Chapter 11
Hydrogeology

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11. HYDROGEOLOGY

11.1 Introduction

This chapter of the Environmental Impact Assessment Report (EIAR) presents the groundwater assessment of the proposed construction and operational phases of the DART+ West project (hereafter referred to as the 'proposed development'). This chapter sets out the relevant legislation, policy, and guidance (Section 11.2), the methodology used in the assessment (Section 11.3), describes the hydrogeological baseline (Section 11.4), and the identification of elements of the proposed development that could cause effects to the groundwater environment (Appendix A11.1 Screening Process in Volume 4 of this EIAR). Sections 11.5 and 11.6 provide the impact assessment and the description measures to mitigate identified impacts and details of the residual impacts post-mitigation are set out in Section 11.8. This chapter should be read in conjunction with the following Chapters, and their Appendices, which present related impacts arising from the proposed development and proposed mitigation measures to ameliorate the predicted impacts:

- Chapter 4 Description of the Proposed Development.
- Chapter 5 Construction Strategy.
- Chapter 8 Biodiversity.
- Chapter 9 Land and Soils.
- Chapter 10 Water (including Hydrology and Flood Risk).

11.2 Legislation, policy, and guidance

11.2.1 Legislation

Córas Iompair Éireann is applying to An Bord Pleanála for a Railway Order for the DART+ West project under the Transport (Railway Infrastructure) Act 2001 (as amended and substituted) ("the 2001 Act") and as recently further amended by the European Union (Railway Orders) (Environmental Impact Assessment) (Amendment) Regulations 2021 in Statutory Instrument No. 743/2021 ("the 2021 Regulations"). The purpose of the 2021 Regulations was to give further effect to the transposition of the EIA Directive (EU Directive 2011/92/EU as amended by Directive 2014/52/EU) on the assessment of the effects of certain public private projects on the environment by amending the 2001 Act. This hydrogeology and groundwater assessment has been undertaken in accordance with these requirements.

Further, this assessment of groundwater considers the impact of construction and operation of the proposed development with regard to policy, plan, and strategy documents, including (but not limited to) the following:

- European Communities Directive 2000/60/EC (Water Framework Directive).
- European Communities Environmental Objectives (Surface Waters) Regulations, 2009 (S.I. No. 272 of 2009).
- European Communities Environmental Objectives (Groundwater) Regulations, 2010 (S.I. No. 9 of 2010).
- European Communities (Water Policy) Regulations, 2003 (S.I. No. 722 of 2003).
- European Communities (Drinking Water) Regulations 2014 (S.I. No. 122 of 2014).
- European Communities (Drinking Water) (No. 2) Regulations 2007 (S.I. No. 278 of 2007).
- European Communities (Natural Habitats) Regulations 1997, (S.I. No. 94 of 1997) and European Communities (Birds and Natural Habitats) Regulations, 2011 (S.I. No. 477 of 2011).

11.2.2 Policy

Relevant policy documents that have informed this chapter include:

- Dublin City Development Plan 2016-2022.

- Draft Dublin City Development Plan 2022-2028.
- Fingal Development Plan 2017-2023.
- Draft Fingal Development Plan 2023-2029.
- Kildare County Development Plan 2017-2023.
- Draft Kildare County Development Plan 2023-2029.
- Meath County Development Plan 2021-2027.
- North Lotts and Grand Canal Dock Strategic Development Zone Planning Scheme 2014.
- Ashtown – Pelletstown Local Area Plan 2014.
- Pelletstown Local Area Plan 2014.
- Hansfield Strategic Development Zone Planning Scheme 2006.
- Kellystown Local Area Plan, January 2021.
- Barnhill Local Area Plan 2019.
- Leixlip Local Area Plan 2020-2023.
- Maynooth Local Area Plan 2013-2019.

11.2.3 Guidance

The following guidelines were used in carrying out the assessment of hydrogeologic impacts:

- National Roads Authority (NRA) (2009) 'Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Scheme.
- Environmental Protection Agency (EPA) (2022), *Guidelines on the Information to be Contained in Environmental Impact Assessment Reports*.
- Environmental Protection Agency (EPA) (2015), *Advice Notes for Preparing Environmental Impact Statements.*
- Institute of Geologists of Ireland (IGI) (2013), *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements*.
- Environmental Protection Agency (EPA) (2003), *Advice notes on Current Practice in the Preparation of Environmental Impact Statements*.
- Environmental Protection Agency (EPA) (2002), *Guidelines on the information to be contained in environmental impact statements.*
- TII Light Rail Environment – *Technical Guidelines for Development* (PE-PDV-00001), 2020.

11.3 Methodology

11.3.1 Study area

The proposed development extends for over 40 km along the existing railway line which runs through county Dublin (Dublin City and Fingal) into counties Meath and Kildare, which are mostly urban and suburban areas. The primary study area includes lands within 250 m of the proposed development. The study area is however flexible for this assessment; where works that could have a significant impact on a wider area are identified, the study area is increased. Consideration is also given to the surface waterbodies that are potentially hydrologically and hydrogeologically linked to the study area, this includes the Tolka and Liffey estuaries. Groundwater bodies that are considered as highly vulnerable to extremely vulnerable with bedrock at or near the surface that are of significance due to their potential use as drinking water sources or linked to groundwater dependent terrestrial ecosystems (GWDTE) are considered along the proposed development.

The land use along the eastern end of the proposed development at Spencer Dock is predominantly urban, becoming more suburban in nature as the development moves west towards Leixlip and Maynooth. The area immediately surrounding the Spencer Dock is developed land comprising a mixture of residential and commercial sites with some greenfield areas as the line moves towards the suburban areas of Dublin City. North of the proposed development on the west side of Leixlip is the Collinstown Industrial Park consisting of several large industrial buildings. West of Leixlip land usage along the route of the proposed development becomes increasingly rural as the railway line moves west beyond Leixlip to Maynooth and parallel to the Royal Canal. There are primarily greenfield sites along the rural end of the line between Leixlip to Maynooth with a mixture of farmland and residential sites immediately surrounding the proposed development.

11.3.2 Survey methodology

11.3.2.1 Desktop study

The desk study involved collecting all relevant hydrogeological data for the study area. The sources of information review include:

- Geological mapping and borehole data from the Geological Survey of Ireland (GSI) (www.gsi.ie/mapping).
- Groundwater flooding data (www.gsi.ie/mapping).
- Groundwater Abstraction data from GSI.
- Historical ordnance survey mapping information from OSI website, including historical maps available, OSI Historic 6” black & white and colour, OSI 6” Cassini and OSI Historic 25” (map.geohive.ie).
- Information on the hydrology and hydrogeology has been obtained from the interactive maps on the GSI website.
- Environmental Protection Agency (EPA).
- Topographical information from LIDAR surveys published on the GSI website.
- Dublin SURGE project data and reporting as published on the GSI website.
- Opensource technologies such as Google Earth and Bing Maps.
- Studies on the tufa springs of the Ryewater.
- Planning applications in the Spencer Dock Area including:
  - Dublin Planning Application - DSDZ2750/16- Site bounded by North Wall Quay, New Wapping Street, Mayor Street Upper and Castleforbes Road, North Lotts, Dublin 1.
  - An Bord Pleanála Case reference: TA29N.305219 - 305219: City Block 2, Spencer Dock, Site bound by Sheriff Street Upper to the north, Mayor Street Upper to the south, New Wapping Street to the east and a development site to the west (also part of Block 2), Dublin 1.

11.3.2.2 Ground investigations

The ground investigation for the proposed development was undertaken with an appropriate number of locations to provide sufficient data to classify and characterise the site conditions for the proposed design elements and to inform on geotechnical and groundwater risks. Refer to Chapter 9 Lands and Soils in Volume 2 of this EIAR for more detail on ground investigations.

11.3.3 Assessment methodology

This Chapter of the EIAR has been produced in accordance with the Environmental Impact Assessment Regulations, relevant guidance published by the EPA (2015 & 2022), and the Institute of Geologists of Ireland (IGI) Guidelines *for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements.* (2013).

The impact assessment methodology developed by NRA (2009) (now Transport Infrastructure Ireland (TII)) that considers both the sensitivity (importance) of the receiving environment and the predicted change (impact significance) in the environment to describe the overall significance of the environmental impact is a useful framework to adopt for this assessment and is reproduced below. This sequential process takes three steps:

- **Step 1:** Quantify the <u>Importance</u> of an environmental feature (see Table 11-1).
- **Step 2:** Estimate the <u>Scale</u> of the impact on the feature from the proposed development (see Table 11-2).

- **Step 3:** Determine the Significance of the impact on the feature from the matrix (see Table 11-3) based on the Importance of the feature and the scale of the impact.

Key hydrogeological attributes that have been considered within the study area include:

- Groundwater supplies to multiple households and their surrounding Source Protection Areas (SPAs).
- Low-yielding wells used for individual dwellings.
- Any significant natural hydrogeological features (including large springs or groundwater dependent habitats).
- The nature of the aquifer(s) underlying the proposed development including aquifer extent, recharge characteristics, and flow patterns within.

The individual importance of these attributes has been then assessed based on the criteria in Table 11-1.

Table 11-1 Criteria for rating site importance of hydrogeological features (NRA, 2009)

Importance	Criteria	Typical Example
Extremely High	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 or value on a regional or national scale.	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 > 2500 homes. Inner source protection area for regionally important water source.
High	Attribute has a high quality or value on a local scale.	Regionally important aquifer. Groundwater provides large proportion of baseflow to local rivers. Locally important potable water source suppling > 1000 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 or value on a local scale.	Locally important aquifer. Potable water source supplying >50 homes. Outer source protection area for locally important water source.
Low	Attribute has a low quality or value on a local scale.	Poor bedrock aquifer. Potable water source supplying <50 homes.

Table 11-2 Criteria for rating impact significance of EIA stage- estimation of magnitude of impact on hydrogeology and geology attribute (NRA, 2009)

Importance	Criteria	Typical Example
Large Adverse	Results in loss of attribute and / or quality and integrity of attribute.	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.	Removal of moderate proportion of aquifer. Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems. Potential medium risk of pollution to groundwater from routine run-off. Calculated risk of serious pollution incident >1% annually.

Importance	Criteria	Typical Example
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute.	Removal of small proportion of aquifer. Changes to aquifer or unsaturated zone resulting in minor change to water supply 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 an attribute but of insufficient magnitude to affect either use or integrity.	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.

Table 11-3 Rating of significance of effects at EIA stage (NRA, 2009)

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

11.3.4 Initial screening of potential impacts/receptors

Only certain elements of the proposed development have the potential to affect the groundwater environment through pollution or changes to groundwater flow. Appendix A11.1 Screening Process in Volume 4 of this EIAR provides a review of the various elements of the proposed development and assesses their overall potential to lead to groundwater related effects. The assessment presented within the table in Appendix A11.1 considers both the operational and construction phases of the proposed development as works to create underground structures or earthworks would have broadly similar effects in the operational and construction phases. Hydrogeological effect mechanisms include the following:

- alteration of groundwater levels and flow pathways or changes to recharge through the development of structures on, or beneath the ground surface, or the creation of new drainage routes and impermeable surfaces.
- increase the vulnerability of groundwater to pollution through the creation of new pollution pathways or decreasing the depth to the water table.
- create potential pollution sources.

The majority of the proposed works lie on bedrock aquifers which are classified by the GSI as being locally important. The magnitude of potential hydrogeological impacts assigned are in the first instance based on the impacts on the attributes of this generic receptor. Where further assessment is required to assess other receptor types this is identified.

The screening process has two potential outcomes:

- No further assessment is required as no feasible hydrogeological impact mechanism can be identified.

- Further assessment is required and the impacts are assessed from Section 11.5 onwards.

11.3.5 Consultation

Chapter 3 of this EIAR details the alternatives considered and the consultation undertaken throughout the project. The key consultation phases and the feedback received that has informed this chapter include:

- Non-statutory EIA Scoping Report.
- Options Selection process and the associated two public consultation periods (PC1 and PC2), local Ashtown public consultation on the revised preferred option, and associated feedback received through submissions and public information events.

11.3.6 Difficulties encountered/limitations

At the time of writing, no detailed site investigation data was available to provide detailed information on ground conditions within some parts of the flood compensatory storage lands west of Maynooth. Assessment of the impacts of this work have been based on desk study information and a review of site investigation data on the immediate boundary, such as borehole logs. The information available provided sufficient data to characterise the general nature of deposits and groundwater conditions in the area.

11.4 Receiving environment

11.4.1 Surface water

In the interest of conciseness, a description of the surface water environment is provided in Chapter 10 Water (including Hydrology and Flood Risk) in Volume 2 of this EIAR.

11.4.2 Geology

11.4.2.1 Quaternary geology

The majority of the study area is covered by deposits of glacial till derived from limestone as shown in Table 11-4. Along the main rivers are bands of alluvium and gravels derived from limestone. These gravels extend beneath the Spencer Dock area. Table 11-4 below and Drawings MAY-MDC-GEO-ROUT-DR-G-91000-D to 91011-D in Volume 3A of this EIAR show how the quaternary deposits vary through the study area.

Table 11-4 Quaternary geology

Deposit	Lithology	Location relative to Study Area	Hydrogeological properties
Urban	Variable- natural and made ground	Through the centre of Dublin	Variable
Alluvium (undifferentiated)	Likely to be Silts and Clays dominated as not classified as Alluvium – Gravels or Alluvium - Sand	Floodplain at Barberstown Ryewater Crossing River Lyreen Crossing	Variable
Alluvium (Gravels)	Gravels	River terraces along Ryewater and River Lyreen	High permeability – intergranular flow dominated
Gravels derived from Limestone	Gravels	Outcrop along the edges of the River Ryewater and River Lyreen and beneath the Spencer Dock area	High permeability – intergranular flow dominated
Till derived from Limestone	Variable	Outcrops across the majority of the study area	Variable – typically lower permeability

Table 11-5 Quaternary deposits and locations along proposed development

Zone	Area description	Teargas Subsoils	Subsoil description	Length (m)
A	Connolly to Newcomen Station	Made	Made ground	460
B	Docklands to North Strand junction	Made	Made ground	1,190
A	Connolly to Glasnevin Junction	Made	Made ground	3,750
B	Docklands to Glasnevin Junction	Made	Made ground	3,750
C	Glasnevin Junction to 175m West of R805 (Ratoath Rd)	Made	Made ground	1,815
C	175m West of R805 to 410m East of M50/N3 interchange	Tills (TLs)	Limestone till	3,390
C	410m East of M50/N3 interchange to Old Navan overbridge	Made	Made ground	565
C	Old Navan overbridge to 54m East of R806 (Castleknock Rd)	Rck	Bedrock at or close to surface	260
C	East of R806 to NW of Castleknock Walk	Made	Made ground	815
C	Small section by Castleknock Walk	Tills (TLs)	Limestone till	190
C	500 East-northeast of Coolmine Station to immediately East of Clonsilla Station	Rck	Bedrock at or close to surface	2,735
D	Split of rail line heading north towards Dunboyne	Rck	Bedrock at or close to surface	280
D	West of split of rail line to crossing unnamed creek	Tills (TLs)	Limestone till	3,415
D	Area immediately around unnamed creek crossing	Rck	Bedrock at or close to surface	100
D	Unname creek crossing to south bank of Tolka River branch	Tills (TLs)	Limestone till	390
D	South bank of Tolka River branch to south of L2228 overbridge	Alluvium (A)	Alluvium undifferentiated	225
D	South of L2228 overbridge to overbridge	Tills (TLs)	Limestone till	90
D	L2228 overbridge to east adjacent to Silver Birches	Made	Made ground	545
D	Silver Birches to north of Millfarm	Tills (TLs)	Limestone till	170
D	North of Millfarm to just south of Tolka River crossing	GLs	Glaciofluvial limestone sand and gravels	505
D	Area immediately north and south of Tolka River	Alluvium (A)	Alluvium undifferentiated	155
D	Area north of first Tolka River crossing to south of second Tolka River crossing	GLs	Glaciofluvial limestone sand and gravels	370
D	Area immediately surrounding second Tolka River crossing	Alluvium (A)	Alluvium undifferentiated	170
D	North of second Tolka River crossing to M3 Parkway	Tills (TLs)	Limestone till	145
E	Clonsilla Station to 70m southwest of Milestown Rd	Tills (TLs)	Limestone till	1,250
E	Southwest of Milestown Road to 30m southwest of unnamed creek crossing	Alluvium (A)	Alluvium undifferentiated	315

Zone	Area description	Teargas Subsoils	Subsoil description	Length (m)
E	Unnamed creek crossing to southwest of Westmanstown Sports & Conference Centre	Tills (TLs)	Limestone till	560
E	Section immediately adjacent to Westmanstown Sport & Conference Centre (WSCC)	Made	Made ground	260
E	WSCC to northwest of Leixlip Waterfall	Tills (TLs)	Limestone till	3,040
E	Northwest of Leixlip Waterfall to 20m North of Rye Water	GLs	Glaciofluvial limestone sand and gravels	280
E	Area immediately North and South of Rye Water	Alluvium (A)	Alluvium undifferentiated	50
E	South of Rye Water to North of Parklands	Tills (TLs)	Limestone till	5,270
E	North of Parklands to Maynooth Station	Made	Made ground	915
F	Maynooth Station to east side of Bond Bridge	Made	Made ground	430
F	East side of Bond Bridge to 620m West of bridge	Tills (TLs)	Limestone till	635
F	Small section west of Bond Bridge	Lacustrine sediments (L)	Lake sediments undifferentiated, glaciolacustrine deposits	125
F	West of Bond Bridge to 65m East of River Lyreen	Tills (TLs)	Limestone till	795
F	Areas East and West immediately around River Lyreen	Alluvium (A)	Alluvium undifferentiated	155
F	River Lyreen to Depot	Tills (TLs)	Limestone till	2,565

11.4.2.2 Bedrock geology

Geological maps from the Geological Survey of Ireland (GSI) were reviewed to obtain an overview of the bedrock geology traversed by the proposed development. The alignment of the proposed development predominantly transverses over three rock formations which are described in Table 11-6 and shown in Drawing MAY-MDC-GEO-ROUT-DR-G-93000-D in Volume 3A of this EIAR. As evident from Table 11-6, the majority of the proposed development is dominated by the Lucan Formation with smaller areas of the Tober Colleen calcareous shales and limestone.

Table 11-6 Bedrock geology

Formation	Lithology	Estimated Thickness (m)[1]	Location relative to the study area	Aquifer description
Lucan formation	Dark limestone and shale	300-800	Underlies much of the route	Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones (LI)
Tober Colleen Formation	Calcareous shale, limestone conglomerate	50-200+	Outcrops east of Maynooth and at Castleknock	Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones (PI)
Waulsortian Limestone (WA)	Massive, unbedded lime-mudstone	0-200	Outcrops east of Maynooth and at Castleknock	Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones (LI)

Table 11-7 Bedrock geology along the proposed development

Zone	Formation name	System	Formation Description	Formation definition	Formation length (m)
A (Connolly to Newcomen Station)	Lucan	Carboniferous	Dark limestone & shale (calp)	Dark-grey to black fine-grained, occasionally cherty, micritic limestones that weather, usually to pale grey. These calcarenitic limestones, sometimes graded, are dark coarser-grained and interbedded dark-grey calcar.	460
B (Docklands to North Strand junction)					1190
A (Connolly to Glasnevin Junction)					3750
B (Docklands to Glasnevin Junction)					3750
C					3300
C	Tober Colleen	Carboniferous	Calcareous shale, limestone conglomerate	Dark-grey, calcareous, commonly bioturbated mudstones and subordinate thin micritic limestones.	1750
	Lucan	Carboniferous	Dark limestone & shale (calp)	Dark-grey to black fine-grained, occasionally cherty, micritic limestones that weather, usually to pale grey. These calcarenitic limestones, sometimes graded, are dark coarser-grained and interbedded dark-grey calcar.	5270
D	Lucan	Carboniferous	Dark limestone & shale (calp)	Dark-grey to black fine-grained, occasionally cherty, micritic limestones that weather, usually to pale grey. These calcarenitic limestones, sometimes graded, are dark coarser-grained and interbedded dark-grey calcar.	7500
E	Lucan	Carboniferous	Dark limestone & shale (calp)	Dark-grey to black fine-grained, occasionally cherty, micritic limestones that weather, usually to pale grey. These calcarenitic limestones, sometimes graded, are dark coarser-grained and interbedded dark-grey calcar.	7630
E	Tober Colleen	Carboniferous	Calcareous shale, limestone conglomerate	Dark-grey, calcareous, commonly bioturbated mudstones and subordinate thin micritic limestones.	680
E	Waulsortian Limestones	Carboniferous	Massive unbedded lime-mudstone	Sometimes informally called "reef" limestones although inaccurate. Dominant pale-grey, crudely bedded or massive limestones	810
E	Tober Colleen	Carboniferous	Calcareous shale, limestone conglomerate	Dark-grey, calcareous, commonly bioturbated mudstones and subordinate thin micritic limestones.	890

Zone	Formation name	System	Formation Description	Formation definition	Formation length (m)
E	Lucan	Carboniferous	Dark limestone & shale (calp)	Dark-grey to black fine-grained, occasionally cherty, micritic limestones that weather, usually to pale grey. These calcarenitic limestones, sometimes graded, are dark coarser-grained and interbedded dark-grey calcar.	2610
F	Lucan	Carboniferous	Dark limestone & shale (calp)	Dark-grey to black fine-grained, occasionally cherty, micritic limestones that weather, usually to pale grey. These calcarenitic limestones, sometimes graded, are dark coarser-grained and interbedded dark-grey calcar.	5000

11.4.2.3 Aquifer classification

The GSI has classified geological strata for hydrogeological purposes based on the value of the groundwater resource and the hydrogeological characteristics. The GSI classify types of aquifer, corresponding to whether they are major, minor or unproductive groundwater resources. These are further subdivided into 10 aquifer categories (see Table 11-8).

Table 11-8 Aquifer types, descriptions, and codes

Aquifer type	Description	Code
Regionally important (R)	Karstified bedrock dominated by diffuse flow	(Rkd)
	Karstified bedrock dominated by conduit flow	(Rkc)
	Fissured bedrock	(Rf)
	Extensive sand & gravel	(Rg)
Locally important (L)	Sand & gravel	(Lg)
	Bedrock which is generally moderately productive	(Lm)
	Bedrock which is moderately productive only in local zones	(Ll)
	Locally important karstified bedrock	(Lk)
Poor (P)	Bedrock which is generally unproductive except for local zones	(Pl)
	Bedrock which is generally unproductive	(Pu)

Table 11-6 provides the aquifer description for the three bedrock types covering the area of the proposed development. The Lucan Formation and Waulsortian Formation are “Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones” and the Tober Colleen Formation is a “Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones”. The aquifer types that are encountered from west to east along the proposed development are summarised in Table 11-9 below and shown in Drawing MAY-MDC-GEO-ROUT-DR-G-92000-D to 92011-D in Volume 3A of this EIAR.

Table 11-9 Aquifer types along the proposed works

Description of Area	Length (km)	Aquifer type
Docklands/Connolly Station 0.9 km east of N3 and M50 Junction	8.85	LI
Area immediately surrounding N3 and M50 junction	1.78	PI
From 280m west of R806 Bridge to 785m west of Blakestown	13.00	LI
370m section heading west towards Maynooth	0.37	PI

Description of Area	Length (km)	Aquifer type
Immediately west of crossing south of Carton Demesne to east end of Parklands Way	1.43	LI
Eastend of Parklands way to immediately west of Maynooth Station	0.91	PI
West of Maynooth Station to Depot	5.15	LI

11.4.2.4 Ground water bodies

Under the Water Framework Directive (WFD), large geographical areas of aquifer have been subdivided into smaller groundwater bodies (GWB) for them to be effectively managed. There is a single GWB traversed by the proposed development referred to as the Dublin GWB. The Dublin GWB currently has good quantitative and chemical status.

The Dublin GWB has been described as a GWB with a flow regime of poorly productive bedrock which includes the following waterbodies found throughout the proposed project area; River Liffey, Tolka River, Ryewater, and Lyreen River. The areas within the Dublin GWB are generally low-lying areas with an area of higher elevations surrounding to the south and to a lesser extent to the north. The elevations decrease toward the various rivers and estuaries around Dublin City. Aquifer types in this area are typically listed as either PI or LI with a general permeability of the rock units to likely be low, typically in the range of 1 to 10 m^3/day.

11.4.2.5 Groundwater recharge

The GSI recharge (see Drawing MAY-MDC-ENV-ROUT-DR-V-110001-D in Volume 3A of this EIAR) across each of the six (6) zones of the proposed development has been reviewed and shows mainly low recharge areas with several small areas of moderate and high recharge. Zones A and B consist of low groundwater recharge areas with recharge coefficients ranging from 7.5% to 20% (of effective rainfall) and average recharge rates of 20 to 55 mm/yr. Zone C of the proposed development consisted of a mixture of low groundwater recharge that consisted of approximately 1.03 km of the 3.75 km length of Zone C with recharge coefficients ranging from 15% to 25% and average recharge rates ranging from 46 to 90 mm/yr. The remaining area of Zone C measuring approximately 2.72 km in length was rated as having high groundwater recharge with recharge coefficients ranging from 60% to 85% and average recharge rate 100 to 200 mm/yr.

Zone D contains several areas rated as having high groundwater recharge. The first section rated as having high groundwater recharge is located at the start of the section where the rail line branches north towards Dunboyne and runs approximately 350 m in length with a recharge coefficient of 85% and an average recharge rate of 200 mm/yr. Two additional sections within Zone D located north of Dunboyne Station near the Tolka River had a recharge coefficient of 85% with an average recharge rate between 143 to 200 mm/yr.

Zone E contains an area of high groundwater recharge located around where the rail line splits west of Clonsilla Station. At Clonsilla Junction, one line continues west as Zone E, towards Maynooth, while the other line heads north towards Dunboyne (part of Zone D). This area is approximately 250m in length with a recharge coefficient of 60% and average recharge rate of 200 mm/yr. A second area of high groundwater recharge is located in the area immediately adjacent to the Rye Water north of Louisa Bridge Station with recharge coefficient of 42.5% and an average recharge rate ranging from 134 to 200 mm/yr. A large section of Zone E measuring approximately 3.82 km in length between Collinstown and the east side of Maynooth was rated as having moderate groundwater recharge with a recharge coefficient of 60% and an average recharge rate of 100 to 200 mm/yr.

Zone F contained no areas of moderate or high groundwater recharge based upon subsoils present and recharge coefficients for those areas.

Subsoils in the areas rated as having high groundwater recharge consisted of the following types:

- Tills overlain with well drained soil (TLs).
- Rock is at ground surface or karst feature (Rck).

- Glaciofluvial sand & gravel overlain by poorly drained soil or peat (GLs).
- Glaciofluvial sand & gravel overlain by well drained soil (GLs).

Areas with high groundwater recharge are of more sensitive due to increased probability of contaminants impacting local soils and groundwater in the event of discharges in the area. In addition, construction within these areas could provide a preferential pathway for groundwater impacts due to the soils high recharge rate and permeability.

11.4.2.6 Groundwater abstraction

The study area is serviced by private and public water supply schemes, which are surface water and groundwater fed. Whilst the majority of the study area is serviced by public water schemes, a single public group scheme is groundwater fed. The public group scheme is situated at Dunboyne in Zone D immediately south of the M3 Parkway station. The Source Protection Area (SPA) for the supply immediately bounds the railway line (see Figure 11-1).

The Dunboyne Public Supply is the main water supply for Dunboyne, Clonee, and other small communities in the area. The area is serviced by a total of four (4) public well sources (PWS) three of which are located along the southern bank of the Tolka River while the fourth is located by the Dunboyne Industrial Estate. The PWS's have been designated as PW-1, PW-2, PW-3, and PW-4. Abstraction rates for the PWs ranges from 115 m^3/day (PW-1) to 535 ^{3}/day (PW-4) and the depth to groundwater among the wells ranges from 2.0m OD to 8.45m OD on average. Hydraulic transmissivity in the formations immediately surrounding the wells ranges from 10 m^2/day to as much as 150 m^2/day. Two of the Public Wells have lower transmissivity of 10 to 50 m^2/day while the remaining two wells have higher transmissivity and are productive wells.

Fingal, Kildare and Meath County Councils were contacted as they have small private water supplies listed on the EPA registry. Information on private water supplies within 1 km of the proposed works was requested. All Councils responded. The only supplies identified in this process are in the Dunboyne area, with two in the centre of the town approx. 500 m east of the railway and one 300 m north of the works at the M3 Parkway (see Figure 11-1).

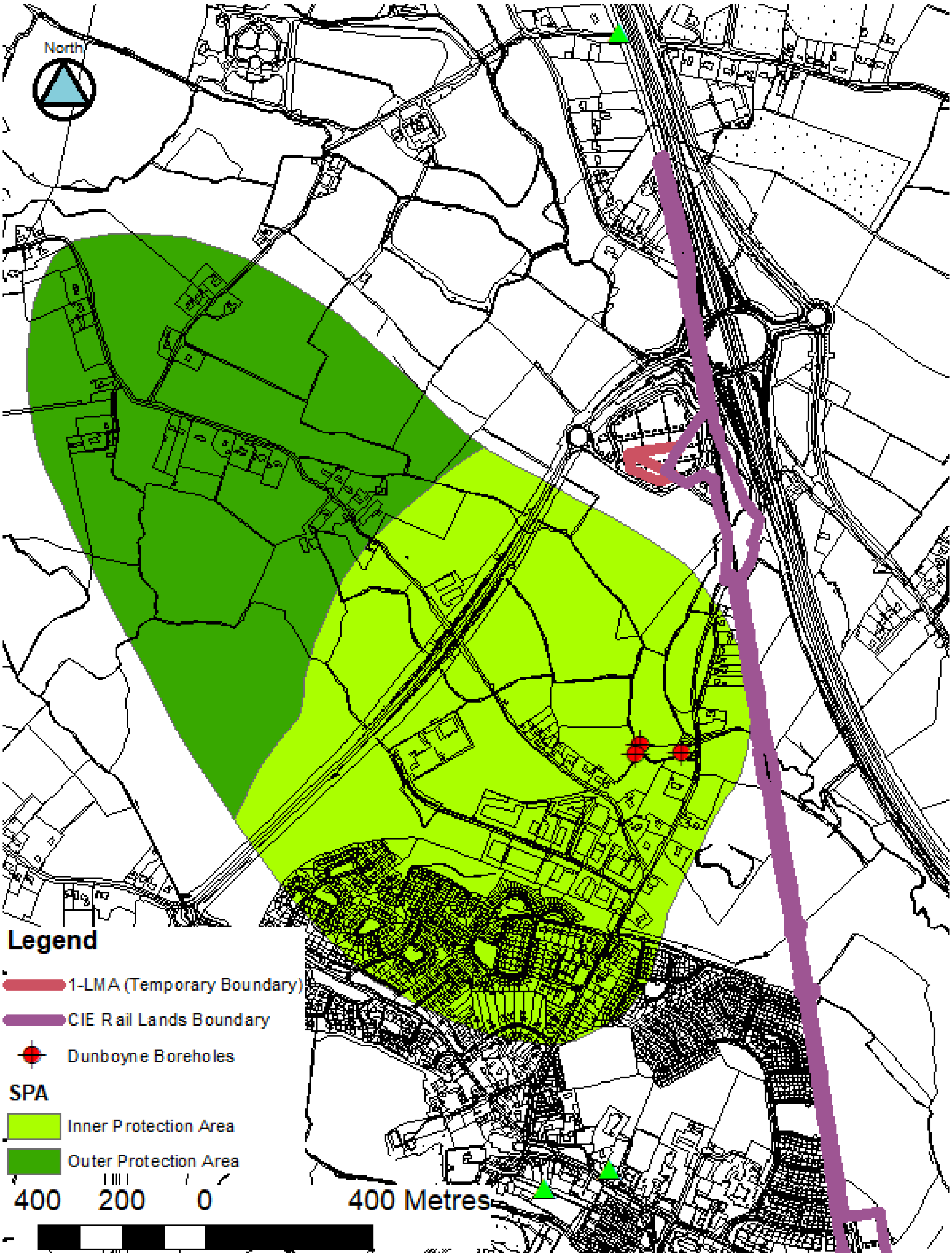

Figure 11-1 Dunboyne SPA and Local PWS

11.4.2.7 Karst features

The closest GSI recorded karst features to the proposed development are shown in Table 11-10. None are within 250m of the proposed development. The features included in the GSI database are not a comprehensive list of karst features and do not include the tufa springs identified in Section 11.4.2.10. Section 9.4.7 of Chapter 9 Land and Soils in Volume 2 of this EIAR also identifies that there are additional karst features observed along the canal in the area of Maynooth.

Table 11-10 GSI recorded Karst Features

Name	Type	Feature No.	Distance from line (m)	Northing	Easting
St. Columbs Well	Spring	2923SWK003	300	701079	736736
N/A	Cave	2923SWK002	480	696910	737726
N/A	Cave	2923SWK001	720	696700	738016

11.4.2.8 Groundwater vulnerability

The risk to groundwater is defined through assessments of groundwater vulnerability, aquifer potential and source protection areas. Groundwater vulnerability represents the intrinsic geological and hydrological characteristics that determine the ease with which groundwater may be contaminated by human activities.

It depends on the travel time of infiltrating water (and contaminants), the number of contaminants that can reach groundwater and the contaminant attenuating capacity of the geological materials through which the water and contaminants infiltrate. The final groundwater vulnerability rating is determined by both the thickness of the unsaturated subsoil which the contaminants move through and the attributes of the overlying subsoil and more specifically the subsoil permeability (DELG/EPA/GSI, 1999). The nature of groundwater recharge (point or diffuse) and how readily water is received also influences the final vulnerably rating of an area. Areas where water (and contaminants) can quickly move from the land surface to groundwater are deemed to be more vulnerable and in that regard groundwater vulnerability is primarily dependant on the permeability and depth of the overburden.

The GSI guidelines given in their Groundwater Protection Schemes (DELG/EPA/GSI, 1999) can be combined with site investigation data (geological and hydrogeological characteristics) to obtain appropriate vulnerability ratings for the ground along the proposed alignment. Four groundwater vulnerability categories are defined: extreme (E), high (H), moderate (M) and low (L). A subset of the 'extreme' category is termed the 'X – extreme' category, and relates to areas of bedrock outcrop or subcrop (<1 m), or within 30 m of a location of point recharge (i.e. karst feature). Table 11-11 outlines the geological and hydrogeological characteristics which determine the vulnerability of an area.

Table 11-11 Description of groundwater vulnerability rating system

Vulnerability rating	Hydrogeological conditions				
	Subsoil permeability (type) and thickness			Unsaturated zone	Karst features
	High permeability (sand/gravel)	Moderate permeability (e.g. sandy subsoils)	Low permeability (e.g. clayey subsoil, clay, peat)	Sand / gravel aquifer only	(<30 m radius)
Extreme (E)	0-3 m	0-3 m	0-3 m	0-3 m	n/a
High (H)	>3 m	3-10 m	3-5 m	>3 m	n/a
Moderate (M)	n/a	>10 m	5-10 m	n/a	n/a
Low (L)	n/a	n/a	>10 m	n/a	n/a

GSI mapping indicates the vulnerability of the groundwater closest to the ground surface from contaminants assumed to be released 1 m to 2 m below the ground surface. Groundwater vulnerability mapping is used for guidance only and should be supported by site investigation data and contaminant specific assessments where appropriate. In this regard, a detailed programme of ground investigations has been undertaken along the proposed development allowing the site-specific vulnerability to be determined. In unsaturated bedrock aquifers the target for protection is the groundwater table within the bedrock unit, and for saturated aquifers it is the top of the bedrock.

11.4.2.8.1 Vulnerability mapping along the proposed works

The groundwater vulnerability mapping is available from the GSI website and GIS datasets. The proposed development traverses all of the vulnerability ratings outlined in Table 11-11 and shown in MAY-MDC-GEO-ROUT-DR-G-94000-D to 94011-D in Volume 3A of this EIAR. The ground investigations completed to date allows a site-specific assessment of groundwater vulnerability to be undertaken along the proposed rail line development. The resulting vulnerabilities are given in Table 11-12 to Table 11-14 along each of the zones of the rail line. For the purposes of developing the tables, changes in vulnerability occurring for lengths of less than 50m were excluded.

Each of the first two zones (Zones A and B) of the rail line is listed as having low groundwater vulnerability (see Table 11-12). These zones run from the Docklands Station to the Glasnevin Junction and run parallel to the Royal Canal through the suburban areas of Dublin City. The low groundwater vulnerability status is due to the high amount of impervious surfaces typically found in the surrounding areas of each zone along with subsoils consisting largely of made ground or tills with low permeability.

Table 11-12 Groundwater vulnerability along proposed development Zones A and B

Zone	Section length (m)	Description of section	GW Vulnerability length (m)	GW Vulnerability area description	GW Vulnerability rating
A	460	Connolly Station to Newcomen Junction	460	Connolly Station to Newcomen Junction	Low
A	3750	Connolly Station to Glasnevin Junction	3750	Connolly Station to Glasnevin Junction	Low
B	1190	Docklands to North Strand Junction	1190	Docklands to North Strand Junction	Low
B	3750	Docklands to Glasnevin Junction	3750	Docklands to Glasnevin Junction	Low

Zone C runs from Glasnevin Junction to the Clonsilla Station and contains areas of varying groundwater vulnerability ranging from low to extreme with rock at/or near surface (Table 11-13).

Table 11-13 Groundwater vulnerability along proposed development for Zone C

Zone	Section length (m)	Description of section	GW vulnerability length (m)	GW Vulnerability area description	GW Vulnerability rating
C	10320	Glasnevin Junction to Clonsilla	115	From Glasnevin Junction to approximately 115m northwest of junction.	Low
			3160	From west of Glasnevin Junction to immediately east of the Ashtown Station	Moderate
			270	East of Ashtown Station to approximately to approximately 145m west of Ashtown Road	High
			315	From 145m west of Ashtown Road to 435m east of Navan Station	Extreme
			1580	435m east of Navan Station to east of N3 and M50 Junction	High
			290	East of N3 and M50 Junction to level crossing at Old Navan Road	Extreme
			275	Level crossing at Old Navan Road to just east of Castleknock Road overbridge	Rock at surface

Zone	Section length (m)	Description of section	GW vulnerability length (m)	GW Vulnerability area description	GW Vulnerability rating
			115	East of Castleknock Road overbridge to Castleknock Station	Extreme
			450	Castleknock Station west to north of Castleknock Rise cul-de-sac in south adjacent residential neighbourhood	High
			425	North of Castlerock Rise cul-de-sac in south adjacent residential neighbourhood to north of Maple Avenue cul-de-sac	Extreme
			2760	North of Maple Avenue cul-de-sac to Clonsilla Station	Rock at surface

Zone D of the proposed development includes the rail line from Clonsilla Station to the M3 Parkway and was categorized from low to extreme with rock at/or near the surface along the zone (see Table 11-14).

Table 11-14 Groundwater vulnerability along proposed development for Zone D

Zone	Section length (m)	Description of Section	GW Vulnerability length (m)	GW Vulnerability area description	GW Vulnerability rating
D	7500	Clonsilla station to M3 Parkway	280	Start at rail line split towards M3 Parkway to area west of split on west side of Royal Canal	Rock at surface
			160	West of Royal Canal to approximately 240 m west of Royal Canal	Extreme
			215	240 m West of Royal Canal to Hansfield Station	High
			355	Hansfield Station to south of Hansfield Secondary School	Moderate
			115	Area immediately south of Hansfield Secondary School	High
			215	Area immediately south of Hansfield Secondary School to northwest of R149 overbridge	Extreme
			510	Northwest of R149 overbridge to approximately 180 m southeast of Clonee footbridge	Moderate
			1205	180 m southeast of Clonee footbridge to 420 m north of Stirling Road overbridge	Low
			230	420 m north of Stirling Road overbridge to north towards M3 Parkway	Moderate
			310	From 670 m north of Stirling Road to approximately 275 m south of unnamed stream crossing	High
			175	275 m south of unnamed stream crossing to 100 m south of stream crossing	Rock at surface
			215	100 m south of unnamed stream crossing to 115 m north of unnamed stream crossing	High
			145	115 m north of unnamed stream crossing to just south of Tolka River branch	Moderate
			710	Just south of Tolka River branch to 250 m north of Dunboyne Station	Low

Zone	Section length (m)	Description of Section	GW Vulnerability length (m)	GW Vulnerability area description	GW Vulnerability rating
		Clonsilla Station to M3 Parkway	400	250 m north of Dunboyne Station to approximately 40 m south of powerline crossing	Moderate
			505	40 m south of powerline crossing to approximately 90 m south of first Tolka River crossing	High
			150	90 m south of first Tolka River crossing to 50 m north of first Tolka River crossing	Moderate
			355	50 m north of first Tolka River crossing to 115 m south of second Tolka River crossing	High
			340	South of second Tolka River crossing to M3 Parkway	Moderate

Zone E of the proposed development runs from Clonsilla Station to Maynooth Station with the section with groundwater vulnerability ranging from moderate to extreme throughout the zone (see Table 11-15).

Table 11-15 Groundwater vulnerability along proposed development for Zone E

Zone	Section length (m)	Description of section	GW vulnerability length (m)	GW Vulnerability area description	GW Vulnerability rating
E	12620	Clonsilla Station to Maynooth Station	1125	Clonsilla Station to just east of Milestown Road	Extreme
			145	East of Milestown Road to 230m north of creek crossing	High
			1830	North of creek crossing to west of Collins Bridge	Moderate
			390	West of Collins Bridge to south of Allenswood	High
			875	South of Allenswood to east of Newtown Creek (approximately 200 m)	Moderate
			380	East of Newtown Creek to approximately 80 m east of Leixlip Station	Extreme
			600	East of Leixlip Station to north of Riverforest Bowl	Moderate
			265	North of Riverforest Bowl to 150 m east of rail line turn to south	High
			405	East of rail line turn to south to creek leading to Leixlip waterfall	Moderate
			410	Adjacent to creek leading to Leixlip waterfall to south of Rye Water	High
			1590	South of Rye Water to 375 m northwest of R449 overbridge	Moderate
			360	Northwest of R449 overbridge to west of Deey Bridge	High
			190	Small section of rail line west of Deey Bridge	Moderate
			3405	West of Deey Bridge to south of Carton Park	High

Zone	Section length (m)	Description of section	GW vulnerability length (m)	GW Vulnerability area description	GW Vulnerability rating
			570	South of Carton Park to Maynooth Station	Moderate

The section running from Maynooth Station to the proposed depot is composed of moderate to extreme groundwater vulnerability with two small areas of high vulnerability which were below 50 m in length (see Table 11-16).

Table 11-16 Groundwater vulnerability along proposed development for Zone F

Zone	Section length (m)	Description of Section	GW Vulnerability length (m)	GW Vulnerability area description	GW Vulnerability rating
F	5000	Maynooth Station to Depot	2030	Maynooth Station to approximately 25 m east of River Lyreen	Moderate
			380	25 m East of River Lyreen to 155 m west of Jackson's Bridge	High / Extreme
			2600	155 m West of Jackson's Bridge to Depot	Moderate

11.4.2.9 Groundwater flooding

The GSI groundwater flood mapping information shows both the extent of historic groundwater flooding, and predictive flood outlines, but shows no areas of groundwater flooding within the area of the proposed development. The closest area of historic groundwater flooding identified on the mapping is south of the Maynooth, centred on ITM 694010, 736230.

11.4.2.10 Groundwater dependent terrestrial ecosystems

Tufa springs are found in the Rye Water Valley, which is crossed by the railway line on a man-made embankment and bridge. A single spring has also been recorded in the Deep Sinking (ITM 706155 737768 and Chainage 76+100) on the north bank of the canal. Tufa Springs correspond to the priority Annex I habitat 'Petrifying springs with tufa formation (Cratoneurion)' (7220) (see Figure 11-2). Leixlip Spa forms part of a seam of hot springs that extend from Co. Kildare to Co. Meath. Warm springs occur in a syncline in the Lucan-Celbridge area, which allows warmer water to reach the surface. The Leixlip Spa is located close to the Celbridge Syncline. The Leixlip Spa comprises a wetland area including the petrifying springs, which has developed on five distinct terraces on shallow bedrock. A complex groundwater system is understood to be present at Leixlip Spa and comprises the following, which is supported by the different hydrochemical signatures of the groundwater (JBA Consulting 2016[1]).

- A deeper, older, warmer groundwater system, which discharges to the spa well. The groundwater is highly mineralized and iron-rich. This groundwater system is considered the main source of groundwater at the spa.
- A shallow groundwater system that flows through conduits in the karstified limestone bedrock and discharges near the spa. Groundwater from the shallow system discharges near rock faces and flows laterally toward the River Rye.
- Mixing of deeper older groundwater with a younger groundwater.

Groundwater flow in the shallow groundwater system at Leixlip Spa occurs largely through conduits in the karstified bedrock.

[1] JBA Consulting (2016), Office of Public Works Arterial Drainage Maintenance Works - Ryewater Arterial Drainage Scheme Natura Impact Statement 2016 to 2020

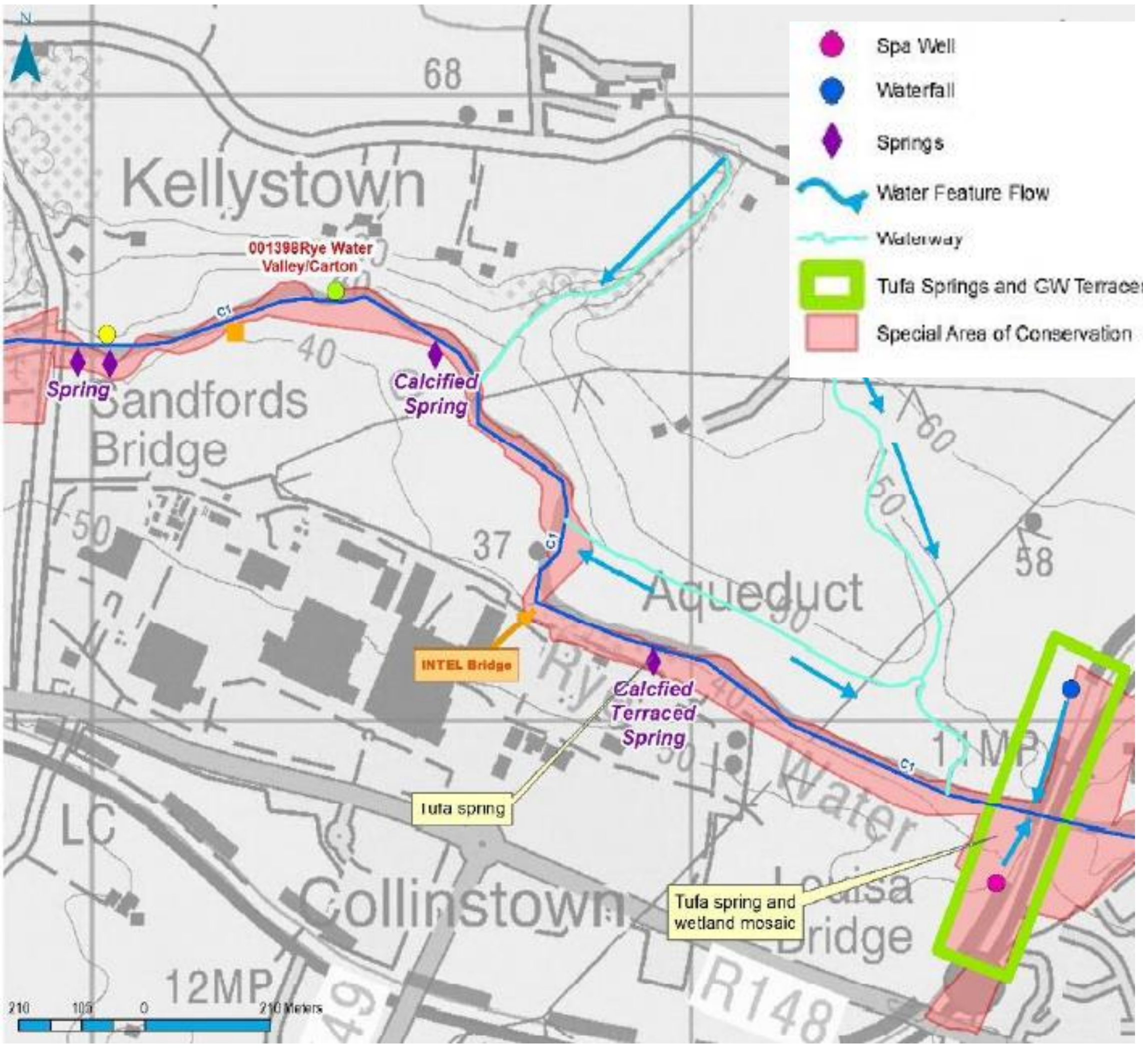

Figure 11-2 Tufa Spring Survey from JBA (2016)

A recent detailed hydrogeological study of the Spa noted the following[2]:

- The deeper groundwater system at Leixlip has a groundwater residence time in excess of 30,000 years.
- The water "*from a gravelly till deposit and was discovered in 1794 during the construction of the Royal Canal (Aldwell and Burdon, 1980). Depth to the limestone bedrock is 8.6 m at the site (data from the GSI). This layer of unconsolidated Quaternary overburden may provide a mixing zone for the warm waters to become diluted by shallow, cooler waters in winter. In contrast, St. Edmundsbury spring issues directly from a fissure in the limestone bedrock on the banks of the River Liffey*."
- Deeper groundwater "*must have their source beneath the carbonate Dublin Basin, perhaps within the Devonian terrestrial strata*."

11.5 Description of Potential Impacts

The following section provides a review of effects on the elements of the proposed development requiring further assessment as identified in Appendix A11.1 Screening Process in Volume 4 of this EIAR.

[2] Blake, S., Henry, T., Murray, J., Flood, R., Muller, M., Jones, A., & Rath, V. (2016). Compositional multivariate statistical analysis of thermal groundwater provenance: A hydrogeochemical case study from Ireland. Applied Geochemistry, 75, 171-188. https://doi.org/10.1016/j.apgeochem.2016.05.008

11.5.1 Do Nothing Scenario

In the Do-Nothing scenario, ongoing maintenance and renewal of the existing mainline infrastructure is likely to require more frequent intervention and replacement of materials such as ballast.

Groundwater contamination issues such as at Spencer Dock will continue to persist in a Do Nothing scenario, so there are potential negative impacts from this scenario.

Where other elements of the railway infrastructure influence the groundwater environment, this is part of the current environment and sensitive groundwater receptors are likely to be dependent on their continued presence for stable groundwater conditions.

11.5.2 Potential Construction Impacts

11.5.2.1 Construction Activities

Impacts to the groundwater environment which may occur as a result of construction activities during the proposed development are as follows:

- Permanent alteration in groundwater flow patterns and levels through activities such as dewatering (i.e. controlling groundwater levels).
- Potential for high alkalinity run-off recharging to ground as a result of the use of concrete based materials.
- Potential for piling at structures to create vertical pathways for pre-existing contamination to flow or pass to aquifer.
- Discharges or releases of potential contaminants such as hydrocarbon based pollutants from mechanical plant used during the construction phases of the proposed development which may lead to both soil and groundwater impacts in the area.

The latter two potential impacts are dealt with in Chapter 9 Land and Soils in Volume 2 of this EIAR.

11.5.2.1.1 Construction Activities impact assessment

Table 11-17 presents the impact assessment for the construction phase. The majority of the proposed works lies on bedrock aquifers which are classified by the GSI as being locally important (the highest aquifer classification in the study area) and the assessment therefore considers broad construction on this basis. Impacts from specific significant elements or on important groundwater receptors are considered later in the section.

Table 11-17 Impact assessment of construction phase

Description of work	Importance of aquifer	Impact mechanism	Magnitude (after embedded mitigation)	Signficance of Effects
Construction of OHLE and other distributed elements	Medium	Pollution	Negligible	Imperceptible
		Changes in groundwater flow pattern	Negligible	Imperceptible
Construction compounds		Pollution	Negligible	Imperceptible

11.5.2.2 Spencer Dock and Zone B During Construction

The construction works in Zone B involve a combination of below ground works which will be undertaken beneath the local water table including:

- Piling activities.
- Excavation and dewatering to control groundwater levels.
- Construction of concrete slabs.

In the construction phase the works could have the following potential effects:

- Dewatering operations have the potential to mobilise fine grained materials within the soils which surround the footprint of the excavation causing instability issues to surrounding structures. However, dewatering activities will be designed to prevent the removal of fines during construction works.
- Generated contaminated water from the dewater process that would require treatment and disposal.

In terms of groundwater resources and conditions in the area the following is of note:

- The area is underlain by bedrock deposits formed by the Lucan Formation, which is classified as a locally important aquifer by the GSI.
- The groundwater vulnerability classification assigned by the GSI is low.
- Ground investigations reveal that the materials which overly the bedrock include extensive deposits of limestone derived gravel units, which is consistent with GSI mapping data. The gravels are likely to act as effective aquifers, however, groundwater contained within the gravels is known to be contaminated as a consequence of the history of development within the surrounding area which are considered further in Chapter 9 Land and Soils in Volume 2 of this EIAR.

Table 11-18 provides a summary of a typical borehole from a recent site investigation, from the north of the station area. It shows that there is a layer of Made Ground, followed by 20 m of superficial deposits, which consist of thick permeable layers separated by gravelly Clay. Ongoing groundwater monitoring shows that the water table lies consistently at the base of the made ground layer at around 0 mOD.

Table 11-18 Summary of DCK-BH01B from 717377.1, 734777.5 (based on GII 2021)

Level (mOD)	Depth (mbgl)	Unit Summary
1.89 - -0.61	0-2.5	Made Ground
-0.61- -2.81	2.5-4.2	Gravelly clayey SILT
-2.81 - -10.41	4.7-12.3	Sandy Gravels
-10.41 - -17.26	12.3-19.15	Gravelly CLAY
-17.26 - -21.61	19.15-23.5	SAND
-21.61 - -27.3+	23.5-27.3+	MUDSTONE

Due to contamination issues, the water resources classification of the groundwater beneath the area is low (see Table 11-1). The main impacts to consider in the area in relation to groundwater is the potential impact on the surrounding infrastructure and changes in groundwater flow patterns and groundwater levels. The use of piled walls would potentially create a barrier to groundwater flow within the gravel aquifers and the potential for groundwater levels to increase above their current levels in the surrounding area which may potentially have an impact upon surrounding infrastructure.

11.5.2.2.1 Mitigation

In the development of the construction methodology of the Spencer Dock Station, mitigation has been incorporated. This is summarised in Table 11-19.

Table 11-19 Spencer Dock Station Construction Mitigation

Effects	Mitigation
Dewatering operations have the potential to mobilise fine grained materials from the surrounding soils	A dewatering strategy for construction will be developed to: • Quantify dewatering volumes. • Assess groundwater drawdown impacts. • Upwell pressure on the concrete pad. • Develop a treatment strategy for the pumped water.

Effects	Mitigation
	• Evaluate potential long term changes in groundwater levels and mitigation to prevent possible future flooding through changes in flow patterns, The strategy will be based upon further groundwater analysis, potentially including the development of a groundwater model of the planned works.
Generation and disposal of contaminated water from dewatering	Water will be monitored, pre-treated where necessary and disposed of in accordance with a discharge licence content issued by the Drainage Division Pollution Control Section of Dublin City Council.

11.5.2.2.2 Spencer Dock Construction Impact Assessment

Table 11-22 below provides an impact assessment for the construction phase of the Spencer Dock Station. Through the mitigation detailed in Section 11.5.2.2.1 impacts are limited to imperceptible.

Table 11-20 Impact assessment of construction phase

Description of work	Importance of Receptor	Impact mechanism	Magnitude (after embedded mitigation)	Impact rating
Dewatering	Aquifer – Low	Mobilisation of Fines from Aquifer Matrix	Negligible	Imperceptible
		Mobilisation of Contaminated Water	Negligible	Imperceptible
	Surface Water Bodies – Medium	Mobilisation of Contaminated Water	Negligible	Imperceptible
	Surrounding Infrastructure - High	Mobilisation of Fines from Aquifer Matrix	Negligible	Imperceptible

11.5.2.2.3 Navan Road Parkway construction compound – Zone C

The construction of the compound at Navan Road Parkway involves earthworks to deal with ground irregularities. These irregularities are formed from deposits of Made Ground only. No excavation of natural ground is expected and therefore it is not anticipated that excavations will take place below the natural water table, or will involve permanent removal of aquifer material. An assessment of pollution risks to address potential contamination issues, which may arise during excavation of made ground are dealt with then in the in Chapter 9 Land and Soils in Volume 2 of this EIAR.

11.5.2.3 Construction Impacts on significant groundwater receptors

11.5.2.3.1 Water Supplies

The following section considers the impacts of the proposed development on particularly important groundwater receptors identified in the baseline description including the water supply borehole array at Dunboyne Public Water Supply is described in Section 11.4.2.6 (see Figure 11-1). Works in the area are limited to Overhead Line Equipment (OHLE) installation and a construction compound. Neither of these planned work elements lie within the GSI mapped Source Protection Area (SPA) of the abstractions. Therefore, it is unlikely that there is a potential impact mechanism between the proposed works and the groundwater supply boreholes (see Figure 11-1). An assessment of potential impacts is outlined in the Table 11-21 below.

Table 11-21 Assessment of Dunboyne PWS

Description of Work	Importance of Dunboyne PWS	Impact Mechanism	Magnitude	Significance of Effects
OHLE installation and construction compound	Very high	Pollution – concrete	Negligible	Imperceptible
		Changes in groundwater flow pattern	Negligible	Imperceptible

11.5.2.3.2 Groundwater dependent ecosystems

Section 11.4.2.10 provides a description of the Tufa spring system in the Rye Water Valley/ Carton SAC, parallel with the MGWR Line. Works in this area are largely limited to upgrading the OHLE. The Royal Canal lies between the spring complex and the railway and limits the potential hydrogeological connectivity between the two areas. No impact pathway could be identified for these small-scale works. An assessment of potential impacts is outlined in Table 11-22.

Table 11-22 Assessment of Ryewater Tufa Springs

Description of Work	Importance of Rye Water Valley SAC	Impact Mechanism	Magnitude	Significance of Effects
OHLE installation – no other activities	Extremely high	Pollution – concrete	Negligible	Imperceptible
		Changes in groundwater flow pattern	Negligible	Imperceptible

11.5.3 Potential Operational Impacts

Several elements of the proposed development have the potential to cause ongoing hydrogeological effects through the following broad impact mechanisms:

- Alteration of groundwater levels and flow pathways or changes to recharge through the development of structures beneath the ground surface, or the creation of new drainage routes and impermeable surfaces.
- Increase the vulnerability of groundwater to pollution through the creation of new pollution pathways or decreasing the depth to the water table.
- Creation of ongoing potential pollution sources.

11.5.3.1 Spencer Dock and Zone B Assessment

There is planned to be extensive groundworks including excavation and piling in the area. Figure 11-3 shows different types of piling including:

- piling of one side of the existing railway line.
- piling of both sides and the construction of a concrete slab, creating an impermeable void beneath ground.

Piling activities have the potential to create sub-surface barriers to groundwater flow through the gravel aquifers identified in the area. This could potentially lead to long term alteration of local groundwater flow patterns and increased groundwater levels in the surrounding area. Figure 11-3 shows the topography around Zone B, with the River Tolka to the north and River Liffey to the south. The lowest-lying areas lie east of the track at around 0.2 mOD. Locally small changes in groundwater flow patterns and levels within the aquifers have the potential to impact infrastructure in the area and hence the area is potentially sensitive to these changes.

Figure 11-3 Topography and Piling Requirements in Zone B

11.5.3.1.1 Operational mitigation

In the development of the long-term operation of the Spencer Dock Station, additonal mitigation has been incorporated. This is summarised in Table 11-23.

Table 11-23 Spencer Dock Station Operational Mitigation

Effects	Mitigation
Changes to groundwater flow patterns and relief of groundwater flooding impacts	Additional data collection and analysis will be undertaken at detailed design stage to assess the impact of the piling and slab work on groundwater flow patterns. This may require the development of a groundwater model. If this identifies that the works will result in higher groundwater levels, that will cause potential groundwater flooding impacts, additional mitigation such as the incorporating use of drainage systems such as shallow relief boreholes will be incorporated into the design. It should be possible to incorporate such mitigation within the existing footprint of the design. The surrounding area has a number of similarly scaled basements for which impacts have successfully been mitigated. Depending on the solution, additional discharge consents may be required to dispose of the water.

11.5.3.2 Spencer Dock Impact Assessment

Table 11-24 below provides an impact assessment for the operational phase of the Spencer Dock Station. The construction phase impact assessment is presented in Section 11.5.2.2. Through the mitigation detailed in Section 11.5.2.2.2 the likely effects are limited to being *imperceptible*.

Table 11-24 Impact assessment of operational phase

Description of work	Importance of Receptor	Impact mechanism	Magnitude (after embedded mitigation)	Significance of Effects
Operation of Station	Surrounding Infrastructure – High	Changes in groundwater flow patterns	Negligible	Imperceptible
		Changes in groundwater recharge and vulnerability	Negligible	Imperceptible

11.5.3.3 Ashtown Underpass (Zone C)

This section considers the effects of the proposed Ashtown underpass on the local groundwater environment. Other than the underlying aquifer, other sensitive groundwater receptors such abstractions or GWDTE are at a considerable distance from the proposed works (10.5 km to the nearest borehole abstraction and 11.5 km to the nearest GWDTE). Therefore, potential impact linkages of the proposed development focus on impacts to the local groundwater system. Key elements of the proposed development in this area (see Chapter 4 Description of the Proposed Development in Volume 2 of this EIAR for further details) include:

- Closing the existing Ashtown level crossing and reconfiguration of the approach road to the station.
- A new pedestrian and cyclist bridge at the station.
- Replacement of the level crossing with a new road and underpass to the west passing under the railway and canal.

The main element that could interact with the groundwater system is the underpass. This will involve altering groundwater flow pathways through construction of elements including:

- Piled retaining wall faced with a reinfored concrete linear and stone cladding and a concrete base slab.
- A railway bridge.
- A viaduct for the canal.

The base of the underpass will be approximately 37.5 mOD but the excavation will be deeper to accommodate the concrete base slab. The underlying bedrock geology in the area is the Lucan Formation (a locally important aquifer) overlain by till. It is expected that in the deeper sections the excavations will extend into the upper surface of the bedrock.

Figure 11-4 shows the LIDAR topography along the line of the underpass. It shows the ground falling northwards from approx. 48 mOD to 37 mOD. The underpass extends below the Royal Canal, 30 m upstream of a lock. The water in the canal in the proposed viaduct section is at approx. 44.8 mOD, with the level downstream of the lock at approx. 40 mOD. Both sections are elevated above the surrounding ground to the north and therefore rely on a lining system to prevent leakage. The viaduct will be effectively connected into the canal and therefore the construction of the underpass will not affect its functioning.

Although sections of the underpass are anticipated to be constructed below the level of the local water table, it aligns broadly with the line of the surrounding topography, and therefore with general groundwater flow pathways. It is therefore unlikely to form a significant groundwater boundary.

Although the underpass will extend into the underlying bedrock, removing the overlying till, it is not expected that this will result in an increase in vulnerability of the aquifer as it is designed to exclude groundwater.

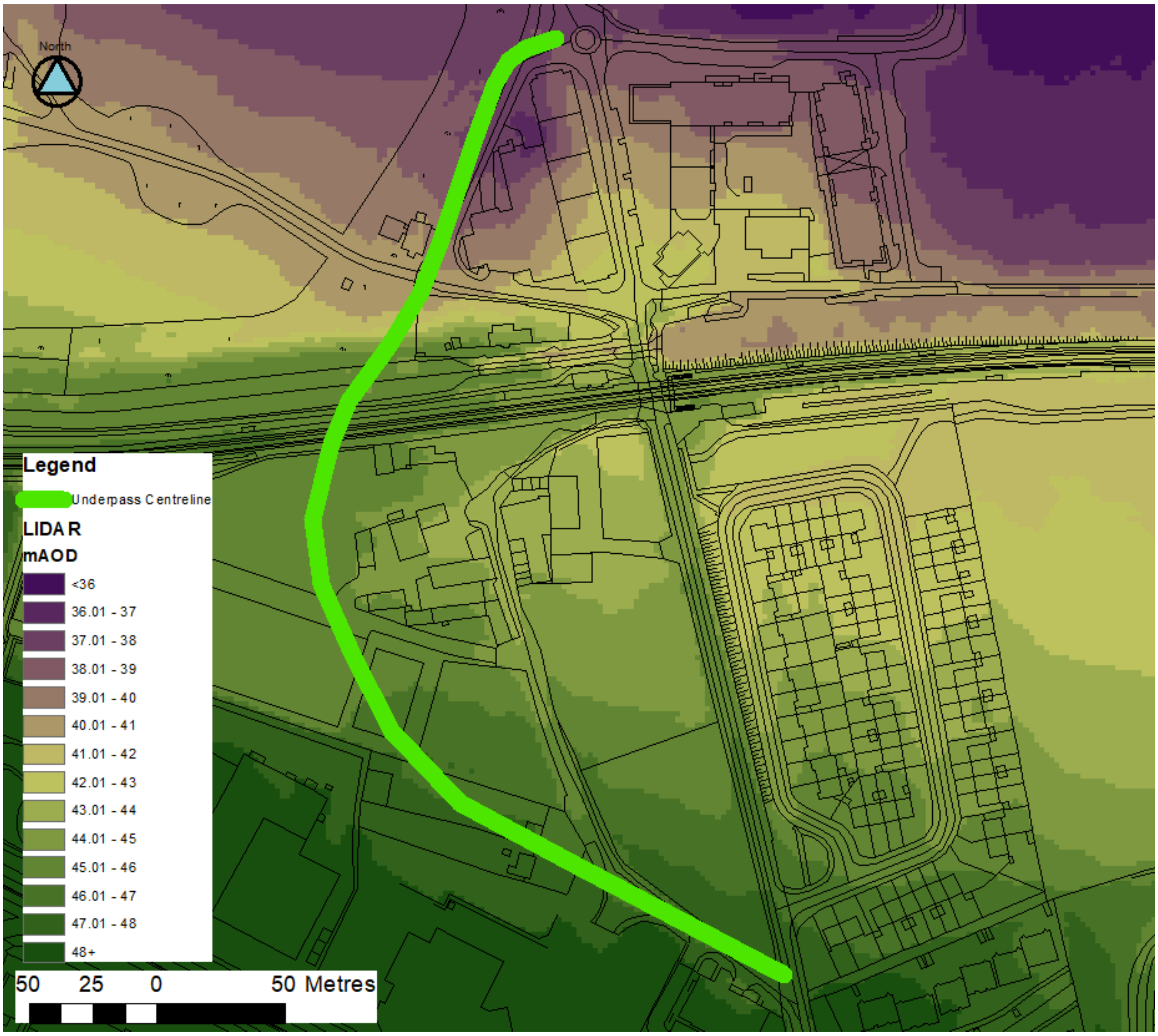

Figure 11-4 LIDAR Topography along the line of the Ashtown Underpass

11.5.3.4 Ashtown Underpass Impact Assessment

Table 11-25 below provides an impact assessment for the operational phase of the Ashtown underpass. The construction phase impact assessment is presented in Section 11.5.2.1.1. By its very nature the underpass is designed to exclude groundwater, not resulting in an increase in groundwater vulnerability. The alignment of the underpass means that it also is not anticipated to have a significant effect on local groundwater flow paths. The likely effects are classed as *imperceptible* in Table 11-3.

Table 11-25 Impact assessment of operational phase

Description of work	Importance of aquifer	Impact mechanism	Magnitude (after embedded mitigation)	Significance of Effects
Underpass	Medium	Pollution	Negligible	Imperceptible
		Changes in groundwater movements	Negligible	Imperceptible

11.5.3.5 Depot and Zone F Assessment

This section considers the effect of the depot area on the local groundwater environment. As it is also a significant element of the development, groundwater impact linkages to the Rye Water Valley/ Carton SAC are also be considered. Key elements of the proposed development in this area (see Chapter 4 Description of the Proposed Development in Volume 2 of this EIAR for further details) include:

- Chief Civil Engineering Compound.
- OBG23A bridge.
- Depot (including carpark, automatic washing plant, workshops, administration and operation buildings, service slab facility).
- Earthworks to grade the site.
- Diversion of stream.
- Drainage arrangement including, filter strips, pervious pavements, and attenuation ponds designed in accordance with Building Regulations, BS EN 752 and EN 12056, and the CIRIA SUDS Manual.
- Compensatory storage areas adjacent to OBG23 and depot lands.

The works could have the following potential impacts on the groundwater environment:

- Pollution from all activities on site including washing and maintenance.
- Reduced recharge to groundwater from increased areas of impermeable hard standing.
- Increased vulnerability of the aquifer through the construction of the compensation storage area and regrading of the site.

Figure 11-5 to Figure 11-7 provides more detailed information on the groundwater setting of the depot area. The following is of note:

- The area lies in the Lyreen catchment which flows into the Ryewater at a confluence approximately 450 m upstream of the Rye Water Valley SAC boundary. The site lies 3 km from the Rye Water Valley SAC and there is approx. a 15 m fall in topography from the lowest point of the depot area to the floodplain of the SAC. Between the two points, the River Lyreen flows through the town of Maynooth.
- The area is underlain by bedrock comprising the Lucan Formation which is classified by the GSI as a locally important aquifer.
- Most of the area is overlain with till derived from limestone. The GSI classifies the area as having low permeability subsoils with recharge coefficient of 15%.
- Along the boundary valley of the River Lyreen, the till is mapped by the GSI as being thin or absent. In this area the Lucan Formation outcrops, and groundwater vulnerability is extreme. Where the till is mapped as being present elsewhere on the site, groundwater vulnerability is classified as being moderate. Based upon GSI mapping data the extremely vulnerable reach is approx. 800 m long, with approx. 350 m contained within the proposed development boundary.

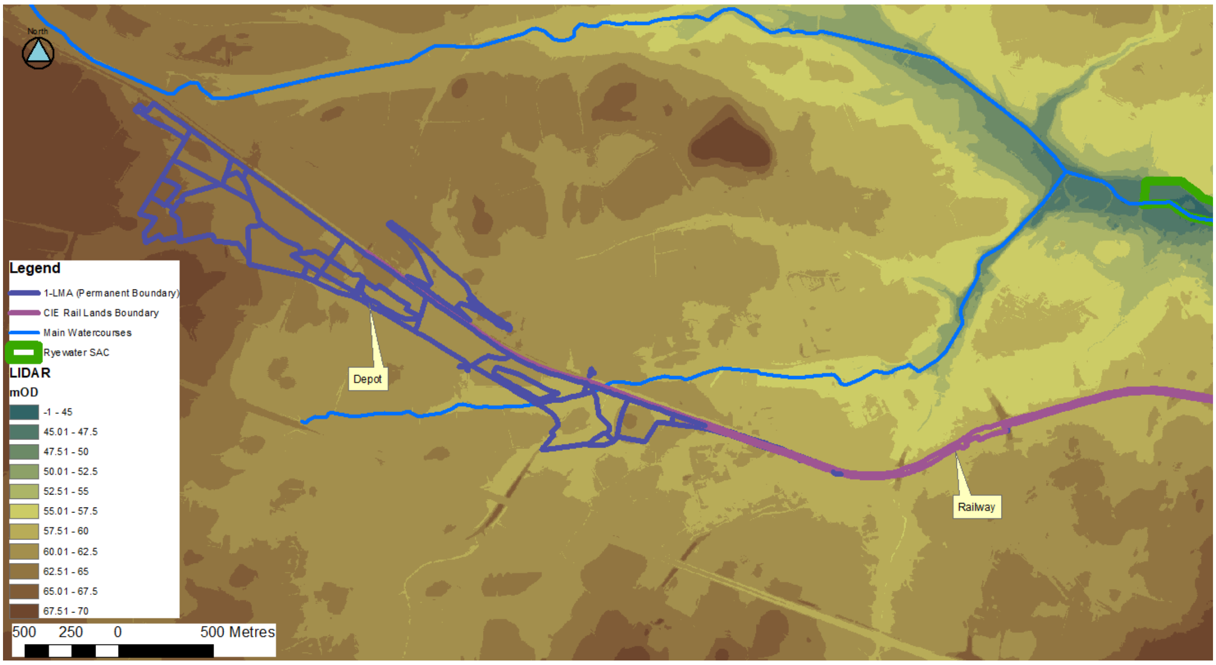

Figure 11-5 Topography between Depot and Rye Water Valley SAC

Figure 11-6 Quaternary Geology between Depot and Rye Water Valley SAC

Figure 11-7 Groundwater Vulnerability between the Depot and Rye Water Valley SAC

11.5.3.6 Embedded mitigation

In the development of the design of the proposed depot, embedded mitigation has been incorporated. This is summarised in Table 11-26.

Table 11-26 Discussion of Depot Embedded Mitigation

Effects	Discussion on embedded mitigation
Pollution from all activities on site including washing and maintenance.	The discharges from site will be routed through a treatment pond. This has been designed and sized in accordance with the CIRIA manual. The pond will act as a location for the settling of silts and suspended material and will offer a level of biological treatment. Hardstanding and a system of soil separates will be used to contain potential spillages on site.
Reduced recharge to underlying bedrock aquifer (Lucan Formation) from increased areas of impermeable hard standing.	Currently recharge through the till derived from limestone on site is relatively low based upon GSI information. Increasing the hardstanding on site will reduce recharge to the aquifer immediately below the footprint of the hardstanding. However, the drainage design will incorporate infiltration strips and other SUDs measures. The attenuation basins will also act to mimic inputs in the River Lyreen system through high rainfall events.
Increased vulnerability of the aquifer through the construction of regrading of the site.	The regrading of the site has the potential to increase the vulnerability of the aquifer to pollution, through reducing the thickness of the till covering parts of the site. The areas of excavation on site are limited to approximately 18% of the depot area with a maximum depth of cut of 1 m with and average of 0.54 m. The areas of cut are limited to high ground where groundwater monitoring shows the surrounding water table to be approx. 1 m below ground level at its highest. This will be mitigated through the use of pollution containment systems detailed within this table. Increased groundwater vulnerability through the depot area will therefore be effectively mitigated.
Increased vulnerability of the bedrock aquifer through the construction of the flood compensation area.	The flood compensation areas, especially the one neighbouring the River Lyreen has the potential to increase groundwater vulnerability through the removal of the overlying till and excavation into the Lucan Formation. Wetland habitats will be incorporated into the design of the compensatory storage areas.

11.5.3.7 Depot Impact Assessment

Table 11-27 below provides an impact assessment for the operational phase of the depot area. The construction phase impact assessment is presented in Section 11.5.2.1. Through the mitigation detailed in Section 11.6.1 impacts are limited to being imperceptible, other than the construction of the compensation area, which may entail some excavation of bedrock which could lead to a removal of a relatively small proportion of the bedrock aquifer. This is based on a conservative assumption that bedrock in the area lies close to the ground surface as no site-specific site investigation is currently available (see Section 11.3.6). The likely effects are classed as *slight* in Table 11-3.

Table 11-27 Impact assessment of construction phase

Description of work	Importance of aquifer	Impact mechanism	Magnitude (after embedded mitigation)	Significance of Effects
Operation of Depot	Medium	Pollution	Negligible	Imperceptible
		Changes in Groundwater Recharge and vulnerability	Negligible	Imperceptible
Operation of Flood Compensation Area		Pollution	Negligible	Imperceptible
		Changes in Groundwater Recharge and vulnerability and excavation of the aquifer	Small adverse	Slight

11.5.3.8 Potential for impacts upon Rye Water Valley SAC

The Rye Water Valley SAC is located approximately 3 km downstream and lies at an elevation approx. 15 m lower than the depot. The Lyreen River flows through the urban lands of Maynooth before reaching the confluence with the Rye Water River. As presented in Table 11-27, it is anticipated that the development will result in *imperceptible to slight* effects on the groundwater system immediately surrounding the depot. These impacts will be attenuated with distance from the depot and it is considered that likely effects upon the SAC will therefore be *imperceptible*.

11.5.3.9 Track lowering

Track lowering has several potential impact mechanisms in relation to groundwater receptors for each section of the proposed development where such activities are planned:

- Changes in shallow groundwater flow conditions (groundwater levels and flow routes) in and around the planned areas of lowering caused by excavations and changes to local drainage patterns.
- Increase pollution vulnerability through removal of superficial deposits overlying bedrock aquifers.
- Changing the integrity of the Royal Canal and allowing the water from canal to leak into the surrounding aquifer.

11.5.3.10 Embedded mitigation

In relation to the Royal Canal the focus of the mitigation for track lowering is on management of the integrity of the liner of the canal not being compromised through the track lowering, which could result in leakage of water from the canal. In the identified lengths next to the canal where track lowering is anticipated, mitigation is required to maintain the integrity of the canal liner to limit the potential for water to leak from the canal into the aquifer (see Table 11-28 for further details).

11.5.3.11 Track lowering impact assessment

Table 11-28 provides an impact assessment for each track reach of the development where track lowering is anticipated. It identifies where the mitigation measures set out in Section 11.5.3.10 are required.

Table 11-28 Impact Assessment of track lowering

Description of works					Groundwater Setting	Assessment			
Structure	Location	Depth of lowering	Length	Description of Drainage Requirements		Importance	Specific Mitigation	Magnitude	Significance of Effects
OBO11	GSWR line at 2+1459 mileage, in Dublin city (Ch. 33+000)	325 mm	330 m	OBO11: Existing carrier drainage runs parallel to the Down-line and outfalls at a gravity foul between Claude Rd and Wigan Rd. A track lowering of 325 mm at the structure means that two existing UTX drainage connections will be impacted. As part of DART+ West, it is proposed that the existing carrier drain be modified to allow for the track lowers, maintaining a fall of 0.12% towards the outfall between Claude Rd and Wigan Rd. A collector drain will be installed on both sides of the track and will connect at intervals to the gravity drain.	Urban area parallel with deeper lowering at OBD221 and OBD222 (410 mm).	Lucan Formation- medium importance	N/A	Negligible	Imperceptible
OBO36	GSWR line at 4+784 mileage, in Dublin City. (Ch. 20+780)	230 mm	200 m	OBO36: it will be necessary the design of a drainage solution to mitigate the risk of service interruption due to a potential flooding issue. Given the track lowering at the low point and the proximity of the water table, the drainage solution should keep the line in service with optimal conditions for the Electric Multiple Units (EMUs).	Neighbouring Royal Canal – mitigation work may be required to prove the integrity of the liner.	Lucan Formation- medium importance	As the lowering is beneath the canal level mitigation is required to maintain the functioning of the canal liner 230 mm of planned lowering is likely to have a negligible impact on shallow groundwater systems in this heavily urbanised area.	Negligible	Imperceptible
OBD227, 227A, 227B	MGWR line at 2+665 mileage, in Dublin City. (Ch. 40+820)	406 mm	180 m	OBD224-227: The proposal is a gravity drainage solution outfalling into an existing connection to the Royal Canal at OBD226. As this outfall is under the canal level when the water level rises, an auxiliary pumping system is also proposed.	Urban area with low groundwater vulnerability.	Lucan Formation- medium importance	As the lowering is beneath the canal level mitigation is required to maintain the functioning of the canal liner.	Negligible	Imperceptible
OBD226, 226A, UBD233	MGWR line at 2+588 mileage, in Dublin City. (Ch. 41+020)	385 mm	220 m						
OBD225	MGWR line at 2+380 mileage, in Dublin City. (Ch. 41+300)	308 mm	290 m						

Description of works					Groundwater Setting	Assessment			
Structure	Location	Depth of lowering	Length	Description of Drainage Requirements		Importance	Specific Mitigation	Magnitude	Significance of Effects
OBD224	MGWR line at 1+1710 mileage, in Dublin City. (Ch. 41+780)	240 mm	185 m						
OBD223	MGWR line at 1+1019 mileage, in Dublin City. (Ch. 42+200)	603 mm	315 m	OBD223: The drainage proposal consists of gravity drainage from OBD221 outfalling to an existing connection at OBD223 to the Royal Canal.					
OBD222	MGWR line at 0+1412 mileage. (Ch. 43+080 - 43+240)	410 mm	575 m	OBD221-OBD222: The drainage proposal consists of gravity drainage from OBD221 outfalling to an existing open ditch that connects with the OBD223 drainage system and outfall to the Royal Canal.					
OBD221	MGWR line at 0mile 1598 yards mileage (Ch. 43+320)	410 mm	575 m						
OBG6C & OBG6D	Maynooth line at Ch. 55+700 & 55+740	Minimal	230 m	No drainage.	Area of high to extreme groundwater vulnerability	Located on Tober Collen Formation classified by the GSI as a poor aquifer - Low importance	N/a	Negligible	Imperceptible
OBG7A	Maynooth line at 4+804 mileage at the roundabout connecting N3 to M50 Ch. 55+840	338 mm	215 m	A collector drain will be installed on both sides of the track and will connect at intervals to the gravity drain. The outfall proposal is an existing gravity combined network.	Area of high to extreme groundwater vulnerability	Located on Tober Collen Formation – by the GSI as a poor aquifer a poor aquifer – Low importance	-	Small Adverse	Imperceptible
OBCN286 Barnhill Bridge	M3 Parkway line at 8+513 mileage (Ch. 101+710)	357 mm	325 m	Drainage outfall to small ditch 170 m south-east of bridge. No reprofiling of receiving ditch is required.	Area of thin or absent quaternary deposits. Outcrop of Lucan Formation with extreme / rock at the surface groundwater vulnerability	Lucan Formation – medium importance	-	Negligible	Imperceptible

Description of works					Groundwater Setting	Assessment			
Structure	Location	Depth of lowering	Length	Description of Drainage Requirements		Importance	Specific Mitigation	Magnitude	Significance of Effects
OBCN290 Dunboyne Bridge OBCN290A Dunboyne Footbridge	M3 Parkway line at 10+493 mileage (Ch. 104+910)	395 mm	215 m	Drainage outfall 300m to the south of OBCN290 at bridge crossing local stream (WFD Name TOLKA 030).	Edge of a floodplain, with the section transitioning from Alluvium to Till derived from limestone On the edge of the town of Dunboyne. TBC	Lucan Formation-medium importance	-	Negligible	Imperceptible
OBG13 Collins Rail Bridge	Maynooth line at 8+1674 mileage (Ch. 72+760)	583 mm	365 m	OBG13: The proposed longitudinal gravity drainage runs along with the cess of the Up track. The vertical alignment low point drainage proposal is a gravity drain from the low point to UBG 13B, running 400 m at 1 in 1,000 gradient.	Moderate groundwater vulnerability of till derived from limestone	Lucan Formation-medium importance	Neighbouring Royal Canal – mitigation work may be required to prove that integrity of the liner. Low point around 0.8 lower than the canal.	Negligible	Imperceptible
OBG18 Pike Bridge	Maynooth line at Ch. 80+000	459 mm	415 m	OBG18: The vertical alignment low point drainage proposal is a gravity drain from the low point discharging at UBG 18A. A gradient of 1 in 1.675 (0.06%) is required to achieve gravity drainage at this location, with an outfall at the lower level of the UBG18A.	Tober Collen Formation – a poor aquifer – Low importance	Tober Collen Formation – a poor aquifer – Low importance	Drawing shows 390mm of lowering – needs to be double checked Low point very similar level to canal WL.	Negligible	Imperceptible

11.6 Mitigation measures

11.6.1 Mitigation in Construction Phase

Mitigation required to protect the groundwater environment from potential sources of pollution during the construction phase is detailed in Chapter 9 Land and Soils and in Chapter 10 Water (including Hyrology & Flood Risk) in Volume 2 of this EIAR. The main elements of this mitigation that are particular to protecting the groundwater environment are reitereated in this section.

A Construction Environmental Management Plan (CEMP) will be prepared for the proposed development (see Appendix A5.1 in Volume 4 of this EIAR) along with an Environmental Operating Plan (EOP) (see Appendix D of Appendix A5.1 in Volume 4 of this EIAR). These will be developed by the selected contractor to suit the detailed construction methodology and allocate responsibilities to individuals in the construction team. In doing so, the measures detailed in the appended CEMP and EOP will be considered minimum requirements to be considered and improved upon. The level of detail provided within the current drafts of the Plans is sufficient to allow an assessment of the anticipated impacts including residual impacts. An Incident Response Plan (see Appendix F of Appendix A5.1 in Volume 4 of this EIAR) will be finalised detailing the procedures to be undertaken in the event of spillage of chemical, fuel or other hazardous wastes, non-compliance with any permit or license, or other such risks that could lead to a pollution incident, including flood risks.

The following outlines the principal mitigation measures that will be adhered to for the construction phase. The groundwater environment is not affected from direct and indirect impacts. The source of groundwater pollution can be through migration of pollutants offsite via surface water pathways and then infiltration to ground, therefore a number of the mitigation measures focus on that potential pathway.

Groundwater Quality Mitigation Measures

1. Site works will be limited to the minimum required to undertake the necessary elements of the project.
2. Surface water flowing onto the construction area will be minimised through the provision of berms, diversion channels or cut-off ditches.
3. Management of excess material stockpiles to prevent siltation of watercourse systems through runoff during rainstorms will be undertaken. This may involve allowing the establishment of vegetation on the exposed soil and bunding.
4. Protection of waterbodies from silt load will be carried out through the use of gully silt/sediment filters and shallow berms in hardstanding areas to provide adequate treatment of runoff to watercourses.
5. Settlement tanks, silt traps/bags and bunds will be used. Where pumping of water is to be carried out, filters will be used at intake points and discharge will be through a sediment trap.
6. The anticipated site compound/storage facility will be fenced off at a minimum distance of 5m from the top of bank. Any works within the 10m buffer zone will require measures to be implemented to ensure that silt laden or contaminated surface water runoff from the compound does not discharge directly to the watercourse. A CEMP has been drafted and will need to be finalised by the appointed Contactor. See the Environmental Operating Plan (EOP) and Construction Environmental Management Plan (CEMP) in Appendix A5.1 in Volume 4 of this EIAR for further detail.
7. Protection measures will be put in place to ensure that all hydrocarbons used during the construction phase are appropriately handled, stored, and disposed of in accordance with the TII document "Guidelines for the crossing of watercourses during the construction of National Road Schemes". All chemical and fuel filling locations will be contained within bunded areas and set back a minimum of 20 m from watercourses.
8. Foul drainage from all site offices and construction facilities will be contained and disposed of in an appropriate manner, off site, to prevent pollution.
9. The construction discharge will be treated such that it will not reduce the environmental quality standard of the receiving watercourses.
10. Concrete waste and wash-down water will be contained and managed on site to prevent pollution of all surface watercourses.

11. On-site concrete batching and mixing activities will only be allowed at the identified construction compound areas.

Contaminated Land Mitigation Measures

1. The excavated soil arising on-site will be screened and re-used within the proposed development where possible however this may be dependent on having suitable areas for the stockpiling and processing operations. Materials to be excavated where structures are to be demolished may also provide suitable sources subject to crushing and testing to meet specific requirements. There is also a likelihood that some materials requiring excavation could also contain excess contamination and thus require disposal or treatment of the offending elements prior to establishing criteria inside the contamination thresholds (to date mainly due to petroleum hydrocarbons).
2. The reusability of a soil will depend upon both its physical or engineering behaviour as well as the chemical constituents and classifications harm. In accordance with the requirements specified by the design, a soil can be classified as environmentally acceptable where the criteria for individual the Generic Assessment Criteria or Suitable for Use Levels (S4ULs) are not exceeded.
3. Where the soil exceeds the threshold imposed and it is excavated it will have to be disposed as non-hazardous or hazardous waste and it will not be possible to improve it by treatment for re-assessment of suitability for re-use.
4. Whenever the excavated / potentially treated soils do not meet the requirements, it will have to be disposed of by the Contractor who will ensure that all subsurface materials excavated during the construction phase of the proposed development are managed in accordance with the relevant waste management legislation, including the Waste Management Act 1996 (as amended).
5. The successful Contractor will have to ensure that all unsuitable materials are removed from the site and sent to authorised waste management facilities (i.e. which hold all relevant, valid permits / licences) which accept the corresponding types of waste.

Additional mitigation required for Spencer Docks is reiterated in the table below.

Table 11-29 Spencer Dock Station Construction Mitigation

Effects	Mitigation
Dewatering operations have the potential to mobilise fine grained materials from the surrounding soils	A dewatering strategy for construction will be developed to: • Quantifying dewatering volumes, • Assessing groundwater drawdown impacts, • Upwelling pressure on the concrete pad, • Develop a treatment strategy for the pumped water, • Evaluate potential long term changes in groundwater levels and mitigation to prevent possible future flooding through changes in flow patterns, The strategy will be based upon the development of a groundwater model of the planned works.
Generation and disposal of contaminated water from dewatering	Water will be monitored, pre-treated where necessary and disposed of in accordance with a discharge licence content issued by the Drainage Division Pollution Control Section of Dublin City Council.

11.6.2 Mitigation by design/ Operational Phase Mitigation

Mitigation for the proposed Spencer Dock Station and the proposed depot are outlined in Section 11.5.3.1.1 and 11.5.3.6 and are reinterated in the table below.

Table 11-30 Mitigation by design/ Operational Phase Mitigation

Location	Effects	Mitigation
Spencer Dock	Changes to groundwater flow patterns and relief of groundwater flooding impacts.	Additional data collection and analysis will be undertaken at detailed design stage to assess the impact of the piling and slab work on groundwater flow patterns. This may require the development of a groundwater model. If this identifies that the works will result in higher groundwater levels, that will cause potential groundwater flooding impacts, additional mitigation such as the incorporating use of drainage systems such as shallow relief boreholes will be incorporated into the design. It should be possible to incorporate such mitigation within the existing footprint of the design. The surrounding area has a number of similarly scaled basements for which impacts have successfully been mitigated. Depending on the solution, additional discharge consents may be required to dispose of the water.
Depot and Zone F	Pollution from all activities on site including washing and maintenance.	The discharges from site will be routed through a treatment pond. This has been designed and sized in accordance with the CIRIA manual. The pond will act as a location for the settling of silts and suspended material and will offer a level of biological treatment. Hardstanding and a system of soil separates will be used to contain potential spillages on site.
	Reduced recharge to underlying bedrock aquifer (Lucan Formation) from increased areas of impermeable hard standing.	Currently recharge through the till derived from limestone on site is relatively low based upon GSI information. Increasing the hardstanding on site will reduce recharge to the aquifer immediately below the footprint of the hardstanding. However, the drainage design will incorporate infiltration strips and other SUDs measures. The attenuation basins will also act to mimic inputs in the River Lyreen system through high rainfall events.
	Increased vulnerability of the aquifer through the construction of regrading of the site.	The regrading of the site has the potential to increase the vulnerability of the aquifer to pollution, through reducing the thickness of the till covering parts of the site. The areas of excavation on site are limited to approximately 18% of the depot area with a maximum depth of cut of 1 m with and average of 0.54 m. The areas of cut are limited to high ground where groundwater monitoring shows the surrounding water table to be circa 1 m below ground level at its highest. This will be mitigated through the use of pollution containment systems detailed within this table. Increased groundwater vulnerability through the depot area will therefore be effectively mitigated.
	Increased vulnerability of the bedrock aquifer through the construction of the flood compensation area.	The compensation storage areas, especially the one neighbouring the Lyreen River has the potential to increase groundwater vulnerability through the removal of the overlying till and excavation into the Lucan Formation. Wetland habitats will be incorporated into the design of the flood compensatory storage areas.

11.7 Monitoring

No ongoing groundwater monitoring requirements have been identified through the assessment process.

11.8 Residual effects

Table 11-31 summarises the likely residual effects of the proposed development. Where further assessment is required as the designs are further advanced these are indicated.

Table 11-31 Summary of Residual Effects

Element	Significance of Effects	Additional Mitigation Requirements through further Assessment
Construction Compounds	Imperceptible	N/A

Element	Significance of Effects	Additional Mitigation Requirements through further Assessment
Catenary System	Imperceptible	N/A
Water tanks	Imperceptible	Once locations confirmed screen for any with 250 m of important receptors. Undertake further assessment if they are located within this radius
Substations	Imperceptible	N/A
Spencer Dock and Zone B	Imperceptible	The depth of the piling required to build the structures is to be confirmed, once this has been further developed a groundwater model may be required to: • Assess rates of dewatering. • Assess impact of the cone of drawdown on adjacent sites. • Assess buoyance issues on the stab. • Identify long-term changes in groundwater flow patterns. • Develop mitigation if required for groundwater flooding issues.
Connolly Station	Imperceptible	N/A
Maynooth and Zone F Including OBG23a crossing	Slight / Imperceptible	
Arched Bridges OBG5 Broombridge. OBG11 Castleknock Bridge. OBG14 Cope Bridge.	Imperceptible	N/A
Ashtown Level Crossing	Imperceptible	N/A
OBG23A	Imperceptible	Assessment in chapter appendix is based on outline foundation designs. Requires confirmation once they have been finalised through detailed design.
Sheriff Street Bridge		
Coolmine Station		
Porterstown Level Crossing		
Clonsilla Level Crossing		
Barberstown Level Crossing		
Clonsilla siding	Imperceptible	N/A
Diswellstown Junction	Imperceptible	Assessment in chapter appendix based on limited GI. Requires confirmation once GI has been completed at detailed design stage.
Tracking Lowering	Imperceptible	N/A

11.9 Cumulative effects

Taking into account embedded mitigation, all impacts were assessed to be imperceptible, with the exception of changes in recharge to the aquifer beneath the depot which was assessed to be slight due to the reduction in infiltration across the site. The assessment identified that some further assessments were required once designs have been further development. This includes that additional groundwater modelling required to assess the impact on groundwater flow patterns at Spencer Dock Station. If this identifies that there will be an increase in groundwater levels, additional mitigation may need to be incorporated into the design to address increased groundwater flooring risk. However, it should be possible to incorporate such mitigation within the existing footprint of the design. The surrounding area has a number of similarly scaled basements for which impacts have successfully been mitigated. Depending on the solution, additional discharge consents may be required to dispose of the water.

Overall, cumulatively, there are *no significant* effects from the development on the groundwater systems, groundwater abstractions, or GWDTE.

The cumulative assessment of relevant plans and projects is undertaken separately in Chapter 26 Cumulative Effects of this EIAR.

11.10 References

DELG/EPA/GSI, 1999, Groundwater Protection Schemes, available at https://www.gsi.ie/documents/Groundwater_Protection_Schemes_report.pdf

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