12 SOILS, GEOLOGY AND HYDROGEOLOGY

This section of the report addresses soils, geology and hydrogeology in the existing environment, identifies potential impacts of the proposed development and outlines measures to mitigate potential impacts.

12.1 Methodology

This section was prepared having regard to the publication "Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters in Environmental Impact Statements" by the Institute of Geologists of Ireland (1). It was prepared using available published literature and included a walkover survey of the site and results of ground investigations.

The literature reviewed included:

1. 'Geology of Kildare-Wicklow' (Sheet 16, Geological Survey of Ireland, 1994) (2)
2. 'General Soil Map of Ireland' (National Soil Survey, 1980) (3)

In addition to the above information, ground investigations were undertaken during October 2015 to provide additional information. The fieldwork included soil sampling, rotary drilling, the installation and sampling of groundwater monitoring wells and laboratory testing of soil and water samples. The information obtained from these investigations is also referenced in this report.

Following the compilation of site data and published information on the existing environment, the details of the proposed development were appraised to identify potential impacts on geology, soils and hydrogeology. The site layout is shown in Figure 3-4.

12.1.1 Study Area

It is proposed to deposit up to 200,000 tonnes of surplus dredge spoil material, mainly silt, clay and gravel at the site, arising from the flood defence works being carried on the River Dargle in Bray.

The placement of the surplus dredge spoil will raise existing ground levels to facilitate the development of an Eco-park for long term community benefit use.

The proposed development is described in Section 3 of this EIS.

The location of the proposed facility is shown in Figure 1-1 with the proposed material placement plan outlined in Figure 3.7. The proposed layout of the associated development areas at the facility is shown in Figure 3.8. The study area is defined as the area within the existing site boundary.

The site is currently covered in vegetation. It is the intention to clear the site of vegetation prior to importing dredge spoil to the site.

Historic mapping for the site shows no evidence of any industrial use for the site. Historically, the site has been subdivided pastures and the historic 6" sheet for the site suggests that the ground was boggy and possibly unsuitable for tillage or pasture compared with the surrounding land. It is possible that the reason for this is that bedrock is shallow and probable low permeability with thin soil cover.

The 1995 aerial photographs for the site suggest that the northern part of the site was cleared of vegetation and may have been quarried (and later backfilled) or just backfilled. It is therefore expected that some fill material is present in the northeast corner of the site. The remainder of the site appears to have been largely undisturbed in recent years.

12.1.2 Consultation

The scope for this appraisal has been informed by pre-application consultation with Wicklow County Council, prescribed bodies and other interested parties as summarised in Section 6 of the EIS.

The Geological Survey of Ireland (GSI) responded to the consultation request in October 2015. The GSI responded that there is no site of geological heritage interest within the perimeter of the study boundary. The audit of County Geological Sites for County Wicklow was carried out in 2014. The GSI stated that the closest sites of interest are the 'Glen of the Downs' and the 'Wicklow- Greystones Coast'. The GSI also stated that they lie within a 2 km radius of the proposed site, however, due to their scale and nature, they are unlikely to be affected by the proposed facility.

12.2 Existing Environment

12.2.1 Overburden Geology

The main soil associations within this part of County Wicklow are Acid Brown Earths (75%) with associated Gleys (15%) and Brown Podzolics (10%). The main Quaternary sediments identified in this area of County Wicklow are glacial till deposits derived from the underlying sandstone and shale which underlies the area. Additionally, limestone sands and gravels underlie the area to the southwest and southeast of the site. The site itself is underlain by shallow bedrock, with little or no quaternary overburden. The Quaternary deposits are shown in Figure 12.1.

12.2.2 Bedrock Geology

The GSI publication 'Geology of Kildare-Wicklow' (2) is the reference source for the description of the bedrock geology of the region. The GSI 1:100,000 scale bedrock geology map (Sheet 16) shows that Cambrian Bray Head Formation underlies the site. The bedrock geology of the site and surrounding area is shown in Figure 12.2.

The Bray Head Formation covers the majority of the Wicklow area and comprises greywacke sandstones and siltstones interbedded with green, purple, red and grey slates and massive quartzites. Bedrock at the site is close to the surface and exposed in parts.

12.2.3 Ground Investigations

Three rotary drilled boreholes were undertaken by Priority Geotechnical Limited (PGL) under the direction of FTC. The boreholes were undertaken near the three corners of the site as shown in Figure 12.5. The boreholes were primarily undertaken in order to install groundwater monitoring wells. A summary of the borehole locations and ground conditions is presented in Table 12.1. Detailed borehole logs are presented in the ground investigations report in Appendix 14.

Table 12.1: Summary of Boreholes

Borehole	GPS Coordinates		Ground Level (mAOD)	Overburden	Bedrock Depth
	X (ING)	*Y (ING)*			
RC01 (down-gradient)	328986.5	209453.5	48.550	Gravelly Cobbles and Clay	9.3m
RC02 (up- gradient)	328846.3	209365.9	52.274	Sand, Clay, Gravel	4.5m
RC03 (down-gradient)	329082.9	209053.0	43.592	Not recovered	0.4m

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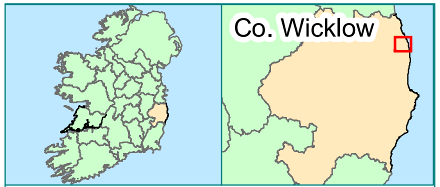

Legend

Study Boundary

Subsoils Data

- A, alluvium
- GLs, limestone sands and gravels - Carboniferous
- L, lake sediment
- Made, made ground
- Mbs, beach / raised beach sand
- Rck, bedrock at surface

Date	15/10/2015
Name Of Client	Wicklow County Council
Name Of Job	EIS for proposed Kilquade Waste Soils Recovery Facility
Title Of Figure	Quaternary Geology Map
Scale Used	1:25,000 @ A4
Figure No.	12.1
Rev	A

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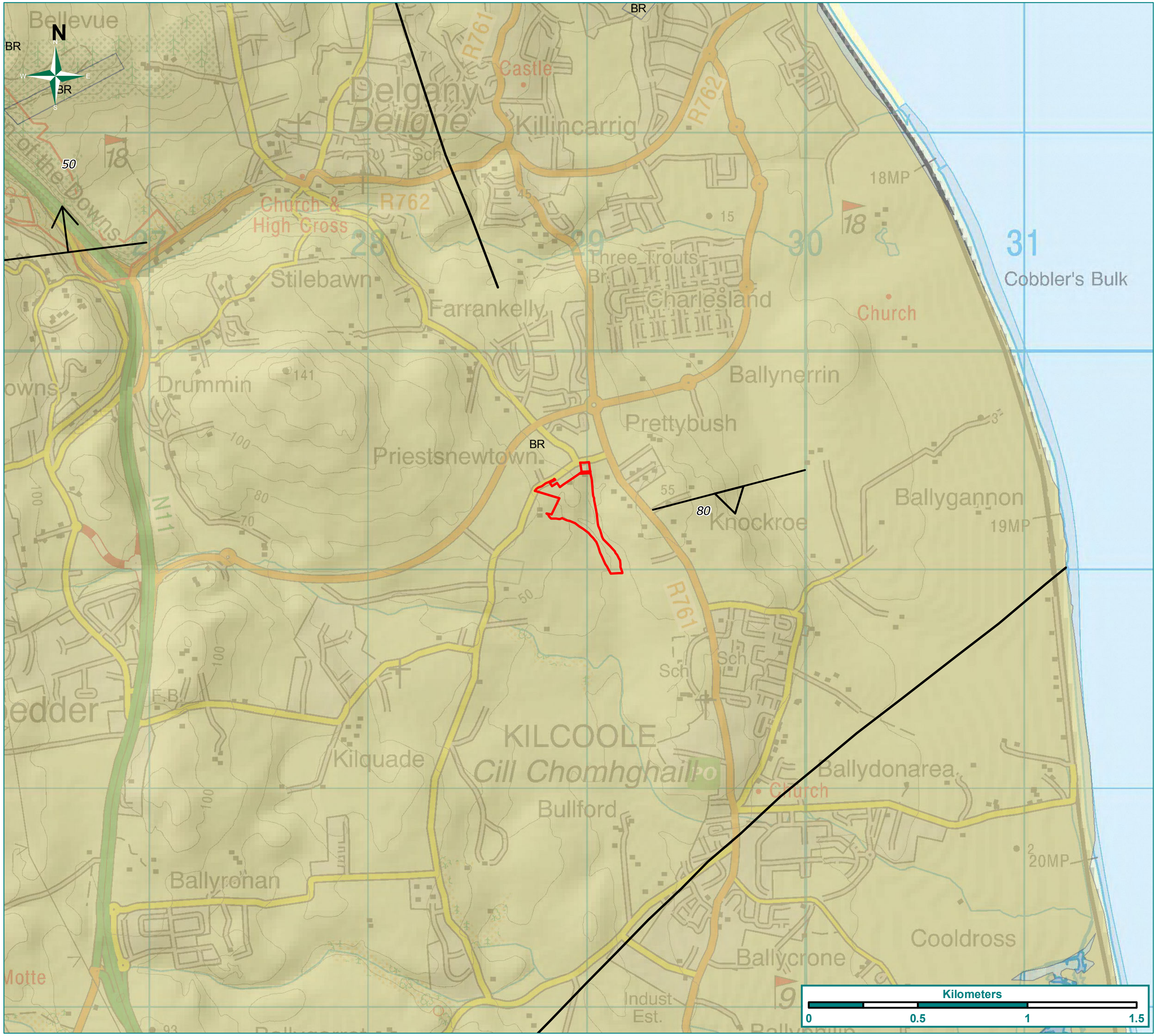

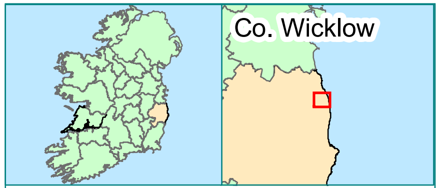

Legend

Study Boundary

Bedrock Geology

BR: Bray Head Formation

Dip of Bedding in Degrees

Structural Linework

65

Date 19/10/2015

Wicklow County Council

Name Of Job

Waste Licence, Planning & EIS for Waste Soils Recovery Facility

Title Of Figure

Bedrock Geology Map

Scale Used 1:25,000 @ A4

Figure No. 12.2

Rev A

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12.2.4 Materials Analysis

Two surface soil samples were recovered from the site and tested for a range of analyses in order to provide a baseline for possible contamination on the site. The results of the soil analysis are presented in Appendix 15 and the results are summarised in Table 12.1.

Analysis was also undertaken of the dredge spoil material proposed for acceptance in order to verify the nature of the material to be imported from the River Dargle Flood Scheme works. Three separate periods of sampling work were undertaken by Gavin and Doherty Geosolutions in February 2015, October 2015 and April 2016. The three individual reports on the dredge material sampled are presented in Appendix 16.

These samples were compared the Waste Acceptance Criteria (WAC) limit values, which classify various wastes as suitable for acceptance at different types of landfill facilities, based on their composition. These criteria are laid down in Council Decision 2003/33/EC and the limit values with which the material is compared are those classified as "inert waste".

It should be noted that these limit values are examined for comparison only, to substantiate the inert nature of the material. As the proposed waste soils recovery activity is not a landfilling activity, the requirement of Council Decision 2003/33/EC and Directive 1999/31/EC on the landfilling of waste, to which it relates, do not apply to the proposed waste activity.

The results of the testing undertaken on the dredge spoil material are summarised in Table 12.2, Table 12.3 and Table 12.4 and are compared with the Inert WAC limit values identified for comparison.

It should be noted that a single sample of the dredge spoil material which was sampled in February 2015 slightly exceeds the comparable WAC inert criteria limit for Total Organic Carbon (TOC). However, this result is consistent with a similar exceedance within an in-situ soil sample analysed from the Pretty Bush site and this exceedance is not considered significant in the context of the development. Furthermore, no WAC inert criteria limits were exceeded for any of the samples obtained from the more recent sampling of dredge spoil material in October 2015 and April 2016.

Table 12-1: Summary of Soil/Eluate Test Results for In-Situ Soils at Pretty Bush

Parameter	Units	Pretty Bush Soil Samples		Landfill Waste Acceptance Criteria (WAC) Limits for Inert Wastes		
		TP 1B	TP 2B	Inert	Stable	Hazardous
Solid Waste						
TOC	%	1.81	3.38	3	5	6
Sum of BTEX	mg/kg	<0.024	<0.024	6	-	-
Sum of 7 PCBs	mg/kg	<0.021	<0.021	1	-	-
Mineral oil	mg/kg	13.5	25.3	500	-	-
PAH sum of 6	mg/kg			-	-	-
PAH sum of 17	mg/kg	<10	<10	100	-	-
10:1 Eluate						
Arsenic	mg/kg	0.00383	0.00395	0.5	2	25
Barium	mg/kg	0.0142	0.0286	20	100	300
Cadmium	mg/kg	<0.001	<0.001	0.04	1	5
Chromium	mg/kg	0.00599	0.00619	0.5	10	70
Copper	mg/kg	0.0288	0.0254	2	50	100
Mercury	mg/kg	0.000165	0.000146	0.01	0.2	2
Molybdenum	mg/kg	<0.0024	<0.0024	0.5	10	30
Nickel	mg/kg	0.0119	0.0121	0.4	10	40
Lead	mg/kg	0.00678	0.0476	0.5	10	50
Antimony	mg/kg	0.00272	0.00395	0.06	0.7	5
Selenium	mg/kg	0.0142	0.0303	0.1	0.5	7
Zinc	mg/kg	0.0175	0.0389	4	50	200
Chloride	mg/kg	<20	<20	800	15000	25000
Fluoride	mg/kg	<5	<5	10	150	500
Sulphate as SO_4	mg/kg	<20	<20	1000	20000	50000
Total Dissolved Solids	mg/kg	105	180	4000	60000	10000
Phenol	mg/kg	<0.02	<0.02	1	-	-
Dissolved Organic Carbon	mg/kg	90.1	82.7	500	800	1000

Table 12-2: Summary of Soil/Eluate Test Results for Incoming Material (Test 1: 23/02/15)

Parameter	Units	Incoming Material Samples										Landfill Waste Acceptance Criteria (WAC) Limits for Inert Wastes		
		TP1 1.1	TP1 3.5	TP2 0.9	TP2 1.2	TP3 2.5	TP6 0.95	TP6 3.3	TP7 2	TP8 2.05	TP9 2.8	Inert	Stable	Hazardous
Solid Waste														
TOC	%	0.82	0.46	0.47	0.46	0.28	1.34	0.6	3.19	0.2	0.2	3	5	6
Sum of BTEX	mg/kg	0.027	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	6	-	-
Sum of 7 PCBs	mg/kg	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	1	-	-
Mineral oil	mg/kg	<45	<45	<45	<45	<45	<45	<45	<45	<45	<45	500	-	-
PAH sum of 6	mg/kg	0.39	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	14.39	<0.22	<0.22	-	-	-
PAH sum of 17	mg/kg	1.03	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	34.77	<0.64	<0.64	100	-	-
10:1 Eluate														
Arsenic	mg/kg	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.5	2	25
Barium	mg/kg	0.11	0.04	0.07	0.07	0.05	0.04	0.06	0.21	<0.03	<0.03	20	100	300
Cadmium	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.04	1	5
Chromium	mg/kg	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.5	10	70
Copper	mg/kg	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	2	50	100
Mercury	mg/kg	0.0021	0.0011	0.0012	0.0013	0.0006	0.0025	0.0057	0.0028	0.0007	0.0018	0.01	0.2	2
Molybdenum	mg/kg	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	<0.02	<0.02	0.5	10	30
Nickel	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	0.4	10	40
Lead	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.5	10	50
Antimony	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	0.7	5
Selenium	mg/kg	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.1	0.5	7
Zinc	mg/kg	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	4	50	200
Chloride	mg/kg	5	5	<3	<3	<3	7	<3	21	5.6	10.3	800	15000	25000
Fluoride	mg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	10	150	500
Sulphate as SO_4	mg/kg	32.9	13.8	26.6	24.2	30.6	77.9	9.9	37.7	5.6	10.3	1000	20000	50000
Total Dissolved Solids	mg/kg	1531	920	940	470	840	1810	1021	1481	1631	830	4000	60000	10000
Phenol	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1	-	-
Dissolved Organic Carbon	mg/kg	60	60	40	50	40	40	50	100	30	<20	500	800	1000

Table 12-3: Summary of Soil/Eluate Test Results for Incoming Material (Test 2: 21/10/15)

Parameter	Units	Incoming Material Samples											Landfill Waste Acceptance Criteria (WAC) Limits for Inert Wastes		
		1	2	3	4	5	6	7	8	9	10	11	Inert	Stable	Hazar-dous
Solid Waste															
TOC	%	0.2	0.16	0.12	0.14	0.22	0.18	0.16	0.2	0.14	0.05	0.17	3	5	6
Sum of BTEX	mg/kg	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	6	-	-
Sum of 7 PCBs	mg/kg	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	1	-	-
Mineral oil	mg/kg	<45	<45	<45	<45	<45	<45	<45	<45	<45	<45	<45	500	-	-
PAH sum of 6	mg/kg	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	-	-	-
PAH sum of 17	mg/kg	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	100	-	-
10:1 Eluate															
Arsenic	mg/kg	0.054	<0.025	0.033	<0.025	<0.025	<0.025	<0.025	<0.025	0.032	<0.025	0.035	0.5	2	25
Barium	mg/kg	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	20	100	300
Cadmium	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.04	1	5
Chromium	mg/kg	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.5	10	70
Copper	mg/kg	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	2	50	100
Mercury	mg/kg	0.0049	0.0049	0.0043	0.0046	0.0049	0.0063	0.0045	0.0001	0.0003	0.0003	0.0002	0.01	0.2	2
Molybdenum	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.5	10	30
Nickel	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.4	10	40
Lead	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.5	10	50
Antimony	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	0.7	5
Selenium	mg/kg	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.1	0.5	7
Zinc	mg/kg	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	4	50	200
Chloride	mg/kg	10	<3	<3	<3	<3	4	<3	<3	<3	<3	<3	800	15000	25000
Fluoride	mg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	10	150	500
Sulphate as SO_4	mg/kg	40.4	3.4	23.7	17.1	15.6	14.7	15.1	17.2	35	19.6	18.5	1000	20000	50000
Total Dissolved Solids	mg/kg	120	800	720	620	720	1040	660	520	<100	540	860	4000	60000	10000
Phenol	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1	-	-
Dissolved Organic Carbon	mg/kg	30	30	30	30	30	30	30	40	30	30	30	500	800	1000

Table 12-4: Summary of Soil/Eluate Test Results for Incoming Material (Test 3: 13/04/16)

Parameter	Units	Incoming Material Samples					Landfill Waste Acceptance Criteria (WAC) Limits for Inert Wastes		
		Sample 1	Sample 3	Sample 5	Sample 7	Sample 9	Inert	Stable	Hazar-dous
Solid Waste									
TOC	%	0.15	0.16	0.22	0.19	0.17	3	5	6
Sum of BTEX	mg/kg	<0.025	<0.025	<0.025	<0.025	<0.025	6	-	-
Sum of 7 PCBs	mg/kg	<0.035	<0.035	<0.035	<0.035	<0.035	1	-	-
Mineral oil	mg/kg	<45	<45	<45	<45	<45	500	-	-
PAH sum of 6	mg/kg	<0.22	<0.22	<0.22	<0.22	<0.22	-	-	-
PAH sum of 17	mg/kg	<0.64	<0.64	<0.64	<0.64	<0.64	100	-	-
10:1 Eluate									
Arsenic	mg/kg	0.063	<0.025	0.037	<0.025	0.044	0.5	2	25
Barium	mg/kg	<0.03	<0.03	<0.03	<0.03	<0.03	20	100	300
Cadmium	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	0.04	1	5
Chromium	mg/kg	<0.015	<0.015	<0.015	<0.015	<0.015	0.5	10	70
Copper	mg/kg	<0.07	<0.07	<0.07	<0.07	<0.07	2	50	100
Mercury	mg/kg	0.0004	0.0004	0.0003	0.0006	0.0004	0.01	0.2	2
Molybdenum	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	0.5	10	30
Nickel	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	0.4	10	40
Lead	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	0.5	10	50
Antimony	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	0.7	5
Selenium	mg/kg	<0.03	<0.03	<0.03	<0.03	<0.03	0.1	0.5	7
Zinc	mg/kg	0.04	0.04	0.03	<0.03	<0.03	4	50	200
Chloride	mg/kg	64	74	66	66	85	800	15000	25000
Fluoride	mg/kg	<3	<3	<3	<3	<3	10	150	500
Sulphate as SO_4	mg/kg	133.2	141.3	128.5	127.9	151.3	1000	20000	50000
Total Dissolved Solids	mg/kg	780	810	710	1040	840	4000	60000	10000
Phenol	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	1	-	-
Dissolved Organic Carbon	mg/kg	30	30	30	20	20	500	800	1000

12.2.5 Hydrogeology

The groundwater section of the GSI website classifies the bedrock underlying the site as a 'Poor Aquifer (Pl)', with bedrock which is 'generally unproductive except locally' as shown in Figure 12.3.

Groundwater within the aquifer occurs mainly within fracture zones which may occur within the rocks. Well specific capacities are generally around 50 m^3/day according to the available GSI information, abstracted mainly by domestic properties and farms.

The GSI lists four wells within 1km of the site boundary and a total of 26 wells within 2km, as shown on Figure 12.5. The wells in this area are mostly constructed to depths of between 12m and 48m according to the data available on the GSI website. It is likely that other properties in the area are also served by groundwater wells for which there is no publically available information.

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

The vulnerability of an aquifer to contamination is influenced by the leaching characteristics of the topsoil, the permeability and thickness of the subsoil, the presence of an unsaturated zone, the type of aquifer, and the amount and form of recharge (the hydrologic process where water moves downward from surface water to groundwater). Groundwater vulnerability is determined mainly according to the thickness and permeability of the subsoil that underlies the topsoil, as these properties strongly influence the travel times and attenuation processes of contaminants that could be released into the subsurface from below the topsoil (as in the case of contaminants from landfills, septic tank systems and underground storage tanks). 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 distribution of vulnerability for the area is predominantly 'Extreme' due to shallow bedrock with a small area of 'High' vulnerability at the southern end of the site as shown in Figure 12.4.

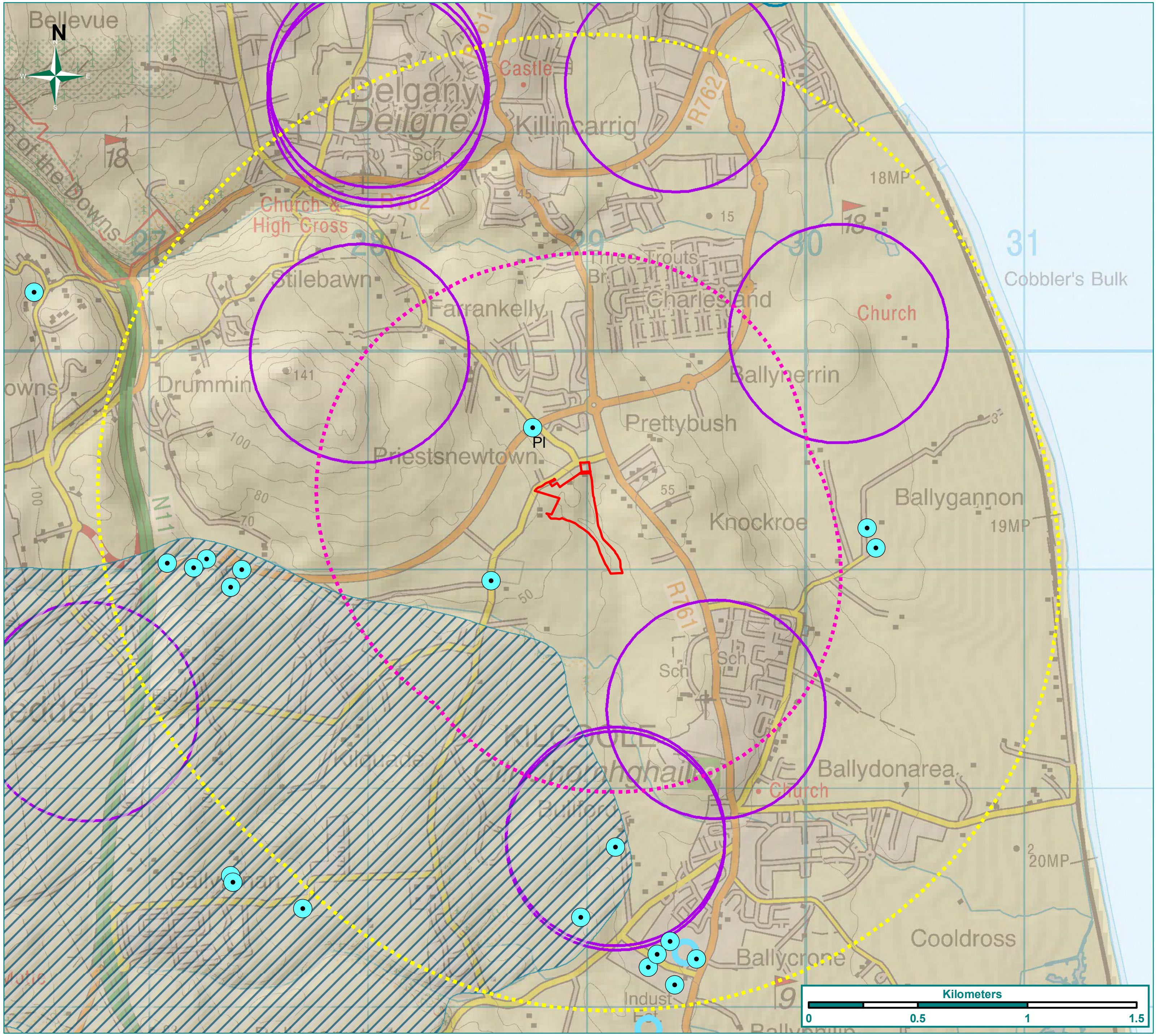
The assessed vulnerability for the majority of the site is shown in Table 12.5. The table illustrates the standard ratings of vulnerability used by the GSI, with the existing site conditions highlighted based on the findings of the ground investigations.

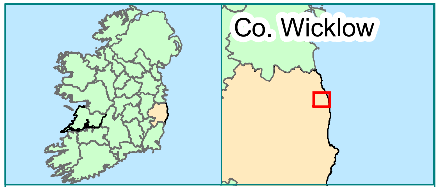
Table 12.5: Groundwater Vulnerability

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

Based on the findings from the desk study and verified by site investigation works and visual assessment onsite, the sub-soil thickness on the site is considered to mostly less than 3 m, hence the assessed vulnerability for the site is 'Extreme'. This suggests that any potential contamination would encounter limited attenuation prior to reaching bedrock.

The overburden deposits of till have generally moderate permeability and may therefore act as a confining layer (where present), preventing the free movement of surface water to the underlying aquifer within the bedrock. The regional topography of the site is generally sloping gently towards the east, although locally, the site comprises two distinct valleys which flow towards the south and southeast. Groundwater at the site is expected to flow in the general direction of the regional topography and surface water courses which flow predominantly from northwest to southeast.





Legend

- Study Boundary
- 2km Buffer of Site Boundary
- 1km Buffer of Site Boundary

Aquifer Classification

- Pl: Poor Aquifer Bedrock Generally Unproductive Except Locally
- GW Well (100m-200m Accuracy)
- GW Well (500m-1km Accuracy)
- GW Well (50m-100m Accuracy)
- GW Wells (10m-50m) Accuracy
- Sand and Gravel Aquifers

Date 19/10/2015

Name Of Client

Wicklow County Council

Name Of Job

Waste Licence, Planning & EIS for Waste Soils Recovery Facility

Title Of Figure

Aquifer Classification

Scale Used 1:25,000 @ A4

Figure No. 12.3

Rev A

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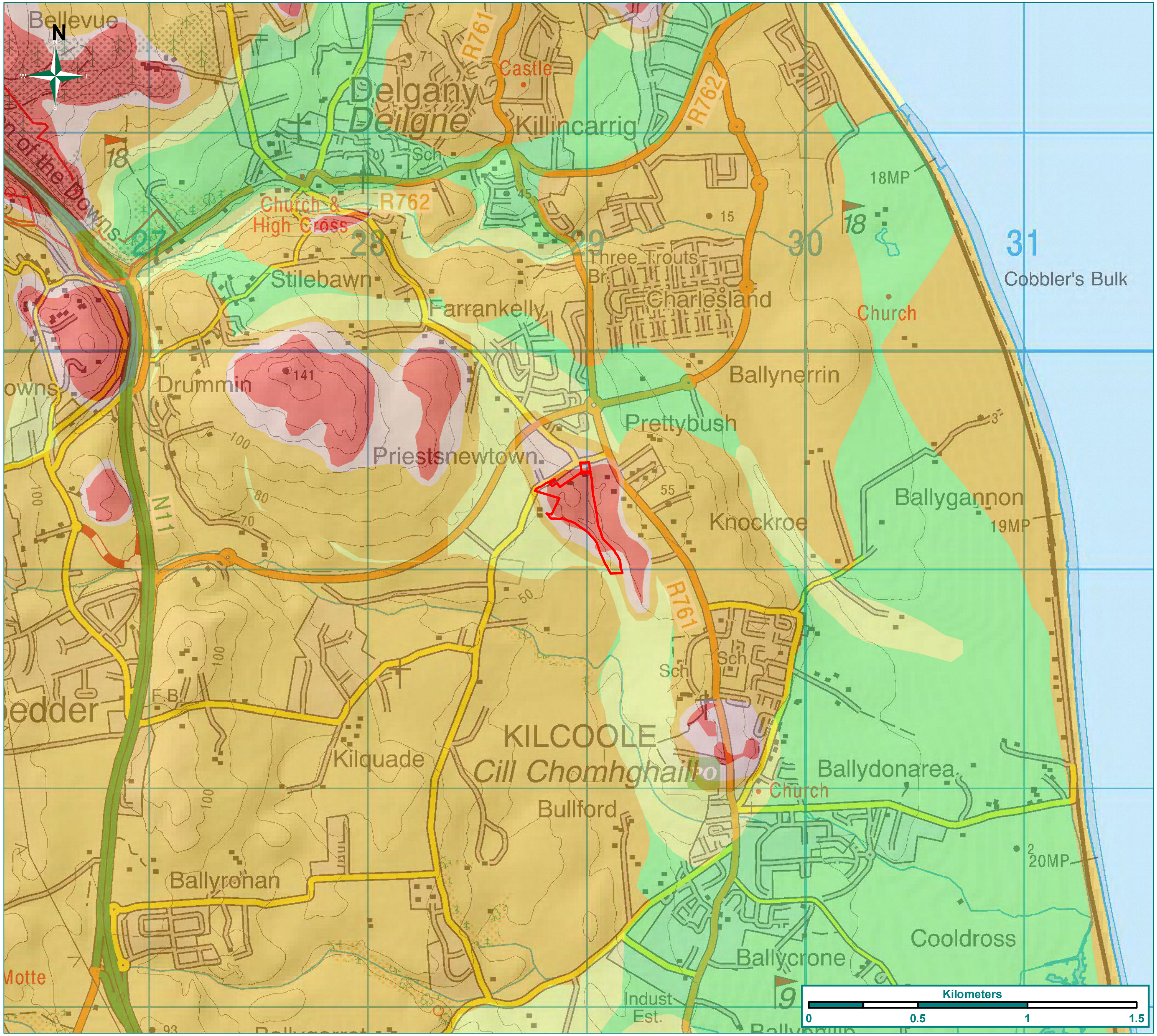

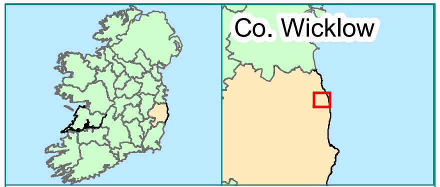

Legend

- Study Boundary

Groundwater Vulnerability

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

Date 15/10/2015

Wicklow County Council

Name Of Job

Waste Licence, Planning & EIS for Waste Soils Recovery Facility

Title Of Figure

Groundwater Vulnerability

Scale Used 1:25,000 @ A4

Figure No. 12.4

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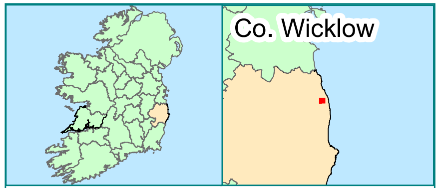

Legend

- Groundwater Monitoring Points / Borehole Locations
- Study Boundary

Date 05/05/2016

Wicklow County Council

Name Of Job

Waste Licence, Planning & EIS for Waste Soils Recovery Facility

Title Of Figure

Borehole and groundwater well locations

Scale Used 1:5,000 @ A4

Figure No. 12.5

Rev A

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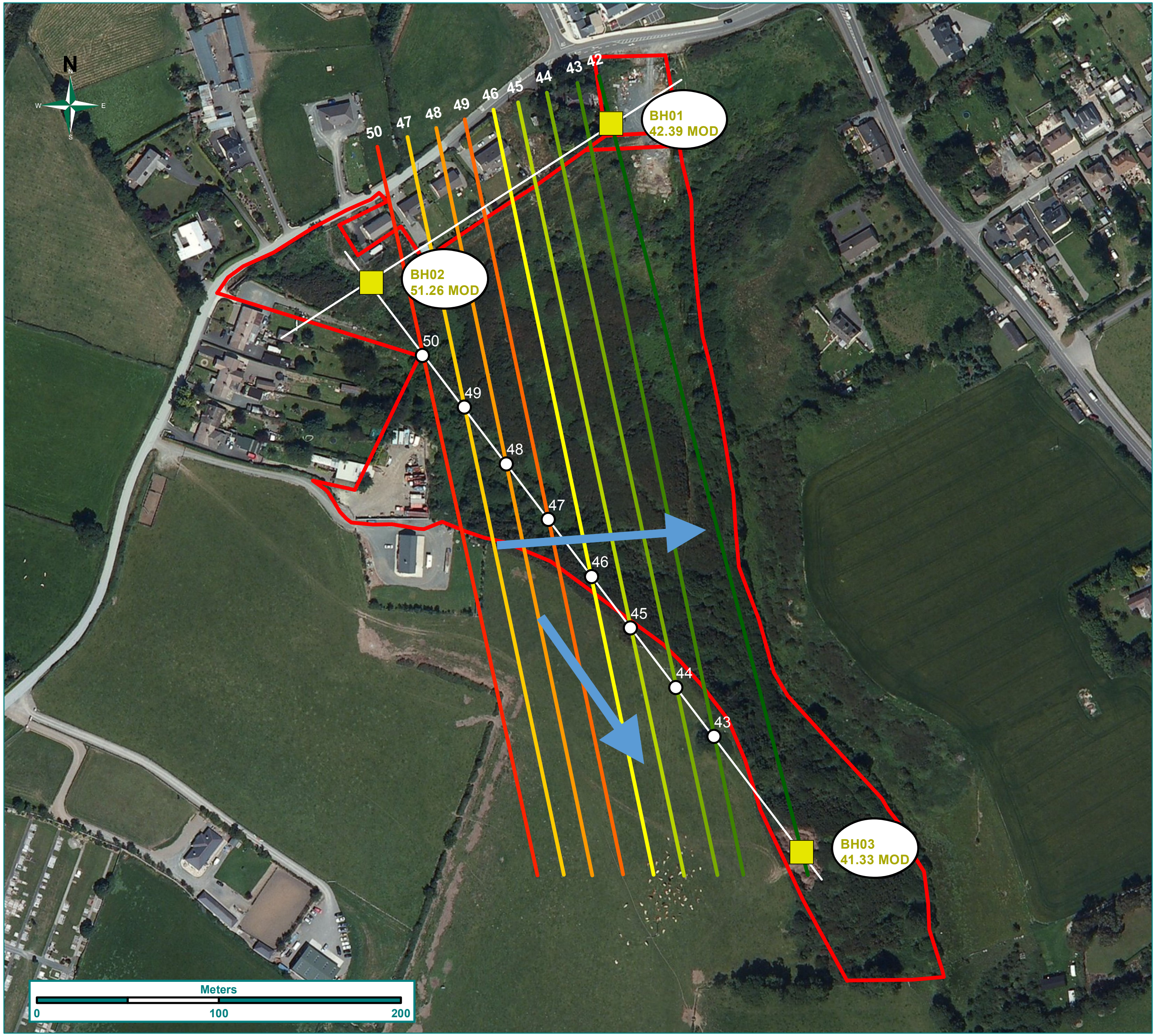

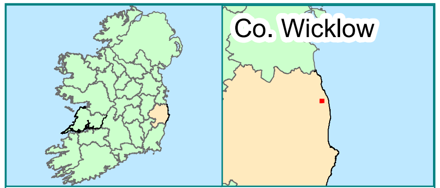

Legend

- Study Boundary
- Borehole Locations
  - BH01, 328486.5, 209453.5
  - BH02, 328846.5, 209365.9
  - BH03, 329082.9, 209053
- Groundwater Flow Direction

Groundwater Levels: 42, 43, 44, 45, 46, 47, 48, 49, 50

Date	06/05/2016
Wicklow County Council	
Name Of Job	Waste Licence, Planning & EIS for Waste Soils Recovery Facility
Title Of Figure	Groundwater Flow Direction
Scale Used	1:3,000 @ A4
Figure No.	12.6
Rev	A

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12.2.6 Groundwater monitoring results

Groundwater measurements were undertaken by FTC using a dipmeter approximately 1 week after installation of the groundwater wells and are presented in Table 12.6.

Table 12.6: Groundwater Readings

Borehole	GPS Coordinates		Ground Level (mAOD)	Depth to Groundwater (mBGL)	Groundwater Level (mAOD)
	X (ING)	*Y (ING)*			
RC01	328986.5	209453.5	48.55	6.16m (bedrock) 6.11m (overburden)	42.39mOD (bedrock) 42.44mOD (overburden)
RC02	328846.3	209365.9	52.274	1.01m (bedrock)	51.264mOD (bedrock)
RC03	329082.9	209053.0	43.592	2.26m (bedrock)	41.332mOD (bedrock)

The groundwater flow direction and gradient was determined using the recorded groundwater levels. By triangulating between the boreholes, it is possible to plot approximate groundwater level contours and thus determine the flow direction and gradient. Figure 12-6 shows that the groundwater flow direction is from west to the east and south east, towards the stream which runs approximately north-south along the eastern boundary of the site. The flow gradient is approximately 1 in 17 or 0.058, indicating that the rate of groundwater flow through the bedrock is relatively quick.

12.2.7 Groundwater Quality

The baseline groundwater quality was established by means of a groundwater monitoring and sampling regime and the borehole installed onsite, as described.

Approximately 1 week after installation, the wells were purged and sampled by FTC. Subsequent to recording the water levels, in-situ tests were undertaken by FTC prior to sampling which included pH, temperature, conductivity and dissolved oxygen. The results of the in-situ tests are presented in Table 12.7 with a comparison with relevant Interim Guidance Values (IGVs) in order to provide a baseline groundwater quality for the site.

Table 12.7: In-Situ Groundwater Analysis

Parameter	Units	GW2	GW3	GW1D (bedrock)	GW1S (overburden)	IGV
pH	Units	7.9	6.8	7.8	6.5	6.5-9.5
Temperature	°C	10.8	10.4	10.5	11.7	<25°C
Conductivity		450	359	477	496	<1000
Dissolved Oxygen	mg/l	4.82	8.51	9.24	2.97	No abnormal change
Appearance/ Odour	µS/cm	Brown, turbid, no odour	Brown/grey, turbid, no odour	Light brown, turbid	Brown, turbid, no odour, very slight oily sheen	No abnormal change

Groundwater samples were also recovered by FTC after purging the wells and sent to Alcontrol's UKAS accredited laboratory for analysis. The results of the analysis are presented in Appendix 17 to this EIS. A summary of results is given in Table 12.8 with a comparison with relevant Interim Guidance Values (IGVs).

With the exception of exceedances in coliforms, manganese, chloride, potassium and iron, the remaining values are below the IGVs set by the EPA. It is likely that the exceedances of manganese, chloride, potassium and iron reflect the chemical composition of the bedrock and groundwater in this area and these levels would not be considered unusual. The bacteriological exceedances (coliforms) may reflect contamination of the groundwater caused by nearby septic tanks or agricultural activities.

Table 12.8: Groundwater Analysis Results

Parameter	Units	GW2	GW3	GW1D (bedrock)	GW1S (overburden)	IGV
Coliforms, Total	CFU/100ml	**8160**	**13000**	**>242000**	**>242000**	0
Coliforms, Faecal	CFU/100ml	**47**	**>100**	**>100**	**68**	0
Suspended solids, Total	mg/l	236	40400	1260	381	-
Alkalinity, Total as CaCO3	mg/l	150	600	160	225	No abnormal change
BOD, filtered	mg/l	<1	<1	<1	<1	-
Organic Carbon, Total	mg/l	<3	<3	<3	20.3	No abnormal change
Ammoniacal Nitrogen as N	mg/l	<0.2	0.644	<0.2	0.713	-
Fluoride	mg/l	<0.5	<0.5	<0.5	<0.5	1.0
COD, unfiltered	mg/l	49.1	230	51.2	180	-
Conductivity @ 20°C	mS/cm	0.396	0.437	0.388	0.424	1.0
Silicon	mg/l	5.62	5.54	4.11	3.47	No abnormal change
Aluminium	µg/l	<2.9	11	5.16	72.6	200
Antimony	µg/l	<0.16	0.565	<0.16	<0.16	-
Arsenic	µg/l	<0.12	0.988	1.91	2.53	10
Barium	µg/l	1.91	5.39	13	54	100
Beryllium	µg/l	<0.07	<0.07	<0.07	<0.07	-
Boron	µg/l	9.65	10.4	16.2	63.1	100
Cadmium	µg/l	<0.1	<0.1	<0.1	0.116	5
Chromium	µg/l	1.3	1.43	1.38	3.45	30
Cobalt	µg/l	<0.06	1.29	1.21	6.84	-
Copper	µg/l	<0.85	1.35	0.903	2.4	30
Lead	µg/l	<0.02	0.035	<0.02	0.156	10
Manganese	µg/l	0.607	**1480**	**926**	**8500**	50
Molybdenum	µg/l	<0.24	3.25	1.48	1.02	-
Nickel	µg/l	0.506	3.28	1.65	4.54	20

Parameter	Units	GW2	GW3	GW1D (bedrock)	GW1S (overburden)	IGV
Phosphorous	µg/l	<6.3	<6.3	<6.3	1.09	-
Selenium	µg/l	<0.39	1.2	0.68	1.09	-
Tellerium	µg/l	<2	<2	<2	<2	-
Thallium	µg/l	<0.96	<0.96	<0.96	<0.96	-
Tin	µg/l	3.68	4.28	2.17	4.17	-
Uranium	µg/l	<1.5	<1.5	3.18	<1.5	9
Titanium	µg/l	<1.5	<1.5	<1.5	<1.5	-
Vanadium	µg/l	0.413	0.54	0.718	1.1	-
Zinc	µg/l	2.21	0.67	1.29	2.28	100
Mercury	µg/l	<0.01	<0.01	<0.01	<0.01	1
Sulphate	mg/l	32.8	16.4	26.7	32.6	200
Chloride	mg/l	26.4	**30.2**	**41.1**	29.2	30
Nitrate	mg/l	<0.0152	<0.0152	0.0167	<0.0152	0.1
Phosphate (ortho) as PO4	mg/l	<0.05	<0.05	0.053	<0.05	0.03
Total Oxidised Nitrogen as N	mg/l	6.46	8.68	1.7	0.341	No abnormal change
Cyanide, Total	mg/l	<0.05	<0.05	<0.05	<0.05	0.01
Calcium	mg/l	42.9	53	54	57.4	200
Sodium	mg/l	23.1	16.7	20.9	21.6	150
Magnesium	mg/l	13.6	13.2	9.49	5.64	50
Potassium	mg/l	1.24	3.47	2.3	**6.04**	5
Iron	mg/l	<0.019	<0.019	<0.019	**0.493**	0.2
pH	Units	8.02	7.82	7.82	7.31	6.5-9.5
Phenol	mg/l	<0.002	<0.002	<0.002	<0.002	0.0005
Cresols	mg/l	<0.006	<0.006	0.01	<0.006	-
Xylenols	mg/l	<0.008	<0.008	<0.008	<0.008	-
Phenols	mg/l	<0.016	<0.016	<0.016	<0.016	0.0005
Silver	µg/l	<1.5	<1.5	<1.5	<1.5	-

12.2.8 Existing Slope Stability

The GSI online Landslides Viewer was accessed on 19 October 2015. There are no known landslides close to the site. The nearest recorded landslide is in the Wicklow hills, approximately 10km west of the site. Slope stability is not expected to be an issue on this site providing earthworks and construction are undertaken in line with best practice with the design and supervision of an experienced geotechnical engineer.

12.3 Potential Impacts

The potential impacts of the development on the geology, hydrogeology and slope stability of the site are assessed below.

12.3.1 Impact Appraisal Methodology

The following elements of the development were examined in order to determine the potential impacts on the geology and hydrogeology aspects of the proposed development:

- characterisation of the topography, geology and geomorphology of the site
- appraisal of stability issues, in the context of the existing environment and the proposed development
- 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.

12.3.2 Assessment of Significance of Geological Impact on the Receiving Environment

An impact rating has been developed for each phase of the development of the site based on the NRA guidance, as recommended by the Institute of Geologists of Ireland (IGI). The importance (sensitivity) of the receiving environment was first identified. Then the magnitude of the potential geological and hydrogeological impact was estimated. This determines the significance of the impact prior to the application of mitigation measures.

The criteria for rating site importance of the geological features is set out in Table 12.9.

Table 12-9: Criteria for Rating Site importance of Geological/Hydrogeological Features

Importance	Criteria	Typical Example
Extremely High (Hydrogeology only)	Attribute has a high quality or value on an international scale.	Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation e.g. SAC or SPA status.
Very High	Attribute has a high quality, significance or value on a regional or national scale. Degree or extent of soil 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.	Geological feature on a regional or national scale (NHA). Large existing quarry or pit. Proven economically extractable mineral resource. Regionally Important Aquifer with multiple wellfields. Groundwater supports river, wetland or surface water body ecosystem protected by national legislation e.g. NHA status. Regionally important potable water source supplying >2,500 homes. Inner source protection area for regionally important water source.
High	Attribute has a high quality, significance or value on a local scale.	Contaminated soil on site with previous heavy industrial usage. Large recent landfill site for mixed wastes.

Importance	Criteria	Typical Example
	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.	Geological feature of high value on a local scale (County Geological Site). Well drained and/or high fertility soils. Moderately sized existing quarry or pit. Marginally economic extractable mineral resource. Regionally Important Aquifer. Groundwater provides large proportion of baseflow to local rivers. Locally important potable water source supplying >1,000 homes. Outer source protection area for regionally important water source. Inner source protection area for locally important water source.
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.	Contaminated soil on site with previous light industrial usage. Small recent landfill site for mixed wastes. Moderately drained and/or moderate fertility soils. Small existing quarry or pit. Sub- economic extractable mineral resource. Locally important Aquifer. Potable water source supplying >50 homes. Outer source protection area for locally important water source.
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.	Large historical and/or recent site for construction and demolition wastes. Small historical and/or recent landfill site for construction and demolition wastes. Poorly drained and/or low fertility soils. Uneconomic extractable mineral resource. Poor bedrock aquifer. Potable water source supplying <50 homes.

Generally, the site geology and hydrogeology ranks as Low importance as the site is underlain by a Poor bedrock aquifer which is generally unproductive except locally. Although there are several groundwater wells registered in this area, it is understood that the vast majority of homes and businesses in the area use mains water supply and do not rely on groundwater wells.

12.3.3 Assessment of Magnitude of the Impact on Geology Attribute (NRA, 2008)

The assessment of the magnitude of an impact incorporates the timing, scale, size and duration of the potential impact. The magnitude criteria for geological and hydrogeological impacts are defined as set out in Table 12.10.

Table 12-10: Estimation of Magnitude of Impact on Geological & Hydrogeological Features

Magnitude	Criterion	Description and Example
Large Adverse	Results in loss of attribute and/or quality and integrity of attribute	• Loss of high proportion of future quarry or pit reserves • Irreversible loss of high proportion of local high fertility soils • Removal of entirety of geological heritage feature • Requirement to excavate / remediate entire waste site • Requirement to excavate and replace high proportion of peat • organic soils and/or soft mineral soils beneath alignment • Removal of large proportion of aquifer • Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems • Potential high risk of pollution to groundwater from routine run-off. • Calculated risk of serious pollution incident >2% annually.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	• Loss of moderate proportion of future quarry or pit reserves • Removal of part of geological heritage feature • Irreversible loss of moderate proportion of local high fertility soils • Requirement to excavate / remediate significant proportion of waste site • Requirement to excavate and replace moderate proportion of peat, • Organic soils and/or soft mineral soils beneath alignment. • Removal of moderate proportion of aquifer. • Changes to aquifer or unsaturated zone resulting in moderate changes to existing water supply of springs and wells, river baseflow or ecosystems. • Potential medium risk of pollution to groundwater from routine run-off • Calculated risk of serious pollution >1% annually
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	• Loss of small proportion of future quarry or pit reserves • Removal of small part of geological heritage feature • Irreversible loss of small proportion of local high fertility soils and/or • High proportion of local low fertility soils • Requirement to excavate / remediate small proportion of waste site • Requirement to excavate and replace small proportion of peat. • Organic soils and/or soft mineral soils beneath alignment. • Removal of small proportion of aquifer.

Magnitude	Criterion	Description and Example
		• Changes to aquifer or unsaturated zone resulting in minor change to water supply of springs and wells, river baseflow or ecosystems. • Potential low risk of pollution to groundwater from routine run-off. • Calculated risk of serious pollution incident >0.5% annually.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	No measurable changes in attributes. Calculated risk of serious pollution incident <0.5% annually.
Minor Beneficial	Results in minor improvement of attribute quality	Minor enhancement of geological heritage feature
Moderate Beneficial	Results in moderate improvement of attribute quality	Moderate enhancement of geological heritage feature
Major Beneficial	Results in major improvement of attribute quality	Major enhancement of geological heritage feature

Generally, the unmitigated impact on the geological environment is considered to be a small adverse effect based on the impact and attributes given in Table 12.10. The reason for this is the perceived low risk of pollution to the aquifer which may be caused as a result of the importation of potentially contaminated sediments or contamination caused by leaks and spills from construction plant or materials.

12.3.4 Assessment of Significance of Geological Impacts (NRA, 2008)

The matrix in Table 12.11 over determines the significance of the impacts based on the importance and magnitude of the impacts as determined by Tables 12.9 and 12.10.

Table 12-11: Ratings of Significant Environmental Impacts for Geology & Hydrogeology

Importance of Attribute	Magnitude of Impact			
	Negligible	Small Adverse	Moderate Adverse	Large Adverse
Extremely High	Imperceptible	Significant	Profound	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

The determination of the significance of each impact for this site is presented over.

12.3.5 Potential Impacts due to the Importation and Placement of Soils – Direct & Indirect

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

- Importation of dredge spoil and topsoil
- Placement of dredge spoil and topsoil
- Earthworks and movement of soils by plant and machinery
- Drainage

The importation and placement of dredge spoil and topsoils and interference with existing site drainage is a direct permanent effect that, without mitigation, could alter the existing hydrogeological balance of the site.

The construction works may impose hydrogeological impacts 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.

Earthworks can have a direct permanent impact on the exposed soils and rock in the form of increased erosion and sediment release that could also have additional impacts on water quality (due to sedimentation of water courses).

Soil compaction may occur due to movement of construction traffic. This could 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 at the development site, prior to mitigation, is considered to be of slight significance.

12.3.6 Potential Impact on Groundwater – Direct & Indirect

Removal of topsoil and subsoil during construction may result in the exposure of the underlying rock to sources of contamination and may temporarily increase the vulnerability of the aquifer whether or not the rock is exposed. Chemical pollution may occur as a result of spillage or leakage of fuels or refuelling activities etc. Chemical pollutants i.e. fuel may enter groundwater supplies and have implications for damage to ecology and local water supplies such as groundwater wells in the area, particularly those located down-gradient of the site.

The importation of soils may result in an increased direct risk of contamination of the underlying groundwater from contaminants within the imported dredge spoil if not properly controlled or regulated. In addition, erosion and run-off from the imported soils may also directly affect the quality of the groundwater if not properly mitigated.

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 sediment transport, flooding and erosion (described in Section 13 Hydrology and Water Quality).

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

A standalone Environmental Risk Assessment (ERA) to assess potential impact on groundwater has also been prepared and is provided in Appendix 18 to this EIS.

12.3.7 Potential Impact of Slope Failure – Direct & Indirect

There is no perceived risk of slope instability on the site at present, given the low soil cover on exiting slopes and the extent of established vegetation at the site and on existing slopes. During construction, importation of dredge spoil will result in slightly steeper slopes which will increase the risk of slope stability slightly. The main risk would be of slope failure during placement of material during construction.

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

12.3.8 Potential Cumulative Impacts on Geology and Hydrogeology

There are no other developments of any significance within the area of the proposed development and hence there are no potential cumulative impacts on the geology and hydrogeology of the site.

12.4 Mitigation Measures for Geology, Hydrogeology & Slope Stability

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

12.1.1 Mitigation by Design

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

- The works will be designed and checked by a suitably qualified and experienced geotechnical engineer or engineering geologist, and hydrologist or drainage engineer.
- The designers will carry out a design risk assessment to evaluate risk levels for the construction, operation and maintenance of the works. Identified risks will be minimised by the application of the 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 prior to any element of the work being carried out.
- Details of the relevant assumptions, relating to methods and sequencing of work will be provided to the contractor.
- No amendments to the designed works will be made without the prior approval of a suitably qualified and experienced engineering geologist or geotechnical engineer familiar with earthworks.
- The construction and environmental management plan for construction will provide for the checking by suitably qualified and experienced staff of equipment, materials storage and materials transfer areas, as well as drainage structures, on a regular basis.
- Earthworks will be monitored by suitably qualified and experienced geotechnical personnel.
- The programming of the works 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.

12.4.1 Mitigation Measures for the Importation and Placement of Soils

Imported spoil will be placed and levelled as quickly as possible after unloading on the site. Any temporary stockpiles will be covered overnight to prevent erosion and sedimentation.

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

12.4.2 Mitigation Measures for Groundwater

To prevent potential impacts resulting from the importation and placement of potential contaminants within the dredge spoil material, the waste identification and characterisation procedures outlined in Section 3.3.4 previously, will be applied – in summary, these being the requirements for a Letter of Suitability of each 5,000 tonnes of material imported to the site and carrying out of weekly random characterisation of all types of material being brought to site.

In order to mitigate against contamination reaching the water table, refuelling and vehicle maintenance will be undertaken only within designated areas which will be bunded to prevent runoff. Additional mitigation measures such as spoil bunding and silt fences will also be provided adjacent to excavations and construction as required in order to reduce run-off and sedimentation of watercourses. Further details are given in Section 13 Hydrology and Water Quality.

In order to further protect the hydrogeology of the area, the existing groundwater wells will be monitored for water level and water quality before, during and after the Construction Phase to ensure that there is no long term impact on the hydrogeology of the area.

12.4.3 Mitigation Measures for Slope Stability

As outlined in Section 12.3.7, the risk of slope failure or slope instability within soil or rock on the site is assessed as imperceptible. No detailed mitigation measures are therefore required, however design and construction best practice will be implemented which will ensure that the long-term stability of the site is maintained during construction and operation of the site. In particular, the following will be undertaken:

- Existing and imported spoil will be assessed prior to construction work by a suitably experienced and qualified geotechnical engineer to ensure that no slope stability issues arise before, during or after the construction phase of the work.
- Spoil will be placed in accordance with an engineering specification to ensure that safe slopes and the necessary compaction levels are achieved.
- On-site testing will be undertaken under the direction of a geotechnical engineer to ensure that the required compaction, moisture content and density are achieved during placement of the soils.
- Initial and final topography will be surveyed and reviewed by the geotechnical engineer to ensure that no slope stability issues will occur.

12.5 Residual Impacts after Mitigation

Residual impacts on the soils, geology and hydrogeology after implementation of the mitigation measures listed are predicted to be imperceptible.

12.6 Conclusion & Summary

The following conclusions can be drawn, in relation to soils, geology and hydrogeology:

- the site geology typically consists of a thin cover of topsoil, subsoil overlying shallow siltstone or sandstone bedrock
- no peat was observed on the site
- drainage of the area comprises surface runoff with natural drains which drain towards drainage ditches to the east and west of the site which flow to the Kilcoole Stream
- the site is mostly covered with low scrub vegetation

The available information indicates that the proposed development at has a negligible risk of slope instability.

A site walkover was undertaken on the site in order to assess the potential impacts on the geology and hydrogeology.

Mitigation measures have been proposed with regard to the design and construction of the proposed development. Provided that these mitigation measures are carefully implemented, the residual risks to the geology and hydrogeology associated with the construction of the site are considered to be imperceptible.

12.7 References

EPA (2003) *Towards Setting Guideline Values for the Protection of Groundwater in Ireland*. Environmental Protection Agency.

GSI (1994) *Geology of Kildare-Wicklow (Sheet 16)*. Geological Survey of Ireland.

National Soil Survey (1980) *General Soil Map of Ireland*. National Soil Survey of Ireland.

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