concentration ranged from 0.0% v/v (first and third monitoring events) v/v to 0.1% v/v (second monitoring event). Carbon dioxide concentration ranged from 0.2% v/v (second monitoring event) to 3.5% v/v (first monitoring event). Hydrogen sulphide was not detected at this well for any of the gas sampling events. Carbon monoxide ranged from 0.0ppm (third monitoring event) to 1.0ppm (first and second monitoring events). The gas monitoring events indicated no flow in the well.

GW3
Stable methane concentration ranged from 0.0% v/v (first and third monitoring events) v/v to 0.1% v/v (second monitoring event). Carbon dioxide concentration ranged from 0.1% v/v (first and second monitoring events) to 0.2% v/v (third monitoring event). Hydrogen sulphide was not detected at this well for any of the gas sampling events. Carbon monoxide was also not detected. The gas monitoring events indicated no flow in the well.

7 TIER 3 – REFINEMENT OF CONCEPTUAL SITE MODEL

In accordance with the EPA CoP the preliminary CSM was refined utilising the information collected during the Tier 2 Intrusive Site Investigations. Refer to Table 7-1 below for the updated CSM and Drawing No. 19 for a schematic CSM of the Site.

Table 7-1: Updated Conceptual Site Model

Element	Description	Rationale
Source	Imported Material	• Overall area of the Site c. 4.09ha – estimated area of imported material c. 1.62ha (geophysical survey) comprising municipal, including minor organic, material mixed with C&D material and clay. • The extent of the waste was delineated according to the Geophysical Survey and the Site Investigations. It covers an area of 1.62ha, mainly comprise municipal waste mixed with C&D material. • Volume of the imported material estimated at 48,600m^3 (68,040tonnes). • Existing capping layer (0.5 to 1.1m thickness) was identified during the site investigation as brown gravelly clay / brown clay and during the geotechnical laboratory report as brown slightly sandy gravelly clay. The clay layer will act as a natural barrier for potential contamination to migrate to the underlying aquifer due to the low permeability (2.3x10^{-8} m/s). • Soil analytical results complied with the inert WAC screening values. Asbestos fibre bundles, which were identified at trial pit locations TP4 and TP5 were below the limit of quantification (<0.001%). Asbestos in soils in such low concentrations poses no risk to human health or the surrounding environment with the current use of the Site. The EPH interpretation indicated "trace of possible PAH's" at TP5. • Leachate – Presence of leachate confirmed during trial pitting and leachate monitoring well installation. The leachate recorded elevated exceedances in ammoniacal nitrogen, sulphate, metals, TPH's and PAH's. • Elevated Methane – Identified at leachate well locations L1 and L3 during the first and second monitoring events. Not detected during the third monitoring event. • VOC's were not detected during the surface monitoring survey within and outside the boundary of the Site and within the leisure centre.
Pathway	Aquifer Beneath the Site	• Shallow Sand & Gravel aquifer and bedrock aquifer identified – no impact identified (groundwater and surface water results).
	Landfill gas migration via soil and subsoils	• Presence of landfill gas – Only detected during the first and second monitoring events (L1 and L3). • No detection at L2 and groundwater wells. • No flow measured in gas wells, which indicates that landfill gas is not generated by the imported materials. • No VOC's detected within the Site or inside the building, which indicates that there is no generation or migration of gas within the Site.
	Leachate	• Leachate at L1 and L3 – Some elevated parameters in leachate, but these were not observed in groundwater or surface water, hence it can be concluded that the exceedances would not pose a risk to the environment and identified receptors. In addition, due to the natural ground (clay layer) underlying the made ground, leachate migration is unlikely. Furthermore, the composition of the imported material is predominantly clay/gravelly clay of low permeability, which limits the infiltration of rainfall to the imported material and will limit the leachate migration through the imported material deposits.
	Surface water Body	• Surface water body (River Barrow) adjoining the Site is not being impacted by the imported material on Site – surface water results.

Element	Description	Rationale
Receptor	Properties	• No risk to receptors identified (properties and human health) – Groundwater and Surface water results. • Presence of leachate - Leachate is unlikely to migrate laterally or horizontally as proven by the groundwater and surface water results. • No identified risk of landfill gas migration into the building (leisure centre) – Surface VOC monitoring surveys.
	Private Wells	• Leachate unlikely to migrate from the Site due to the natural ground (clay layer) and based on groundwater and surface water results.
	Public Water Supply Well	• The public water supply wells to the north of the Site are not impacted – According to the waterworks office at KCC (September 2019) they are no longer in use and no longer supply water to Athy town. • Public Supply Source Protection Area (Source Inner (SI) and Source Outer (SO)) - No impact on SO or SI due to lack of impact on groundwater and surface water quality.
	Surface Water	• River Barrow adjoining the Site - No impact arising from the imported material as demonstrated in the surface water results.
	Aquifer Beneath the Site	• Leachate results reported exceedances of a number of parameters at L1 and L3. However, it was concluded that leachate is not migrating to the identified receptors and aquifer beneath the site (groundwater and surface water results).
	Protected Sites	• Site located within a receiving environment with a high environmental sensitivity – however, groundwater and surface water results demonstrated that the underlying aquifers and the SAC have not been impacted.

The updated risk prioritisation assessment is presented in Table 7-2 below.

Table 7-2: Updated Site Prioritisation Summary

SPR	Linkages	Pathway via	SPR Value	Maximum Score	Normalised Score
SPR1	Leachate c:>Surface Water	Combined groundwater and surface water	105	300	35%
SPR2	Leachate c:> SWDTE	Combined groundwater and surface water	105	300	35%
SPR3	Leachate c:> Human Presence (private well)	Groundwater Pathway	105	240	44%
SPR4	Leachate c:> GWDTE	Groundwater Pathway	105	240	44%
SPR5	Leachate c:> Aquifer	Groundwater Pathway	175	400	44%
SPR6	Leachate c:> Public Supply	Groundwater Pathway	245	560	44%
SPR7	Leachate c:> Surface Water	Groundwater Pathway	105	240	44%
SPR8	Leachate c:> Surface Water	Surface Water Pathway	0	60	0%
SPR9	Leachate c:> SWDTE	Surface Water Pathway	0	60	0%
SPR10	Landfill Gas c:> Human Presence – off-site	Lateral and Vertical	35	150	23%
SPR11	Landfill Gas c:> Human Presence – onsite	Lateral and Vertical	35	250	14%
OVERALL RISK SCORE				**MODERATE**	

Risk Classification	Range of Risk Scores
HIGH Risk (Class A)	Score greater than or equal to 70% for any individual SPR linkages
MODERATE Risk (Class B)	Score between 40% and 70% for any individual SPR linkages
LOW Risk (Class C)	Score less than 40% for any individual SPR linkages

The results of the individual SPR linkages have been altered on the basis of the results of the Tier 2 Site Investigation so that the risk prioritisation for the Site has been classified as Moderate. Refer to Appendix B for the updated Risk Screening.

As discussed in section 4.2, pollutant linkages SPR1 and SPR4 were not considered further as they were deemed negligible. During the refinement of the CSM, it was concluded that SPR8 and SPR9 were no longer identified as pollutant linkages as there was no evidence to suggest that leachate would have an impact on identified surface water receptors. The following sections discuss the SPR linkages identified during the refinement of the CSM.

7.1 Imported Material

Analytical results for the imported material indicated that the made ground complied with the inert WAC. Asbestos (chrysotile) fibre bundles were visually identified in the laboratory at sampling locations TP4 and TP5. The concentrations were below the limit of quantification (<0.001%). Therefore, it can be concluded that asbestos does not pose a risk to the identified receptors with the current use of the Site.

7.1.1 Vertical and Horizontal Extent of Waste

In order to verify the vertical and horizontal extent of the waste body identified during the geophysical survey, a number of site investigations were undertaken (excavation of trial pits and installation of monitoring wells (leachate and groundwater)). The monitoring locations were positioned within and outside of the waste body at selected locations in accordance with BS10175-2011+A2:2017. The information from the site investigations were used to 'fine tune' the results of the geophysical survey to further increase the confidence of the geophysical model.

According to the geophysical report, the type of waste encountered on Site was as follows:

- Made ground/waste (municipal, including minor organic, mixed with C&D material and clay), with a thickness of c. 0.2-5.6mbgl, where present, with thickest areas east and south of the main building (sports and leisure facility) on site.

The total volume of imported material within the Site, according to the geophysical survey, is still estimated to be in the region of 48,600m^3 (i.e. 68,040tonnes when using a multiplier of 1.4 tonnes/m^3).

Further a topsoil cover of c. 0.5-1.1m was observed on site. This capping material is impeding rainfall infiltration into the imported material, preventing leachate generation and further resulting in boggy conditions near the River Barrow.

7.2 Leachate

Leachate was encountered during the trial pitting excavation and during the installation of the leachate/gas wells L1 and L3. Leachate samples were retrieved from leachate wells L1 and L3 during both monitoring events, whereas L2 was reported dry.

A number of parameters analysed exceeded the regulation values and are further considered below:

Conductivity is affected by the geology of the area and limestone and clay soils have higher values. There is no human health risk associated with electrical conductivity, as it is used as an indicator parameter only.

Sulphate concentrations reported slight exceedances of the Groundwater Regulation values at L1 during both monitoring events. Sulphate was reported below the Groundwater Regulation value at L3. Additionally, L1 and L3 encountered natural material (clay layer) underlying the imported material, which indicates that the slightly elevated concentration of sulphates reported at L1 are not likely to migrate to the underlying aquifer, as the clay will act as a natural attenuation layer beneath the imported material. Furthermore, exceedances were not reported at the groundwater wells (GW1-GW3), and therefore, the slightly exceedances reported in sulphate in the leachate would not pose a risk to groundwater or any identified receptors and is not considered to be a contaminant of potential concern

Ammoniacal nitrogen concentrations reported exceedances at both monitoring locations L1 and L3. Concentrations of ammoniacal nitrogen of c. 30-40mg/l are typical for leachate in a landfill containing organic waste of this age (1980-1985). The geophysical survey interpreted the imported material as municipal waste, including some organic material mixed in with C&D material and clay. Ammoniacal nitrogen exceedances were not reported in the groundwater or surface water, indicating that there is no pathway connecting the leachate to identified receptors. Consequently, ammoniacal nitrogen concentrations would not pose a risk to groundwater or any identified receptors and it is not considered to be a contaminant of potential concern.

BOD concentrations reported exceedances of the surface water guidance value at L1 and L3.

Calcium, manganese and potassium concentrations reported exceedances at both monitoring sampling events (L1 and L3). Iron concentrations reported exceedances at L3 during the second monitoring event. These parameters are naturally occurring and are normally associated with the type of bedrock and soils present. Therefore, there is no human health risk associated with these exceedances and they would not pose a risk to groundwater. They are not considered to be a contaminant of potential concern.

Total aliphatics and aromatics (C5-35) concentrations exceeded the EPA IGV limit at L3 during both monitoring events. However, TPHs have not reported exceedances at the groundwater and surface water. Therefore, they are not considered to be a contaminant of potential concern.

A number of PAHs, phthalates and organochlorine pesticide concentrations exceeded regulation values (groundwater, drinking water, EPA IGV and surface water) in the samples of leachate. However, concentrations of those parameters were below the threshold regulation value, where applicable, for the groundwater (GW1 to GW3), surface water (SW1 and SW2) and soil samples (TP3, TP4 and TP5), and were reported in very low concentrations. It was concluded that the elevated concentrations in PAH's, phthalates and organochlorine pesticides would not pose a risk to groundwater or any identified receptors (human health) and they are not considered to be contaminants of potential concern.

The leachate results were all below the respective human health (SoBRA GAC) values used to assess the risk to human health of vapour migration into the onsite building. It is therefore concluded that there is no vapour risk to on or off-site human receptors from volatile constituents in the landfill leachate.

The elevated concentrations of the parameters identified in the leachate were not identified in any of the groundwater and surface water results, with the exception in potassium at GW3 (upgradient well). Therefore, it is reasonable to assume that the leachate generated is not migrating downwards or horizontally and accordingly will not pose a risk to the underlying aquifer and potential receptors.

7.3 Groundwater

There were a number of faecal and total coliform exceedances at the upgradient and downgradient wells during both monitoring events, with the exception at GW3 during the first monitoring event. The higher exceedances were observed at the downgradient groundwater wells (GW1 and GW2). It is considered that the source of the elevated coliforms is not likely to the imported material due to its age, as microbiological pathogens can only survive up to 400 days in groundwater depending on the soil temperature (NCBI, 2019), but rather to be originating from an outside source (such as leaking foul sewers from the residential development). Total and faecal coliforms are not considered to be a contaminant of potential concern.

Exceedances in potassium concentration were reported at the upgradient well (GW3) during both monitoring events, which slightly exceeded the EPA IGV value. Potassium is relatively immobile in soil and subsoil and occurs widely in the environment (WHO, 2009). Exceedances were not reported at the downgradient wells; therefore, the Site does not result in any impact on downgradient water quality or the underlying aquifer. Potassium is not considered a contaminant of potential concern.

7.4 Surface Water

Laboratory surface water results from sampling locations upstream and downstream (SW1 and SW2) in the River Barrow, which runs along the eastern boundary of the Site, were compared with the applicable guideline values. The results indicated that there were no exceedances of any of the parameters analysed. Reported concentrations indicated that water quality upstream of the River Barrow at SW1 was very similar to water quality downstream of the River at SW2.

7.5 Landfill Gas

The landfill gas assessment identified methane concentrations within the imported material ranging from 0% (v/v) to 20.3% (v/v) and carbon dioxide ranging from 11.2% (v/v) to 12.7% (v/v). Refer to Table 6 (see table at the end of the report) for complete results. No flow was detected.

Methane was not identified at locations outside the imported materials (GW1 to GW3). Carbon dioxide ranged between 0.1% (v/v) and 3.5% (v/v). No flow was detected.

The flow rate indicates the level of gas movement through the permeable layers. “The purpose of measuring gas flow rates is to predict surface emissions and from these deduce the potential for gas ingress into buildings” (CIRIA, 2007). Furthermore, the surface emission rate measures the potential for gas to escape from a particular area of the ground. The very low flow rates observed and the results of the surface VOC monitoring survey (surface emissions), inside and outside the Site and inside the leisure centre building, demonstrated that the imported material is not actively generating landfill gas and it is therefore not migrating vertically or laterally, and hence, would not affect any potential receptors (on or off-site).

8 TIER 3 – GENERIC QUANTITATIVE RISK ASSESSMENT

In accordance with the EPA COP a quantitative risk assessment is required where the site is deemed, following the risk screening process, to intrinsically pose a high or moderate risk to the environment or human health. There are two basic types of quantitative risk assessments:

- **Generic Quantitative Risk Assessment (GQRA)**, which uses relevant generic assessment criteria (GAC) (i.e. values which are generally applicable to an entire class or group e.g. based on proposed future land use) or guidelines; and
- **Detailed Quantitative Risk Assessment (DQRA),** which requires the development of site-specific assessment criteria (SSAC). Subsequently the representative site concentrations are compared to the site-specific criteria. Different risk assessment modelling tools and numerical groundwater flow models can be utilised during the process.

The decision on which type of QRA should be used is site specific. For this environmental risk assessment, which deemed the Site as a Moderate risk Site, it was considered sufficient to carry out a GQRA due to the availability of Site-Specific environmental quality data (i.e. results of environmental monitoring were compared against existing guideline values and generic assessment criteria).

8.1 Generic Assessment Criteria

According to the EPA CoP, the potential risk shall be assessed for each identified pollutant linkage by comparing the representative site concentrations with generic assessment criteria (groundwater, EPA IGV, drinking water and surface water regulations) or screening levels.

8.2 Results of Generic Risk Assessment

This Environmental Risk Assessment (Tier 2 Site Investigation and Testing, Tier 3 Risk Assessment: Refinement of Conceptual Site Model and Quantitative Risk Assessment and Recommendations) at Greenhills refuse depot concluded as follows:

- The leachate results reported a number of exceedances (electrical conductivity, sulphate, ammoniacal nitrogen, BOD, calcium, manganese, potassium, Total aliphatics and aromatics (C5-35), a number of PAH's and phthalates and an organochlorine pesticide). However, there is no evidence that the leachate generated from the imported material is impacting on groundwater, surface water and associated receptors;
- The groundwater quality underlying the Site reported a number of exceedances (potassium, faecal and total coliforms). However, there is no evidence that the Site is impacting on groundwater quality;
- The surface water monitoring results of the River Barrow showed that the concentrations upstream and downstream of the site were broadly similar, and therefore, it is evident that there is no impact arising from the Site; and,
- Landfill gas migration is not taking place.

Based on the assessment of the groundwater, surface water, leachate and landfill gas results, there is now sufficient data to confirm that the imported material does not pose an unacceptable risk to groundwater, human health or associated receptors. The residential properties, the school and the shopping centre identified around the Site are not considered at risk, as there is no evidence that the Site is impacting groundwater and surface water, and therefore, the potential pollutant linkages (SPR2, SPR3, SPR5, SPR6 and SPR7) are no longer valid.

The linkages of greatest concern according to the preliminary conceptual site model include the risk of landfill gas migration to off-site receptors (SPR10) and the risk of landfill gas

migration to onsite receptors (SPR11). These linkages reported a normalised score of 23% and 14% respectively. As described in section 7.5, due to the site location, the low flow rates observed in all monitoring locations and the findings during the VOC monitoring surveys within and outside the site boundary and within the leisure centre, it can be concluded that the observed landfill gas concentrations do not pose a risk to human health or the environment, and therefore that the pollutant linkages SPR10 and SPR11 are no longer valid.

9 CONCLUSIONS

The Tier 1 Conceptual Site Model (KCC, 2018), Risk Screening and Prioritisation, Tier 2 Main Site Investigation and Testing and the Refinement of Conceptual Site Model and Quantitative Risk Assessment (undertaken by MOR in accordance with the CoP) included the following works:

- Installation of five (5 No.) trial pits (TP1 to TP5), three (3 No.) leachate/gas monitoring wells (L1 to L3) and three (3 No.) groundwater monitoring wells; and
- Laboratory analysis of three (3 No.) soil samples, six (6 No.) groundwater samples, four (4 No.) surface water and four (4 No.) leachate samples and the completion of three (3 No.) landfill gas monitoring events and one (1 No.) gas monitoring survey (surface emissions).

Based on the findings of the Site Investigations and data assessment undertaken by MOR between January and April 2019 in accordance with the CoP, it is reasonable to conclude the following;

- According to KCC's files the Site was used as a refuse depot from approximately 1st January 1980 to 31st December 1985;
- The Site is located within a sensitive receiving environment due to the proximity of key receptors including the River Barrow and River Nore SAC adjacent to the Site (eastern boundary) and the high-extreme vulnerability rating assigned based on the Source of Inner Protection (SI) within the Site. It is noted that the GSI mapping assigned a moderate vulnerability rating;
- The hydrogeological setting of the Site comprises a regionally important sand and gravel aquifer underlain by the Milford Formation which is a regionally important karstified bedrock aquifer;
- Groundwater flow direction in the underlying aquifer is interpreted to be generally to the east / north-east towards the River Barrow;
- The preliminary CSM identified the source associated with the Site;
    - *The imported material underneath the Site.*

  The potential pathways were identified as follows;
    - *Shallow Sand and Gravel aquifer, bedrock aquifer and subsoils.*

  The key environmental receptors were identified as follows;
    - *The groundwater (sand & gravel and bedrock aquifers) beneath the Site, the surface water (River Barrow), residential properties in the vicinity of the Site and a number of public water supply wells and ecologically protected sites within the 10km radius.*
- In general, the imported material comprises clay, gravelly clay and sandy clay with rare C&D material with a thickness of c. 0.0-6.7mbgl, which overlies a natural clay / sand and gravel layer. According to the geophysical survey, municipal waste with minor organic material mixed with C&D material and clay were also identified on site. The bedrock was interpreted as weathered limestone over competent limestone bedrock;
- The capping material encountered during the site investigations was identified as brown gravelly clay/brown clay with a thickness of 0.5 to 1.1m. According to the geotechnical results the capping material was classified as brown slightly sandy gravelly clay with a permeability of $2.3x10^{-8}$ m/s. The low permeability of the capping

material overlying the imported material would impede rainfall infiltration and therefore reduce the generation of leachate;

- The soil laboratory results of three (3 No.) of the trial pits did not record any exceedances in any of the parameters analysed. There was a visual identification only of asbestos fibres at TP4 and TP5, which were further quantified at concentrations <0.001%, confirming that the imported material present on Site, with the current use of the Site, poses a low risk of contamination to the underlying strata (natural ground);
- The leachate results confirmed that there are some exceedances of the parameters analysed. However, due to the natural layer (clay) beneath the Site and the fact that the groundwater and surface water results did not report exceedances on those parameters, it was concluded that the leachate did not pose a risk to any identified receptors;
- The groundwater results confirm that the imported material has not negatively impacted the underlying aquifer. There were elevated concentrations of coliforms detected in groundwater but these are highly unlikely to be from the imported material as microbiological pathogens (i.e. coliforms) can only survive up to 400 days in groundwater, and therefore, are unlikely to survive the 35 to 40 years since the imported material was deposited;
- The surface water results confirm that the imported materials have not negatively impacted upon the River Barrow, the risk to surface water is therefore considered to be low;
- This assessment did not identify any impacts from the imported materials on the ecological receptors on-Site or within the surrounding vicinity;
- Elevated Methane (CH_4) was detected at leachate/gas locations L1 and L3. Methane was not detected at groundwater monitoring locations external to the imported materials (GW1 to GW3) during any sampling event. Given the very low flow concentrations of methane and the results of the surface VOC monitoring surveys on and off-Site (including within the leisure centre building), the detected gas concentrations are not considered to represent a risk to any identified receptors on or off-Site;
- In strict accordance with this Code of Practice and taking cognisance of the intrusive site investigation and the updated conceptual site model, the site would be classified as a Moderate risk site. However, during the data assessment, it was concluded that the pathways to the receptors were broken and therefore the pollutant linkages no longer exist; and,
- According to the Environmental Risk Assessment carried out for the Site, it is concluded that the imported materials have not resulted in any impacts on the identified human receptors or environmental receptors.

10 RISK EVALUATION

The site is deemed Moderate Risk based on the risk evaluation of the Site set out below:

- **The End Use of the Site** – a leisure centre and a public park are currently located within the Site;
- **Source** – The Site was used as refuse depot from approximately 1st January 1980 and 31st December 1985 mainly for municipal waste mixed with C&D material across an area of 1.62ha, with an estimated imported material volume of 48,600m^3 (68,040 tonnes). The areas where imported materials were deposited have been capped with variable depths of low permeability soils.
- **Pathways** – The Site investigations and testing have shown that there is no potential for leachate and landfill gas migration, i.e. the rate of leachate generation within the Site is considered to be low and the landfill gas flow rates are also low; and
- **Receptor** –The underlying groundwater body, the River Barrow, the sports and leisure centre, the nearby school, the shopping centre and the residential dwellings can be considered as receptors of potential contamination (i.e. leachate and landfill gas migration). The site investigations (Tier 1 – CSM, Risk Screening and Prioritisation) indicated potential linkages between landfill gas within the site and the closest receptor within and in close proximity to the Site. Landfill gas surveys and leachate assessment carried out during the Tier 2 – Exploratory and Main Site Investigation and Tier 3 – Quantitative Risk Assessment confirmed that landfill gas and leachate are not migrating off-site.

According to the EPA CoP the Site has been classified as Class B – Moderate Risk.

Revised Risk Classification

In general terms, former landfill sites that are not generating leachate or landfill gas or sites where active remediation measures have been undertaken to eliminate potential risks can be classified as low risk sites. Sites that do present potential risks are categorised as high-risk sites and typically require some active remedial measures. Sites that have the potential to generate gas and leachate but have been confirmed not to present any current risks that would warrant active remedial measures, would fall into the moderate risk category.

Site specific data collected during the Tier 2 Site Investigation and Tier 3 Refinement of CSM and Quantitative Risk Assessment have established that there were no significant environmental or human health risks to the assessed on and offsite receptors.

According to the CoP, “it is not acceptable to reduce the risk classification purely on the basis that the data indicates that there is no impact”. However, if the SPR linkages have been broken and the level of risk has been reduced, “then the classification of the Site may be lowered accordingly in consultation with the regulatory authority”. Therefore, it is considered appropriate that the Site be reclassified as a Moderate category risk (Class B). Validation sampling is recommended as a prudent approach to further validate the findings of the risk assessment.

11 RECOMMENDATIONS

We would consider that the Site has been well characterised at this juncture given the comprehensive investigations undertaken. Based on the evaluation of the current data set in accordance with recognised best practice criteria, it is our opinion that there is enough evidence to conclude that the Site does not present a potential environmental risk to the underlying aquifer or potential receptors and therefore, in strict accordance with the CoP, no further actions are required.

12 REMEDIAL MEASURES

The CoP requires that suitable remedial measures are discussed depending on the results of the QRA. As stated in the previous Section 11, the Site has been well characterised and it has been concluded that the Site, in its current status, does not require any further actions, hence no remedial measures are proposed.

According to the CoP, a hazard may be present even if a Site has been classified as a low risk site. “It is critical…that if there is a proposed change in land-use then a re-appraisal of the risk, based on detailed site investigations, shall be carried out.” The CoP requires that the Sites should be reviewed every year taking cognisance of new information, it also requires that the Sites “should be re-assessed after 5 years to take account of further guidance issued and any change to the land use or new developments in the vicinity of the Site.”

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TABLES

Greenhills, Athy
County Kildare

Table 1: Groundwater Level Measurements

Well ID	Elevation of Reference (cover level)	Total Depth	Total Depth	Diff Total Depth inner and outer	Depth to Water	Water Level (Column of Water)	Depth to Water	Water Level (Column of Water)
	mAOD	mbtoc	mbtoci	m	mbtoci	mAOD	mbtoci	mAOD
					23/04/2019		08-09/05/2019	
L1	56.27	4.15	4.00	0.15	2.30	53.97	2.24	54.03
L2	55.61	1.90	1.79	0.11	dry	-	dry	-
L3	59.10	6.00	5.83	0.17	4.75	54.35	4.79	54.31
GW1	53.72	9.45	9.41	0.04	0.52	53.20	0.56	53.16
GW2	57.86	14.30	14.27	0.03	3.71	54.15	3.79	54.07
GW3	56.32	9.75	9.66	0.09	2.05	54.27	2.11	54.21

Notes:

mAOD	denotes metres above ordnance datum.
mbtoci	denotes metres below top of inner casing.
-	denotes not available/not measured.

Greenhills, Athy
County Kildare

Table 2: Soils Analytical Results

Sample ID			Waste Acceptance Criteria (WAC)[1]			TP3	TP4	TP5
Laboratory Report No.			Inert Waste Acceptance Criteria	*Non-Hazardous Waste Acceptance Criteria*	Hazardous Wate Acceptance Criteria	Exova 19/1584 Depth 0.50-1.10m	Exova 19/1584 Depth 1.00-2.00m	Exova 19/1584 Depth 2.00-2.50m
Laboratory Sample No.						1-3	4-6	7-9
Sample Date						16/01/19	16/01/19	16/01/2019
Parameter	**Units**	**LOD**						
Soil Characteristic Parameters								
Natural Moisture Content	%	0.1	~	~	~	55.8	16.6	18.8
Moisture Content (% Wet Weight)	%	0.1	~	~	~	35.8	14.2	15.8
Moisture Content 105C (% Dry Weight)	%	0.1	~	~	~	42.1	19.1	22.2
Dry Matter Content Ratio 105°C	%	0.1	~	~	~	70.4	84.0	81.9
pH	Ph Units	0.01	~	~	~	7.7	7.9	7.89
Indicatiors and Inorganics								
Total Organic Carbon	%	0.02	3	~	6	2.2	NDP	NDP
Sulphide	mg/kg	10	~	~	~	<10	<10	<10
Elemental Sulphur	mg/kg	1	~	~	~	11.0	20.0	23
Asbestos Screen & Identification								
General Description						soil-stones	soil-stones	soil-stones
Asbestos Fibres			~	~	~	NAD	Fibre Bundles	Fibre Bundles
Asbestos Fibres (2)			~	~	~			
Asbestos ACM			~	~	~	NAD	NAD	NAD
Asbestos ACM (2)			~	~	~			
Asbestos Type			~	~	~	NAD	Chrysotile	Chrysotile
Asbestos Type (2)			~	~	~			
Asbestos Level Screen			~	~	~	NAD	less than 0.1%	less than 0.1%
Mass of Dry Sample		g	~	~	~	-	-	-
Total Detailed Gravimetric Quantification (% Asb)[#]						NA	<0.001	<0.001
Total Gravimetric Quantification (ACM + Detailed) (% Asb)[#]						NA	<0.001	<0.001
Total ACM Gravimetric Quantification	mass %	0.001	~	~	~	NA	<0.001	<0.001
Asbestos PCOM Quantification (Fibres)	mass %	0.001	~	~	~	NA	<0.001	<0.001
Asbestos Gravimetric & PCOM Total	mass %	0.001	~	~	~	NA	<0.001	<0.001
Mass of raw test portion	kg		~	~	~	0.1	0.1	0.1095
Mass of dried test portion	kg		~	~	~	0.1	0.1	0.09
Metals (Totals)								
Antimony	mg/kg	1	~	~	~	2.0	1.0	<1
Arsenic	mg/kg	0.5	~	~	~	7.6	12.5	8.3
Barium	mg/kg	1	~	~	~	630.0	71.0	132
Cadmium	mg/kg	0.1	~	~	~	2.4	1.0	1
Chromium	mg/kg	0.5	~	~	~	86.8	17.4	11.9
Copper	mg/kg	1	~	~	~	21.0	28.0	27
Lead	mg/kg	5	~	~	~	28.0	98.0	68
Mercury	mg/kg	0.1	~	~	~	<0.1	0.2	<0.1
Molybdenum	mg/kg	0.1	~	~	~	2.8	1.2	1
Nickel	mg/kg	0.7	~	~	~	39.6	24.4	21.7
Selenium	mg/kg	1	~	~	~	3.0	<1	<1
Total Sulphate as SO4	mg/kg	50	~	~	~	971.0	698.0	582
Water Soluble Boron	mg/kg	0.1	~	~	~	1.3	1.0	2
Zinc	mg/kg	5	~	~	~	222.0	140.0	185
Hexavalent Chromium	mg/kg	0.3	~	~	~	<0.3	<0.3	<0.3
Chromium III	mg/kg	0.5	~	~	~	86.8	17.4	11.9
Total Cyanide	mg/kg	0.5	~	~	~	<0.5	<0.5	<0.5
Polycyclic Aromatic Hydrocarbons (PAHs) (M-S)								
Naphthalene	mg/kg	0.04	~	~	~	<0.04	<0.04	<0.04
Acenaphthylene	mg/kg	0.03	~	~	~	<0.03	<0.03	0.08
Acenaphthene	mg/kg	0.05	~	~	~	<0.05	<0.05	<0.05
Fluorene	mg/kg	0.04	~	~	~	<0.04	<0.04	0.05
Phenanthrene	mg/kg	0.03	~	~	~	<0.03	0.1	0.24
Anthracene	mg/kg	0.04	~	~	~	<0.04	<0.04	0.13
Fluoranthene	mg/kg	0.03	~	~	~	0.1	0.3	0.71
Pyrene	mg/kg	0.03	~	~	~	<0.03	0.2	0.62
Benzo(a)anthracene	mg/kg	0.06	~	~	~	<0.06	0.2	0.46
Chrysene	mg/kg	0.02	~	~	~	0.1	0.1	0.38
Benzo(bk)fluoranthene	mg/kg	0.07	~	~	~	<0.07	0.3	0.82
Benzo(a)pyrene	mg/kg	0.04	~	~	~	<0.04	0.2	0.43
Indeno(123cd)pyrene	mg/kg	0.04	~	~	~	<0.04	0.1	0.27
Dibenzo(ah)anthracene	mg/kg	0.04	~	~	~	<0.04	<0.04	0.11
Benzo(ghi)perylene	mg/kg	0.04	~	~	~	<0.04	0.1	0.26
Coronene	mg/kg	0.04	~	~	~	<0.04	<0.04	0.06
PAH 6 Total	mg/kg	0.22	~	~	~	<0.22	1.0	2.49
PAH 17 Total	mg/kg	0.64	100*	~	~	<0.64	1.7	4.62
Benzo(b)fluoranthene	mg/kg	0.05	~	~	~	<0.05	0.2	0.59
Benzo(k)fluoranthene	mg/kg	0.02	~	~	~	<0.02	0.1	0.23
Benzo(j)fluoranthene	mg/kg	1	~	~	~	<1	<1	<1
PAH Surrogate % Recovery	%	0	~	~	~	100.0	97.0	103
EPH CWG Interpretation			~	~	~	No interpretation possible	No interpretation possible	Trace of possible PAH's
Mineral Oil (C10-C40)	mg/kg	30	500	~	~	<30	<30	<30
TPH CWG								
Aliphatics								
>C5-C6	mg/kg	0.1	~	~	~	<0.1	<0.1	<0.1
>C6-C8	mg/kg	0.1	~	~	~	<0.1	<0.1	<0.1
>C8-C10	mg/kg	0.1	~	~	~	<0.1	<0.1	<0.1
>C10-C12	mg/kg	0.2	~	~	~	<0.2	<0.2	<0.2
>C12-C16	mg/kg	4	~	~	~	<4	<4	<4
>C16-C21	mg/kg	7	~	~	~	<7	<7	<7
>C21-C35	mg/kg	7	~	~	~	<7	<7	<7
>C35-C40	mg/kg	7	~	~	~	<7	<7	<7
Total aliphatics C5-40	mg/kg	26	~	~	~	<26	<26	<26
>C6-C10	mg/kg	0.1	~	~	~	<0.1	<0.1	<0.1
>C10-C25	mg/kg	10	~	~	~	<10	<10	<10
>C25-C35	mg/kg	10	~	~	~	<10	<10	<10
Aromatics								
>C5-EC7	mg/kg	0.1	~	~	~	<0.1	<0.1	<0.1
>EC7-EC8	mg/kg	0.1	~	~	~	<0.1	<0.1	<0.1
>EC8-EC10	mg/kg	0.1	~	~	~	<0.1	<0.1	<0.1
>EC10-EC12	mg/kg	0.2	~	~	~	<0.2	<0.2	<0.2
>EC12-EC16	mg/kg	4	~	~	~	<4	<4	<4
>EC16-EC21	mg/kg	7	~	~	~	<7	<7	<7
>EC21-EC35	mg/kg	7	~	~	~	<7	<7	63
>EC35-EC40	mg/kg	7	~	~	~	<7	<7	<7
Total aromatics C5-40	mg/kg	26	~	~	~	<26	<26	63
Total aliphatics and aromatics(C5-	mg/kg	52	~	~	~	<52	<52	63
>EC6-EC10	mg/kg	0.1	~	~	~	<0.1	<0.1	<0.1
>EC10-EC25	mg/kg	10	~	~	~	<10	<10	<10
>EC25-EC35	mg/kg	10	~	~	~	<10	<10	50

Greenhills, Athy
County Kildare

Table 2: Soils Analytical Results

Sample ID			Waste Acceptance Criteria (WAC)[1]			TP3	TP4	**TP5**
Laboratory Report No.			**Inert Waste Acceptance Criteria**	*Non-Hazardous Waste Acceptance Criteria*	Hazardous Wate Acceptance Criteria	Exova 19/1584 Depth 0.50-1.10m	Exova 19/1584 Depth 1.00-2.00m	Exova 19/1584 Depth 2.00-2.50m
Laboratory Sample No.						1-3	4-6	7-9
Sample Date						16/01/19	16/01/19	16/01/2019
Parameter	**Units**	**LOD**						
Petroleum Hydrocarbons								
MTBE	ug/kg	5	~	~	~	<5	<5	<5
Benzene	ug/kg	5	6000	~	~	<5	<5	<5
Toluene	ug/kg	5	6000	~	~	<5	<5	<5
Ethylbenzene	ug/kg	5	6000	~	~	<5	<5	<5
m/p-Xylene	ug/kg	5	6000	~	~	<5	<5	<5
o-Xylene	ug/kg	5	6000	~	~	<5	<5	<5
Polychlorinated Biphenyls (PCBs)								
PCB 28	ug/kg	5	~	~	~	<5	<5	<5
PCB 52	ug/kg	5	~	~	~	<5	<5	<5
PCB 101	ug/kg	5	~	~	~	<5	<5	<5
PCB 118	ug/kg	5	~	~	~	<5	<5	<5
PCB 138	ug/kg	5	~	~	~	<5	<5	<5
PCB 153	ug/kg	5	~	~	~	<5	<5	<5
PCB 180	ug/kg	5	~	~	~	<5	<5	<5
Total 7 PCBs	ug/kg	5	1000	~	~	<35	<35	<35
Phenols								
Phenol	mg/kg	0.01	~	~	~	<0.01	<0.01	<0.01
Leachate CEN 10:1								
Parameters								
Dissolved Antimony	mg/kg	<0.02	0.06	0.7	5	<0.02	0.03	0.06
Dissolved Arsenic	mg/kg	<0.025	0.5	2	25	<0.025	<0.025	0.053
Dissolved Barium	mg/kg	<0.03	20	100	300	0.6	0.3	0.19
Dissolved Boron	mg/kg	<0.12	~	~	~	0.4	0.2	0.5
Dissolved Cadmium	mg/kg	<0.005	0.04	1	5	<0.005	<0.005	<0.005
Dissolved Chromium	mg/kg	<0.015	0.50	10	70	<0.015	<0.015	<0.015
Dissolved Copper	mg/kg	<0.07	2	50	100	<0.07	<0.07	<0.07
Dissolved Lead	mg/kg	<0.05	0.5	10	50	<0.05	<0.05	<0.05
Dissolved Molybdenum	mg/kg	<0.02	0.5	10	30	<0.02	0.1	0.16
Dissolved Nickel	mg/kg	<0.02	0.4	10	40	<0.02	<0.02	<0.02
Dissolved Selenium	mg/kg	<0.03	0.10	0.50	7	<0.03	<0.03	<0.03
Dissolved Zinc	mg/kg	<0.03	4	50	200	<0.03	<0.03	<0.03
Mercury Dissolved by CVAF	mg/kg	<0.0001	0.01	0.20	2	<0.0001	<0.0001	<0.0001
Total Phenols	mg/kg	<0.1	1	~	~	<0.1	<0.1	<0.1
Fluoride	mg/kg	<3	10	150	500	<3	<3	<3
Ammoniacal Nitrogen as N	mg/kg	<0.3	~	~	~	0.9	0.7	3
Sulphate as SO4	mg/kg	<0.5	1000	20000	50000	138.0	253.0	209
Chloride	mg/kg	<3	800	15000	25000	8.0	<3	<3
Dissolved Organic Carbon	mg/kg	<20	500	800	1000	50.0	30.0	40
Total Dissolved Solids	mg/kg	<350	4000	60000	100000	1880	1940	2160

Notes:

1	Council Decision of 19 December 2002 Establishing Criteria and
Bold	Denotes value exceeds Inert Waste Acceptance Criteria
Italics	Denotes value exceeds Non-Hazardous Waste Acceptance Criteria
Underline	Denotes value exceeds Hazardous Wate Acceptance Criteria
NAD	NAD. No asbestos detected
*	Muphys Environmental (inert) waste acceptance screening value. Waste Licence W0129-02. EPA Waste Licence are taken from the 2002 European

Greenhills, Athy
County Kildare

Table 3: Groundwater Analytical Results

Sample ID		Groundwater Quality Standards			GW1		GW2		GW3	
Laboratory Report No.		Groundwater Regulations (S.I. No. 9 of 2010, SI No. 149 of 2012, SI No. 366 of 2016) [1]	*EPA Interim Guideline Value (IGV) for Groundwater* [2]	Drinking Water Standards (S.I. 278 of 2007 & S.I. 122 of 2014 & S.I. 464 of 2017[3])	19/6650	19/7496	19/6650	19/7496	19/6650	19/7496
Sample Date					23/04/2019	08/05/2019	23/04/2019	08/05/2019	23/04/2019	08/05/2019
Field Parameters	**Unit**									
Temperature	ºC	~	25	~	11.94	10.17	14.17	11.43	14.56	11.16
Dissolved Oxygen	mg/l	~	~	~	5.02	6.00	5.44	7.00	4.29	6.00
Dissolved Oxygen (DO)	%	~	NAC	~	47.66	36.02	54.29	50.70	43.23	36.24
Electrical Conductivity (EC)	µS/cm	800 / 1,875 #	1,000	2,500	688	708.00	787.00	767.00	733.00	719.00
Oxidation Reduction Potential (ORP)	mV	~	~	~	330.61	165.78	335.51	186.59	308.18	198.20
pH	pH units	~	6.5-9.5	6.5-9.5	7.57	7.39	7.35	7.30	7.37	7.34
Colour	N/A	~	NAC	ATC and NAC	Brown	Brown	Brown	Brown	Brown	Brown
Odour / Other observations	N/A	~	~	ATC and NAC	S.S. NEC	Silty, NEC	Very Silty, NEC	Silty, NEC	S.S. NEC	Silty, NEC
Laboratory Parameters										
Inorganics										
Sulphate	mg/l	187.5	200	250	26.8	51.1	33.1	36.9	75.9	75.7
Chloride	mg/l	187.5	30	250	*30.8*	*31.4*	13.4	12.8	*32.5*	*32.7*
Fluoride	mg/l	~	1	0.8	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Molybdate Reactive Phosphuros (MRP)	mg/l P	0.035	~	~	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Ammoniacal Nitrogen as N	mg/l	0.065	0.12 *	0.23 *	0.05	<0.03	0.04	<0.03	0.04	0.03
Indicators										
Total Organic Carbon (TOC)	mg/l	~	NAC	NAC	<2	<2	3	<2	<2	<2
Total Cyanide	µg/l	~	10	50	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Alkalinity as $CaCO_3$	mg/l	~	NAC	~	608	1194	4038	1930	3712	2114
Total Oxidised Nitrogen as N	mg/l	~	NAC	~	8	8.10	12.00	12.40	6.50	7.20
Total Dissolved Solids (TDS)	mg/l	~	1,000	~	421	487	476	515	448	493
Microbiological										
Faecal Coliforms	cfu/100ml	~	0	0	*13*	*48*	<1	<1	<1	*1*
Total Coliforms	cfu/100ml	~	0	0	*116.9*	*1,090.0*	*2.0*	*238.2*	<1.0	*79.8*
Metals										
Dissolved Arsenic	ug/l	7.5	10	10	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Dissolved Boron	ug/l	~	1,000	1,000	41	41	37	47	40	48
Dissolved Cadmium	ug/l	~	5	5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dissolved Calcium	mg/l	~	200	~	114.2	119.8	131.6	142.1	107.2	111.0
Dissolved Chromium	ug/l	37.5	30	50	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Dissolved Copper	ug/l	~	30	2000	<7	<7	<7	<7	<7	<7
Total Dissolved Iron	ug/l	~	200	200	<20	<20	<20	<20	<20	<20
Dissolved Lead	ug/l	7.5	10	10	<5	<5	<5	<5	<5	<5
Dissolved Magnesium	mg/l	~	50	~	17.6	16.8	16.9	15.1	18.3	17.9
Dissolved Manganese	ug/l	~	50	50	<2	<2	25	<2	<2	<2
Dissolved Mercury	ug/l	0.75	1	1	<1	<1	<1	<1	<1	<1
Dissolved Nickel	ug/l	~	20	20	<2	<2	<2	<2	<2	<2
Dissolved Potassium	mg/l	~	5	~	1.7	1.7	4.4	4.4	*10.4*	*9.6*
Dissolved Sodium	mg/l	~	150	200	11.4	11	11	11	18	18
Dissolved Zinc	ug/l	75	100	~	<3	<3	<3	<3	<3	<3
Pesticides										
Atrazine	µg/l	0.075	1	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Simazine	µg/l	0.075	1	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Organochlorine Pesticides										
Aldrin	ug/l	~	0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Alpha-HCH (BHC)	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Beta-HCH (BHC)	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chlorothalonil	ug/l	~	~	~	<2.50	<2.50	<2.50	<2.50	<2.50	<2.50
cis-Chlordane	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Delta-HCH (BHC)	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dieldrin	ug/l	0.075	0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endosulphan I	ug/l	~	0.001	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endosulphan II	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endosulphan sulphate	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Endrin	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Gamma-HCH (BHC)	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heptachlor	ug/l	~	~	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heptachlor Epoxide	ug/l	~	~	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexachlorobenzene	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Isodrin	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o,p'-DDE	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o,p'-DDT	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o,p'-Methoxychlor	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o,p'-TDE	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
p,p'-DDE	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
p,p'-DDT	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
p,p'-Methoxychlor	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
p,p'-TDE	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pendimethalin	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Permethrin I	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Permethrin II	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Quintozene (PCNB)	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tecnazene	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Telodrin	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
trans-Chlordane	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Triadimefon	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Triallate	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Trifluralin	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acid Herbicides										
Benazolin	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bentazone	ug/l	0.075	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bromoxynil	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Clopyralid	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
4 - CPA	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,4 - D	ug/l	0.075	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,4 - DB	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dicamba	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dichloroprop	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Diclofop	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fenoprop	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Flamprop	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Flamprop – isopropyl	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ioxynil	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
MCPA	ug/l	0.075		~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
MCPB	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mecoprop	ug/l	0.075		~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Picloram	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pentachlorophenol	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,4,5 - T	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,3,6 - TBA	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Triclopyr	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Organophosphorus Pesticides										
Azinphos ethyl	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Azinphos methyl	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbophenothion	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chlorfenvinphos	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chlorpyrifos	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chlorpyrifos-methyl	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Diazinon	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dichlorvos	ug/l	~	0.001	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Disulfoton	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dimethoate	ug/l			~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethion	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethyl Parathion (Parathion)	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Etrimphos	ug/l			~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenitrothion	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenthion	ug/l			~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Malathion	ug/l	~	0.01	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methyl Parathion	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mevinphos	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosalone	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pirimiphos Methyl	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propetamphos	ug/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Triazophos	ug/l				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibutyltin	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tributyltin	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Triphenyltin	ug/l	~	~	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Greenhills, Athy
County Kildare

Table 3: Groundwater Analytical Results

Sample ID		Groundwater Quality Standards			GW1		GW2		GW3	
Laboratory Report No.		Groundwater Regulations (S.I. No. 9 of 2010, SI No. 149 of 2012, SI No. 366 of 2016) [1]	*EPA Interim Guideline Value (IGV) for Groundwater* [2]	Drinking Water Standards (S.I. 278 of 2007 & S.I. 122 of 2014 & S.I. 464 of 2017[3])	19/6650	19/7496	19/6650	19/7496	19/6650	19/7496
Sample Date					23/04/2019	08/05/2019	23/04/2019	08/05/2019	23/04/2019	08/05/2019
Field Parameters	**Unit**									
TPH CWG										
Aliphatics										
>C5-C6	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>C6-C8	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>C8-C10	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>C10-C12	ug/l	~	~	~	<5	<5	<5	<5	<5	<5
>C12-C16	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>C16-C21	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>C21-C35	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
Total aliphatics C5-35	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
Aromatics										
>C5-EC7	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>EC7-EC8	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>EC8-EC10	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>EC10-EC12	ug/l	~	~	~	<5	<5	<5	<5	<5	<5
>EC12-EC16	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>EC16-EC21	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
>EC21-EC35	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
Total aromatics C5-35	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
Total aliphatics and aromatics(C5-35)	ug/l	~	10	~	<10	<10	<10	<10	<10	<10
GRO (>C4-C8)	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
GRO (>C8-C12)	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
GRO (>C4-C12)	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
Methyl Tertiary Butyl Ether	ug/l	10	30	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzene	ug/l	0.75	1	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	ug/l	525	10	~	<5	<5	<5	<5	<5	<5
Ethylbenzene	ug/l	~	10	~	<1	<1	<1	<1	<1	<1
m/p-Xylene	ug/l	~	10	~	<2	<2	<2	<2	<2	<2
o-Xylene	ug/l	~	10	~	<1	<1	<1	<1	<1	<1
EPH (C8-C40)	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
C8-C40 Mineral Oil (Calculation)	ug/l	~	~	~	<10	<10	<10	<10	<10	<10
Semi-Volatile organic compounds (SVOCs)										
Phenols										
2-Chlorophenol	µg/ l	~	200	~	<1	<1	<1	<1	<1	<1
2-Methylphenol	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2-Nitrophenol	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2,4-Dichlorophenol	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2,4-Dimethylphenol	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
2,4,5-Trichlorophenol	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2,4,6-Trichlorophenol	µg/ l	~	200	~	<1	<1	<1	<1	<1	<1
4-Chloro-3-methylphenol	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4-Methylphenol	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
4-Nitrophenol	µg/ l	~	~	~	<10	<10	<10	<10	<10	<10
Pentachlorophenol	µg/ l	~	2	~	<1	<1	<1	<1	<1	<1
Phenol	µg/ l	~	0.5 ◊	~	<1	<1	<1	<1	<1	<1
Total Phenols HPLC	mg/l	~	~	~	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PAHs										
2-Chloronaphthalene	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
2-Methylnaphthalene	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
Naphthalene	µg/ l	~	1	~	<1	<1	<1	<1	<1	<1
Acenaphthylene	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Acenaphthene	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
Fluorene	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phenanthrene	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Anthracene	µg/ l	~	10,000	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fluoranthene	µg/ l	~	1	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pyrene	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)anthracene	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chrysene	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(bk)fluoranthene	µg/ l	0.075 [4]	0.55 [7]	0.1 [4]	<1	<1	<1	<1	<1	<1
Benzo(a)pyrene	µg/ l	0.0075	0.01	0.01	<1	<1	<1	<1	<1	<1
Indeno(123cd)pyrene	µg/ l	0.075 [4]	0.05	0.1 [4]	<1	<1	<1	<1	<1	<1
Dibenzo(ah)anthracene	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(ghi)perylene	µg/ l	0.075 [4]	0.05	0.1 [4]	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phthalates										
Bis(2-ethylhexyl) phthalate	µg/ l	~	8	~	<5	<5	<5	<5	<5	<5
Butylbenzyl phthalate	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
Di-n-butyl phthalate	µg/ l	~	2	~	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Di-n-Octyl phthalate	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
Diethyl phthalate	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
Dimethyl phthalate	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
Additional SVOCs										
1,2-Dichlorobenzene	µg/ l	~	10	~	<1	<1	<1	<1	<1	<1
1,2,4-Trichlorobenzene	µg/ l	~	0.4	~	<1	<1	<1	<1	<1	<1
1,3-Dichlorobenzene	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
1,4-Dichlorobenzene	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
2-Nitroaniline	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
2,4-Dinitrotoluene	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2,6-Dinitrotoluene	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
3-Nitroaniline	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
4-Bromophenylphenylether	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
4-Chloroaniline	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
4-Chlorophenylphenylether	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
4-Nitroaniline	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Azobenzene	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bis(2-chloroethoxy)methane	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bis(2-chloroethyl)ether	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
Carbazole	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dibenzofuran	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene	µg/ l	~	0.03	~	<1	<1	<1	<1	<1	<1
Hexachlorobutadiene	µg/ l	~	0.1	~	<1	<1	<1	<1	<1	<1
Hexachlorocyclopentadiene	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
Hexachloroethane	µg/ l	~	~	~	<1	<1	<1	<1	<1	<1
Isophorone	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
N-nitrosodi-n-propylamine	µg/ l	~	~	~	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrobenzene	µg/ l	~	10	~	<1	<1	<1	<1	<1	<1

Greenhills, Athy
County Kildare

Table 3: Groundwater Analytical Results

Sample ID		Groundwater Quality Standards			GW1		GW2		GW3	
Laboratory Report No.		Groundwater Regulations (S.I. No. 9 of 2010, SI No. 149 of 2012, SI No. 366 of 2016) [1]	*EPA Interim Guideline Value (IGV) for Groundwater* [2]	Drinking Water Standards (S.I. 278 of 2007 & S.I. 122 of 2014 & S.I. 464 of 2017[3])	19/6650	19/7496	19/6650	19/7496	19/6650	19/7496
Sample Date					23/04/2019	08/05/2019	23/04/2019	08/05/2019	23/04/2019	08/05/2019
Field Parameters	**Unit**									
Volatile organic compounds (VOCs)										
Dichlorodifluoromethane	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
Methyl Tertiary Butyl Ether	µg/l	10	30	~	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chloromethane	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
Vinyl Chloride	µg/l	0.375	~	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bromomethane	µg/l	~	~	~	<1	<1	<1	<1	<1	<1
Chloroethane	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
Trichlorofluoromethane	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
1,1-Dichloroethene	µg/l	~	30	~	<3	<3	<3	<3	<3	<3
Dichloromethane	µg/l	~	10	~	<5	<5	<5	<5	<5	<5
trans-1-2-Dichloroethene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
1,1-Dichloroethane	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
cis-1-2-Dichloroethene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
2,2-Dichloropropane	µg/l	~	~	~	<1	<1	<1	<1	<1	<1
Bromochloromethane	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
Chloroform	µg/l	75 [5]	~	100 [5]	<2	<2	<2	<2	<2	<2
1,1,1-Trichloroethane	µg/l	~	500	~	<2	<2	<2	<2	<2	<2
1,1-Dichloropropene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
Carbon tetrachloride °	µg/l	~	2	~	<2	<2	<2	<2	<2	<2
1,2-Dichloroethane	µg/l	2.25	3	3	<2	<2	<2	<2	<2	<2
Benzene	µg/l	0.75	1	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trichloroethene	µg/l	7.5	70	10 [6]	<3	<3	<3	<3	<3	<3
1,2-Dichloropropane	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
Dibromomethane	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
Bromodichloromethane	µg/l	75 [5]	~	100 [5]	<2	<2	<2	<2	<2	<2
cis-1-3-Dichloropropene	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
Toluene	µg/l	525	10	~	<5	<5	<5	<5	<5	<5
trans-1-3-Dichloropropene	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
1,1,2-Trichloroethane	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
Tetrachloroethene	µg/l	7.5 [6]	40	10 [6]	<3	<3	<3	<3	<3	<3
1,3-Dichloropropane	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
Dibromochloromethane	µg/l	75 [5]	~	100 [5]	<2	<2	<2	<2	<2	<2
1,2-Dibromoethane	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
Chlorobenzene	µg/l	~	1	~	<2	<2	<2	<2	<2	<2
1,1,1,2-Tetrachloroethane	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
Ethylbenzene	µg/l	~	10	~	<1	<1	<1	<1	<1	<1
p/m-Xylene	µg/l	~	10 **	~	<2	<2	<2	<2	<2	<2
o-Xylene	µg/l	~	10 **	~	<1	<1	<1	<1	<1	<1
Styrene	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
Bromoform	µg/l	75 [5]	~	100 [5]	<2	<2	<2	<2	<2	<2
Isopropylbenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
1,1,2,2-Tetrachloroethane	µg/l	~	~	~	<4	<4	<4	<4	<4	<4
Bromobenzene	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
1,2,3-Trichloropropane	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
Propylbenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
2-Chlorotoluene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
1,3,5-Trimethylbenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
4-Chlorotoluene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
tert-Butylbenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
1,2,4-Trimethylbenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
sec-Butylbenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
4-Isopropyltoluene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
1,3-Dichlorobenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
1,4-Dichlorobenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
n-Butylbenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3
1,2-Dichlorobenzene	µg/l	~	10	~	<3	<3	<3	<3	<3	<3
1,2-Dibromo-3-chloropropane	µg/l	~	~	~	<2	<2	<2	<2	<2	<2
1,2,4-Trichlorobenzene	µg/l	~	0.4	~	<3	<3	<3	<3	<3	<3
Hexachlorobutadiene	µg/l	~	0.1	~	<3	<3	<3	<3	<3	<3
Naphthalene	µg/l	~	1	~	<2	<2	<2	<2	<2	<2
1,2,3-Trichlorobenzene	µg/l	~	~	~	<3	<3	<3	<3	<3	<3

Notes:

Bold denotes value exceeds groundwater regulations.
Italics denotes value exceeds IGV where no groundwater regulation is available.
Underlined denotes value exceeds drinking water standards.
MDL denotes method detection limit.
ATC denotes acceptable to consumers
NEC denotes no evidence of contamination
SS denotes Suspended Solids.
NAC denotes no abnormal change.
- denotes parameter not analysed/ recorded.
~ denotes groundwater quality standard unavailable.
" denotes groundwater regulations are for dissolved metals, used groundwater regulation for total metals for comparison purposes only.
◊ denotes standard relates to phenols.
/ ISO17025 (UKAS accredited - UK
# denotes lower value - assessment for the presence of saline/other instrusion; higher value - assessment of the general quality of groundwater in terms of whether its ability to support human uses has been significantly impaired by pollut
denotes lower value - assessment of adverse impacts of chemical inputs from groundwater on associated surface water bodies; higher value - assessment of the general quality of groundwater in terms of whether its ability to support human uses has been significantly impaired by pollution.
* denotes standards converted from ammonium (NH4) to ammonia as N (=14/18).
** denotes standard is for total xylenes.
1: European Communities Environmental Objectives (Groundwater) Regulations 2010; S.I. No. 9 of 2010. Amendment SI no 149 of 2012, Amendment SI No. 366 of 2016.
2: Environmental Protection Agency (EPA), 2003. Towards Setting Guideline Values for the Protection of Groundwater in Ireland - Interim Report. EPA, Ireland.
3: SI No. 278 of 2007; European communities (Drinking Water) (No. 2) Regulation 2007. SI No. 122 of 2014. SI No. 464 of 2017; European Union (Drinking Water) Regulations 2014
4: Denotes regulation value is for "Total Polycyclic Aromatic Hydrocarbons", sum of 4 (Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(123cd)pyrene & Benzo(ghi)perylene).
5: Denotes regulation value is for "Total Trihalomethanes".
6: Denotes regulation value is for "Total Tetrachloroethene and Trichloroethene".
7: Denotes groundwater quality standard is the sum of Benzo(b)fluoranthene & Benzo(k)fluoranthene.

Greenhills, Athy
County Kildare

Table 4: Leachate Analytical Results

Sample ID		Groundwater Quality Standards			Surface Water Quality Standards	L1		L3	
Laboratory Report No.		Groundwater Regulations (S.I. No. 9 of 2010, SI No. 149 of 2012, SI No. 366 of 2016) [1]	*EPA Interim Guideline Value (IGV) for Groundwater* [2]	*Drinking Water Standards (SI 278 of 2007 Drinking Water Standards & SI 122 of 2014)* [3]	**Surface Water Regulations 2009 (SI No. 272 of 2009) as amended (S.I. No. 372 of 2012 and S.I. No. 386 of 2015) - Annual Mean**	19-6650	19-7496	19-6650	19-7496
Sample Date						23/04/19	08/05/19	23/04/19	08/05/19
Field Parameters	**Unit**								
Temperature	ºC	~	25	~	~	~		~	
Dissolved Oxygen	mg/l	~	~	~	~	5	6	3	2
Oxidation Reduction Potential (ORP)	mV	~	~	~	~	304.28	9.12	71.95	-109.04
Electrical Conductivity (EC)	µS/cm	800 / 1,875 #	1,000	2,500	~	***1,449***	***1509***	***1740***	***2078***
pH	pH units	~	6.5-9.5	6.5-9.5	~	7.24	7.22	7.26	7.29
Colour	N/A	~	NAC	ATC and NAC	~	Brown	Brown	Brown	Brown
Odour / Other observations	N/A	~	~	ATC and NAC	~	Very Silty, NEC	Very Silty, NEC	Waste odour, very silty, NEC	Waste odour, very silty, NEC
Laboratory Parameters									
Sulphate	mg/l	187.5	200	250	~	**189.2**	***212.50***	46.00	<0.5
Chloride	mg/l	187.50	30	250	~	16.8	13.80	20.50	25.60
Fluoride	mg/l	~	1	0.8	1.5	<0.3	<0.3	<0.3	<0.3
Total Oxidised Nitrogen as N	mg/l	~	NAC	~	~	<0.2	<0.2	<0.2	<0.2
Molybdate Reactive Phosphuros (MRP)	mg/l P	0.035	~	~	0.025	<0.03	<0.03	<0.03	<0.03
Total Cyanide	µg/l	~	10	50	10	<0.01	<0.01	<0.01	0.02
Ammoniacal Nitrogen as N	mg/l	0.065	0.12	0.23	≤0.040	***8.22***	***6.06***	***27.41***	***40.56***
BOD (Settled)	mg/l	~	~	~	1.3	**16**	**16**	**21**	**24**
COD (Settled)	mg/l	~	~	~	~	57	37	120	140
Metals (Dissolved)									
Arsenic	µg/l	7.5	10	10	20	<2.5	<2.5	<2.5	<2.5
Boron	µg/l	~	1,000	1,000	~	108	141	186	197
Cadmium	µg/l	~	5	5	0.2	<0.5	<0.5	<0.5	<0.5
Calcium	mg/l	~	200	~	~	*293.6*	*293.6*	*327.6*	*353.5*
Chromium	µg/l	37.5	30	50	0.6	<1.5	<1.5	<1.5	<1.5
Copper	µg/l	~	30	2,000	5	<7	<7	<7	<7
Iron	µg/l	~	200	200	~	<20	<20	67	*332*
Lead	µg/l	7.5	10	25	1.3	<5	<5	<5	<5
Magnesium	mg/l	~	50	~	~	20.7	20	36	41
Manganese	µg/l	~	50	50	~	*1690*	*3.546*	*2.796*	*2.425*
Mercury	µg/l	0.75	1	1	~	<1	<1	<1	<1
Nickel	µg/l	~	20	20	8.6	8	6	6	4
Potassium	mg/l	~	5	~	~	*11.1*	*8.7*	*19.2*	*24.7*
Sodium	mg/l	~	150	200	~	54.5	33	27.6	32.4
Zinc	µg/l	75	100	~	40	8	6	13	<3
Dibutyltin	µg/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Tributyltin	µg/l	~	~	~	0.0002	<0.1	<0.1	<0.1	<0.1
Triphenyltin	µg/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
TPH CWG									
Aliphatics									
>C5-C6	ug/l	~	~	~	~	<10	<10	<10	<10
>C6-C8	ug/l	~	~	~	~	<10	<10	<10	<10
>C8-C10	ug/l	~	~	~	~	<10	<10	<10	<10
>C10-C12	ug/l	~	~	~	~	<5	<5	<5	74
>C12-C16	ug/l	~	~	~	~	<10	<10	<10	440
>C16-C21	ug/l	~	~	~	~	<10	<10	<10	1110
>C21-C35	ug/l	~	~	~	~	<10	<10	1640	9720
Total aliphatics C5-35	ug/l	~	~	~		<10	<10	1640	11344
Aromatics									
>C5-EC7	ug/l	~	~	~	~	<10	<10	<10	<10
>EC7-EC8	ug/l	~	~	~	~	<10	<10	<10	<10
>EC8-EC10	ug/l	~	~	~	~	<10	<10	<10	<10
>EC10-EC12	ug/l	~	~	~	~	<5	<5	<5	<5
>EC12-EC16	ug/l	~	~	~	~	<10	<10	<10	160
>EC16-EC21	ug/l	~	~	~	~	<10	<10	<10	790
>EC21-EC35	ug/l	~	~	~	~	<10	<10	1160	6730
Total aromatics C5-35	ug/l	~	~	~	~	<10	<10	1160	7680
Total aliphatics and aromatics(C5-35)	ug/l	~	10	~	~	<10	<10	*2800*	*19024*
GRO (>C4-C8)	ug/l	~	~	~	~	<10	<10	13	<10
GRO (>C8-C12)	ug/l	~	~	~	~	<10	<10	42	<10
GRO (>C4-C12)	ug/l	~	~	~	~	<10	<10	55	<10
Methyl Tertiary Butyl Ether	ug/l	10	30	~		<0.1	<0.1	<0.1	<0.1
Benzene	ug/l	0.75	1	1		<0.5	<0.5	<0.5	<0.5
Toluene	ug/l	525	10	~		<5	<5	<5	<5
Ethylbenzene	ug/l	~	10	~		<1	<1	<1	<1
m/p-Xylene	ug/l	~	10	~		<2	<2	<2	<2
o-Xylene	ug/l	~	10	~		<1	<1	<1	<1
EPH (C8-C40)	ug/l	~	~	~		<10	900	5770	20380
C8-C40 Mineral Oil (Calculation)	ug/l	~	~	~		<10	<10	3170	13534
Pesticides									
Organochlorine Pesticides									
Aldrin	ug/l	~	0.01	0.03	Σ=0.005	<0.40	<0.01	<0.75	<0.02
Alpha-HCH (BHC)	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Beta-HCH (BHC)	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Chlorothalonil		~	~	~	~	<100.00	<0.01	<187.50	<0.02
cis-Chlordane		~	~	~	~	<0.40	<0.01	<0.75	<0.02
Delta-HCH (BHC)	ug/l	~	~	~		<0.40	<0.01	<0.75	<0.02
Dieldrin	ug/l	~	0.01	0.03	Σ=0.005	<0.40	<0.01	<0.75	<0.02
Endosulphan I	ug/l	~	0.001	~	~	<0.40	<0.01	<0.75	<0.02
Endosulphan II	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Endosulphan sulphate	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Endrin	ug/l	~	~	~	Σ=0.005	<0.40	<0.01	<0.75	<0.02
Gamma-HCH (BHC)	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Heptachlor	ug/l	~	~	0.03	~	<0.40	<0.01	<0.75	<0.02
Heptachlor Epoxide	ug/l	~	~	0.03	~	<0.40	<0.01	<0.75	<0.02
Hexachlorobenzene	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Isodrin	ug/l	~	~	~	Σ=0.01	<0.40	<0.01	<0.75	<0.02
o,p'-DDE	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
o,p'-DDT	ug/l	~	~	~	0.01	<0.40	<0.01	<0.75	*0.04*
o,p'-Methoxychlor	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
o,p'-TDE	ug/l	~	~	~	~	<0.40	<0.01	<0.75	0.05
p,p'-DDE	ug/l	~	~	~	~	<0.40	<0.01	<0.75	0.12
p,p'-DDT	ug/l	~	~	~	~	<0.40	<0.01	<0.75	0.09
p,p'-Methoxychlor	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
p,p'-TDE	ug/l	~	~	~	~	<0.40	<0.01	<0.75	0.21
Pendimethalin	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Permethrin I	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Permethrin II	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Quintozene (PCNB)	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Tecnazene	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Telodrin	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
trans-Chlordane	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Triadimefon	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Triallate	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Trifluralin	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Benazolin	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Bentazone	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Bromoxynil	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Clopyralid	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
4 - CPA	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
2,4 - D	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
2,4 - DB	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Dicamba	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Dichloroprop	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Diclofop	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Fenoprop	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Flamprop	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Flamprop – isopropyl	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Ioxynil	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
MCPA	ug/l	0.075	~	~	~	<0.1	<0.1	<0.1	<0.1
MCPB	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Mecoprop	ug/l	0.075	~	~	~	<0.1	<0.1	<0.1	<0.1
Picloram	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Pentachlorophenol	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
2,4,5 - T	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
2,3,6 - TBA	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Triclopyr	ug/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1

Greenhills, Athy
County Kildare

Table 4: Leachate Analytical Results

Sample ID		Groundwater Quality Standards			Surface Water Quality Standards	L1		L3	
Laboratory Report No.		Groundwater Regulations (S.I. No. 9 of 2010, SI No. 149 of 2012, SI No. 366 of 2016) [1]	*EPA Interim Guideline Value (IGV) for Groundwater* [2]	*Drinking Water Standards (SI 278 of 2007 Drinking Water Standards & SI 122 of 2014)* [3]	**Surface Water Regulations 2009 (SI No. 272 of 2009) as amended (S.I. No. 372 of 2012 and S.I. No. 386 of 2015) - Annual Mean**	19-6650	19-7496	19-6650	19-7496
Sample Date						23/04/19	08/05/19	23/04/19	08/05/19
Organophosphorus Pesticides									
Azinphos ethyl	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Azinphos methyl	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Carbophenothion	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Chlorfenvinphos	ug/l	~	~	~	0.1	<0.40	<0.01	<0.75	<0.02
Chlorpyrifos	ug/l	~	~	~	0.03	<0.40	<0.01	<0.75	<0.02
Chlorpyrifos-methyl	ug/l	~	~	~		<0.40	<0.01	<0.75	<0.02
Diazinon	ug/l	~	0.001	~	0.01	<0.40	<0.01	<0.75	<0.02
Dichlorvos	ug/l	~	~	~	0.00006	<0.40	<0.01	<0.75	<0.02
Disulfoton	ug/l			~	~	<0.40	<0.01	<0.75	<0.02
Dimethoate	ug/l	~	~	~	0.8	<0.40	<0.01	<0.75	<0.02
Ethion	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Ethyl Parathion (Parathion)	ug/l			~	~	<0.40	<0.01	<0.75	<0.02
Etrimphos	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Fenitrothion	ug/l			~	~	<0.40	<0.01	<0.75	<0.02
Fenthion	ug/l	~	0.01	~	~	<0.40	<0.01	<0.75	<0.02
Malathion	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Methyl Parathion	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Mevinphos	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Phosalone	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Pirimiphos Methyl	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Propetamphos	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Triazophos	ug/l	~	~	~	~	<0.40	<0.01	<0.75	<0.02
Atrazine	µg/l	0.075	1	~	0.6	<0.40	<0.01	<0.75	<0.02
Simazine	µg/l	0.075	1	~	1	<0.40	<0.01	<0.75	<0.02
Semi-Volatile Organic Compounds (SVOC's)									
Phenols									
2-Chlorophenol	µg/ l	~	200	~	~	<1	<1	<1	<2
2-Methylphenol	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
2-Nitrophenol	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
2,4-Dichlorophenol	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
2,4-Dimethylphenol	µg/ l	~	~	~	~	<1	<1	<1	<2
2,4,5-Trichlorophenol	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
2,4,6-Trichlorophenol	µg/ l	~	200	~	~	<1	<1	<1	<2
4-Chloro-3-methylphenol	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
4-Methylphenol	µg/ l	~	~	~	~	<1	<1	<1	<2
4-Nitrophenol	µg/ l	~	~	~	~	<10	<10	<10	<20
Pentachlorophenol	µg/ l	~	2	~	0.4	<1	<1	<1	<2
Phenol	µg/ l	~	0.5	~	8	<1	<1	<1	<2
PAHs									
2-Chloronaphthalene	µg/ l	~	~	~	~	<1	<1	<1	<2
2-Methylnaphthalene	µg/ l	~	~	~	~	<1	<1	<1	<2
Naphthalene	µg/ l	~	~	~	2	<1	<1	<1	<2
Acenaphthylene	µg/ l	~	~	~	~	<0.5	<0.5	0.9	<1.0
Acenaphthene	µg/ l	~	1	~	~	<1	<1	<1	<2
Fluorene	µg/ l	~	~	~	~	<0.5	<0.5	0.7	1.1
Phenanthrene	µg/ l	~	~	~	~	0.9	<0.5	4.1	3.9
Anthracene	µg/ l	~	~	~	0.1	<0.5	<0.5	**1.7**	**1.8**
Fluoranthene	µg/ l	~	~	~	0.0063	**1.7**	**0.5**	**16.3**	**17.4**
Pyrene	µg/ l	~	10,000	~	~	1.5	0.5	14.7	15.7
Benz(a)anthracene	µg/ l	~	1	~	~	*1.1*	<0.5	*9.6*	*12.1*
Chrysene	µg/ l	~	~	~	~	1	<0.5	10.5	11
Benzo(bk)fluoranthene	µg/ l	0.075 [3]	0.55	0.1 [4]	0.03	***2***	<1	***21***	***22***
Benzo(a)pyrene	µg/ l	0.0075	0.01	0.01	0.00017	***1***	<1	***12***	***13***
Indeno(123cd)pyrene	µg/ l	0.075 [3]	0.05	0.1 [4]	0.002	<1	<1	***7***	***8***
Dibenzo(ah)anthracene	µg/ l	~	~	~	~	<0.5	<0.5	2.6	2.8
Benzo(ghi)perylene	µg/ l	0.075 [3]	0.05	0.1 [4]	0.002	***0.8***	<0.5	***9.3***	***10.5***
Phthalates									
Bis(2-ethylhexyl) phthalate	µg/ l	~	8	~	1.3	<5	<5	*22*	*26*
Butylbenzyl phthalate	µg/ l	~	~	~	~	<1	<1	<1	<2
Di-n-butyl phthalate	µg/ l	~	2	~	~	<1.5	<1.5	<1.5	<3.0
Di-n-Octyl phthalate	µg/ l	~	~	~	~	<1	<1	<1	<2
Diethyl phthalate	µg/ l	~	~	~	~	<1	<1	<1	<2
Dimethyl phthalate	µg/ l	~	~	~	~	<1	<1	<1	<2
Additional SVOCs									
SVOC TICs (trace organics)	µg/l	~	~	~	~				
1,2-Dichlorobenzene	µg/ l	~	10	~	~	<1	<1	<1	<2
1,2,4-Trichlorobenzene	µg/ l	~	0.4	~	0.4	<1	<1	<1	<2
1,3-Dichlorobenzene	µg/ l	~	~	~	~	<1	<1	<1	<2
1,4-Dichlorobenzene	µg/ l	~	~	~	~	<1	<1	<1	<2
2-Nitroaniline	µg/ l	~	~	~	~	<1	<1	<1	<2
2,4-Dinitrotoluene	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
2,6-Dinitrotoluene	µg/ l	~	~	~	~	<1	<1	<1	<2
3-Nitroaniline	µg/ l	~	~	~	~	<1	<1	<1	<2
4-Bromophenylphenylether	µg/ l	~	~	~	~	<1	<1	<1	<2
4-Chloroaniline	µg/ l	~	~	~	~	<1	<1	<1	<2
4-Chlorophenylphenylether	µg/ l	~	~	~	~	<1	<1	<1	<2
4-Nitroaniline	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
Azobenzene	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
Bis(2-chloroethoxy)methane	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
Bis(2-chloroethyl)ether	µg/ l	~	~	~	~	<1	<1	<1	<2
Carbazole	µg/ l	~	~	~	~	<0.5	<0.5	0.6	<1.0
Dibenzofuran	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
Hexachlorobenzene	µg/ l	~	0.03	~	0.05	<1	<1	<1	<2
Hexachlorobutadiene	µg/ l	~	0.1	~	0.6	<1	<1	<1	<2
Hexachlorocyclopentadiene	µg/ l	~	~	~	~	<1	<1	<1	<2
Hexachloroethane	µg/ l	~	~	~	~	<1	<1	<1	<2
Isophorone	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
N-nitrosodi-n-propylamine	µg/ l	~	~	~	~	<0.5	<0.5	<0.5	<1.0
Nitrobenzene	µg/ l	~	10	~	~	<1	<1	<1	<2

Greenhills, Athy
County Kildare

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Sample ID		Groundwater Quality Standards			Surface Water Quality Standards	L1		L3	
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Sample Date						23/04/19	08/05/19	23/04/19	08/05/19
VOCs									
VOCs TICs (trace organics)	µg/l	~	~	~	~	<2	<2	<2	<2
Dichlorodifluoromethane	µg/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Methyl Tertiary Butyl Ether	µg/l	10	30	~	~	<3	<3	<3	<3
Chloromethane	µg/l	~	~	~	~	<0.1	<0.1	<0.1	<0.1
Vinyl Chloride	µg/l	0.375	~	~	~	<1	<1	<1	<1
Bromomethane	µg/l	~	~	~	~	<3	<3	<3	<3
Chloroethane	µg/l	~	~	~	~	<3	<3	<3	<3
Trichlorofluoromethane	µg/l	~	~	~	~	<3	<3	<3	<3
1,1-Dichloroethene	µg/l	~	30	~	~	<5	<5	<5	<5
Dichloromethane	µg/l	~	10	~	20	<3	<3	<3	<3
trans-1-2-Dichloroethene	µg/l	~	~	~	~	<3	<3	<3	<3
1,1-Dichloroethane	µg/l	~	~	~	~	<3	<3	<3	<3
cis-1-2-Dichloroethene	µg/l	~	~	~	~	<1	<1	<1	<1
2,2-Dichloropropane	µg/l	~	~	~	~	<2	<2	<2	<2
Bromochloromethane	µg/l	~	~	~	~	<2	<2	<2	<2
Chloroform	µg/l	75 [4]	12	~	~	<2	<2	<2	<2
1,1,1-Trichloroethane	µg/l	~	500	~	~	<3	<3	<3	<3
1,1-Dichloropropene	µg/l	~	~	~	~	<2	<2	<2	<2
Carbon tetrachloride	µg/l	~	2	~	12	<2	<2	<2	<2
1,2-Dichloroethane	µg/l	2.25	3	3	10	<0.5	<0.5	<0.5	<0.5
Benzene	µg/l	0.75	1	1	10	<3	<3	<3	<3
Trichloroethene	µg/l	7.5 [5]	10	10 [7]	~	<2	<2	<2	<2
1,2-Dichloropropane	µg/l	~	~	~	~	<3	<3	<3	<3
Dibromomethane	µg/l	~	~	~	~	<2	<2	<2	<2
Bromodichloromethane	µg/l	75 [4]	~	100 [6]	20	<2	<2	<2	<2
cis-1-3-Dichloropropene	µg/l	~	~	~	~	<5	<5	<5	<5
Toluene	µg/l	525	10	~	10	<2	<2	<2	<2
trans-1-3-Dichloropropene	µg/l	~	~	~	~	<2	<2	<2	<2
1,1,2-Trichloroethane	µg/l	~	~	~	~	<3	<3	<3	<3
Tetrachloroethene	µg/l	7.5 [5]	10	~	~	<2	<2	<2	<2
1,3-Dichloropropane	µg/l	~	~	~	~	<2	<2	<2	<2
Dibromochloromethane	µg/l	75 [4]	~	~	~	<2	<2	<2	<2
1,2-Dibromoethane	µg/l	~	~	~	~	<2	<2	<2	<2
Chlorobenzene	µg/l	~	1	~	~	<2	<2	<2	<2
1,1,1,2-Tetrachloroethane	µg/l	~	~	~	~	<1	<1	<1	<1
Ethylbenzene	µg/l	~	10	~	~	<2	<2	<2	<2
p/m-Xylene	µg/l	~	10 **	~	~	<1	<1	<1	<1
o-Xylene	µg/l	~	10 **	~	10	<2	<2	<2	<2
Styrene	µg/l	~	~	~	10	<2	<2	<2	<2
Bromoform	µg/l	75 [4]	~	~	~	<3	<3	<3	<3
Isopropylbenzene	µg/l	~	~	~	~	<4	<4	<4	<4
1,1,2,2-Tetrachloroethane	µg/l	~	~	~	~	<2	<2	<2	<2
Bromobenzene	µg/l	~	~	~	~	<3	<3	<3	<3
1,2,3-Trichloropropane	µg/l	~	~	~	~	<3	<3	<3	<3
Propylbenzene	µg/l	~	~	~	~	<3	<3	<3	<3
2-Chlorotoluene	µg/l	~	~	~	~	<3	<3	<3	<3
1,3,5-Trimethylbenzene	µg/l	~	~	~	~	<3	<3	<3	<3
4-Chlorotoluene	µg/l	~	~	~	~	<3	<3	<3	<3
tert-Butylbenzene	µg/l	~	~	~	~	<3	<3	<3	<3
1,2,4-Trimethylbenzene	µg/l	~	~	~	~	<3	<3	<3	<3
sec-Butylbenzene	µg/l	~	~	~	~	<3	<3	<3	<3
4-Isopropyltoluene	µg/l	~	~	~	~	<3	<3	<3	<3
1,3-Dichlorobenzene	µg/l	~	~	~	~	<3	<3	<3	<3
1,4-Dichlorobenzene	µg/l	~	~	~	~	<3	<3	<3	<3
n-Butylbenzene	µg/l	~	~	~	~	<3	<3	<3	<3
1,2-Dichlorobenzene	µg/l	~	10	~	~	<2	<2	<2	<2
1,2-Dibromo-3-chloropropane	µg/l	~	~	~	~	<3	<3	<3	<3
1,2,4-Trichlorobenzene	µg/l	~	0.4	~	0.4	<3	<3	<3	<3
Hexachlorobutadiene	µg/l	~	0.1	~	0.6	<2	<2	<2	<2
1,2,3-Trichlorobenzene	µg/l	~	~	~	~	<3	<3	<3	<3

Notes:
" denotes groundwater regulations are for dissolved metals, used groundwater regulation for total metals for comparison purposes only.
NAC denotes not abnormal colour
# denotes lower value - assessment for the presence of saline/other instrusion; higher value - assessment of the general quality of groundwater in terms of whether its ability to support human uses has been significantly im
NA denotes Not Applicable.
SS denotes Suspended Solids
** denotes standard is for total xylenes.
- denotes parameter not analysed/ recorded.
1: European Communities Environmental Objectives (Groundwater) Regulations 2010; S.I. No. 9 of 2010. Amendment SI no 149 of 2012, Amendment SI No. 366 of 2016.
2: Environmental Protection Agency (EPA), 2003. Towards Setting Guideline Values for the Protection of Groundwater in Ireland - Interim Report. EPA, Ireland.
3: SI No. 278 of 2007; European communities (Drinking Water) (No. 2) Regulation 2007. SI No. 122 of 2014; European Union (Drinking Water) Regulations 2014 [8]
3: Denotes regulation value is for "Total Polycyclic Aromatic Hydrocarbons", sum of 4 (Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(123cd)pyrene & Benzo(ghi)perylene).
4: Denotes regulation value is for "Total Trihalomethanes".
5: Denotes regulation value is for "Total Tetrachloroethene and Trichloroethene".

Greenhills, Athy
County Kildare

Table 5: Surface Water Analytical Results

Sample ID		**Surface Water Quality Standards**	SW1		SW2	
Laboratory Report No.		**Surface Water Regulations 2009 (SI No. 272 of 2009) as amended (S.I. No. 372 of 2012 and S.I. No. 386 of 2015) - Annual Mean**	19-6650	19-7606	19-6650	19-7606
Sample Date			23/04/19	09/05/19	23/04/19	09/05/19
Field Parameters	**Unit**					
Temperature	ºC	~	14.72	9.82	15.33	9.89
Dissolved Oxygen	mg/l	~	8.87	10	9.44	10
Dissolved Oxygen (DO)	%	>=80 <=120	90.13	100	98.77	100
Oxidation Reduction Potential (ORP)	mV	~	159.24	91.16	175.32	141.55
Electrical Conductivity (EC)	µS/cm	~	686.00	644.00	688.00	653.00
pH	pH units	>=6.0 <=9.0	8.26	8.27	8.29	8.26
Colour	N/A	~	Clear	Clear	Clear	Clear
Odour / Other observations	N/A	~	NEC	NEC	NEC	NEC
Laboratory Parameters						
Sulphate	mg/l	~	34.60	37.80	35.20	36.70
Chloride	mg/l	~	26.50	27.40	26.70	27.30
Fluoride	mg/l	1.5	<0.3	<0.3	<0.3	<0.3
Total Oxidised Nitrogen as N	mg/l	~	3.50	3.50	3.50	3.70
Molybdate Reactive Phosphuros (MRP)	mg/l P	0.025	<0.03	<0.03	<0.03	<0.03
Total Cyanide	µg/l	10	<0.01	<0.01	<0.01	<0.01
Ammoniacal Nitrogen as N	mg/l	0.04	<0.03	<0.03	<0.03	0.03
Total Alkalinity as CaCO3	mg/l	~	306	282	290	302
Total Suspended Solids	mg/l	~	<10	<10	<10	<10
BOD (Settled)	mg/l	High Status <=1.3 mean Good Status<=1.5mean	1	<1	1	<1
COD (Settled)	mg/l	~	30	17	32	18
Metals (Dissolved)						
Arsenic	µg/l	20	<2.5	<2.5	<2.5	<2.5
Boron	µg/l	~	20	23	21	27
Cadmium	µg/l	0.2	<0.5	<0.5	<0.5	<0.5
Calcium	mg/l	~	124.30	123.90	125.50	125.50
Chromium	µg/l	0.6	<1.5	<1.5	<1.5	<1.5
Copper	µg/l	5	<7	<7	<7	<7
Iron	µg/l	~	32	57	31	59
Lead	µg/l	1.3	<5	<5	<5	<5
Magnesium	mg/l	~	11.90	11.10	11.80	11.30
Manganese	µg/l	~	<2	28	<2	29
Mercury	µg/l	0.07	<1	<1	<1	<1
Nickel	µg/l	8.6	<2	<2	<2	<2
Potassium	mg/l	~	2.40	2.20	2.40	2.30
Sodium	mg/l	~	12.40	12.50	12.60	12.60
Zinc	µg/l	40	<3	<3	<3	<3
Dibutyltin	µg/l	~	<0.1	<0.1	<0.1	<0.1
Tributyltin	µg/l	0.0002	<0.1	<0.1	<0.1	<0.1
Triphenyltin	µg/l	~	<0.1	<0.1	<0.1	<0.1
TPH CWG						
Aliphatics						
>C5-C6	ug/l	~	<10	<10	<10	<10
>C6-C8	ug/l	~	<10	<10	<10	<10
>C8-C10	ug/l	~	<10	<10	<10	<10
>C10-C12	ug/l	~	<5	<5	<5	<5
>C12-C16	ug/l	~	<10	<10	<10	<10
>C16-C21	ug/l	~	<10	<10	<10	<10
>C21-C35	ug/l	~	<10	<10	<10	<10
Total aliphatics C5-35	ug/l	~	<10	<10	<10	<10
Aromatics						
>C5-EC7	ug/l	~	<10	<10	<10	<10
>EC7-EC8	ug/l	~	<10	<10	<10	<10
>EC8-EC10	ug/l	~	<10	<10	<10	<10
>EC10-EC12	ug/l	~	<5	<5	<5	<5
>EC12-EC16	ug/l	~	<10	<10	<10	<10
>EC16-EC21	ug/l	~	<10	<10	<10	<10
>EC21-EC35	ug/l	~	<10	<10	<10	<10
Total aromatics C5-35	ug/l	~	<10	<10	<10	<10
Total aliphatics and aromatics(C5-35)	ug/l	~	<10	<10	<10	<10
GRO (>C4-C8)	ug/l	~	<10	<10	<10	<10
GRO (>C8-C12)	ug/l	~	<10	<10	<10	<10
GRO (>C4-C12)	ug/l	~	<10	<10	<10	<10
Methyl Tertiary Butyl Ether	ug/l	~	<0.1	<0.1	<0.1	<0.1
Benzene	ug/l	8	<0.5	<0.5	<0.5	<0.5
Toluene	ug/l	10	<5	<5	<5	<5
Ethylbenzene	ug/l	~	<1	<1	<1	<1
m/p-Xylene	ug/l	10	<2	<2	<2	<2
o-Xylene	ug/l	10	<1	<1	<1	<1
EPH (C8-C40)	ug/l	~	<10	<10	<10	<10
C8-C40 Mineral Oil (Calculation)	ug/l	~	<10	<10	<10	<10
Pesticides						
Organochlorine Pesticides						
Aldrin	ug/l	Σ=0.005	<0.01	<0.01	<0.01	<0.01
Alpha-HCH (BHC)	ug/l	~	<0.01	<0.01	<0.01	<0.01
Beta-HCH (BHC)	ug/l	~	<0.01	<0.01	<0.01	<0.01
Chlorothalonil		~	<2.50	<2.50	<2.50	<2.50
cis-Chlordane		~	<0.01	<0.01	<0.01	<0.01
Delta-HCH (BHC)	ug/l	~	<0.01	<0.01	<0.01	<0.01
Dieldrin	ug/l	Σ=0.005	<0.01	<0.01	<0.01	<0.01
Endosulphan I	ug/l	~	<0.01	<0.01	<0.01	<0.01
Endosulphan II	ug/l	~	<0.01	<0.01	<0.01	<0.01
Endosulphan sulphate	ug/l	~	<0.01	<0.01	<0.01	<0.01
Endrin	ug/l	Σ=0.005	<0.01	<0.01	<0.01	<0.01
Gamma-HCH (BHC)	ug/l	~	<0.01	<0.01	<0.01	<0.01
Heptachlor	ug/l	1×10^{8}	<0.01	<0.01	<0.01	<0.01
Heptachlor Epoxide	ug/l	~	<0.01	<0.01	<0.01	<0.01
Hexachlorobenzene	ug/l	0.05	<0.01	<0.01	<0.01	<0.01
Isodrin	ug/l	Σ=0.005	<0.01	<0.01	<0.01	<0.01
o,p'-DDE	ug/l	~	<0.01	<0.01	<0.01	<0.01
o,p'-DDT	ug/l	~	<0.01	<0.01	<0.01	<0.01
o,p'-Methoxychlor	ug/l	~	<0.01	<0.01	<0.01	<0.01
o,p'-TDE	ug/l	~	<0.01	<0.01	<0.01	<0.01
p,p'-DDE	ug/l	~	<0.01	<0.01	<0.01	<0.01
p,p'-DDT	ug/l	0.01	<0.01	<0.01	<0.01	<0.01
p,p'-Methoxychlor	ug/l	~	<0.01	<0.01	<0.01	<0.01
p,p'-TDE	ug/l	~	<0.01	<0.01	<0.01	<0.01
Pendimethalin	ug/l	~	<0.01	<0.01	<0.01	<0.01
Permethrin I	ug/l	~	<0.01	<0.01	<0.01	<0.01
Permethrin II	ug/l	~	<0.01	<0.01	<0.01	<0.01
Quintozene (PCNB)	ug/l	~	<0.01	<0.01	<0.01	<0.01
Tecnazene	ug/l	~	<0.01	<0.01	<0.01	<0.01
Telodrin	ug/l	~	<0.01	<0.01	<0.01	<0.01
trans-Chlordane	ug/l	~	<0.01	<0.01	<0.01	<0.01
Triadimefon	ug/l	~	<0.01	<0.01	<0.01	<0.01
Triallate	ug/l	~	<0.01	<0.01	<0.01	<0.01
Trifluralin	ug/l	~	<0.01	<0.01	<0.01	<0.01
Benazolin	ug/l	~	<0.1	<0.1	<0.1	<0.1
Bentazone	ug/l	~	<0.1	<0.1	<0.1	<0.1
Bromoxynil	ug/l	~	<0.1	<0.1	<0.1	<0.1
Clopyralid	ug/l	~	<0.1	<0.1	<0.1	<0.1
4 - CPA	ug/l	~	<0.1	<0.1	<0.1	<0.1
2,4 - D	ug/l	~	<0.1	<0.1	<0.1	<0.1
2,4 - DB	ug/l	~	<0.1	<0.1	<0.1	<0.1
Dicamba	ug/l	~	<0.1	<0.1	<0.1	<0.1
Dichloroprop	ug/l	~	<0.1	<0.1	<0.1	<0.1
Diclofop	ug/l	~	<0.1	<0.1	<0.1	<0.1
Fenoprop	ug/l	~	<0.1	<0.1	<0.1	<0.1
Flamprop	ug/l	~	<0.1	<0.1	<0.1	<0.1
Flamprop – isopropyl	ug/l	~	<0.1	<0.1	<0.1	<0.1
Ioxynil	ug/l	~	<0.1	<0.1	<0.1	<0.1
MCPA	ug/l	~	<0.1	<0.1	<0.1	<0.1
MCPB	ug/l	~	<0.1	<0.1	<0.1	<0.1
Mecoprop	ug/l	~	<0.1	<0.1	<0.1	<0.1
Picloram	ug/l	~	<0.1	<0.1	<0.1	<0.1
Pentachlorophenol	ug/l	0.4	<0.1	<0.1	<0.1	<0.1
2,4,5 - T	ug/l	~	<0.1	<0.1	<0.1	<0.1
2,3,6 - TBA	ug/l	~	<0.1	<0.1	<0.1	<0.1
Triclopyr	ug/l	~	<0.1	<0.1	<0.1	<0.1

Greenhills, Athy
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Table 5: Surface Water Analytical Results

Sample ID		Surface Water Quality Standards	SW1		SW2	
Laboratory Report No.		Surface Water Regulations 2009 (SI No. 272 of 2009) as amended (S.I. No. 372 of 2012 and S.I. No. 386 of 2015) - Annual Mean	19-6650	19-7606	19-6650	19-7606
Sample Date			23/04/19	09/05/19	23/04/19	09/05/19
Organophosphorus Pesticides						
Azinphos ethyl	ug/l	~	<0.01	<0.01	<0.01	<0.01
Azinphos methyl	ug/l	~	<0.01	<0.01	<0.01	<0.01
Carbophenothion	ug/l	~	<0.01	<0.01	<0.01	<0.01
Chlorfenvinphos	ug/l	0.1	<0.01	<0.01	<0.01	<0.01
Chlorpyrifos	ug/l	0.03	<0.01	<0.01	<0.01	<0.01
Chlorpyrifos-methyl	ug/l		<0.01	<0.01	<0.01	<0.01
Diazinon	ug/l	0.01	<0.01	<0.01	<0.01	<0.01
Dichlorvos	ug/l	0.00006	<0.01	<0.01	<0.01	<0.01
Disulfoton	ug/l	~	<0.01	<0.01	<0.01	<0.01
Dimethoate	ug/l	0.8	<0.01	<0.01	<0.01	<0.01
Ethion	ug/l	~	<0.01	<0.01	<0.01	<0.01
Ethyl Parathion (Parathion)	ug/l	~	<0.01	<0.01	<0.01	<0.01
Etrimphos	ug/l	~	<0.01	<0.01	<0.01	<0.01
Fenitrothion	ug/l	~	<0.01	<0.01	<0.01	<0.01
Fenthion	ug/l	~	<0.01	<0.01	<0.01	<0.01
Malathion	ug/l	~	<0.01	<0.01	<0.01	<0.01
Methyl Parathion	ug/l	~	<0.01	<0.01	<0.01	<0.01
Mevinphos	ug/l	~	<0.01	<0.01	<0.01	<0.01
Phosalone	ug/l	~	<0.01	<0.01	<0.01	<0.01
Pirimiphos Methyl	ug/l	~	<0.01	<0.01	<0.01	<0.01
Propetamphos	ug/l	~	<0.01	<0.01	<0.01	<0.01
Triazophos	ug/l	~	<0.01	<0.01	<0.01	<0.01
Atrazine	µg/l	0.6	<0.01	<0.01	<0.01	<0.01
Simazine	µg/l	1	<0.01	<0.01	<0.01	<0.01
Semi-Volatile Organic Compounds (SVOC's)						
Phenols						
2-Chlorophenol	µg/ l	~	<1	<1	<1	<1
2-Methylphenol	µg/ l	~	<0.5	<0.5	<0.5	<0.5
2-Nitrophenol	µg/ l	~	<0.5	<0.5	<0.5	<0.5
2,4-Dichlorophenol	µg/ l	~	<0.5	<0.5	<0.5	<0.5
2,4-Dimethylphenol	µg/ l	~	<1	<1	<1	<1
2,4,5-Trichlorophenol	µg/ l	~	<0.5	<0.5	<0.5	<0.5
2,4,6-Trichlorophenol	µg/ l	~	<1	<1	<1	<1
4-Chloro-3-methylphenol	µg/ l	~	<0.5	<0.5	<0.5	<0.5
4-Methylphenol	µg/ l	~	<1	<1	<1	<1
4-Nitrophenol	µg/ l	~	<10	<10	<10	<10
Pentachlorophenol	µg/ l	0.4	<1	<1	<1	<1
Phenol	µg/ l	8	<1	<1	<1	<1
PAHs						
2-Chloronaphthalene	µg/ l	~	<1	<1	<1	<1
2-Methylnaphthalene	µg/ l	~	<1	<1	<1	<1
Naphthalene	µg/ l	2	<1	<1	<1	<1
Acenaphthylene	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Acenaphthene	µg/ l	~	<1	<1	<1	<1
Fluorene	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Phenanthrene	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Anthracene	µg/ l	0.1	<0.5	<0.5	<0.5	<0.5
Fluoranthene	µg/ l	0.0063	<0.5	<0.5	<0.5	<0.5
Pyrene	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Benz(a)anthracene	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Chrysene	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Benzo(bk)fluoranthene	µg/ l	0.03	<1	<1	<1	<1
Benzo(a)pyrene	µg/ l	0.00017	<1	<1	<1	<1
Indeno(123cd)pyrene	µg/ l	0.002	<1	<1	<1	<1
Dibenzo(ah)anthracene	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Benzo(ghi)perylene	µg/ l	0.002	<0.5	<0.5	<0.5	<0.5
Phthalates						
Bis(2-ethylhexyl) phthalate	µg/ l	1.3	<5	<5	<5	<5
Butylbenzyl phthalate	µg/ l	~	<1	<1	<1	<1
Di-n-butyl phthalate	µg/ l	~	<1.5	<1.5	<1.5	<1.5
Di-n-Octyl phthalate	µg/ l	~	<1	<1	<1	<1
Diethyl phthalate	µg/ l	~	<1	<1	<1	<1
Dimethyl phthalate	µg/ l	~	<1	<1	<1	<1
Additional SVOCs						
SVOC TICs (trace organics)	µg/l	~				
1,2-Dichlorobenzene	µg/ l	~	<1	<1	<1	<1
1,2,4-Trichlorobenzene	µg/ l	0.4	<1	<1	<1	<1
1,3-Dichlorobenzene	µg/ l	~	<1	<1	<1	<1
1,4-Dichlorobenzene	µg/ l	~	<1	<1	<1	<1
2-Nitroaniline	µg/ l	~	<1	<1	<1	<1
2,4-Dinitrotoluene	µg/ l	~	<0.5	<0.5	<0.5	<0.5
2,6-Dinitrotoluene	µg/ l	~	<1	<1	<1	<1
3-Nitroaniline	µg/ l	~	<1	<1	<1	<1
4-Bromophenylphenylether	µg/ l	~	<1	<1	<1	<1
4-Chloroaniline	µg/ l	~	<1	<1	<1	<1
4-Chlorophenylphenylether	µg/ l	~	<1	<1	<1	<1
4-Nitroaniline	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Azobenzene	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Bis(2-chloroethoxy)methane	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Bis(2-chloroethyl)ether	µg/ l	~	<1	<1	<1	<1
Carbazole	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Dibenzofuran	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene	µg/ l	0.05	<1	<1	<1	<1
Hexachlorobutadiene	µg/ l	0.6	<1	<1	<1	<1
Hexachlorocyclopentadiene	µg/ l	~	<1	<1	<1	<1
Hexachloroethane	µg/ l	~	<1	<1	<1	<1
Isophorone	µg/ l	~	<0.5	<0.5	<0.5	<0.5
N-nitrosodi-n-propylamine	µg/ l	~	<0.5	<0.5	<0.5	<0.5
Nitrobenzene	µg/ l	~	<1	<1	<1	<1
VOCs						
VOCs TICs (trace organics)	µg/l	~	<2	<2	<2	<2
Dichlorodifluoromethane	µg/l	~	<0.1	<0.1	<0.1	<0.1
Methyl Tertiary Butyl Ether	µg/l	~	<3	<3	<3	<3
Chloromethane	µg/l	~	<0.1	<0.1	<0.1	<0.1
Vinyl Chloride	µg/l	~	<1	<1	<1	<1
Bromomethane	µg/l	~	<3	<3	<3	<3
Chloroethane	µg/l	~	<3	<3	<3	<3
Trichlorofluoromethane	µg/l	~	<3	<3	<3	<3
1,1-Dichloroethene	µg/l	~	<5	<5	<5	<5
Dichloromethane	µg/l	20	<3	<3	<3	<3
trans-1-2-Dichloroethene	µg/l	~	<3	<3	<3	<3
1,1-Dichloroethane	µg/l	~	<3	<3	<3	<3
cis-1-2-Dichloroethene	µg/l	~	<1	<1	<1	<1
2,2-Dichloropropane	µg/l	~	<2	<2	<2	<2
Bromochloromethane	µg/l	~	<2	<2	<2	<2
Chloroform	µg/l	~	<2	<2	<2	<2
1,1,1-Trichloroethane	µg/l	~	<3	<3	<3	<3
1,1-Dichloropropene	µg/l	~	<2	<2	<2	<2
Carbon tetrachloride	µg/l	12	<2	<2	<2	<2
1,2-Dichloroethane	µg/l	10	<0.5	<0.5	<0.5	<0.5
Benzene	µg/l	10	<3	<3	<3	<3
Trichloroethene	µg/l	~	<2	<2	<2	<2
1,2-Dichloropropane	µg/l	~	<3	<3	<3	<3
Dibromomethane	µg/l	~	<2	<2	<2	<2
Bromodichloromethane	µg/l	20	<2	<2	<2	<2
cis-1-3-Dichloropropene	µg/l	~	<5	<5	<5	<5
Toluene	µg/l	10	<2	<2	<2	<2
trans-1-3-Dichloropropene	µg/l	~	<2	<2	<2	<2
1,1,2-Trichloroethane	µg/l	~	<3	<3	<3	<3
Tetrachloroethene	µg/l	~	<2	<2	<2	<2
1,3-Dichloropropane	µg/l	~	<2	<2	<2	<2
Dibromochloromethane	µg/l	~	<2	<2	<2	<2
1,2-Dibromoethane	µg/l	~	<2	<2	<2	<2
Chlorobenzene	µg/l	~	<2	<2	<2	<2
1,1,1,2-Tetrachloroethane	µg/l	~	<1	<1	<1	<1
Ethylbenzene	µg/l	~	<2	<2	<2	<2
p/m-Xylene	µg/l	10	<1	<1	<1	<1
o-Xylene	µg/l	10	<2	<2	<2	<2
Styrene	µg/l	~	<2	<2	<2	<2
Bromoform	µg/l	~	<3	<3	<3	<3
Isopropylbenzene	µg/l	~	<4	<4	<4	<4
1,1,2,2-Tetrachloroethane	µg/l	~	<2	<2	<2	<2
Bromobenzene	µg/l	~	<3	<3	<3	<3
1,2,3-Trichloropropane	µg/l	~	<3	<3	<3	<3
Propylbenzene	µg/l	~	<3	<3	<3	<3
2-Chlorotoluene	µg/l	~	<3	<3	<3	<3
1,3,5-Trimethylbenzene	µg/l	~	<3	<3	<3	<3
4-Chlorotoluene	µg/l	~	<3	<3	<3	<3
tert-Butylbenzene	µg/l	~	<3	<3	<3	<3
1,2,4-Trimethylbenzene	µg/l	~	<3	<3	<3	<3
sec-Butylbenzene	µg/l	~	<3	<3	<3	<3
4-Isopropyltoluene	µg/l	~	<3	<3	<3	<3
1,3-Dichlorobenzene	µg/l	~	<3	<3	<3	<3
1,4-Dichlorobenzene	µg/l	~	<3	<3	<3	<3
n-Butylbenzene	µg/l	~	<3	<3	<3	<3
1,2-Dichlorobenzene	µg/l	~	<2	<2	<2	<2
1,2-Dibromo-3-chloropropane	µg/l	~	<3	<3	<3	<3
1,2,4-Trichlorobenzene	µg/l	0.4	<3	<3	<3	<3
Hexachlorobutadiene	µg/l	0.6	<2	<2	<2	<2
1,2,3-Trichlorobenzene	µg/l	~	<3	<3	<3	<3

Notes:
" denotes groundwater regulations are for dissolved metals, used groundwater regulation for total metals for comparison purposes only.
NAC denotes not abnormal colour
# denotes lower value - assessment for the presence of saline/other instrusion; higher value - assessment of the general quality of groundwater in terms of whether its ability to support human uses has been significantly impaired by pollution.
NA denotes Not Applicable.
SS denotes Suspended Solids
** denotes standard is for total xylenes.
- denotes parameter not analysed/ recorded.
1: European Communities Environmental Objectives (Groundwater) Regulations 2010; S.I. No. 9 of 2010. Amendment SI no 149 of 2012, Amendment SI No. 366 of 2016.
2: Environmental Protection Agency (EPA), 2003. Towards Setting Guideline Values for the Protection of Groundwater in Ireland - Interim Report. EPA, Ireland.
3: SI No. 278 of 2007; European communities (Drinking Water) (No. 2) Regulation 2007. SI No. 122 of 2014; European Union (Drinking Water) Regulations 2014[8]
3: Denotes regulation value is for "Total Polycyclic Aromatic Hydrocarbons", sum of 4 (Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(123cd)pyrene & Benzo(ghi)perylene).
4: Denotes regulation value is for "Total Trihalomethanes".
5: Denotes regulation value is for "Total Tetrachloroethene and Trichloroethene".

Greenhills, Athy
County Kildare

Table 6: Landfill Gas Monitoring Results

Monitoring Well I.D.	Monitoring Event	Monitoring Date	Monitoring Time (24 hr)	Flow Measurement	Stable Methane (CH_4)	Carbon Dioxide (CO_2)	Oxygen (O_2)	Balance	LEL	Peak Methane (CH_4)	Atmospheric Pressure	Relative Pressure	Carbon Monoxide (CO)	Hydrogen Sulphide (H_2S)
			Units	l/h	%	%	%	%	%	%	mb	mb	ppm	ppm
L1	M1	23/04/2019	-	0.0	**2.0**	**11.2**	2.6	84.2	40.0	**2.0**	991	64.87	0.0	0.0
	M2	08/05/2019	-	0.0	**3.2**	**11.6**	1.1	84.1	63.0	**3.2**	985	61.79	0.0	0.0
	M3	29/05/2019	10:01	0.1	0.0	**11.2**	9.9	79.0	0.0	0.0	1007	65.46	0.0	0.0
L2	M1	23/04/2019	-	0.0	0.0	**12.1**	6.5	81.4	0.0	0.0	991	61.78	0.0	0.0
	M2	08/05/2019	-	0.0	0.1	**12.7**	4.6	82.6	2.0	0.1	985	61.72	0.0	0.0
	M3	29/05/2019	09:50	0.0	0.0	**12.1**	9.1	78.8	0.0	0.0	1007	61.84	0.0	0.0
L3	M1	23/04/2019	-	-0.1	**12.1**	**11.3**	0.0	76.6	>>>	**12.1**	991	61.99	0.0	0.0
	M2	08/05/2019	-	0.0	**20.3**	**12.0**	0.0	67.6	>>>	**20.4**	984	61.80	0.0	0.0
	M3	29/05/2019	10:10	0.0	0.3	**11.8**	2,4	85.0	0.0	0.3	1007	65.41	0.0	0.0
GW1	M1	25/04/2019	-	0.0	0.0	0.1	20.6	79.3	0.0	0.0	987	62.03	0.0	0.0
	M2	08/05/2019	-	0.0	0.1	0.1	21.0	78.8	1.0	**1.9**	985	61.83	0.0	0.0
	M3	29/05/2019	09:35	0.0	0.0	0.1	20.8	79.1	0.0	0.0	1007	61.94	0.0	0.0
GW2	M1	25/04/2019	-	0.0	0.0	**3.5**	16.9	79.6	0.0	0.0	987	62.03	1.0	0.0
	M2	08/05/2019	-	0.2	0.1	0.2	20.7	79.0	1.0	0.1	986	61.87	1.0	0.0
	M3	29/05/2019	10:22	0.0	0.0	0.5	20.4	79.1	0.0	0.0	1007	62.10	0.0	0.0
GW3	M1	25/04/2019	-	0.0	0	0.1	20.8	79.1	0.0	0.1	987	61.93	0.0	0.0
	M2	08/05/2019	-	0.1	0.1	0.1	21	78.8	1.0	0.1	989	61.79	0.0	0.0
	M3	29/05/2019	10:30	0.0	0.0	0.2	20.6	79.0	0.0	0.0	1007	62.12	0.0	0.0
EPA 1997 Thresholds[1]				~	**1.0**	**1.5**	~	~	~	**1.0**	~	~	~	~

Notes:
LEL denotes Lower Explosive Limit (expressed as percentage of 5% v/v methane).
- denotes not measurement
>>> denotes exceeds the LEL.
~ denotes no threshold available.
Bold denotes level exceeds EPA threshold.
1: Environmental Protection Agency (EPA) 1997: Landfill Manuals - Landfill operational Practices. EPA, Ireland.

DRAWINGS

N
W
E
S

Legend

- Site Location

Subsoils

- Alluvium
- Cut
- FenPt
- Glaciofluvial sands and gravels
- Karstified limestone bedrock as surface
- Lacustrine Sediments
- Made
- Limestone till (Carboniferous)

TLs
Made
Made
GLs
A
L
TLs
Made
GLs
A
TLs
GLs
GLs
TLs
Made
A
KaRck
KaRck
GLs
GLs
GLs
FenPt
GLs
Made
A
L
GLs
GLs
TLs

0 500 1000 m

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Ground Floor –Unit 3,
Bracken Business Park,
Bracken Road, Sandyford,
Dublin 18, D18 V32Y
Tel: + 353 1 567 7655
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Client	Description
Kildare Co Co	Subsoils Map
Job: Environmental Risk Assessment	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	1	DRAFT	A3	1:15,000	May 19	UD

N
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Legend

Site Location

Bedrock

Ballyadams Formation

Ballysteen Formation

Milford Formation

BA

MI

M

0 500 1000 m

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Client	Description
Kildare Co Co	Bedrock Map
Job: Environmental Risk Assessment	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	2	DRAFT	A3	1:15,000	May 19	UD

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Legend

- Site Location

Bedrock Aquifer

- Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones
- Regionally Important Aquifer - Karstified (diffuse)

Rkd

kd

LI

0 500 1000 m

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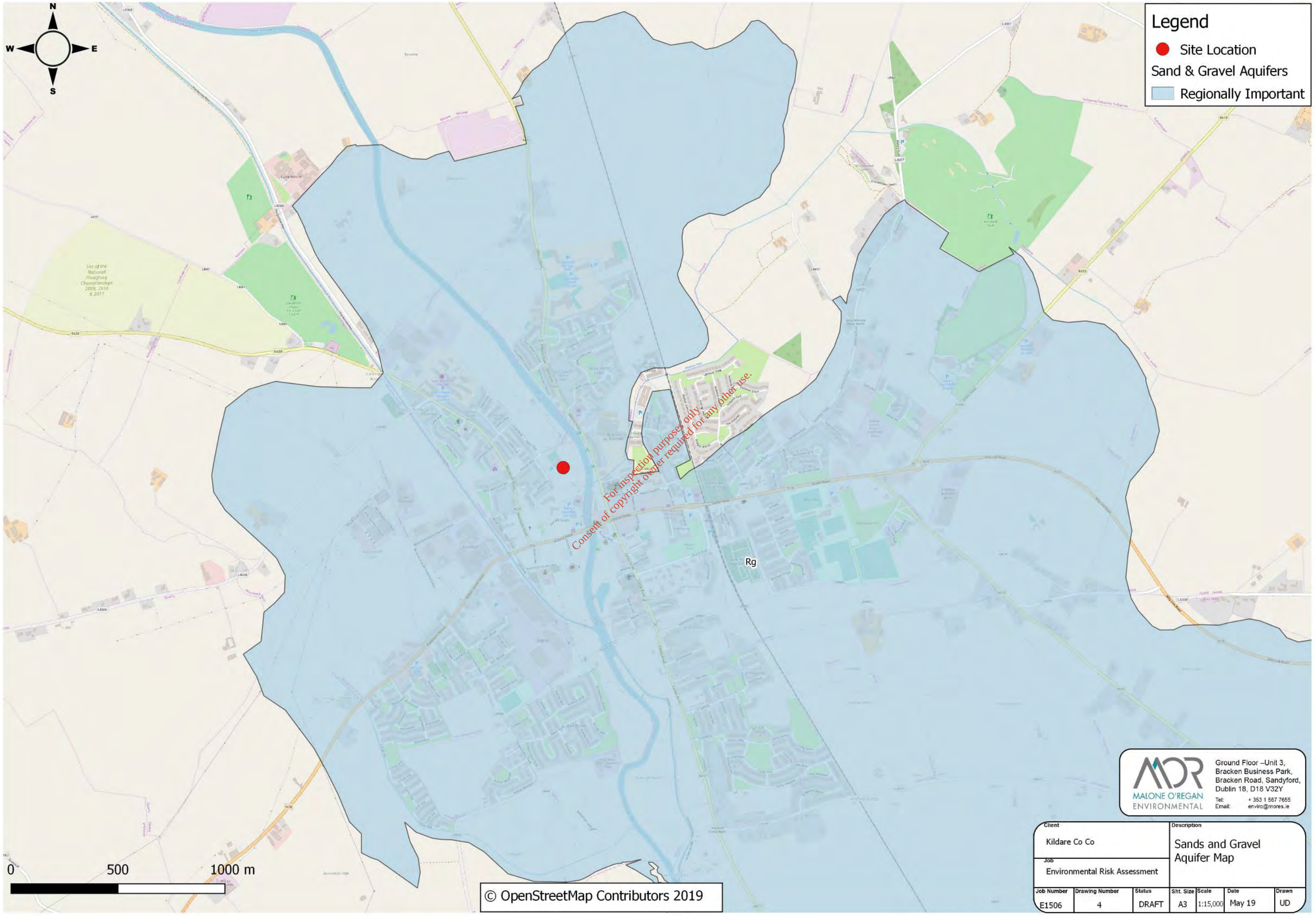
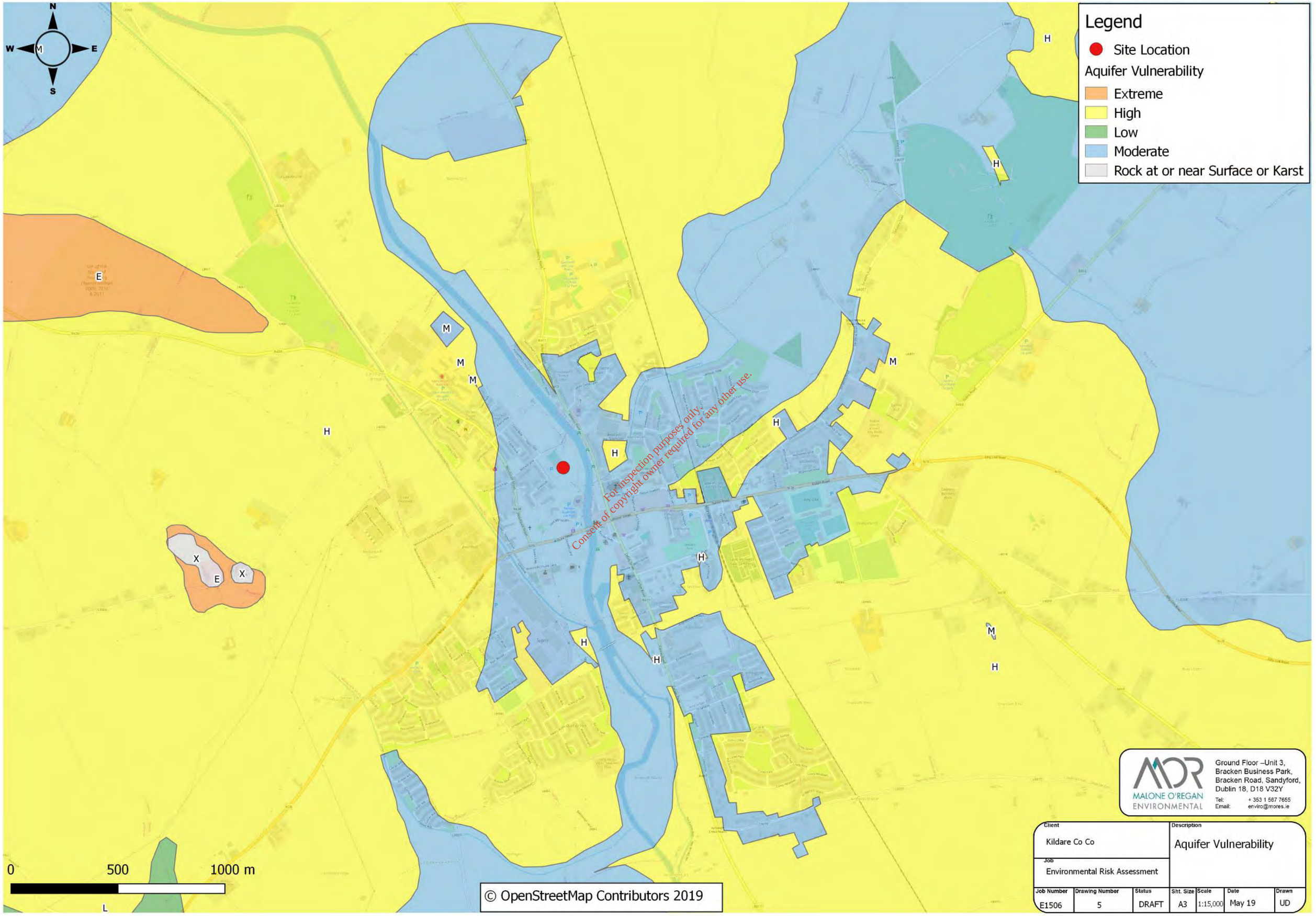
Client	Description
Kildare Co Co	Bedrock Aquifer
Job: Environmental Risk Assessment	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	3	DRAFT	A3	1:15,000	May 19	UD





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Client	Description
Kildare Co Co	Aquifer Vulnerability
Job: Environmental Risk Assessment	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
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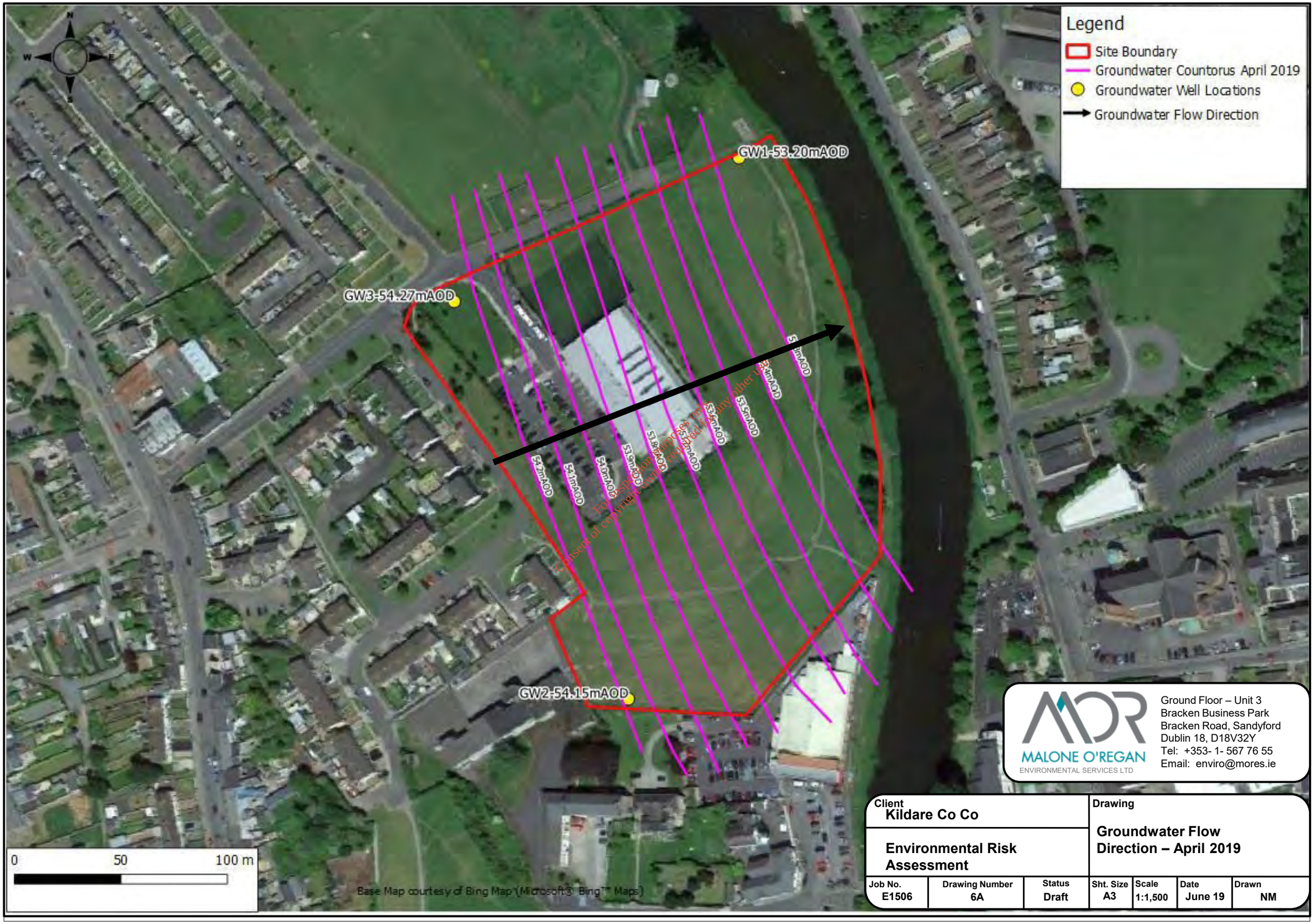

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Ground Floor – Unit 3
Bracken Business Park
Bracken Road, Sandyford
Dublin 18, D18V32Y
Tel: +353- 1- 567 76 55
Email: enviro@mores.ie

Client	Drawing
Kildare Co Co	Groundwater Flow Direction – April 2019
Environmental Risk Assessment	

Job No.	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	6A	Draft	A3	1:1,500	June 19	NM

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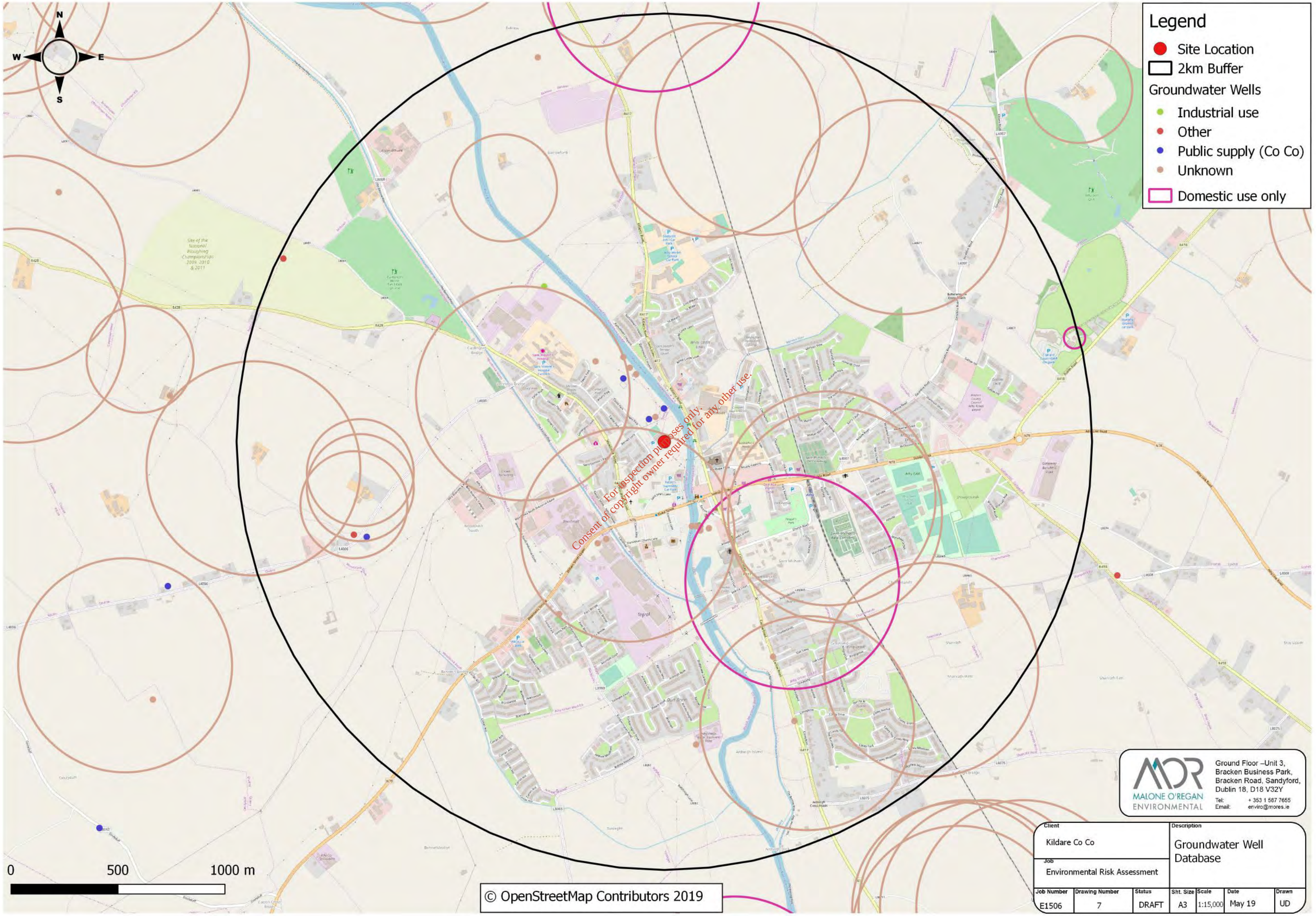
Client	Kildare Co Co
	Environmental Risk Assessment
Drawing	Groundwater Flow Direction – May 2019

Job No.	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	6B	Draft	A3	1:1,500	June 19	NM



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Legend
- Site Location
- OSI Rivers
- OSI Streams

Barrow
SALISBURY
SMALLFORD
Athy (Stream)
Athy (Stream)
Athy (Stream)
Athy (Stream)
Barrow
Barrow
Barrow
Barrow
Barrow
Coneyburrow, Trib Barrow
Coneyburrow, Trib Barrow
BALLYNASCULLOGE
Bennetsbridge (Stream)

0 500 1000 m

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Client	Description
Kildare Co Co	Hydrlogical Receptors Map
Job: Environmental Risk Assessment	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	8	DRAFT	A3	1:15,000	May 19	UD

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Legend

- Site Location

Groundwater Source Protection Areas

- Inner Zone
- Outer Zone

ATHY

ATHY

0 500 1000 m

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Client	Description
Kildare Co Co	Groundwater Source Protection Areas (SI/SO)
Job: Environmental Risk Assessment	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
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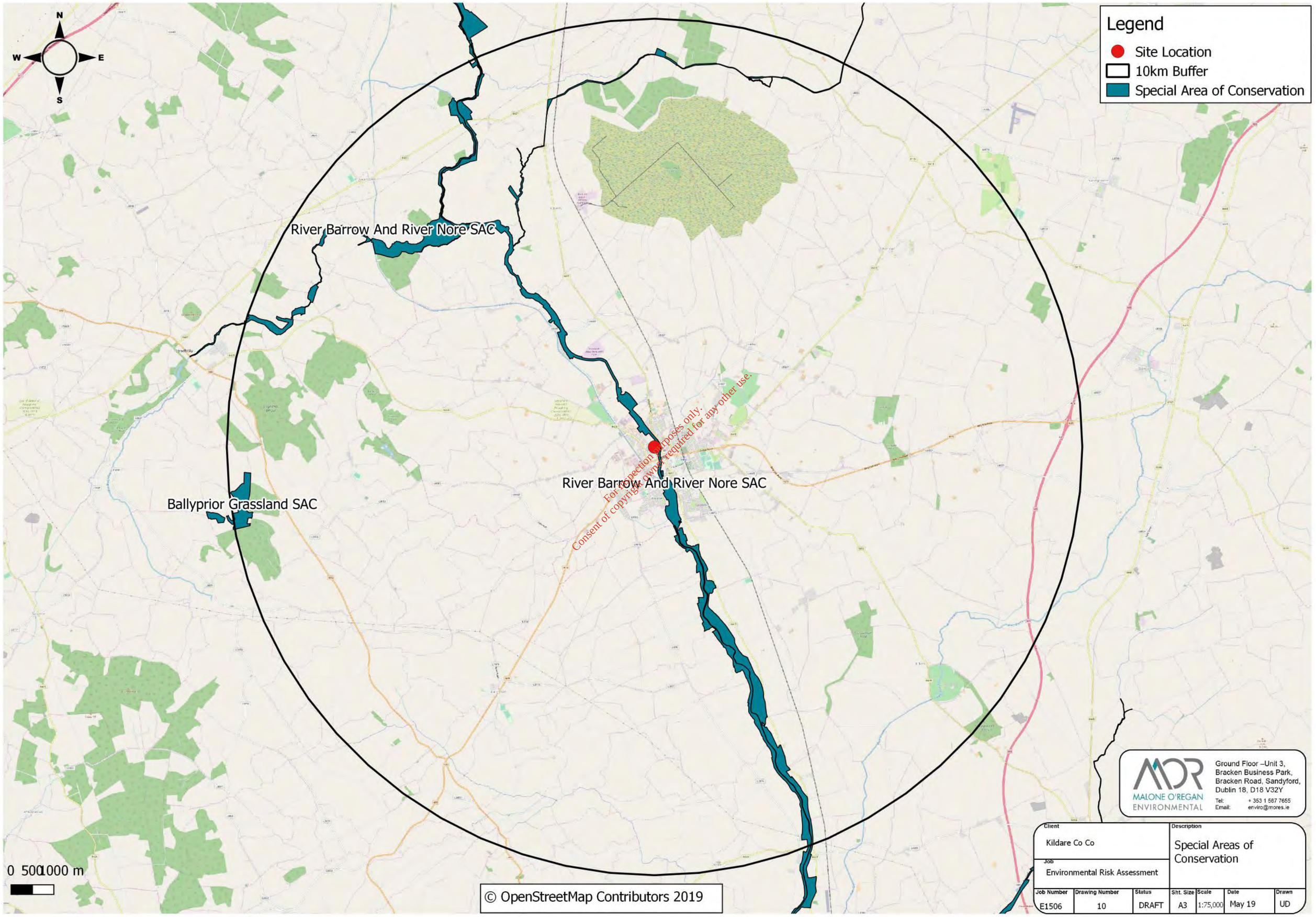

N
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Legend
Site Location
10km Buffer
Proposed Natural Heritage Areas

Derries Wood
th Of Portlaoise
Grand Canal
Derryvullagh Island
Kilteale Hill
Dunamase
Stradbally Hill
Grand Canal
Timahoe Esker
Clopook Wood
Ballylynan
Barrow Valley At Tankardstown Bridge
Barrow Valley At Tankardstown Bridge
Ballycore Rath
Corballis Hill

0 500 1000 m

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Client	Description
Kildare Co Co	Proposed Natural Heritage Areas
Job: Environmental Risk Assessment	

Job Number	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	11	DRAFT	A3	1:75,000	May 19	UD

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Client	Drawing
Kildare Co Co	Trial Pit Locations
Job Environmental Risk Assessment	

Job No.	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	12	Draft	A3	1:1,500	June 19	NM

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Client	Kildare Co Co
Job	Enviornmentall Risk Assessment
Drawing	Leachate / Gas Well Locations

Job No.	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	13	Draft	A3	1:1,500	June 19	NM

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Client	Drawing
Kildare Co Co	Groundwater Well Locations
Job Environmental Risk Assessment	

Job No.	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	14	Draft	A3	1:1,500	June 19	NM

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Bracken Business Park
Bracken Road, Sandyford
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Client	Drawing
Kildare Co Co	Site investigation Locations
Job: Enviornmental Risk Assessment	

Job No.	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
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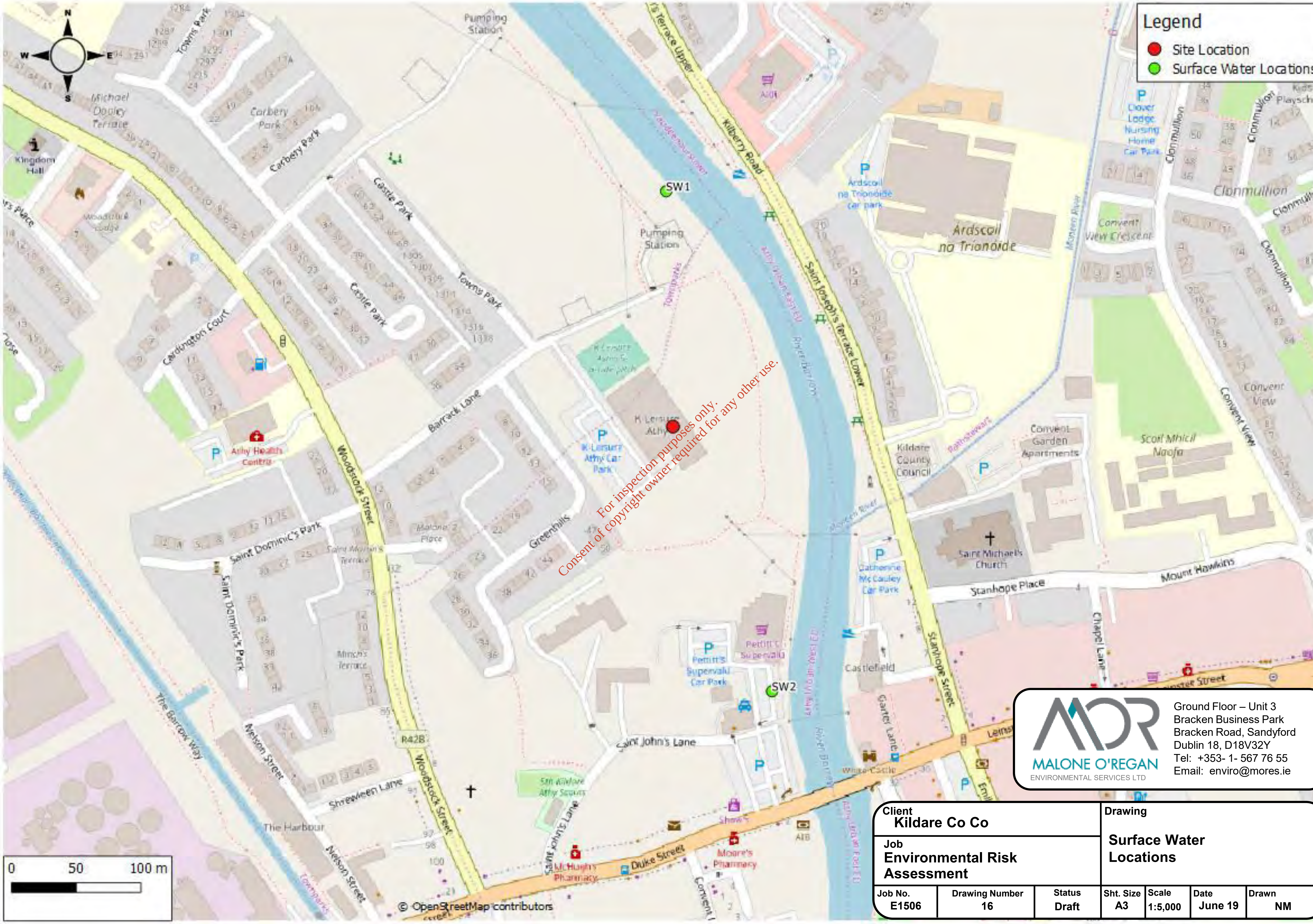

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Ground Floor – Unit 3
Bracken Business Park
Bracken Road, Sandyford
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Tel: +353- 1- 567 76 55
Email: enviro@mores.ie

Client	Drawing
Kildare Co Co	Surface Water Locations
Job: Environmental Risk Assessment	

Job No.	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	16	Draft	A3	1:5,000	June 19	NM

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Client	Drawing
Kildare Co Co	Surface VOC Survey Locations
Job Environmental Risk Assessment	

Job No.	Drawing Number	Status	Sht. Size	Scale	Date	Drawn
E1506	17	Draft	A3	1:1,500	June 19	NM

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Dublin 18, D18V32Y
Tel: +353- 1- 567 76 55
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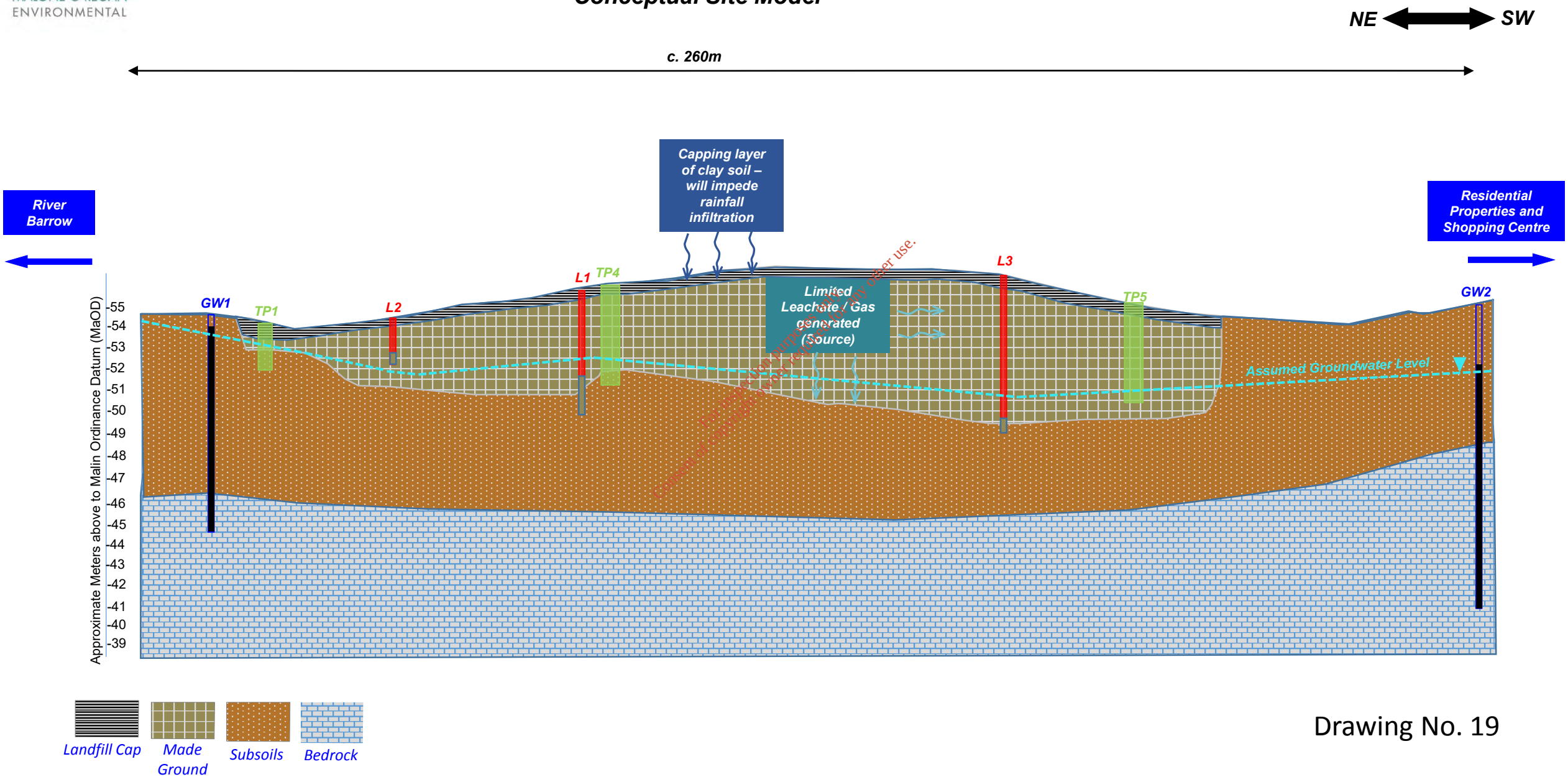
Client: Kildare County Council			Drawing: Approximate Extent of the Waste			
Job: Environmental Risk Assessment						
Job No. E1506	Drawing Number 18	Status DRAFT	Sht. Size A3	Scale 1:10,000	Date June 19	Drawn NM

Greenhills Site, Athy, Co. Kildare – Conceptual Site Model



Drawing No. 19