N6 GALWAY CITY RING ROAD, CO. GALWAY

ABP-302848-18 & ABP-302885-18

HYDROGEOLOGY

REPORT BY

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On behalf of

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CONTENTS

1 INTRODUCTION

1.1 My name is James Dodds and I am a UK Chartered Geologist specialising in Hydrogeology and Water Management. I hold a BSc (Honours) Degree in Geology from the University of London, a Diploma in Hydrogeology from University College London (DUC) and a MSc Degree in Hydrogeology from the University of London, which I gained in 1986. I am a Fellow of the Geological Society of London and gained Chartered Status from that body in 1992. My Fellowship number is 1001807.

1.2 I have been working as a Consultant Hydrogeologist since 1987, gaining experience over the last 34 years in natural water related issues, in many parts of the world and in many different geological and topographical terrains. I have experience and expertise in karst hydrogeology and development in karst terrains. I worked on a large project in Ireland between 1992 and 1997, being based there for about two years in total, between those dates.

Background

1.3 The proposed development is for a Motorway Scheme and a Protected Road Scheme. It is referred to as the N6 Galway City Ring Road. The proposed road development is generally routed around the outskirts of Galway City extending from the R336 west of Bearna in the west, to the new N6/M6 motorway at Briarhill in the east.

1.4 In summary, the development or scheme comprises:

- Approximately 5.6km of single carriageway (Protected Road)
- Approximately 11.9km of dual carriageway (Motorway)
- A bridge over the River Corrib
- Two viaducts – one traversing NUIG Sporting Campus and the other across non-designated priority Annex I habitat at Menlough
- Two tunnels one beneath the Lough Corrib cSAC near Lackagh Quarry, and the other under part of the Galway Racecourse as well as tunnel maintenance buildings
- Four main Link Roads at N59 Link Road North, N59 Link Road South, Parkmore Link Road and City North Business Park Link
- Side Roads, junctions, roundabouts, pedestrian and cyclist facilities, lighting, fencing and noise barriers
- 10 underbridges and 7 overbridges
- Culverts and underpasses
- 29 Gantry Signs
- Drainage works
- Attenuation ponds
- Diversions of utilities

- Demolition of 44 residential properties and acquisition of 10
- Demolition of 2 industrial properties (1 comprising 4 buildings)
- Demolition of 2 commercial properties
- Acquisition of 17 farm buildings and modifications/revoking planning permissions
- Demolition of one protected structure
- Environmental measures including lands north of Menlo Castle to provide an enhancement of the core foraging habitat for the Lesser Horseshoe bat known to roost at Menlo Castle, and all other associated works
- Temporary site compounds
- Landscaping works
- Material Deposition Areas
- Utilities and services diversion works, and
- Associated works on lands.

1.5 With respect to planning history, a previous scheme known as the Galway City Outer Bypass (GCOB), was submitted for approval to An Bord Pleanála (the Board) on the 1st December 2006. The Board granted approval for the eastern part of the scheme on 28th November 2008. The Board was not satisfied that the part of the proposed road development between the N59 Moycullen Road and the R336 Road would not be prejudicial to the preservation of the Tonabrocky bog habitat or that significant adverse effects would not be avoidable or could not be avoided by an alternative route and considered this part of the route to be contrary to sustainable development.

1.6 Following a judicial review of the Board's decision on the basis that the Board erred in its interpretation of Article 6 of the Habitats Directive, the High Court upheld the Board's decision. A third party appealed this judgment to the Supreme Court who sought the opinion of the Court of Justice of the European Union (CJEU). The CJEU opinion delivered on the 11th April 2013 established that the loss of a small area of Priority Annex I habitat for which the Lough Corrib cSAC is selected would adversely affect the integrity of the cSAC and the provisions of Article 6(4) must apply in granting consent. Following this opinion, the Supreme Court quashed the earlier Board decision to grant approval of the eastern section of the GCOB under Article 6(3) of the Habitats Directive.

1.7 Following this decision and the Board's refusal to approve the western end of the project, the applicant decided to reassess the work to ensure all possible alternatives were investigated. The resulting project is the subject of these applications for approval now before the Board.

1.8 The current applications were submitted after pre-consultation with An Bord Pleanála.

Role & Responsibilities

1.9 My primary role is to advise on hydrogeological issues, based on a hydrogeological assessment undertaken as part of the submitted Environmental Impact Assessment Report (EIAR) and as part of the Natura Impact Assessment Statement (NIS), both of which are supported by a substantial number of appendices, maps and specific studies.

1.10 An Ecologist, Dr. Richard Arnold, was also appointed to assist with the assessment of the application and I have liaised with him, particularly with respect to assessing the impact of the various elements of the road (tunnel, Material Deposition Areas, over bridges, road surface, drainage system/discharge points) with respect to the water flow pathways through the limestone and potential effect on Ground Water Dependent Terrestrial Ecosystems (GWDTE).

1.11 The specific requirements of the role (my brief) are set out as follows:

- Review and consider the relevant documentation and observations submitted by the applicant, prescribed bodies and third parties at all stages of the process, focussing particularly on the relevant sections of the EIAR (with particular reference to Chapters 8, 9, 10 and 11, and associated figures and appendices), as well as the NIS and associated figures and appendices.

- Liaise with the Ecologist in relation to GWDTE.

- Carry out a site visit(s).

- Attend relevant modules of the oral hearing (as advised by the Inspector), including questioning participants or seeking clarification of relevant issues as agreed with the Inspector.

- Prepare and submit a report (this report) and make recommendations on:

    a. the adequacy and robustness of the methodology used in the EIAR and NIS of the hydrogeological impact of the project, and the baseline information;
    b. the likely impacts of the proposed development on the hydrogeology of the area, having regard to GWDTE, EIA, Habitats and Birds Directives.
    c. the appropriateness of the responses and solutions proposed;
    d. the report shall also contain advice on proposed mitigation measures, and on any additional mitigation measures and/or conditions considered necessary; and

e. the report shall include a clear recommendation regarding consent for the development from a hydrogeological perspective including relevant conditions or reasons for refusal as appropriate.

Tasks Completed

1.12 To perform my brief, I undertook the following tasks:

- Review of documentation, provided to me by An Bord Pleanála, in both hard copy and digital format.
- Development of preliminary overview and identification of items requiring clarification.
- Site visit on 30th and 31st January 2020, to carry out a general visual assessment of the topography and setting of the proposed development, and to visit specific key features on foot, where appropriate. During part of the site visit I was accompanied by Niall Haverty (Planning Inspector).
- Attendance at Oral Hearing, G Hotel, Galway on the following dates 17th to 21st February 2020; 24th to 26th February 2020; and 10th to 11th March 2020.
- Preparation of this report.

Key Questions Addressed in my Assessment

1.13 Having reviewed the documentation and undertaken the site visit, I consider the following questions need to be addressed as part of my assessment.

A. Did the applicant and its advisors commission and undertake appropriate investigations to adequately define the baseline hydrogeological conditions?

B. Did the applicant and its advisors commission and undertake appropriate investigation and interpretation of the findings of these investigations to enable them to develop and present a robust conceptual model which demonstrates a sufficient understanding of the hydrogeological environment?

C. Based on the conceptual model, did the applicant and its advisors provide sufficient analysis to rule out any potential impacts derived from changes of water quantity and quality on the integrity/conservation objectives of Natura 2000 sites including the River Corrib, GWDTE and including consideration of any supporting aquatic habitats outside the Natura 2000 sites, such as Coolagh Lakes, beyond all reasonable scientific doubt?

D. In the case of non-Natura 2000 sites, are the baseline conditions and potential impacts adequately described and are the mitigation proposals put forward justifiable and reasonable?

E. Assuming that the mitigation proposals put forward are justifiable and reasonable, are there any residual risks despite the mitigation, and if so what degree of risk remains and if impacts occurred, would it be sufficient to undermine the conservation objectives for the river and the lakes (or any other GWDTE in the cSAC or surrounding area)?

F. With respect to the screening assessment for the Appropriate Assessment – is the applicant correct to screen out all but the Lough Corrib and Galway Bay Natura 2000 sites, or are there any impact pathways not considered that should have been?

G. For the Environmental Impact Assessment (and to a lesser extent the Appropriate Assessment), in respect of bird populations also using Galway Bay and Lough Corrib, will there be a significant impact on water quality and in Ballindooley Lough and/or Moycollen Bogs, or other wet habitats such as wet heath?

Structure of this Proof of Evidence

1.14 Section 2 of this reports presents a summary review the hydrogeological setting of the proposed development, the features that are potentially at risk, and the conceptual model described by the applicant.

1.15 Section 3 presents an analysis of the key questions posed above. I answer each question in turn at the end of each analysis.

1.16 Section 4 presents a discussion of the points raised by objectors which relate to my evidence.

1.17 Section 5 presents clear conclusions and a recommendation regarding consent for the development from a hydrogeological perspective including relevant conditions or reasons for refusal as appropriate.

Submitted Reports

1.18 The following reports, or parts of reports, have been reviewed as part of my analysis.

Title	Reference	Chapter
Environmental Impact Assessment Report		Volume 1 – Non Technical Summary
N6 Galway City Ring Road Environmental Impact Assessment Report	GCOB-4.04-019 | Issue 1 | 28 September 2018 | Arup	10 Hydrogeology and Appendix A10
N6 Galway City Ring Road Environmental Impact Assessment Report	GCOB-4.04-019 | Issue 1 | 28 September 2018 | Arup	11 Hydrology and Appendix A11
N6 Galway City Ring Road Natura Impact Statement	GCOB-4.04-021 | Issue 3 | 28 September 2018 | Arup	Volume 2 – Main report
N6 Galway City Ring Road Natura Impact Statement	GCOB-4.04-021.2 | Issue 3 | 26 July 2018	Appendix A – Hydrogeology Assessment Report
N6 Galway City Ring Road Natura Impact Statement	GCOB-4-04-021.003 | Issue 3 | 26 July 2018	Appendix C - Construction Environmental Management Plan
N6 Galway City Ring Road Natura Impact Statement	GCOB-4.03-04.16 | Issue 3 | 26 July 2018	Appendix F – Lackagh Tunnel Report
Statement of Evidence Responses to Hydrogeology Objection/Submissions	Dr Leslie Brown & Catherine Buckley	
Construction Environmental Management Plan	GCOB-4-04-021.003 | Issue 3 | 26 July 2018	Sediment, Erosion & Pollution Control Plan (SEPCP)
		Appendix C – Karst Protocol
Request for Further Information Response	GCRR-4.03-36.2-001 | Issue 1 |30 August | Arup	4.12 Clarification of Groundwater Impacts

Additional Information and Corrigenda

1.19 During the Oral Hearing a number of Corrigenda (Errata) and additional information reports were submitted. Those pertinent to this report are listed below, together with a comment on the content.

Title	Reference	Comment
Corrigendum	GCRR | Issue 1 | 21 February 2020 | Arup	Section 2 Hydrogeology, with associated drawings
Corrigendum	GCRR | Issue 1 | 11 March 2020 | Arup	EIAR A.10.4 & A.10.6
Response to queries raised in Module 2 of the N6 Galway City Ring Road – Oral Hearing	GCRR_4.03.34_001 10 March 2020	Biodiversity; Planning; Hydrogeology; Soils & Geology; Engineering
Appendix D	Groundwater Monitoring	Monitoring point locations, and groundwater level contours
Appendix E	Hydrographs	Comparison between groundwater & surface water levels and recharge; & cumulative rainfall

Title	Reference	Comment
Appendix F	EIAR Figures	Selected operational zone of influence drawings
Appendix G	Hydrogeological cross section – Castlegar Cut	Relationship between groundwater level and zone of dewatering at Castlegar Cut
Schedule of Additional Environmental Commitments (4 November 2020)	GCOB-4.03-034-12 | Issue 2 Final | 4 November 2020	21.11 Hydrogeology
Statement of Evidence	Gerry Clabby, National Parks and Wildlife Service – Dept. of Culture, Heritage & Gaeltacht	Paragraph 8
Statement of Evidence	Gerry Clabby, National Parks and Wildlife Service – Dept. of Culture, Heritage & Gaeltacht	11 March 2020 Appendix – Minutes of meeting on 27 February 2020
Eco-hydrogeology Summary Report for Lough Corrib cSAC	GCRR_4.03.34_002	
Eco-hydrogeology Summary Report for Moycullen Bogs NHA	GCRR_4.03.34_002	

Comments Made by Objectors

1.20 In reviewing the documents before me and during those parts of the Oral Hearing that I attended, I took notice of the comments made by objectors. Section 4 of the Statement OF Evidence by Dr Leslie Brown provides detailed responses to comments raised by 16 of the 296 submissions/objections made to ABP.

1.21 The list of objectors together with the topics that they raised are:

1.22 Potential impacts to private domestic wells

Ob_152: Sean and Audrey Dineen
Ob_239: Ann Codyre
Ob_311: Matthew and Eileen Burke
Ob_496: Michael Mullins
S_78: HSE

1.23 Potential impacts to private commercial wells

Ob_602_698_699_704.1, Ob_602_698_699_704.2: Clada Group Ltd.
Ob_691: Galway Race Committee

1.24 Possible impacts to water supply quality

S_008: Aughnacurra Residents association, Henry O. Bourke

S_36.2: Irish Water

1.25 Potential impacts to private wastewater treatment systems

Ob_602_698_699_704.1, Ob_602_698_699_704.2: Clada Group Ltd.

S_062: Sarah Patricia Silke

S_063: Sarah Silke

S_066: Siobhan Silke

Ob_134: Gerard & Susan O'Dell.

1.26 Potential impact to a geothermal borehole

S_063: Sarah Silke
S_066: Siobhan Silke

1.27 Potential for groundwater flooding at Lackagh Quarry

Ob_584.1, Ob_584.2: Linda Rabbitte

S_074: James & Cathleen Barrett, Menlo-Ballindooley Residents

1.28 Potential for structural instability in areas of groundwater drawdown

Ob_134: Gerard & Susan O'Dell.

1.29 Potential for impacts to Lough Corrib cSAC through the hydrogeological interactions

S_018, S_18.2: Development Applications Unit, Department of Culture, Heritage and the Gaeltacht

S_074: James & Cathleen Barrett, Menlo-Ballindooley Residents

1.30 Potential for impact to Moycullen Bogs NHA through hydrogeological interactions

S_018, S_18.2: Development Applications Unit, Department of Culture, Heritage and the Gaeltacht

S_074: James & Cathleen Barrett, Menlo-Ballindooley Residents

1.31 Subsequent to the hearing, Clada Group Ltd withdrew their objections (Ob_602_698_699_704.1, Ob_602_698_699_704.2).

1.32 A discussion of these points is presented in Section 4 of this report.

2 HYDROGEOLOGICAL SETTING

2.1. The fundamental aspect of the hydrogeological setting of this development is the contrasting geology between the western and eastern parts, essentially split by the N59 Moycullen Road and the concomitant linkages between the groundwater system and the European protected ecological areas.

2.2. The western part of the study area, from the R336 Coast Road west of Bearna Village to the N59 Moycullen Road, is underlain by granite; while the eastern part of the study area, from the N59 Moycullen Road to the N6 Junction at Coolough, is underlain by limestone.

2.3. These two different bedrock strata have entirely different geological, geotechnical and hydrogeological properties, which result in very different topography, drainage, ecological setting and hazards, being associated with them.

2.4. In essence, granite is characterised by its very low permeability and as a result its inability to store or transmit water, other than in isolated and infrequent fracture zones. The rock is hard, strong, and weathers slowly. As a result, the granite area is associated with a low undulating landscape, poor drainage leading to the development of pools and bogs, and numerous small ditches and streams draining small sub-catchments. The quantity of groundwater flow is very small compared to surface run-off and occurs in isolated and poorly connected fractures. The general rock mass is effectively impermeable.

2.5. In contrast, limestone is characterised by it being susceptible to relatively rapid chemical and physical weathering. This leads to the development of 'karst' which results from the dissolution of fractures and bedding planes in the limestone by slightly naturally acidic rainfall, which are further enlarged by the physical action and erosion of the fractures by the water running through them. Karst is therefore characterised by a bedrock that may contain no fractures, small unweathered fractures, all the way to large open conduits and ultimately caves. Where no fractures are present the rock mass is effectively impermeable and where large conduits are present groundwater flows are significant and very fast. This range in permeability and other properties is often termed 'the karst continuum', which is a useful way of considering the very large variation in properties. The open fractures and conduits are connected to the surface and allow rainfall and run-off to easily enter the ground, leading to the development of a topography which is devoid of surface streams on the higher ground and characterised by streams, rivers and lakes in low lying areas. In karst areas, the proportion of groundwater flow is very large compared to surface run-off.

2.6. In both the west and east areas, the bedrock is overlain by more recent geological materials associated with glaciation and post glacial process. These materials sit on top of an ancient (palaeo) land surface, which existed at and developed immediately after the last glaciation. Due to the different bedrock geologies, these palaeo-landforms were very different. The granite area would have had an undulating bare rock surface, with relatively low relief; while the limestone area would have been characterised by steep, and deep valleys and gorges draining a higher plateau. Glacial retreat and the deposition of clay held within the glaciers led to these valleys being filled, while the high run-off from the granite led to similar material being continually washed off.

2.7. The different geological and hydrogeological processes results in very different interactions between the hydrogeology and the environment in the east and west areas.

2.8. The groundwater system is divided into groundwater bodies (GWB) as defined by the Geological Survey of Ireland (GSI). In essence, the GWBs are groundwater catchment areas, taking account of the geology and topographic catchments. The GWBs are important for linking the groundwater system to the ecology at surface and GWDTE. In essence, if a development affects the groundwater system in a GWB it might affect a GWDTE connected to the same GWB, but not something in a different GWB. The locations of the relevant GWBs relative to the proposed road development and European sites are shown on EIAR Figures 10.1.1 and Figure 10.1.2. and are:

- Spiddal GWB Granite area
- Maam – Clonbur GWB Granite area
- Ross Lake GWB Limestone area
- Clare-Corrib GWB Limestone area
    - Clare-Corrib (Ballindooley West)
    - Clare-Corrib (Ballindooley East)
    - Clare-Corrib (Terryland)
- Clarinbridge GWB Limestone area

2.9. Associated with the GWBs are three GWDTE areas:

- Lough Corrib Fen 1 (Menlough) Limestone area
- Lough Corrib Fen 2 Limestone area
- Lough Corrib Fens 3 & 4 Limestone area

2.10. While apparently complicated, the important aspect in understanding impacts is whether the GWBs are in the granite or limestone areas, as that defines the magnitude of groundwater contribution, if any, to the protected habitats.

2.11. The River Corrib and Galway Bay form the local hydrological base in the area, and therefore the discharge points (via various routes) for groundwater. As such, all the GWBs are connected directly, or indirectly to Galway Bay Complex cSAC and Inner Galway Bay SPA; Lough Corrib cSAC and Lough Corrib SPA. However, only the Lough Corrib cSAC is directly traversed by the proposed development and as such is the only cSAC that has the potential to be directly impacted with respect to hydrogeology. The other protected areas can only be affected indirectly, by way of groundwater connectivity.

2.12. The Spiddal GWB and the Maam – Clonbur GWB theoretically contribute groundwater to Galway Bay Complex cSAC and Inner Galway Bay SPA (see EIAR Figure 10.1.1). However, both are in the granite area and almost all rainfall will run-off to streams and rivers, with only a very small component of groundwater discharging to Galway Bay.

2.13. The Ross Lake GWB contributes groundwater to the River Corrib, which in this area lies within Lough Corrib cSAC and Lough Corrib SPA (see EIAR Figures 10.1.1 and 10.1.2).

2.14. The Clare-Corrib GWB contributes groundwater to the River Corrib (Lough Corrib cSAC and Lough Corrib SPA), and the Terryland River which ultimately drains to Galway Bay and therefore the Galway Bay Complex cSAC and Inner Galway Bay SPA (see EIAR Figures 10.1.2 and 10.2.2). Clare-Corrib GWB includes Ballindooley Lough and the surrounding wetlands.

2.15. The Clarinbridge GWB also contributes groundwater to Galway Bay and hence Galway Bay Complex cSAC and Inner Galway Bay SPA (see EIAR Figures 10.1.2 and 10.2.2).

2.16. The GWDTE Lough Corrib Fen 1 extends east from the River Corrib to the townland of Coolough. Groundwater supports the Coolagh Lakes and the River Corrib. Site investigation work during the

development of this scheme has allowed the Lough Corrib Fen 1 GWDTE area to be re-defined, which is discussed in 2.25 Below.

2.17. The GWDTE Lough Corrib Fen 2 contributes groundwater to the River Corrib.

Proposed Development & the Hydrogeological Setting

2.18. Construction activities, and operation of the proposed road development, have the potential to interact with the hydrogeology and therefore receptors[1], by changing the quantity and/or quality of the groundwater upon which the receptor is dependent. The relationship between the proposed road development and the hydrogeological regime are discussed in the following paragraphs.

2.19. The aspects which determine the potential for hydrogeological impacts on receptors can be summarised as:

- The groundwater flow direction and speed (e.g is the receptor downgradient, and where on the karst continuum does the local permeability lie).
- The degree of aquifer connectivity (e.g. is the receptor in the same groundwater body as the proposed road development, or is there a hydraulic divide between the two?).
- The requirement for dewatering, which depends on the excavation depth of the proposed road development relative to the seasonally fluctuating groundwater level.
- The proximity to the receptor (e.g. is the receptor within the drawdown zone of influence or areas of potential pollution?).
- The water chemistry associated with the receptor and how drainage from the proposed road development may change it.

[1] Receptors is being used as a generic term with respect to environmental risk and refers to any feature which by virtue of its connection to a groundwater system might be considered at risk from the development or scheme.

- Changes in the amount and location of recharge of rainfall to the GWBs, due to pavement construction and drainage arrangements.

Groundwater Levels

2.20. Groundwater levels are a fundamental data set because they define the location and extent of GWBs; the direction of groundwater flow; the requirement for dewatering of tunnels and cuttings; and together with permeability, the speed of groundwater flow.

2.21. Clarification on groundwater levels and hydraulic gradients was requested as part of the Request for Further Information. This was a strong theme of discussion during the Oral Hearing and formed parts of the errata submitted, also during the Oral Hearing.

2.22. Based on the information submitted, the responses to questioning and the corrections submitted, I am satisfied that the data collected and interpreted is sufficient to adequately understand the groundwater levels in and around the area; their seasonal variation; and their interaction with the proposed road development.

Groundwater Bodies (GWB)

2.23. The definition of GWBs is a fundamental part of assessing the impact of this proposed road development. The locations and boundaries of the GWBs determine which, if any, cSACs and SPA could be at risk. As discussed above the GSI have defined GWBs however, the site investigation work undertaken by the developer has collected data which shows that the Clare-Corrib GWB should be further sub-divided. The base evidence for this is the identification of deep clay filled palaeo valleys, which create hydraulic barriers to groundwater flow within the GWB. The evidence for such features comes from deep drilled boreholes and geophysical surveys; as well as confirmation from the interpretation of groundwater levels.

2.24. Based on the data and interpretation presented, I am satisfied that the deep buried valleys are present and that due to them the sub-division of the Clare-Corrib GWB is warranted.

2.25. The Clare-Corrib GWB has been divided into two areas, namely Lough Corrib Fen 1 (Menlough) and Lough Corrib Fen 1 (Lackagh). Lough Corrib Fen 1 (Menlough) lies north of Coolagh Lakes and Lough Corrib Fen 1 (Lackagh) forms a small GWB (<0.04km^2) between Lough Corrib and Lackagh Quarry.

2.26. Groundwater flows westwards within the Lough Corrib Fen 1 (Menlough) to the Coolagh Lakes and the River Corrib and supports Western Coolagh Spring (K25[2]), a karst spring which provides groundwater flow to the upper lake of Coolagh Lakes.

2.27. Due to the compartmentalisation of the aquifer by the deep buried valleys, the groundwater in Lough Corrib Fen 1 (Lackagh) is largely contained and disconnected from the Western Coolagh Spring (K25). Instead, groundwater flow from Lough Corrib Fen 1 (Lackagh) is likely to flow eastwards to Lackagh Quarry during peak groundwater levels, where it either evaporates or overflows into the Clare-Corrib (Ballindooley West) GWB. During periods of low groundwater levels, the groundwater in Lough Corrib Fen 1 (Lackagh) is likely to be effectively pooled and cannot move eastwards.

2.28. There was much discussion in the technical reports regarding Eastern Coolagh Spring (K45[3]), which sits within Lough Corrib Fen 1 (Menlough). The functioning of this spring has been interpreted as a discharge from superficial deposits and not a karst spring, due to the low permeability and thickness of the clayey subsoil. This is based on evidence from groundwater levels and measured flow rates which are not synchronous. As such, I agree that, if present, seepages from the subsoil to the Eastern Coolagh Spring would represent a very small fraction of the groundwater contribution to Coolagh Lakes, when compared to the karst inflow at Western Coolagh Spring, and that the quantity and chemistry of the water in Coolagh Lakes is not materially affected by flows from the Eastern Coolagh Spring.

2.29. Further subdivisions of the Clare-Corrib GWB are:

- Clare-Corrib (Ballindooley West), which lies to the north of Lackagh Quarry and east of Lough Corrib Fen 2.
- Clare-Corrib (Ballindooley East), which lies to the east of Lough Corrib (Ballindooley West) and is separated from it by a north - south trending buried valley.

[2] K25 is a reference to the spring number from the Karst Survey Report (Ref. Appendix A.10.2 of the EIAR)
[3] K45 is a reference to the spring number from the Karst Survey Report (Ref. Appendix A.10.2 of the EIAR)

- Clare-Corrib (Terryland), which lies to the south of Lackagh Quarry and Clare-Corrib (Ballindooley East), and is separated from the Clarinbridge GWB by a north east - south west trending buried valley.

- The same north east - south west trending buried valley modifies the boundary between Clare-Corrib (Balindooley East) GWB and Clarinbridge GWB.

2.30. The sub-divisions and changes presented in 2.29 do not materially affect the impact assessments as they are not connected to the Lough Corrib cSAC.

Dewatering

2.31. The proposed road development has the potential to cause an impact on groundwater levels in the receiving environment as it will require the lowering of groundwater levels by dewatering of bedrock aquifers during construction and operation, in excavations which are deeper than the local groundwater level, at any particular time of the year. Dewatering of the bedrock aquifer will lower water levels locally. This can have a direct impact on receptors which are within the Zone of Influence (ZoI) of the dewatering, and an indirect impact on receptors further away by diverting groundwater flows, if the dewatered water is discharged outside the receptors catchment area. In this case, the GWB is being taken as the catchment feeding a receptor, which is a reasonable conservative approach.

2.32. The extent of the ZoI of any dewatering is dependent on two fundamental aspects. The hydraulic conductivity (permeability[4]) and the drawdown[5] imposed by the dewatering. The developer has used a simple analytical method to calculate the ZoI which in my experience overestimates the value of ZoI and therefore gives a conservative estimate.

2.33. The ZoI calculation is sensitive to the value of permeability used. I questioned the developer's representatives in some detail on the field testing and derived values of permeability, and errata were submitted during the Oral Hearing on this topic. The possible range of values of permeability for the

[4] For the sake of this report hydraulic conductivity and permeability are used synonymously
[5] Drawdown is the fall in water level from a natural (unstressed) level, to the level as a result of the stress – in this case the dewatering

granite area and the limestone area are very different. The methods that the developer has used to measure permeability in these terrains will by their nature, produce a relatively narrow range of values.

2.34. In the case of the granite area the measured permeability ranges from $9.7x10^{-7}$ m/s and $4.6x10^{-6}$ m/s (EIAR Appendix A.10.6 Hydraulic Calculations). Data presented in a standard text book[6] provides a typical range of between $1x10^{-13}$ m/s and $1x10^{-10}$ m/s for unfractured igneous rock and range of between $1x10^{-9}$ m/s and $1x10^{-4}$ m/s for fractured igneous rock (granite is an igneous rock). The measured range will reflect permeabilities either associated with the test borehole construction or an isolated fracture in the granite. Testing the permeability of unfractured granite with a very low permeability is not possible in the field. Therefore, in the case of the granite area, I believe that the values obtained from field testing are an overestimate of the likely real values attributable to the rock mass, and are more representative for isolated fractures.

2.35. The discussion about granite permeability is important in that the calculation of the ZoI is based on the permeability value. The developers have used a value of $1x10^{-6}$ m/s in their calculation of ZoI in the granite area, as representative of the bulk rock mass. This is a highly conservative value. If a value of $1 x10^{-8}$ m/s, which based on typical ranges is more realistic, the ZoI calculation would report answers that are 10x SMALLER.

2.36. Chapter 10 of the EIAR assesses the impact from the dewatering of cuttings within the granite area. The chapter concludes that there is a Large Adverse hydrogeology impact on Annex 1 habitats between chainages 0+650 to 0+750; 1+250 to 1+500; 1+850 to 2+400; 3+300 to 3+900; and 4+800 to 5+900 (Tables 10.24, 10.25 and 10.26). In all cases this is due to the habitat being within the calculated ZoI. The impact assessment must be viewed within the context that the surface water ponding within wetland sites in the granite area is not derived from groundwater, but rather it is caused by ponding above rock head where the rainfall and runoff is perched and trapped by basins in the bedrock topography. In addition, in my opinion the risk assessment is based on a ZoI calculation which is too conservative. Table 10.17 provides the calculated maximum ZoI for the cuttings, with the largest being 54m. In my opinion,

[6] Freeze & Cherry. Groundwater. Chapter 2: Physical Properties and Principals.

Table 10.17 overestimates the ZoI by up to a factor of 10. That is the largest ZoI would more likely be between 5.4m and 27m.

2.37. While dewatering of the cuttings in the granite area will remove water from the granite, based on the likely functioning of the bogs and the smaller ZoI, I believe that there will be no material impact on the Annex 1 habitats. Where higher permeability fractures are encountered the mitigation measures presented in the Construction Environmental Management Plan (CEMP) allow for the fractures to be grouted and sealed, thus preventing drainage.

2.38. In the case of the limestone area, the values obtained represent one part of the karst continuum. The karst continuum is recognised in the developer's assessment, and in this recognition and ultimately the design of the road and construction mitigation, the values used in the ZoI calculation and the way that the resulting numbers have been used and interpreted are reasonable and conservative.

2.39. A critical aspect of development within a karst setting is the management of the unexpected. By its nature a karst terrain is unpredictable at the small and medium scales, that is the construction scale. It is therefore important that this uncertainty is managed through mitigation measures. The greatest risk with this development is the intersection of unknown and unknowable conduit flow systems, which could increase inflow to dewatering systems; greatly increase the ZoI; and greatly increase the risk associated with contamination. Several design/mitigation measures have been incorporated into the scheme to protect the hydrogeological regime and minimise the risk to receptors, these include:

- No dewatering of the bedrock aquifer during construction at Menlough Viaduct or Lackagh Tunnel (and its approaches).
- The construction program for the scheme considers the seasonal groundwater fluctuation. During the winter groundwater high it may be necessary to limit the depth of works so that dewatering is not required in sensitive areas.
- Any groundwater intercepted will be collected and piped to the surface water receptor it would naturally have drained to within the granite area.
- In the limestone area, intercepted groundwater will be controlled and infiltrated back to the same groundwater body from which it is abstracted.

2.40. There will be no active (pumped) dewatering required during the operation phase but passive (gravity) dewatering of the bedrock aquifer will occur at a number of cutting locations along the

alignment, which will result in long term lowering of the groundwater levels, locally. This lowering has been assessed in a conservative manner, and it has been found that it will not impact directly on relevant receptors. In addition, all groundwater intercepted by the proposed road drainage will be discharged back to the same GWB thereby, maintaining the overall recharge rate to the local aquifer.

2.41. Point discharges to groundwater from the infiltration basins will lead to local increases in the groundwater level. This has been assessed conservatively, and it has been found that it will not impact directly on sensitive receptors.

2.42. Based on the conservative assessment of ZoI in the granite area; the management of uncertainty in the limestone area; and the design and mitigation measures put in place, I consider that the risks associated with dewatering during the construction and operational phases have been approached and managed appropriately, and in the case of the granite area over state the potential impacts.

Groundwater Pollution

2.43. Groundwater pollution is an important aspect of any development, but particularly a development on or in karst where contaminants can be transported quickly and for long distances, if transported in a conduit system[7]. This risk is recognised in the assessment and is linked to the definition of GWBs and the management of uncertainty associated with the karst. The approach taken is based on the assessment of receptors in the downgradient part of any particular GWB below the development area. This is a reasonable, conservative approach, which is based both on the groundwater level data analysis and the re-definition of the GWBs.

2.44. During construction and operation, there is a risk of groundwater pollution from hazards such as, concrete/grout pours, accidental spillages, fines (silt and clay) being washed from construction areas during storm events; accidents, fuel and other spills; run-off from the final pavement; and placement of geological materials with a different provenance from the specific locality. These hazards pose a high risk to groundwater in the limestone areas, particularly where conduit pathways are present.

[7] A conduit system refers to an interconnected network of solution weathered fractures, bedding planes and other discontinuities which effectively act as a pipe network in the limestone. It is a feature of karst flow systems.

2.45. The risks associated with groundwater pollution are mitigated by:

- The Construction Environmental Management Plan (CEMP), with the Sediment, Erosion & Pollution Control Plan (SEPCP) and the Karst Protocol being key components of the CEMP in this regard.
- The location, design and construction of wetland treatment and soakaway areas designed to Irish TR11 Standards.
- The drainage design, including the design of the infiltration basins, minimises the risk of a pollution event during operation affecting groundwater quality. Risk of spillage is low (<0.5%) and any impacts that do accidentally occur will be temporary.
    - All the infiltration basin designs include a containment area, a hydrocarbon interceptor and a wetland treatment component.
- The infiltration basins will promote settlement of fines and prevent entry of fines into the groundwater system.

2.46. The bedrock geology changes from the granite area in the west, to the limestone in the east. The two bedrock geology's have different chemical compositions. In simple terms the granite bedrock leads to base poor, low pH water, while the limestone water leads to base enriched neutral or high pH water. Therefore, if limestone derived material is placed over granite bedrock, surface water run-off and/or groundwater from the placed limestone has the potential to locally impact local areas of peatland habitats by changing the pH of the run-off and/or groundwater. I consider that, the consequence of such an impact on groundwater pH is likely to be imperceptible. Due to the largely chemically inert nature of granite (which produces base poor run-off and groundwater), if it is transported and used on embankments on limestone then there are no water chemistry concerns in terms of hydrogeology.

2.47. Risks of groundwater pollution are associated with all developments. The measures proposed to mitigate the risks within the context of this development are, in my opinion, concomitant with the nature and scale of the development and the level of the identified risks. As such the resultant risks associated with groundwater pollution and changes to water quality or chemistry at the European sites are, in my opinion, insignificant.

Groundwater Recharge

2.48. The construction and operation of the development will change the manner and potential for groundwater recharge[8]. As such there is a small, but real risk of an impact to receptors. Aspects of the proposed development which have the potential to affect recharge include:

- Vegetation and soil removal, which leads to an increase in the quantity of rainfall reaching the bedrock surface. In the granite area this is most likely to increase run-off rather than recharge; while in the limestone area this is likely to increase recharge.

- Pavement construction, which will lead to a loss of aquifer recharge area (zero recharge) along the alignment of the road, and diversion of rainfall to run-off.

2.49. The CEMP calls for all run-off to be discharged either to the same surface water catchment in the granite area, or the same GWB in the limestone area. As such, there will be minimal change to the quantity of water within the catchments, although there will be small differences in the distribution of recharge/run-off at the small (local) scale. These changes will quickly dissipate at the medium scale and in my opinion do not pose a material risk at the catchment or GWB scale, or on the cSAC/SPA scale.

2.50. The exception to this is where the road pavement directly crosses the Lough Corrib cSAC, south of Menlough Castle. In this location, the road pavement will prevent direct recharge to the underlying limestone. While the total quantity of groundwater reaching the cSAC will not change (due to the drainage arrangements), there will be a loss of rainfall reaching the bedrock surface directly under the pavement. This may have a negative impact on the flora below the elevated section of the pavement.

[8] Groundwater recharge is that component of rainfall which passes through the soil superficial material and unsaturated bedrock to reach the 'water table' or saturated zone, to become part of the groundwater flow system.

3 ANALYSIS OF KEY QUESTIONS

3.1. This section provides an analysis of the questions posed at paragraph 1.14 of this report.

Q1 Did the applicant and its advisors commission and undertake appropriate investigations to adequately define the baseline hydrogeological conditions?

3.2. The applicant and its advisors based their investigations on a desk study, field investigations and baseline monitoring of groundwater level and chemistry.

3.3. In summary, the desk study included the review of:

- Current and historical Ordnance Survey maps available for the study area (1:2,500 and 1:10,560 scales)
- Aerial photography
- Aerial imagery from Google and Bing
- LiDAR elevation data commissioned by OPW (Office of Public Works)
- Geological and hydrogeological maps produced by and ground investigation reports held by the Geological Survey of Ireland (GSI)
- Internationally published scientific and technical papers on the local geology, hydrogeology, soil, construction practices
- Reports and documents produced as part of the N6 Galway City Outer Bypass Scheme (2000 - 2006)

3.4. The field studies included a number of surveys and walkovers, together with intrusive drilling and field-testing investigations, including:

- Geophysical surveys to provide additional detail on subsurface ground conditions along the route of the proposed development.
- A condition survey of existing monitoring wells which were installed as part of the 2006 Galway City Outer Bypass studies, which allowed historic monitoring points to be incorporated into the monitoring network for the proposed road development.

- A regional karst survey was completed for the constraints and route selection studies for the proposed road development in 2014 and was updated in July 2016 following completion of site walkovers and ground investigations.

- Integration with five geological, geotechnical and hydrogeological ground investigations which included boreholes, trial pits and window sampling, aquifer permeability testing, groundwater sampling and analysis and water level monitoring.

3.5. In summary, the hydrogeological field investigations comprised the following:

- 34 No. groundwater monitoring wells
- 16 No. groundwater level monitoring rounds
- 12 No. groundwater quality monitoring rounds
- 15 No. infiltration tests
- 16 No. small scale pumping test and variable head permeability tests
- 8 No. Packer tests
- 1 No. step pumping test

3.6. Groundwater monitoring was undertaken between February 2015 and April 2017. This included a total of 16 groundwater monitoring rounds. Measurements on individual wells were also taken during commissioning, well testing and spot checks. In total, 54 individual wells were regularly measured. While not all monitoring points were included in all monitoring rounds, the exceptionally high rainfall in the winter of 2015/16 resulted in high groundwater levels which were captured during the monitoring, allowing a groundwater high to be established in and around Lackagh Quarry.

3.7. All site specific investigation locations were sited based on the alignment and design of the proposed road development. Groundwater level, groundwater quality and aquifer testing in particular, was focused on locations of cuttings, structures and receptors.

3.8. Within the context of the Natura 2000 related groundwater dependent receptors, these locations were investigated either by direct investigation, e.g. water level monitoring, water sampling and analysis; or by inference from the wider surveys e.g. geophysics and groundwater level monitoring, to determine

the hydrogeological regime relevant to them. Due to the ecologically sensitive nature of the Natura 2000 sites, the investigation methodologies selected were those that would not impact directly on the European sites.

3.9. In terms of undertaking the impact assessment and designing mitigation, the key data required was the groundwater level, particularly high groundwater levels, and aquifer permeability. This data is fundamental to the definition of GWBs and the assessment of direct impacts as a result of dewatering. *In my professional opinion the applicant and its advisors did commission and undertake appropriate investigations to adequately define the baseline hydrogeological conditions.*

Q2 Did the applicant and its advisors commission and undertake appropriate interpretation of the findings of these investigations to enable them to develop and present a robust conceptual model which demonstrates a sufficient understanding of the hydrogeological environment?

3.10. The results of the investigations have been used to develop a conceptual hydrogeological model which describes the following key features:

- The differences between the granite area to the west of the development and the limestone area to the east.
- The hydraulic properties of the bedrock aquifers in the two areas, and in the context of the limestone area acknowledgment of the highly variable nature of the aquifer in terms of permeability (the karst continuum).
- The interpretation of ground investigation and geophysical results, as well as groundwater levels and their seasonality to be able to better define GWBs within the limestone area.
- The link between GWDTE and lakes and the underlying groundwater systems.

3.11. I challenged the conceptual model and its veracity during the Oral Hearing, which resulted in several errata and correction documents being produced, together with improved representation of the model. Those corrections and representations did not materially change the conceptual model but provided a more robust baseline data set to support the model and made the understanding of the data easier.

3.12. In my professional opinion the applicant and its advisors have undertaken appropriate interpretation of the findings of the investigations, in a manner which enabled them to develop and present a robust

conceptual model, and which demonstrates a sufficient understanding of the hydrogeological environment.

Q3 Based on the conceptual model, did the applicant and its advisors provide sufficient analysis to rule out any potential impacts derived from changes of water quantity and quality on the integrity/conservation objectives of Natura 2000 sites including the River Corrib, GWDTEs and including consideration of any supporting aquatic habitats outside the Natura 2000 sites, such as Coolagh Lakes, beyond all reasonable scientific doubt?

3.13. Two important observations can be drawn from the conceptual model. The first is that the hydrogeology in the granite area is reasonably predictable, and the second is that in the limestone area there is always a degree of uncertainty due to the naturally highly variable nature of the ground.

3.14. With this in mind, the potential impacts in the granite area are well understood, and the analysis of the hydrogeological data within the context of the hydrogeological conceptual model and the proposed scheme, demonstrates that there is effectively zero risk derived from possible changes in water quantity or quality on the integrity/conservation objectives of Natura 2000 sites, beyond scientific doubt.

3.15. In the limestone area, it is acknowledged that residual risks remain due to the inherent uncertainty in the hydraulic properties in karst terranes. To this end, the design of the scheme has incorporated features which from a water management and hydrogeological perspective, will prevent potential impacts from occurring.

3.16. While Lough Corrib SPA is generally upstream of the proposed road development, a single outfall (the proposed drainage outfall for the N59 Link Road North) eventually discharges to a part of the River Corrib which falls within the SPA designation. It is also recognised that the proposed scheme also crosses GWBs that support groundwater dependent wetland habitats within European sites and traverses a number of watercourses that lie within or drain to a European site.

3.17. Therefore, the drainage of the scheme includes combined filter drains, carrier drains, surface water channels, narrow filter drains, cut-off and toe drains, attenuation ponds, grassed surface water channels, petrol and oil interceptors, wetlands and infiltration basins; in accordance with current TII Publications, guidance documents and industry best practice methods.

3.18. To maintain the existing water quality in receiving watercourses, flow control measures will be provided at all outfalls and discharge points along the length of the mainline of the scheme to ensure discharge does not cause any adverse effects on flow rates in the receiving watercourse or sewers, and

where appropriate to allow sufficient time for infiltration to discharge to the ground. As such, there will be 'no worsening' of flow rates outside of the site boundary up to the 1 in 100 year storm event.

3.19. Within the limestone area, a sealed drainage system is provided to protect the underlying sensitive aquifers, and the drainage design takes into account the distribution of groundwater bodies so that rainfall remains within the groundwater body to which it would naturally recharge.

3.20. Pollution control measures are provided on all networks on the mainline of the scheme prior to out-falling/discharging to ensure that receiving water bodies are not contaminated by run-off during the construction or operational phases.

3.21. To maintain the existing hydrogeological regime and minimise the risk of impacts to groundwater quality in receiving GWBs, there will be no groundwater lowering within groundwater bodies that support groundwater dependent habitats within a European site.

3.22. All infiltration basins include systems to remove floating hydrocarbons, dissolved metals in road run-off and suspended solids, by incorporating a hydrocarbon interceptor and an engineered wetland, and include a containment area to provide an appropriate holding time to contain accidental spillages. The basins will be over excavated by 2m to accommodate the provision of a minimum of 2m thickness of appropriate subsoil (as per TII definition in HD45/15), to provide a further attenuating layer for dissolved or suspended contaminants in the road run-off.

3.23. As such, the combination of the engineered wetlands with the infiltration basins and associated features, provides an appropriate level of protection to prevent contamination of groundwater from the road run-off.

3.24. The area around the Lackagh Tunnel and the Menlough Viaduct is, and has been recognised as, particularly sensitive, due to the potential for an impact on the Lough Corrib GWB and in turn on the Lough Corrib cSAC. Considerable effort has gone into the understanding of the hydrogeology in this area and the interactions between GWDTE, lakes, groundwater, and the development. As a result, the design of the scheme around Lackagh Quarry does not allow dewatering of the bedrock aquifer to be undertaken in association with Lackagh Tunnel and its western approach, and the Menlough Viaduct.

3.25. To avoid construction of the Lackagh Tunnel affecting QI Annex I habitats in Lough Corrib cSAC or affecting the existing hydrogeological regime supporting wetland habitats in Lough Corrib cSAC, the following designs and construction protocols have been put in place:

- The Lackagh Tunnel is a mined (drill and blast) twin bored tunnel within rock located beneath the Lough Corrib cSAC, with the following features:
    - each bore maintains at least 8m clear rock above the crown of the tunnel to the top of the Lough Corrib cSAC ground surface
    - a 7m wide pillar separating the twin bores
- Stabilisation of the western quarry face will be completed in advance of tunnelling works including a composite support system of rock bolts, rock dowels, steel mesh and sprayed concrete.
- Blast design and limitations are set out and include, a conservative design approach, and a vibration assessment which determined that a maximum vibration limit of 25mm/sec at the ground level will not pose a risk to habitats within Lough Corrib cSAC. A target construction blast vibration limit of 20mm/sec will be implemented ensuring the maximum vibration limit is not exceeded. A monitored trial blast will be undertaken in the same bedrock formation by the blasting contractor in a controlled location that will pose no risk to sensitive receptors, including habitats within Lough Corrib cSAC. The trial blast will not exceed the vibration limitations of the local sensitive receptors and therefore pose no impact. The information obtained from the trial blast will be used to calibrate and refine the blast design to a site-specific design.
- The infiltration basin in Lackagh Quarry has been designed to retain the natural recharge pattern by maintaining recharge to the groundwater body below.
- In order to maintain recharge catchments, any inflows into the tunnel during construction will be managed by designing them to infiltrate to the floor of the tunnel until their inflow is sealed off.
- All construction works will remain above the local groundwater level for the duration of the works to ensure that the groundwater is not intercepted, and dewatering of the bedrock aquifer is not required. The construction schedule will be tailored so that the excavation of the lower section will occur when the groundwater level is low and is below the construction level.
- The tunnel will be fully lined with concrete.

- On the western approach to Lackagh Tunnel a watertight seal will be installed on the underside of the road base and the cutting sides to protect against groundwater inflow and prevent contamination of groundwater.

- Retaining systems are included at pinch point locations to prevent encroachment on Annex I habitats.

- The retaining walls on the western approach will be watertight to a level of +17.7mOD to seal out any groundwater in the subsoil or bedrock and will prevent contamination of groundwater.

3.26. While other parts of the scheme within the limestone area have the potential to impact on the groundwater system, they are not in direct contact with Natura 2000 sites and only have weak connections, or pathways associated with the Inner Galway Bay SPA, and Galway Bay Complex cSAC and do not pose a direct risk to either.

3.27. Based on the conceptual model the differences between the granite and limestone areas, the proposed scheme, and the design considerations included to protect Natura 2000 sites, it is my professional opinion that the applicant and its advisors have provided sufficient analysis to rule out any potential impacts derived from changes in groundwater quantity and quality on the integrity/conservation objectives of Natura 2000 sites, including the River Corrib, GWDTE and including consideration of any supporting aquatic habitats outside the Natura 2000 sites, such as Coolagh Lakes, beyond all reasonable scientific doubt.

Q4 In the case of non-Natura 2000 sites, are the baseline conditions and potential impacts adequately described and are the mitigation proposals put forward justifiable and reasonable?

3.28. As described in the previous sections, in my professional opinion the baseline conditions and potential impacts are adequately described.

3.29. The Construction Environmental Management Plan (CEMP) is an important tool in managing risk. The CEMP summarises the overall environmental management strategy that will be adopted and implemented during the construction phase of the proposed road development. The purpose of the CEMP is to demonstrate how the proposed construction works can be delivered in a logical, sensible and safe sequence with the incorporation of specific environmental control measures relevant to construction works of this nature. The CEMP sets out the mechanism by which environmental protection

is to be achieved during the construction phase of the proposed road development. Implementation of the CEMP must ensure that disruption and nuisance are kept to a minimum.

3.30. The CEMP has been prepared in accordance with industry best practice guidance including:

- TII's Guidelines for the Creation, Implementation and Maintenance of an Environmental Operating Plan.
- Construction Industry Research and Information Association (CIRIA) in the UK, Environmental Good Practice on Site Guide, 4th Edition (CIRIA 2015).

3.31. The CEMP has been prepared with reference to the Environmental Impact Assessment Report (EIAR) and the Natura Impact Statement (NIS).

3.32. Of particular note with respect to water management is the Sediment, Erosion and Pollution Control Plan (SEPCP), which summarises the procedures and technical practices for implementing effective sediment, erosion and pollution control through a variety of delivery methods for the construction phase of the proposed road development. The SEPCP demonstrates that run-off from the construction site can be controlled so as not to impact any receptors.

3.33. With respect to the hydrogeology of the limestone area in particular, the Karst Protocol (contained within the CEMP) summarises the procedures and technical practices for the identification of karst conduits within the limestone during construction. Investigation and treatment is necessary to ensure that there is no, or effectively no, impact on the quantity or quality of groundwater either as a result of construction or operation of the proposed development.

3.34. In summary, the full and proper implementation of the CEMP will ensure that any direct or indirect or ex-situ impacts on the non-Natura 2000 are avoided and on that basis, in my professional opinion, the mitigation proposals put forward are justifiable and reasonable.

Q5 Assuming that the mitigation proposals put forward are justifiable and reasonable, are there any residual risks despite the mitigation, and if so what degree of risk remains and if impacts occurred, would it be sufficient to undermine the conservation objectives for the river and the lakes (or any other GWDTE in the SAC or surrounding area)?

3.35. The risks associated with hydrogeological related impacts manifest themselves via a reduction in water quantity or quality at any particular receptor. These risks have been assessed on an appropriately robust quantitative data set, which has been interpreted in a conservative manner. The assessment

within the granite area is particularly conservative, and the residual risks are in my professional opinion effectively zero. Within the karst area, residual risks remain due to the inherent, natural variation associated with the karst continuum. The residual risks relate to water quality, as the design of the scheme maintains the water balance within each GWB and dewatering will not be undertaken in those GWBs with a direct link to Natura 2000 sites.

3.36. The residual risks associated with water quality are mitigated by the CEMP and its associated SECP and the Karst Protocol. The SECP and Karst Protocol serve to reduce the risk of introduction and transport of polluting materials into the ground to an absolute minimum, and to ensure that karst conduits discovered during construction are investigated and treated appropriately.

3.37. The operational design of the scheme reduces the risk of contaminated water entering the ground by the provision of engineered treatment wetlands prior to soakaway areas and the incorporation of valves to hold back run-off from accidental spillages. The residual risks therefore result from an incident or sequence of occurrences which overwhelm the system and/or poor maintenance of the mitigation. In the case of the former, this risk cannot be ever reduced to zero, however the design of the systems is in line with government guidance and is robust. Failure due to natural events will be associated with high rainfall and run-off and therefore by definition will be short-lived and associated with high volumes of dilution.

3.38. It is important, that in order to provide ongoing mitigation, that the drainage systems, treatment wetlands and soakaways are well maintained, in perpetuity.

3.39. Assuming that the CEMP is implemented in full and to a high standard, it is my professional opinion that residual risk is very low and insufficient to undermine the conservation objectives for the River Corrib and associated lakes (or any other GWDTE in the cSAC or surrounding area), and that in the unlikely event that impacts occurred, that they would it be short-lived and insignificant.

Q6 With respect to the screening assessment for the Appropriate Assessment – is the applicant correct to screen out all but the Lough Corrib and Galway Bay Natura 2000 sites, or are there any impact pathways not considered that should have been?

3.40. The groundwater pathways or vectors that link the proposed road development with the wider environment are well understood. The technical basis for the screening assessment with respect to hydrogeology is the groundwater catchment (or in this case the GWB). The screening was carried out based on mapped surface water catchments and the GWBs mapped by the GSI. On that basis the

screening identified that the only at-risk receptors were the Lough Corrib and Galway Bay Natura 2000 sites, which in my professional opinion was correct. As part of the technical hydrogeological investigation the Clare-Corrib GWB was re-defined and split into several sub-catchments. This was based on good scientific data and did not alter the broader picture represented in the Appropriate Assessment.

3.41. Given the hydrogeological setting in both the granite and limestone areas, and the technical hydrogeological investigations that have been undertaken it is my professional opinion that there are no other impact pathways which should have been considered.

Q7 For the Environmental Impact Assessment (and to a lesser extent the Appropriate Assessment), in respect of bird populations also using Galway Bay and Lough Corrib, will there be a significant impact on water quality and in Ballindooley Lough and/or Moycollen Bogs, or other wet habitats such as wet heath?

3.42. There are two mechanisms by which the water quality at Ballindooley Lough and/or Moycollen Bogs, or other wet habitats such as wet heath, could be affected by the proposed road development. The first is due to contaminated run-off during the construction or operation entering watercourses or groundwater and entering the lakes or other wet habitats. The other is a change in the provenance of water entering the lake or other wet habitats of such magnitude that it affects the chemistry of the water and the ecology that relies upon it.

3.43. The conservative nature of the technical assessments, the design of the scheme and the mitigation that is proposed demonstrate, in my opinion, that the risks to the wet habitats in the granite area including Moycollen Bog are effectively zero.

3.44. In the limestone area, and in the area of Ballindooley Lough (and Lough Corrib) the technical assessment has shown that the lakes are effectively isolated from a significant groundwater flux, by virtue of thick underlying low permeability material, as such any small effect on groundwater flow (flux) as a result of the proposed road scheme would have no material effect on the provenance and mix of the water chemistry. The mitigation included in the design and management of the construction and operation of the scheme effectively reduces the risk of an impact on water quality in Ballindooley Lough and/or Moycollen Bogs, or other wet habitats such as wet heath, to essentially zero.

3.45. *Therefore in my professional opinion, the risk of an effect with respect to a groundwater pathway or vector, sufficient to impact on the bird populations using the Galway Bay and Lough Corrib SPAs, is effectively zero.*

4 OBJECTORS COMMENTS

4.1 A list of objectors and the topics that they raise are provided in Section 1. In summary the topics that have been raised are:

- Potential impacts to private domestic wells
- Potential impacts to private commercial wells
- Possible impacts to water quality
- Potential impacts to private wastewater treatment systems
- Potential impact to a geothermal borehole
- Potential for groundwater flooding and sediment mobilisation at Lackagh Quarry
- Potential for structural instability in areas of groundwater drawdown
- Potential for impacts to Lough Corrib cSAC through the hydrogeological interactions
- Potential for impact to Moycullen Bogs NHA through hydrogeological interactions

4.2 The hydrogeological assessment, presented in Chapter 10 of the EIAR and Appendix A of the NIS, includes detailed consideration of groundwater features located within the study area, assessment of changes to the hydrogeological environment from design elements and mitigation measures proposed in respect of the proposed road development.

4.3 I have reviewed these documents and consider that the applicant and its advisors commissioned and undertook appropriate investigations to adequately define the baseline hydrogeological conditions, and that they used the results from the investigations and analysed and interpreted them appropriately. This enabled them to develop and present a robust conceptual model which demonstrates a sufficient understanding of the hydrogeological environment, to allow potential impacts to have been evaluated.

4.4 In his Statement of Evidence submitted on 20 February 2020, Dr Leslie Brown responded to submissions/objections and provided further information and clarification on the assessments undertaken and put these in the specific context of the objections raised. During his oral evidence I

robustly challenged Dr Brown, resulting in erratum and additional clarification being submitted during the hearing.

4.5 As part of this four water supply wells that were not identified in the EIAR were assessed using the methods described in Chapter 10 of the EIAR. The assessment provides mitigation for impacts, and where necessary identifies those wells that will need to be decommissioned and replaced.

4.6 The four commercial wells identified in the objections will be impacted by the proposed road development and mitigation measures have been proposed to provide alternative replacement wells at the Galway Racecourse. As stated in Section 1 of this report Clada Group Ltd withdrew their objections after the hearing.

4.7 Mitigation measures have been incorporated to manage runoff of contaminated water during all the phases of the development, including construction. The mitigation takes account of the special risks associated with karst terrain.

4.8 Concerns about the impact of the development on private water treatment systems reliant on soakaways for treated effluent have been examined. In summary, the locations in question are adjacent to cuttings where groundwater is likely to be lowered, rather than raised. For this reason, the percolation areas highlighted in the submissions/objections are not at risk from the proposed road development.

4.9 The geothermal well referenced in two submissions is located outside the zone of influence of the proposed and therefore will not be impacted.

4.10 The concerns raised regarding the flooding of Lackagh Quarry relate to the level that the water level will rise and the mobilisation of suspended solids. The hydrogeology of the Lackagh Quarry area has been studied in detail and the design of the proposed development through all the phases takes account of the full range of seasonal groundwater levels including peak conditions experienced in the winter of 2015/2016, to ensure that the design is robust and does not alter the current groundwater regime. The mitigation measures put forward with respect to the design, construction and vegetation of the material deposition areas will prevent fines from being mobilised into the groundwater system.

4.11 An issue was raised in submission, Ob_134, regarding the structural stability of a house where groundwater levels are reported to be lowered adjacent to cuttings. This property is on the edge of the zone of influence created by drainage from the cutting, which means that in this area the

groundwater levels may be reduced, but only by a very small amount. The risk of settlement is very low, but the developers have agreed that a property condition survey will be undertaken.

4.12 The Department of Culture, Heritage and the Gaeltacht raised a number of concerns regarding groundwater interaction between Lackagh Tunnel, Lough Corrib Fen 1 GWB and Lough Corrib cSAC and whether groundwater flow paths would change post construction.

4.13 The Department of Culture, Heritage and the Gaeltacht also raised concerns regarding potential impacts to Moycullen Bogs NHA.

4.14 In response to these concerns Dr Brown provided further clarity and a comprehensive explanation describing the interaction between groundwater and surface water at the European sites, including the Lough Corrib cSAC, and NHA sites, including the Moycullen Bogs NHA at Letteragh. These topics were also discussed at the oral hearing and I spoke independently to representatives of the Department. Concerns were raised by the Department about high permeability pathways in the granite that may connect cuttings in the road alignment with the NHA.

4.15 In summary, Coolagh Lakes are fed primarily from one significant groundwater spring, Western Coolagh Spring. The habitat around the periphery of Coolagh Lakes is identified as being water dependant, and as such the habitats at Coolagh Lakes are GWDTE. Robust mitigation measures have been designed so flows to Western Coolagh Spring are not affected during any phase of the development. Furthermore, karst specific measures incorporated into the construction design will ensure that groundwater flow paths will not change post-construction.

4.16 With respect to Moycullen Bogs NHA, all areas of the Moycullen Bogs NHA are in separate catchments or sub-catchments to road cuttings for the proposed road development. Based on assessment of each cutting, the maximum drawdown reach will remain with its own sub-catchment extent and on this basis, the proposed road development will have no impact to the Moycullen Bogs NHA. The zone of influence calculations in the granite are robust and conservative and while high permeability fractures in the granite may occur, their extent and continuous permeability are highly likely to be restricted, and any transmission of ground water will as a result be very small in comparison to the overall water balance which is dominated by rainfall.

5 OVERALL CONCLUSIONS

5.1 In considering the documentation available to me, and the responses to questions posed at the Oral Hearing by myself and my colleagues, I draw the following overall conclusions.

5.2 The applicant and its advisors commissioned and undertook appropriate investigations to adequately define the baseline hydrogeological conditions.

5.3 The applicant and its advisors used the results from the investigations and analysed and interpreted them appropriately to enable them to develop and present a robust conceptual model which demonstrates a sufficient understanding of the hydrogeological environment, to allow potential impacts to have been evaluated, and reduced to an appropriate level through the design of construction and operation of the scheme and its associated mitigation measures.

5.4 Based on the conceptual model, the applicant and its advisors have provided sufficient analysis to rule out any potential impacts derived from changes of water quantity and quality on the integrity/conservation objectives of Natura 2000 sites including the River Corrib, GWDTEs and including consideration of any supporting aquatic habitats outside the Natura 2000 sites, such as Coolagh Lakes, beyond all reasonable scientific doubt.

5.5 In the case of non-Natura 2000 sites, the baseline conditions and potential impacts are adequately described and the mitigation proposals put forward are justifiable and reasonable.

5.6 Taking account of the design of the scheme and the proposed mitigation, there are no residual risks that would be sufficient to undermine the conservation objectives of the River Corrib and associated lakes, or any other GWDTE in the cSAC or surrounding area.

5.7 The applicant was correct to screen out all but the Lough Corrib and Galway Bay Natura 2000 sites in the Appropriate Assessment, and there are not any other impact pathways that should have been considered.

5.8 With respect to the bird populations using Galway Bay and Lough Corrib SPAs, there will not be a significant impact on water quality or quantity in Ballindooley Lough and/or Moycollen Bogs, or other wet habitats such as wet heath.

5.9 In my professional opinion, the comments and objections raised by the public, companies and the Department of Culture, Heritage and the Gaeltacht have been considered and answered in detail and fully.

5.10 An important part of the protection of both the Natura 2000 sites and other receptors is the implementation of the CEMP and associated SECP and Karst Protocol, to a very high standard; together with the continuous maintenance of the drainage systems, wetland treatment and soakaway areas, in perpetuity. Failure to do either of these could result in an unacceptable impact.

5.11 It is my considered view that with respect to hydrogeology and following the implementation of the mitigation measures prescribed in the design the proposed road development will not, by itself or in combination with other plans or projects, have any adverse effect on the integrity of any European sites in view of their conservation objectives and there is no reasonable scientific doubt as to that conclusion. On that basis and subject to other aspects outside my area of expertise, my recommendation would be to approve the planning application.

6 DECLARATION

4.17 The report I have prepared and provide for this application references ABP 302848-18 & ABP 302885-18 is true and has been prepared and is given in accordance with the guidance of my professional institution, the Geological Society of London, and I confirm that the opinions expressed are my true and professional opinions.

4.18 I have objectively addressed all the issues pertaining to this hearing, to which I am professionally qualified to comment upon and required to address. I have also strived to ensure that the evidence in this report and related opinions are as informed, objective and accurate as possible, based on the tangible evidence which was available to me.

4.19 I confirm that I have not entered into any arrangement whereby the payment of my professional fees, charges or expenses is in any way dependent upon the decision of the Board. Consequently, all the professional judgements expressed in this report are my own and represent my true professional opinion of the matters under consideration.

4.20 It should be noted that if any aspect covered in this report does not specifically mention comments or issues raised by the applicant, there agents, third parties or consultees, it does not necessarily mean that I agree with such comments or issues.

James Dodds MSc DUC CGeol FGS
May 2021