9. Soils and Geology

9.1 Introduction

As set out in Chapter 1, Introduction of this updated EIAR, this is an update to Chapter 9, Soils and Geology of the EIAR submitted to An Bord Pleanála in October 2018 as part of the application for approval of the proposed N6 GCRR pursuant to Section 51 of the Roads Act 1993 (as amended). It forms part of the response to the request by ABP for further information in December 2023 where they (in addition to a number of other requests) requested GCC to "*Update the Environmental Impact Assessment Report*". This chapter provides an appraisal of the Project under the heading of soils and geology. Where there have been any changes to the soils and geology assessment and/or any updates since the 2018 EIAR, these have been set out in this updated chapter.

This chapter initially sets out the methodology followed in carrying out the appraisal (Section 9.2), describes the soils and geology receiving environment (Section 9.3) and summarises the main characteristics of the Project which are of relevance for soils and geology (Section 9.4). The likely significant effects of the Project on soils and geology are described (Section 9.5). Measures are proposed to mitigate likely significant effects (Section 9.6), residual effects (Section 9.7) and cumulative impacts are described (Section 9.8). The chapter concludes with a summary (Section 9.9) and reference section (Section 9.10).

This chapter has utilised the information gathered during the constraints and route selections studies for the proposed N6 GCRR, the studies to inform the 2018 EIAR, for the 2019 Response to Request for Further Information and for the oral hearing in 2020 plus data gathered during site visits undertaken in 2023 and 2024 to inform the soils and geology impact appraisal for this updated EIAR. Sections 4.4, Section 6.5.2 and Section 7.6.2 of the Route Selection Report for the proposed N6 GCRR considered the soils and geology constraints within the scheme study area and compared the potential soils and geology effects of the proposed route options respectively. These sections of the Route Selection Report contributed to the design of the proposed N6 GCRR, which forms a major part of the Project that this chapter appraises.

The key changes to the chapter since the 2018 EIAR involve updating:

- The methodology to take account of updated guidelines
- The description of the receiving environment and impact assessments to take account of changes, new developments, updated to the Galway City Development Plan and Galway Count Development Plan, etc.
- The evaluation of the effect on geological features of importance, such as a more detailed assessment of soil in line with the EU Soil Strategy for 2030
- The appendices and figures associated with Chapter 9
- To take account of points raised from the Brief of Evidence presented to An Bord Pleanála (ABP) at the oral hearing in 2020 and from the ABP Inspector's Report dated June 2021
- In terms of significant soils and geology residual effects, this updated EIAR confirms one new additional significant / moderate residual effect due to the loss of a proportion of the Geological Heritage Site (GC001) Doughiska N6 Road Cut. This is in addition to the unchanged significant / moderate residual impact to Limestone pavement

Further information relating to the soils and geology assessment can be found in the following appendices

- Appendix A.7.3: Lackagh Tunnel Geotechnical and Hydrogeological Appraisal
- Appendix A.9.1a: Ground Investigation Reports – Part 1
- Appendix A.9.1b: Ground Investigation Reports – Part 2
- Appendix A.9.1c: Ground Investigation Reports – Part 3

- Appendix A.9.1d: Ground Investigation Reports – Part 4
- Appendix A.9.2: Blast Feasibility and Exclusion Requirements
- Appendix A.9.3: MDA Baseline Report (with Lackagh Quarry MDA Requirements appended)
- Appendix A.9.4: Cumulative Impact Assessment

9.2 Methodology

9.2.1 Introduction

The following section outlines the legislation and guidelines considered and the adopted methodology for the preparation of this chapter as updated from the 2018 EIAR.

Updates in this section since the 2018 EIAR include:

- Inclusion of updated guidance from the Environmental Protection Agency (EPA) for information to be included in an EIAR, released in 2022. Change in terminology of 'impacts' to 'effects'
- Expansion of the study area to include for lands associated with the proposed development at Galway Racecourse
- Continued and updated consultation with the relevant public bodies
- Additional baseline data collection, including site walkovers in July 2024 and inclusion of a project-specific ground investigation undertaken at the Galway Racecourse, as described in Section 9.2.4
- Assessment methodology (Section 9.2.5) has been updated, in particular Table 9.3, to reflect the updated guidance documentation (EPA, 2022)

9.2.2 Guidelines

The main guidelines used for the soils and geology assessment have been reviewed and updated as appropriate to include publications issued since the 2018 EIAR.

The main guidelines used in preparing this chapter of the updated EIAR are:

- Environmental Protection Agency (2022) Guidelines on the Information to be contained in Environmental Impact Assessment Reports (May 2022) (EPA Guidelines) – This document supersedes previous draft documentation and other outdated guidelines (as of 2025) produced by the EPA used for the 2018 EIAR
- European Commission (EC), Environmental Impact Assessment of Projects Guidance on the preparation of the Environmental Impact Assessment Report (2017)
- Transport Infrastructure Ireland (TII, the operational name of the National Roads Authority) guidelines on procedures for assessment and treatment of geology, hydrology and hydrogeology for National Road Schemes (NRA, 2008a), referred to as the TII Guidelines within this chapter – This 2008 guidance remains the most relevant guidance from TII at the date of this updated EIAR
- TII Environmental Impact Assessment of National Road Schemes – A Practical Guide (TII, 2008b) – This 2008 guidance remains the most relevant guidance from TII at the date of this updated EIAR
- Institute of Geologists of Ireland (IGI) Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of EISs (IGI, 2013) – This 2013 guidance remains the most relevant guidance from the IGI at the date of this updated EIAR

9.2.3 Study Area

The soils and geology study area for the Project extends 250m beyond the Assessment Boundary (lands required for the construction and /or operation of the proposed N6 GCRR plus the extents of the lands included within the planning boundary for the proposed development at Galway Racecourse). This is in

accordance with the TII Guidelines (NRA, 2008a). Where appropriate, the study area has been extended to include nearby geological features which may be impacted as a result of the construction and operation of the Project. The soils and geology study area is presented on Figures 9.1.001 to 9.9.002.

9.2.4 Baseline Data Collection

9.2.4.1 Introduction

In order to identify and quantify the potential effect of the construction and operation of the Project, it is first necessary to undertake a detailed study of the existing (baseline) geological environment along the route of the Project. This requires the collation and evaluation of available regional and local information and more site-specific data obtained from walkover surveys and both historical and commissioned ground investigations.

The information presented in this chapter is based on information obtained from two main data collections:

- Regional and local baseline desk study from:
  - Desk Study Information
  - Historical Ground Investigations
  - Consultations
- Project-specific information from:
  - Ground Investigations
  - Field Surveys and Walkovers

The relevant publicly available sources of information have been reviewed as part the soils and geology assessment for this updated EIAR. Alterations or additions since the 2018 EIAR noted during the review of the publicly available information have been incorporated into this updated baseline assessment.

9.2.4.2 Regional and local baseline desk study

Desk Study Information

The following sources of information, as presented in Table 9.1, were reviewed[1] in order to evaluate the soils and geological environment in the vicinity of the Project. This review included a review of any changes since the 2018 EIAR and the most recently available information has been utilised for this updated EIAR.

Table 9.1 Publicly available datasets

Source	Name	Description
Publicly available datasets		
Tailte Éireann (TÉ)[2]	Current and historical ordnance survey maps	Current and historical survey maps produced by TÉ
Google	Aerial photography	Current and historical aerial imagery produced by Google (including imagery produced since 2018)
	Topography	Topography from transects in Google Earth

[1] The latest review of all available information sources was conducted in October 2024

[2] In 2023, Ordnance Survey Ireland merged with the Property Registration Authority of Ireland and the Valuation Office to create Tailte Éireann, a state body under the Department of Housing, Local Government and Heritage.

Source	Name	Description
Bing	Aerial photography	Current and historical aerial imagery produced by Bing (including imagery produced since 2018)
Teagasc	Teagasc Soils Data	Surface soils classification and description
Geological Survey Ireland (GSI)	Teagasc Classification	Geological maps of the site area produced by the GSI and available on GSI online map viewer
	Quaternary Mapping	
	Bedrock Mapping	
	Karst Database	
	Geology of Galway Bay 1:100,000 scale Bedrock Geology Map Series, Sheet 14, Galway Bay	Geological map (1:100,000) of the Galway Bay region
	Geology of Galway Bay: A geological description to accompany the Bedrock Geology 1: 100,000 Scale Map Series, Sheet 14, Galway Bay	Written report documenting the geology of Galway Bay
Environmental Protection Agency (EPA)	CORINE Land Cover 2018[3]	These datasets are based on interpretation of satellite imagery and national in-situ vector data
	River Network Map	
	EPA Licence & Permit Databases	Information on any EPA IE/IPC licences and Permits in the area
National Parks and Wildlife Service (NPWS)	Special Protection Areas (SPA), Special Areas of Conservation (SAC) Sites, Natural Heritage Areas (NHA) and proposed NHAs (pNHA)	This dataset provides information on protected sites
Department of Housing, Local Government and Heritage	Historic Environment Viewer	Provides information on the Archaeological Survey of Ireland and the National Inventory of Architectural Heritage records
Office of Public Works (OPW)	LiDAR elevation data	Topographic data commissioned by the OPW. Available on the GSI online map viewer

In addition to the publicly available information used to compile the desk study assessment of the study area, other sources of information were assessed, including:

- Aerial photography (2012 and 2016) of the study area, supplemented with a sectional drone survey in April 2016. These datasets have been compared against current publicly available aerial photography in 2024
- Flood, P. and Eising, J. (1987). The use of vertical band drains in the construction of the Galway Eastern Approach Road. Proceedings of the 9th European Conference on Soil Mechanics and Foundation Engineering, Dublin, Ireland
- Gannon, M.J. (year unknown) Corrib Quincentenary Bridge, Paper presented to Engineers Ireland
- Results from karst field surveys reported in the June 2016 karst report (updated in July 2024 for this updated EIAR), Appendix A.10.2

[3] CORINE Land Cover dataset for reference year 2018 has been assessed for this updated EIAR, replacing the previous 2012 reference year dataset assessed as part of the 2018 EIAR submission.

- Constraints reports from the previous N6 Galway City Outer Bypass Scheme (2006 GCOB). These reports continue to be of relevance for this updated soils and geology assessment as was the position in the 2018 EIAR:
  - Galway City Outer Bypass R336 Western Approach Constraints Study Report 2000
  - N6 Galway City Outer Bypass Constraints Study Report (2000)
  - N6 Galway City Outer Bypass R336 Western Approach Link Route Selection Report (2001)
  - N6 Galway City Outer Bypass East Route Selection Report (2001)
  - N6 Galway City Outer Bypass Environmental Impact Statement Volume 2 (2006)

Historical Ground Investigations

Ground investigation reports held by the GSI for the study area were sourced as part of this updated EIAR. The historical ground investigations available within the study area through the GSI have remained unchanged since the 2018 EIAR. Details of the historical ground investigations sourced as part of this updated chapter are as follows:

- R1340 Galway County Council Eastern Approach Road Galway (N6) (Ballybane – Doughiska), 1993
- R1365 Thos. Garland and Partners Digital Limited, Galway Industrial Estate, 1983
- R3176 Dermot Rooney and Associates I.D.A Business Park, Dangan, Galway, 1997
- R5906 Irish Linen Proposed Irish Linen Factory, Rahoon, Galway, 2005
- R6136 Galway County Council Residential Development, Headford Road, Galway, 2006
- R6898 Storm Technology Office Block Development, Dangan, Galway, 2006

In addition, ground investigation reports made available within the study area, which remain of relevance for this updated EIAR, were also sourced and include the following:

- SSE Renewables Ireland, Galway Wind Park 110kV River Corrib Crossing, Menlough, Galway, 2013
- Galway County Council Galway City Outer Bypass Preliminary Ground Investigation, 2006

Consultations

Consultation was carried out with the relevant bodies, including additional consultation as part of this updated EIAR, as detailed below. A review of the publicly available information provided by the relevant public bodies was undertaken during this consultation, as detailed in Table 9.1, including:

- Geological Survey Ireland (GSI)
- Department of Housing, Local Government and Heritage[4]
- Exploration & Mining Division of the Department of the Environment, Climate and Communications[4]
- Teagasc
- Office of Public Works (OPW)
- Galway County Council
- Galway City Council
- Environmental Protection Agency (EPA)

[4] Please note that department names have changed during the course of the assessment since the 2018 EIAR and consultation may be addressed to a previous superseded name. The names which these departments are referred to currently are provided.

- Landowners

As part of this updated EIAR, the GSI was consulted with regards to the updated Geological Heritage Areas, as described in Section 9.3.10. Galway City Council and Galway County Council were consulted with regards to legacy landfill sites and permitted facilities (active quarries) within the study area.

Consultation with these relevant bodies, along with the other specialists on the project team, is ongoing since 2014 to 2025.

9.2.4.3 Project-Specific Information

Site-specific data was obtained from the following sources:

- Historical Ground Investigations (extracts from baseline data collection outlined in Section 9.2.4.2)
- Project-Specific Ground Investigations, as outlined below
- Field Surveys and Walkovers, including additional surveys carried out in 2024 as part of this updated EIAR

The scope of the ground investigations within the study area include:

- Shell and auger boreholes
- Rotary core boreholes
- Trial pits
- Window samples[5]
- Geophysical surveys
- Groundwater level monitoring
- Geotechnical and environmental testing on soil and groundwater samples

Commissioned Ground Investigations for the proposed N6 GCRR

Preliminary ground investigations (GI) were commissioned to inform the design and environmental evaluation of the proposed N6 GCRR and details of these are as follows:

- N6 GCTP Phase II Ground Investigation Contract I, November 2015
- N6 GCTP Phase III Ground Investigation Contract I, April 2016
- N6 GCTP Phase III Ground Investigation Contract II, December 2015
- N6 GCTP Phase III Ground Investigation Contract III, December 2016

The ground investigation factual reports for each of these GI is include in Appendix A.9.1a, A.9.1b and A.9.1c. A summary of the project-specific ground investigation for the proposed N6 GCRR has also been provided in Table 9.2. The ground investigation locations are presented on Figures 9.8.001 to 9.8.012, 9.9.001 and 9.9.002.

[5] A window sample is used to bore shallow boreholes, usually up to 5 m BGL depending on the soil type, to obtain soil samples for assessment.

Table 9.2 Summary of Project-Specific Ground Investigations for the proposed N6 GCRR

Project Specific-Ground Investigation						
Ground Investigation Activity	**Unit**	**Phase 1 C1**	**Phase 2 C1**	**Phase 3 C1**	**Phase 3 C2**	**Phase 3 C3**
Cable Percussive Boreholes	No.	-	-	29	-	1
Rotary Holes	No.	2	4	40	5	3
Rotary Percussive Holes	No.	-	5	-	-	1
Trial Pits	No.	-	-	38	-	4
Soakaway Testing	No.	-	-	2	-	17
Window Samples	No.	-	-	4	-	
Multi Analysis Surface Wave	m	1726	-	-	-	
Seismic Refraction	m	1726	1285	8496	-	2175
2D Resistivity Survey	m	-	973	6027	-	2175
Electrical Resistivity Tomography	m	-	-	-	1897	
Microgravity	stations	-	-	-	118	

Commissioned Ground Investigation for the Galway Racecourse Stables

A site-specific ground investigation for the proposed development applied at by Galway Racecourse, (namely the temporary and permanent stables and other ancillary works) which forms part of the Project that has been considered and assessed for EIA and AA purposes, was undertaken to inform this assessment and comprises the following:

- 11 no. Trial pits
- 7 no. Dynamic Probes
- 2 no. Cable Percussive Boreholes
- 3 no. Trial wells
- Geophysical survey, including nine (9 no.) Electrical Resistivity Tomography lines (2257m) and 17 no. Seismic refraction profiles (1009m)
- Associated geoenvironmental and geotechnical in situ and laboratory testing

The available data from this site investigation has been included in this assessment. The ground investigation factual reports for this GI are included in Appendix A.9.1d.

Walkover Surveys

Walkover surveys were conducted while scoping the ground investigation in September and October 2015 and throughout the duration of the ground investigation fieldwork which was conducted between January to May 2016 and December 2016. Site walkovers were carried out in July 2024 to inform this updated EIAR

and identify if there were any changes to the receiving environment. See also Chapter 10, Hydrogeology for a description of karst[6] field surveys.

9.2.4.4 Technical Limitations

The data included in the geological assessment includes existing data from earlier investigations in the region as well as dedicated field surveys and walkovers commissioned for the Project. The data collected provides a comprehensive geological dataset across the Project.

The data points provide valuable information on the soils and geology environment at point locations. Between each point, the data is assessed by conservative interpretation. While soils and geology can vary, the exploratory locations have been selected following the completion of the comprehensive baseline data collection. This review was completed by studying local geological maps, aerial photography, historical ground investigation, and completing site walkovers to provide an understanding of the soils and geology. The location and the spacing of the exploratory locations were chosen to gain an understanding of the ground conditions. The ground investigation findings for the majority of cases compared favourably with the baseline data collection desk study. In instances where it did not, supplementary ground investigation was undertaken, these locations were:

- Peat areas, additional window samples were undertaken to the establish the peat extent
- Adjacent to the River Corrib, to establish the transition from granite to limestone and the extent of karst
- Menlough, for Lackagh Tunnel to establish rockhead and extent of palaeokarst fill due to an unexpected, buried valley feature which was encountered
- Briarhill, to investigate the water table due to unexpected groundwater conditions which were encountered (refer to Chapter 10, Hydrogeology)

Based on the comparability of the ground investigation and the baseline data collection the information is deemed sufficient to complete the soils and geology evaluation.

9.2.5 Assessment Methodology

Having defined the extent and form of the Project, an evaluation is made of its potential likely significant effects[7] on the soils and geology environments. Mitigation measures are identified to mitigate any significant adverse effects, where feasible. The assessment methodology has been updated as part of this updated chapter since the 2018 EIAR to account for changes in the EPA Guidelines (EPA, 2022), as discussed in Section 9.2.2.

This assessment methodology is in accordance with the guidance outlined in the EPA Guidelines (EPA, 2022) and in Section 5.4 of the TII Guidelines (NRA, 2008a). In accordance with the TII Guidelines (NRA, 2008a), all potential effects of the Project must be identified and assessed. Descriptive conditions of the effects to be considered as part of the assessment methodology are outlined in Table 3.4 of the EPA Guidelines (EPA, 2022), which is reproduced in Table 9.3 below (which has been updated since the 2018 EIAR in line with current EPA guidelines).

[6] Karst refers to a distinctive terrain that evolves through dissolution of the bedrock and development of efficient underground drainage. The special landforms of karst include sinkholes, dry valleys, pavements, cave systems and associated springs (Waltham *et al.* 2005)

[7] The EPA Guidelines (2022) uses the term ‘effects’. The TII Guidelines (NRA, 2008) uses the term ‘impacts’. Excluding direct reference to the TII Guidelines, the term ‘effects’ will be used in this chapter when referring to construction and/or operation effects on soils and geology.

Table 9.3 Description of Effects (Table 3.4 of EPA Guidelines (EPA, 2022))

Condition	Classification	Description
Quality of Effects	**Positive Effects**	A change which improves the quality of the environment
	Neutral Effects	No effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error
	Negative/Adverse Effects	A change which reduces the quality of the environment
Significance of Effects	**Imperceptible**	An effect capable of measurement but without significant consequences
	Not significant	An effect which causes noticeable changes in the character of the environment but without significant consequences
	Slight Effects	An effect which causes noticeable changes in the character of the environment without affecting its sensitivities
	Moderate Effects	An effect that alters the character of the environment in a manner that is consistent with existing and emerging baseline trends
	Significant Effects	An effect which, by it character, magnitude, duration, or intensity, alters a sensitive aspect of the environment
	Very Significant	An effect which, by its character, magnitude, duration, or intensity, significantly alters most of a sensitive aspect of the environment
	Profound Effects	An effect which obliterates sensitive characteristics
Extent and Context of Effects	**Extent**	Describe the size of the area, the number of sites, and the proportion of a population affected by an affect
	Context	Describe whether the extent duration, or frequency will conform or contrast with established (baseline) conditions
Probability of Effects	**Likely Effects**	The effects that can reasonably be expected to occur because of the planned project if all mitigation measures are properly implemented
	Unlikely Effects	The effects that can reasonably be expected to not occur because of the planned project if all mitigation measures are properly implemented
Duration and Frequency of Effects	**Momentary Effects**	Effects lasting from seconds to minutes
	Brief Effects	Effects lasting less than a day
	Temporary Effects	Effects lasting less than a year
	Short-term Effects	Effects lasting one to seven years
	Medium-term Effects	Effects lasting seven to fifteen years
	Long-term Effects	Effects lasting fifteen to sixty years
	Permanent Effects	Effects lasting over sixty years
	Reversible Effects	Effects that can be undone, for example through remediation or restoration
	Frequency of Effects	Describe how often the effect will occur (once, rarely, occasionally, frequently, constantly – or hourly, daily, weekly, monthly, annually)
Types of Effects	**Indirect Effects**	Effects on the environment, which are not a direct result of the project, often produced away from the project site or because of a complex pathway
	Cumulative Effects	The addition of many minor or insignificant effects, including effect on other projects, to create longer more significant effects

Condition	Classification	Description
	'Do-nothing Effects'	The environment as it would be in the future should the subject project not be carried out
	'Worst-case' Effects	The effects arising from a project in the case where mitigation measures substantially fail
	Indeterminable Effects	When the full consequences of a change in the environment cannot be described
	Irreversible Effects	When the character, distinctiveness, diversity, or reproductive capacity of an environment is permanently lost
	Residual Effects	The degree of environmental change that will occur after the proposed mitigation measures have taken effect
	Synergistic Effects	Where the resultant effect is of greater significance than the sum of its constituents

The significance of effects, as defined in the EPA Guidelines (EPA, 2022) and presented in Table 9.3 above, has been determined through intermediary steps in accordance with Section 5.4.3 of the TII Guidelines (NRA, 2008a), and Appendix C of the IGI Guidelines (IGI, 2013). The rating criteria for assessing the importance of geological features within the study area are outlined in Table 9.4 (which has been updated since the 2018 EIAR in line with current EPA guidelines) and the rating criterion for quantifying the magnitude of impacts is outlined in Table 9.5 (unchanged from the 2018 EIAR). The rating of potential environmental effects on the soils and geology environment are based on the matrix presented in Table 9.6 (unchanged from the 2018 EIAR) below which takes account of both the importance of an attribute and the magnitude of the potential environmental effects of the Project on these attributes. The criteria apply to potential effects during both the construction and operational phases.

Table 9.4 Criteria for rating the importance of identified geological features (Table C2 (IGI, 2013) and Box 4.1 (NRA, 2008a))

Importance	Criteria	Typical Example
Very High	Attribute has a high quality, significance, or value on a regional or national scale. Degree or extent of soil contamination is significant on a national or regional scale. Volume of peat and / or soft organic soil underlying route is significant on a national or regional scale.	Geological feature rare on a regional or national scale (NHA) Large existing quarry or pit Proven economically extractable mineral resource
High	Attribute has a high quality, significance, or value on a local scale. Degree or extent of soil contamination is significant on a local scale. Volume of peat and / or soft organic soil underlying route is significant on a local scale.	Contaminated soil on site with previous heavy industrial usage Large recent landfill site for mixed wastes Geological feature of high value on a local scale (County Geological Site) Well drained and / or highly fertility soils
Medium	Attribute has a medium quality, significance, or value on a local scale. Degree or extent of soil contamination is moderate on a local scale. Volume of peat and / or soft organic soil underlying route is moderate on a local scale.	Contaminated soil on site with previous light industrial usage Small recent landfill site for mixed wastes Moderately drained and / or moderate fertility soils Small existing quarry or pit

Importance	Criteria	Typical Example
Low	Attribute has a low quality, significance, or value on a local scale. Degree or extent of soil contamination is minor on a local scale. Volume of peat and / or soft organic soil underlying route is small on a local scale*.	Large historical and / or recent site for construction and demolition wastes Small historical and / or recent landfill site for construction and demolition wastes Poorly drained and / or low fertility soils. Uneconomically extractable mineral resource

Note: * relative to the total volume of inert soil disposed of and/or recovered

Table 9.5 Criteria for Rating Soil and Geology Impact Significance and Magnitude at EIA Stage (Table C4 (IGI, 2013) and Box 5.1 (NRA, 2008a))

Magnitude of Impact	Criteria	Typical Examples
Large Adverse	Results in loss of attribute	Loss of high proportion of future quarry or pit reserves Irreversible loss of high proportion of local high fertility soils Removal of entirety of geological heritage feature Requirement to excavate / remediate entire waste site Requirement to excavate and replace high proportion of peat, organic soils and / or soft mineral soils beneath alignment
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Loss of moderate proportion of future quarry or pit reserves Removal of part of geological heritage feature Irreversible loss of moderate proportion of local high fertility soils Requirement to excavate / remediate significant proportion of waste site Requirement to excavate and replace moderate proportion of peat, organic soils and / or soft mineral soils beneath alignment
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Loss of small proportion of future quarry or pit reserves Removal of small part of geological heritage feature Irreversible loss of small proportion of local high fertility soils and / or high proportion of local low fertility soils Requirement to excavate / remediate small proportion of waste site Requirement to excavate and replace small proportion of peat, organic soils and/or soft mineral soils beneath alignment
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	No measurable changes in attributes
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

Magnitude of Impact	Criteria	Typical Examples
Major Beneficial	Results in major improvement of attribute quality	Major enhancement of geological heritage feature

Table 9.6 Rating of Significant Environmental Impacts at EIA Stage (Table C6 (IGI, 2013) and Box 5.4 (NRA, 2008a))

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

The appraisal of the potential likely significant effects of the Project on soils and geology will consider the following specific topics in accordance with the EPA Guidelines (EPA, 2022) and the TII Guidelines (NRA, 2008a):

- Effect on topsoil health due to excavation activities – This is an additional effect included in the soils and geology assessment since the 2018 EIAR
- Soils, subsoils, and solid geology
- Requirements for treatment and / or handling of soft, unstable or contaminated soils, subsoils or other geological materials
- Requirements for excavation, disposal and / or recovery of soils, subsoils or other geological materials which may be unsuitable for re-use in construction of earth structures or present a risk to human health and/or the environment
- Environmental effect of engineering works on, in or over karst features (buried open / infilled cavities, slope and pavement stability)
- Effect on Economic Geology (mines, pits and quarries) either currently being extracted or potentially developable in the future
- Geological Heritage
- Requirements for piling, excavation and tunnel construction in soil and rock (requiring rock breaking and/or blast) to achieve the design level and construction of new structures which may impact on existing structures or infrastructure nearby (noise and vibration, settlement, instability)
- Requirements for transportation and truck movements of excavated material and disposal of waste material (traffic, noise, and vibration)

An evaluation of the potential effects of the Project on soils and geology during construction and operation is presented in Section 9.5.

Through the evolution of the design of the Project, measures were included in the design to reduce or avoid specific effects where possible. Following the evaluation of potential effects as a result of the design, specific mitigation measures have been developed to avoid, prevent, reduce and, if possible, remedy any significant

adverse effects on the soils and geology. Matters arising as relevant to soils and geology following submission of the 2018 EIAR, submission of the 2019 RFI Response and during the Oral Hearing in 2020 have also been considered. These are described in Section 9.6 below. Residual effects which are the final effects which result after mitigation measures have been fully established are described in Section 9.7, and specifically in Table 9.20 for the Construction Phase and in Table 9.21 for the Operational Phase.

9.3 Receiving Environment

9.3.1 Introduction

This section describes the soils and geology within the study area. A regional overview is provided in terms of the geomorphology, topography, soils, and solid geology of the local area followed by subsections identifying the feature importance ranking of the agricultural soils, superficial deposits, bedrock geology, soft and unstable ground, contaminated land, karst solution features, mineral and aggregate resources, and geological heritage sites within the study area.

When examining the receiving environment of the study area, the Project has been divided into four sections, with reference to the chainage along the proposed N6 GCRR, for ease of presentation and due to the volume of information available. For consistency, these sub-divisions are also applied in Chapter 10, Hydrogeology. The four sections are as follows:

- Section 1: Chainage 0+000 to 8+500 (R336 to the N59 Moycullen Road)
- Section 2: Chainage 8+500 to 9+400 (N59 Moycullen Road to the River Corrib)
- Section 3: Chainage 9+400 to 14+000 (River Corrib to the N83 Tuam Road)
- Section 4: Chainage 14+000 to 17+500 (N83 Tuam Road to the existing N6 at Coolagh)

These four sections are discussed in Sections 9.3.2 to Section 9.3.12.

The description of the regional overview is sub-divided and discussed in terms of the western and eastern areas, which are separated by the River Corrib. Section 1 and 2 of the study area covers the western area and the eastern area covers Sections 3 and 4.

The receiving environment is presented on Figures 9.1.001 to 9.8.012.

In Section 9.3.12, a conceptual site model is presented on Figures 9.8.001 to 9.8.0012 and summarised in Table 9.16. The conceptual model plots the factual ground investigation data within the study area along the existing ground level against the proposed road level, earthworks areas, and chainage of the Project. Table 9.16 presents additional information for each earthworks area.

Updates to the receiving environment since the 2018 EIAR include:

- Feature importance ranking has been applied to the superficial deposits encountered across the study area.
- Feature importance of High assigned to Topsoil and Peat, as shown in Table 9.8.
- Inclusion of lacustrine sediments within the superficial deposits associated with the expansion of the study area to take account of the lands included in the assessment boundary at Galway Racecourse.
- Updates to Table 9.10 regarding karst features within the study area to account for changes in the updated Karst Survey report (Appendix A.10.2 of this updated EIAR).
- Addition of landslide susceptibility within the study area as part of the soft and/or unstable ground assessment (Section 9.3.7).
- Assessment of the CORINE 2018 dataset, which was released following publication of the 2018 EIAR.
- Addition of Made Ground to Table 9.12 as a geological feature of importance relating to contaminated land.

- Updates and amendments to the Geological Heritage Areas within the study area to account for updates to the Irish Geological Heritage Programme, as described in Section 9.3.10.
- Review of the Galway County Development Plan (2022–2028) and relevant Heritage and Biodiversity policy (NHB 5) and Geological Sites policies.

9.3.2 Regional Overview

The Project traverses from west to east of Galway on the northern side of Galway City. This section will discuss the following aspects of the region surrounding the Project:

- Regional Geomorphology and Topography
- Regional Soils and Bedrock Geology

9.3.2.1 Regional Geomorphology and Topography

The general geomorphology of the western area consists of gently undulating to hummocky[8] topography in areas overlying granite. The ground level is lowest at the shores of Lough Corrib and along the coast (10m OD) and rises to the high points at Gortacleva / Tonabrocky (111m OD), Derry Crih (96m OD) and Corcullen (90m OD). The GSI maps indicate ridge lines exist at Tonabrocky and Derry Crih which run northwest-southeast.

The Project crosses the River Corrib near Menlo Castle on the eastern bank and on the western side it passes through University of Galway (UoG) Sporting Campus at Dangan. On crossing the River Corrib, the topography to the eastern area is less undulating than in the western area. The area around the River Corrib is relatively flat and rises to the east. The highest point (65m OD) is directly beside the disused Lackagh Quarry in Menlough. From this point the ground surface gently slopes towards Ballindooley Lough and rises again towards Two Mile Ditch (60m OD). The GSI have produced Quaternary Geology[9] mapping for Ireland. A presentation of the geomorphological features from this mapping is provided in Figures 9.1.001 to 9.1.002 and Figure 9.1.101 to 9.1.115.

The Galway Granite Batholith is recorded as an indicator erratic or a known source area, with path direction or known erratic train to the south of Ireland. Glacial erratics are evident east of the River Corrib.

Striation[10] is rather non-uniform to the west of the River Corrib. However, the majority of striae direction and drumlins face in a north to northeast direction. The striae direction, streamlined bedrock, and drumlin direction in the east of the River Corrib is provided as a northeast direction.

The Lower Carboniferous Visean Limestone is known to contain karst solution feature including surface features such as springs, turloughs, and swallow holes which are present east of the River Corrib. Limestone pavement is also common throughout the study area east of River Corrib and is located both outside and within the Lough Corrib SAC, refer to Chapter 8, Biodiversity for the ecological assessment of Limestone pavement.

The Project intercepts several watercourses, predominately to the west of the River Corrib. To the east of the River Corrib, due to the highly karstic nature of the terrain, there is a very sparse network of watercourse features. Lake features include Coolagh Lakes and Ballindooley Lough which are located east of the River Corrib. For further details refer to Chapter 11, Hydrology. Blanket peat is widespread on the west of the River Corrib but reduces toward the river. Some isolated areas of cutover peat also exist on the eastern side of the River Corrib.

[8] Hummocky terrain is defined as uneven or undulating surface which contains subdued and rolling landforms.

[9] The Quaternary mapping consists of unconsolidated sediments, the distribution and outline of the main geomorphological features and ice direction indicators.

[10] This refers to glacial striation or scratches, gouges cut into bedrock by glacial abrasion during movement of the glacier.

9.3.2.2 Regional Soils and Bedrock Geology

Generally, the western area consists of a mix of peaty podzols, blanket peat, lithosols / regosols, and surface water gleys, overlying predominantly granular glacial till over Early to Middle Devonian granite intrusions known as the Galway Granite Batholith (comprising of granite and orthogranite) and other igneous intrusive rocks. The lowest ground level is at the shores of Lough Corrib where alluvial deposits and fen peat are encountered. The land in the western area is predominantly used as agricultural land with the lands closer to the River Corrib becoming more urban with many residential, commercial and University areas.

The soils in the east consist predominantly of grey brown podzolics, lithosols, peat, and renzinas / lithosols, overlying cohesive glacial till derived from the underlying bedrock consisting of overly karstified Carboniferous Visean Limestone. Pracht, *et al*, 2004 refer to these limestones as the Burren Formation. Palaeolandscape features (and likely palaeokarst) were identified which comprise of features of significantly deep infilled buried valleys. The land in the eastern area is predominantly used as agricultural land with the area between Ballybrit and Briarhill as an urban environment. Within this area there is an active and disused limestone quarry located in Two Mile Ditch and Menlough respectively.

9.3.3 Agricultural Soils

Soil within the study area was assessed based on agricultural usage, fertility, and drainage characteristics. Teagasc developed a national indicative soil map, which classifies the soils of Ireland into simplified categories. The Teagasc Soil Mapping has been reproduced in Figure 9.2.001 to Figure 9.2.002 and Figure 9.2.101 to 9.2.115. Cognisance was taken of the CORINE (Co-Ordinated Information on the Environment) data series, established by the European Community (EC) and nationally coordinated by the EPA, when interpreting the Teagasc soil map. The CORINE 2018 dataset, which has been published since the 2018 EIAR, was used for this updated assessment. This section looks at the agriculture soil only. Potential agriculture effects are assessed in Chapter 14, Material Assets Agriculture of this updated EIAR.

A summary of the agricultural soils encountered within the study area and their associated feature importance is provided in Table 9.7.

Section 1: Chainage 0+000 to 8+500

The soil from Na Foraí Maola to Aille is typically described as poorly drained shallow deposits with peaty topsoil. From Aille to Dangan, the soil description changes to become a shallow to deep, well drained, non-calcareous deposit. These areas are typically described as agricultural lands with arable land and pastures. Some vegetation typical of peatlands exists in both An Chloch Scoilte and Aille.

Section 2: Chainage 8+500 to 9+400

Soil in the central part of the study area, in the vicinity of the River Corrib, is primarily described as made ground with alluvial deposits indicated along the river catchment. This area has no agricultural soil value as it is part of the urban fabric.

Section 3: Chainage 9+400 to 14+000 and Section 4: Chainage 14+000 to 17+500

To the east of the River Corrib, the majority of the land is described as shallow to deep, well drained, with a high percentage of agricultural, fertile land, mixed with small clusters of residential and industrial facilities. There are minor lacustrine deposits present to the east of the River Corrib, including at the Galway Racecourse.

Land is predominantly natural however the potential for contaminated ground is further discussed in Section 9.3.8.

Table 9.7 Geological Feature Importance of Soil within Study Area

Soil Type	Description	Location / General Extent	Feature Importance Ranking
Teagasc Soils			
AminSRPT	Shallow, lithosolic or podzolic type soils potentially with peaty topsoil. Predominantly shallow soils derived from non-calcareous (granite) rock or gravels with / without peaty surface horizon	Generally from Na Foraí Maola to An Chloch Scoilte	Low
BktPt	Blanket Peat	An Chloch Scoilte	Low
AminSW	Shallow well drained mineral. Derived from mainly non-calcareous (granite) parent materials	Generally from An Chloch Scoilte to Ballard	High
AminDW	Deep well drained mineral soils derived from mainly non-calcareous (granite) parent materials	Aille to Cappagh and Ballyburke to Dangan	High
AminPD	Deep poorly drained mineral derived from mainly non-calcareous (granite) parent materials	Various locations along the western section of the study area	Low
Made	Made Ground	Dangan to Menlough and Ballybrit	Low
AlluvMIN	Mineral Alluvium	Menlough	Low
BminSW	Shallow well drained mineral. Derived from mainly calcareous (limestone) parent materials	Generally from Menlough to Ballindooley	High
BminSRPT	Shallow, lithosolic or podzolic type soils potentially with peaty topsoil. Predominantly shallow soils derived from calcareous (limestone) rock or gravels with / without peaty surface horizon	Lackagh and Ballybrit	Low
Cut	Cutover Peat	River Corrib and Ballindooley Lough	Low
BminDW	Deep well drained mineral. Derived from mainly calcareous (limestone) parent minerals	Generally from Ballindooley to Coolagh	High
BminPD	Deep poorly drained mineral. Derived from mainly calcareous parent minerals	Various locations along the eastern section of the study area	Low
BminPDPT	Poorly drained mineral soils with peaty topsoil. Derived from mainly calcareous (limestone) parent materials	Various locations along the eastern section of the study area	Low
Lac	Lacustrine type soils	Present in the vicinity Galway Racecourse	Low

9.3.4 Superficial Deposits

Superficial deposits, in this chapter, refers to geological deposits associated with the youngest geological deposits formed during the most recent period of geological time, the Quaternary, which extends back about 2.6 million years from the present.

Superficial deposits provide a range of functions for natural systems, including topsoils and peat in particular. Topsoils are a finite natural resource which provide a living medium for the support of biodiverse ecosystems. Topsoils provide a nature based solution for filtration and drainage functions. Peat and peaty topsoils act a natural sink for carbon sequestration. As such when compared with the 2018 EIAR, topsoils and peat, where encountered, are now classified as features with a high importance ranking.

The Irish Soil Information System[11] project has developed a national association soil map for Ireland, providing information on soil types and properties across Ireland.

Superficial deposits were established based on the Irish National Soil Map 1:250,000, the Irish National Subsoil Map, and relevant ground investigation information across the Project.

A reproduction of the Irish National Soil map 1:250,000, as provided by Teagasc and Cranfield University, has been provided in Figure 9.3.001 to Figure 9.3.002 and Figure 9.3.101 to Figure 9.3.115. The Irish National Subsoil Map, produced by Teagasc, EPA, and GSI, was also consulted. This map has also been reproduced in Figure 9.4.001 to Figure 9.4.002 and Figure 9.4.101 to Figure 9.4.115.

A summary of the superficial deposits encountered within the study area and their associated feature importance is provided in Table 9.8. Feature importance ranking has been included in this Table 9.8 of this updated EIAR.

Section 1: Chainage 0+000 to 8+500

Generally, Section 1 consists of peat over a mixture of granular glacial deposits and highly weathered granite.

Section 2: Chainage 8+500 to 9+400

Section 2 is comprised of shallow granular granite derived till over weathered granite, with some instances of peat. This changes to soft to firm sandy gravelly clay over weathered limestone at the intersection of the rock types.

Section 3: Chainage 9+400 to 14+000 and Section 4: Chainage 14+000 to 17+500

East of the River Corrib, the study area typically consists of glacial till derived from limestone, over weathered limestone. Instances of palaeolandscape infilling were uncovered in various low-lying areas within the study area in Menlough, Castlegar and Terryland. Minor lacustrine deposits are indicated at Galway Racecourse (which are new when compared with the 2018 EIAR).

Areas of soft and / or unstable ground are discussed further in Section 9.3.7.

Table 9.8 Geological Feature Importance of Superficial Deposits within Study Area

Stratum[12]	General Extent / Location	Depth to Top of Strata (m BGL)	Thickness Range (m)	Notes / Description	Feature Importance Ranking
Topsoil	Widespread	0.0	0.0 – 0.7	Occasionally peaty in nature	High
Made Ground	Widespread	0.0 – 0.3	0.0 – 1.9	Occasional fragments of concrete, red brick, ceramic pipe, timber	Low
Peat	Section 1 and 3	0.0 – 0.8	0.0 – 1.3	Occasionally slightly sandy	High
Glacial Till derived from Granite	Section 1	0.1 – 2.3	0.0 – 3.5	Cohesive and granular mix	Low

[11] The Irish Soil Information System project has developed a national association soil map for Ireland at a scale of 1:250,000. The project is co-funded by Teagasc and the Environmental Protection Agency (EPA) Science, Technology and Research & Innovation for the Environment (STRIVE) programme (http://gis.teagasc.ie/isis/about.php)

[12] Strata indicated may not be present at all locations along the Project.

Stratum[12]	General Extent / Location	Depth to Top of Strata (m BGL)	Thickness Range (m)	Notes / Description	Feature Importance Ranking
Glacial Till derived from Limestone	Section 2 to 4	0.1 – 1.9	0.0 – 21.6	Cohesive and granular mix	Low
Palaeolandscape Fill	Section 2 and 3	13.7 – 101.5	87m (only confirmed thickness)	Described as silt, organic clay, and a transition zone consisting of cobbles and boulders	Low
Lacustrine	Section 4	N/A	N/A	The GSI and EPA indicate that these are undifferentiated sediments deposited in a glacial lake environment	Low

9.3.5 Bedrock Geology

The underlying bedrock geology was determined based on the GSI Bedrock Geology 1:100,000 online mapping, and relevant ground investigation across the Project and is presented in Figures 9.5.001 to Figure 9.5.002 and Figure 9.5.104 to Figure 9.5.115.

A summary of the bedrock formations encountered within the study area and their associated feature importance is provided in Table 9.9. Feature importance ranking has been included in this Table 9.9 of this updated EIAR.

Section 1: Chainage 0+000 to 8+500

Section 1 is underlain by the Galway Granite Batholith which consists of a number of distinct granite intrusions and is faulted into three main parts by the Shannawona north northeast trending faults and the Bearna northwest trending faults. The Bearna Fault is indicated by the GSI as running approximately through the centre of Section 1 at Aille / Ballard. Faulting in the Galway Granite Batholith was not confirmed in intrusive investigation.

To the west of the inferred Bearna Fault, the underlying granite is described as a black, grey, pink, biotite Megacrystic-Porphyritic Granite. The coarse grained, pink, phenocrystic K-feldspar granite known as the Errisbeg Townland Granite occurs to the east of the fault.

Late stage felsite, quartz porphyry and granite porphyry dykes cross almost all of these intrusions.

The white to grey fine grained aphyric felsic Murvey Granite occurs at or near the margins of the batholith and also at the eastern end of Section 1 in Dangan. The Murvey Granite is considered to be the most fractionated of all the granites in the batholith.

Section 2: Chainage 8+500 to 9+400

West of the River Corrib, the study area is typically underlain by Early to Middle Devonian granite intrusions within the Galway Granite Batholith. The Murvey Granite occurs at the outer periphery of the Errisbeg Townland Granite, adjacent to the Lower Carboniferous Visean Limestone known as the Burren Formation.

The area of limestone between the western shore of the River Corrib and the fault bounding the pre-Carboniferous rocks to the west were originally mapped by C.V. MacDermot in the late 1960's and early 1970's. Based on the results of the project-specific ground investigation, the rock type change occurs in the vicinity of the unconformity line. Intrusive investigation and geophysical investigation confirmed the high

likelihood that the change in rock type occurs at Ch. 8+880 of the proposed N6 GCRR. On the limestone side of the indicative chainage, a zone of low resistivity that is up to 40m wide and greater than 20m deep was encountered. This is likely to be a highly weathered zone at the contact zone. East of this zone, the geology sharply reverts to high resistivity, typical of competent limestone. Therefore, this unconformity line / fault is still considered valid and provided in Figures 9.5.001 to Figure 9.5.002 and Figure 9.5.106, Figure 9.5.107, and Figure 9.5.012.

The rock is described as thick to thinly bedded; however, the majority of intrusive coring indicates that the limestone rockmass is thinly bedded. Average depth to rock is approximately 5.0m below ground level (BGL), however intrusive investigation along the River Corrib indicates that rock can drop to 78m BGL.

Section 3 and 4: Chainage 9+400 to 17+500

The area to the east of the River Corrib is underlain by the Burren Formation (Visean) of the Lower Carboniferous age. There is limited available information on the depositional sequencing of the Burren Formation. The exploratory descriptions for the limestones encountered during the site investigation vary widely and therefore no trend or isolated areas of distinct characteristics have been observed. The bedrock topography associated with the palaeolandscape was encountered at depths deeper than elsewhere within the study area.

Some argillaceous (clayey) material was recorded in the coreholes. The nature of the limestone strongly influences its susceptibility to karstification. Purer limestones (>90% calcite) are more susceptible than impure (shaley / argillaceous) limestones.

The average depth to rock across the Sections 3 and 4 (excluding areas of palaeolandscape features) is approximately 2.4 m BGL. Intrusive coring indicates that the rock is massive to thinly bedded. Geophysical surveys carried out at the Galway Racecourse indicates rock depths of up 26 m BGL.

Karst within the limestone is discussed in Section 9.3.6.

Table 9.9 Geological Feature Importance of Rock Formations within Study Area

Geological Period	Bedrock Unit	Formation	Description	General Extent / Location	Feature Importance Ranking
Carboniferous	Dinantian Pure Bedded Limestone	Burren Formation (Visean)	Medium to very strong massive to thinly bedded blueish dark grey fine grained slightly weathered	Section 2, 3 and 4 East of River Corrib, with small section west of riverbank	Low
Early-Middle Devonian	Galway Granite Batholith	Porphyritic-Megacrystic Granite	Very strong grey, white, pink, black biotite slightly weathered	Section 1 Coast Road (R336) to Aille Principal granite mass west of the Bearna Fault	Low
		Fine Grained Foliated Granite	Very strong thickly to thinly banded brown pink green medium to coarse grained slightly weathered	Section 1 Between An Chloch Scoilte and Ballard	Low

Geological Period	Bedrock Unit	Formation	Description	General Extent / Location	Feature Importance Ranking
		Errisbeg Townland Granite	Very strong thickly to thinly banded brownish purple fine to coarse grained slightly weathered	Section 1 and 2 Aille to Dangan Principal granite mass east of Bearna Fault	Low
		Murvey Granite	Very strong thickly to thinly banded green, white fine coarse grained moderately weathered	Section 1 and 2 Dangan Border formation between principal granite and visean limestone	Low
Ordovician	Other Igneous Intrusive Rocks	Metagrabbo and Orthogneiss Suite (undifferentiated)		Section 1 and 2 Dangan	Low

9.3.6 Karst Solution Features

From the N59 Moycullen Road at Dangan (Section 2) to the existing N6 at Coolagh, Briarhill (Section 4) the study area is underlain by clean non-argillaceous limestone which is prone to karst. A range of solution features were identified within the study area and presented in Figure 10.1.001 to Figure 10.1.002 and Figure 10.1.101 to Figure 10.1.115. These include:

- Limestone pavement
- Epikarst
- Dolines (enclosed depressions)
- Caves
- Estavelles
- Springs
- Superficial Solution Features
- Wells
- Swallow holes
- Turloughs

The solution features have been identified based on the GSI Karst Database and were further assessed in a project-specific karst survey, which is available in Appendix A.10.2.

A summary of the karst solution features encountered within the study area and their associated feature importance is provided in Table 9.10.

Section 1: Chainage 0+000 to 8+500

There is no karst in Section 1 as this area is underlain by granite which is not susceptible to karst.

Section 2, 3 and 4: Chainage 8+500 to 17+500

The Irish National Subsoil Map indicates that approximately 40% of the landcover over the limestone bedrock is karstified outcrop or subcrop. Site walkovers and ground investigation established that much of Section 3 and 4 is limestone subcrop with a thin / shallow layer of topsoil, glacial till.

Areas of Limestone pavement were uncovered and mapped in Sections 3 and 4. Limestone pavement, which is underlain by limestone bedrock accounts for approximately 10% of the land cover. Limestone pavement occurs within and outside European designated sites. For the purpose of the geological assessment no differentiation has been made between Limestone pavement located within or outside the European designated sites. Refer to Chapter 8, Biodiversity for an ecological assessment of Limestone pavement.

Most of the karstification identified across the Project consists of a weak to well-developed zone of epikarst[13], ranging from approximately 0m to 2.7m in thickness[14].

In a smaller number of areas, more intense karstification has led to deeper weathering (below the epikarst zone) and clay infilling of solutionally enlarged features (typically joints). In some of these, even more intense karstification has occurred, leading to the development of relatively large dissolution features which are typically infilled with sediments. The establishment of the location of these features is achieved through geophysical surveys and intrusive investigation.

Palaeokarst features have been identified with the bedrock formation. These consist of large, buried valleys filled with silt and clay.

Various anomalies were encountered in both intrusive investigation and geophysical surveys, which may likely be karst related. These include the following:

- Non intact zones identified in rotary coreholes below bedrock level
- Cavities in rotary coreholes
- Calcite deposits and infilled voids identified in rotary coreholes
- Significant drop in resistivity values recorded during the geophysical survey which do not coincide with typical bedrock resistivity values

Such anomalies were encountered at various locations across the study area underlain by limestone bedrock. The locations of these anomalies are presented in the ground investigation factual data and are not included in Table 9.10 [15].

Refer to Chapter 10, Hydrogeology for a full description of both surface karst features and anomalies recorded from the ground investigations.

[13] Epikarst comprises of refers to the zone of partially weathered or highly weathered carbonate bedrock immediately underlying the surface or superficial deposits where present and immediately overlying the unweathered bedrock.

[14] The values provided are representative of the typical thicknesses observed / recorded. Weathered rock was recorded as 6.4m thick in BH 3/35R conducted during the N6 GCTP Phase 3 Contract 1 Ground Investigation in 2016. However, based on site observations during monitoring of the works and available geophysical data, the material was a mixture of cobbles and boulders with dense granular content. This was an isolated record.

[15] Following updates to the Karst Survey report in July 20204, a number of karst features have been removed from Table 9.10 in this updated EIAR as they could not be identified during additional surveying undertaken in July 2024.

Table 9.10 Geological Feature Importance of Karst Features within Study Area

ID Code	Karst Feature	Information Source	Location / General Extent	Feature Importance Ranking
Limestone Pavement				
LP	Limestone pavement	Field mapping from Ecologist	Widespread throughout Sections 3 and 4	Very High[16]
Palaeolandscape (Palaeokarst)				
PK	Palaeokarst Valley	Mapping from Hydrogeologist	Menlough, Ballindooley Castlegar	Medium
Surface Karst Solution Features				
K7	Spring	Field Survey	Bushypark	Medium
K10	Enclosed Depression	Field Survey	Bushypark	Medium
K11	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Bushypark	Medium
K12	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Bushypark	Medium
K17	Spring	Field Survey	Menlough	Medium
K25	Spring	Lidar, Bing Maps, Google Maps, Aerial Photography, OSI Water Line	Menlough	Medium
K31	Turlough	Scott Cawley Ecologists Surveys	Menlough	Medium
K44	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Coolagh	Medium
K45	Spring	Lidar, Bing Maps, Google Maps, Aerial Photography, OSI Water Line	Coolagh	Medium
K49	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Coolagh	Medium
K51	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Coolagh	Medium
K54	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Coolagh	Medium
K57	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Coolagh	Medium
K59	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Coolagh	Medium
K61	Enclosed Depression	Field Survey	Coolagh	Medium

[16] Limestone pavement is ranked based on its soils and geological feature importance not as ecological importance. Refer to Chapter 8, Biodiversity for ecological importance rating.

ID Code	Karst Feature	Information Source	Location / General Extent	Feature Importance Ranking
K62	Enclosed Depression	Field Survey	Coolagh	Medium
K64	Enclosed Depression	Field Survey	Coolagh	Medium
K67	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Coolagh	Medium
K70	Enclosed Depression	Field Survey	Coolagh	Medium
K71	Enclosed Depression	Field Survey	Coolagh	Medium
K97	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Castlegar	Medium
K104	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Castlegar	Medium
K131	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Parkmore	Medium
K172	Enclosed Depression	Lidar, Bing Maps, Google Maps, Aerial Photography	Coolagh	Medium
K175	Enclosed Depression	Field Survey	Coolagh	Medium
K179	Enclosed Depression	Field Survey	Coolagh	Medium
K193	Enclosed Depression	Field Survey	Coolagh	Medium
K328	Enclosed Depression	Bing Maps	Parkmore	Medium

9.3.7 Soft and/or Unstable Ground

Soft deposits consist of peat, alluvium, or very soft cohesive material. These soft compressible deposits, which are located within the study area, are presented in Figure 9.7.001 to Figure 9.7.002 and Figure 9.7.101 to Figure 9.7.115. Various sources of information were consulted in establishing these areas along the study area namely:

- Irish National Subsoil map, produced by Teagasc, EPA, and GSI
- GSI database of historical landslides
- Ground Investigation data

The Irish National Subsoil map outlined locations of soft soil within the study area and the GSI database shows no recorded landslide events within the study area. The landslide susceptibility is predominantly low / low (inferred) across the study area with smaller areas mapped as having a moderately low to moderately high susceptibility.

Areas containing peat and very soft to soft cohesive material identified within the study area were primarily obtained through assessment of intrusive investigation and consultation of the Irish National Subsoil mapping. The ground investigation soil log descriptions (soft, very soft) and in-situ strength testing were

used to determine the location of soft deposits. In accordance with EN ISO 14688-2:2004, material with an undrained shear strength of 40 kPa is considered a soft deposit.

According to the Irish National Subsoil mapping for the county, less than 1% of the peatland areas in County Galway fall within the study area. Areas containing peat and soft soil are displayed in Figure 9.7.001 to Figure 9.7.002 and Figure 9.7.101 to Figure 9.7.115 and the conceptual site model as presented in Figure 9.8.001 to Figure 9.8.012.

A summary of the soft and/or unstable ground and geohazards encountered within the study area and their associated feature importance is provided in Table 9.11.

Section 1: Chainage 0+000 to 8+500

Intrusive investigation indicates the existence of peaty topsoil and shallow deposits of peat throughout Section 1. The evidence and likelihood of this material reduces at Dangan, where the landcover enters the urban fabric. Typically, the depths observed for the peat were less than 1.0m however a number of locations were identified where the peat extended up to thicknesses of 2.0m or soft deposits up to thicknesses of 3.6m, as presented in Figure 9.8.001 to Figure 9.8.012. The soft deposits are typically non-organic, however organic deposits were encountered in Na Foraí Maola and Aille. These are isolated instances only and are likely due to the overlying peat.

There are minor areas of Moderately High landslide susceptibility along Section 1, including at Cnoc na Gréine, Baile an Bhúrcaigh, and Dangan.

Section 2: Chainage 8+500 to 9+400

Peat is recorded in the upper, northern part of the study area within Section 2. Alluvial deposits and highly organic soft deposits were encountered along the bank of the River Corrib.

Section 3: Chainage 9+400 to 14+000

Peat was observed in the valley area at Menlough, west of Lackagh Quarry. This is mixed with highly organic soft ground deposits and alluvial deposits as per the intrusive investigation and Irish National Subsoil mapping. Geophysical surveying during the commissioned site investigation indicates that the likely deposition of these deposits is associated with infilling of deep buried valleys or palaeovalleys.

A significant palaeokarst feature was uncovered west of Lackagh quarry with palaeokarst fill encountered to 101.5m BGL in one exploratory hole. This is significantly deeper than the shallow bedrock in the immediate vicinity which includes Limestone pavement.

Peat was also encountered at Ballindooley Lough, with historical ground investigation showing peat up to 3.7m in thickness. Soft deposits, mixed with peat are expected both west and east of the N84 Headford Road, as the geophysical survey indicate the potential presence of deep buried valleys either side of the N84 Headford Road.

There are minor areas classified as Moderately High landslide susceptibility in Section 3, including in Menlough, Coolagh, and Castlegar.

Section 4: Chainage 14+000 to 17+500

Isolated instances of soft ground were encountered in Section 4. A buried valley was uncovered following a geophysical survey, with intrusive investigation confirming the anomaly. Only two isolated instances of peat were encountered in historical and recent intrusive investigations, along with only one instance of slightly organic material. The Irish National Subsoil mapping indicates an area of lacustrine sediments at the Galway Racecourse.

According to the GSI landslide susceptibility mapping, an area of Moderately High landslide susceptibility is mapped at the beginning of Section 4, northwest of Galway Racecourse. It is believed that classification is primarily due to topographical change and shallow overburden deposits.

Table 9.11 Geological Feature Importance for Geohazards within Study Area

Feature	Description	Feature Importance Ranking
GEOHZ01	Peat	Low
GEOHZ02	Soft Organic[17]	Low
GEOHZ03	Soft Non-organic	Low

9.3.8 Contaminated Land

Various sources of information were consulted in assessing the study area for locations of potential contaminated land:

- CORINE land cover mapping
- Teagasc Soil map
- EPA
- Ground Investigation data

No known areas of contaminated ground were identified. Industrial sites may be the source of locally contaminated land due to site activities. Approximately 5% of the study area is comprised of Industrial and Commercial Units in accordance with the CORINE land cover mapping. However, these sites operate within the EPA Industrial Emissions (IE) licence framework and due to the regulated nature of their activities, the risk of contamination is low.

There are no sites within the study area that have been granted a wastewater discharge licence.

Made ground has been defined as soil which has been altered in some way by human activity (imported and placed in-situ). Made ground has been observed in the form of inclusions of metal, glass, copper piping, ceramic piping. All locations of made ground are presented in the conceptual site model Figure 9.8.001 to Figure 9.8.012. Based on the Teagasc Soil mapping less than 10% of the study area is comprised as made ground with approximately 30% of the study area comprised of artificial surfaces.

In 1996, the EPA began licensing certain activities in the waste sector which include landfills, transfer stations, hazardous waste disposal and other significant waste disposal and recovery activities. It has been determined from consultation with Galway City and County Council (initially 29 August 2016 and reconfirmed on 11 September 2024) that there are no known historical (or legacy) landfills within the study area.

A summary of the features associated with contaminated land encountered within the study area and their associated feature importance is provided in Table 9.12.

Section 1: Chainage 0+000 to 8+500

No known areas of contaminated ground were identified.

CORINE and Irish National Subsoil mapping highlight areas of artificial surfaces due to residential dwellings, commercial properties, and industrial usage.

One site was identified which previously had a Certificate of Registration for the importation of Construction and Demolition Waste. The certificate expired on the 28 May 2015.

[17] Palaeolandscape fill is anticipated to be organic in nature, particularly due to the highly organic material encountered along the River Corrib and isolated instance at other locations identified to be overlaying palaeolandscape valleys. No organic testing has been conducted in the palaeolandscape fill in the project-specific ground investigation.

Section 2: Chainage 8+500 to 9+400

No known areas of contaminated ground were identified.

CORINE and Irish National Subsoil mapping highlight areas of artificial surfaces due to residential dwellings, commercial properties, industrial usage, and university buildings.

Section 3: Chainage 9+400 to 14+000

No known areas of contaminated ground were identified.

CORINE and Irish National Subsoil mapping highlight areas of artificial surfaces due to residential dwellings, commercial properties, and industrial usage.

Section 4: Chainage 14+000 to 17+500

No known areas of contaminated ground were identified.

CORINE and Irish National Subsoil mapping highlight areas of artificial surfaces due to residential dwellings, commercial properties, sport and leisure facilities and industrial usage.

Three licenced IPPC facilities were identified in Section 4. These are tabulated in Table 9.12 and are provided in in Figure 9.7.001 to Figure 9.7.002 and Figure 9.7.101 to Figure 9.7.115.

Table 9.12 Geological Feature Importance for Contaminated Land within Study Area

Feature	Status / Extent in Percentage	Description	Location / General Extent	Feature Importance Ranking
Made Ground (MG)				
MG	-	Made Ground	Widespread	Low
Licensed IPPC Facilities				
IP01	Licensed	Medtronic Vascular Galway Ltd.	Parkmore	Low
IP02	Surrendered	Irish Finishing Technologies Ltd.	Ballybrit	Low
IP03	Licensed	Boston Scientific Ireland Ltd.	Ballybrit	Low

9.3.9 Mineral / Aggregate Resources

Various datasets were consulted in establishing the economic geology of the study area including:

- GSI: aggregate potential mapping
- GSI: mineral localities
- EPA: active mine sites

These datasets are presented in Figure 9.6.001 to Figure 9.6.002 and Figure 9.6.101 to Figure 9.6.115.

A detailed description of how the Aggregate Potential Mapping was developed is available in Issue No. 15 of Geology Matters as part of the Newsletter of the Geological Survey Ireland or on the GSI website[18].

The existence of high or very high potential aggregate within the study area will result in a loss of available aggregate. However, such potential is beneficial during construction as material can be sourced on site removing the need to import suitable / compliant[19] material during the construction stage in its place.

[18] The Aggregate Potential Mapping section of the Spring 2014 Newsletter of the Geological Survey Ireland is available as pdf on the GSI website (https://www.gsi.ie/Newsletters/Aggregate+Potential+Mapping.htm)

[19] Updated terminology for material classification since the 2018 EIAR as per TII Series 600 Earthwork Specification (TII, 2024)

No active metallic mines exist today in the study area. Over the past 50 years, parts of the area have been extensively prospected by mineral exploration companies for base metals, but no economically viable deposits have been discovered to date. There is no record of underground mining in the area therefore there would be a low risk of underground structure collapse due to underground excavations, and as such this assessment does not consider this feature any further.

A summary of the mineral / aggregate resources encountered within the study area and their associated feature importance is provided in Table 9.13.

Section 1: Chainage 0+000 to 8+500

The majority of Section 1 consists of very high crushed rock aggregate potential derived from granite with instances of high crushed rock aggregate potential at the beginning of Section 1, Na Foraí Maola, in the middle at An Chloch Scoilte, and at the eastern end of Section 1 in Letteragh and Ballagh. Two instances of medium crushed rock aggregate potential were identified in Section 1, at An Chloch Scoilte and Dangan.

An area of low sand and gravel aggregate potential was identified in Rahoon.

All of the metallic mineral localities identified in the study area are located at the beginning of Section 1 in Na Foraí Maola.

One non-metallic locality was identified in An Chloch Scoilte which is described as low lying granite pavement. Four historical pits and one historical quarry were identified in the eastern extent of Section 1, between Keeraun and Dangan.

Section 2: Chainage 8+500 to 9+400

The majority of Section 2 consists of very high crushed rock aggregate potential with smaller instances of both high and moderate crushed rock aggregate potential. The potential crushed rock in the limestone section is predominantly very high potential.

Section 3: Chainage 9+400 to 14+000

Section 3 is ultimately an area of very high crushed limestone rock aggregate potential with some very small, isolated instances of high potential.

One active (Roadstone Quarry at Two Mile Ditch) and one disused quarry (Lackagh Quarry in Menlough) are located in Section 3.

Section 4: Chainage 14+000 to 17+500

Section 4 is regarded as having very high crushed limestone rock aggregate potential. Two historical quarries and one historical gravel pit are located in Section 4.

Table 9.13 Geological Feature Importance of Mineral / Aggregate Resources within the Study Area

ID	Type	Description	Location / Extent	Feature Importance Ranking
Active Quarries				
Q01	Disused	Lackagh Quarry	Lackagh	Medium
Q02	Active	Roadstone Two Mile Ditch Quarry	Polkeen	Very High
Active and Historical Quarries				
HPQ01	Historical	Sourced from OSI 6inch mapping	Keeraun	Low
HPQ02	Historical	Sourced from OSI 6inch mapping	Keeraun	Low

ID	Type	Description	Location / Extent	Feature Importance Ranking
HPQ03	Historical	Sourced from OSI 6inch mapping	Keeraun	Low
HPQ04	Historical	Sourced from OSI 6inch mapping	Letteragh	Low
HPQ05	Historical	Sourced from OSI 6inch mapping	Ballagh	Low
HPQ06	Historical	Sourced from OSI 6inch mapping	Ballybrit	Low
HPQ07	Historical	Sourced from OSI 6inch mapping	Ballybrit	Low
HPQ08	Historical	Sourced from OSI 6inch mapping	Parkmore	Low
Aggregate Potential				
VHPCR	Crushed Rock	Very high crushed rock aggregate potential	Entire Study Area (89%)	Very High
HPCR	Crushed Rock	High crushed rock aggregate potential	Na Foraí Maola, An Chloch Scoilte, Rahoon, Letteragh, Dangan (10%)	High
MPCR	Crushed Rock	Moderate crushed rock aggregate potential	An Chloch Scoilte, Dangan (1%)	Medium
LPSAGR	Sand and Gravel	Low sand and gravel aggregate potential	Rahoon and Ballybrit	Low
Mineral Localities				
ML01	Metallic	Copper	Na Foraí Maola	Low
ML02	Metallic	Iron	Na Foraí Maola	Low
ML03	Metallic	Molybdenum	Na Foraí Maola	Low
ML04	Metallic	Iron	Na Foraí Maola	Low
ML05	Metallic	Molybdenum	Na Foraí Maola	Low
ML06	Metallic	Copper	Na Foraí Maola	Low
ML07	Metallic	Copper	Na Foraí Maola	Low
ML08	Metallic	Iron	Na Foraí Maola	Low
ML09	Metallic	Molybdenum	Na Foraí Maola	Low
ML10	Metallic	Iron	Na Foraí Maola	Low
ML11	Metallic	Copper	Na Foraí Maola	Low
ML12	Metallic	Copper	Na Foraí Maola	Low
ML13	Metallic	Iron	Na Foraí Maola	Low

ID	Type	Description	Location / Extent	Feature Importance Ranking
ML14	Metallic	Molybdenum	Na Foraí Maola	Low
ML15	Metallic	Copper	Na Foraí Maola	Low
ML16	Metallic	Iron	Na Foraí Maola	Low
ML17	Metallic	Fluorspar	Na Foraí Maola	Low
ML18	Non-Metallic	Low lying Granite pavement	An Chloch Scoilte	Low
ML19	Non-Metallic	Disused Granite Quarry	Letteragh	Low
ML20	Non-Metallic	Disused Granite Quarry	Ballagh	Low
ML21	Non-Metallic	Dimension stone	Lackagh Quarry, Coolagh	Low
ML22	Non-Metallic	Limestone (in general)	Lackagh Quarry, Coolagh	Low
ML23	Non-Metallic	Dimension stone	Roadstone Quarry, Two Mile Ditch	Very High
ML24	Non-Metallic	Limestone (in general)	Roadstone Quarry, Two Mile Ditch	Very High

9.3.10 Geological Heritage Areas

The Irish Geological Heritage Programme is a partnership between the GSI and the National Parks and Wildlife Service (NPWS). The programme was developed to identify, document, protect and conserve geological heritage areas. Consultation was conducted with the GSI in order to identify all geological heritage sites within the study area.

The Galway County Development Plan (2022–2028) states that it is a Natural Heritage and Biodiversity policy (NHB 5) to support the protection and enhancement of biodiversity and ecological connectivity in non-designated sites, including geological and geo-morphological systems. Also, Geological Sites policy (PG 1) states the objective to protect and conserve geological and geo-morphological systems, county geological heritage sites and features from inappropriate development that would detract from their heritage value, and (PG 3) to encourage greater awareness of geological heritage sites of the county and promote, where appropriate, public access.

Consideration was given to Table 5.6 Network of Local Biodiversity Areas and Table 5.7 Other Areas/Features of Local Importance in the City from the Galway City Development Plan 2023–2029.

The Geological Heritage Areas (GHAs) encountered within the study area are presented in Table 9.14 below.

An updated audit of the GHAs in Galway City and Galway County was undertaken in 2020 and 2019 respectively by the GSI. New GHAs since the 2018 EIAR have been added and any changes to existing GHAs have been noted below.

Section 1: Chainage 0+000 to 8+500

There are no Geological Heritage Areas within Section 1.

Igneous Intrusions – GHA06, which was previously included in the 2018 EIAR has been removed from the assessment as it is no longer part of the GSI's audited GHA register.

Section 2: Chainage 8+500 to 9+400

Lough Corrib (GY093), a large lake situated between County Galway's western acidic uplands and the limestone lowlands which is of international conservation importance for its lakeshore karst assemblages, is located within the northern portion of Section 2 of the study area. This is a new GHA since the 2018 EIAR.

Section 3: Chainage 9+400 to 14+000

Two Mile Ditch Quarry (GY132), a very large working quarry which is a good representation of the Carboniferous Limestones of east Galway, is located at Two Mile Ditch in Section 3. Please note that the GHA referencing has been changed since the 2018 EIAR.

Section 4: Chainage 14+000 to 17+500

Doughiska N6 Road Cut (GC001), a one kilometre long road cut section into the Carboniferous Burren Formation limestone, is located along the existing N6 in Section 4. This is a new GHA since the 2018 EIAR.

Table 9.14 Geological Feature Importance of Heritage Areas within Study Area

ID	Site Name	Principle Characteristic	Feature Importance Ranking
GY093	Lough Corrib	A large lake situated between County Galway's western acidic uplands and the limestone lowlands which is of international conservation importance for its lakeshore karst assemblages	Very High
GY132	Two Mile Ditch Quarry	A very large working quarry which is a good representation of the Carboniferous Limestones of east Galway	Very High
GC001	Doughiska N6 Road Cut	Road section cut into Carboniferous Burren Formation limestone. Clay wayboard layers interbedded with limestone. Calcite-flourite veins occur in the road cut walls	Very High

9.3.11 Summary of Geological Feature Importance

A summary of the geological features for further consideration from a soils and geology perspective (with an importance of medium or higher found within the study area), are presented below in Table 9.15. Those features identified in Section 9.3 with an importance ranking of low are not considered further in this assessment.

Table 9.15 Summary of Geological Features

ID	Feature Name / ID	Description / Location	Feature Importance Ranking
Agricultural Soils			
AminDW	Deep well drained non-calcareous soil	Deep well drained non-calcareous soil. Widespread in Section 1	High
AminSW	Shallow well drained non-calcareous soil	Shallow well drained non-calcareous soil. Widespread in Section 1	High
BminDW	Deep well drained calcareous soil	Deep well drained calcareous soil. Widespread in Section 3 and 4	High
BminSW	Shallow well drained calcareous soil	Shallow well drained calcareous soil. Widespread in Section 3 and 4	High
Superficial Deposits			
Topsoil	Topsoil	Occasionally peaty in nature	High
Peat	Peat	Occasionally slightly sandy	High
Karst Features			
LP	Limestone pavement	Widespread across Section 3 and 4	Very High
PK	Palaeokarst Valley	Menlough, Ballindooley, Castlegar	Medium

ID	Feature Name / ID	Description / Location	Feature Importance Ranking
K7	Spring	Bushypark	Medium
K10	Enclosed Depression	Bushypark	Medium
K11	Enclosed Depression	Bushypark	Medium
K12	Enclosed Depression	Bushypark	Medium
K17	Spring	Menlough	Medium
K25	Spring	Menlough	Medium
K31	Turlough	Menlough	Medium
K44	Enclosed Depression	Coolagh	Medium
K45	Spring	Coolagh	Medium
K49	Enclosed Depression	Coolagh	Medium
K51	Enclosed Depression	Coolagh	Medium
K54	Enclosed Depression	Coolagh	Medium
K57	Enclosed Depression	Coolagh	Medium
K59	Enclosed Depression	Coolagh	Medium
K61	Enclosed Depression	Coolagh	Medium
K62	Enclosed Depression	Coolagh	Medium
K64	Enclosed Depression	Coolagh	Medium
K67	Enclosed Depression	Coolagh	Medium
K70	Enclosed Depression	Coolagh	Medium
K71	Enclosed Depression	Coolagh	Medium
K97	Enclosed Depression	Castlegar	Medium
K104	Enclosed Depression	Castlegar	Medium
K131	Enclosed Depression	Parkmore	Medium
K172	Enclosed Depression	Coolagh	Medium
K175	Enclosed Depression	Coolagh	Medium
K179	Enclosed Depression	Coolagh	Medium
K193	Enclosed Depression	Coolagh	Medium
K328	Enclosed Depression	Parkmore	Medium
Aggregate / Resource Potential			
Q01	Lackagh Quarry - Disused	Coolagh	Medium

ID	Feature Name / ID	Description / Location	Feature Importance Ranking
Q02	Roadstone Quarry	Two Mile Ditch	Very High
VHPCR	Crushed Rock	Very high crushed rock aggregate potential. Entire Study Area.	Very High
HPCR	Crushed Rock	High crushed rock aggregate potential. Na Foraí Maola, An Chloch Scoilte, Rahoon, Letteragh, Dangan.	High
MPCR	Crushed Rock	Moderate crushed rock aggregate potential. An Chloch Scoilte, Dangan.	Medium
ML23	Roadstone Dimension Stone	Two Mile Ditch	Very High
ML24	Roadstone Limestone (in general)	Two Mile Ditch	Very High
Geological Heritage			
GY093	Lough Corrib	A large lake situated between County Galway's western acidic uplands and the limestone lowlands which is of international conservation importance for its lakeshore karst assemblages	Very High
GY132	Two Mile Ditch Quarry	A very large working quarry which is a good representation of the Carboniferous Limestones of east Galway	Very High
GC001	Doughiska N6 Road Cut	Road section cut into Carboniferous Burren Formation limestone. Clay wayboard layers interbedded with limestone. Calcite-flourite veins occur in the road cut walls	Very High

9.3.12 Conceptual Site Model

The CSM for the proposed N6 GCRR is presented in Table 9.16. The information is also presented on Figure 9.8.001 to Figure 9.8.012 in plan and profile format with the profile illustrating the existing and proposed ground levels, earthwork sections, local ground investigation logs and geophysical data along the centreline of the proposed N6 GCRR. See Appendix A.9.1a, A.9.1b and A.9.1c for all ground investigation data.

The configuration of the proposed development at Galway Racecourse, which is included as part of the Project has changed since the 2018 EIAR, as detailed in Chapter 5, Project Description, of this updated EIAR, and as such additional ground investigations were undertaken to inform its design. The associated ground investigation data provided in Appendix A.9.1d.

Table 9.16 Earthwork Areas of Cut and Fill

Earthwork Reference	Dominant Earthworks Type	Environment Section	Length (m)	Max Fill (m)	Average Fill (m)	Max Cut (m)	Average Cut (m)	Generalised Overburden and Bedrock Description	Average Depth to Rock (mBGL)
EW01	CUT	Section 1 Na Foraí Maola	460	1.63	0.14	-3.13	-1.06	Peat over granite derived glacial gravels with areas of made ground over granite bedrock	0.50
EW02	FILL	Section 1 Na Foraí Maola to An Chloch Scoilte	2270	5.38	1.65	-3.34	-0.22	Peat over granite derived glacial gravels and some deposits of cohesive glacial till with areas of made ground over granite bedrock	0.60
EW03	FILL	Section 1 Ballard West	280	5.66	2.47	0	0	Peat over granite derived glacial gravels over granite bedrock	0.50
EW04	CUT	Section 1 Ballard	800	3.61	0.06	-6.97	-3.86	Peat over granite derived glacial gravels over granite bedrock	0.50
EW05	FILL	Section 1 Aille	530	6.47	2.41	-2.20	-0.17	Peat over granite derived glacial gravels with isolated instances of made ground and possibly alluvial deposits near stream. Area overlying granite bedrock	0.80
EW06	FILL	Section 1 Cappagh	820	4.31	1.53	-2.45	-0.27	Peat over granite derived glacial gravels over granite bedrock	1.40
EW07	CUT	Section 1 Ballyburke	350	2.66	0.28	-8.91	-2.18	Granite derived glacial gravels over granite bedrock	1.00
EW08	FILL	Section 1 Ballymoneen to Letteragh	1550	11.78	3.40	-6.79	-0.25	Peat over granite derived glacial gravels with areas of made ground over granite bedrock	1.30

Earthwork Reference	Dominant Earthworks Type	Environment Section	Length (m)	Max Fill (m)	Average Fill (m)	Max Cut (m)	Average Cut (m)	Generalised Overburden and Bedrock Description	Average Depth to Rock (mBGL)
EW09	FILL	Section 1 Knocknafroska / Knocknabrona	300	10.12	7.54	0.00	0.00	Peat over granite derived glacial gravels over granite bedrock	2.70
EW10	FILL	Section 1 Knocknafroska / Knocknabrona	300	6.98	2.73	-4.28	-0.84	Peat over granite derived glacial gravels over granite bedrock	4.50
EW11	CUT	Section 1 Knocknafroska / Knocknabrona	400	0.00	0.00	-14.89	-8.49	Peat over granite derived glacial gravels over granite bedrock	2.60
EW12	CUT	Section 1 Upper Dangan	150	1.62	0.17	-6.89	-3.05	Granite derived glacial gravels over granite bedrock	2.20
EW13	FILL	Section 1 and 2 Dangan	550	9.70	5.03	-1.35	-0.04	Granite derived glacial gravels with areas of made ground over granite bedrock	3.00
EW14	FILL	Section 2 Dangan to River Corrib	450	16.60	10.65	0.00	0.00	Deposits of limestone derived cohesive glacial till over glacial gravels with areas of made ground over limestone bedrock	5.50
EW15	RIVER CORRIB STRUCTURE	Section 2 River Corrib	200	No Cut / Fill due to existence of structure				Deposits of limestone derived cohesive glacial till over glacial gravels with some isolated alluvial deposits present along the River Corrib	N/A[20]

[20] Depth to rockhead is unavailable over the extent of the River Corrib as no intrusive investigation was conducted.

Earthwork Reference	Dominant Earthworks Type	Environment Section	Length (m)	Max Fill (m)	Average Fill (m)	Max Cut (m)	Average Cut (m)	Generalised Overburden and Bedrock Description	Average Depth to Rock (mBGL)
EW16	FILL	Section 3 Menlough	600	19.37	10.01	0.00	0.00	Peat over limestone derived cohesive glacial till with isolated instances of made ground and alluvial deposits. Identified location of palaeokarst valleys Area overlying limestone bedrock	2.30
EW17	MENLOUGH VIADUCT	Section 3 Menlough	330	No Cut / Fill due to existence of structure				Deposits of limestone derived cohesive glacial till over glacial gravels with some alluvial deposits over limestone bedrock	0.00[21]
EW18	FILL	Section 3 Menlough	380	10.01	3.73	-4.09	-0.12	Deposits of limestone derived cohesive glacial till over glacial gravels mixed with Limestone pavement Identified location of palaeokarst valleys Area overlying limestone bedrock	1.80
EW19	CUT	Section 3 Coolagh	330	4.76	0.34	-15.46	-6.45	Deposits of limestone derived cohesive glacial till over glacial gravels Identified location of palaeokarst valleys Area overlying limestone bedrock	55.00[22]

[21] Some overburden including topsoil exists along the extents of the structure. However, the majority of the area consists of outcropping Limestone pavement. Therefore, the average depth has been provided as 0m to reflect the typically shallow rock.

[22] The change in rockhead, based on intrusive and geophysical ground investigation, is quite significant in this area, with the maximum depth recorded of 109m BGL. However, this maximum depth is quite isolated with the rockhead typically quite shallow.

Earthwork Reference	Dominant Earthworks Type	Environment Section	Length (m)	Max Fill (m)	Average Fill (m)	Max Cut (m)	Average Cut (m)	Generalised Overburden and Bedrock Description	Average Depth to Rock (mBGL)
EW20	LACKAGH TUNNEL	Section 3 Coolagh	280	No Cut / Fill due to existence of structure				Shallow deposits of limestone cohesive glacial till mixed with Limestone pavement Identified location of palaeokast valleys Area overlying limestone bedrock	0.00[23]
EW21	FILL	Section 3 Coolagh	300	10.67	4.98	-7.49	-0.55	Deposits of limestone derived cohesive glacial till with areas of made ground over limestone bedrock	0.00[24]
EW22	CUT	Section 3 Ballindooley	200	11.82	4.06	-24.64	-8.60	Deposits of limestone derived cohesive glacial till over glacial gravels over limestone bedrock	3.50
EW23	FILL	Section 3 Ballindooley	270	9.47	3.72	-7.97	-0.75	Limestone derived cohesive glacial till / glacial gravels with areas of made ground Identified location of palaeokarst valleys Area overlying limestone bedrock	10.50
EW24	FILL	Section 3 Ballindooley	310	16.28	10.94	0.00	0.00	Peat over limestone derived cohesive glacial till / glacial gravels Identified location of palaeokarst valleys Area overlying limestone bedrock	7.00

[23] While topsoil exists in some of the extent of this earthwork area, the majority consists of outcropping Limestone pavement. This gave rise to the construction of a tunnel through the rock. Therefore, the average depth to rockhead has been indicated as 0m in order to reflect this environment.

[24] This earthworks area extends along the floor of the disused Lackagh Quarry. Therefore, the depth to rockhead has been provided as zero.

Earthwork Reference	Dominant Earthworks Type	Environment Section	Length (m)	Max Fill (m)	Average Fill (m)	Max Cut (m)	Average Cut (m)	Generalised Overburden and Bedrock Description	Average Depth to Rock (mBGL)
EW25	CUT	Section 3 Castlegar	420	9.49	0.70	-7.61	-4.03	Deposits of limestone derived cohesive glacial till. Identified location of palaeokarst valleys Area overlying limestone bedrock	2.80
EW26	FILL	Section 3 Castlegar	130	8.17	2.79	-4.35	-0.70	Deposits of limestone derived cohesive glacial till with areas of made ground Identified location of palaeokarst valleys Area overlying limestone bedrock	14.30
EW27	CUT	Section 3 Castlegar	600	7.85	0.26	-12.65	-7.58	Deposits of limestone derived cohesive glacial till with areas of made ground Identified location of palaeokarst valleys Area overlying limestone bedrock	5.90
EW28	FILL	Section 3 and 4 N83 Tuam Road	500	12.65	7.52	-3.70	-0.12	Deposits of limestone derived cohesive glacial till with areas of made ground Identified location of palaeokarst valleys Area overlying limestone bedrock	17.80
EW29	CUT	Ballybrit	300	5.66	0.32	-12.84	-8.85	Deposits of limestone derived cohesive glacial till over limestone bedrock	2.70
EW30	CUT	Ballybrit	500	0.00	0.00	-11.20	-8.85	Deposits of limestone derived cohesive glacial till with areas of made ground over limestone bedrock	7.50

Earthwork Reference	Dominant Earthworks Type	Environment Section	Length (m)	Max Fill (m)	Average Fill (m)	Max Cut (m)	Average Cut (m)	Generalised Overburden and Bedrock Description	Average Depth to Rock (mBGL)
EW31	GALWAY RACECOURSE TUNNEL	Galway Racecourse	240	0.00	0.00	-9.52	-8.63	Deposits of limestone derived cohesive glacial till with areas of made ground over limestone bedrock	6.30
EW32	CUT	Ballybrit	310	1.73	0.11	-9.52	-4.64	Deposits of limestone derived cohesive glacial till over limestone bedrock	4.60
EW33	FILL	Briarhill	700	8.43	5.08	-0.98	-0.03	Deposits of limestone derived cohesive glacial till with areas of made ground over limestone bedrock	2.40
EW34	CUT	Briarhill	700	2.82	0.22	-7.44	-2.46	Deposits of limestone derived cohesive glacial till over limestone bedrock	1.90
EW35	CUT	Ardaun, Coolagh	640	1.34	0.11	-9.48	-2.35	Deposits of limestone derived cohesive glacial till with areas of made ground over limestone bedrock	2.00
N59 LINK	CUT/FILL	Letteragh	2170	8.77	0.91	-12.99	-2.25	Peat over granite derived glacial gravels with areas of made ground over limestone bedrock	2.10

9.4 Characteristics of the Project

A detailed description of the Project and construction activities are provided in Chapter 5, Project Description and Chapter 7, Construction Activities of this updated EIAR.

This section of the report outlines the key design features and the construction, operation characteristics and activities of the Project of relevance to soils and geology. The potential effects related to such construction and operational activities are provided in Section 9.5. The Project comprises five phases.

9.4.1 Phase 1

Phase 1 includes the construction of a temporary stableyard including horsebox parking, machinery shed, maintenance shed, ESB substation, two wells, new pre-parade ring and pavilion on Galway Racecourse lands. (Approval for which was granted by Galway City Council in December 2024 Planning Ref. No.:24/60279).

9.4.1.1 Phase 1 Construction

The proposed temporary stables are to be located on an existing grassed area in the centre of the racetrack i.e. the infield. The construction will include the construction of a retaining wall and foundations, reprofiling of existing slopes, and the excavation of topsoil, subsoil and rock. Excess material or material unsuitable for reuse will be removed from site. Temporary dewatering of the excavation may be required.

9.4.1.2 Phase 1 Operation

For Phase 1, general maintenance will be required of landscaping slopes and drainage channels.

9.4.2 Phase 2

Phase 2 comprises the construction and operation of the proposed N6 GCRR.

9.4.2.1 Phase 2 Construction

As discussed in Chapter 7, Construction Activities, it is envisaged that an east to west build will be adopted for the construction of the proposed N6 GCRR and it may be completed in two concurrent stages or a single overall contract. The two stages are:

- Stage A – N6 Coolagh to N59 Letteragh Junction – 9.9km (Including the N59 Link Road North and South)
- Stage B – N59 Letteragh Junction – R336 West of Bearna 7.5km

The construction of the proposed N6 GCRR will involve various key design features of relevance to avoid or reduce the effect to soils and geology features, in particular Limestone pavement, which are outlined in the following sub-sections:

- Lackagh Tunnel and the Western Approach
- Menlough Viaduct and Culvert
- Reinforced / retained slopes

The construction activities involved in the proposed N6 GCRR relevant to soils and geology are listed below and further discussed in the following sub-sections. The construction activities relevant to soils and geology include:

- Embankment construction
- Excavation of cuts
- Soil and rock slopes
- Reuse and processing of site material
- Importation, exportation and disposal of materials

- Tunnelling
- Construction of foundations for structures
- Contaminated ground
- Soft Soil
- Karst features
- Dewatering

A Construction Environmental Management Plan (CEMP) is provided in Appendix A.7.5.

Key Design Feature – Lackagh Tunnel and the Western Approach

Lackagh Tunnel comprises of three sections between Ch. 10+775 to Ch. 11+420 of the proposed N6 GCRR namely Section 1 Lackagh Quarry Face, Section 2 Lackagh Tunnel and Section 3 Western Approach, refer to Plate 9.1.

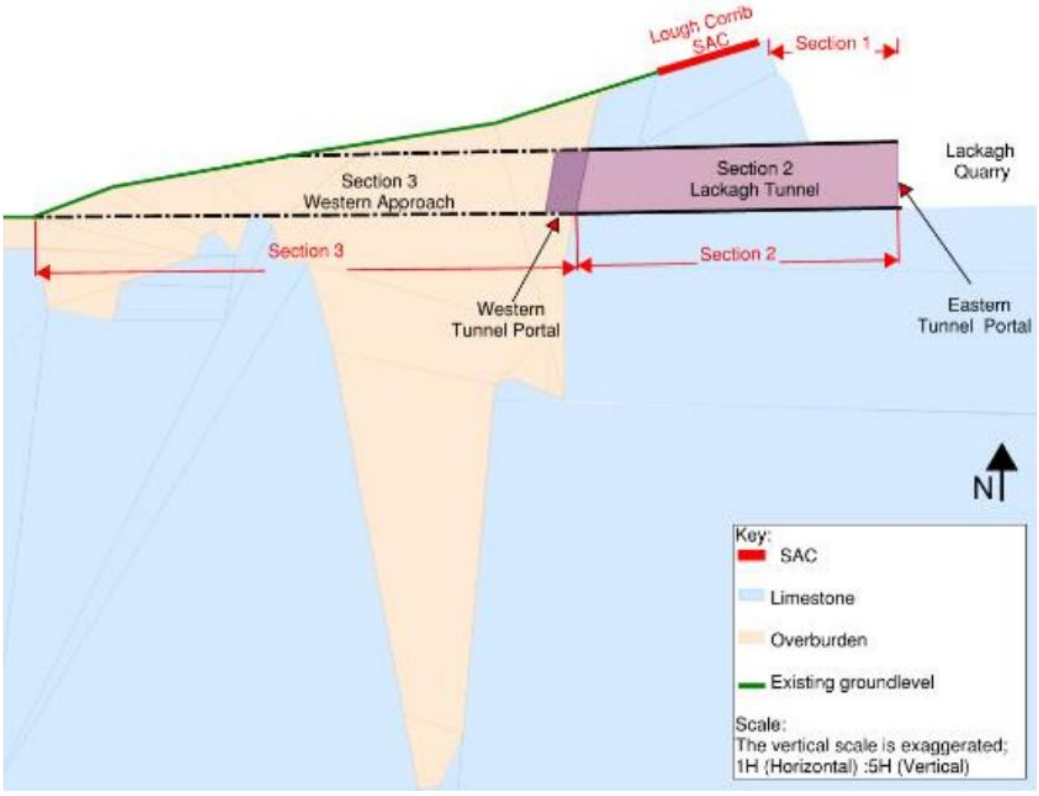

Plate 9.1 Schematic cross section of Sections 1-3 at Lackagh Tunnel

Lough Corrib SAC which includes Limestone pavement is located immediately west of Section 1. Section 2, Lackagh Tunnel (ST11/01) is a drill and blast mined twin bored tunnel approximately 270 m long, from Ch. 11+150 to Ch. 11+420. Section 2 tunnels beneath Lough Corrib SAC, including Limestone pavement, between approximately Ch. 11+240 and Ch. 11+350. Section 3 lies partially within the Lough Corrib SAC and traverses between areas of Limestone pavement which is located north and south of the proposed N6 GCRR.

Given the presence of Limestone pavement, the potential geological effects of Lackagh Tunnel and its immediate approaches on Limestone pavement include:

- Rock mass instability and slope instability in Sections 1 and 3 resulting in potential encroachment onto Limestone pavement within Lough Corrib SAC, due to its proximity to the proposed N6 GCRR
- Blasting activities required for the construction of Sections 2 and 3 resulting in potential effect on the structural integrity of the Limestone pavement

- Collapse of the tunnel and ground settlement from the tunnel bore in Section 2 resulting in potential effect on the Limestone pavement within Lough Corrib SAC

To avoid these geological effects the following measures are included in the design of Lackagh Tunnel and its approaches (Sections 1, 2 and 3) along with a conservative design approach:

- In Section 1, stabilisation of Lackagh Quarry face will be carried out around the eastern tunnel portal in order to prevent rock mass instability and slope instability. The conservative design approach requires that stabilisation of the Lackagh Quarry face (western face of the quarry) around the eastern tunnel portal will be completed in advance of tunnelling works for Section 2 (Lackagh Tunnel). These stabilisation works include a composite support system of rock bolts, rock dowels, steel mesh and sprayed concrete
- Section 2 is a mined twin bore tunnel in rock constructed using a drill and blast methodology. This method of construction is commonly used for tunnels of this length through hard rock. The conservative design approach of Section 2 requires the following tunnel design elements to ensure that collapse of the tunnel and ground settlement does not arise:
  - At least 8.0m of clear bedrock is required above the crown of the tunnel bore to the top of the Limestone pavement ground surface in order to maintain the bore stability. This design requirement is achieved in the Lackagh Tunnel design with the proposed alignment providing bedrock cover ranging from ~10m to 14.5m above the crown of the tunnel to the Limestone pavement ground surface
  - A 7m wide separation pillar is required between the two bores in order to maintain the twin bore stability. This design requirement has also been achieved in the Lackagh Tunnel design with the proposed alignment allowing for a rock pillar of 7.3m between the two bores
- In Sections 2 and 3, to prevent rock mass instability, rock mapping assessments will be completed by a geotechnical expert following each tunnel blast in Section 2, rock blast in Section 3 and during the excavation of Section 3. The outcome of these assessments will govern which rock stability design solution and tunnel design support measure to be employed.
- In Section 3, retaining systems will be implemented at pinch points along the Western Approach to support the cut face between existing ground level and the proposed road level preventing slope instability and encroachment onto Limestone pavement. The conservative design approach includes the following retaining systems:
  - Rock bolts, rock dowels, steel mesh, and sprayed concrete in areas of rock only
  - Piled retaining walls, supported with ground anchors in areas of overburden only and in areas with a combination of overburden and rock that will be monitored during construction and compared with the design
- In all sections blast design limitations will apply, including a maximum construction target vibration limit of 20mm/sec which is less than the maximum vibration limit (of 25mm/sec) and a monitored trial blast undertaken in the same bedrock formation by the blasting contractor in a controlled location that will pose no risk to sensitive receptors. The trial blast will not exceed the vibration limitations of the local sensitive receptors. The information obtained from the trial blast will calibrate and refine the blast design to a site-specific design.

The tunnel construction activity is outlined further below under the sub-heading, *Construction Activity – Tunnelling*. Potential construction and operational effects are outlined in Section 9.5.3.4 and Section 9.5.4 with mitigation measures presented in Section 9.6. Refer to Chapter 8, Biodiversity for the ecological assessment and Chapter 10, Hydrogeology for the hydrogeology assessment.

Further details on Lackagh Tunnel can be found in Appendix A.7.3.

Key Design Feature – Menlough Viaduct and Culvert

The design includes a viaduct structure, Menlough Viaduct (ST10/01) from Ch. 10+100 to Ch. 10+420 of the proposed N6 GCRR. The total length of the viaduct is governed by the area of Limestone pavement and a Turlough (karst feature ID code K31), which are both located outside of the Lough Corrib SAC. The viaduct has a total length of approximately 320m, and the proposed N6 GCRR is on embankment on both

approaches to it. The viaduct contains eight spans of a similar 40 m span length. The span lengths have been adjusted to minimise the substructure and foundation footprint on the Limestone pavement and avoid the extent of the Turlough.

There is a culvert in Menlough that is also included in the design from approximately Ch. 10+025 to Ch. 10+050 of the proposed N6 GCRR. This structure spans Limestone pavement surface (outside of the Lough Corrib SAC) avoiding the removal of the feature at this location.

Key Design Feature – Reinforced Slopes

The retaining wall in the Menlough area (between Ch. 9+850 and Ch. 10+050 of the proposed N6 GCRR) is located adjacent to the Lough Corrib SAC. This structure will be constructed to retain the embankment of the proposed N6 GCRR from encroachment on the Annex I habitat of the Lough Corrib SAC including Limestone pavement. The construction of the retaining wall will be undertaken within the Assessment Boundary and outside the areas of Annex I habitat.

Construction Activity – Embankment Construction

As outlined in the conceptual site model in Figures 9.8.001 to 9.8.012 and Table 9.16, certain areas along the proposed N6 GCRR will require the placement of fill material to achieve the proposed alignment level. These embankment sections will be formed using imported fill or site won[25] material. The imported fill will be transported on site access roads using trucks and on routes outlined in Chapter 7, Construction Activities of this updated EIAR.

For embankments less than 3m in height, topsoil will require removal from beneath the embankment footprint. For areas identified as medium and high karst risk, topsoil will require removal in order to proof roll the underlying material. Topsoil will be excavated, transported and stored at a designated stockpile on site and reused for landscaping across the proposed N6 GCRR.

Material evaluated to be soft beneath the footprint of the embankment will be removed in order to provide a more suitable founding stratum. Bituminous or hard standing material will also be removed.

The potential effects from this construction activity are discussed in Section 9.5.3.1.

Construction Activity – Excavation of cuts

Where the proposed road level is below the existing ground level, existing material will require excavation and removal. As outlined in Table 9.16, these cut areas along the proposed N6 GCRR will require the removal of overburden (fertile soil, soft soils, made ground, superficial deposits) and bedrock (granite and limestone).

Based on the factual ground investigation information available, for cuts in rock, hard ripping using a hydraulic hammer or blasting of the bedrock will be required. See Appendix A.9.1 for ground investigation data. All other excavation, and removal of broken or blast rock, will be completed using an excavator and transported to other areas of the site or to a designated disposal site.

Significant rock cuttings (e.g. greater than 10m depth) are located in areas such as Knocknafroska / Knocknabrona at the N59 Letteragh Junction (EW11), Ballindooley at the N84 Headford Road Junction (EW22), Castlegar adjacent to the Castlegar Nursing Home (EW27), Ballybrit adjacent to the N83 Tuam Road Junction (EW29) and along the N59 Link Road in Letteragh. As outlined in 'Response to Submission on behalf of Prof. Michael and Dr. Annette Kerin' at the Oral Hearing in 2020, significant rock cuttings, for example in areas such as Letteragh (EW11), are not equivalent to a commercial quarry. Standard highway rock cuttings construction practices are to be used. Rock cuttings for the proposed N6 GCRR are of similar depth and scale as can be observed on existing road schemes, such as M17M18 Gort to Tuam PPP Scheme and the N25 New Ross Bypass which also involved execution of blasting and rock extraction to create cuttings on either side of the carriageway. However, as outlined in Chapter 18, Noise and Vibration, of this updated EIAR, where rock blasting is progressed no more than one instantaneous blast per day in any one site will be undertaken.

[25] Material which has been recovered as part of the construction excavation activities. If purposed for use in embankment construction, the material must comply with material properties and constituents outlined in the TII Series 600 Earthworks Specification (TII, 2024).

Topsoil will be excavated, transported, stored at a designated stockpile on site and reused for landscaping across the proposed N6 GCRR. See details in relation to waste in Chapter 20, Resource and Waste Management, of this updated EIAR.

As outlined in the Soils and Geology Statement of Evidence submitted at the Oral Hearing in 2020[26], an assessment has been completed to determine feasibility of blasting adjacent to sensitive receptors (including structures and dwellings) and the subsequent exclusion zones required based on blasting activities in the bedrock underlying the Project. Full details of this assessment were provided in the 2019 RFI Response and remain unchanged and are presented in Appendix A.9.2.

As outlined in the Soils and Geology Statement of Evidence submitted at the Oral Hearing in 2020, where blasting is deemed as the preferable option for excavation of rock in cuttings, a site-specific blast assessment will be undertaken to confirm that blasting is viable. A site-specific blast assessment will include a desk-based assessment which will involve defining the area of proposed blasting, identifying the local receptors (e.g. properties, dwellings), defining the ground conditions and their engineering properties and defining the rock excavation sequence. Where the outputs from the blast assessment determine that blasting is feasible, the blast design assessment will be refined. As part of the blast design assessment monitored trial blasts in the same bedrock formation as the proposed blast locations at locations of proposed blasting will be conducted. These trial blasts will further calibrate the blast design to site-specific designs and will refine and validate the blast design properties. Trial blasts will not exceed the limitations of the local sensitive receptors.

As outlined in the Soils and Geology Statement of Evidence submitted at the Oral Hearing in 2020, one advantage of blasting is that the time period over which impacts from blasting are experienced are significantly shorter when compared to other extraction methods. Following a blast, the broken rock will be excavated and transported from the area.

Where the blast assessment determines that blasting is not feasible, a blast exclusion zone will be implemented and alternative extraction methods, as outlined in Appendix A.9.2, will be implemented where appropriate.

Excavations are typically undertaken in a 'dry' environment, therefore cuts that intercept the groundwater table may require temporary dewatering, if permitted. These locations are outlined and assessed in Chapter 10, Hydrogeology.

The potential effects related to this activity are further discussed in Section 9.5.3.1.

Construction Activity – Reuse and processing of site material

Site won material, obtained from cuttings, will where possible be reused as fill for the construction of embankments and other elements along the proposed N6 GCRR. Crushing and processing of suitable material obtained on site during the earthworks for re-use will be employed insofar as is possible.

Site won material generated during construction but surplus to the fill requirements of the proposed N6 GCRR will be used for beneficial reuse within Material Deposition Areas (MDAs). Full details of the MDAs and the associated assessment is provided in Appendix A.9.3 of this updated EIAR.

As outlined in Appendix A.9.3, a total of 32 site areas have been identified as MDAs along the route of the proposed N6 GCRR and their locations are shown on Figures 7.301 and 7.302 of this updated EIAR. Material that will be generated during excavation was firstly quantified and classified and is summarised in Chapter 7, Construction Activities of this updated EIAR. Then this material was assessed for its compliance for re-use as part of construction. Following this, the volume of material surplus to the fill requirements of the proposed N6 GCRR was determined. As referenced in Clause 4.8.14 of ABP's Inspector's Report dated 22 June 2021, the analysis determined that approximately 475,800m^3 of bulked surplus material will be generated, comprising of 98,800m^3 of peat and 377,000m^3 of non-compliant (non-hazardous) material. The total allowable capacity of the MDAs is 597,200m^3.

[26] https://www.n6galwaycityringroad.ie/sites/default/files/media/GCRR_4.03_34.3.12%20BoE%20Soils%20and%20Geology_I1.pdf

As outlined in Appendix A.9.3 and which was previously outlined in Appendix A.1.11 of the 2019 RFI Response, MDAs are required to satisfy the necessary engineering, environmental and safety requirements for the proposed N6 GCRR in the following locations:

- Construction within the grade separated junctions, where the ground level of the junction is much higher than the surrounding landscape
- Landscaping and attenuation pond construction
- Slope stabilisation at Lackagh Quarry in areas where the exposed quarry has significant blast damage
- To facilitate the creation of ecological habitat creation

While supporting the requirements highlighted above, MDAs also allow for the placement of surplus (to the fill requirement of the proposed N6 GCRR) earthworks material generated during construction. As outlined in the 'Responses to Queries raised in Module 2 of the N6 Galway City Ring Road in respect of Lackagh Quarry Material Deposition Areas' at the Oral Hearing in 2020[27], it is recommended to deposit excess material arising as close as possible to the point of extraction as doing so results in most sustainable deposition of such excess materials. The reuse of this surplus material will ensure this natural resource will remain in productive use for longer and reduce / avoid the need for removal of the material as a waste. This approach is in line with circular economy principles outlined in the National Waste Policy 2020-2025, National Waste Regulations, the European Union Waste Directives and is directly aligned with the objectives and actions outlined in Section 20 'The Circular Economy and Other Emissions' of the Climate Action Plan 2024.

MDAs are located east and west of the River Corrib within the Assessment Boundary. The MDAs at Lackagh Quarry are designed, combining material placement with direct and indirect rock slope stability solutions, to provide stability to the existing blast damaged rock face and thereby prevent encroachment on the Lough Corrib SAC, including Annex I habitat, and to facilitate the creation of compensatory ecological habitat.

As outlined in the Lackagh Quarry: Material Deposition Assessment Report submitted in the 2019 RFI Response, a remodelling exercise was completed of the MDAs in Lackagh Quarry which resulted in the removal of DA23, the addition of DA25 and the modification of DA24, DA27 and DA28. Annex A of Appendix A.9.3 of this updated EIAR contains the detailed breakdown and arrangement of MDAs in Lackagh Quarry.

In the case of peat, the majority of peat generated as part of the proposed N6 GCRR is west of the River Corrib. The design process aimed to maximise placement of peat within MDAs west of the River Corrib. However, not all MDAs west of the River Corrib could facilitate the placement of peat with consideration of the criteria such as engineering, environmental and site-specific requirements (please note that further detail is provided on these requirements in Appendix A.9.3 of this updated EIAR). Therefore, the next nearest MDAs east of the River Corrib were reviewed to optimise placement of peat (namely, DA24, DA25 and DA28 in Lackagh Quarry). As outlined in the 'Responses to Queries raised in Module 2 of the N6 Galway City Ring Road in respect of Lackagh Quarry Material Deposition Areas' at the Oral Hearing in 2020, DA 24 and DA 25 are therefore critical MDAs in particular for the sustainable deposition of peat extracted as a result of the construction of the proposed N6 GCRR.

As outlined in the 'Responses to Queries raised in Module 1 of the N6 Galway City Ring Road' at the Oral Hearing in 2020[28] and in accordance with Environmental Commitment 9.22, where an area of habitat planting has a requirement for a free draining layer beneath the surface and it corresponds with a proposed MDA where peat may be placed, a free draining layer will be placed by the Contractor between the peat placement and the habitat to be created layer. The free drainage material will be contained within a filter separator layer (e.g. geotextile), above and below to prevent the migration of fines sediment therefore ensuring the functionality of the layer. For MDAs within Lackagh Quarry, where calcareous grassland is required, a contained drainage layer with a minimum depth of 350mm will be provided to ensure free

[27] https://www.n6galwaycityringroad.ie/sites/default/files/media/GCRR_4-03.34.13.004_Lackagh%20Quarry%20Response_I1.pdf

[28] https://www.n6galwaycityringroad.ie/sites/default/files/media/GCRR-4.03.34.17%20Response%20to%20Queries_I2.pdf

drainage of surface water from the calcareous grassland. This layer will be provided between the calcareous grassland and the MDA.

As outlined in the 'Responses to Queries raised in Module 1 of the N6 Galway City Ring Road' at the Oral Hearing in 2020, where peat is to be placed in MDAs requiring a drainage layer for ecological habitat compensation, mixed peat shall be used in the upper areas of the MDA, with the final surface shaped to drain towards and shed surface water runoff to the perimeter of the swale and shallow surface drains which will be installed to accommodate surface drainage, as per the requirements of the CEMP in Appendix A.7.5 of this updated EIAR.

As outlined in the 'Responses to Queries raised in Module 1 of the N6 Galway City Ring Road' at the Oral Hearing in 2020 and in accordance with Environmental Commitment 9.25, the composition of the mixed peat in material deposition areas with calcareous grassland will ensure that the magnitude of immediate, primary, and secondary consolidation will not exceed 250mm.

As outlined in 'Responses to Queries raised in Module 2 of the N6 Galway City Ring Road in respect of Lackagh Quarry Material Deposition Areas' at the Oral Hearing in 2020, and based on the summary volumes presented in Appendix A.9.3 of this updated EIAR, there is approximately 26% additional/spare capacity within the MDAs. However, there is only approximately 2% spare capacity for peat. The overall spare capacity is likely to reduce further when considering the variable ground conditions across the proposed N6 GCRR, bulking arising from the direct reuse of over 2.6 million cubic meters of material across the full extent of the proposed N6 GCRR (see Chapter 7, Construction Activities of this updated EIAR for further details), and general construction related factors (for example variable weather conditions impacting material reusability, temporary excavations).

The potential effects related to this activity are discussed in Section 9.5.3.2.

Construction Activity – Importation, exportation, and disposal of materials

Earthworks quantities along the proposed N6 GCRR are subdivided into a number of earthworks sections based upon natural physical boundaries such as rivers and existing roads. The estimated quantities of imported and exported fill within these areas are outlined in Chapter 7, Construction Activities.

The construction of Stage A of the proposed N6 GCRR will result in a surplus of material however in the unlikely event that the construction of Stage B of the proposed N6 GCRR takes place first this will result in a deficit of complaint material.

The deficit of aggregate will require the importation of suitable material. Material shall be sourced from quarries which are listed on the register maintained by the local authority. Designated haulage routes and access routes have been identified and are further discussed in Chapter 7, Construction Activities.

In line with Section 20 'The Circular Economy and Other Emissions' of the Climate Action Plan 2024 and principles of sustainable development, the volume of material brought into the construction site will be kept to a minimum. This will be achieved by re-using as much of the materials generated during construction as possible subject to further testing to determine if materials meet the specific engineering standards for their proposed end-use.

Where the excavation contains a combination of compliant and non-compliant material for reuse, the excavation will be conducted so that compliant material is excavated separately without contamination by the non-compliant material.

Any hazardous material, as evaluated from appropriate environmental testing, will result in the necessity for off-site disposal to designated disposal sites in accordance with all relevant legislation. This is further discussed in Chapter 7, Construction Activities.

The potential effects related to this activity are further discussed in Section 9.5.3.3.

Construction Activity – Tunnelling

Two tunnels are proposed along the proposed N6 GCRR as follows:

- Mined Tunnel at Menlough (Lackagh Tunnel – Approximately 270m tunnel through limestone bedrock and overburden)

- Cut and Cover at Ballybrit (Galway Racecourse Tunnel – Approximately 230m tunnel in limestone bedrock)

Mined Tunnel

The proposed mined tunnel, Lackagh Tunnel, comprises two bores for the eastbound and westbound carriageways of the proposed N6 GCRR. Each bore comprises an approximately 15m wide span tunnel with watertight concrete arch lining with the internal elements (road, walkways, lighting, ventilation etc.) placed within this shell. The proposed alignment for Lackagh Tunnel provides bedrock cover ranging from approximately 10m to 14.5m above the tunnel crown below the Limestone pavement surface.

The tunnel excavation, in Menlough, will be a mined tunnel (drill and blast), which is commonly used for tunnels through hard rock. The tunnel commences in Lackagh Quarry at the tunnel portals using drill and blast methods. Excavation progresses for the tunnel in a cyclic manner with drilling, blasting, rock face mapping, mucking out, installation of support measures and then preparing for the next advance of the tunnel.

Further details on Lackagh Tunnel can be found in Appendix A.7.3.

Cut and Cover Tunnel

The cut and cover tunnel, Galway Racecourse Tunnel, will consist of 230m twin box construction, with a maximum depth of approximately 11m BGL, with all elements constructed using cast in-situ reinforced concrete or precast concrete box units, which are assembled longitudinally and transversely from discrete precast elements.

The tunnel excavation will be undertaken from ground level. The overburden will be excavated, followed by blasting of the bedrock in order to break it prior to excavation. Rock excavation will progress in a cyclic manner with drilling blast holes, blasting, rock face mapping, and mucking out.

The potential effects related to tunnelling are further discussed in Section 9.5.3.4.

Construction Activity – Construction of Structures

The proposed N6 GCRR requires the construction of a number of structures. The proposed structures are discussed in Chapter 5, Project Description of this updated EIAR.

In general, foundations are likely to require shallow solutions which require a limited, shallow excavation at the footing locations. However, depending on the structure and the ground conditions encountered, some areas will require a more robust solution, which may include:

- Pile foundation in areas of poor, soft ground or in areas of high karst risk
- Earth retaining structures in areas where soil must be restrained at unnatural slopes
- Excavate and replace at footing locations due to karst risk, to expose rock surface in areas underlain by limestone

From existing ground information, the structures identified in Table 9.17 will likely require deep or a specialised foundation solution due to ground conditions or karst risk.

The potential effects related to this activity are further discussed in Section 9.5.3.5.

Table 9.17 Structures requiring specialised foundation solutions

Reference	Assessment Section	Name / Function	Approx. Chainage
S08/04	2	River Corrib Bridge Structure	9+300
C09/01	3	Culvert	9+520
C09/02	3	Culvert	9+560
C09/03	3	Culvert	9+580

Reference	Assessment Section	Name / Function	Approx. Chainage
C09/04	3	Culvert	9+590
C09/05	3	Culvert	9+600
S09/03	3	Accommodation Underpass S09/03	9+910
C10/01	3	Local access Underpass	10+060
S10/01	3	Menlough Viaduct	10+110
S12/01	3	N84 Headford Road Underbridge	12+150
C12/02	3	Culvert	12+350
C12/03	3	Culvert	12+390
C12/04	3	Culvert	12+450
C13/01	3	Mammal Underpass	12+980
C13/02	3	Mammal Underpass	13+700
S13/02	3 / 4	N83 Tuam Road Underbridge (WB merge)	13+925
S13/03	3 / 4	N83 Tuam Road Underbridge (Mainline and EB diverge)	13+975
S15/02	4	Briarhill Business Park Underbridge	15+725
S15/03	4	Monivea Road R339 Underbridge	15+880

Construction Activity – Contaminated ground

Ground investigation information along with the current and historical site activities indicated the potential locations of contamination. These included areas adjacent to existing road networks, infrastructure networks, man-made drainage systems and general built construction.

No areas of contamination were identified during the investigations. See conceptual site model in Figure 9.8.001 to Figure 9.8.012. While areas of contamination are unlikely, out of an abundance of caution, all potential locations will be further investigated during construction and the makeup of the ground evaluated. Any shallow made ground deposits will be excavated and replaced.

Hazardous material removed as part of the excavation may require specialist disposal to designated disposal sites. This is further discussed in Chapter 7, Construction Activities of this updated EIAR.

The potential effects related to this activity are further discussed in Section 9.5.3.6.

Construction Activity – Soft soil

Soft soil, which includes both peat and soft organic clay / silt, exist across the study area. Typically, peat is present in the western section, underlain by granite, while the limestone area has soft organic and alluvial material. Soft ground areas have been identified and are indicated in Figure 9.7.001 to Figure 9.7.002 and Figure 9.7.101 to Figure 9.7.115.

Areas of shallow deposits will likely be excavated and removed. Deeper soft soil deposits may require excavation or in-situ ground improvement.

The potential effects related to this activity are further discussed in Section 9.5.3.7.

Construction Activity – Karst Features

In Sections 2, 3, and 4, from the N59 Moycullen Road at Dangan to the existing N6 at Coolagh, the proposed N6 GCRR overlies Visean Limestone which is prone to karst. The proposed N6 GCRR subsequently crosses numerous karst features. Identified surface karst features are presented in Table 9.10.

Certain anomalies were encountered during the ground investigation in the area underlain by karstified limestone, refer to Appendix A.9.1 for all ground investigation data and Figures 9.8.001 to 9.8.012.

The hydrogeology of karst features is dealt with in Chapter 10, Hydrogeology.

Construction Activity - Dewatering

The ground investigation data suggests that groundwater will be encountered in some areas of cut and for a number of foundation excavations, refer to Chapter 7, Construction Activities. Dewatering is required where significant ingress of water will occur during construction.

The potential effects of this dewatering and dewatering limitations are assessed and presented in Chapter 10, Hydrogeology.

9.4.2.2 Phase 2 Operation

The proposed N6 GCRR will require periodic maintenance of various aspects which interact with soils and geology including embankment slopes, cut slopes, tunnels and drainage channels.

9.4.3 Phase 3

Phase 3 comprises the construction of the new permanent stableyard including horsebox parking post-handover of the proposed N6 GCRR. (Approval for which was granted by Galway City Council in December 2024 Planning Ref. No.:24/60279).

9.4.3.1 Phase 3 Construction

Construction of the new permanent stables and yard will be undertaken at surface on the lands acquired for the construction and permanent retention of the proposed N6 GCRR including the Galway Racecourse Tunnel. Construction will also include construction of a number of permanent buildings and permanent horsebox parking spaces.

As such there will be minimal interactions from a soils and geology environmental perspective with effects from the Galway Racecourse Tunnel, as a working platform for the construction of the new permanent stableyard will be provided at the conclusion of Phase 2.

9.4.3.2 Phase 3 Operation

As identified at Phase 2, the Project will continue to require periodic maintenance of various aspects which interact with soils and geology including embankment slopes, cut slopes, tunnels and drainage channels.

9.4.4 Phase 4

Phase 4 comprises the demolition of the temporary stables constructed in Phase 1. (Approval for which was granted by Galway City Council in December 2024 Planning Ref. No.:24/60279).

9.4.4.1 Phase 4 Construction

The bases beneath the temporary stables will be retained and reinstated as car parking. The rubberised surface in the temporary stable yard will be removed and this area will be repurposed as the circulatory area for carparking. There will be minimal interaction with the natural soils and geology environment.

9.4.4.2 Phase 4 Operation

As identified at Phase 2 and Phase 3, the Project will continue to require periodic maintenance of various aspects which interact with soils and geology including embankment slopes, cut slopes, tunnels, and drainage channels.

9.4.5 Phase 5

Phase 5 is the operational phase of the Project.

9.4.5.1 Construction

Not applicable.

9.4.5.2 Operation

The Project will continue to require periodic maintenance of various aspects which interact with soils and geology including embankment slopes, cut slopes, tunnels, and drainage channels.

9.5 Evaluation of Effects

9.5.1 Introduction

An appraisal of the potential effects to geological features and of construction activities was undertaken in accordance with the TII Guidelines (NRA, 2008a) considerations as presented in Section 9.2.5 of this chapter. The evaluation and corresponding effect significance for geological features are presented and summarised in Table 9.18. Section 9.5.3 and Section 9.5.4 describe the potential construction and operational activity effects respectively on soils and geology pre-mitigation.

This Section has been updated since the 2018 EIAR to incorporate additional effects as follows:

- A more detailed assessment of the effects on soil in line with the EU Soil Strategy for 2030, specifically in terms of potential reduction in soil health, i.e. topsoil quality, erosion, compaction, sealing, and loss of feature. This replaces previously assessed effects regarding agricultural soils and compression of substrata
- Loss and damage to peat has been assessed as part of this updated EIAR
- Updated assessment of the effects relating to Geological Heritage Areas to account for updates to the Irish Geological Heritage Programme, as detailed in Section 9.3.10

9.5.2 Do-Nothing Effects

In the case where the Project was not to be developed there would be no resulting effects on the soils or geology along the footprint of the Project. The effect would therefore be *neutral*.

9.5.3 Construction Phase Effects

The potential soils and geology effects during the construction phase for all phases described in Section 9.4 are presented in this section, along with their effect significance. These potential effects also relate to and interact with other environmental factors which are described within this updated EIAR. Specific interactions are outlined below, with further detail provided in the relevant chapters.

The potential soils and geology effects during the construction phase are presented in Table 9.18. Though the magnitude of the effect may vary depending on the scale of activities and location of the activity relative to the affected important feature, only the maximum magnitude of the effect of the Project is discussed.

9.5.3.1 Earthworks construction

The soils and geology at each earthworks area are identified in Table 9.16. This section relates to potential effects associated with earthworks, including embankment construction and cutting excavation, as discussed in Section 9.4.2.1.

The potential effects of earthworks construction are listed and described below:

- Loss or damage to topsoil and subsoil[29]

[29] Additional earthworks effect included in this updated EIAR following consultation with the EPA. Replaces previously included effects regarding agricultural soils and compression of substrata.

- Loss of Solid Geology
- Loss of Future Quarry Reserves
- Introduction of Material derived from a different Lithology
- Flood Barrier
- Earthworks Haulage
- Washout of Fines / Sediment Runoff
- Effect on Surrounding Ground

Loss or damage to topsoil and subsoil

Topsoil, including peat, is a non-renewable resource which if removed or damaged can result in a permanent irreversible negative effect. Topsoil, peat, and the underlying subsoil, can be damaged due to the following construction activities associated with the Project:

- Removal of topsoils, including peat, to construct haulage roads and construction compounds on site
- Stripping of topsoils, peat, and subsoils as part of construction works for structures or related activities of the Project, including embankment and cutting activities
- Construction of haul routes on subsoils on site
- Stockpiling of topsoils and subsoils on site, and deposition of peat in Material Deposition Areas (MDAs)
- Construction of impervious sealed areas as part of the Project

Threats to topsoils and subsoils during construction are summarised as follows:

- Poor soil management when stripping topsoils which result in a degradation of the physical and chemical properties of the topsoil, thus reducing the topsoil quality
- Over compaction of underlying subsoils under haul routes, construction compounds, and embankments which will reduce the infiltration capacity of the subsoils and will prevent root penetration, thus reducing the subsoils functionality to support topsoil
- Poor construction and management of topsoil stockpiles which result in erosion of topsoils, loss of organic matter, pollution to watercourses, an increase to flood risk, and limitations to the reuse of topsoils
- Poor soil management practices of peat material during excavation, transportation, and deposition in MDAs resulting in a breakdown of the peat structure and release of carbon
- Removal and sealing of vast areas of land which can cause an increase in flood risk
- Loss of arable or pastural agricultural land in areas of construction activities including the Project structures and associated enabling a works. Refer also to Chapter 14, Material Assets – Agricultural of this updated EIAR

Chapter 7, Construction Activities highlights that excavations will be required for construction of the Project. It is expected that much of the topsoil and subsoil will be stripped and temporarily stored separately at designated excavated storage areas within the Assessment Boundary.

Where topsoils and subsoils are stripped to accommodate the works outlined above, all of the above effects have the potential to occur. The magnitude of these potential, likely effects is small adverse, and the significance of these potential, likely effects is moderate / slight.

Loss of Solid Geology

This effect applies to cuttings in rock only.

In accordance with the aggregate potential mapping, the study area is predominately classified as a very high aggregate potential. The construction of the Project would result in the loss of the aggregate resource.

The type of bedrock that will be excavated is widely available, and as per the TII Guidelines (NRA, 2008a), the portion to be removed will be small adverse in comparison to the volumes retained.

In areas of moderate crushed rock aggregate potential, the magnitude of this effect is small adverse, resulting in a significance rating of slight.

In areas of high crushed rock aggregate potential, the magnitude of this effect is small adverse, resulting in a significance rating of moderate / slight.

In areas of very high crushed rock aggregate potential, the magnitude of this effect is small adverse, resulting in a significance rating of significant / moderate.

Loss of Future Quarry Reserves

This effect applies to Lackagh Quarry (disused quarry) and Two Mile Ditch Quarry (active quarry).

Lackagh Quarry (disused) intersects the Project, effecting future quarry reserves at this location. With appropriate planning permission, the potential for future quarry reserves at Lackagh Quarry, are located beneath the disused quarry footprint and along the east and southern boundaries. Given the presence of a European designated site along the north and western boundaries of Lackagh Quarry expansion in these directions is highly unlikely. The magnitude of effect for loss of a moderate proportion of future reserves is moderate adverse.

The significance of the potential effect is moderate.

The Project is located south of the active Two Mile Ditch Quarry and does not directly affect the quarry. The magnitude of the effect is considered negligible, as the effect to the active quarry is of insufficient magnitude to affect the use or future quarry reserves.

The significance of the potential effect is imperceptible.

Introduction of Material derived from a different Lithology

This effect applies in granite bedrock areas.

The overburden across the study area consists of glacial till derived from the underlying bedrock. The bedrock changes in Section 2 at the N59 Moycullen Road, from a granite to a limestone bedrock which have different chemical compositions.

If limestone derived material is placed over granite bedrock, surface water run-off or groundwater movements through the material have the potential to affect local areas of peatland habitats by changing the pH of the groundwater.

This is further discussed in Chapter 8, Biodiversity, Chapter 10, Hydrogeology, and Chapter 11, Hydrology of this updated EIAR.

The significance of the potential effect is significant / moderate.

Refer also to Chapter 7, Construction Activities of this updated EIAR.

Flood Barrier

This effect applies to embankments only.

There is no significant encroachment of any significant floodplains. Embankment constructed in areas prone to flooding have the potential to erode, resulting in a change in the local environment and potential ground movement at the base of the embankment slope. Potential for flooding is discussed further in Chapter 11, Hydrology of this updated EIAR.

The significance of the potential effect is significant / moderate.

Earthworks Haulage

During earthworks construction, heavily loaded large earthmoving vehicles will travel through the site, causing ground vibrations, unwanted compaction and disturbance of natural ground of unfinished road surfaces. Trafficking along designated haul routes is required. Noise, dust and vibration will be generated as a result of the construction works and earthworks haulage.

See also Chapter 7, Construction Activities, Chapter 16, Air Quality, Chapter 17, Climate, and Chapter 18, Noise and Vibration of this updated EIAR.

The magnitude of this potential effect is small adverse. The significance of the potential effect is slight.

Washout of Fines / Sediment Runoff

During or following heavy rainfall events, surface water run-off from embankments comprising of fine material (silt and clay) or exposed cuttings could have a high percentage of suspended solids and result in accumulation of unwanted material in adjacent lands.

See also Chapter 10, Hydrogeology and Chapter 11, Hydrology of this updated EIAR.

The significance of the potential effect is slight.

Effect on Surrounding Ground

Soil and rock excavation has the potential to induce movement and settlement of surrounding ground. The breaking or blasting of the bedrock could result in ground vibrations and destabilisation of existing slopes, existing rock slopes, with affects felt in the immediate vicinity of the works.

See also Chapter 7, Construction Activities, Chapter 8, Biodiversity, Chapter 16, Air Quality and Climate and Chapter 18, Noise and Vibration of this updated EIAR.

The significance of the potential effect is moderate / slight.

9.5.3.2 Re-use and processing of site material

The effects associated with the introduction of material derived from a different lithology and earthworks haulage are applicable for the re-use and processing of site material. As mentioned in Section 9.5.3.1 the potential effects include:

- in the granite bedrock area, where limestone derived material is placed over granite bedrock there is potential to affect the local areas of peatland habitats by changing the pH of the groundwater. The significance of this potential effect is significant / moderate.
- ground vibrations, unwanted compaction and disturbance of natural ground of unfinished road surfaces as a result of haulage during the earthworks construction where heavily loaded large earthmoving vehicles will travel through the site. The significance of this potential effect is slight.

See also Chapter 7, Construction Activities, Chapter 16, Air Quality, Chapter 17, Climate and Chapter 18, Noise and Vibration of this updated EIAR.

9.5.3.3 Importation, exportation and disposal of materials

The effects associated with the introduction of material derived from a different lithology and earthworks haulage are applicable for the importation, exportation and disposal of materials, the effects are mentioned above in Section 9.5.3.2.

See also Chapter 7, Construction Activities, Chapter 16, Air Quality, Chapter 17, Climate and Chapter 18, Noise and Vibration of this updated EIAR.

9.5.3.4 Tunnelling

This section outlines the associated effects for the construction of the mined tunnel at Menlough (Lackagh Tunnel) and the cut and cover tunnel at Ballybrit (Galway Racecourse Tunnel).

A summary of the potential effects for the proposed tunnel construction at each of the tunnel locations are provided below:

Potential Effect on Limestone Pavement

The potential geological effect, due to tunnelling, on Limestone pavement applies to Lackagh Tunnel only.

Potential geological effect on the integrity of the geological attribute (Limestone pavement), due to the mined tunnel, include such effects as ground settlement, and rock mass instability. The potential geological effects from the mining activities could include blast damage due to ground vibration and air blast vibrations. See also Chapter 8, Biodiversity and Chapter 10, Hydrogeology of this updated EIAR.

Considering the key design features presented in Section 9.4.2.1 and the conservative design approach the magnitude of the potential geological effect is considered to be negligible, as the potential geological effect would result in impact on the attribute but of insufficient magnitude to affect either use or integrity, as per Table 9.5. Further details on the proposed Lackagh Tunnel are provided in Appendix A.7.3.

The significance, as per

Table 9.6, of the potential geological effect is imperceptible.

Other potential geological effects to Limestone pavement are discussed in Section 9.5.3.5 where Limestone pavement occurs under structures and in Section 9.5.3.8 where it occurs within the study area.

Loss of Feature

The tunnel bores are to advance through Visean limestone, resulting in the loss of the intact rock. The cut and cover tunnel in Ballybrit will require the excavation of Visean limestone, which will also result in the loss of intact rock.

The effects associated with the loss of solid geology are applicable for loss of feature. As mentioned in Section 9.5.3.1 the potential effect which applies to cuttings in rock only will result in the loss of the aggregate resource. The significance of this potential effect is significant / moderate.

Ground Settlement

The effects associated with the effects to surrounding ground are applicable for ground settlement. As mentioned in Section 9.5.3.1 soils and rock excavations, including the breaking or blasting of the bedrock, could result in ground vibrations and destabilisation of existing slopes and existing rock slopes and has the potential to affect the surrounding ground by inducing movement. The significance of this potential effect is moderate / slight.

Potential Effect due to Blasting

The effects to surrounding ground are also applicable for potential impact due to blasting and are outlined above.

Other potential construction effects from Lackagh Tunnel and Galway Racecourse Tunnel are discussed in Chapter 7, Construction Activities, Chapter 8, Biodiversity, Chapter 10, Hydrogeology, Chapter 11, Hydrology, Chapter 16, Air Quality, Chapter 17, Climate, and Chapter 18, Noise and Vibration of this updated EIAR where the potential effects of construction traffic, dewatering, dust and noise and vibration from blasting bedrock are described in detail.

9.5.3.5 Construction of Structures

The construction activities for structures presented in Chapter 5, Project Description of this updated EIAR may impose some of the following effects, dependant on the geology encountered at the location of the structure footings:

- Ground Settlement
- Noise and vibration
- Material disposal i.e. bored pile installation

See also Chapter 7, Construction Activities, Chapter 16, Air Quality, Chapter 17, Climate and Chapter 18, Noise and Vibration of this updated EIAR.

The significance of the potential effect is slight.

Potential Effect on Limestone Pavement

Two structures along the Project traverse Limestone pavement in Menlough. It should be noted, at both of these locations the Limestone pavement is outside the Lough Corrib SAC, refer to Chapter 8, Biodiversity of this updated EIAR for the ecological assessment.

The Project includes the construction of a viaduct in Menlough. The proposed Menlough Viaduct will result in the minor loss (circa 500m^2) of a small part of the attribute (Limestone pavement).

The magnitude of the potential geological effect, as per Table 9.5, is considered small adverse, as the potential geological effect would result in loss of small part of the attribute[30].

The significance of the potential geological effect, as per Table 9.6, is significant / moderate.

A culvert is located in an area of Limestone pavement in Menlough. The magnitude of the potential geological effect is negligible, as the structural integrity of the Limestone pavement is maintained. The significance of the potential geological effect is imperceptible.

Other potential geological effects to Limestone pavement are discussed in Section 9.5.3.4 for Lackagh Tunnel and in Section 9.5.3.8 where Limestone pavement occurs within the study area.

9.5.3.6 Contaminated Ground

No known areas of contaminated ground were located within the study area. Exposure of locations of contamination and excavation of contaminated soil may potentially lead to a risk to the surrounding environment or underlying soil if not dealt with in an appropriate manner in accordance with the Environmental Protection Agency guidance on Land Contamination.

The underlying soil could be affected from the exposure of previous buried hazardous material, in an unlicensed dumping site for example, or from the discharge of wash water from concrete operations.

The potential effects could also include the potential for leakage or spillage of construction related materials, contaminating the subsoils present.

For example, raw or uncured concrete and grouts, washed down water from exposed aggregate surfaces, cast-in-place concrete from concrete trucks, fuels, lubricants and hydraulic fluids for equipment used on the development site, bitumen and sealants used for waterproofing concrete surfaces can all potentially impact on soils and groundwater during construction stage.

The significance of the potential effect is moderate / slight.

9.5.3.7 Soft soil

The potential effects associated with soft ground removal are discussed under Effects of Surrounding Ground in Section 9.5.3.1.

As mentioned in Section 9.5.3.1 soil excavations could result in destabilisation of existing slopes and has the potential to affect the surrounding ground by inducing movement.

The significance of this potential effect is moderate / slight.

The potential effect associated with the presence of soft ground at structure locations is ground settlement as discussed Section 9.5.3.5.

9.5.3.8 Karst features

The study area contains the following karst features (which have a geological feature importance of medium or higher):

- Limestone pavement

[30] Box 5.1: Criteria for rating impact significance at EIA stage. A magnitude of impact of small adverse is one where there is a "minor impact on integrity of attribute or loss of small part of attribute" (NRA, 2008a)

- Turlough
- Springs

See also Chapter 10, Hydrogeology.

Potential Effect on Limestone Pavement (with respect to soils & geology)

The Project traverses six locations of Limestone pavement in Sections 3 and 4. These locations include:

- One location at Lackagh Tunnel, which passes under an area of Limestone pavement, within Lough Corrib SAC, refer to Section 9.5.3.4. The significance of this potential effect is imperceptible
- Two locations of Limestone pavement are under structures in Menlough, located outside Lough Corrib SAC, refer to Section 9.5.3.5. The significance of this potential effect at these locations is considered significant / moderate and imperceptible
- Three other locations, all outside the Lough Corrib SAC, are under the proposed N6 GCRR and discussed below.

At these three locations the Limestone pavement is encapsulated under the proposed N6 GCRR. Two of these locations are in Menlough and one location is in Coolagh, at these locations the proposed N6 GCRR results in loss of small part of the Limestone pavement.

The significance of the potential effect for areas of Limestone pavement lost under the proposed N6 GCRR is significant / moderate.

All other Limestone pavement areas within the study area are not directly affected by the proposed N6 GCRR.

The significance of the potential effect for areas of Limestone pavement within the study area but outside of the Project is imperceptible.

Refer to Chapter 8, Biodiversity for the potential effects to Limestone pavement from an ecological perspective.

Surface Karst Solution Features

The Project will result in the loss of part of the enclosed depression (K12), the enclosed depression (K97) and the spring (K193).

The significance of the potential effect for these attributes is moderate.

Additional individual karst features have been identified in the study area, as presented in Table 9.10, however, these additional ones, excluding K12, K97, and K193, will not be directly affected by the Project as they exist outside the Assessment Boundary.

In such situations, the significance of the potential effect is imperceptible.

9.5.3.9 Geological Heritage Areas

The sealing, contamination, or excavation of soil and rock during construction can diminish the value of Geological Heritage Areas. This can result in a permanent irreversible loss of the in-situ characteristics of the land, soil, and geology of the area. Three Geological Heritage Areas were identified within the study, as described in Section 9.3.10:

- Lough Corrib (GY093)
- Two Mile Ditch Quarry (GY132)
- Doughiska N6 Road Cut (GC001)

The Lough Corrib (GY093) County Geological Site (CGS) is located approximately 100m northwest of the Project and given that there are no major works planned directly adjacent to the CGS, the magnitude of this effect is expected to be negligible. The resulting significance of this effect at this CGS feature is imperceptible and will not be considered further in this assessment.

Similarly, the Two Mile Ditch Quarry (GY132) CGS is located approximately 90m northwest of the Project and given that there are no major works planned directly adjacent to the CGS, the magnitude of this effect is expected to be negligible. The resulting significance of this effect at this CGS feature is imperceptible and will not be considered further in this assessment.

Conversely, the Project has a substantial interaction with the Doughiska N6 Road Cut (GC001) CGS with major works planned directly within the CGS footprint. This will entail the removal of the current rock cutting faces of this CGS, however more rock faces will be exposed as part of the construction process. As such, the magnitude of this effect is expected to be small adverse with an associated significance rating of significant / moderate.

Table 9.18 Summary of the Predicted Construction Phase effects of the Project[31]

Feature	Description	Importance	Effect	Quality	Duration	Scale	Magnitude	Significance
Geological Features								
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Reduction in topsoil quality	Negative	Permanent	Local	Small adverse	Moderate / slight
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Over compaction	Negative	Permanent	Local	Small adverse	Moderate / slight
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Erosion	Negative	Permanent	Local	Small adverse	Moderate / slight
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Sealing	Negative	Permanent	Local	Small adverse	Moderate / slight
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Loss of feature	Negative	Permanent	Local	Small adverse	Moderate / slight
Peat	Peat	High	Loss or damage of feature	Negative	Permanent	Local	Small adverse	Moderate / slight
VHPCR	Crushed Rock – Very High Potential	Very High	Loss of solid geology	Negative	Permanent	Local	Small adverse	Significant / moderate
HPCR	Crushed Rock – High Potential	High	Loss of solid geology	Negative	Permanent	Local	Small adverse	Moderate / slight
MPCR	Crushed Rock – Moderate	Medium	Loss of solid geology	Negative	Permanent	Local	Small adverse	Slight

[31] Additional table included in this updated EIAR to summarise the predicted construction phase effects of the Project.

Feature	Description	Importance	Effect	Quality	Duration	Scale	Magnitude	Significance
Q01	Lackagh Quarry – Disused	Medium	Loss of future quarry or pit reserve	Negative	Permanent	Local	Moderate adverse	Moderate
Q02	Roadstone Quarry	Very High	Loss of future quarry or pit reserve	Negative	Permanent	Local	Negligible	Imperceptible
ML23	Roadstone Dimension Stone	Very High	Loss of future quarry or pit reserve	Negative	Permanent	Local	Negligible	Imperceptible
ML24	Roadstone Limestone (in general)	Very High	Loss of future quarry or pit reserve	Negative	Permanent	Local	Negligible	Imperceptible
General Earthworks Construction								
Topsoil	Peatlands in Granite Lithology	High	Loss of integrity of feature due to introduction of material from different lithology	Negative	Permanent	Local	Moderate adverse	Significant / moderate
Soils & Geology – General	Soils & Geology Receiving Environment	High	Loss or damage of topsoils and subsoils - embankment construction in areas prone to flooding causing erosion of embankment or flooding on adjacent topsoils/subsoils	Negative	Permanent	Local	Moderate adverse	Significant / moderate
Soils & Geology – General	Soils & Geology Receiving Environment	High	Loss or damage of topsoil and subsoils - Ground vibrations, unwanted compaction and disturbance of natural ground due to earthworks haulage	Negative	Permanent	Local	Small adverse	Moderate / slight
Soils & Geology – General	Soils & Geology Receiving Environment	High	Loss or damage of topsoil and subsoils – Washout of Fines and sediment deposition (from embankments and cuttings)	Negative	Permanent	Local	Small adverse	Moderate / slight
Soils & Geology – General	Soils & Geology Receiving Environment	High	Effect on surrounding ground (incl. ground vibrations, settlement, destabilisation of existing slopes) due to soil and rock excavations (incl. blasting) and deposition	Negative	Permanent	Local	Small adverse	Moderate / slight

Feature	Description	Importance	Effect	Quality	Duration	Scale	Magnitude	Significance
Soils & Geology – General	Soils & Geology Receiving Environment	High	Effect on surrounding ground (incl. ground vibrations, settlement, destabilisation of existing slopes) due to construction of structures (incl. piling, tunnelling)	Negative	Permanent	Local	Small adverse	Moderate / slight
Contaminated Land								
Soils & Geology – General	Soils & Geology Receiving Environment	High	Exposure of previous buried hazardous material	Negative	Permanent	Local	Small adverse	Moderate / slight
Soils & Geology – General	Soils & Geology Receiving Environment	High	Construction Contamination – Chemical spillage, material accumulation, or concrete activities	Negative	Permanent	Local	Small adverse	Moderate / slight
Karst Features								
Limestone pavement	Menlough Viaduct (outside European designated sites)	Very High	Loss of part of feature	Negative	Permanent	Local	Small adverse	Significant / Moderate
Limestone pavement	Covered by the Project (outside European designated sites)	Very High	Loss or damage of feature	Negative	Permanent	Local	Small adverse	Significant / Moderate
Limestone pavement	Lackagh Tunnel (within European designated sites)	Very High	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Limestone pavement	All other areas (Both within and outside European designated sites)	Very High	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible

Feature	Description	Importance	Effect	Quality	Duration	Scale	Magnitude	Significance
Palaeokarst	Palaeokarst deposits as encountered during the project-specific ground investigation	Medium	Loss or damage of feature	Negative	Permanent	Local	Small adverse	Slight
Karst: K7	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K10	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K11	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K12	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Moderate adverse	Moderate
Karst: K17	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K25	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K31	Turlough	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K44	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K45	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K49	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K51	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K54	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K57	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible

Feature	Description	Importance	Effect	Quality	Duration	Scale	Magnitude	Significance
Karst: K59	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K61	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K62	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K64	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K67	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K70	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K71	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K97	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Moderate adverse	Moderate
Karst: K104	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K131	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K172	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K175	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K179	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Karst: K193	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Moderate adverse	Moderate

Feature	Description	Importance	Effect	Quality	Duration	Scale	Magnitude	Significance
Karst: K328	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible
Geological Heritage Areas								
GY093	Lough Corrib	Very High	Loss or damage of a proportion of a Geological Heritage Area	Negative	Permanent	Local	Negligible	Imperceptible
GY132	Two Mile Ditch Quarry	Very High	Loss or damage of a proportion of a Geological Heritage Area	Negative	Permanent	Local	Negligible	Imperceptible
GC001	Doughiska N6 Road Cut	Very High	Loss or damage of a proportion of a Geological Heritage Area	Negative	Permanent	Local	Small adverse	Significant / moderate

9.5.4 Operational Phase Effects

The significance rating on the soils and geology from the operational phase of the Project will generally be Imperceptible according to the TII Guidelines criteria (NRA, 2008a). Overall, there is neutral long term effect on the soils and geology across the Project. The potential geological effects on the environment have been provided below for the operational phase.

Contamination

Maintenance works could lead to occasional accidental leakage of oil, petrol or diesel, allowing contamination of the surrounding environment. However, the magnitude of the effect is negligible as spills will be contained and materials will be disposed of appropriately using a fully licensed waste contractor with the appropriate permits. The significance of the potential effect is imperceptible.

Ground Movement

The mined tunnel in Menlough, Lackagh Tunnel, may experience minimal long term ground movement (settlement) of the local environment. With the support measures as outlined in the design phase, Section 9.4.2.1, and monitoring during the construction phase the magnitude of the potential effect is negligible.

The significance of the potential effect is imperceptible.

9.6 Mitigation Measures

9.6.1 Introduction

This section describes the mitigation measures to reduce or avoid potential effects where possible, for both the construction (Section 9.5.3) and operational phases (Section 9.5.4) of the Project.

This Section has been updated since the 2018 EIAR to account the 2019 RFI Response and the Oral Hearing in 2020, including any additional Environmental Commitments made at that time.

9.6.2 Construction Phase

The mitigation measures for the potential construction effects are provided below.

9.6.2.1 Earthworks construction

Construction techniques that comply with the requirements of statutory bodies in terms of noise, vibration, soil and groundwater contamination and disposal of contaminated material for both soil and rock cuttings will be adopted.

Loss or damage of Topsoil and Subsoil, and Loss of Solid Geology

All earthworks will be undertaken in accordance with a project-specific earthworks specifications ensuring that all excavated material and imported material is classified appropriately so as to allow maximum opportunity for the reuse of materials on the Project.

As outlined in Appendix A.9.3, careful handling is essential to retain any existing structure and integrity of the excavated materials, where minimising agitation of the acrotelm will safeguard important processes such as carbon sequestration. The following principles will be employed when handling peat during the construction phase of the proposed N6 GCRR:

- Minimise plant movements and haul distances in relation to any peat earthworks activities by utilising the nearest available MDA (where peat is permitted)
- Appropriate temporary storage areas for excavated peat close to the excavation will be developed
- Peat placement will occur as soon as possible after excavation where practicable

Excavated topsoil will be stockpiled using appropriate methods to minimise the effects of weathering. Care will be taken in reworking this material to minimise dust generation, groundwater infiltration and generation of runoff.

To reduce the compaction and erosion of topsoil outside the areas of direct construction, haul routes will be along predetermined routes as detailed in Chapter 7, Construction Activities of this updated EIAR and deliveries will be along predetermined routes outside the Project extents. Where compaction occurs due to truck movements and other construction activities on unfinished surfaces, remediation works will be undertaken to reinstate the ground to its original condition. Where practical, compaction of any soil or subsoil which is not part of the works or to remain in-situ within the site will be avoided.

The contractor will ensure that any excavated topsoil, subsoil or rock is assessed for re-use within the Project ensuring the appropriate handling, processing and segregation of the material. Where practical the removal of excavated material from the Project will be avoided. Any surplus suitable excavated material that is not required in the Project, will be reused on other projects where possible. The reuse of this material as a by-product on other construction sites would be subject to Regulation 27 notification to the EPA. This material would have to be shown to be suitable for such use and subject to appropriate control and testing according to earthworks specifications of the source and destination sites. Alternatively, the surplus excavated material will be disposed of at suitable authorised waste facilities.

Where appropriate, excavated material, including topsoil, subsoil, and crushed rock shall be reused as construction fill within the Project or placed in deposition areas. Excavated material will contribute to the construction material requirements for the Project.

Introduction of Material derived from a different Lithology

The CEMP included in Appendix A.7.5 of this updated EIAR, which is a working document and will be updated and finalised by the Contractor following appointment and prior to the commencement of the construction works, so as to include any additional measures required pursuant to any decision to grant approval. It includes within it details of the requirements of a construction earthworks programme which the Contractor will implement prior to earthwork activities taking place. The earthworks programme will categorise the source of material for each fill section which have been set out and assessed in this updated EIAR at Sections 9.4.2.1 and 9.5.3. The detailed construction earthworks programme will outline the use of all cut material on the haulage routes are identified on Figures 7.1.001 and 7.1.002 and assessed throughout this updated EIAR and will set out the continuous monitoring of earthwork movement. During the finalisation of this programme, the Contractor shall adhere to the fill limitations outlined below.

To prevent impact to the local peatland habitats, described in Chapter 8, Biodiversity of this updated EIAR, the following fill limitations will be incorporated at the locations identified in Table 9.19.

- Only pavement and capping layers protected from surface water runoff and groundwater movements are permitted to be derived from non-native material
- All other compliant fill material will be derived from native material or other pH compatible material

Table 9.19 Fill Limitation Areas

Location	Annex I Habitat / Fossitt (2000) ID Codes*	Fill Limitation Chainage Area	
		From	To
1	4030 mosaic	0+620	0+775
2	*7130/4010 mosaic, 4010 and PF2	1+150	1+475
3	4010	1+830	2+050
4	4010	2+200	2+325
5	4010 and PF2	2+875	3+175
6	4010	3+450	3+550
7	4030/4010 and 4010	3+595	3+890
8	4030 mosaic and 4010	4+650	5+150
9	4010 and PF2	7+750	7+900

*Refer to Chapter 8, Biodiversity for details

Flood Barrier

A drainage layer or starter layer, in accordance with the TII publication CC-SCD-00606, will be implemented for the construction of embankments in areas prone to flooding. The introduction of a drainage layer will ensure hydraulic conductivity exists across the floodplain and removes the risk of the embankment acting as a flood barrier.

Earthworks Haulage

Earthworks haulage will be along predetermined routes within and outside the Assessment Boundary as outlined in Chapter 7, Construction Activities and as shown on Figures 7.101 to 7.123 of this updated EIAR.

The identified haulage routes are along existing national, regional, and local routes or within the Project extents.

Where compaction occurs due to truck movements and other construction activities on unfinished surfaces, remediation works will be undertaken to reinstate the ground to its original condition. Where practicable, compaction of any soil or subsoil which is to remain in-situ along the Project will be avoided.

Washout of Fines / Sediment Runoff

The use of granular fill material in embankment construction will remove the likelihood of the washout of fines. However, in the event where an embankment is constructed of local material in areas prone to flooding, the introduction of a drainage layer or starter layer (as discussed in Flood Barrier section above) will reduce the likelihood of run-off of fine material.

Alternatively, the introduction of a geotextile separator will reduce the potential effect in areas. A composite system, combining a drainage layer and a geotextile separator will be implemented in embankments constructed with cohesive fill material.

Sediment control methods are outlined in the CEMP in Appendix A.7.5 of this updated EIAR, and in Chapters 10, Hydrogeology and 11, Hydrology of this updated EIAR.

Effect on Surrounding Ground

Where appropriate, ground settlement, horizontal movement, and vibration monitoring will be implemented during construction activities to ensure that the construction does not exceed the design limitations. The design limitations will ensure no cosmetic damage to adjacent properties.

In situations where the site-specific blast design has determined that blasting is not feasible in a particular location due to excessive ground vibrations, a blast exclusion zone, where blasting is not permitted, will be implemented. In such situations, alternative extraction methods such as hydraulic breaking, hydraulic splitting, chemical splitting and electrical disintegration may be implemented and monitored. Monitoring will be implemented during blasting, during excavation of cuts, for overburden slopes steeper than 1V:2H (V= vertical slope, H = horizontal slope) and rock slopes steeper than 1V:1.5H. As a precaution, prior to vibration and movement related construction works commencing (including blasting), pre-condition surveys will be undertaken for all receptors within a zone of influence.

In line with best practice, a geotechnical expert will be appointed by the Contractor and will be present to monitor the surrounding ground vibrations near sensitive receptors (including domestic dwellings) during blasting works. The Employer's Site Monitoring Team will be monitoring the reports on a weekly basis to ensure compliance with the commitments in relation to vibration limits. In the unlikely event that the blast vibration limit at the surface is exceeded, blasting works will cease on site until it is understood the basis for the increased vibration. The blast design will then be recalibrated and blasting works will proceed with continued monitoring.

As per the 2018 EIAR, a key contact person will be appointed during the construction phase to facilitate communications between affected property owners, informing them of proposed works in their area, including blasting. After vibration and movement related construction works have ceased, a post condition survey will be undertaken for all receptors within a zone of influence. In the highly unlikely event that damage from vibration is observed, the damage will be repaired.

Allowable distances for the various construction methods are outlined in Chapter 18, Noise and Vibration of this updated EIAR.

Construction of structures will be completed in accordance with the CEMP in Appendix A.7.5. The construction of the River Corrib Bridge, Menlough Viaduct, Lackagh Tunnel and Galway Racecourse Tunnel will meet the requirements of Appendices A.7.1, A.7.2, A.7.3, and A.7.4 of this updated EIAR respectively.

Ground settlements and movement will be controlled through selection of the foundation type and method of construction which are suitable for the particular ground conditions. To minimise soil movements due to pile operations in the vicinity of sensitive receptors, each pile shall be constructed sequentially in a direction away from the sensitive receptor. Previously installed piles act as a shield as soil movements are greater in a direction away from a stiff zone, for example away from the piles and sensitive receptors.

9.6.2.2 Reuse and processing of site material

A construction earthworks programme will be implemented for the Project as part of the CEMP, as outlined in Appendix A.7.5 of this updated EIAR, which categorises the source of material for each fill section. During the finalisation of this programme the fill limitations outlined in Section 9.6.2.1 will be incorporated at the locations presented in Table 9.19.

9.6.2.3 Importation, exportation and disposal of materials

Importation of materials from outside the site will be minimised by ensuring that materials arising within the site area are used to the greatest extent possible. Any surplus material remaining which cannot be incorporated into the construction fill activities shall be placed in MDAs within the Project. This will significantly reduce the deposition of material off-site.

Hazardous material will be transported off site for disposal or recovery at appropriately licence or permitted sites as outlined in Chapter 7, Construction Activities of this updated EIAR.

9.6.2.4 Tunnelling

The adopted construction techniques will comply with the requirements of statutory bodies in terms of noise, vibration, soil and groundwater contamination and disposal of contaminated material.

Engineering design solutions that reduce the effect on the integrity of the geological feature include sufficient rock above the tunnel bores, a suitable pillar between the bores to protect the tunnel from collapse and suitable blasting sequences. The site control measures include probing ahead of the tunnel and mapping of the tunnel blast face and monitoring of the blast. Where required the introduction of stability measures will be implemented including rock bolts, and a robust steel tunnel lining. These engineering design solutions will be monitored during construction.

During the construction of Lackagh Tunnel the supported rock face of Lackagh Quarry Face and retaining walls for the Western approach will be monitored for movement. A geotechnical expert will be appointed, by the contractor and will be present to monitor the rock mass stability during their construction period. In the unlikely event that instability within the rock mass is observed, additional support measures will be installed to ensure that there is no impact to the surface above. The additional rock support measures comprise ground anchors, rock bolts, rock dowels, rock mesh, shotcrete or a combination of these measures, designed to the relevant design standards and best practice guidance documents (Eurocode 7, BS8081). However, based on the conservative design approach it is considered that the risk of instability will be avoided, and additional support measures will not be required.

A geotechnical expert will be appointed by the contractor and will be present to monitor the vibrations at the surface, including the areas of Limestone pavement, during blasting works for the construction of Lackagh Tunnel and the Western Approach. The blast target vibration limit is defined as 20mm/sec, which is 20% more conservative than the conservative design approach vibration limit of 25mm/sec at the ground surface which includes areas of Limestone pavement, which provides an added factor of safety to the construction works to ensure that blasting will not impact the structural integrity of the Limestone pavement. In the unlikely event that the blast target vibration limit at the surface is exceeded, blasting works will cease on site until it is understood the basis for the increased vibration. The blast design will then be recalibrated and blasting works will proceed with continued monitoring.

For further information on Lackagh Tunnel is presented in Appendix A.7.3 of this updated EIAR.

9.6.2.5 Construction of Structures

Construction of structures will be completed in accordance with the Construction Environmental Management Plan (CEMP) in Appendix A.7.5 of this updated EIAR and as described in the following:

- River Corrib Bridge Constructability Examination Appendix A.7.1 of this updated EIAR
- Menlough Viaduct Constructability Examination Appendix A.7.2 of this updated EIAR
- Lackagh Tunnel Geotechnical and Hydrogeological Appraisal Appendix A.7.3 of this updated EIAR
- Galway Racecourse Tunnel Constructability Report Appendix A.7.4 of this updated EIAR

Ground settlements and movement will be controlled through selection of the foundation type and method of construction which are suitable for the particular ground conditions.

To minimise soil movements due to pile operations in the vicinity of sensitive receptors, each pile shall be constructed sequentially in a direction away from the sensitive receptor. Previously installed piles act as a shield as soil movements are greater in a direction away from the stiffer zone i.e. away from the piles and sensitive receptors.

With respect to the Menlough Viaduct, the magnitude of the loss of the Limestone pavement was minimised during the design stage, where the number of piers and size of the pier footings were kept to a minimum. During construction, the Limestone pavement at Menlough Viaduct will be protected and will not be affected by implementing a protection system comprising of geogrid, protection geotextile and layers of material, as per Plate 9.2. This will be removed once construction is complete. Refer to Menlough Viaduct Constructability Report in Appendix A.7.2 of this updated EIAR for further details.

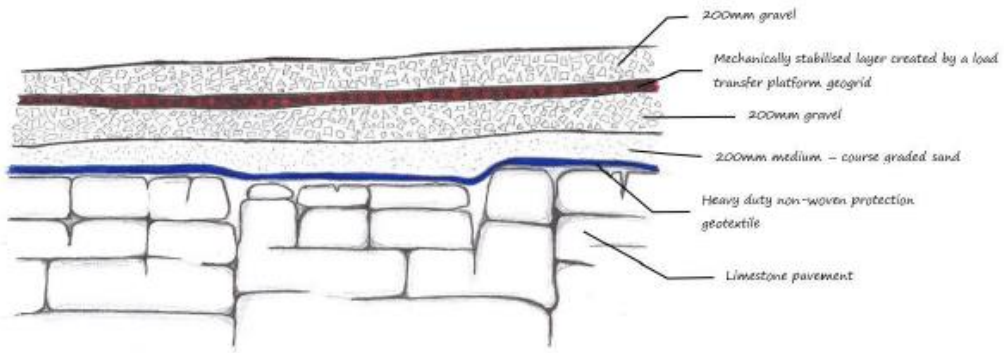

Plate 9.2 Limestone pavement protection system

9.6.2.6 Contaminated ground

No known areas of contaminated ground were located within the study area. Samples of ground suspected of contamination will be tested for contamination during the detailed investigation and ground excavated from these areas will be disposed of to a suitably licenced or permitted site(s) in accordance with the current Irish Waste Management legislation.

Good housekeeping (daily site clean-ups, use of disposal bins, etc.) on the site, and the proper use, storage and disposal of these substances and their containers will be implemented to prevent soil contamination.

For all activities involving the use of potential pollutants or hazardous materials, material such as concrete, fuels, lubricants and hydraulic fluids will be carefully handled and stored to avoid spillages. Potential pollutants shall also be adequately secured against vandalism and will be provided with proper containment according to codes of practice. Any spillages will be immediately contained and contaminated soil removed from the site and disposed of to an appropriately permitted or licenced site according to the current Irish Waste Management Legislation by the contractor.

The Contractor will make provision for removal of any concrete wash water. Concrete trucks will be directed back to their batching plant for washout. The arrangement for concrete deliveries to the site will be discussed

with suppliers before commencement of work, outlining the agreed assessed routes, prohibiting on site washout and discussing emergency procedures.

Good construction management practices will be employed to minimise the risk of transmission of hazardous materials as well as pollution of adjacent watercourses and groundwater. Measures to be implemented to minimise the risk of spills and contamination of soils and waters will include:

- Employing only competent and experienced workforce, and site-specific training of site managers, foremen and workforce, including all subcontractors, in pollution risks and preventative measures.
- Ensure that all areas where liquids (including fuel) are stored, or cleaning is carried out, are in designated impermeable areas that are isolated from the surrounding area and within a secondary containment system, e.g., by a roll-over bund, raised kerb, ramps or stepped access.
- The location of any fuel storage facilities will be considered in the design of all construction compounds and will be fully bunded. These are to be designed in accordance with relevant and current guidelines and codes of best practice at the time of construction.
- All concrete mixing and batching activities will be located in designated areas away from watercourses and drains.
- Potential pollutants will be adequately secured against vandalism in containers in a dedicated secured area.
- Provision of proper containment of potential pollutants according to relevant and current codes of practice and legal requirements.
- Thorough control during the entire construction stage to ensure that any spillage is identified at early stage and subsequently effectively contained and managed.
- Spill kits to be provided and to be kept close to the temporary construction compounds. Staff to be trained on how to use spill kits correctly.

Best construction management practices, as outlined in the Construction Industry Research and Information Association (CIRIA) Control of Water Pollution from Construction Sites – Guidance for consultants and contractors (Masters-Williams et al. 2001) will be reflected in the CEMP. This 2001 guidance remains the most relevant guidance at the date of this updated EIAR.

An Emergency Response Plan has been prepared and included in the CEMP in Appendix A.7.5 of this updated EIAR and will be further developed by the appointed contractor prior to the commencement of works and regularly updated, identifying the actions to be taken in the event of a pollution incident. The Emergency Response Plan will address the following:

- Secure oil and chemical storage in over-ground bunded areas, limited to the minimum volume required to serve immediate needs with specified delivery and refuelling areas
- No refuelling or fuel storage within 50m of waterways and only on a sealed surface
- Emergency spill kits will be retained at sensitive locations, with portable kits provided to plant and equipment operators
- Cessation of work and development of measures to contain and/or remove pollutant should an incident be identified
- Silt traps will be employed and maintained in appropriate locations
- Temporary interception bunds and drainage ditches will be constructed up slope of excavations to minimise surface runoff ingress and in advance of excavation activities
- Excavation and earthworks will be suspended for review as required during and immediately following periods of heavy rainfall to minimise sediment generation and soil damage

9.6.2.7 Karst features

As a minimum, the carriageway drainage network will be sealed in areas where the Project crosses rock particularly prone to karstification. Through the use of engineered solutions, including an impermeable barrier, cement slurry or grout, direct run-off from the paved surface of the Project will be prevented from entering into the rock along the proposed alignment, as this could cause further deterioration and instability of the rock mass. Individual mitigation measures will be assessed on a case by case basis by the designer, determined by the extent of karst and make up of the Project as outlined in the karst protocol which is part of the CEMP (Appendix A.7.5 of this updated EIAR). Inspections of karst features will be undertaken by a hydrogeologist and/or geotechnical expert in order to determine the appropriate remediation measure. These remedial measures include but are not limited to the removal of all loose, soft, weak or voided soil material, backfilling voids with an agreed combination of boulders cobbles / chunk rock / cement slurry and installation of a high strength geosynthetic to form a competent, safe foundation platform.

Mitigation measures for the protection of karst features are further outlined in Chapter 10, Hydrogeology and included in the CEMP as part of the karst protocol in Appendix A.7.5 of this updated EIAR.

9.6.2.8 Geological Heritage Areas

Prior to backfilling / removal of portions of the existing exposed rock face for the existing road cutting along the existing N6 in Doughiska (GC001), the Contractor shall notify the GSI to ensure a site visit can be arranged for an assessment of the rock face prior to backfilling / removal.

Where the design permits (including environmental mitigation measures, safety requirements and engineering constraints), significant bedrock cuttings will be designed to remain visible. Where this cannot be achieved, digital photographic records of significant new excavations will be recorded by the Contractor and/or visits from GSI will be facilitated by the Contractor.

In additional, the Contractor shall notify the GSI of bedrock cuttings to facilitate a site visit prior to any backfilling.

9.6.3 Operational Phase

During the operational phase, monitoring of the rock mass stability will continue. The rock and overburden retaining systems in Lackagh Quarry and Western Approach will continue to be monitored as part of the local authority maintenance schedule to ensure that they continue to operate as intended for the design life of the Project. In the extremely unlikely event that instability within the rock mass is observed additional support measures, outlined above in Section 9.4.2.1 and Section 9.6.2.4, for the construction phase will be installed to ensure that there is no impact to the structural integrity[32] of the Limestone pavement. However, based on the conservative design approach, (the installed composite support system and monitoring during construction) it is considered that the risk of instability will be avoided, and additional support measures will not be required.

Operation mitigation measures for Lackagh Tunnel are further discussed in Appendix A.7.3 of this updated EIAR.

The implementation of the design, construction methodology control measures and mitigations measures result in no other operational phase mitigation measures for avoiding potential direct and indirect effect to the soils and geology environment for the Project.

9.7 Residual Effects

9.7.1 Construction and Operation Residual Effects

Implementing the outlined mitigation measures will result in a number of significant residual negative effects on the soil and geological environment at the construction phase. These effects occur where the construction of the Project will result in a small loss of Limestone pavement (all outside European designated sites) and in the loss of a portion of a geological heritage area (existing N6 Rock Cutting in Doughiska).

[32] Structural Integrity of the rock mass that supports the mosaic of Limestone pavement and Calcareous grassland is the physical and mechanical geotechnical properties that control the behaviour of the geotechnical Limestone pavement environment.

Implementation of the outlined mitigation measures will result in imperceptible residual negative effects on the soil and geological environment at the operation phase.

The residual effects for the construction phase and operational phase are shown in Table 9.20 and Table 9.21, respectively.

Table 9.20 Predicted Residual Effects for Geological Features and Activities during Construction Phase[33]

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
Geological Features										
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Reduction in topsoil quality	Negative	Permanent	Local	Small adverse	Moderate / slight	Small adverse	Moderate / slight
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Over compaction	Negative	Permanent	Local	Small adverse	Moderate / slight	Small adverse	Moderate / slight
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Erosion	Negative	Permanent	Local	Small adverse	Moderate / slight	Small adverse	Moderate / slight
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Sealing	Negative	Permanent	Local	Small adverse	Moderate / slight	Small adverse	Moderate / slight
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Loss or damage of topsoil – Loss of feature	Negative	Permanent	Local	Small adverse	Moderate / slight	Small adverse	Moderate / slight
Peat	Peat	High	Loss or damage of peat	Negative	Permanent	Local	Small adverse	Moderate / slight	Small adverse	Moderate / slight
VHPCR	Crushed Rock – Very High Potential	Very High	Loss of solid geology	Negative	Permanent	Local	Small adverse	Significant / moderate	Small adverse	Moderate / slight

[33] Table structure updated as part of this updated EIAR.

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
HPCR	Crushed Rock – High Potential	High	Loss of solid geology	Negative	Permanent	Local	Small adverse	Moderate / slight	Negligible	None
MPCR	Crushed Rock – Moderate	Medium	Loss of solid geology	Negative	Permanent	Local	Small adverse	Slight	Negligible	None
Q01	Lackagh Quarry – Disused	Medium	Loss of future quarry or pit reserve	Negative	Permanent	Local	Moderate adverse	Moderate	Moderate adverse	Moderate
Q02	Roadstone Quarry	Very High	Loss of future quarry or pit reserve	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
ML23	Roadstone Dimension Stone	Very High	Loss of future quarry or pit reserve	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
ML24	Roadstone Limestone (in general)	Very High	Loss of future quarry or pit reserve	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
General Earthworks Construction										
Topsoil	Peatlands in Granite Lithology	High	Loss of integrity of feature due to introduction of material from different lithology	Negative	Permanent	Local	Moderate adverse	Significant / moderate	Negligible	Imperceptible
Soils & Geology – General	Soils & Geology Receiving Environment	High	Loss or damage of topsoils and subsoils - embankment construction in areas prone to flooding causing erosion of embankment or flooding on	Negative	Permanent	Local	Moderate adverse	Significant / moderate	Small adverse	Moderate / slight

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
			adjacent topsoils/subsoils							
Soils & Geology – General	Soils & Geology Receiving Environment	High	Loss or damage of topsoil and subsoils - Ground vibrations, unwanted compaction and disturbance of natural ground due to earthworks haulage	Negative	Permanent	Local	Small adverse	Moderate / slight	Small adverse	Moderate / slight
Soils & Geology – General	Soils & Geology Receiving Environment	High	Loss or damage of topsoil and subsoils – Washout of fines and sediment deposition (from embankments and cuttings)	Negative	Permanent	Local	Small adverse	Slight	Negligible	Imperceptible
Soils & Geology – General	Soils & Geology Receiving Environment	High	Effect on surrounding ground (incl. ground vibrations, settlement, destabilisation of existing slopes) due to soil and rock excavations (incl. blasting) and deposition	Negative	Permanent	Local	Small adverse	Moderate / slight	Small adverse	Moderate / slight
Soils & Geology – General	Soils & Geology Receiving Environment	High	Effect on surrounding ground (incl. ground vibrations, settlement, destabilisation of existing slopes)	Negative	Permanent	Local	Small adverse	Moderate / slight	Small adverse	Moderate / slight

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
			due to construction of structures (incl. piling, tunnelling)							
Contaminated Land										
Soils & Geology – General	Soils & Geology Receiving Environment	High	Exposure of previous buried hazardous material	Negative	Permanent	Local	Small adverse	Moderate / slight	Negligible	Imperceptible
Soils & Geology – General	Soils & Geology Receiving Environment	High	Construction Contamination – Chemical spillage, material accumulation, or concrete activities	Negative	Permanent	Local	Small adverse	Moderate / slight	Negligible	Imperceptible
Karst Features										
Limestone pavement [34]	Menlough Viaduct (outside European designated sites)	Very High	Loss of part of feature	Negative	Permanent	Local	Small adverse	Significant / Moderate	Small adverse	Significant / Moderate
Limestone pavement	Covered by the Project (outside European designated sites)	Very High	Loss or damage of feature	Negative	Permanent	Local	Small adverse	Significant / Moderate	Small adverse	Significant / Moderate
Limestone pavement	Lackagh Tunnel (within	Very High	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible

[34] This table presents the geological assessment of Limestone pavement, refer to Chapter 8, Biodiversity for an ecological assessment.

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
	European designated sites)									
Limestone pavement	All other areas (Both within and outside European designated sites)	Very High	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Palaeokarst	Palaeokarst deposits as encountered during the project-specific ground investigation	Medium	Loss or damage of feature	Negative	Permanent	Local	Small adverse	Slight	Small adverse	Slight
Karst: K7	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K10	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K11	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K12	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Moderate adverse	Moderate	Moderate adverse	Moderate
Karst: K17	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K25	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K31	Turlough	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
Karst: K44	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K45	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K49	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K51	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K54	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K57	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K59	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K61	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K62	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K64	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K67	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K70	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K71	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
Karst: K97	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Moderate adverse	Moderate	Moderate adverse	Moderate
Karst: K104	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K131	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K172	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K175	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K179	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Karst: K193	Spring	Medium	Loss or damage of feature	Negative	Permanent	Local	Moderate adverse	Moderate	Moderate adverse	Moderate
Karst: K328	Enclosed Depression	Medium	Loss or damage of feature	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
Geological Heritage Areas										
GY093	Lough Corrib	Very High	Loss or damage of a proportion of a Geological Heritage Area	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
GY132	Two Mile Ditch Quarry	Very High	Loss or damage of a proportion of a Geological Heritage Area	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
GC001	Doughiska N6 Road Cut	Very High	Loss or damage of a proportion of a Geological Heritage Area	Negative	Permanent	Local	Small adverse	Significant / moderate	Small adverse	Significant / moderate

Table 9.21 Predicted Residual Effects for Geological Features and Activities during Operational Phase

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
Topsoil	AminDW, AminSW, BminDW, BminSW	High	Results in an effect on attribute but of insufficient magnitude to affect either use or integrity	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
Peat	Peat	High	Results in an effect on attribute but of insufficient magnitude to affect either use or integrity	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
VHPCR	Crushed Rock – Very High Potential	Very High	No measurable change to the attribute	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
HPCR	Crushed Rock – High Potential	High	No measurable change to the attribute	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
MPCR	Crushed Rock – Moderate Potential	Medium	No measurable change to the attribute	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Q02	Roadstone Quarry	Very High	Results in an effect on attribute but of insufficient magnitude to affect either use or integrity	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
ML23	Roadstone Dimension Stone	Very High	No measurable change to the attribute	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
ML24	Roadstone Limestone (in general)	Very High	No measurable change to the attribute	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Soils & Geology – General	Soils & Geology Receiving Environment	High	Maintenance Works - Contamination: Contamination possible from machinery used	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
Soils & Geology – General	Soils & Geology Receiving Environment	High	Maintenance Works - Trafficking: Settlement, disturbance due to trafficking	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
Q01	Lackagh Quarry – Disused	Medium	Rock Stability: Stability of quarry face	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
Soils & Geology – General	Soils & Geology Receiving Environment	High	Long term Ground Movements: Ground movement, settlement due to tunnel construction	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
Limestone pavement	Menlough Viaduct (outside European designated sites)	Very High	Results in effect on attribute but of insufficient magnitude	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
Limestone pavement	Covered by the Project (outside	Very High	Results in effect on attribute but of	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible

Feature	Description	Importance	Effect	Quality	Duration	Scale	Pre-mitigation Magnitude	Pre-mitigation Significance	Post-mitigation Magnitude	Post-mitigation Significance
	European designated sites)		insufficient magnitude							
Limestone pavement	Lackagh Tunnel (within European designated sites)	Very High	Results in effect on attribute but of insufficient magnitude	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
Limestone pavement	All other areas (Both within and outside European designated sites)	Very High	Results in effect on attribute but of insufficient magnitude	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	Imperceptible
GY093	Lough Corrib	Very High	No measurable change to the attribute	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
GY132	Two Mile Ditch Quarry	Very High	No measurable change to the attribute	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None
GC001	Doughiska N6 Road Cut	Very High	No measurable change to the attribute	Negative	Permanent	Local	Negligible	Imperceptible	Negligible	None

9.8 Cumulative Impacts

This section of the chapter presents the assessment carried out to examine whether the Project along with any other projects or plans could cumulatively result in a likely significant landscape and / or visual effects.

It is assessed that construction of the Project on its own gives rise to a number of significant residual negative effects on the soil and geological environment and the Project on its own gives rise to imperceptible residual negative effects on the soil and geological environment at the operation phase. These impacts are generally focused within the immediate corridor of the proposed N6 GCRR on the urban / rural edge of the city. To the west and north of the city much of the lands along the corridor are identified for agricultural and / or amenity uses.

The identification of planned and committed projects for the assessment of cumulative effects has considered Galway City and County planning registers, with projects identified according to the methodology laid out in Chapter 21 of this updated EIAR. Thereafter, planned and committed projects have been scoped for assessment in this chapter based on relative proximity and potential soils and geology impacts due to the proposed developments.

The identification of projects for the long list considered the following sources:

- An Bord Pleanála (ABP) website (http://www.pleanala.ie/index.htm) – for details of Strategic Infrastructure Developments (SIDs), Strategic Housing Developments (SHDs) and permissions made on appeal
- Local authorities (Galway City Council and Galway County Council) for up-to-date planning applications and local development plan designations

The types of projects considered:

- Local Planning Applications – those projects for which planning permission is applied for through the local planning authorities themselves and were identified from local authority planning application lists
- Strategic Housing Developments (SHDs) – housing developments of a certain type and scale (e.g., 100 or more houses or student accommodation units) where applications were lodged directly with An Bord Pleanála
- Large Scale Residential Developments (LRDs) – housing developments of a certain type and scale (e.g., 100 or more houses or student accommodation units comprising 200 bed spaces or more) for which planning permission is applied for through the local planning authorities
- Strategic Infrastructure Development (SIDs) - major infrastructure developments by local authorities and others for which applications are lodged directly with An Bord Pleanála

A five-year timeframe was deemed the most appropriate period for planning searches, as permissions granted more than five years ago would generally be constructed, partially constructed, or are under construction when the planning registers were viewed.

An initial sift was carried out to exclude applications that were not considered relevant in the ‘long list’. This included applications that are either not currently active (i.e. retention, invalid, withdrawn, refused-and not appealed, refused on appeal), or applications of a minor scale. The planning application lists were searched to identify and exclude these minor applications from the long list on the basis that given their minor nature these were not likely to have a cumulative effect noticeable over the effects of the Project in isolation. Examples of planning applications which were excluded from the preliminary long list were applications to construct or demolish conservatories, house extensions, loft conversions, change of uses for single or small numbers of buildings, construction of outbuildings, modifications to driveways and retention applications.

The final list of planned and committed projects within 250m of the Assessment Boundary have been assessed in order to predict any cumulative effects (at both construction and operation) from a soils and geology perspective. A 250m buffer from the Assessment Boundary was considered an appropriate buffer to align with the soils and geology study area. Consideration was also given to any significant development in close proximity to the 250m buffer which could have the potential for cumulative impacts.

Cumulative soils and geology effects can occur when other projects in the locality have similar soils and geology potential effects as the Project. Cumulative effects have been assessed based on the residual effect[35] of these effects on the planned and committed projects, within the soils and geology study area as outlined in Section 9.2.3, in combination with the Project. A summary of the cumulative effects assessment is provided in Appendix A.9.4.

From a soils and geology perspective, the following feature / construction activity effects were identified in the planned and committed projects and/or present in the Project:

- Loss or damage to topsoils (including peat) and subsoils
- Loss of solid geology and aggregate potential (economic geology)
- Excavation of potentially contaminated ground
- Loss or damage to Geological Heritage Areas
- Movement, settlement or damage to surrounding ground due to construction activities (including earthworks haulage)
- Loss or damage to surface-based karst features

From a soils and geology perspective, most of the proposed projects which involve new development will result in the loss or damage to topsoils, subsoils and solid geology, where the cumulative magnitude of the loss is considered small adverse, and therefore will not result in a cumulative significant effect on soils and geology. New developments will also result in effects to the surrounding ground, including excavation of potentially contaminated ground, where the cumulative magnitude of the effect is considered small adverse, and therefore will not result in a cumulative significant effect on soils and geology.

When the planned and committed projects are assessed cumulatively with the Project, there will be significant effects on soils and geology due to the significant / moderate residual effect on Limestone pavement (outside of European designated sites) and significant / moderate residual effect on the county geological heritage area of rock cutting along the N6 in Doughiska. Cumulatively, the significance of these cumulative effects remains as significant / moderate.

There are no likely significant direct or indirect cumulative effects of the Project in combination with the planned and committed projects works on soils and geology during the Operational Phase.

9.9 Summary

The soils and geology environment will be affected by the Project.

Certain geological features will be affected in all earthwork sections, and these are highlighted in Section 9.9.1, loss of attributes.

Potential effects due to construction or operational activities have the potential to occur, but the significance of the effect will be reduced, where possible, with implementation of mitigation measures. The potential residual effects are presented in Section 9.9.2 and Section 9.9.3 respectively.

A summary review of the four sections of the Project is presented in Section 9.9.3.1 to Section 9.9.3.4.

Construction will be completed in accordance with the Construction Environmental Management Plan in Appendix A.7.5 of this updated EIAR.

The key changes to the chapter since the 2018 EIAR involve updating:

- The methodology to take account of updated guidelines

[35] This infers that mitigation measures have been implemented and the cumulative impact is assessed against the residual risk.

- The description of the receiving environment and impact assessments to take account of changes, new developments, updated to the Galway City Development Plan and Galway Count Development Plan, etc.
- The evaluation of the effect on geological features of importance, such as a more detailed assessment of soil in line with the EU Soil Strategy for 2030
- The appendices and figures associated with Chapter 9
- To take account of points raised from the Brief of Evidence presented to An Bord Pleanála (ABP) at the oral hearing in 2020 and from the ABP Inspector's Report dated June 2021
- In terms of significant soils and geology residual effects, this updated EIAR confirms one new additional significant / moderate residual effect due to the loss of a proportion of the Geological Heritage Site (GC001) Doughiska N6 Road Cut. This is in addition to the unchanged significant / moderate residual impact to Limestone pavement

9.9.1 Loss of Attributes

A proportion of topsoils (including peat), subsoils, and solid geology (including crushed rock aggregate potential) will be lost within the footprint of the Project. The significance of such a loss in all cases is considered a moderate / slight effect, excluding the loss of very high crushed rock potential which is considered a significant / moderate effect. Application of mitigation measures outlined in this updated EIAR (including appropriate handling, haulage and deposition) will reduce the effect on the materials, while excavated material will be used as construction fill or placed in deposition areas, thus contributing to the construction material requirements for the Project. The re-use of the crushed rock aggregate potential is considered to be a reduction in effect to future quarry reserves, thus reducing the effect to a residual effect of moderate / slight. These measures are in line with Section 20 'The Circular Economy and Other Emissions' of the Climate Action Plan 2024

The loss of part of three karst features will result from the Project, enclosed depression (K12), enclosed depression (K97) and spring (K193). The significance of the potential effect for these attributes is moderate.

The Project traverses locations of Limestone pavement in Sections 3 and 4 that is located both within and outside European designated sites. The geological assessment (importance and effect) has not differentiated between Limestone pavement located within or outside the European designated sites. Refer to Chapter 8, Biodiversity, of this updated EIAR for an ecological assessment of Limestone pavement.

Lackagh Tunnel passes under an area of Limestone pavement that is within a European designated site resulting in minimal to no effect on the feature from a geological perspective. Menlough Viaduct and a culvert in Menlough pass over Limestone pavement (both outside European designated sites), resulting in a loss of a small part of the attribute under the viaduct piers and no effect on the feature under the culvert. There are three locations where the Project traverses and covers Limestone pavement (all outside European designated sites): two locations in Menlough and one location in Coolagh. At these locations it will result in loss of a small part of the Limestone pavement, it should be noted that both of these locations are outside of the European designated sites.

The geological significance of loss of Limestone pavement was assessed at each location with the results ranging from imperceptible where there is no effect, to significant/ moderate where loss of small part of the attribute occurs.

The Project will result in the loss of part of the palaeolandscape in the east of the city. These features are known to be located in Menlough, Ballindooley and Castlegar. The significance of the loss of these features is slight.

The Project will also result in the moderate loss of future reserves, with appropriate planning, at Lackagh Quarry (disused quarry). The significance of the loss of future reserves is considered moderate.

The Project will also result in the loss of a proportion of a Geological Heritage Area in Doughiska of rock cutting along the proposed N6 GCRR, as identified during a review of the publicly available information as part of this updated EIAR. The significance of the loss is significant / moderate.

9.9.2 Residual Effects due to Construction

Introduction of material derived from a different lithology, washout of fines, spread of contamination, or unwanted disturbance of the soils and geology environment are all potential construction effects on the receiving environment. Development and implementation of mitigation measures identified in this updated EIAR reduce such effects to a moderate / slight or imperceptible residual effect on the soils and geology environment.

9.9.3 Residual Effects due to Operation

All operational activities of the Project are deemed to produce imperceptible effects to the surrounding geological environment.

9.9.3.1 Section 1: Chainage 0+000 to 8+500 (R336 to the N59 Moycullen Road)

Section 1 contains the least number of potential effects out of all four sections. All unique effects applicable to Section 1 are presented in this section.

Settlement or movement of the surrounding environment can be induced adjacent to large cuttings, such as in Ballard or Letteragh. A clear understanding of the soil /rock behaviour, following detailed ground investigation, will contribute to the development of the detailed design and construction methodology in order to reduce or completely remove construction induced movement.

Blasting will be required for deep cuttings in rock, such as the characteristics anticipated for the cut sections in Ballard and Letteragh. Data obtained from trial blasts will calibrate the blast design to site-specific designs and will refine the blast design properties. Where blasting is not viable, rock breaking will be conducted by hydraulic breaking/splitting or other industry methods.

In this granite region to prevent impact to the local peatland habitats**,** the following fill limitations will be incorporated at the locations identified Table 9.19 of this chapter:

- Only pavement and capping layers protected from surface water runoff and groundwater movements are permitted to be derived from non-native material
- All other compliant fill material will be derived from native material or other pH compatible material

This will be included in the construction earthworks programme, as outlined in the CEMP (Appendix A.7.5 of this updated EIAR), which categorises the source of material for each fill section.

9.9.3.2 Section 2: Chainage 8+500 to 9+400 (N59 Moycullen Road to the River Corrib)

Section 2 is completely in fill and contains the second least number of potential effects of all sections. The section is also the shortest length at only 900m. All unique effects applicable to Section 2 are presented in this section.

The bedrock changes from granite to limestone in Section 2 at the N59 Moycullen Road, with the overlying materials having different chemical compositions. As such at the locations identified in Table 9.19 in the granite region the following fill limitations will be incorporated:

- Only pavement and capping layers protected from surface water runoff and groundwater movements are permitted to be derived from non-native material
- All other compliant fill material will be derived from native material or other pH compatible material

River Corrib Bridge will require a specialised foundation solution due to the soft ground anticipated and karst risk in the area. The foundation solution will require the installation of piles which could induce ground settlement in the surrounding environment and cause noise and vibrations from the installation works.

9.9.3.3 Section 3: Chainage 9+400 to 14+000 (River Corrib to the N83 Tuam Road)

Section 3 contains the largest number of effects out of all four sections. All unique effects applicable to Section 3 are presented in this section.

Sixteen structures located in Section 3 will potentially require specialised foundation solutions. The location and name of these structures are presented in Table 9.17. Two of the structures are located on the boundary between Section 3 and 4.

The Project traverses' locations of Limestone pavement located within and outside European designated sites in Sections 3. These locations are:

- Menlough Viaduct and a culvert structure traverse over areas of Limestone pavement both outside European designated sites resulting in loss of a small part of Limestone pavement at the viaduct
- There are two other locations in Menlough which will result in loss of part of the Limestone pavement that is located outside European designated sites through encapsulation
- Lackagh Tunnel traverses beneath Limestone pavement that is located within European designated sites and will emerge into Lackagh Quarry. A conservative design approach has been adopted for Lackagh Tunnel including ground anchors, rock bolts, rock dowels, steel mesh and shotcrete controlling rock stability and tunnel design features. As an additional control measure, a geotechnical expert will be appointed to monitor the rock mass stability at construction and operation phases. In the extremely unlikely event, due to the adopted conservative design approach, that instability within the rock mass is observed additional support measures such as ground anchors, rock bolts, rock dowels will be installed to ensure that there is no effect to the Limestone pavement. Based on the conservative design approach, it is considered that the risk of instability will be avoided, and additional support measures will not be required. The residual risk is considered imperceptible to the Limestone pavement. Further details in relation to this can be found in Appendix A.7.3 of this updated EIAR.

The remaining structures in Table 9.17 are likely to require a robust foundation solution due to soft ground or karst which is present throughout section 3. The foundation solutions will require either the installation of piles or an excavation and replacement of soft ground, which could induce ground settlement in the surrounding environment and cause noise and vibrations from the works.

Settlement or movement of the surrounding environment can be induced adjacent to large cuttings. The implemented design and selected construction methodology will reduce or completely remove construction induced movement.

Blasting will be required for the tunnel construction and for deep cuttings in rock. Blasting may not be viable at all locations as a result of the local receptors limitations. Where blasting is not viable, alternative rock breaking methods will be implemented such as hydraulic breaking/splitting or other industry methods. As part of the blast design assessment monitored trial blasts in the same bedrock formation as the proposed blast locations at locations of proposed blasting will be conducted. These trial blasts will calibrate the blast design to site-specific designs and will refine the blast design properties. Trial blasts will not exceed the limitations of the local sensitive receptors.

The Project intersects a disused Lackagh Quarry and is located south of the active Two Mile Ditch Quarry. Considering the Project, the quarry location, proximity and status the potential effect of future reserves were assessed. The Project will result in the loss of moderate proportion of future quarry reserves at Lackagh Quarry. The magnitude of such an effect is considered moderate adverse. No mitigation measure can be implemented to reduce this effect. The significance of the effect is moderate for the disused Lackagh Quarry. At Two Mile Ditch Quarry the Project does not directly affect the quarry. The magnitude of the effect is considered negligible, as the effect to the active quarry is of insufficient magnitude to affect the use or future quarry reserves. The significance of the potential effect is imperceptible for the active Two Mile Ditch Quarry.

9.9.3.4 Section 4: Chainage 14+000 to 17+500 (N83 Tuam Road to the existing N6 at Ardaun, Coolagh)

All unique effects applicable to Section 4 are presented in this section.

Two structures in Section 4 will potentially require specialised foundation solutions. The location and name of these structures are presented in Table 9.17.

The foundation solution may require the installation of piles, which could induce ground settlement in the surrounding environment and cause noise and vibrations from the piling works.

Settlement or movement of the surrounding environment can be induced adjacent to large cuttings. The implemented design and selected construction methodology will reduce or completely remove construction induced movement. Tolerances will be set for cuttings adjacent to properties.

The Project traverses one location of Limestone pavement in Section 4 (at Coolagh), which is located outside the European designated sites, resulting in the loss of small part of the Limestone pavement.

Blasting will be required for the construction of the Galway Racecourse cut and cover tunnel as part of the proposed N6 GCRR. As part of the blast design data obtained from trial blasts will calibrate the blast design to site-specific designs and will refine and validate the blast design properties. Where blasting is not viable, rock breaking will be conducted by hydraulic breaking/splitting or other industry methods.

Construction of the proposed N6 GCRR will result in the loss of a proportion of the geological heritage site along the existing N6 at Doughiska, which consists of exposed rock cutting. Where the design permits (including environmental mitigation measures, safety requirements and engineering constraints), significant bedrock cuttings will be designed to remain visible, including in this area of the proposed N6 GCRR.

9.10 References

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