ENVIRONMENTAL BALANCE IN DESIGN AND CONSTRUCTION

KNOCKHARLEY LANDFILL LTD.

ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED DEVELOPMENT AT KNOCKHARLEY LANDFILL

VOLUME 2 – MAIN EIAR

CHAPTER 11 – LAND, SOILS & GEOLOGY

NOVEMBER 2018

Knockharley Landfill Ltd.
Kentstown, Navan,Co.Meath

FEHILY TIMONEY & COMPANY

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11 LAND, SOILS & GEOLOGY

11.1 Introduction

This chapter has been prepared to examine the potential impacts of the proposed development at Knockharley Landfill facility as outlined below in Section 11.2.1 on the land, soils and geology in the local environment. The effects of the proposed development are considered, having taken account of mitigation measures to reduce or eliminate any residual impacts on the surrounding land, soils, geology and hydrogeology. Land use is addressed in Chapter 13 Landscape and Visual Impact Assessment.

11.2 Methodology

11.2.1 Study Area

The existing Knockharley Landfill facility comprises an area of 135.2 hectares (333-acre site) and has been in operation since 2004. The landfill currently accepts residual household, commercial and industrial wastes together with construction/demolition wastes and incinerator bottom ash (IBA). The site boundary for the existing facility, along with the proposed layout is illustrated in Drawing No.'s LW14-821-01-P-0000-002 Existing Site Layout and LW14-821-01-P-0000-003 Proposed Site Layout in Volume 4 of this EIAR.

A detailed description of the proposed development is provided in Chapter 2 of this EIAR. The development will include intensification of the landfill within its existing permitted footprint, an IBA Facility, a second surface water attenuation pond, wetland and associated infrastructure, a leachate management facility, screening berms, tree felling, replanting and compensation planting, a biological treatment facility and ancillary infrastructure. The study area is defined as all areas within the proposed development footprint.

The current planning permission permits the development of approximately 25 hectares of landfill cells.

11.2.2 Relevant Guidance

The following guidelines were considered in the development of this chapter to identify relevant objectives relating to:

- Environmental Impact Assessment of Projects Guidance on the preparation of the Environmental Impact Assessment Report [1]
- Guidelines on the information to be contained in Environmental Impact Statements [2]
- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements [3]
- Revised Guidelines on the Information to be Contained in Environmental Impact Statements, September 2015 [4]
- Advice Notes for Preparing Environmental Impact Statements Draft September 2015 [5]
- Guidelines on the information to be contained in Environmental Impact Assessment Reports, Draft August 2017 [6]

An assessment of the soils, geology and hydrogeology aspects of the site was undertaken using the following sources of information:

- Geology in Environmental Impact Statements [7]
- Online landslide database [8]
- Online heritage database [9]
- Online Aggregate Potential Mapping database [10]
- GSI Public Data Viewer - www.spatial.dcenr.gov.ie [11]
- OSI Online Historic Maps www.maps.osi.ie/publicviewer/ [12]

- Geology of Meath, Sheet 13 [13]
- NRA Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes [14]
- General Soil Map of Ireland [15]
- Groundwater Protection Scheme for County Meath (on GSI website) [16]
- EPA Envision Map Viewer [17]
- BS 8002:2015 - Code of practice for earth retaining structures [18]
- Control of Groundwater for Temporary Works (CIRIA Report R113) [19]
- Review of previous site investigation reports from 2015 & 2016 for the site:
  - OCM - Tier 3 Risk Assessment 2015
  - Priority Geotechnical – Geophysical Survey 2016
  - Priority Geotechnical – Interpretive Report 2017

11.2.3 Consultation

The scope for this assessment has been informed by consultation with statutory consultees, bodies with environmental responsibility and other interested parties as summarised in Chapter 5 of the EIAR.

Following consultation with the EPA on 29th August 2016, one of the key points raised was the requirement for a hydrogeological risk assessment to be completed as new cells are proposed.

FT consulted the Geological Survey of Ireland (GSI) with regards any potential impacts from the development, however, no response was received. FT has taken the points raised by the HSE, Irish Water and Meath County Council into account during the preparation of this chapter.

11.2.4 Desk Study

Prior to undertaking the site walkover and intrusive site investigations, a desk study was undertaken in order to help determine the baseline conditions within the study area and planning boundary to provide relevant background information.

The desk study included an assessment of the sources of information listed in Section 11.2.2.

11.2.5 Field Assessments

A site walkover was undertaken by FT in June 2016 with an intrusive geotechnical site investigation undertaken by Priority Geotechnical from 5th August to 18th September 2016. The scope of the geotechnical survey is summarised below with the information obtained referenced in this chapter:

- Advancement of 10 No. cable percussive boreholes to a maximum depth of 10m BGL;
- Advancement of 1 No. rotary core borehole to a maximum depth of 30m BGL;
- Installation of groundwater/ ground gas monitoring installations;
- Collection of samples for geotechnical testing; and
- Seismic Refraction Profiling, 2D Electrical Resistivity (ERT) surveying and Multi-Channel Analysis of Surface Wave (MASW) along pre-designated transects in the proposed cell development area to the north and east of the existing landfill.

11.2.6 Evaluation Criteria

During each phase (construction, operation, maintenance and decommissioning) of the proposed development, a number of activities will take place on site, some of which will have the potential to cause impacts on the geological regime at the site and the associated soils, geology and hydrogeology. These potential impacts are discussed in detail in Section 11.4.2.

11.3 Existing Environment

11.3.1 Site Description

The site currently comprises a licensed landfill facility where waste disposal and recovery activities are undertaken with waste acceptance commencing in December 2004. The licensed boundary of the licence facility is shown in red on LW14-821-01-P-0000-002 Existing Site Layout in Volume 4 of this EIAR and the ownership boundary (of Knockharley Landfill Ltd.) is shown in blue. A detailed description of the existing development is outlined in Section 2.2 in Chapter 2 – Description of the Proposed Development of this EIAR.

The site is a mix of, constructed landfill and associated facilities with some woodland and wet grassland. Prior to development as a landfill, the land was used for agriculture and a network of field drains were installed to improve the land. The site is sloped with elevations ranging from 70 mOD in the north west to 55 mOD in the south east of the site.

11.3.2 Overburden Geology

The Teagasc online mapping for the site indicates that the soils underlying the site and the surrounding area mainly comprise poorly drained acidic mineral soils consisting of surface water gleys and groundwater gleys. Gley soils are derived from shale and sandstone parent material and are responsible for the poor drainage characteristics evident in this part of County Meath.

The GSI online Quaternary Geology mapping shows that the overburden consists of glacial till predominantly derived from the underlying Namurian shales and sandstones, with the southern part of the site being underlain by tills derived from Carboniferous limestone. Two narrow swathes of alluvium deposits are identified within the southern section of the site and along the northern boundary, with glacial till derived from the Limestone identified to the south of the site.

This locally thick and continuous till deposit thins in all directions away from the site as bedrock is noted at the surface approximately 1.2 km to the east and west of the site.

A review of historic site investigations pertinent to the development of the original landfill from 2001 has indicated that the glacial tills vary in thickness from 12 to 21.5 m across the site, with the thickest deposits being encountered to the west and thinnest to the east of the site.

The till comprises cobbles and boulders in a silty Clay matrix with minor sand content. The till has a low permeability in the range of 1×10^{-9} m/sec to 4.63×10^{-11} m/sec, determined by permeability testing conducted by K.T Cullen for the EIS submitted as part of the original landfill application in 2001.

This permeability range is further supported by testing completed by Priority Geotechnical in 2016. A total of 9 no. samples selected for testing returned permeability results in the range of 1×10^{-9} m/sec to 7×10^{-11} m/sec. The results indicate that the till has a low permeability which places the Knockharley deposit in the lower range of permeability values for Irish tills.

The development of the existing phases of the landfill has involved excavation into the glacial till. The excavated clays have been re-compacted to form the basal clay liner and have provided material for the various embankments located around the footprint of the site.

The Quaternary Geology of the site and its surrounds is presented in Figure 11.1.

11.3.3 Bedrock Geology

The site lies regionally within the south-eastern limb of a synclinal axis containing the Namurian aged Balrickard Formation. The dip of the rocks within the syncline are variable. The syncline is bounded to the east and west by two northwest-southeast trending faults.

Figure 11.2 shows the bedrock geology underlying the site as described in the "Geology *of Meath"* map (Sheet 13, GSI, 2001). The 1:100,000 scale bedrock map shows that the site is underlain by Carboniferous aged (Namurian) Balrickard Formation described by the GSI as '*coarse feldspathic micaceous sandstone with shale and argillaceous limestone and fossiliferous shale'*. The Balrickard Formation is underlain by similar strata to the north and south belonging to the Donore Formation and passes up into similar rocks of the Walshstown Formation to the northeast.

Bedrock recovered from the boreholes undertaken for the site investigation from 2000 and 2004 comprised fine grained light-coloured sandstone and darker coloured siltstone / mudstone. The elevation of the bedrock surface varies from 40 to 50 mOD, falling away towards the south, following the slope of the topography. The depth to bedrock encountered in the boreholes varies between about 12 m bgl towards the east of the site to about 21.5 m bgl towards the west of the site.

Similar geological characteristics were reported during the 2016 site investigation. Of the 9 no. boreholes advanced in the northern portion of the site, 1 no. borehole reported identifying slate / mudstone bedrock at 17.0m bgl. The geophysical survey indicated a variation in elevation across the bedrock profile from 45 – 60 mOD. The bedrock geology of the site and surrounding area is presented in Figure 11.2.

11.3.4 Geological Heritage

The GSI Online Irish Geological Heritage database indicates that the proposed development area is not located in an area of specific geological heritage interest. The nearest site of significant geological heritage features fields of megafluting, located approximately 800 m to the east of the site. This geological feature covers 115 km^2 area and forms part of the largest field of such features in Ireland.

11.3.5 Economic Geology

The GSI online Aggregate Potential Mapping database indicates that the site is located within an area of high potential for crushed rock aggregate. No other geological features of economic significance were noted within a 2-km radius of the site. The operational Duleek Quarry is located 5.1 km east of the site.

11.3.6 Site Investigations

As part of the initial planning application for the landfill, an intrusive investigation was undertaken in November 2000 by KT Cullen & Co. to confirm the geological succession underlying the site. The investigation comprised the excavation of 20 No. trial pits to a maximum depth of 4.7 m below ground level (bgl), 14 No. shallow shell and augur boreholes to maximum depths 10.0 m bgl and 8 No. deep rotary boreholes to a maximum depth of 30.0 m bgl.

Topsoil was encountered across the site to depths of approximately 1.0 m bgl overlying a low permeability boulder clay encountered across the site to depths ranging from 12.5 to 21.5 m bgl. This predominantly comprised a *Stiff gravelly silty Clay with frequent cobbles, minor sand content and limited sand lenses.*

Bedrock was encountered at eight locations and comprised interbedded siltstone / mudstone and fine-grained sandstones interbedded with siltstone / mudstone. Bedrock cores retrieved from the site investigation described the bedrock as *Fine-grained Light-coloured Sandstone and darker coloured Siltstone / Mudstone.* Where weathered rock head was encountered, the shallow fractures of clay filled to depth of approximately 1 m.

An additional site investigation was undertaken in August 2004 to facilitate the installation of a replacement deeper groundwater monitoring well for MWS16d and 19 No. shallow ground gas monitoring wells. The site investigation revealed low permeability boulder clay across the site to a maximum depth of 12.1 m bgl (MW16d) comprising *Stiff Gravelly Clay with frequent cobbles.*

This was underlain by bedrock comprising *Dark black weathered Siltstone / Mudstone* from 12.1 to 15.6 m bgl, with black Mudstone encountered to 30.0 m bgl.

Geotechnical Site Investigations were undertaken by Priority Geotechnical (PGL) in August and September 2016 to support both the design and planning application for the proposed development. The site investigation comprised the advancement of 1No. rotatory cored borehole (RC01) to 27.0 m bgl and 10 No. shallow shell and auger boreholes (BH01 – BH10) to a maximum depth of 15.0 m bgl.

The site investigation generally encountered overburden comprising *Firm to stiff slightly sandy gravelly Clay* to depths of between 6.0 to 15.0 m bgl in boreholes BH01, BH02 and BH03. Boreholes BH04 to BH10 encountered a *Dense clayey sandy Gravel* between 3.5m bgl to 7.1m bgl. A *Clayey / silty gravelly Sand* was encountered at RC01 from 7.0 to 17.0 m bgl. Bedrock was encountered at 17.0m bgl.

In conjunction with the intrusive site investigation outlined above Priority Geotechnical Ltd undertook a geophysical survey to identify overburden horizons present beneath the site and to confirm the depth to bedrock beneath overburden deposits. The geophysical survey comprised of continuous 2D Electrical Resistivity (ERT), Seismic Refraction Profiling and Multi-Channel Analysis of Surface Wave (MASW) along pre-designated transects in the proposed cell development area to the north of the existing landfill.

Resistivity values for the overburden were generally relatively low, typically ranging between 75 and 100ohm-m, increasing to a maximum of c. 150ohm-m. Resistivity values for the overburden deposits were generally very consistent across the site reflecting overburden to be a relatively homogenous material typical of Glacial Till (Sandy Gravelly CLAY) as encountered during the intrusive investigations.

Seismic velocities were seen to increase rapidly to >1000m/s, indicative of stiff overburden below 2.0m BGL. P-wave seismic velocities ranged from 2000 - 2600m/indicative of a very stiff material. From the findings of the geophysical surveys the thickness of Glacial Till deposits varied between 15 to 20 m but were generally around 17 m in thickness.

P-wave seismic velocity was used to delineate the Glacial Till / Bedrock boundary in areas where a resistivity contrast was not observed. Bedrock was identified by an increase in P-wave velocity to >2900 m/s indicative of fresh rock. The Glacial Till / Bedrock boundary was seen to range in elevation from 42 to 52 m OD across the site. The bedrock was interpreted to comprise a Shale / Mudstone material due to the low resistivity and observed seismic velocity.

The site investigations were generally consistent with the published GSI maps for the region. The site investigation factual report is provided in Appendix 11.1, Volume 3 of this EIAR.

11.3.7 Soil Laboratory Testing

Laboratory testing was scheduled by PGL on behalf of FT. Soil testing was carried out in accordance with BS1377 (1990) - *Methods of Test for Soils for Civil Engineering Purposes*. A total of 125 no. bulk disturbed samples (B), 109 no. small disturbed samples (D) and 9 no. undisturbed clay samples (U) were recovered from the exploratory holes.

11.3.8 Determination of Characteristic Geotechnical Parameters

Topsoil

Topsoil was encountered in eight of the nine exploratory holes to depths of between 0.2 and 0.4 m bgl.

Glacial Till

The Glacial Till Deposits encountered at the site were generally described as *Firm to very stiff slightly sandy gravelly CLAY with low to medium Cobble content*.

Table 11-1: Geotechnical Laboratory Testing

Geotechnical Tests				
Type	**N**	**Min**	**Max**	**Remarks**
Standard Penetration Test (N Value)	91	12	N>50	12 to 82 with refusals (N>50)
Natural Moisture Content	78	11%	34%	Typically, 11% to 18%. Elevated (>20%) in the upper 2.0m.
Atterberg Limits	31	PI8	PI21	Liquid Limit, LL 24% to 51% Plastic Limit, PL 15% to 3% Plasticity Index, PI 8 to 21 Material falls in the low to intermediate plasticity (CL – CI) CLAY range
Particle Size Distribution	47	-	-	Includes 29 No. hydrometer analysis on fine soils
Loss on Ignition	05	1.1%	2.5%	-
Moisture Condition Value (MCV)	20	0	6.5	-
Max dry density/moisture content relationship	14	9%/1.95 mg/m^3	14%/2.11 mg/m^3	-
Permeability in triaxial cell	09	7.26×10^{-10} ms^{-1}	1.12×10^{-10} ms^{-1}	Results are indicative of impermeable 'intact' Clay

The Glacial Till at the site is broadly described as a cohesive deposit, with a plasticity index of PI8 to PI21.

SPT N values were recorded during the site investigation, with N values of between 12 to refusal where N>50 indicating Stiff to Hard cohesive deposits. Based on SPT 'N' values the strength of this deposit is very high and as such, based on Figure 2 in BS8002:2015, the characteristic weight density of the Glacial Till has been taken as 21 kN/m^3.

Soil Classification

Atterberg classification testing was carried out on 31 no. samples of the Overburden Deposits. The results of the Atterberg testing at the site shows the Glacial Till deposits fall within the low and intermediate plasticity (CL – CI) CLAY range. The plasticity index of the samples ranged from 8 to 21%. At borehole BH09 and BH10 in the upper 1.5 m a high plasticity SILT was identified with moisture contents (w) of 34%.

Permeability Parameters

Determination of Permeability in a Triaxial Cell test was undertaken on 8 No. samples of Glacial Till collected during the site investigation.

Direct measurement of permeability (k) in hydraulic triaxial cell indicated values of 7.26×10^{-11} $ms^{-1}$to 1.12×10^{-10} ms^{-1}. This is indicative of impermeable 'intact' Clay deposit (CIRIA 1986).

Moisture Content

Recorded natural moisture content values (*w)* lay within the range 9% to 20% with the exception of shallow Silt Deposits encountered in BH09 and BH10 with a measured natural moisture content of 34%. Dry densities of 90% to 99% maximum dry density were achieved at natural moisture content.

Optimum moisture contents ranged between 9% to 14%. Typically, natural moisture content was 'wet' of the optimum within the range omc+1% to omc+8%.

The moisture content data recorded during the site investigation indicated the glacial deposits at natural moisture content will require to be dried to bring them closer to optimum moisture content prior to reuse during the proposed development.

11.3.9 Soil Contamination

There are no known areas of soil contamination within the proposed development site. No evidence of soil contamination was noted during site walkovers. Historical OSI mapping for the site indicates no evidence of any industrial use for the site with the site comprising agricultural land. As such it is possible that minor fuel spills and leaks have occurred locally in the past.

There was a minor fuel spill on site in 2016 on grass directly adjacent to the bunded fuel storage area. The spill was identified immediately, and a clean-up was carried out with EPA approval.

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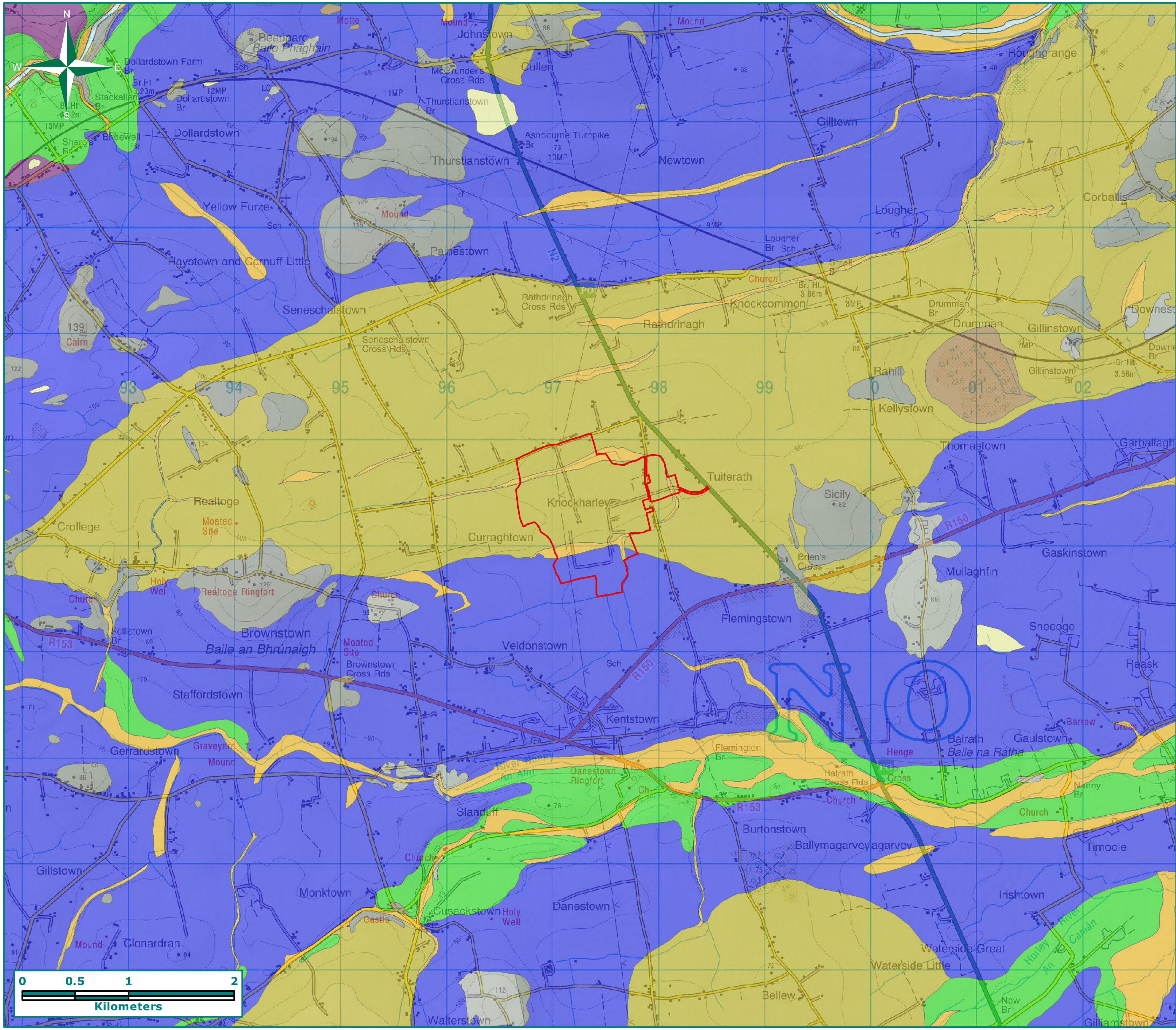


Legend

	Site Boundary

Quaternary Geology

- Alluvium
- Fen peat
- Cutover raised peat
- Gravels derived from Lower Palaeozoic sandstones and shales
- Gravels derived from limestones
- Bedrock outcrop or subcrop
- Karstified bedrock outcrop or subcrop
- Lacustrine sediments
- Till derived from Lower Palaeozoic sanstones and shales
- Till derived from limestones
- Till derived from Namurian sandstones and shales
- Water

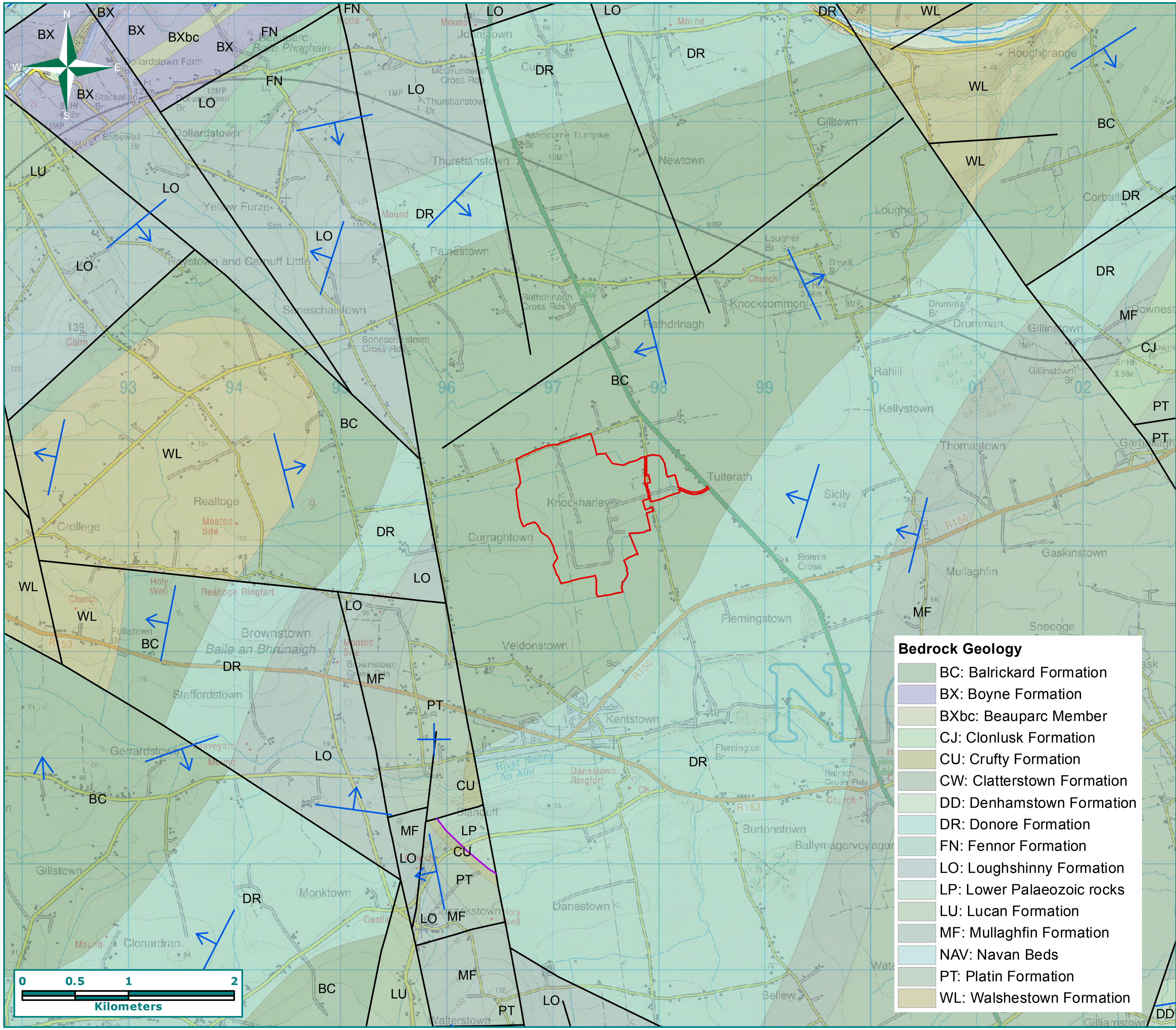
Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Quaternary Geology
Figure No.	11.1
Rev.	A
Scale	1:50,000 @ A4

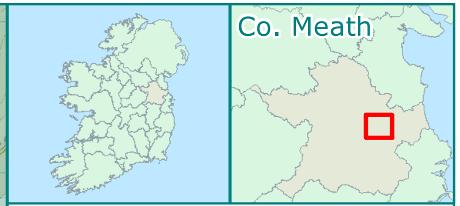
FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES

Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464

Unit 16 J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501

W: www.fehilytimoney.ie E: info@ftco.ie





Legend

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

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Bedrock Geology
Figure No.	11.2
Rev.	A
Scale	1:50,000 @ A4

FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES
Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464
Unit 16 J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501
W: www.fehilytimoney.ie E: info@ftco.ie

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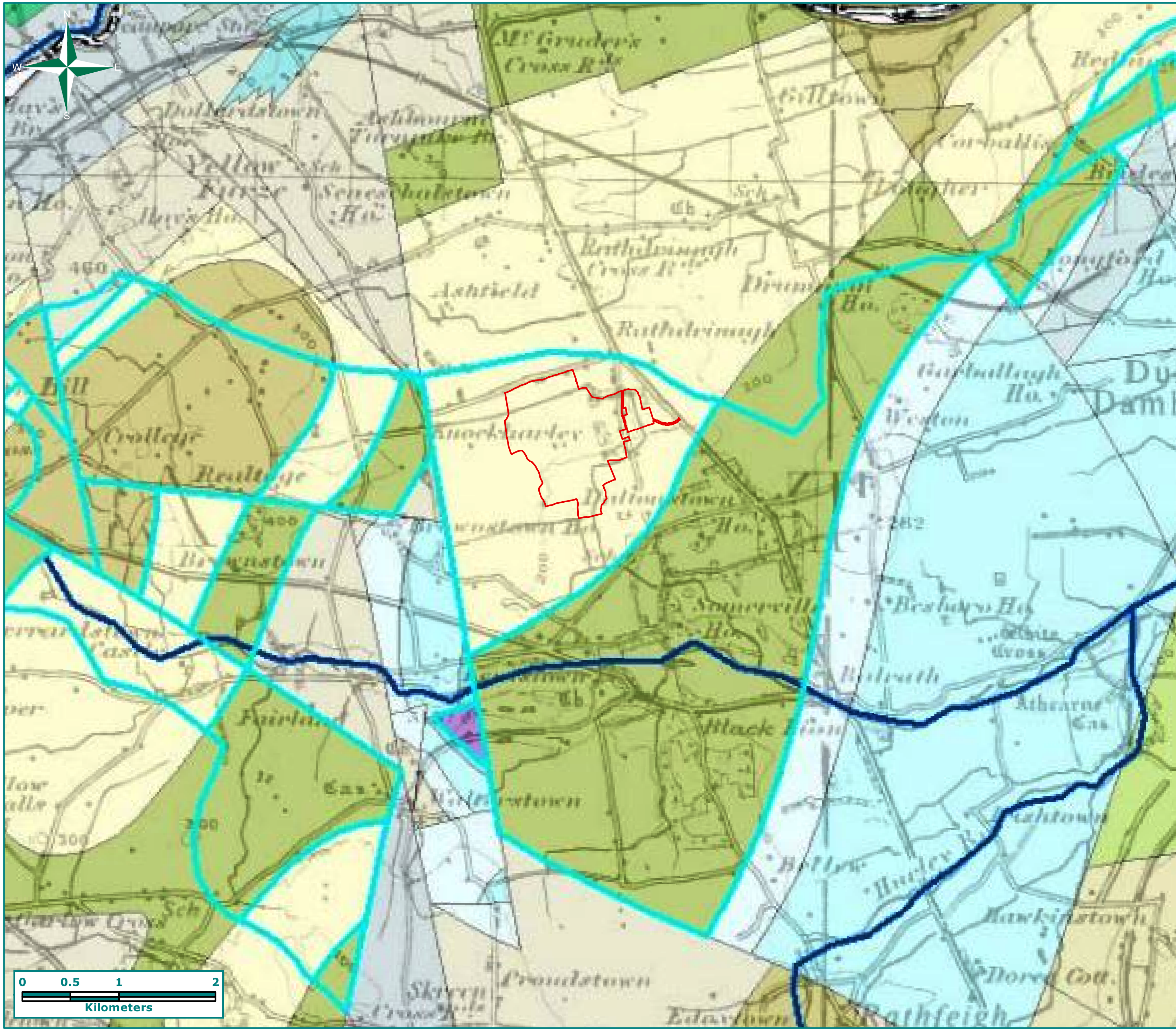
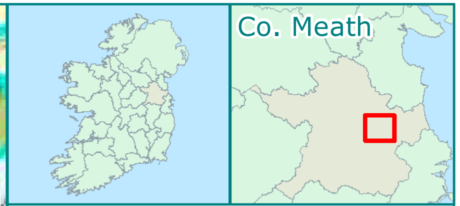




Legend

Site Boundary

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Realtage Groundwater Body
Figure No.	11.3
Rev.	A
Scale	1:55,000 @ A4

FEHILY TIMONEY & COMPANY

CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES

Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464

Unit 16 J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501

W: www.fehilytimoney.ie E: info@ftco.ie

11.3.10 Hydrogeology

Groundwater is an important natural resource, with increasing dependence on it as a drinking water supply source. The Knockharley Landfill site is located within one groundwater body – the Realtage Groundwater Body (GWB) as shown in Figure 11.3 above. This GWB is located in Co. Meath between Navan and Duleek. The area lies on the topographic boundary between the Boyne and Nanny River catchments.

The GSI classifications for the aquifers in the study area, including the principal aquifer characteristics are summarised in Table 11.2, and shown on Figure 11.4. All aquifers in the study area are bedrock aquifers; there are no gravel aquifers within the study area (i.e. a gravel deposit of greater than 1 km^2 with a saturated thickness of greater than 5 m).

Table 11-2: Summary of Aquifer Classifications & Characteristics

Aquifer Name	GSI Aquifer Classification	Groundwater Body	Transmissivity (m^2/day)
Balrickard Formation	Locally important aquifer, moderately productive only in local zones (LI)	Realtage GWB	1 – 10m^2/day

The bedrock aquifer lies within the underlying fine-grained siltstones and mudstones. The bedrock is confined or sealed by the low permeability of the overlying glacial tills (boulder clay). A pumping test undertaken during the site investigation in 2000 at MW16d confirmed these poor aquifer conditions returning less than 10 m^3/day. The aquifer classification for the site is shown in Figure 11.4.

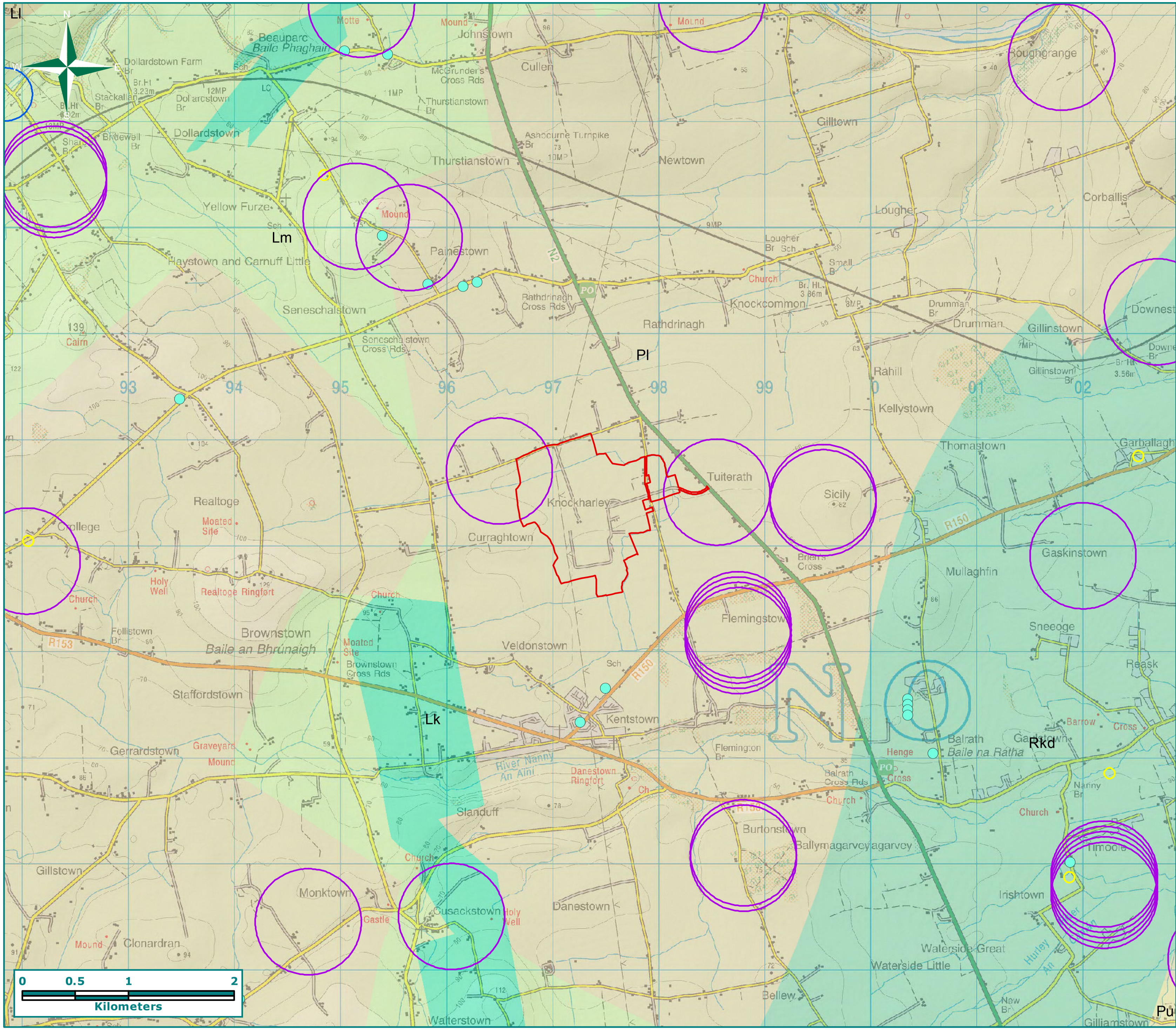
There are no groundwater-sourced drinking water protection areas within the study area. The closest drinking water protection area is the Slane Outer Protection Area located 5.75 km north of the site.

Figure 11.4 also shows the location of groundwater wells included in the GSI dataset. There may be other wells in the study area in additional to those included in the GSI dataset. The available details for these wells are summarised in Table 11.3.

Table 11.3: Abstraction Well Characteristics

BH/Spring	Yield class	Yield (m^3/d)	Use	Depth (m)	Distance from site (km)	Date
2927SWW063	Poor	27.3	-	29	0.3	1962
2925NWW033	Poor	11	-	25.9	0.9	1899
2925NWW027	Poor	32.7	-	18.3	2.1	1969
2925NWW030	Poor	32.7	-	18.6	1.4	1966
2925NWW058	Poor	-	-	-	4.2	1899
2925NWW046	Poor	21.8	Public Supply	24.4	2.9	1966

The GSI lists two wells within 1 km of the site boundary and a further seven wells within a 5 km radius of the site boundary, the majority of which are down-gradient. The well locations are presented in Figure 11.4. Both wells located within 2 km of the site are classified as having poor yields of between 11 – 29 m^3/day. The wells were drilled between 1899 and 1966 and vary in depth between 11 m and 32.7 m with poor yields of between 18 and 29 m^3/d. The known private wells are also identified in Figure 11.4. Mains water is generally available in the area, however, the GSI mapping does indicate that private groundwater wells for residents and farms are apparent.



Legend

- Site Boundary

Aquifer Classification

- Lk: Locally Important Aquifer -
- Ll: Locally Important Aquifer - Bedrock Mod Productive Locally
- Lm: Locally Important Aquifer - Bedrock Generally Mod Productive
- Pl: Poor Aquifer Bedrock Generally Unproductive Except Locally
- Pu: Poor Aquifer Bedrock Generally Unproductive
- Rkd: Regionally Important Aquifer - Karstified (diffuse)
- GW Well (500m-1km Accuracy)
- GW Well (200m-500 Accuracy)
- GW Well (100m-200m Accuracy)
- GW Well (50m-100m Accuracy)
- GW Well (10m-50m Accuracy)

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Client Name	Knockharley Landfill Ltd.
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Figure Title	Aquifer Classification
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FEHILY TIMONEY & COMPANY
CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES
Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464
Unit 16 J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501
W: www.fehilytimoney.ie E: info@ftco.ie

11.3.11 Groundwater Vulnerability

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

The vulnerability of an aquifer to contamination is influenced by the leaching characteristics of the topsoil, the permeability and thickness of the subsoil, the presence of an unsaturated zone, the type of aquifer, and the amount and form of recharge (the hydrologic process where water moves downward from surface water to groundwater). Groundwater vulnerability is determined mainly according to the thickness and permeability of the subsoil that underlies the topsoil, as these properties strongly influence the travel times and attenuation processes of contaminants that could be released into the subsurface from below the topsoil. The type of recharge is also considered where indirect recharge (termed 'point recharge' in Ireland) can occur through swallow holes or sinking streams.

The GSI online groundwater data viewer classifies the site as '*Low Vulnerability'* due to the relatively thick cover of low permeability Glacial Till (boulder clay) in the area. The aquifer vulnerability of the site and surrounding area are shown in Figure 11.5.

A summary of the groundwater vulnerability for the site is presented in Table 11.4. This table outlines the standard ratings of vulnerability used by the GSI, with the existing site conditions highlighted based on the findings of the site investigations.

Table 11.4: Groundwater Vulnerability

Vulnerability Rating	**Hydrogeological Conditions**		
	Subsoil Permeability (Type) and Thickness		
	High Permeability (Sand/gravel)	**Moderate Permeability (e.g., Sandy soil)**	**Low Permeability (e.g., Clayey subsoil, clay, peat)**
Extreme (E)	0 - 3.0 m	0 - 3.0 m	0 - 3.0 m
High (H)	> 3.0 m	3.0 -10.0 m	3.0 - 5.0 m
Moderate (M)	Not applicable	>10.0 m	5.0 - 10.0 m
Low (L)	Not applicable	Not applicable	**>10 m**

The GSI's Response Matrix for Landfills combines the aquifer vulnerability, and the classification of the aquifer (Pl), to give a response for site suitability for landfills. Table 11.5 below details the response matrix for landfills under the GSI guidelines.

Table 11.5: GSI Guidelines – Response Matrix for Landfills

Vulnerability Rating	**RESOURCE PROTECTION**					
	Aquifer Category					
	Regionally Important (R)		Locally Important (L)		Poor Aquifers (P)	
	Rk	**Rf / Rg**	**Lm/Lg**	**Ll**	**Pl**	**Pu**
Extreme (E)	R4	R4	R3[2]	R2[2]	R2[1]	R2[1]
High (H)	R4	R4	R3[1]	R2[1]	R2[1]	R1
Moderate (M)	R4	R3[1]	R2[2]	R2[1]	R2[1]	R1
Low (L)	R4	R3[1]	R1	R1	**R1**	R1

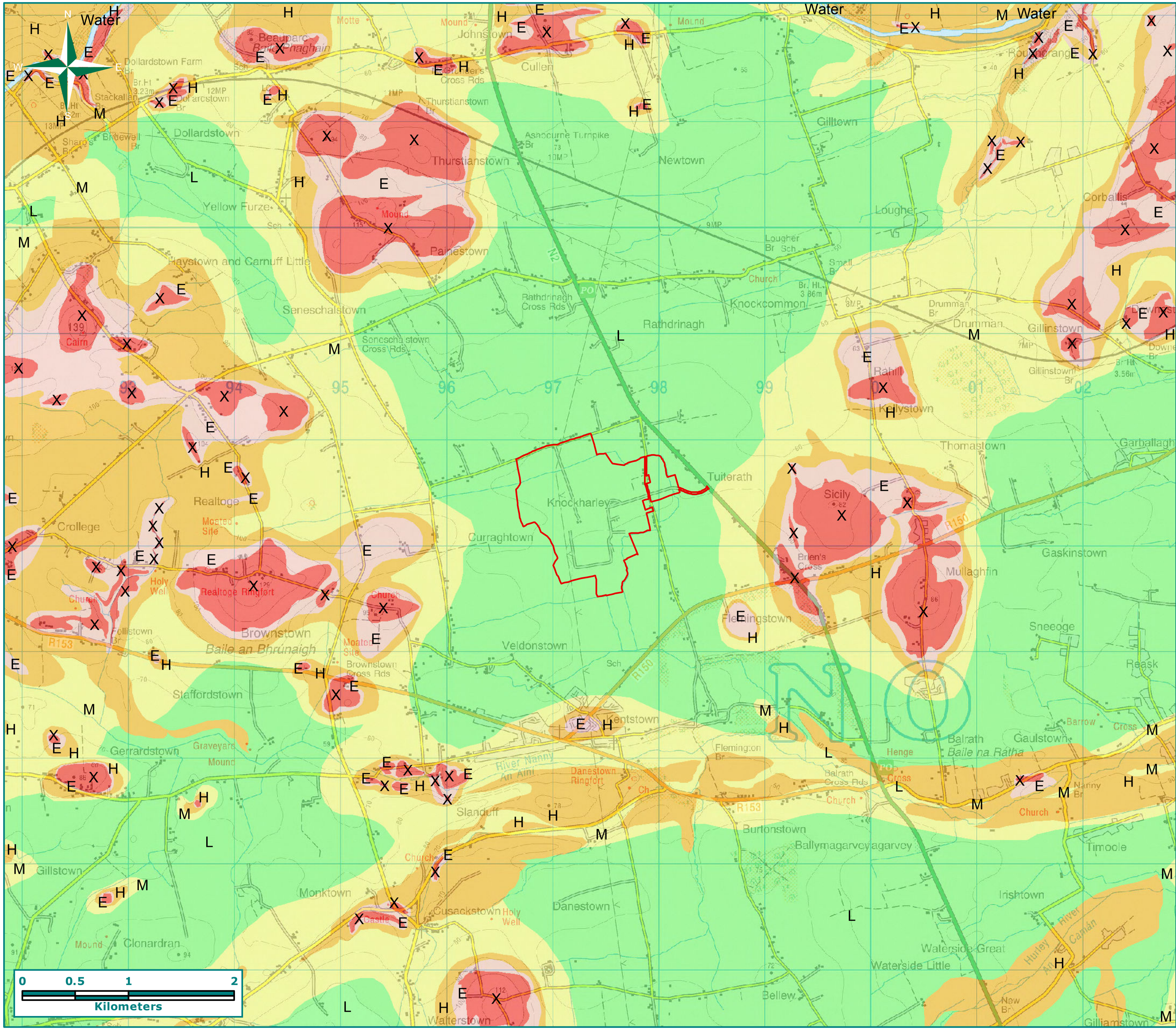
Thus, a resource protection response of R1 is adopted. That is, the landfill development is acceptable subject to guidance in the EPA Landfill Design Manual (CAREY, P et al., 2000) or (for R2[1] areas) to the following conditions of the waste licence:

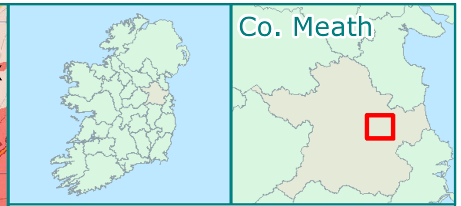
a) attention to be given to the presence of high permeability zones, existing wells and future aquifer development

No high permeability zones of significance were encountered during the geotechnical site investigations from 2000 and 2016. Site investigations have confirmed thicknesses of >10m of low permeability Glacial Till deposits overlying bedrock at the site.

The existing groundwater wells on site are monitored on a regular basis in accordance with the IE licence. Furthermore, a new groundwater monitoring well has been installed as part of this development downgradient of the proposed IBA Facility and Leachate Facility and will be monitored on a quarterly basis in accordance with the IE licence. The low productivity of the bedrock aquifer excludes it from significant future development or abstractions.

Map: R:\Map Production\2014\LW14\821\01\Workspace\MXD\EIS\LW14-821-01_Fig11-5_GroundwaterVulnerability_A4.mxd





Legend

Site Boundary

Groundwater Vulnerability

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

Date	18/05/2018
Client Name	Knockharley Landfill Ltd.
Project Title	Proposed Development at Knockharley Landfill
Figure Title	Groundwater Vulnerability
Figure No.	11.5
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FEHILY TIMONEY & COMPANY

CONSULTANTS IN ENGINEERING & ENVIRONMENTAL SCIENCES

Core House, Pouladuff Road, Cork, T12 D773, Ireland
T: +353-21-4964133, F: +353-21-4464

Unit 16 J5 Plaza, North Park Business Park, Dublin 11, D11 PXTO, Ireland
T: +353-1-6583500, F: +353-1-6583501

W: www.fehilytimoney.ie E: info@ftco.ie

11.3.12 Water Framework Directive Status and Risk Assessment

The Water Framework Directive (WFD) (2000/60/EC) was adopted by the (then entitled) European Community in 2000. This Directive was transposed into Irish law from December 2003 by, *inter alia*, the European Communities (Water Policy) Regulations 2003, (S.I. No 722 of 2003) and subsequent amendments. The first cycle ran from 2009-2015. The Directive runs in 6-year cycles (2016-2021). A draft second cycle River Basin Management Plan was published for public consultation in August 2017 and the finalised second cycle River Basin Management Plan for Ireland 2018-2021 is in place. This plan includes measures for the projection of groundwaters.

The overriding purpose of the WFD is to achieve at least "good status" in all European waters and ensure that no further deterioration occurs in these waters. European waters are classified as groundwaters, rivers, lakes, transitional and coastal waters. The first cycle of river basin management planning, which covered the period 2009-2015, developed plans and associated programmes of measures on the basis of eight River Basin Districts (RBDs) within the island of Ireland. These plans set ambitious targets that envisaged that most water bodies would achieve good status by 2015.

This second cycle plan aims to build on the positive aspects of the first cycle and learn from those aspects which did not progress as well as expected which are summarised as three key learnings.

The proposed development site is underlain by the Realtage GWB (IE_EA_G_020) as presented in Figure 11.3. This groundwater body achieved "good status" during the later stages of the first round of assessments as updated in May 2015[1].

11.3.13 Groundwater Quality

Information obtained from the GSI Groundwater Data Viewer indicates that the groundwater in this region is expected to be soft to moderately hard with a calcium bicarbonate signature. However, monitoring of the deep boreholes on site revealed hardness (as $CaCO_3$) ranging from 250 – 382 mg/l, indicating moderately hard to hard water. Alkalinity (as $CaCO_3$) was classified as high, returning concentrations ranging from 177 to 304 mg/l. Additionally, given the presence of the underlying Balrickard Formation Aquifer, the groundwater is expected to be siliceous.

Groundwater monitoring was undertaken to establish baseline conditions for the site in 2000 prior to the acceptance of waste. Monitoring was undertaken in both shallow and deep boreholes across the site. The groundwater in the overburden is characterised by naturally elevated sodium, potassium and sulphate levels.

These, together with high manganese and low nitrate levels are indicative of reducing levels in the low permeability till. There are also some levels of cation exchange taking place, which again suggests slow groundwater movement and long resistance time.

The groundwater in the bedrock displays a similar natural groundwater signature to the overburden groundwater with elevated sodium, potassium and sulphate levels. The presence of a thick, low permeability till layer overlying the bedrock aquifer is reflected in the low total organic carbons, chloride and nitrate values. The elevated manganese levels again are a characteristic of the Namurian rock type with the reducing conditions encouraging the mobilisation of this metal in the groundwater regime.

11.3.14 Groundwater Monitoring

Groundwater quality and groundwater level monitoring has been undertaken in accordance with Schedule D of the EPA licence since 2003. In accordance with the licence, groundwater trigger levels (GTLs) were set for the site, and monitoring results are compared to those GTLs. In the event of adverse impact from the landfill activity on groundwater, it would be reflected by differences between up-gradient and down-gradient analytical results. Groundwater flows on the site from northwest to southeast. Groundwater wells MW1d, MW2d, MW3d and MW7d are located up-gradient of the landfill and MW5d, MW6d, MW16d and MW17d are located downgradient of the landfill. The locations of the monitoring wells are shown on Drawing No. LW14-821-01-P0050-001 in Volume 4 of this EIAR.

[1] EPA 2015 Water Quality in Ireland 2010 - 2012 https://www.epa.ie/pubs/reports/water/waterqua/wqr20102012/WFD_GWBStatus.xls

The groundwater monitoring laboratory results from 2011 – quarter 3 2018 are presented in Appendix 11.2, Volume 3 of this EIAR. These results have been compared to site GTL's and the overall threshold values (OTVs) from the European Communities Environmental Objectives (Groundwater) Regulations 2010 as appropriate.

Quarterly field parameters (pH, electrical conductivity, dissolved oxygen) have remained stable overall and within normal values for groundwater. The laboratory results have indicated that elevated ammoniacal nitrogen levels are present in almost all the wells. While occasionally they exceed the OTV for groundwater, the trigger level has never been exceeded. Given that the higher ammonia values are in up gradient wells (MW-1d and MW-7d) any such elevated levels are not associated with the landfill and are attributable to the naturally occurring reducing conditions. Chloride has remained stable and below trigger levels during the monitoring period.

Iron was above site trigger levels in 2012, 2013, 2014 across all wells on site and above site trigger levels at well MW2D in Q2 2015. However, it has remained below site trigger levels at all wells in the remainder of the period. Elevated iron levels can often occur due to groundwater movements through geological formations. Furthermore, sodium has remained stable and below site trigger levels.

Potassium had slight exceedance of at screening criteria at MW1d and MW3d on several occasions, but both are up-gradient of the landfill. The results were otherwise below the site trigger levels.

Total Oxidised Nitrogen and Total Organic Carbon have remained stable and low across all wells on site. Phenol results were below the laboratory limit of detection (LOD), while coliforms (faecal and total) results were variable for this period but have been detected historically at all wells on site.

For annual parameters, whilst variations were noted for metals, they have remained relatively stable and most results were recorded at low levels or below the laboratory LOD for the period. Results overall in up gradient and downgradient wells remained relatively stable. Pesticides overall have remained at low levels or below the laboratory LOD during the annual rounds 2011-2018.

Based on the results from 2011-2018, similar concentrations across all parameters tested were detected in both the up-gradient and down-gradient boreholes, therefore indicating that site activities are not impacting on the groundwater quality.

A new groundwater monitoring well was installed in August 2016, as part of the site investigation works (MW17d). It is located downgradient of the proposed IBA Facility. Quarterly monitoring of baseline conditions commenced in Q3 of 2017 and will be included in the amended licence for the site. To date, all parameters tested under the sample testing schedule have remained stable overall and within GTL's set for the site and OTV limits for groundwater quality.

A groundwater risk assessment was completed in February 2015 which assessed the landfill design and construction, including remedial measures, the type and age of the waste, the geological and hydrogeological conditions and any sensitive receptors.

This investigation concluded there was no evidence that the landfill has impacted on groundwater quality down gradient of the site and the engineered landfill liner and 10-20m of low permeability subsoil provide sufficient protection to ensure that the groundwater resource, albeit of limited value, is protected from future impacts.

11.3.15 Material Balance, Storage and Re-Use

The quantities of material to be excavated and utilised for the proposed Knockharley Landfill are presented below in Table 11.6.

Table 11-6: Proposed Excavation and Filling Volumes

Proposed Development	Development Stage	Cut Volume (m^3)
MSW Cells	Phase 5: Cell 17 - 20	285,897
	Phase 6: Cell 21 - 24	209,521
	Phase 7: cell 25 - 28	165,673
	Additional Cut for Cell Liner	122,871
IBA Facility	IBA Cells 29 - 33	153,316
	Additional Cut for Cell Liner	60,067
Biological Treatment Plant	Building Plan & Hardstanding Area	38,628
Leachate Plant	Lagoons & Leachate Holding Tanks	41,394
Surface Water Attenuation Pond & Holding Pond	Lower Pond 1 & Upper Pond 2	40,128
Wetlands	Low lying area below Lower Pond 1	7,980
	Total Cut Volume	**1,125,475**
Proposed Development	**Development Stage**	**Fill Volume (m^3)**
Screening Berms	10 m Eastern Berm	217,910
	6 m Eastern Berm	12,755
	Western Berm	513,107
	Total Fill Volume	**743,772**

The total quantity of soil to be excavated for the development of the proposed MSW landfill, IBA Facility, Attenuation Pond and Holding Pond, Biological Treatment Facility, Leachate Facility and ancillary services is estimated to be approximately 1,125,475 m^3.

The total quantity of overburden material required for the construction of the proposed screening berms is estimated to be approximately 743,772 m^3.

The estimated volume of available overburden material from the development of MSW Cells 17 - 28 and the IBA Facility is outlined in Table 11.7 over. Note, the quantity of suitable recoverable Clay material for lining is based on a 40% reduction of the recovered volume.

Table 11-7: Estimated Overburden & Boulder Clay Recovery

Development Phase	Cells	Overburden Volume (m³) above 4.0m bgl	Overburden Volume (m³) below 4.0m bgl	Volume (m³) suitable for use in lining
MSW Phase 5	17	35,102	45,148	18,059
	18	35,102	45,148	18,059
	19	35,102	45,148	18,059
	20	35,102	45,148	18,059
MSW Phase 6	21	35,107	26,050	10,420
	22	35,107	26,050	10,420
	23	35,107	26,050	10,420
	24	35,107	26,050	10,420
MSW Phase 7	25	35,113	15,084	6,033
	26	35,113	15,084	6,033
	27	35,113	15,084	6,033
	28	35,113	15,084	6,033
Total	17 – 28	421,288	345,125	138,050

Development Phase	Cells	Overburden Volume (m³) above 3.0m bgl	Overburden Volume (m³) below 3.0m bgl	Volume (m³) suitable for use in lining
IBA Facility	29	18,020.10	3,318	1,327
		18,020.10	3,318	1,327
	30	18,020.10	3,318	1,327
		18,020.10	3,318	1,327
	31	18,020.10	3,318	1,327
		18,020.10	3,318	1,327
	32	18,020.10	3,318	1,327
		18,020.10	3,318	1,327
		18,020.10	3,318	1,327
Total	29 – 32	144,161	26,546	10,618
Total	MSW + IBA	565,449	371,671	148,668

Engineered Clay Liner

As can be seen in Table 11.7, the quantity of suitable Boulder Clay material for the engineered clay liners, following a conservative 40% reduction factor for aggregate screening, returns a potential recoverable volume of 148,668 m^3. Preliminary calculations show approximately 153,375 m^3 of suitable Glacial Till will be required for the engineered clay liners at both MSW and IBA areas.

The above conservative estimate indicates a volume shortfall of 4,707 m^3 may arise during the recovery process. Therefore, a requirement to import the remaining Clay liner material to satisfy this shortfall may be needed. It should be noted that the re-use potential of the recovered Glacial Till will be subject to further in-situ testing before being placed in layers and compacted to 95% maximum dry density.

Capping

The quantity of overburden material required for capping the MSW and IBA cells is estimated to be approximately 148,850 m^3. Future permanent capping will continue on a phased basis during the development of the IBA and MSW cells where suitable capping material will be recovered.

Table 11.8 outlines the capping and clay liner requirements for the MSW Cells and IBA Facility.

Table 11-8: Proposed Capping and Clay Liner Requirements

Development Stage	Development Stage	Net Volume (m^3)
MSW Cells 17 - 28	Capping	94,789.80
	Engineered Clay Liner	105,322.00
IBA Facility	Capping	54,060.30
	Engineered Clay Liner	48,053.60

Stockpile Survey 2018

An updated topographical survey was completed in January 2018 of the existing overburden stockpile located in the north-western portion of the site. The results of the survey indicate approximately 20,886 m^3 of soil material remain available for use as capping or developing the screening berms.

Screening Berms

The proposed perimeter screening berms will be constructed using excavated overburden material from the proposed development areas.

Table 11.9 below summarises the overburden material balance available for developing the screening berms.

Table 11-9: Proposed Capping and Clay Liner Requirements

Development Stage	Net Volume (m^3)
MSW Cells 17 - 28	565,449
IBA Cells 29 - 32	
Biological Treatment Plant	128,130
Leachate Facility	
Surface Water Attenuation Pond and Holding Pond	
Wetlands	
2018 Stockpile Survey	20,886
Total	**714,465**

The overburden balance in Table 11.9 presents a total overburden volume of 714,465 m^3.

Of the recovered overburden material available, 148,850 m^3 will primarily be used as capping for the proposed MSW and IBA cells. Deducting the capping volume required, the quantity of overburden material available for developing the screening berms is estimated to be approximately 565,615 m^3.

Overall, the material balance indicates a shortfall of approximately 178,175 m^3 will be encountered when assessed against the proposed screening berm design. In view of the shortfall identified, FT has considered the following options with respect to berm construction:

- In the event of a need for future cell development, an opportunity is presented to place recovered overburden in the locations where a shortfall is identified;
- Reduce the scale of the western screening berm volume.

Phasing & Material Use:

Overburden to a maximum depth of 4.0 m bgl will be recovered from the excavation of the MSW & IBA areas and will be used for construction and landscaping the screening berms along the western and north-east boundaries of the site. Engineered Clay Liner material will be won from the underlying Glacial Till excavated from approximately 3m to 7.0m bgl during development of the MSW Cells and IBA areas to form the engineered clay liner for both developments.

The construction works phasing for the proposed landfill development will progress in sequence through 4 no. separate phases (Phase 1 to Phase 4) and will involve a combination of cutting and filling measures.

Each phase of material removal and the materials end-use is detailed below in Table 11.10. Note, phasing is assumed to proceed in 2-year intervals subsequent to planning approval.

All recovered overburden will be directed to the screening berms in a phased sequence referenced Berm A to Berm E. The screening berm layout and material phasing is illustrated Drawing LW14-821-01-P-0050-011, Volume 4 of this EIAR. Final berm heights may vary to below the maximum 10.0m level subject to volumes of surplus material recovered during the works.

Table 11-10: Construction Phasing Sequence

Construction Phase	Development Stage	Cut Volume (m^3)	Area of development (m^2)	Volume of Overburden (m^3)	Volume of Boulder Clay (m^3)	Material Re-Use	
						ECL Volume (m^3)	Screening Berms (m^3)
Phase 1 (Year: 0, 1 & 2)	MSW: Cell 19 & 20	160,500	17,551	70,204	90,296	36,118	70,204
	MSW: Cell 21 & 22	122,314	17,554	70,214	52,100	20,840	70,214
	MSW: Cell 28	50,197	8,778	35,113	15,084	6,033	35,113
	IBA: Cell 29 & 1/2 of 32	64,015	18,020	54,060	9,955	3,982	54,060
	Biological Treatment Plant	32,308	16,160	32,308	-		32,308
	Leachate Lagoon L3	9,314	4,657	9,314	-		9,314
	Leachate Treatment Yard	2,000	2,500	2,000			2,000
	Surface Water Attenuation Pond and Holding Pond	40,131	13,200	40,131	-		40,131
	Wetland	7,980		7,980			7,980
					Total Volume	**66,973**	**321,321**
Phase 2 (Year: 3 & 4)	MSW: Cell 24, 26 & 27	161,550	26,333	105,333	56,217	22,487	105,333
	MSW: Cell 17 & 18	160,500	17,551	70,204	90,296	36,118	70,204
					Total Volume	**58,605**	**175,537**
Phase 3 (Year: 5 & 6)	MSW: Cell 23 & 25	111,354	17,555	70,220	41,134	16,453	70,220
	IBA: Cell 30	42,677	12,013	36,040	6,636	2,655	36,040
					Total Volume	**19,108**	**106,260**
Phase 4 (Year: 7 & 8)	Leachate Lagoon L2 & L4	30,080	15,040	30,080	-	-	30,080
	IBA Cell 31, 1/2 of 32	64,015	18,020	54,060	9,955	3,982	54,060
					Total Volume	**3,982**	**84,140**

*Note: ECL - Engineered Clay Liner

11.4 Potential Impacts

The main characteristics of the proposed Knockharley Landfill development that could impact on soils, geology and hydrogeology in the absence of mitigation are:

1. Construction and operation of new dedicated cells for the acceptance and placement of non-hazardous incinerator bottom ash (IBA), until the cells are full.
2. Construction and operation of a biological treatment facility.
3. Expansion of the existing leachate management infrastructure comprising plant, storage tanks and lagoons, and associated ancillary equipment, for leachate treatment/conditioning prior to off-site treatment.
4. Development of screening berms along the western, southern and north-eastern flanks of the site to a maximum height of 10 m.
5. Development of a surface water attenuation pond, holding pond, compensatory flood plain and wetland and associated drainage infrastructure.
6. Overburden topsoil and subsoil excavation / reuse.
7. Temporary material storage areas.
8. Felling and re-planting of trees (as per normal commercial forestry lifecycle).
9. Relocation of an existing 20 kV ESB powerline to facilitate screening berm development.

The material balance will be managed by the creation of screening berms.

Mitigation measures to minimise these potential impacts are described in the following section.

11.4.1 Do Nothing Impact

If the proposed development were not constructed, it is likely that the facility will continue to operate as a landfill as permitted. The impact on the land, soils, geology and hydrogeology would remain largely unaltered as a result.

11.4.2 Impact Appraisal Methodology

The following elements of the development were examined to determine the potential impacts on the soils, geology and hydrogeology underlying the site:

- characterisation of the soils, geology and hydrogeology of the site
- evaluation of the risks and potential impacts of the proposed development

The following sections detail the potential impacts that have been identified from the appraisal methodology presented above. Appropriate mitigation measures are then proposed to avoid or adequately mitigate these impacts.

11.4.3 Assessment of Significance of Impact on the Receiving Environment

An impact rating has been developed for each of the phases of the proposed development based on the IGI Guidance for the preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements (IGI 2013). In line with IGI Guidance the receiving environment (Geological Features) was first identified, then the importance of the geological features is rated (Table 11-10) followed by an estimation of the magnitude of the impact (Table 11-11). This determines the significance of the impact prior to application of mitigation measures as set out in Table 11.12.

Table 11.11: Importance Rating Site Attributes of Soils, Geology and Hydrogeology (NRA, 2008)

Importance	Criteria
Extremely High (Hydrogeology only)	Attribute has a high quality or value on an international scale.
Very High	• Attribute has a high quality, significance or value on a regional or national scale. • Degree or extent of soil/ groundwater contamination is significant on a national or regional scale. • Volume of peat and/or soft organic soil underlying the site is significant on a national or regional scale.
High	• Attribute has a high quality, significance or value on a local scale. Degree or extent of soil contamination is significant on a local scale. • Volume of peat and/or soft organic soil underlying the site is significant on a local scale.
Medium	• Attribute has a medium quality, significance or value on a local scale. Degree or extent of soil contamination is moderate on a local scale. • Volume of peat and/or soft organic soil underlying the site is moderate on a local scale.
Low	• Attribute has a low quality, significance or value on a local scale. • Degree or extent of soil contamination is minor on a local scale. • Volume of peat and/or soft organic soil underlying the site is small on a local scale.

The assessment of the magnitude of an impact incorporates the timing, scale, size and duration of the potential impact. The rating criteria for soil, geological and hydrogeological impacts are defined as set out in Table 11.11.

Table 11.12: Estimation of Significance of Impact on Soils, Geological and Hydrogeology (TII/NRA, 2008)

Magnitude	Criterion
Large Adverse	Results in loss of attribute and/or quality and integrity of attribute
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity
Minor Beneficial	Results in minor improvement of attribute quality
Moderate Beneficial	Results in moderate improvement of attribute quality
Major Beneficial	Results in major improvement of attribute quality

The matrix in Table 11.12 determines the significance of the impacts based on the importance and magnitude of the impacts as determined by Tables 11.10 and 11.11.

Table 11.13: Ratings of Magnitude of Significant on Soils, Geology and Hydrogeology (NRA, 2008)

Importance of Attribute	Magnitude of Impact			
	Negligible	Small Adverse	Moderate Adverse	Large Adverse
Extremely High (Hydrogeology only)	Imperceptible	Significant/ Moderate	Profound/Significant	Profound
Very High	Imperceptible	Significant/ Moderate	Profound/Significant	Profound
High	Imperceptible	Moderate/ Slight	Significant/ Moderate	Profound/Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight/Moderate

11.4.4 Potential Impacts During Construction

The characteristics of the proposed development that could pose potential impacts to soils, geology and hydrogeology in the absence of mitigation are outlined in this Section. In general, the potential impacts on soils and geology typically associated with cell construction include slope stability, excavation of soils for the various proposed infrastructure, use of concrete for foundations, use and storage of fuels presenting a contamination risk and erosion of soils exposed during earthworks and tree felling/replanting.

11.4.4.1 Construction Impacts on Soils and Geology

The following on-site activities have been identified as the sources of potential risks to soils and geology from the development:

Forestry Felling

The forestry in Knockharley is commercial forestry and will be felled and replanted as per the normal commercial forestry cycle regardless of the proposed development.

The proposed development includes the development of screening berms of the northern and western boundaries of the site and to facilitate it, felling is required. The berms will be replanted.

Forestry felling, if not properly mitigated, could cause or contribute to ground condition instability due to ground vibration and ground loading from tree felling equipment. However, given the relatively flat topography of the proposed felling area and the absence of peat ground conditions, the potential impact of forestry felling on soils and geology is considered to be minimal. Appropriate specific mitigation measures will nonetheless be implemented in respect of forestry felling, to minimise any potential for impacts on geology, including best practice felling methodologies and monitoring.

Overburden Excavation

The potential impact to soils and geology is limited to the excavation and removal of topsoil and subsoil during the construction phase of the IBA Facility, northern Surface Water Management infrastructure, leachate management facility, biological treatment facility and ancillary infrastructure including roads, drainage, etc. The development of the IBA facility will involve a significant amount of excavation works comprising the removal of till material to a depth of approximately 7.0m BGL across an area of 57,829m^2 (excluding 'wedge' infill).

Direct impacts additional to the excavation of materials which may occur during the construction of the proposed development include:

- Soil erosion as a result of earthworks, excavations and temporary storage of excavated materials represents a potential source of impact. Control of both erosion and sediment entrainment in runoff will be a key undertaking for the duration of the project.
- Use of construction plant and associated use and storage of fuels and hydrocarbons with potential for spills or leaks could cause soil and groundwater contamination. Depending on the size of the spillage, unmitigated, a fuel spill has the potential to require intervention to remove contamination which includes the removal of soils to a disposal unit which is licenced for to accept this waste.
- Excavated soils can become exposed to erosion from wind and rain which, if unmitigated, this may lead to breakdown of the soils and in the case of excavated cohesive soils may lead to them changing from acceptable soils for re-use (e.g. engineered clay liner) to unacceptable soils which require use on screening berms or possibly disposal.

Clay barrier material will be won from underlying boulder clays excavated from the MSW and IBA cells. Boulders within the excavated clay will be removed via screening and engineered clay will be placed in layers and compacted to 95% maximum dry density.

Furthermore, the overburden will be excavated to varying depths in the areas for the ancillary facilities and their associated services such as the biological treatment facility, leachate treatment plant, leachate lagoons and surface water attenuation pond and holding pond. This will expose the underlying glacial till to erosion from storm water run-off at active areas of the site.

The movement and management of the excavated material will be a major operation with the excavated soils and till stored and reused for screening berms and landscaping onsite and as capping material. The material excavated on site should be sufficiently segregated and stockpiled for reuse.

Soil compaction may occur due to movement of construction and maintenance traffic. This will occur particularly within areas of topsoil which are highly compressible. This could lead to an increase in runoff and subsequently to an increase in erosion.

The magnitude of these potential impacts, prior to mitigation, is considered to be of moderate significance.

11.4.4.2 Construction Impacts on Hydrogeology

A significant proportion of the glacial till will be removed during the construction phase of the proposed development.

This may result in the exposure of the weathered bedrock to sources of contamination and may temporarily increase the vulnerability of the aquifer whether or not the rock is exposed. However, given that 10m - 15m of glacial till is present below the site the impact is unlikely to occur.

If the proposed IBA cells and ancillary infrastructure are not constructed and operated in accordance with the IE licence conditions', there is potential for groundwater contamination as a result of leachate contamination. The proposed development will be designed in accordance with EPA guidance, best practice and best available technique reference notes (BREF) and will be subject to EPA approval prior to construction and CQA and EPA approval of same post construction prior to operation. It is described in Chapter 2 of Volume 2 of this EIAR.

Dewatering may potentially be required during the construction stage if high groundwater is encountered during excavation. There will be no direct impacts on hydrogeology as a result.

Chemical pollution may occur in the absence of mitigation as a result of spillage or leakage of chemicals, runoff from vehicle washing facilities, unset concrete, storage of fuels or refuelling activities etc.

The construction works may impose hydrogeological impacts in the absence of mitigation by modifying the natural seepage of the soils, which may deprive ditches and streams of their natural supply of water which may lead to a reduced baseflow and reduced recharge to the bedrock aquifer.

The excavation into the glacial till will result in some local lowering of the shallow subsoil water table and the piezometric surface in the bedrock. However, these groundwater levels will revert to the pre-construction situation when there is no longer a requirement to manage the level of the shallow overburden water table within the footprint area.

The construction of additional drainage channels and other infrastructure may result in localised drawdown of the water table and, where gravel is used during construction, may also result in localised preferential drainage pathways. The changes in the drainage regime may also result in changes to the moisture content of the soils which may have implications for ecology (described in Chapter 10 Biodiversity), sediment transport, flooding and erosion (described in Chapter 12 Surface Water Quality and Drainage).

The magnitude of these potential impacts, prior to mitigation, is considered to be of slight significance.

11.4.5 Potential Indirect Impacts During Construction

Minor amounts of granular material may be required for the construction of the biological treatment facility, leachate treatment plant and construction & maintenance of new site tracks during operation which will place intermittent minor demand on local quarries. Concrete works required for the biological treatment facility and leachate treatment plant will typically require local excavations, drainage and suspended solids management for dig and concrete pours and into which structures will be built requiring placement of blinding, shutters, reinforcement and final concrete pour.

Dewatering may potentially be required during the construction stage if high groundwater is encountered during excavation. In the absence of mitigation, there could be an indirect impact on local stream levels of groundwater wells.

11.4.6 Potential Cumulative Impacts During Construction

The surrounding area predominantly comprises agricultural farmland with no other significant industries identified. Furthermore, given the resultant moderate / slight significant impact of the potential development, there would be no cumulative impact on the geology and hydrogeology of the site.

There may be indirect cumulative impacts in terms of demands placed on local quarries for aggregate and concrete required during the construction phase of the development.

As a result, the proposed development at Knockharley Landfill is not expected to contribute to any significant, negative cumulative effects with other existing or proposed developments in the vicinity. The effective implementation and efficacy of the mitigation measures will prevent a significant release of silt into the receiving watercourses and/or the avoidance of spills/leaks. In these circumstances, any effects on the receiving environment would be negligible.

11.4.7 Summary & Discussion of Potential Direct Impacts During Construction

The following construction stage potential impacts for the proposed development are summarised below:

Soils and Geology

- Possible contamination, by leakage and spillage of soil, may occur from mobile plant and associated equipment during the construction phase only, where soil is excavated and transported to another area. This may lead to contamination of surface water features with increased concentrations of suspended solids.
- Transfer of suspended solids in natural water courses leading to siltation of stream beds with subsequent implications for fauna and flora as well as increased flood risk.
- Movement of construction traffic or construction of temporary access roads may lead to compaction of the soil reducing soil permeability and rainfall infiltration. This could lead to an increase in run-off and a subsequent increase in erosion.

Hydrogeology

- During the construction stage there is potential for contamination of groundwater from spillages of fuels and lubricants from construction machinery.
- During the construction phase, there may be a requirement for dewatering of excavations. This may have an indirect effect on groundwater levels in the immediate area.

11.4.8 Potential Impacts during Operation

11.4.8.1 Potential Direct Impacts

Very few potential direct impacts are envisaged during the operational phase of the development. By virtue of the design standards required, and the operational conditions of the licence, the potential for an uncontrolled direct impact is unlikely. The potential impacts in the absence of mitigation are related to the risk of accidents which include:

- Control of leachate impact on the hydrogeology include leachate minimisation and leachate containment using the in-situ composite liner system.
- Some construction traffic will be necessary for maintenance plus normal operational traffic which could result in minor accidental leaks or spills of fuel/oil.
- Storage of fuels on site and refuelling of vehicles.
- Uncontrolled leachate breakouts from the waste body or holding ponds
- A spill during leachate transport off site.

11.4.8.2 Potential Cumulative Impacts

No cumulative impacts are envisaged during operation with respect to impacts on the surrounding geological and hydrogeological environment outside of the site boundary.

11.4.9 Potential Impacts during Decommissioning

The potential impacts associated with decommissioning will be similar to those associated with construction but of reduced magnitude.

11.4.10 Summary of Potential Impacts

A summary of unmitigated potential impacts on soils, geology and hydrogeology due to the proposed development is provided in Table 11.13 over. The sensitivity of the environments is based on the perceived importance of the receptor on a local, national or international scale as discussed in Section 11.4.2.

Table 11-14: Summary of Potential Impact Significance on Soils, Geology and Hydrogeology

Activity	Potential Impact	Attribute	Sensitivity	Prior to Mitigation	
				Magnitude	Significance
Construction Phase					
Excavations for IBA cells, site roads, bio-plant, leachate plant surface water management infrastructure and sub-station construction. Tree felling and replanting	Removal of material, soil compaction, increased runoff causing erosion, and possible contamination.	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor aquifer.	Medium	Small Adverse	Moderate/ Slight
Construction of cells, lagoons, tanks and ponds	Slope failure	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor Aquifer	Medium	Small Adverse	Moderate/ Slight
Construction of hardstanding areas and access roads.	Removal of material, soil compaction, increased runoff causing erosion, and possible contamination.	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor Aquifer.	Medium	Negligible	Imperceptible
Operation Phase					
Screening berms, IBA Facility, Trafficking	Erosion and sedimentation if not managed appropriately	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor Aquifer.	Medium	Negligible	Imperceptible
Leachate management	Groundwater contamination	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor Aquifer.	Medium	Negligible	Imperceptible

11.5 Mitigation Measures

The following section outlines appropriate mitigation measures to avoid or reduce the potential impact of the proposed development.

11.5.1 Mitigation by Design and Best Practice

With regard to the proposed development, detailed design best practice will be implemented as follows:

- The proposed waste infrastructure will be designed in accordance with best practice and subject to EPA approval prior to construction and subject to CQA and approval of such by EPA prior to operation (Refer Chapter 2 of Volume 2 of this EIAR).
- The works will be designed and checked by a geotechnical and civil engineer, suitably qualified and experienced in cell design, construction and operation.
- Any excavation and construction related works will be subject to a design risk assessment at detailed design stage to evaluate risk levels for the construction, operation and maintenance of the works. Identified risks will be minimised by the application of principles of avoidance, prevention and protection. Information on residual risks will be recorded and relayed to appropriate parties
- A method statement for each element of the works will be prepared by the Contractor prior to any element of the work being carried out.
- Given that the works comprises a significant proportion of excavation and earthworks, suitably qualified and experienced geotechnical personnel will be required on site to supervise the works.
- The surface water management infrastructure will be constructed in the northern catchment prior to any other construction works to mitigation potential impacts on hydrogeology.
- The Contract will require programming of the works such that earthworks are not scheduled during severe weather conditions. Where such weather is forecast, suitable measures will be taken to secure the works.
- Historically groundwater has required drainage systems below the cell liner systems to intercept such groundwater as may be present. Typically, groundwater from the Knockharley site has been present in sand lenses within the boulder clay and flow rates are historically very low. In the event such groundwater is encountered it will be pumped and directed to the existing attenuation ponds as is presently the case or to the proposed northern attenuation pond. Historic evidence shows that groundwater pumping has little if any influence on surrounding groundwater elevations.

11.5.2 Mitigation Measures During Construction

The following sections outline appropriate mitigation measures to avoid or reduce the potential impact of the proposed development.

11.5.2.1 Outline Construction Environmental Management Plan

The Outline Construction Environmental Management Plan (CEMP) to be adopted during the construction phase is provided in Appendix 2.0 of Volume 3 of this EIAR. The Outline CEMP defines the work practices, environmental management procedures and management responsibilities relating to the construction phase of the proposed development. The CEMP describes how the contractor for the main construction works will implement a site Environmental Management System (EMS) on this project to meet the specified contractual, regulatory and statutory requirements and environmental impact statement mitigation measures.

All site personnel will be required to be familiar with the environmental management plan's requirements as related to their role on site. The plan describes the project organisation, sets out the environmental procedures that will be adopted on site and outlines the key performance indicators for the site.

- The CEMP is a controlled document and will be reviewed and revised as necessary.
- A copy of the CEMP will be located at the site office.

- All employees, suppliers and contractors whose work activities cause/could cause impacts on the environment will be made aware of the CEMP and its contents.

11.5.2.2 Excavation, Storage and Removal of Subsoils

The development will be constructed in a phased manner to reduce the potential impacts of the development on the soils and geology. Phased construction reduces the amount of clearing and soil excavation required at any one time.

One of the primary mitigation measures employed at the preliminary design stage is the minimisation of volumes of soil excavation. Excavated overburden soils will be reused as far as possible. This will include:

- Use of suitable impermeable material for the engineered clay barrier.
- Constructing screening berms to mitigate nuisance and visual impacts on adjacent sensitive receptors.
- Facilitate final capping of the landfill cells and IBA cells

Some temporary stockpiles (not exceeding 2 m in height) of material may be necessary to facilitate capping works, however no permanent stockpiles of material will remain after construction and it is not proposed to remove waste soil or rock from site.

Although the removal of topsoil and vegetation exposes soil to erosion from surface water run-off at active areas at the site, practices are already in place to protect the soil from erosion. Drainage of surface water is incorporated into the site design. This will divert storm water runoff away from the working area. Storm water run-off is directed and will continue to be directed to the existing and proposed attenuation pond / holding pond and wetlands prior to discharge. Weekly measurements will continue to monitor the quality of the discharge. Chapter 12 'Surface Water Quality and Drainage' discusses surface water issues in more detail.

To mitigate against erosion of the exposed soil or rock, all excavations will be constructed and backfilled as quickly as possible. Excavations will stop during or prior to heavy rainfall events. To mitigate against possible contamination of the exposed bedrock/aquifer, refueling of machinery and plant will only occur at designated refueling areas. Refueling will be conducted from refueling trucks with drip trays and spill kits available. A designated refueling area will be located at the site compound.

If dewatering of excavations is required, monitoring of groundwater supplies within an appropriate radius of the excavation will be carried out. If there is evidence of lowering of local water supplies, alternative arrangements will be made.

11.5.2.3 Control of Sediment & Nutrient Loading

The soil stability will also be assessed at site-specific locations particularly at stockpile, screening berms and stream bank locations where earthworks are proposed. Best practices will be employed in the prevention of silt laden run-off from entering watercourses.

Silt Protection Controls (SPCs) are proposed at the location of watercourse crossings and where access roads pass close to watercourses during construction. Silt fencing will be used to mitigate any contamination of streams with silt at the flowing locations:

a. all stockpile material will be bunded adequately and/or surrounded by silt fences and protected from heavy rainfall to reduce silt run-off, where necessary.
b. all open water bodies adjacent to proposed construction areas will be protected by fencing, including the proposed attenuation pond.
c. along the banks of any streams at the location of the proposed tree felling to provide additional protection to the watercourses in this area.

11.5.2.4 Attenuation Ponds & Screening Berms

Screening berms will be constructed on a phased basis concurrent with overburden recovery from cell excavation works. Prior to berm installation, top soil will be stripped back, formation compacted, and soils as may become available placed and compacted in layers. Layers will be overfilled and once berms are at the final height is reached will have side slopes profiled receive and allow subsequent placement of topsoil, seeding and tress as required.

The proposed development will require the construction of an additional surface water attenuation pond / holding pond north of the IBA facility to cater for the expected increase in run-off from this area and from the run-off from the northern end of the landfill.

To minimise erosion impacting storm water, storm drainage will be installed prior to bulk earth moves with silt fences and temporary settlement ponds placed around screening berms and pond banks until such time as a vegetation cover has become established. Further details of the surface water mitigation measures are discussed in Chapter 12.

Prior to earthworks taking place temporary haul roads will also be installed.

11.5.2.5 IBA Cells

Overburden will be removed and placed in screening berms. Clay barrier material will be won from underlying boulder clays excavated to form cells. Boulders within the excavated clay will be removed via screening and engineered clay will be placed in layers and compacted to 95% maximum dry density.

A ground water drainage system will be installed to accommodate prevailing site conditions upon which the engineered clay barrier will be installed and compacted to 95% maximum dry density.

11.5.2.6 Measures for Spills

Detail of oil spill protection measures adjacent to a watercourse are outlined in Appendix 2.0 of Volume 3 of this EIAR which outlines the proposed Outline CEMP.

Drip trays and spill kits will be kept available on site, to ensure that any spills from the vehicle are contained and removed off site. Any diesel or fuel oils stored at the temporary site compounds will be bunded. The bund capacity will be sufficient to contain 110% of the tank's maximum capacity.

All personnel currently working on site are trained in pollution incident control response and this will be a requirement of the construction contract(s). Emergency Silt Control and Spillage Response Procedures are contained within the Outline CEMP.

11.5.2.7 Slope Stability

With regard to slope stability issues, detailed design best practice will be implemented as follows:

- The works will be designed and supervised by a suitably qualified and experienced geotechnical engineer or engineering geologist, and hydrologist or drainage engineer.
- A Outline CEMP accompanies this EIAR. Prior to construction the CEMP construction will be finalised, which will incorporate all measures set out in the Outline CEMP and other measures required on foot of conditions attached to any grant of permission.
- Identified risks will be minimised by the effective implementation of the measures identified in the EIAR and the Outline CEMP, which will be reviewed and finalised prior to commencement of construction.
- A method statement for each element of the works will be finalised prior to any element of the work being carried out. A draft of the methods is provided in the Outline CEMP and will be reviewed and finalised prior to commencement of construction.
- The CEMP for construction will place emphasis on the regular checking of equipment, temporary stockpiles, as well as drainage structures and their attenuation ability by suitably qualified and experienced staff.

- Excavation works will be monitored by suitably a qualified and experienced geotechnical personnel.
- The programming of the works (by the Contractor) will be such that earthworks are not scheduled to be carried out during severe weather conditions. Where such weather is forecast, suitable measures will be taken to secure the works.

11.5.2.8 Mitigation Measures for Groundwater

Groundwater protection related to Intensification of MSW landfilling & IBA cells, stormwater attenuation and holding ponds, leachate management facility and biological facility are discussed below:

Cell Development

All cells, whether in the permitted landfill development or proposed IBA Facility, will require a composite lining in accordance with the Landfill Directive for non-hazardous cells. This requires a 2 mm HDPE barrier overlying a 1.0m clay barrier k= $1*10^{-9}$ m/s or equivalent. This requirement is also conditioned in the current IED licence for the facility.

Surface Water Lagoons

Surface water lagoon and the holding pond will be constructed using a similar lining system as the cells comprising a 2 mm HDPE barrier overlying a 1.0m clay barrier k $1*10^{-9}$ m/s or equivalent, albeit that lining systems may have additional cover systems using soil, concrete or other to facilitate maintenance and or safety criteria as required during detailed design.

Storage Systems

The section applies to all storage facilities (leachate lagoons, bunded containment associated with proprietary leachate treatments as may be required).

All above ground tanks for leachates or other treatment related products will be bunded to contain a minimum storage volume in accordance with Agency guidance[2] to be not less than the greater of:

- 110% capacity of the tank within the bunded area, or;
- 25% of the total volume of the substance stored within the bunded area.

This is to facilitate containment of contents of one or more tanks in the event of a tank failure. All tanks will have covers to prevent rainfall ingress.

Below ground tanks will be surrounded with a 1.0m clay barrier k $1*10^{-9}$ m/s or equivalent.

Below ground lagoons (leachate, holding pond or attenuation pond) will be constructed using a composite lining system comprising a 2 mm HDPE barrier overlying a 1.0m clay barrier k $1*10^{-9}$ m/s or equivalent. All below ground lagoons will have floating covers to prevent rainfall ingress.

Refuelling During Construction

Diesel tanks, used to store fuel for the various items of machinery, will be self-contained and double-walled. Refuelling will be carried out from these tanks or from delivery vehicles at a designated refuelling area. There will be a designated refuelling area at the site compound. Specific mitigation measures relating to the management of hydrocarbons are as follows:

- Fuels, lubricants and hydraulic fluids for equipment used on the construction site will be carefully handled to avoid spillage, properly secured against unauthorised access or vandalism, and provided with spill containment according to best codes of practice - (Enterprise Ireland BPGCS005);

- Any spillage of fuels, lubricants or hydraulic oils will be immediately contained, and the contaminated soil removed from the site and properly disposed of;
- Waste oils and hydraulic fluids will be collected in leak-proof containers and removed from the site for disposal or re-cycling; and
- Appropriate spill control equipment, such as oil soakage pads, will be kept within the construction compound and in each item of plant to deal with any accidental spillage.

11.5.3 Mitigation Measures During Operation

Current measures employed at the site to control leachate impact on the hydrogeology include leachate minimisation and leachate containment using the in-situ composite landfill liner system. Therefore, the risk of leachate reaching the bedrock is considered negligible. Furthermore, groundwater monitoring undertaken at the site in accordance with the licence will continue to monitor measures for the protection of groundwater in the area.

Although the overburden water table will be depressed by drainage and/or pumping during cell construction, this is a temporary measure during construction. In the long-term, post closure, the piezometric level will be allowed to rise to natural levels which are likely to be above the cell base level. The groundwater monitoring programme, as set out in the licence, will continue to assess groundwater quality at the site.

The emergency response procedures in place under the licence also address possible spillages. Corrective Action Procedures on the site ensure that any non-compliance with the waste licence are investigated and corrected and that measures are put in place to remedy and prevent reoccurrence of the non-compliance.

To mitigate against possible contamination of the exposed bedrock / aquifer, refuelling of machinery and plant during operation of the facility will only occur offsite or in specially designated areas such as site compounds, using designated refuelling bowsers.

All temporary cuts / excavations will be carried out such that they are stable or adequately supported. Unstable temporary cuts / excavations will not be left unsupported.

Temporary cuts and excavations will be protected against the ingress of water or erosion. Temporary works will be such that they do not adversely interfere with any existing drainage channels.

11.5.4 Mitigation Measures during Decommissioning

Mitigation measures applied during decommissioning activities will be similar to those applied during construction where relevant.

Mitigation measures to avoid contamination by accidental fuel leakage and compaction of soil by on-site plant will be implemented as per the construction phase mitigation measures in Section 11.5.2.

11.6 Residual Impacts

Residual impacts that are most likely to occur at the proposed facility during the construction phase are as follows:

- There will be a change in ground conditions at the site with the replacement of natural materials such as glacial deposits and bedrock by HDPE geocomposite liner or 1 mm fully welded LLDPE liner, sub-grade drainage stone, leachate collection pipework, ground ducting for water, telemetry and power, and surfacing materials (e.g. concrete, new access roads). This is a direct permanent change to the material composition of the site.

Residual impacts that are most likely to occur at the facility during the Operational phase are as follows:

- Changes in ground surfacing including areas of new hardstands (i.e. leachate plant and biological treatment) and tree felling will impact on the hydrology of the site and may result in increased runoff of rainwater and increased drainage discharge.
- The drainage infrastructure that will be emplaced as part of the proposed development will also change the sub-surface hydrology by replacing some manmade drainage systems with line interceptors and point discharges to buffered outfalls. Careful design of this drainage to mimic natural conditions will help to mitigate negative impacts of artificial drainage.

The residual significance of the effects of the proposed development on soils, geology and hydrogeology is expected to be low taking account of the effective implementation of the mitigation measures as outlined in Section 11.5.

The residual impact is summarised in Table 11.14, using the impact assessment methodology outlined above in Section 11.4.2 and taking account of mitigation measures in Section 11.5 of this document.

Table 11-15: Residual Geological Impact Significance for Sensitive Receptors

Activity	Potential Impact	Attribute	Importance	Before Mitigation		After Mitigation	
				Magnitude	Significance	Magnitude	Residual Significance
Construction Phase							
Excavations for landfill, ducting, hardstands, sub-station, treatment plant, leachate ponds, attenuation ponds.	Removal of material, soil compaction, increased runoff & sedimentation, contamination	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor Aquifer.	Medium	Small Adverse	Moderate/ Slight	Negligible	Imperceptible
Construction of landfill cells, storage lagoons and screening berms.	Slope failure	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor Aquifer	Medium	Small Adverse	Moderate/ Slight	Negligible	Imperceptible
Construction of hardstanding and access roads.	Removal of material, soil compaction, increased runoff causing erosion, and possible contamination.	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor Aquifer.	Medium	Negligible	Imperceptible	Negligible	Imperceptible
Operation & Maintenance Phase							
Site access tracks, sub-station, treatment plant	Increase in rate of run-off, contamination	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor Aquifer.	Medium	Negligible	Imperceptible	Negligible	Imperceptible

Activity	Potential Impact	Attribute	Importance	Before Mitigation		After Mitigation	
				Magnitude	Significance	Magnitude	Residual Significance
Landfill screening berms and storage lagoons	Erosion and sedimentation	Soil, rock & aquifers. Low permeability, poorly drained soils. Poor Aquifer.	Medium	Negligible	Imperceptible	Negligible	Imperceptible

It can be observed from Table 11.14 that, following the implementation of mitigation measures, the residual impact significance to the receiving environment would be moderate/slight to imperceptible during the construction period and imperceptible in all respects assessed during the operation of the proposed landfill. Mitigation measures will be monitored throughout the construction and operational phases.

Mitigation systems will, where required, be in place before development works commence.

As a result of the mitigation measures being implemented, the proposed development is expected to have an imperceptible impact on the receiving environment.

The proposed development is not expected to contribute to any significant, negative cumulative effects of other existing developments in the vicinity. When the mitigation measures are implemented in full, any effects on the receiving environment will be imperceptible.

11.7 Conclusions

A study has been undertaken which has identified the principal impact of the construction of the proposed development. The following conclusions can be drawn, in relation to soils, geology and hydrogeology:

- A site walkover and intrusive investigation were undertaken on the site in order to assess the potential impacts on the soils, geology and hydrogeology.
- The site's geology typically consists of a thin layer of topsoil, glacial till overburden predominantly comprising cohesive gravelly clay (boulder clay) greater that 10m in thickness and overlying sandstone / siltstone bedrock.
- The proposed areas for development is located to the north and east of the current permitted landfill footprint including screening berms to the west.

Overall, the material balance has indicated a shortfall of approximately 178,175 m^3 will be encountered when assessed against the proposed screening berm design. In view of the shortfall identified, FT has considered the following options with respect to screening berm construction:

- In the event of a need for future development, an opportunity is presented to place recovered overburden in the locations where a shortfall has been identified.
- Reduce the scale of the western screening berm volume by 178,175 m^3.
- Import the remaining overburden material externally to meet the shortfall identified.

A number of potential impacts have been identified associated with the excavation of overburden on the site. The significance of these potential impacts is assessed as being of moderate/slight significance prior to mitigation.

Potential impacts from the proposed development on the underlying soils, geology and hydrogeology occur due to the removal of the overburden which exposes the underlying soil to erosion and to possible sources of contamination, both during and post construction. Individual assessments of these impacts have been conducted and are outlined separately within this EIAR.

Effective mitigation measures to deal with construction & operational impacts have already been implemented and are outlined above. Provided that these mitigation measures continue to be effectively implemented, as proposed, the residual risks to the soils, geology and hydrogeology associated with the construction, operation and decommissioning of the site are considered to be imperceptible.

11.8 References

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[3] EPA, "Advice Notes on Current Practice in the Preparation of Environmental Impact Statements," 2003.

[4] EPA, "Revised Guidelines on the Information to be Contained in Environmental Impact Statements, September 2015," 2015.

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